NORTH PEORIA AREA DRAINAGE MASTER PLAN

Attachment 2
Hydrologic and Hydraulic Technical Data Notebook

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PREPARED FOR:

FLOOD CONTROL DISTRICT
of
Maricopa County
and
City of Peoria

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FLOOD CONTROL DISTRICT of MARICOPA COUNTY 1959

CITY OF PEORIA

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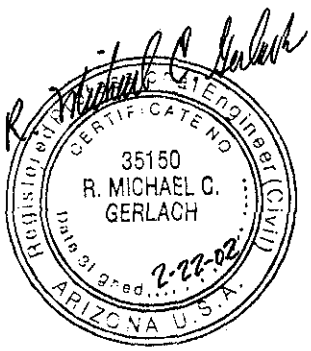

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SECTION 1: INTRODUCTION

The following report is a comprehensive document that contains the results, supporting data and calculations for the hydrologic and hydraulic analyses conducted as part of the North Peoria Area Drainage Master Plan. This study was undertaken by the Flood Control District of Maricopa County in cooperation with the City of Peoria for the purpose of developing policies and guidelines for the management of impending development with the study area. The results of the hydrologic and hydraulic analyses are used, in part, in the establishment of the policies and guidelines, but also as a tool for managing the development.

The North Peoria Area Drainage Master Plan (NPADMP) study area is located in the north-central portion of Maricopa County and encompasses approximately 67 square miles, as shown in Figure 1-1. More than half of this area falls within the City of Peoria corporate limits, as shown in Figure 1-2. The remaining area lies within unincorporated portions of Maricopa and Yavapai Counties. Currently, the study area is almost entirely undeveloped desert mountain, hill slope and range land terrain that is drained by numerous tributaries of the Agua Fria River. The study area is exclusive of the Agua Fria River, as similar issues regarding the river are addressed in the Agua Fria River Watercourse Master Plan. The excluded area is defined by the Agua Fria River 100-year floodplain.

Hydrologic analyses are conducted for the entire study area including a portion of the watershed that extends into Yavapai County in accordance with the methodologies set forth in the Drainage Design Manual for Maricopa County, Volume I, Hydrology, 1995. Hydrologic modeling is performed for both existing and future watershed conditions for multiple storm frequencies.

Hydraulic analyses are conducted for numerous watercourses within the study area for both existing and future watershed conditions. The locations of these watercourses are shown in Figure 1-3. Part of this effort includes floodplain delineation for 11 watercourses and their tributaries totaling approximately 36 miles. Detailed documentation of the hydrologic and hydraulic analyses conducted for the delineation of these floodplains is provided in a separate report entitled North Peoria Area Drainage Master Plan, Flood Insurance Study Hydrology and Hydraulic Submittal Technical Data Notebook (Stantec, 2001).

Figure 1-1

Location Map

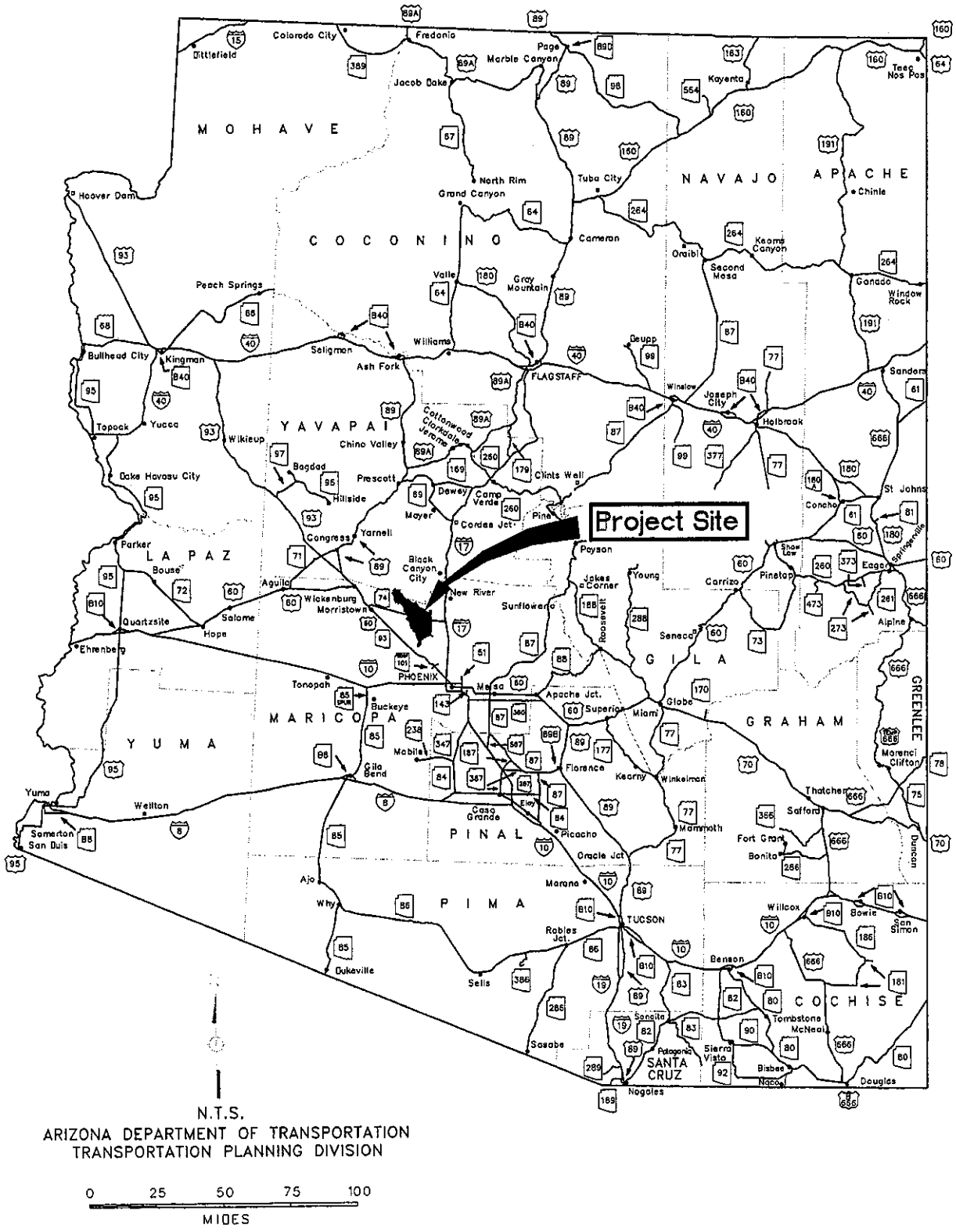


Figure 1-2

Vicinity Map

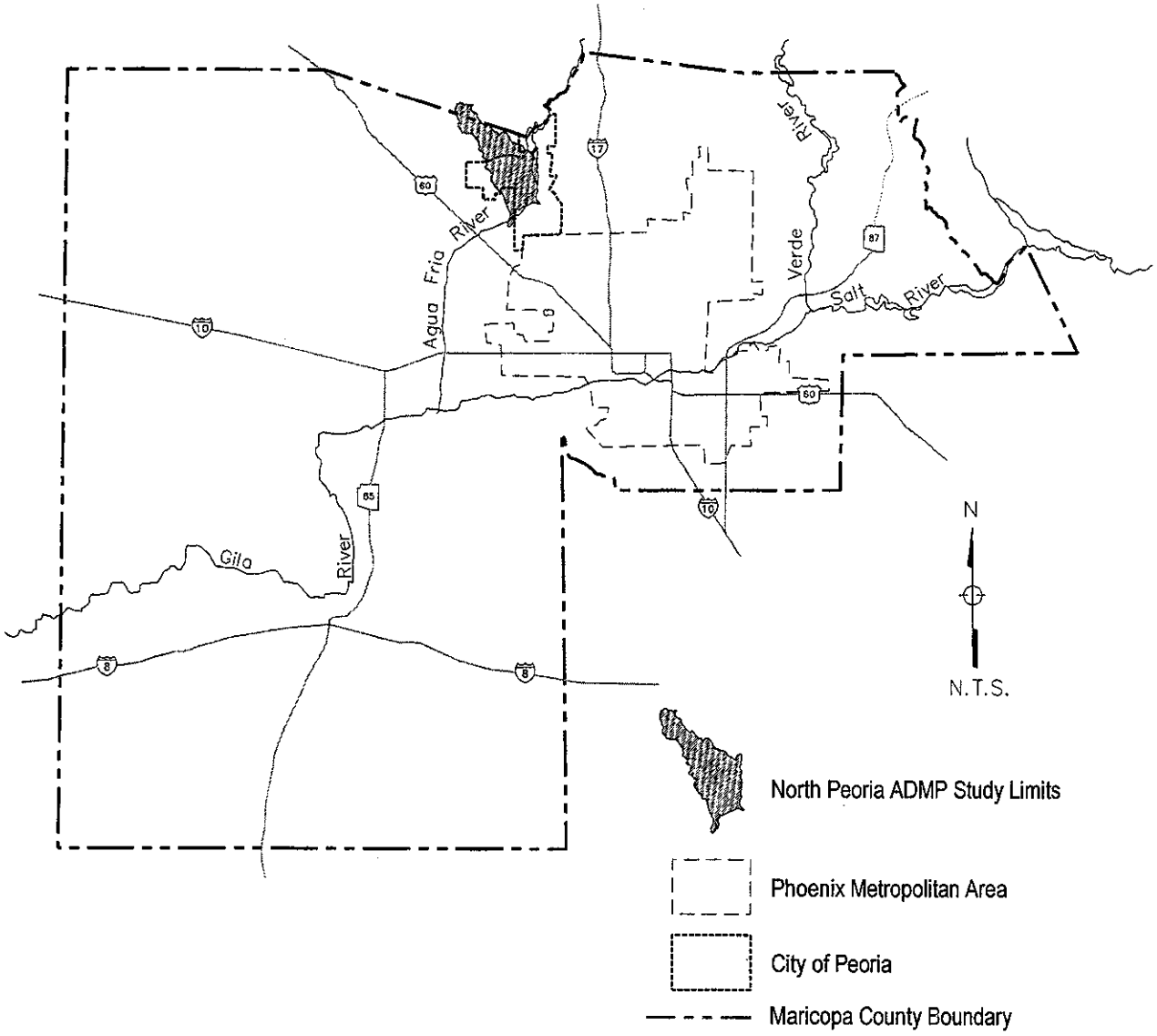
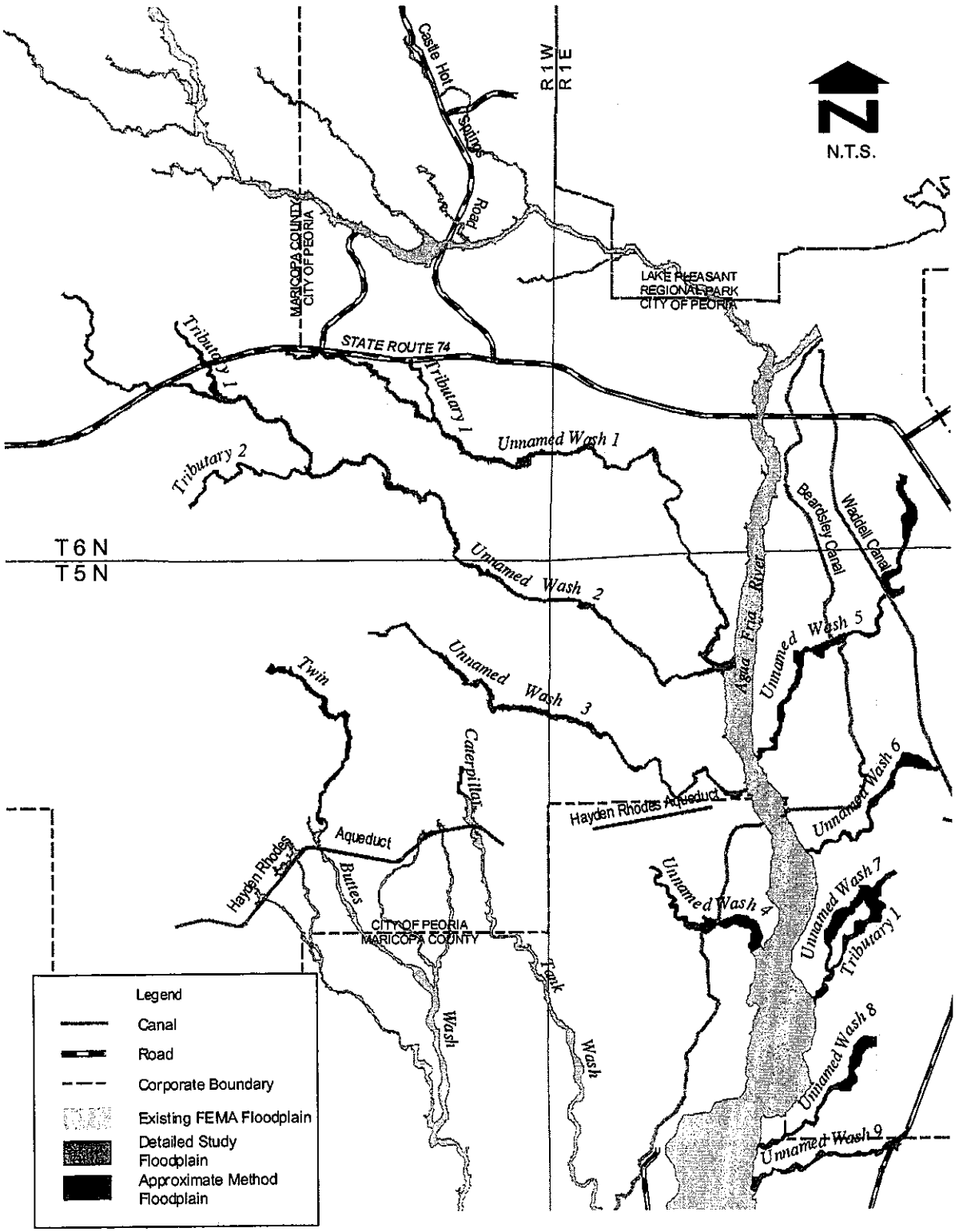


Figure 1-3

Study Watercourse Location Map



SECTION 2: MAPPING AND SURVEY INFORMATION

2.1 Description of Mapping

The base mapping data used to produce exhibits for the hydrologic portion of this study are summarized by exhibit map as follows:

Watershed Map (Plate 1) - The base mapping used for Plate 1 comprises a mosaic of all or portions of the following United States Geological Survey (USGS) 7.5 Minute Quadrangle Maps:

Baldy Mountain:	Revised in 1978, Published in 1983, 20-foot contour interval (CI), National Geodetic Vertical Datum (NGVD) of 1929.
Biscuit Flat:	1965 mapping from 1962 photography, photo revised 1981, 20-foot CI, NGVD of 1929.
Calderwood Butte:	Published 1972, 10-foot CI, NGVD of 1929.
Garfias Mountain:	1965 mapping from 1962 photography, photo revised 1978, 40-foot CI, NGVD of 1929.
Governors Peak:	1965 mapping from 1962 photography, photo revised 1978, 40-foot CI, NGVD of 1929.
Hedgepeth Hills:	Published 1972, 10-foot CI, NGVD of 1929
Hieroglyphic Mnts SW:	Revised 1978, published 1982, 20-foot CI, NGVD of 1929.

Digital images for these USGS Quadrangle Maps were combined into a single file to produce a basemap in AutoCAD format. The horizontal coordinate system of the digital images is the North American Datum of 1983 (NAD83) Arizona State Plane, central zone. The final plotting scale for Plate 1 is 1 inch = 2,000 feet.

Soils Map (Plate 2) - The base mapping data for Plate 2 is derived from the following three sources:

1. Soil Conservation Service, 1986, Soil Survey of Aguila-Carefree, Parts of Maricopa and Pinal Counties, Arizona (herein called Aguila SCS Survey),

2. Soil Conservation Service, 1977, Soil Survey of Maricopa County, Arizona, Central Part (herein called Central SCS Survey),

3. Soil Conservation Service, 1976, Soil Survey of Yavapai County, Arizona, Western Part (herein called Yavapai SCS Survey).

A digital file of both the Maricopa County SCS Survey soil boundaries were provided by the District as an ArcView shape file along with the associated database of the soil properties. Soil boundaries and distribution of soil types for the Yavapai County portion of the watershed were digitized from the detailed soils maps included as part of the Yavapai SCS Survey. The Yavapai County soils boundaries and the associated physical properties were then merged with the Maricopa County soils data to produce a single soils ArcView shape file and associated database for the entire watershed. The final plotting scale for Plate 2 is 1 inch = 2,000 feet.

Existing Conditions Land Use Map (Plate 3) - Existing condition land use boundaries and associated information for the Maricopa County portion of the watershed was supplied by the District digitally in AutoCAD format. The AutoCAD drawing file was then converted into an ArcView shape file and associated to a database of land use properties and zoning information. Land use boundaries and zoning information are based on the Maricopa Association of Governments (MAG) land use plan, in 1995. Corporate boundaries and zoning were checked against current data and revised as necessary. The Yavapai County portion of the watershed is assumed to be undeveloped, unincorporated county land. An ArcView shape file and associated database of land use properties and zoning information is created for the entire watershed. Final plotting scale for Plate 3 is 1 inch = 2,000 feet.

Future Condition Land Use Map (Plate 9) - Future condition land use boundaries and associated information for the City of Peoria were adapted from the City of Peoria General Land Use Plan, dated October 2000. That plan also covers the unincorporated Maricopa County portions of the watershed. The land use for the Yavapai County portion of the watershed is assumed to remain undeveloped. The final plotting scale for Plate 9 is 1 inch = 2,000 feet.

The base mapping data used to produce exhibits for the detailed study reaches of the hydraulic portion of this study were prepared by Cooper Aerial Surveys Company (Cooper). The aerial photography flight date was 18 February 2000 with survey control provided by Valco Surveying Corporation (Valco). The mapping was prepared at a scale of 1 inch = 400 feet with a contour interval of 2 feet. The horizontal and vertical datums are NAD83 and NGVD29. The horizontal projection is Arizona State Plane, central zone. Cartographic features identified by the mapping company include roadways (both paved and unpaved), buildings and culverts. Base mapping for the approximate method study reaches are the 7.5 Minute Quadrangle Maps which are the same as those used for the hydrologic portion of this study.

Preparation of the base maps used for the detailed hydraulic analysis includes verification of the map accuracy. Two methods of verification were utilized to determined if the base mapping meets the accuracy standards as set forth in Flood Insurance Study Guidelines and Specifications for Study Contractors, Federal Emergency Management Agency, April 1999 (FEMA 37). The first method is the Root Mean Square Error test (RMSE) as defined in Appendix 4 of FEMA 37. The data used in the determination of the RMSE are provided in a separate report entitled North Peoria Area Drainage Master Plan, Attachment 1 Filed Survey Report. The second method is a comparison of field survey cross sections to cross sections read from the triangulated irregular network (TIN) prepared from the photogrammetric data provided by Cooper. Sixteen cross sections were prepared and plotted for visual inspection. The plots for each cross section as well as a figure showing the location of the cross sections along the watercourses are provided in Appendix I of the floodplain delineation study report entitled North Peoria Area Drainage Master Plan, Flood Insurance Study Hydrologic and Hydraulics Technical Data Notebook. The results of these verification methods show that the mapping meets the FEMA 37 accuracy standards.

2.2 Index of Maps

Each hydrology plate (Plates 1, 2, 3 and 9) is a single sheet map, and therefore, does not require a mapping index. A reduced scale copy of the index sheet map for the floodplain and floodway maps is provided in Appendix N. A full size index map is provided with the Flood Insurance Study report entitled North Peoria Area Drainage Master Plan, Flood Insurance Study Hydrologic and Hydraulics Submittal Technical Data Notebook (Stantec 2001).

2.3 Survey Field Notes

No survey information was used in the hydrologic analysis. Valco provided the horizontal and vertical control used for the detailed mapping. That data is documented in a separate report entitled North Peoria Area Drainage Master Plan, Attachment 1 Filed Survey Report (Valco 2001). Also included in that report are descriptions of the elevation reference marks (ERM's) established for this study.

2.4 Watershed Maps, Hydrologic Analysis Maps

Plates 1, 2, 3 and 9 represent the maps used for the hydrologic analyses that are summarized in this report. Folded copies of each map are provided in pockets at the back of this report.

Plate 1 is a map of the study watershed showing subbasin boundaries, concentration points, time of concentration flow paths, reach route flow paths and cadastral boundaries. The cadastral information includes Township, Range and Section lines, municipal boundaries and associated text. All of this information overlays the USGS quadrangle basemap discussed in Section 2.1.

Plate 2 is a soils map for the study watershed. In addition to the base information discussed in Section 2.1, Plate 2 displays soil type and distribution, subbasin and cadastral boundaries within the watershed.

Plate 3 is the existing condition land use map for the study watershed. In addition to the base information discussed in Section 2.1, Plate 3 displays land use type and distribution, subbasin and cadastral boundaries within the watershed.

Plate 9 is the future condition land use map for the study watershed. In addition to the base information discussed in Section 2.1, Plate 9 displays land use types and distribution, subbasin and cadastral boundaries within the watershed.

2.5 Hydraulic Analysis Maps

Plates 4 through 7 represent the maps used for the hydraulic analyses that are summarized in this report. Reduced scaled copies of each map are provided in Appendix N. Full size copies are

provided in the Flood Insurance Study report entitled North Peoria Area Drainage Master Plan, Flood Insurance Study Hydrologic and Hydraulic Submittal Technical Date Notebook (Stantec 2001).

Plate 4 is a set of 6 sheets covering the study limits for Unnamed Wash 1. In addition to the base information discussed in Section 2.1, this plate shows the floodplain and the floodway limits, base flood elevations, cross section locations and cadastral information. Cadastral information includes Township, Range and Section lines, municipal boundaries and associated text. The final plotting scale for Plate 4 is 1 inch = 200 feet.

Plate 5 is a set of 6 sheets covering the study limits for Unnamed Wash 2. In addition to the base information discussed in Section 2.1, this plate shows the floodplain and the floodway limits, base flood elevations, cross section locations and cadastral information. Cadastral information includes Township, Range and Section lines, municipal boundaries and associated text. The final plotting scale for Plate 5 is 1 inch = 200 feet.

Plate 6 is a set of 4 sheets covering the study limits for Unnamed Wash 3. In addition to the base information discussed in Section 2.1, this plate shows the floodplain and the floodway limits, base flood elevations, cross section locations and cadastral information. Cadastral information includes Township, Range and Section lines, municipal boundaries and associated text. The final plotting scale for Plate 6 is 1 inch = 200 feet.

Plate 7 is a set of 6 sheets covering the approximate method study limits for several watercourses within the project boundary. This plate shows the floodplain limits, cross section locations and cadastral information. Cadastral information includes Township, Range and Section lines, municipal boundaries and associated text. The final plotting scale for Plate 7 is 1 inch = 400 feet.

2.6 Miscellaneous Maps

An Existing Facilities Map (Plate 8) has been prepared and included for reference at the back of this report. This map shows the location of hydraulic and other structural features in the watershed that have the potential to impact drainage patterns. Individual structures are located

graphically on the basemap described in Section 2.1 and have an associated numeric identifier. A key note table is included on the map that lists each structure identifier along with brief description of the structure. Location and descriptive information for each structure is obtained from the following sources:

1. State Highway, Morristown-New River, Maricopa County: As-Built Plan & Profile,
2. Central Arizona Project, Plan & Profile As-Built plans for the Waddell Canal and Granite Reef Aqueduct,
3. Castle Hot Springs Road, Plan and profile drawings,
4. 1999 Aerial photography, and
5. Field Investigations.

SECTION 3: EXISTING CONDITION HYDROLOGIC ANALYSIS

3.1 Method Description

Watershed modeling is conducted in accordance with the methodologies set forth in the Drainage Design Manual for Maricopa County, Volume I, Hydrology, (Flood Control District of Maricopa County, 1995), which is herein referred to as the Design Manual. Modeling is performed for both existing and future watershed conditions for multiple storm frequencies. The analytical methods employed for this study are the Rational Method and rainfall-runoff modeling. Rainfall-runoff modeling is accomplished using the US Army Corps of Engineers (COE) HEC-1 Computer Program, version 4.1, dated June 1998. Both the 6- and 24-hour duration storms are modeled for each frequency (2-, 5-, 10-, 25-, 50- and 100-year) for both existing and future watershed conditions. Two storm durations are used in order to determine which storm results in the higher magnitude of peak discharge and runoff volumes at the various locations in the watershed. The rainfall depth-duration-frequency statistics for both the 6- and 24-hour storm durations are obtained from the NOAA Atlas II, Arizona. The rainfall distributions used are the SCS Type II for the 24-hour storm and the 6-hour storm patterns suggested in the Design Manual. Rainfall losses are estimated using the Green and Ampt infiltration equation with additional consideration for surface retention losses and impervious areas. The Clark Unit Hydrograph is used for runoff hydrograph development for all subbasins in the watershed. Runoff hydrographs are routed through the watershed using Modified Puls channel storage routing. Storage routing at crossings of existing structures is accomplished using the Modified Puls reservoir routing option of HEC-1. Retention of the increased runoff due to future watershed conditions is based on the 100-year, 2-hour rainfall depth.

The Rational Method is used to estimate peak discharges at several locations where hydrologic routing is not required and/or where very small drainage areas make rainfall-runoff modeling impractical. The Rational Method relates the rainfall intensity, a runoff coefficient and drainage area to generate a peak discharge. The rainfall intensity is estimated using the rainfall intensity-duration-frequency relation in the Design Manual. Selection of runoff coefficients is based on both the existing and proposed land use using information contained in the Design Manual.

The purpose of the hydrologic analysis is to estimate peak discharges for each storm event for both existing and future watershed conditions at key flow concentration locations in the watershed. In general, those locations are:

1. Major wash confluences and major culvert crossings of existing facilities.
2. Beginning and ending points in addition to intermediate points of washes designated for floodplain delineation, and
3. Sufficient locations along the washes for the determination of flooding hazards.

The computed peak discharges are then used in the hydraulic and alternative analyses conducted for this study. The combination of results and conclusions of these analyses will be used in the development of policies and guidelines regarding the management of future development in the watershed.

3.2 Parameter Estimation

3.2.1 Drainage Area Boundaries

The study area encompasses approximately 67 square miles of the Agua Fria River watershed below New Waddell Dam. The delineation of this area is shown on Plate 1. The eastern boundaries of the study watershed are contiguous with the New River watershed, which generally follows the Lake Pleasant Road alignment. The western boundaries of the study watershed are contiguous with the McMicken Dam Outlet Channel Watershed. The study watershed is dissected by four major features that impact subbasin delineation:

1. The Agua Fria River, which flows south through the watershed,
2. The Central Arizona Project Canal (CAP), which flows to the east through the southern quarter of the watershed. A portion of the CAP, the Waddell Canal, runs north to south in the upper east side of the watershed,
3. The Beardsley Canal, which flows south from the New Waddell Dam through the eastern portion of the watershed to a point approximately where the CAP crosses the Agua Fria River and then flows southwesterly across the southern portion of the watershed, and
4. State Route 74, which generally runs east to west across the central portion of the watershed.

The study watershed consists of two distinct physiographic regions. The first region lies to the north of the CAP and west of the Agua Fria River. This region comprises the majority of the study watershed and is characterized by the rugged desert mountain and hillslope terrain of the Hieroglyphic Mountains. The elevations in this region range from a high of 3,651 feet at an unnamed peak in the Morgan City Wash sub-watershed to a low of 1,340 feet along the Agua Fria River. The soils in this region are primarily loams and clay loams with a high percentage of rock outcropping. Sandy loam soils occur mainly in the wash bottoms. The second region lies to the south of the CAP and east of the Agua Fria River. This region is characterized by desert rangeland and fan terraces that are dissected by numerous small washes. The elevations in this region range from a high of 2,020 feet at an unnamed peak located near the CAP tunnel to a low of 1,235 feet at the Agua Fria River. The soils in this region are alluvial deposits consisting primarily of loams and clay loams.

The majority of the study watershed is divided into six sub-watersheds to facilitate modeling and to allow for the use of naming conventions that make it easier to follow the logic of the HEC-1 model. Three of these sub-watersheds contain watercourses that are designated for detailed floodplain and floodway delineation. The drainage basins contributing to these study washes are labeled on Plate 1 by S100, S200 and S300 series alpha-numeric identifiers that correspond to Unnamed Washes 1, 2 and 3, respectively. Floodplain delineations currently exist for washes in the three other sub-watersheds and were determined by previous flood insurance studies. Hydrology for these areas is revised for the purpose of extending the existing floodplains upstream, using Zone A approximate method delineations. The drainage basins contributing to these watercourses are labeled on Plate 1 by S400 (Caterpillar Tank Wash), S500 (Twin Buttes Wash) and S600 (Morgan City Wash) series alpha-numeric identifiers. Subbasin delineation for this portion of the watershed is appropriate for drainage master planning purposes with subbasins areas limited, in general to 1 square mile.

The remaining portion of the study watershed is drained by numerous small watercourses directly tributary to the Agua Fria River. Many of these watercourses have drainage areas less than 160 acres and are therefore modeled using the Rational Method. Rational Method subbasins are distinguished on Plate 1 from HEC-1 subbasins by alpha-numeric identifiers that begin with "R".

3.2.2 Physical Parameters

3.2.2.1 General

Physically based hydrologic parameters for the watershed and modeling subbasins are estimated in conformance with the Design Manual. The procedures used for estimation of those parameters for both existing and future watershed conditions are discussed in the following sections. Pertinent supporting data and calculations are provided in the technical appendices as noted.

3.2.2.2 Watershed Subbasin Delineation and Area Parameters

The watershed and subbasin boundaries are delineated using the topographic basemap discussed in Section 2. Reconnaissance trips to the watershed served as guidance for delineation along the CAP and Beardsley canals and other locations found to be lacking sufficient topographical detail for boundary determination. The resulting delineation is used for both existing and future condition modeling and those boundaries are plotted on Plates 1, 2, 3 and 9.

Subbasin boundaries were digitized directly into the digital topographic basemap in AutoCAD format. Subbasin areas were determined by converting the AutoCAD basin boundary polylines into an ArcView shape file. An application extension of ArcView was then used to perform the necessary area calculations. Data results were spot-checked for errors, as well as cross-checked with soil and land use polygon data obtained by the same software, for each subbasin (soils and land use area calculations are discussed later in Section 3).

3.2.2.3 Rainfall Loss Parameters

General

Rainfall losses for the watershed are estimated using the Green and Ampt infiltration equation as implemented in the HEC-1 computer program. The variable XKSAT (hydraulic conductivity at natural saturation) is estimated by evaluating natural condition soil properties and textures as they occur on the watershed and assigning values to those soils using the methods in the Design Manual. Variables PSIF (wetting front capillary suction) and

DTHETA (antecedent volumetric soil moisture deficit) are functions of soil texture, and therefore, XKSAT. The variable DTHETA is additionally related to the moisture condition of the soil and is categorized as either dry, normal, or saturated. Dry DTHETA is considered typical for natural land and normal DTHETA is considered typical for developed areas where irrigation and other factors tend to maintain higher moisture content in the soil. Saturated DTHETA conditions are not considered to exist in the watershed for this study. Table A-1 of Appendix A is a tabular summary of PSIF and DTHETA values for a corresponding value of XKSAT. Effective imperviousness, RTIMP, is attributed to rock outcrop in natural areas. Roofs, paving, permanent water surfaces, and compaction associated with gravel roads contribute to RTIMP in developed areas. Surface retention, IA, is an estimate of the initial surface storage that occurs during a storm event.

With the exception of the bare ground XKSAT and PSIF variables, separate composite Green and Ampt rainfall loss parameters are calculated for natural and developed land areas within each subbasin. The two composite values are then area averaged to obtain final subbasin Green and Ampt method parameters. The bare ground value of XKSAT is estimated using the soils data and applies to the pervious portion of the entire subbasin for both natural and developed areas. Values for PSIF, DTHETA (dry) and DTHETA (normal) are directly related to the bare ground XKSAT value and are obtained from Figure 4.3 of the Design Manual and shown for reference in Table A-1 of Appendix A. Values of PSIF corresponding to the bare ground XKSAT remain constant for all pervious areas in the subbasin, and DTHETA (dry) and DTHETA (normal) are estimated for natural and developed areas respectively. As a final step, the bare ground XKSAT value is adjusted for vegetation per the Design Manual using the subbasin average vegetative cover percentage.

Soil Parameters

General - Soil properties and texture classifications are used to estimate the bare ground XKSAT variable of the Green and Ampt equation and are applicable for both existing and future condition modeling. Typically, soils information and studies also identify the presence of rock outcrop and often provide percentage estimates as part of the study.

Data Sources - Three sources of information are used in this study to estimate the type and location of soils occurring on the watershed and are described in Section 2.1. Each source provides mapped soil unit boundaries with soil type and layer depth estimates. Rock outcrop percentages are also provided for map units in which they are significant. Plate 2 is a composite map of all three sources as they occur on the watershed, with map units for each source delineated and general source boundary limits provided. The watershed and subbasin boundaries and labels are included for reference.

SCS Survey XKSAT and Rock Outcrop - The SCS Survey soil unit mapping for the Maricopa County portion of the study watershed was supplied in digital format by the District. Composite bare ground XKSAT values and rock outcrop percentages are taken directly from the Design Manual and are summarized in Table 3-1 for each soil map unit that occurs within the watershed.

Composite bare ground XKSAT values and rock outcrop percentages for the Yavapai County portion of the study were assigned by comparing the soil map unit boundaries and descriptions from the Yavapai SCS Survey to those of the adjacent soil map units from the Aguila SCS Survey. In general, the soil map unit boundaries and descriptions from the Yavapai SCS Survey were found to closely match those of the Aguila SCS Survey. Therefore the soil texture, XKSAT and rock outcrop percentage for the Aguila SCS Survey soil map units were assigned to the corresponding soil map units of the Yavapai SCS Survey. That data is summarized in Table 3-2.

Table 3-1

Summary of XKSAT and RTIMP values for soil map units within Maricopa County

Soil Class (1)	Bare Ground XKSAT in/hr (2)	RTIMP % (3)	Soil Class (1)	Bare Ground XKSAT in/hr (2)	RTIMP % (3)
10	0.94	0	52	0.16	20
100	0.40	20	55	0.27	0
103	0.10	65	63	0.14	25
104	0.14	60	66	0.23	0
108	0.31	30	68	0.63	0
109	0.35	35	70	0.36	0
110	0.13	0	72	0.09	30
112	0.39	0	77	0.05	0
113	0.39	0	8	0.96	0
118	0.42	0	93	0.33	0
12	0.01	0	95	0.04	0
13	0.01	0	98	0.37	0
16	0.44	15	CF	0.50	0
21	0.38	0	Es	0.25	0
3	0.58	0	LcA	0.25	0
41	0.17	0	MTB	0.15	0
44	0.03	0	PRB	0.28	0
45	0.03	0	PWB	0.38	0
47	0.11	0	PYD	0.20	0
49	0.06	0	TB	0.40	0
51	0.24	0	TSC	0.14	0
			W	0.00	100

Table 3-2

Summary of XKSAT and RTIMP values for soil map units within Yavapai County

Map Unit (1)	Soil Description (2)	Assigned Soil Texture (3)	Corresponding Aguila SCS Survey Map Unit (4)	Log Average Bare Ground XKSAT in/hr (5)	RTIMP % (6)
CmD	Very gravelly sandy loam	Sandy loam	16	0.44	15
Le	Gravelly clay loam	Sandy clay loam	72	0.09	30
Lh	Extremely rocky clay loam	Sandy clay loam	104	0.14	60
Rr	Rock Outcrop	Clay	103	0.01	50

Soil Map Unit Polygon Areas by Subbasin - Areas of soil map unit polygons as they exist within a subbasin were obtained using ArcView by first, intersecting the soil boundaries by the subbasin boundaries. The area of each unique soil map unit contained within each subbasin was then calculated from the intersected soils and subbasin ArcView shape file. Data results for each subbasin were spot-checked for errors and cross-checked with subbasin and land use classification polygon area data obtained by the same software.

IA - Surface retention losses (IA) are assigned to each soil map unit. The basis for this assignment is the establishment of a relation of soil map unit descriptions and average ground slope on which each soil typically occurs, to descriptions for natural surface cover listed in Table 4.1 of the Design Manual. The descriptions and slope data for each map unit were tabulated and checked against the topographic mapping for reasonableness. The soil map units were then grouped into one of the three categories of surface cover for natural conditions listed in Table 4.1 of the Design Manual. Those classifications and corresponding values of IA are:

1. Desert and rangeland, flat slope; IA = 0.35 inches,
2. Hillslopes, Sonoran Desert; IA = 0.15 inches,
3. Mountain, with vegetated surface; IA = 0.25 inches.

Soil map unit descriptions with average ground slopes of 0 to 10% were assigned an IA of

0.35 inches corresponding to desert and rangeland surface covers. Soil map unit descriptions with average ground slopes of 3 to 30% were assigned an IA of 0.15 inches corresponding to hillslope surface cover. Soil map unit descriptions with average ground slopes of 5 to 70% were assigned an IA of 0.25 inches corresponding to mountain surface cover. A listing of the value of IA assigned to each soil map unit along with the soil description and slope is provided in Table 3-3.

Natural Area Parameters for each Subbasin

XKSAT, PSIF, DTHETA (dry), IA and RTIMP - Composite value calculations for natural area XKSAT, PSIF, DTHETA (dry), IA and RTIMP are summarized in the worksheets of Table A-2, Appendix A. Example step-by-step calculations for Subbasin S207 are provided in Appendix A for tracking of the spreadsheet calculation procedures.

Vegetative Cover Density - Six vegetation transects were taken at various locations within the watershed and are used in conjunction with circa 1999 aerial photography to provide a basis for the estimation of the natural condition vegetative cover density (VCD) for each subbasin. Descriptions of each transect location are provided in Appendix B, along with photographs of the general area. Based on the transect data, natural condition VCD values are assigned to each subbasin and summarized by subbasin in Table 3-4. VCD values are used to adjust bare ground XKSAT values.

Existing Condition Land Use Parameters

General - The watershed is subdivided into polygons of common land use elements. Those elements are lumped into two general categories of either "natural" or "developed," with sub-categories labeled as classifications. The natural category includes all undeveloped or generally natural condition land use classifications. All other land use classifications are included in the developed category.

Land Use Mapping – In general, under existing conditions the study watershed is considered to be entirely undeveloped. There are, however, a few isolated pockets of developed parcels of land that occur within the study watershed that are included in the hydrologic analysis. Land use polygons and zoning classifications that occur within the

study watershed were supplied by the District in digital format. This data was checked for accuracy using circa 1999 aerial photography and field reconnaissance trips.

Land Use Classifications – Land use classifications and developed conditions are assigned to each parcel based on guidance provided in the Design Manual, inspection of circa 1999 aerial photography, field reconnaissance and descriptive data provided in the land use digital file. Where appropriate, land use classification descriptions provided in the Design Manual are modified or new classifications are added that are representative of the conditions present in the watershed. A summary listing of those identifiers and their descriptions are provided in Table 3-5. The resulting existing condition land use classifications and developed conditions are shown on Plate 3.

RTIMP, VCD and IA Values by Land Use Classification – Selection of values of VCD, IA and RTIMP for each land use classification are based on circa 1999 aerial photography, field reconnaissance, topographic maps and guidance provided in the Design Manual. Where appropriate, the values in the Design Manual are modified to be representative of the conditions present in the watershed. The values of VCD and IA reflect typical conditions (for both the pervious and impervious portions of each land use area) associated with each land use classification. The selected values of RTIMP, VCD and IA for each land use classification are summarized in Table 3-5.

Table 3-3

Summary of assigned surface retention losses for each soil map unit

Soil Map Unit (1)	Description (2)	Slope Range % (3)	IA in (4)
10	Floodplains and drainage ways	1 - 5	0.35
100	Mountain slopes and hill slopes	20 - 65	0.25
103	Mountain slopes	5 - 55	0.25
104	Hill slopes and mountain slopes	15 - 65	0.25
108	Mountain slopes and hill slopes	3 - 25	0.15
109	Mountain slopes and hill slopes	25 - 65	0.25
110	Fan terraces	1 - 7	0.35
112	Fan terraces	0 - 3	0.35
113	Fan terraces	0 - 3	0.35
118	Fan terraces	0 - 3	0.35
12	Fan terraces	1 - 8	0.35
13	Fan terraces	0 - 3	0.35
16	Hill slopes and mountain slopes	10 - 70	0.25
18	Hill slopes and mountain slopes	5 - 60	0.25
21	Fan terraces	0 - 3	0.35
3	Floodplains and drainage ways	0 - 3	0.35
31	Mountain slopes and hill slopes	25 - 65	0.25
33	Fan terraces and stream terraces	1 - 8	0.35
41	Fan terraces	20 - 40	0.25
44	Fan terraces and stream terraces	1 - 8	0.35
45	Fan terraces	8 - 20	0.15
47	Fan terraces	3 - 25	0.15
48	Fan terraces	3 - 20	0.15
49	Fan terraces	20 - 40	0.25
51	Hill slopes	8 - 25	0.15
52	Mountain slopes and hill slopes	7 - 55	0.25
55	Floodplains and alluvial fans	0 - 3	0.35
63	Pediments, hill slopes and mountain slopes	10 - 65	0.25
66	Fan terraces	1 - 7	0.35
68	Fan terraces	1 - 7	0.35
70	Fan terraces	1 - 25	0.25
72	Hill slopes and mountain slopes	8 - 65	0.25
77	Fan terraces	0 - 3	0.35
8	Floodplains	0 - 3	0.35
93	Fan terraces	8 - 30	0.15
95	Fan terraces and stream terraces	0 - 3	0.35

Table 3-3 (Continued)

Summary of assigned surface retention losses for each soil map unit

Soil Map Unit (1)	Description (2)	Slope Range % (3)	IA in (4)
98	Fan terraces	1 - 10	0.35
CF	Adjacent to channels of the Gila, Salt and Hassayampa Rivers	N/A	0.35
CmD	Hill slopes	8 - 30	0.25
Es	Valley plains and alluvial fans	0 - 1	0.35
LcA	Valley plains and alluvial fans	0 - 1	0.35
Le	Hill slopes and mountain slopes	8 -45	0.25
Lh	Hill slopes and mountain slopes	8 -60	0.25
MTB	Valley plains	0 - 3	0.35
PRB	Valley plains and alluvial fans	0 - 3	0.35
PWB	Valley plains and alluvial fans	0 - 3	0.35
PYD	Alluvial fans	1 - 10	0.35
Rr	Gently sloping to steep hill slopes and mountain slopes	N/A	0.25
TB	Alluvial fans	1 - 5	0.35
TSC	Alluvial fans	0 - 5	0.35
W	Water	N/A	0.35

Notes:

(4): Assigned slope ranges for surface cover types from Table 4.1 of the Design Manual
Desert and Rangeland, flat slope = slope ranges from 0 to 10%
Hillslopes, Sonoran Desert = slope ranges from 3 to 30%
Mountains, with vegetated surface = slope ranges from 5 to 70%

Table 3-4

Summary of vegetative cover densities for existing watershed conditions of each subbasin

Subbasin ID (1)	Vegetative Cover Density % (2)	Subbasin ID (1)	Vegetative Cover Density % (2)	Subbasin ID (1)	Vegetative Cover Density % (2)
S100	32	S505	26	S700	32
S101	32	S506	26	S701	32
S102	32	S507	26	S702	32
S103	32	S508	26	S703	32
S104	32	S509	26	S704	32
S105	32	S510	26	S705	32
S106	32	S511	26	S705AF	15
S107	32	S512	26	S706	26
S200	32	S513	26	S707	26
S201	32	S514	26	S708	15
S202	32	S515	26	S709	15
S203	32	S516	26	S710	15
S204	32	S600	32	S711	15
S205	32	S601	32	S712	15
S206	32	S602	32	S713	15
S207	32	S603	32	S714	15
S208	32	S604	32	S715	15
S209	32	S605	32	S716	15
S210	32	S606	32	S717	15
S211	32	S607	32	S718	15
S300	32	S608	32	S719	15
S301	32	S609	32	S720	15
S302	32	S610	32	S721	15
S303	32	S611	32	S722	15
S304	32	S612	32	S723	15
S400	26	S613	32	S724	15
S401	26	S614	32	S725	15
S402	26	S615	32	S726	15
S403	26	S616	32	S727	15
S404	26	S617	32	S728	15
S500	32	S618	32		
S501	32	S619	32		
S502	26	S620	32		
S503	26	S621	32		
S504	26	S622	32		

Table 3-5

Rainfall loss characteristics for each land use classification for existing watershed conditions

Land-use Class (1)	Base RTIMP % (2)	Veg. Cover % (3)	IA in (4)
LDR	5	25	0.30
COMM	10	15	0.10
IND	10	0	0.15
OPEN	0	0	0.00
ARP	50	5	0.10
DESERT	0	0	0.00
PF	50	0	0.10

Land-use Class	Description
LDR	Low density residential, < 1 dwelling unit per acre
COMM	Commercial
IND	Industrial/Mining
OPEN	Lake Pleasant Regional Park
ARP	Turf Soaring School Airfield
DESERT	Undeveloped Natural Desert
PF	Public Facilities (APS Substation)

Land Use Polygon Areas by Subbasin - Areas of existing condition land use polygons, both developed and undeveloped as they exist within a subbasin were obtained using ArcView by first, intersecting the land use boundaries by the subbasin boundaries. The area of each unique land use classification, both developed and undeveloped contained within each subbasin was then calculated from the intersected land use and subbasin ArcView shape file. Data results for each subbasin were spot-checked for errors and cross-checked with subbasin and soil polygon area data obtained by the same software.

Existing Condition Developed Area Parameters for each Subbasin

XKSAT, PSIF and DTHETA (normal) - The bare ground XKSAT and PSIF values remain the same as the natural area values for each subbasin. DTHETA (normal) values for

developed areas are taken from Figure 4.3 of the Design Manual and shown for reference in Table A-1 of Appendix A.

RTIMP, VCD and IA - Existing condition developed area composite IA and VCD value calculations for each subbasin are summarized in the worksheets of Table A-3, Appendix A. Example step-by-step calculations for Subbasin S207 are provided in Appendix A for tracking of the spreadsheet calculation procedures.

Existing Condition Area Weighted Rainfall Loss Parameters for each Subbasin

Table A-4 of Appendix A summarizes the final area weighting calculations of rainfall loss parameters for each subbasin in the watershed. Table 3-6 is a summary of the final Green and Ampt HEC-1 input parameters for each subbasin.

Table 3-6
Summary of Green and Ampt rainfall loss input parameters for existing watershed conditions

Subbasin ID (1)	Area sq. mi. (2)	IA inches (3)	DTHETA (4)	PSIF inches (5)	XKSAT in/hr (6)	RTIMP % (7)
S100	0.574	0.19	0.35	4.65	0.34	25
S101	0.631	0.26	0.37	5.30	0.25	15
S102	0.449	0.15	0.35	4.45	0.39	30
S103	0.395	0.24	0.38	5.60	0.22	17
S104	0.900	0.22	0.38	5.60	0.22	13
S105	0.594	0.22	0.38	5.60	0.22	13
S106	0.567	0.19	0.37	5.20	0.26	7
S107	0.936	0.15	0.35	4.90	0.30	0
S200	0.959	0.25	0.35	4.25	0.44	35
S201	0.350	0.25	0.35	4.25	0.44	35
S202	0.127	0.25	0.35	4.25	0.44	35
S203	0.373	0.25	0.35	4.25	0.44	35
S204	0.951	0.25	0.35	4.25	0.44	32
S205	0.413	0.21	0.35	4.60	0.35	21
S206	0.853	0.25	0.35	4.65	0.34	27
S207	0.957	0.25	0.35	4.35	0.41	34
S208	1.103	0.23	0.37	5.30	0.25	24
S209	0.650	0.22	0.36	5.00	0.29	15
S210	0.481	0.16	0.36	5.00	0.29	2

Table 3-6 (Continued)
Summary of Green and Ampt rainfall loss input parameters for existing watershed conditions

Subbasin ID (1)	Area sq. mi. (2)	IA inches (3)	DTHETA (4)	PSIF inches (5)	XKSAT in/hr (6)	RTIMP % (7)
S211	0.488	0.19	0.37	5.20	0.26	4
S300	0.615	0.25	0.35	4.55	0.36	25
S301	0.994	0.25	0.35	4.25	0.44	35
S302	0.465	0.24	0.35	4.55	0.36	24
S303	0.708	0.22	0.35	4.60	0.35	10
S304	0.823	0.18	0.36	5.10	0.27	3
S400	1.048	0.23	0.34	5.40	0.21	14
S401	0.646	0.30	0.36	5.10	0.26	7
S402	0.740	0.31	0.38	5.60	0.21	3
S403	0.559	0.30	0.30	8.00	0.08	0
S404	0.263	0.27	0.37	6.60	0.14	0
S500	1.054	0.25	0.35	4.25	0.44	35
S501	0.614	0.22	0.35	4.45	0.39	23
S502	0.403	0.27	0.35	4.50	0.35	14
S503	0.994	0.21	0.31	4.65	0.28	17
S504	0.326	0.35	0.35	4.40	0.38	0
S505	0.143	0.25	0.35	4.40	0.38	14
S506	0.151	0.29	0.39	5.70	0.20	9
S507	0.666	0.34	0.39	5.70	0.20	1
S508	0.295	0.33	0.37	5.30	0.24	0
S509	0.170	0.28	0.35	4.65	0.32	23
S510	0.127	0.32	0.33	7.30	0.11	6
S511	0.385	0.29	0.39	5.70	0.20	19
S512	0.214	0.35	0.30	8.00	0.08	0
S513	0.778	0.32	0.38	5.40	0.22	1
S514	0.650	0.28	0.32	7.60	0.09	0
S515	1.102	0.32	0.27	8.80	0.06	0
S516	0.540	0.35	0.35	4.80	0.29	0
S600	2.018	0.25	0.35	4.00	0.49	22
S601	0.901	0.25	0.39	5.70	0.21	44
S602	1.883	0.25	0.35	4.35	0.41	35
S603	0.665	0.25	0.39	5.80	0.20	41
S604	2.656	0.25	0.35	4.35	0.41	35
S605	1.085	0.25	0.35	4.35	0.41	35
S606	0.660	0.26	0.35	4.50	0.37	35
S607	0.822	0.25	0.36	5.10	0.27	34
S608	0.508	0.25	0.39	5.80	0.20	37

Table 3-6 (Continued)
Summary of Green and Ampt rainfall loss input parameters for existing watershed conditions

Subbasin ID (1)	Area sq. mi. (2)	IA inches (3)	DTHETA (4)	PSIF inches (5)	XKSAT in/hr (6)	RTIMP % (7)
S609	0.560	0.27	0.35	4.10	0.47	27
S610	0.603	0.26	0.36	5.10	0.27	39
S611	0.569	0.25	0.35	4.35	0.41	35
S612	0.808	0.25	0.38	6.40	0.16	31
S613	1.797	0.25	0.35	4.55	0.36	34
S614	1.079	0.24	0.35	4.40	0.40	34
S615	1.055	0.25	0.39	6.20	0.17	55
S616	0.505	0.22	0.37	5.20	0.26	19
S617	0.675	0.23	0.35	4.80	0.31	23
S618	0.958	0.20	0.37	5.20	0.26	22
S619	0.827	0.27	0.36	6.80	0.14	39
S620	0.444	0.23	0.38	6.40	0.16	37
S621	0.923	0.17	0.35	4.80	0.31	3
S622	0.897	0.18	0.35	4.90	0.30	4
S700	0.610	0.17	0.36	5.10	0.27	5
S701	0.720	0.22	0.38	5.60	0.22	14
S702	0.257	0.17	0.36	5.10	0.27	4
S703	0.257	0.15	0.35	4.90	0.30	0
S704	0.408	0.26	0.35	4.90	0.30	11
S705	0.754	0.22	0.38	6.40	0.16	7
S705AF	0.183	0.31	0.22	10.10	0.03	0
S706	0.713	0.29	0.39	5.70	0.20	7
S707	0.638	0.28	0.39	6.20	0.16	8
S708	0.706	0.22	0.25	9.70	0.04	0
S709	0.441	0.30	0.19	11.20	0.02	0
S710	0.112	0.15	0.22	10.10	0.03	0
S711	0.159	0.28	0.19	11.20	0.02	0
S712	0.068	0.17	0.22	10.10	0.03	0
S713	0.107	0.15	0.22	10.10	0.03	0
S714	0.060	0.35	0.29	8.40	0.06	0
S715	0.220	0.31	0.19	11.20	0.02	0
S716	1.128	0.27	0.22	10.10	0.03	1
S717	0.286	0.25	0.19	11.20	0.02	0
S718	0.442	0.22	0.18	11.20	0.02	2
S719	0.154	0.23	0.11	12.40	0.01	4
S720	0.370	0.27	0.19	11.20	0.02	1
S721	0.335	0.30	0.33	7.30	0.09	0

Table 3-6 (Continued)
Summary of Green and Ampt rainfall loss input parameters for existing watershed conditions

Subbasin ID (1)	Area sq. mi. (2)	IA inches (3)	DTHETA (4)	PSIF inches (5)	XKSAT in/hr (6)	RTIMP % (7)
S722	0.955	0.30	0.25	9.70	0.04	0
S723	0.085	0.29	0.22	10.10	0.03	0
S724	1.156	0.27	0.19	11.20	0.02	0
S725	1.158	0.30	0.27	8.80	0.05	0
S726	0.334	0.31	0.39	5.70	0.18	7
S727	0.375	0.27	0.25	9.70	0.04	0
S728	0.276	0.35	0.37	5.20	0.22	0

Future Condition Land Use Parameters

Land Use Mapping - Future condition land use mapping was adapted from the City of Peoria General Land Use Plan, dated October 2000. That plan was provided by the City of Peoria and covers the entire study area (including the unincorporated Maricopa County portions of the study area) except for the portion of the watershed that extends into Yavapai County. The intent of the General Plan is to act as a long range guide for how an area should develop. It should be noted that this plan does not prevent or even restrict plan amendments of rezoning, therefore if the plan is amended it may be necessary to revise the hydrologic model accordingly.

Land Use Classifications - Included in the City of Peoria General Plan are zoning descriptions for each land use. Those descriptions are categorized as residential and non-residential. The residential category is further subdivided into target densities. Those target densities are used for the assignment of the land use classifications specified in the Design Manual. For example, the residential zone with target densities of 2 to 5 dwelling units per acre is assigned to the Low Density Residential land use classification (LDR). The LDR classification is described in the Design Manual as single family residential with lot sizes ranging from 14,000 to 35,000 square feet. Two of the residential zoning subcategories identified in the General Plan have target densities (8 to 15 and 15+ dwelling units per acre) that are equal to or greater than the most dense land use classification listed in the Design

Manual. That classification is Multiple Family Residential (MFR) and it is assigned to both the 8 to 15 and 15+ dwelling units per acre subcategories. Additionally, the MFR classification is also assigned to the resort development and mixed use zoning subcategories. In order to track these four zoning subcategories separately, a numeric suffix is added to the MRF classification. For example, the areas zoned as residential with target densities of 8 to 15 dwelling units per acre are identified as MFR-1. Separate tracking of these areas may facilitate revisions to the hydrologic model if there are amendments to the General Plan.

With the exception of the public/quasi-public subcategory, the non-residential zoning subcategories were directly assigned to a land use classification. The public/quasi-public subcategory is described as community centers and ball parks. Because of the potential variability of this subcategory, a new land use classification, public facilities (PF) is created for this subcategory.

The location and classification of each land use within the watershed is shown along with the subbasin delineation on Plate 9. For the portion of the watershed that extends into Yavapai County, it is assumed that the land use will remain as undeveloped desert open space.

RTIMP, VCD and IA Values by Land Use Classification - Values of RTIMP, VCD and IA for each land use classification are provided in the Design Manual and are listed in Table 3-7. These values represent typical conditions for Maricopa County and may need to be revised for the specific conditions of each development to be constructed within the watershed. Additionally, the values listed in the Design Manual for VCD (shown in column 3) are for pervious area only. The actual, effective VCD associated to each land use classification is computed based on the percent impervious (RTIMP) for that classification and is shown in column 5 of Table 3–7.

Land Use Polygon Areas by Subbasin - Areas of future condition land use polygons as present within each subbasin were obtained using ArcView by first intersecting the land use boundaries by the subbasin boundaries. The area of each unique land use classification

contained within each subbasin was then calculated from the intersected land use and subbasin ArcView shape file. Data results for each subbasin were spot-checked for errors and cross-checked with subbasin and soil polygon area data obtained by the same software.

Future Condition Developed Area Parameters for each Subbasin

XKSAT, PSIF and DTHETA (normal) - The bare ground XKSAT and PSIF variables remain the same as the existing condition natural areas for each subbasin. DTHETA (normal) values for developed areas are taken from Table A-1 of Appendix A.

RTIMP, VCD and IA - Developed area composite RTIMP, VCD and IA value calculations for each subbasin are summarized in the worksheets of Table A-5 of Appendix A.

Future Condition Area Weighted Rainfall Loss Parameters for each Subbasin

Table A-6 of Appendix A summarizes the final area weighting calculations of rainfall loss parameters for each subbasin in the watershed. Table 3-8 is a summary of the final Green and Ampt rainfall loss parameters input to HEC-1 for each subbasin.

Table 3-7
Rainfall loss characteristics for each land use classification for <u>future watershed conditions</u>

Land Use Class (1)	Base RTIMP % (2)	Veg. Cover % (3)	IA in (4)	Effective VCD % (5)
ARP	50	5	0.10	5
COMM	80	75	0.10	15
DESERT	0	0	0.00	0
H20	100	0	0.00	0
IND	55	60	0.15	27
LDR	15	50	0.30	43
MDR	30	50	0.25	35
MFR_1	45	50	0.25	28
MFR_2	45	50	0.25	28
MFR_3	45	50	0.25	28
MFR_4	45	50	0.25	28
OPEN	0	0	0.00	0
PF	50	0	0.00	0
VLDR	5	30	0.30	29
P	0	0	0.00	0

Land Use Class	Description
VLDR	Very low density and low density residential = < 2.0 dwelling units per acre
LDR	Low density residential = 2.0 - 5.0 dwelling units per acre
MDR	Medium density residential = 5.0 - 8.0 dwelling units per acre
MFR_1	Multiple family residential = 8.0 - 15.0 dwelling units per acre
MFR_2	Multiple family residential = 15+ dwelling units per acre
MFR_3	Mixed use
MFR_4	Resort development, multiple family residential
PF	Public Facilities/Quasi-public (Community Centers/Ball Park)
COMM	Neighborhood/Community Commercial
IND	Business Park, industrial
OPEN	Natural Desert Park/Open space
ARP	Airport
H2O	Water
DESERT	Unincorporated/undeveloped natural desert

Table 3-8
Summary of Green and Ampt rainfall loss input parameters for <u>future watershed conditions</u>

Subbasin ID (1)	Area sq. mi. (2)	IA inches (3)	DTHETA (4)	PSIF inches (5)	XKSAT in/hr (6)	RTIMP % (7)
S100	0.574	0.21	0.33	4.65	0.33	26
S101	0.631	0.26	0.37	5.30	0.25	15
S102	0.449	0.22	0.30	4.45	0.38	32
S103	0.395	0.24	0.38	5.60	0.22	17
S104	0.900	0.21	0.35	5.60	0.22	23
S105	0.594	0.24	0.31	5.60	0.23	23
S106	0.567	0.27	0.28	5.20	0.26	11
S107	0.936	0.25	0.28	4.90	0.29	3
S200	0.959	0.25	0.35	4.25	0.44	35
S201	0.350	0.25	0.35	4.25	0.44	35
S202	0.127	0.25	0.35	4.25	0.44	35
S203	0.373	0.28	0.29	4.25	0.43	37
S204	0.951	0.25	0.35	4.25	0.44	32
S205	0.413	0.21	0.31	4.60	0.34	34
S206	0.853	0.29	0.28	4.65	0.33	30
S207	0.957	0.27	0.32	4.35	0.41	35
S208	1.103	0.25	0.32	5.30	0.25	29
S209	0.650	0.23	0.34	5.00	0.28	16
S210	0.481	0.22	0.31	5.00	0.28	4
S211	0.488	0.25	0.30	5.20	0.26	7
S300	0.615	0.28	0.28	4.55	0.37	32
S301	0.994	0.29	0.26	4.25	0.45	42
S302	0.465	0.26	0.31	4.55	0.36	29
S303	0.708	0.24	0.32	4.60	0.35	11
S304	0.823	0.25	0.29	5.10	0.27	7
S400	1.048	0.24	0.30	5.40	0.22	36
S401	0.646	0.29	0.27	5.10	0.26	13
S402	0.740	0.25	0.28	5.60	0.22	33
S403	0.559	0.23	0.16	8.00	0.09	37
S404	0.263	0.26	0.33	6.60	0.14	8
S500	1.054	0.28	0.29	4.25	0.43	39
S501	0.614	0.27	0.29	4.45	0.38	27
S502	0.403	0.27	0.30	4.50	0.36	22
S503	0.994	0.27	0.28	4.65	0.33	31
S504	0.326	0.24	0.25	4.40	0.39	33
S505	0.143	0.24	0.33	4.40	0.37	20
S506	0.151	0.23	0.32	5.70	0.19	27

Table 3-8 (continued)
Summary of Green and Ampt rainfall loss input parameters for <u>future watershed conditions</u>

Subbasin ID (1)	Area sq. mi. (2)	IA inches (3)	DTHETA (4)	PSIF inches (5)	XKSAT in/hr (6)	RTIMP % (7)
S507	0.666	0.28	0.25	5.70	0.21	12
S508	0.295	0.28	0.26	5.30	0.25	22
S509	0.170	0.28	0.26	4.65	0.33	33
S510	0.127	0.24	0.15	7.30	0.11	44
S511	0.385	0.29	0.28	5.70	0.22	29
S512	0.214	0.19	0.15	8.00	0.08	48
S513	0.778	0.28	0.25	5.40	0.25	19
S514	0.650	0.24	0.16	7.60	0.10	31
S515	1.102	0.25	0.16	8.80	0.06	29
S516	0.540	0.22	0.27	4.80	0.29	47
S600	2.018	0.25	0.35	4.00	0.49	22
S601	0.901	0.25	0.39	5.70	0.21	44
S602	1.883	0.25	0.35	4.35	0.41	35
S603	0.665	0.25	0.39	5.80	0.20	41
S604	2.656	0.25	0.35	4.35	0.41	35
S605	1.085	0.25	0.35	4.35	0.41	35
S606	0.660	0.26	0.35	4.50	0.37	35
S607	0.822	0.26	0.35	5.10	0.27	35
S608	0.508	0.27	0.36	5.80	0.20	37
S609	0.560	0.28	0.32	4.10	0.47	28
S610	0.603	0.28	0.30	5.10	0.27	40
S611	0.569	0.25	0.35	4.35	0.41	35
S612	0.808	0.29	0.26	6.40	0.16	34
S613	1.797	0.28	0.29	4.55	0.35	36
S614	1.079	0.26	0.32	4.40	0.39	35
S615	1.055	0.25	0.39	6.20	0.17	55
S616	0.505	0.25	0.32	5.20	0.26	21
S617	0.675	0.26	0.31	4.80	0.31	24
S618	0.958	0.21	0.36	5.20	0.26	22
S619	0.827	0.27	0.36	6.80	0.14	39
S620	0.444	0.23	0.38	6.40	0.16	37
S621	0.923	0.22	0.31	4.80	0.31	4
S622	0.897	0.19	0.35	4.90	0.30	4

Table 3-8 (continued)
Summary of Green and Ampt rainfall loss input parameters for <u>future watershed conditions</u>

Subbasin ID (1)	Area sq. mi. (2)	IA inches (3)	DTHETA (4)	PSIF inches (5)	XKSAT in/hr (6)	RTIMP % (7)
S700	0.610	0.28	0.26	5.10	0.27	9
S701	0.720	0.28	0.29	5.60	0.22	18
S702	0.257	0.23	0.27	5.10	0.26	24
S703	0.257	0.19	0.32	4.90	0.30	1
S704	0.408	0.28	0.29	4.90	0.29	14
S705	0.754	0.25	0.21	6.40	0.16	33
S705AF	0.183	0.31	0.22	10.10	0.03	0
S706	0.713	0.26	0.25	5.70	0.21	37
S707	0.638	0.21	0.23	6.20	0.17	51
S708	0.706	0.29	0.16	9.70	0.05	7
S709	0.441	0.29	0.13	11.20	0.02	9
S710	0.112	0.23	0.16	10.10	0.04	13
S711	0.159	0.28	0.10	11.20	0.03	22
S712	0.068	0.27	0.13	10.10	0.04	19
S713	0.107	0.20	0.18	10.10	0.03	12
S714	0.060	0.35	0.29	8.40	0.06	0
S715	0.220	0.31	0.17	11.20	0.02	4
S716	1.128	0.26	0.14	10.10	0.04	23
S717	0.286	0.26	0.15	11.20	0.02	10
S718	0.442	0.27	0.15	11.20	0.02	6
S719	0.154	0.31	0.07	12.40	0.01	12
S720	0.370	0.28	0.11	11.20	0.03	19
S721	0.335	0.21	0.15	7.30	0.11	50
S722	0.955	0.26	0.16	9.70	0.05	23
S723	0.085	0.22	0.17	10.10	0.03	28
S724	1.156	0.18	0.11	11.20	0.02	45
S725	1.158	0.18	0.16	8.80	0.06	50
S726	0.334	0.27	0.28	5.70	0.21	29
S727	0.375	0.18	0.16	9.70	0.05	54
S728	0.276	0.21	0.30	5.20	0.22	46

3.2.2.4 Unit Hydrograph Parameters

General

The use of the S-Graph method as prescribed in the Design Manual is primarily for large natural watersheds. Although the total drainage area for this study is approximately 67 square miles, the study area is composed of several smaller sub-watersheds. The average drainage area of the subbasins being modeled is less than one square mile. Given these area constraints the S-Graph method is not appropriate for use in this study. The Clark unit hydrograph is therefore used to model all subbasins in the study watershed.

Clark Unit Hydrograph

Time of Concentration - The time of concentration for use with the Clark unit hydrograph is estimated using Equation 5.5 (Papadakis and Kazan empirical equation) of the Design Manual:

$$T_c = 11.4\, L^{0.50}\, K_b^{\;0.52}\, S^{-0.31}\, i^{-0.38}$$

where: T_c = subbasin time of concentration in hours;

L = length of hydraulically longest flow path in miles;

S = watercourse slope in feet per mile;

K_b = representative watershed resistance coefficient; and

i = average rainfall excess intensity, during the time T_c, in inches/hour.

Solution of the T_c equation is an iterative process dependent on *i*, and is accomplished using a modified version of the Maricopa County Unit Hydrograph Procedure (MCUHP1) computer program provided by the District with the Design Manual.

The length of the hydraulically longest flow path for each subbasin is determined using the topographic basemap shown in Plate 1. The location, and therefore the length and slope, of the flow path for each subbasin shown on Plate 1 are assumed to be appropriate for both existing and future watershed conditions. The slope is calculated using top and bottom elevations of the flow path and the flow path length. For flow paths with steep slopes, an adjustment to the computed value is made using Figure 5.4 of the Design Manual. The

following expressions are mathematical approximations of the curve plotted on that figure and are used to calculate the adjusted slope.

$$S_{adj} = b + m(\ \ln\ (S\ ))$$

where: S < 225 feet/mile no adjustment is necessary

and: 225 feet/mile < S <400 feet/mile

m = 133.8009

b = -500.865

and: S > 400 feet/mile

m = 61.54998

b = -74.6827

The watershed resistance coefficient (K_b) is a function of drainage area and the surface roughness characteristics of the drainage area. The value of K_b is determined using the data and equation provided in Table 5.1 of the Design Manual. That table lists four types of roughness conditions and the corresponding values of the K_b equation variables. In addition to those types, three intermediate types (A/B, B/C and C/D) are interpolated to provide additional definition for those areas of mixed characteristics. The interpolated values of the variables *m* and *b* for use in the K_b equation for each intermediate type, are summarized as follows:

Type	M	b
A/B	-0.01000	0.060
B/C	-0.01938	0.115
C/D	-0.02750	0.175

For existing conditions, each subbasin is assigned a K_b type by inspection of the topography and aerial photography as well as from field observations of surface roughness elements. In general, the surface roughness characteristics for the study area range from desert rangeland with moderately low roughness elements (Type B) to hillslope terrain with moderately high

roughness elements (Type C). Selection of K_b types and therefore the computed K_b value is assumed, for the purposes of this study, to be appropriate for all storm frequencies.

For future conditions, each unique land use type is assigned a K_b type. The developed land use types (LDR, MDR etc) are assigned K_b type A. For subbasins that have open space (or any natural land use) the K_b type assigned is the same as what is determined for that subbasin under existing conditions. The K_b values for each land use type for each subbasin are then areally weighted to produce a single, composite value. The resulting areally weighed K_b values for each subbasin are assumed, for the purposes of this study, to be appropriate for all storm frequencies.

The length, slope and K_b input parameters to the T_c equation are summarized in Tables C-1 and C-14 for existing and future watershed conditions, respectively. The results of iterative T_c calculations for each storm frequency (100-, 50-, 25-, 10-, 5- and 2-year) are summarized for the 6- and 24-hour storm durations for existing watershed conditions in Tables 3-9 and 3-10, respectively. The future watershed condition T_c results for the 6- and 24-hour storm durations are summarized in Tables 3-11 and 3-12, respectively.

A procedural limitation of the T_c equation is a maximum computational time of 1.5 hours. The limitation is based on the data set used to test the appropriateness of the Papadakis and Kazan T_c equation for use in Maricopa County and does not necessarily reflect a true upper limit of the procedure. Using a T_c value that is less than what would actually be calculated without this limitation would result in an over estimation of the peak discharge. Tables 3-9 through 3-12 list the T_c for each subbasin for all return periods for the different storm durations and watershed conditions. Subbasin T_c that are set to the 1.5 hour limit are highlighted for reference. Inspection of these tables show that for both durations and watershed conditions, all subbasin have 100- and 50-year T_c values less than the 1.5 hour limit. These tables also show that for the more frequent events, particularly the existing condition 2-year, 6-hour storm that numerous subbasins have reached the 1.5 hour limitation.

Table 3-9
Time of concentration summary for the existing conditions 6-hour storm

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S100	0.646	0.704	0.792	0.929	1.071	1.458
S101	0.521	0.571	0.642	0.779	0.917	1.308
S102	0.746	0.817	0.904	1.054	1.208	1.500
S103	0.796	0.875	0.983	1.183	1.379	1.500
S104	0.754	0.833	0.946	1.171	1.417	1.500
S105	0.917	1.008		1.400	1.500	1.500
S106	0.679	0.746	0.854	1.050	1.250	1.500
S107	0.858	0.958	1.113	1.450	1.500	1.500
S200	0.621	0.679	0.758	0.888	1.008	1.358
S201	0.483	0.525	0.583	0.679	0.775	1.029
S202	0.308	0.329	0.363	0.421	0.479	0.650
S203	0.696	0.763	0.842	0.971	1.108	1.500
S204	0.729	0.800	0.900	1.058	1.221	1.500
S205	0.604	0.663	0.746	0.879	1.013	1.413
S206	0.954	1.050	1.183		1.500	1.500
S207	0.967	1.063	1.196	1.413	1.500	1.500
S208	1.033	1.133	1.275	1.500	1.500	1.500
S209	0.700	0.771	0.875	1.063	1.254	1.500
S210	0.538	0.596	0.679	0.833	0.996	1.496
S211	0.671	0.742	0.850	1.042	1.246	1.500
S300	0.746	0.821		1.092	1.263	1.500
S301	0.708	0.775	0.871	1.017	1.167	1.500
S302	0.613	0.675	0.754	0.883	1.017	1.417
S303	0.679	0.754	0.867	1.067	1.271	1.500
S304	0.796	0.892	1.025	1.308	1.500	1.500
S400	0.833	0.917	1.033	1.267	1.500	1.500
S401	0.804	0.896	1.029	1.283	1.500	1.500
S402	0.717	0.796	0.921	1.171	1.438	1.500
S403	0.908	0.996	1.117	1.350	1.500	1.500
S404	0.317	0.342	0.371	0.438	0.525	0.767
S500	1.004	1.104	1.242	1.467	1.500	1.500
S501	0.650	0.717	0.808	0.954	1.104	1.500
S502	0.500	0.550	0.621	0.746	0.875	1.292
S503	0.700	0.758	0.854	1.042	1.254	1.500
S504	0.963	1.092	1.254	1.500	1.500	

Table 3-9 (continued)
Time of concentration summary for the existing conditions 6-hour storm

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S505	0.242	0.254	0.279	0.329	0.388	0.583
S506	0.338	0.363	0.396	0.475	0.563	0.825
S507	0.746	0.838	0.971	1.238	1.500	1.500
S508	0.563	0.621	0.717	0.888	1.075	1.500
S509	0.267	0.283	0.308	0.363	0.421	0.588
S510	0.500	0.542	0.600	0.717	0.858	1.213
S511	0.388	0.417	0.458	0.546	0.633	0.875
S512	0.617	0.671	0.738	0.896	1.079	1.500
S513	1.246	1.396	1.500	1.500	1.500	
S514	0.929	1.021	1.150	1.392	1.500	1.500
S515	0.942	1.025	1.146	1.388	1.500	1.500
S516	0.988	1.117	1.300	1.500	1.500	
S600	0.796	0.892	1.029	1.304	1.500	1.500
S601	0.575	0.617	0.675	0.779	0.888	1.125
S602	0.800	0.875	0.983	1.183	1.375	1.500
S603	0.400	0.429	0.467	0.538	0.608	0.779
S604	1.121	1.229	1.379	1.500	1.500	1.500
S605	0.725	0.792	0.888	1.046	1.196	1.500
S606	0.575	0.625	0.696	0.808	0.917	1.225
S607	0.700	0.763	0.846	0.996	1.146	1.500
S608	0.483	0.525	0.575	0.671	0.763	0.975
S609	0.721	0.792	0.879	1.029	1.196	1.500
S610	0.763	0.833	0.921	1.067	1.217	1.500
S611	0.479	0.521	0.579	0.671	0.767	1.013
S612	0.713	0.767	0.850	1.000	1.167	1.500
S613	1.088	1.188	1.333	1.500	1.500	1.500
S614	0.929	1.017	1.142	1.358	1.500	1.500
S615	0.867	0.929	1.013	1.163	1.317	1.500
S616	1.258	1.388	1.500	1.500	1.500	1.500
S617	0.754	0.833	0.933	1.117	1.300	1.500
S618	0.763	0.838	0.938	1.142	1.350	1.500
S619	0.688	0.738	0.808	0.942	1.079	1.396
S620	0.642	0.692	0.758	0.883	1.000	1.288
S621	0.613	0.675	0.771	0.996	1.233	1.500
S622	0.929	1.038	1.200	1.500	1.500	1.500
S700	0.675	0.746	0.854	1.063	1.271	1.500

Table 3-9 (continued)
Time of concentration summary for the existing conditions 6-hour storm

Subbasin ID (1)	Time of Concentration, in hours* 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S701	1.029	1.138	1.288	1.500	1.500	1.500
S702	0.525	0.575	0.654	0.800	0.954	1.392
S703	0.467	0.508	0.579	0.713	0.858	1.296
S704	0.425	0.463	0.521	0.629	0.742	1.092
S705	0.625	0.679	0.758	0.933		1.500
S705AF	0.454	0.483	0.521	0.592	0.671	0.908
S706	0.700	0.771	0.883	1.108	1.342	1.500
S707	0.683	0.750	0.850	1.046	1.263	1.500
S708	0.529	0.567	0.613	0.692	0.779	1.075
S709	0.479	0.508	0.546	0.613	0.688	0.908
S710	0.275	0.292	0.313	0.346	0.379	0.463
S711	0.267	0.283	0.304	0.338	0.371	0.454
S712	0.154	0.158	0.167	0.183	0.196	0.225
S713	0.217	0.225	0.238	0.258	0.283	0.342
S714	0.229	0.242	0.254	0.283	0.317	0.438
S715	0.450	0.479	0.513	0.579	0.646	0.850
S716	0.692	0.733	0.792	0.904	1.033	1.433
S717	0.279	0.296	0.317	0.350	0.383	0.475
S718	0.879	0.938	1.017	1.171	1.342	1.500
S719	0.508	0.542	0.583	0.650	0.713	0.871
S720	0.533	0.571	0.617	0.692	0.771	1.021
S721	0.333	0.354	0.388	0.446	0.521	0.750
S722	0.717	0.763	0.829	0.971	1.142	1.500
S723	0.283	0.300	0.325	0.358	0.400	0.508
S724	0.650	0.692	0.742	0.833	0.938	1.250
S725	0.917		1.096	1.313	1.500	1.500
S726	0.267	0.283	0.308	0.363	0.433	0.638
S727	0.621	0.667	0.721	0.829		1.342
S728	0.646	0.717	0.829	1.033	1.250	1.500

Notes:

Tc exceeded 1.5 hour limit, therefore it was set to 1.5 hour

Error in Tc calculation

Table 3-10
Time of concentration summary for the existing conditions 24-hour storm

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S100	0.692	0.750	0.821	0.958	1.108	1.488
S101	0.542	0.592	0.650	0.771	0.904	1.279
S102	0.813	0.879	0.963	1.121	1.288	1.500
S103	0.871	0.946	1.042	1.217	1.408	1.500
S104	0.792	0.863	0.950	1.113	1.296	1.500
S105	0.988	1.079	1.188	1.392	1.500	1.500
S106	0.729	0.796	0.879	1.046	1.233	1.500
S107	0.896	0.979	1.092	1.308	1.500	1.500
S200	0.629	0.679	0.750	0.871	1.008	1.275
S201	0.517	0.558	0.617	0.721	0.838	1.058
S202	0.367	0.388	0.413	0.458	0.513	0.654
S203	0.758	0.817	0.900	1.046	1.208	1.500
S204	0.750	0.813	0.896	1.050	1.217	1.500
S205	0.654	0.708	0.783	0.921	1.075	1.471
S206	1.008	1.092	1.200	1.400	1.500	1.500
S207	1.017	1.096	1.204	1.400	1.500	1.500
S208	1.079	1.167	1.279	1.483	1.500	1.500
S209	0.746	0.808	0.896	1.054	1.242	1.500
S210	0.579	0.633	0.704	0.842	1.008	1.500
S211	0.729	0.796	0.888	1.054	1.254	1.500
S300	0.800	0.867	0.954	1.121	1.304	1.500
S301	0.725	0.783	0.863	1.004	[illegible]	1.467
S302	0.663	0.717	0.792	0.933	1.088	1.463
S303	0.713	0.779	0.867	1.038	1.246	1.500
S304	0.842	0.921	1.021	1.217	1.450	1.500
S400	0.867	0.942	1.038	1.208	1.388	1.500
S401	0.858	0.938	1.042	1.246	1.496	1.500
S402	0.750	0.825	0.917	1.100	1.317	1.500
S403	0.971	1.046	1.154	1.354	1.500	1.500
S404	0.371	0.392	0.417	0.458	0.508	0.746
S500	1.046	1.129	1.242	1.446	1.500	1.500
S501	0.692	0.750	0.829	0.979	1.150	1.500
S502	0.533	0.583	0.646	0.775	0.925	1.317
S503	0.721	0.783	0.858	1.000	[illegible]	1.500
S504	1.025	[illegible]	1.292	1.500	1.500	1.500

Table 3-10 (continued)
Time of concentration summary for the existing conditions 24-hour storm

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S505	0.304	0.321	0.346	0.383	0.433	0.592
S506	0.392	0.408	0.438	0.488	0.567	0.833
S507	0.788	0.867	0.967	1.171	1.417	1.500
S508	0.596	0.654	0.733	0.892	1.092	1.500
S509	0.329	0.346	0.367	0.408	0.450	0.596
S510	0.529	0.571	0.625	0.729	0.838	1.171
S511	0.433	0.454	0.483	0.550	0.642	0.892
S512	0.667	0.713	0.779	0.904	1.050	1.450
S513	1.300	1.433	1.500	1.500	1.500	
S514	0.983	1.063	1.179	1.392	1.500	1.500
S515	0.975	1.046		1.329	1.500	1.500
S516	1.058	1.163	1.308	1.500	1.500	1.500
S600	0.763	0.833	0.925	1.113	1.325	1.500
S601	0.588	0.629	0.683	0.775	0.871	1.096
S602	0.788	0.854	0.933	1.088	1.250	1.500
S603	0.433		0.479	0.533	0.600	0.771
S604	1.100	1.188	1.300	1.500	1.500	1.500
S605	0.742	0.800	0.875	1.017	1.175	1.492
S606	0.600	0.650	0.713	0.825	0.950	1.221
S607	0.738	0.792		0.996	1.133	1.471
S608	0.517	0.554	0.604	0.692	0.783	1.008
S609	0.767	0.838	0.925	1.100	1.292	1.500
S610	0.829	0.888	0.967	1.108	1.254	1.500
S611	0.504	0.542	0.600	0.700	0.808	1.029
S612	0.750	0.804	0.879	1.004	1.138	1.471
S613	1.096	1.183	1.296	1.500	1.500	1.500
S614	0.963	1.042	1.142	1.329	1.500	1.500
S615	0.913	0.975	1.054	1.183	1.313	1.500
S616	1.375	1.496	1.500	1.500	1.500	1.500
S617	0.808	0.875	0.963	1.125	1.300	1.500
S618	0.796	0.863	0.946		1.267	1.500
S619	0.721	0.775	0.842	0.954	1.067	1.350
S620	0.696	0.750	0.813	0.925	1.038	1.321
S621	0.621	0.675	0.754	0.904	1.083	1.500
S622	0.971	1.063	1.179	1.413	1.500	1.500
S700	0.725	0.792	0.875	1.042	1.233	1.500

Table 3-10 (continued)
Time of concentration summary for the existing conditions 24-hour storm

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S701	1.100	1.200	1.321	1.500	1.500	1.500
S702	0.563	0.613	0.683	0.813	0.963	1.454
S703	0.496	0.538	0.600	0.721	0.867	1.367
S704	0.463	0.492	0.538	0.642	0.767	1.121
S705	0.650	0.704	0.779	[illegible]	1.054	1.492
S705AF	0.488	0.513	0.546	0.613	0.671	0.842
S706	0.738	0.804	0.892	1.058	1.254	1.500
S707	0.725	0.788	0.875	1.029	1.196	1.500
S708	0.550	0.583	0.625	0.700	0.775	0.983
S709	0.508	0.538	0.579	0.638	0.700	0.846
S710	0.333	0.346	0.363	0.388	0.413	0.463
S711	0.325	0.338	0.354	0.379	0.400	0.450
S712	0.188	0.196	0.204	0.221	0.233	0.263
S713	0.267	0.275	0.288	0.308	0.329	0.367
S714	0.283	0.296	0.308	0.338	0.363	0.425
S715	0.483	0.504	0.542	0.600	0.654	0.792
S716	0.708	0.750	0.804	0.896	0.988	1.254
S717	0.333	0.350	0.367	0.392	0.413	0.463
S718	0.971	1.025	1.100	1.225	1.350	1.500
S719	0.554	0.588	0.625	0.688	0.742	0.867
S720	0.579	0.613	0.654	0.725	0.792	0.958
S721	0.383	0.400	0.425	0.463	0.504	0.692
S722	0.742	0.788	0.850	0.954	1.075	1.413
S723	0.342	0.354	0.371	0.400	0.425	0.483
S724	0.663	0.700	0.750	0.833	0.908	1.108
S725	0.950	1.013	1.100	1.267	1.446	1.500
S726	0.329	0.346	0.367	0.404	0.446	0.629
S727	0.671	0.713	0.767	0.858	0.958	1.246
S728	0.696	0.763	0.854	1.029	1.250	1.500

Notes:

Tc exceeded 1.5 hour limit, therefore it was set to 1.5 hour

Error in Tc calculation

Table 3-11
Time of concentration summary for the <u>future conditions 6-hour storm</u>

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S100	0.638	0.696	0.779	0.921	1.054	1.425
S101	0.521	0.571	0.642	0.779	0.917	1.308
S102	0.521	0.567	0.629	0.733	0.833	1.096
S103	0.679	0.746	0.842	1.004	1.171	1.500
S104	0.629	0.683	0.754	0.908	1.071	1.446
S105	0.671	0.729	0.817	0.971	1.129	1.500
S106	0.504	0.550	0.617	0.750	0.883	1.254
S107	0.571	0.625	0.704	0.888	1.117	1.500
S200	0.621	0.679	0.758	0.888	1.008	1.358
S201	0.483	0.525	0.583	0.679	0.775	1.029
S202	0.308	0.329	0.363	0.421	0.479	0.650
S203	0.588	[redacted]	0.708	0.817	0.925	1.225
S204	0.729	0.800	0.900	1.058	1.221	1.500
S205	0.421	0.450	0.492	0.575	0.654	0.850
S206	0.783	0.854	0.954	1.142	1.321	1.500
S207	0.813	0.888	0.992	1.175	1.342	1.500
S208	1.008	[redacted]	1.229	1.471	1.500	1.500
S209	0.604	0.663	0.746	0.904	1.058	1.488
S210	0.458	0.500	0.558	0.683	0.817	1.196
S211	0.496	0.542	0.613	0.746	0.879	1.271
S300	0.375	0.400	0.442	0.513	0.592	0.788
S301	0.367	0.396	0.429	0.496	0.563	0.729
S302	0.458	0.496	0.550	0.646	0.738	0.983
S303	0.588	0.646	0.738	0.904	1.075	1.500
S304	0.533	0.583	0.654	0.813	0.992	1.475
S400	0.429	0.458	0.496	0.571	0.654	0.846
S401	0.396	0.425	0.471	0.563	0.667	0.933
S402	0.342	0.363	0.392	0.446	0.513	0.667
S403	0.300	0.321	0.342	0.379	0.421	0.521
S404	0.313	0.338	0.367	0.425	0.496	0.692
S500	0.675	0.729	0.813	0.950	1.079	1.421
S501	0.438	0.471	0.525	0.621	0.713	0.963
S502	0.424	0.467	0.521	0.617	[redacted]	0.983
S503	0.567	0.613	0.679	0.804	0.929	1.233
S504	0.450	0.483	0.533	0.621	0.708	0.921

Table 3-11 (continued)
Time of concentration summary for the future conditions 6-hour storm

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S505	0.238	0.254	0.275	0.317	0.371	0.525
S506	0.258	0.275	0.296	0.338	0.383	0.500
S507	0.350	0.375	0.413	0.479	0.567	0.792
S508	0.246	0.258	0.279	0.321	0.367	0.492
S509	0.179	0.188	0.200	0.221	0.238	0.308
S510	0.258	0.271	0.292	0.321	0.354	0.433
S511	0.254	0.271	0.292	0.329	0.375	0.496
S512	0.313	0.333	0.354	0.392	0.429	0.521
S513	0.408	0.438	0.479	0.571	0.671	0.913
S514	0.338	0.354	0.379	0.425	0.471	0.596
S515	0.363	0.383	0.408	0.450	0.496	0.617
S516	0.383	0.408	0.442	0.504	0.567	0.708
S600	0.796	0.892	1.029	1.304	1.500	1.500
S601	0.575	0.617	0.675	0.779	0.888	1.125
S602	0.400	0.875	0.983	1.183	1.375	1.500
S603	0.800	0.429	0.467	0.538	0.608	0.779
S604	0.575	1.229	1.379	1.500	1.500	1.500
S605	0.725	0.792	0.888	1.046	1.196	1.500
S606	1.121	0.625	0.696	0.808	0.917	1.225
S607	0.654	0.758	0.842	0.992	1.138	1.496
S608	0.700	0.450	0.492	0.575	0.650	0.838
S609	0.421	0.721	0.804	0.938	1.083	1.500
S610	0.521	0.563	0.617	0.717	0.813	1.033
S611	0.596	0.521	0.579	0.671	0.767	1.013
S612	0.479	0.642	0.696	0.808	0.933	1.217
S613	0.913	0.996	1.108	1.317	1.500	1.500
S614	0.854	0.933	1.042	1.242	1.421	1.500
S615	0.479	0.929	1.013	1.163	1.317	1.500
S616	0.867	0.563	0.629	0.750	0.863	1.171
S617	0.517	0.521	0.583	0.692	0.800	1.083
S618	0.758	0.833	0.938	1.138	1.346	1.500
S619	0.688	0.738	0.808	0.942	1.079	1.396
S620	0.642	0.692	0.758	0.883	1.000	1.288
S621	0.517	0.567	0.642	0.808	1.000	1.500
S622	0.929	1.038	1.200	1.500	1.500	1.500
S700	0.342	0.367	0.404	0.479	0.571	0.821

Table 3-11 (continued)
Time of concentration summary for the future conditions 6-hour storm

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S701	0.675	0.733	0.821	0.988	1.175	[illegible]
S702	0.288	0.308	0.333	0.383	0.442	0.583
S703	0.400	0.433	0.488	0.596	0.717	1.075
S704	0.304	0.325	0.354	0.421	0.492	0.696
S705	0.321	0.342	0.367	0.413	0.463	0.596
S705AF	0.454	0.483	0.521	0.592	0.671	0.908
S706	0.288	0.304	0.329	0.371	0.421	0.533
S707	0.279	0.296	0.317	0.354	0.392	0.483
S708	0.396	0.304	0.325	0.363	0.400	0.513
S709	0.288	0.338	0.363	0.400	0.438	0.542
S710	0.321	0.150	0.158	0.171	0.183	0.208
S711	0.167	0.146	0.154	0.167	0.179	0.204
S712	0.167	0.096	0.100	0.108	0.117	0.133
S713	0.167	0.133	0.142	0.154	0.163	0.188
S714	0.167	0.167	0.175	0.192	0.208	0.246
S715	0.167	0.379	0.408	0.450	0.500	0.633
S716	0.358	0.458	0.492	0.542	0.600	0.742
S717	0.438	0.238	0.254	0.279	0.304	0.363
S718	0.229	0.738	0.796	0.896	1.017	[illegible]
S719	0.692	0.338	0.363	0.400	0.433	0.525
S720	0.321	0.317	0.342	0.375	0.413	0.508
S721	0.300	0.204	0.217	0.233	0.250	0.296
S722	0.196	0.467	0.500	0.558	0.621	0.788
S723	0.442	0.171	0.179	0.192	0.208	0.233
S724	0.167	0.433	0.458	0.504	0.546	0.646
S725	0.413	0.583	0.621	0.688	0.754	0.925
S726	0.550	0.204	0.213	0.233	0.254	0.333
S727	0.192	0.433	0.463	0.513	0.563	0.683
S728	0.408	0.421	0.454	0.521	0.588	0.733

Notes:
[illegible] Tc exceeded 1.5 hour limit, therefore it was set to 1.5 hour
[illegible] Error in Tc calculation

Table 3-12
Time of concentration summary for the future conditions 24-hour storm

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S100	0.688	0.742	0.813	0.946	1.088	1.454
S101	0.542	0.592	0.650	0.771	0.904	1.279
S102	0.558	0.604	0.663	0.767	0.879	1.150
S103	0.742	0.804	0.883	1.033	[redacted]	1.500
S104	0.646	0.700	0.767	0.883	1.008	1.354
S105	0.721	0.783	0.854	0.988	1.125	1.500
S106	0.533	0.579	0.638	0.746	0.871	1.238
S107	0.571	0.621	0.688	0.817	[redacted]	1.463
S200	0.629	0.679	0.750	0.871	1.008	1.275
S201	0.517	0.558	0.617	0.721	0.838	1.058
S202	0.367	0.388	0.413	0.458	0.513	0.654
S203	0.633	0.688	0.750	0.867	0.992	1.267
S204	0.750	0.813	0.896	1.050	1.217	1.500
S205	0.458	0.483	0.517	0.596	0.679	0.888
S206	0.829	0.892	0.975	1.125	1.288	1.500
S207	0.846	0.913	1.000	1.163	1.333	1.500
S208	1.054	1.142	1.246	1.433	1.500	1.500
S209	0.638	0.692	0.763	0.892	1.042	1.458
S210	0.488	0.525	0.583	0.692	0.817	1.229
S211	0.529	0.575	0.638	0.754	0.883	1.292
S300	0.413	0.433	0.463	0.517	0.596	0.783
S301	0.388	0.408	0.433	0.475	0.529	0.675
S302	0.492	0.525	0.575	0.671	0.775	1.025
S303	0.608	0.663	0.738	0.879	1.046	1.500
S304	0.542	0.588	0.650	0.767	0.900	1.317
S400	0.438	0.458	0.483	[redacted]	0.604	0.779
S401	0.429	0.450	0.479	0.546	0.633	0.896
S402	0.375	0.392	0.417	0.454	0.492	0.629
S403	0.350	0.367	0.383	0.413	0.438	0.496
S404	0.371	0.388	0.408	0.450	0.492	0.671
S500	0.688	0.738	0.808	0.933	1.063	[redacted]
S501	0.467	0.492	0.533	0.625	0.725	0.967
S502	0.471	0.496	0.542	0.642	0.750	1.021
S503	0.567	0.613	0.671	0.775	0.883	[redacted]
S504	0.483	0.513	0.558	0.646	0.738	0.963

Table 3-12 (continued)
Time of concentration summary for the <u>future conditions 24-hour storm</u>

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S505	0.300	0.317	0.338	0.375	0.413	0.533
S506	0.321	0.333	0.354	0.383	0.417	0.500
S507	0.392	0.408	0.433	0.475	0.533	0.738
S508	0.304	0.321	0.338	0.371	0.404	0.496
S509	0.225	0.238	0.250	0.271	0.296	0.350
S510	0.317	0.329	0.342	0.367	0.392	0.442
S511	0.313	0.329	0.346	0.379	0.408	0.496
S512	0.367	0.383	0.400	0.429	0.454	0.508
S513	0.433	0.454	0.479	0.542	0.625	0.854
S514	0.375	0.392	0.408	0.442	0.471	0.554
S515	0.379	0.392	0.413	0.442	0.471	0.546
S516	0.425	0.446	0.471	0.513	0.575	0.721
S600	0.763	0.833	0.925	1.113	1.325	1.500
S601	0.588	0.629	0.683	0.775	0.871	1.096
S602	0.433	0.854	0.933	1.088	1.250	1.500
S603	0.788		0.479	0.533	0.600	0.771
S604	0.600	1.188	1.300	1.500	1.500	1.500
S605	0.742	0.800	0.875	1.017	1.175	1.492
S606	1.100	0.650	0.713	0.825	0.950	1.221
S607	0.700	0.792	0.863	0.988	1.125	1.454
S608	0.733	0.483	0.513	0.588	0.667	0.858
S609	0.458	0.763	0.842	0.992	1.163	1.496
S610	0.546	0.588	0.642	0.733	0.825	1.050
S611	0.617	0.542	0.600	0.700	0.808	1.029
S612	0.504	0.663		0.817	0.913	1.163
S613	0.925	0.992	1.083	1.246	1.413	1.500
S614	0.888	0.954	1.046	1.213		1.500
S615	0.496	0.975	1.054	1.183	1.313	1.500
S616	0.913	0.600	0.658	0.767	0.883	1.204
S617	0.554	0.533	0.588	0.683		1.071
S618	0.796	0.858	0.942	1.096	1.263	1.500
S619	0.721	0.775	0.842	0.954	1.067	1.350
S620	0.696	0.750	0.813	0.925	1.038	1.321
S621	0.508	0.554	0.617	0.738	0.879	1.342
S622	0.975	1.063	1.183	1.417	1.500	1.500
S700	0.388	0.408	0.433	0.479	0.546	0.788

Table 3-12 (continued)
Time of concentration summary for the <u>future conditions 24-hour storm</u>

Subbasin ID (1)	Time of Concentration, in hours 100-Year (2)	50-Year (3)	25-Year (4)	10-Year (5)	5-Year (6)	2-Year (7)
S701	0.708	0.771	0.846	0.979	1.125	1.500
S702	0.350	0.367	0.388	0.421	0.458	0.592
S703	0.446	0.471	0.504	0.604	0.721	1.121
S704	0.363	0.379	0.404	0.450	0.500	0.708
S705	0.358	0.375	0.392	0.425	0.454	0.542
S705AF	0.488	0.513	0.546	0.613	0.671	0.842
S706	0.329	0.346	0.363	0.396	0.425	0.504
S707	0.329	0.342	0.358	0.388	0.413	0.471
S708	0.442	0.342	0.358	0.388	0.413	0.471
S709	0.329	0.388	0.404	0.433	0.458	0.517
S710	0.371	0.183	0.192	0.208	0.221	0.246
S711	0.179	0.179	0.188	0.200	0.213	0.238
S712	0.171	0.117	0.121	0.129	0.138	0.154
S713	0.167	0.167	0.171	0.183	0.196	0.221
S714	0.167	0.204	0.217	0.233	0.250	0.292
S715	0.196	0.421	0.442	0.475	0.500	0.600
S716	0.404	0.458	0.479	0.521	0.567	0.679
S717	0.442	0.292	0.304	0.325	0.346	0.383
S718	0.279	0.800	0.854	0.942	1.029	1.254
S719	0.754	0.388	0.404	0.433	0.458	0.508
S720	0.375	0.371	0.388	0.413	0.438	0.488
S721	0.354	0.250	0.263	0.283	0.300	0.338
S722	0.242	0.471	0.496	0.542	0.596	0.725
S723	0.454	0.208	0.217	0.233	0.246	0.275
S724	0.200	0.438	0.458	0.488	0.521	0.604
S725	0.421	0.583	0.621	0.688	0.750	0.888
S726	0.550	0.250	0.267	0.288	0.313	0.367
S727	0.242	0.471	0.492	0.533	0.583	0.688
S728	0.450	0.458	0.483	0.538	0.600	0.750

Notes:

Tc exceeded 1.5 hour limit, therefore it was set to 1.5 hour

Error in Tc calculation

In addition to the 1.5 hour computational limitation, the T_c should also not be longer than the duration of the most intense portion of the rainfall excess. The validity of the calculated T_c values, based on this criteria, can be checked by inspection of Tables C-2 through C-13 and C-15 through C-26 of Appendix C for existing and future watershed conditions, respectively. Each of these tables lists by subbasin the rainfall excess values for the most intense 90 minute period, the total excess rainfall depth and the computed T_c. The T_c value can then be compared to the duration of rainfall excess. Comparing these values shows that for the 100-year 6-hour event as many as 12 subbasins fail this criteria. However, further inspection of this data for each of these subbasins shows that, in general, the length of time beyond the duration of rainfall excess is relatively small compared to T_c. This small over estimation is considered to be insignificant when compared to the overall results of the watershed analysis. Inspections of these tables for all other storm frequencies show that the number of subbasins that fail this criteria increases with increasing storm frequency with a maximum of 80% of the subbasins failing for the 2-year, 6-hour existing watershed condition. Additionally, the length of time beyond the duration of rainfall excess also increases with increasing storm frequency. These results indicate that the Clark unit hydrograph may not be appropriate for the modeling of all return periods for these subbasins. However, these results are based on the following key assumptions.

- The rainfall is distributed over the entire watershed simultaneously;
- The 6-hour temporal rainfall distributions developed from the historic storm over Queen Creek, Arizona in 1954 is representative of the distributions for all storm frequencies, and
- The rainfall losses characteristics particularly the RTIMP parameter, are constant for all storm frequencies.

Given these assumptions and in consideration of the purpose of this study, these results are considered to be reasonable for planning purposes.

Storage Coefficient - The Clark unit hydrograph storage coefficient, R, is estimated using the calculated T_c values and equation 5.6 of the Design Manual. The results of the R value calculations are summarized in Tables C-2 through C-13 and C-15 through C-26 of Appendix C for existing and future watershed conditions, respectively.

Time-Area Relation - A dimensionless time-area relation of contributing area versus travel time to subbasin outlet, is required for the Clark unit hydrograph procedure. It is impractical to develop individual time-area relations for each subbasin of a numerous subbasin model, therefore, synthetic time-area relations are used in this study. For existing watershed conditions, the Natural time-area relation, shown as N-D in Figure 5.7 of the Design Manual is used for all subbasins in the watershed.

For future watershed conditions, subbasins with developed area percentages greater than 50 percent are assigned the urban time-area relation. Subbasins with developed area percentages less than 50 percent but with high density land use types are also assigned the urban time-area relation. All other subbasins are assigned the natural time-area relation. The urban time area relation is show as U-D in Figure 5.6 of the Design Manual.

3.2.2.5 Reach Route Parameters

General

Routing of subbasin hydrographs is performed using the normal depth option of the Modified Puls channel storage method of HEC-1. Routing reach paths are shown on Plate 1, with each route identified by a name that consists of the upper and lower concentration point numbers that define the reach. For example, Reach 102103 is the reach with concentration point 102 at the upstream and concentration point 103 at the downstream.

Physical Parameters

Cross Section Geometry - Representative cross section geometry for each reach route was obtained during field reconnaissance trips for the portions of the watershed that are currently unstudied. Cross sectional geometry was measured using a hand level, graduated range pole, and a 100-foot measuring tape. For watercourses that have been previously studied (Morgan City Wash, Caterpillar Tank Wash, Twin Buttes Wash and tributaries), routing reach section geometry was determined from the detailed mapping associated with those studies. A listing of the data source for each routing reach is provided in Table 3-13.

Manning's n Estimates - The normal depth option of the Modified Puls channel storage routing method requires a Manning's n-value estimate for the main channel and both the left

and right overbank. In general all routing reaches are characterized by a well defined main channel with the bed material consisting primarily of gravel and course gravel. Overbank areas are typically steep with either dense vegetation or rocky abutments. Representative Manning's n-value estimates for the 100-year event for each routing reach were made based on photographs taken during the field reconnaissance and judgement. Field reconnaissance photographs taken for each routing reach are provided in Appendix D.

For the routing reaches within the limits of the detail study watercourses (Unnamed Washes 1, 2 and 3), the Manning's n-values estimated as part of the hydraulic analysis are used. Representative routing reach Manning's n-values are determined by selection of the predominant values for all cross sections located within each routing reach. The 100-year n-values estimated for each reach are used for all other modeled storm frequencies for both existing and future watershed conditions.

Table 3-13

Summary of reach route physical data

Reach Route Concentration Points		In		Length		Elevation (feet)		Slope
Top	Bottom	Subbasin	Cross Section Source	Feet	Miles	Top	Bottom	(ft/ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
100	102	S101	Hydrology Field Reconnaissance	6535	1.2377	1770	1680	0.0138
101	102	S103	Hydrology Field Reconnaissance	7254	1.3738	1780	1680	0.0138
102	103	S104	Hydrology Field Reconnaissance	8068	1.5280	1680	1580	0.0124
103	104	S106	Hydrology Field Reconnaissance	8625	1.6336	1580	1440	0.0162
104	105	S107	Hydrology Field Reconnaissance	6956	1.3174	1440	1360	0.0115
200	201	S201	Hydrology Field Reconnaissance	3952	0.7485	1940	1850	0.0228
201	203	S203	Hydrology Field Reconnaissance	3233	0.6123	1850	1800	0.0155
202	203	S203	Hydrology Field Reconnaissance	2353	0.4457	1840	1800	0.0170
203	204	S205	Hydrology Field Reconnaissance	1325	0.2510	1800	1780	0.0151
204	205	S206	Hydrology Field Reconnaissance	5007	0.9484	1780	1710	0.0140
205	206	S208	Hydrology Field Reconnaissance	11893	2.2526	1710	1635	0.0063
206	207	S209	Hydrology Field Reconnaissance	4972	0.9416	1635	1480	0.0312
207	105	S211	Hydrology Field Reconnaissance	7176	1.3591	1480	1360	0.0167
300	301	S302	Hydrology Field Reconnaissance	5117	0.9692	1620	1550	0.0137
301	302	S303	Hydrology Field Reconnaissance	8124	1.5387	1550	1480	0.0086
302	303	S304	Hydrology Field Reconnaissance	7304	1.3834	1480	1340	0.0192
400	401	S401	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	7424	1.4060	1525	1450	0.0101
401	402	S402	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	8029	1.5206	1450	1360	0.0112
402	403	S403	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	6138	1.1625	1360	1330	0.0049
403	404	S404	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	4256	0.8061	1330	1260	0.0164
500	501	S501	Hydrology Field Reconnaissance	5972	1.1311	1660	1580	0.0134
501	502	S502	Hydrology Field Reconnaissance	5021	0.9509	1580	1500	0.0159
502	505	S504	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	8775	1.6619	1500	1420	0.0091
503	505	S507	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	9136	1.7304	1525	1420	0.0115
504	505	S507	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	7754	1.4685	1520	1420	0.0129

Table 3-13 (Continued)

Summary of reach route physical data

Reach Route Concentration Points		In		Length		Elevation (feet)		Slope
Top	Bottom	Subbasin	Cross Section Source	Feet	Miles	Top	Bottom	(ft/ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
505	509	S508	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	6213	1.1767	1420	1380	0.0064
506	508	S510	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	4023	0.7619	1520	1460	0.0149
507	508	S512	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	5400	1.0227	1520	1460	0.0111
508	509	S513	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	10349	1.9601	1460	1380	0.0077
509	510	S514	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	1958	0.3709	1380	1360	0.0102
510	511	S515	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	6722	1.2731	1360	1315	0.0067
511	512	S516	C.A.P. Overchutes, Agua Fria FDS, FCD 90-09	9226	1.7473	1315	1240	0.0081
600	601	S601	Morgan City Wash FDS, FCD 90-09	3190	0.6042	2555	2440	0.0361
601	602	S603	Morgan City Wash FDS, FCD 90-09	6017	1.1395	2440	2280	0.0266
602	603	S606	Morgan City Wash FDS, FCD 90-09	7614	1.4420	2280	2150	0.0171
603	604	S609	Morgan City Wash FDS, FCD 90-09	7830	1.4830	2150	2000	0.0192
604	605	S608	Morgan City Wash FDS, FCD 90-09	1543	0.2922	2000	1990	0.0065
605	606	S610	Morgan City Wash FDS, FCD 90-09	5520	1.0455	1990	1880	0.0199
606	608	S613	Morgan City Wash FDS, FCD 90-09	1141	0.2160	1880	1860	0.0175
607	608	S613	Hydrology Field Reconnaissance	11167	2.1149	2130	1860	0.0242
608	609	S614	Morgan City Wash FDS, FCD 90-09	6518	1.2344	1860	1780	0.0123
609	611	S617	Morgan City Wash FDS, FCD 90-09	6519	1.2346	1780	1760	0.0031
610	611	S616	Hydrology Field Reconnaissance	7981	1.5115	1840	1760	0.0100
611	613	S618	Morgan City Wash FDS, FCD 90-09	4445	0.8418	1760	1590	0.0382
612	613	S620	Hydrology Field Reconnaissance	8752	1.6576	1880	1590	0.0331
613	614	S621	Morgan City Wash FDS, FCD 90-09	5557	1.0525	1590	1530	0.0108
614	615	S622	Morgan City Wash FDS, FCD 90-09	7995	1.5142	1530	1415	0.0144
704	705O	S705	Hydrology Field Reconnaissance	7534	1.4269	1480	1340	0.0186
705O	705AF	S705AF	Agua Fria FIS, FCD 95-05	2254	0.4269	1338	1320	0.0082
709	710	S710	Agua Fria FIS, FCD 95-05	2683	0.5082	1490	1420	0.0261

Table 3-13 (Continued)
Summary of reach route physical data

Reach Route Concentration Points		In		Length		Elevation (feet)		Slope
Top	Bottom	Subbasin	Cross Section Source	Feet	Miles	Top	Bottom	(ft/ft)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
711	712	S712	Agua Fria FIS, FCD 95-05	1586	0.3004	1490	1420	0.0441
712	714	S714	Agua Fria FIS, FCD 95-05	2032	0.3848	1420	1385	0.0172
713	714	S714	Agua Fria FIS, FCD 95-05	831	0.1575	1420	1385	0.0421
716	717	S717	Agua Fria FIS, FCD 95-05	4232	0.8015	1495	1420	0.0177
717	718	S718	Agua Fria FIS, FCD 95-05	7146	1.3534	1420	1345	0.0105
721	722	S722	Agua Fria FIS, FCD 95-05	8812	1.6690	1480	1330	0.0170
726	727	S727	Agua Fria FIS, FCD 95-05	6228	1.1796	1395	1280	0.0185

Routing Reach Length and Slope - The normal depth option parameters of reach length and energy slope (assumed to be the channel slope) are measured either from Plate 1 or the detailed mapping associated with the previously studied watercourses. Table 3-13 summarizes those values for each routing reach.

Channel Infiltration Losses - Channel infiltration losses are estimated for select routing reaches using the steady state loss rate option of HEC-1. There is no stream flow gage data available for this watershed to provide guidance in selection of loss rates. However, it is expected that some losses due to infiltration exist within the routing reaches. Steady state loss rates for each reach are estimated by inspection of Plate 2.

Channel infiltration losses are estimated only for those routing reaches for which a unique soil map unit is determined for the watercourse. The XKSAT value for that soil map unit is then assigned as the steady state loss rate. For the routing reaches that do not have a unique soil map unit associated with the watercourse, it is assumed, based on field reconnaissance that the soil characteristics of the watercourse are sufficiently different from the surrounding land surface such that the assignment of a steady state loss rate based on data other than what is representative of the actual watercourse soil characteristics is unwarranted. The resulting routing reaches for which channel infiltration losses are estimated are summarized in Table 3-14.

Table 3-14

Transmission losses

Reach Route ID (1)	XKSAT in/hr (2)
402403	0.03
403404	0.03
501502	0.94
502505	0.94
503505	0.63
505509	0.94
507508	0.39
508509	0.94
509510	0.38
510511	0.38
511512	0.40
602603	0.96
603604	0.96
605606	0.96
606608	0.96
608609	0.94
609611	0.94
611613	0.94
613614	0.94
614615	0.94
717718	0.03
721722	0.03

Computational Parameters

General – Other than the physical parameters that describe the routing reaches, the normal depth option of the Modified Puls channel storage routing method is a function of two computational parameters. Those parameters are the model computational time interval (NMIN) and the number of routing computation steps (NSTPS).

Computational Time Interval - The modeling computational time interval directly impacts the hydrologic routing of a flood hydrograph and the minimum allowable reach length. Values of NMIN are typically selected to provide adequate definition of the unit hydrograph and should lie within the range of 0.1 to 0.25 times the minimum T_c occurring in the

watershed. For the existing condition 100-year, 6-hour model, the shortest T_c is 0.154 hours (9 minutes), resulting in a range of 1 to 2.5 minutes. For the existing condition 100-year, 24-hour model, the shortest T_c is 0.188 hours (11 minutes), resulting in a range of 1.1 to 2.8 minutes. The selected NMIN value for both the existing condition 6- and 24-hour models is 2 minutes. This value is also applied to all other modeled storm frequencies for both existing and future watershed conditions.

Assuming an average travel velocity of 8 feet per second, the minimum length of routing reach required for the floodwave to travel one time step (NMIN = 2 minutes) is:

$$L_{min} = (2 \text{ min})(60)(8 \text{ fps}) = 960 \text{ feet.}$$

Initially, hydrologic routing was performed for all travel reaches regardless of reach length. Those reaches that did not lag the hydrograph one time step and provide attenuation, were subsequently removed from the model and replaced with a KM record commenting that reach is too short to route.

Reach Route Step Estimation - Estimation of the number of routing steps for input to the HEC-1 models is an iterative process. The number of routing steps for each reach may vary with the storm duration being considered. The process for estimating the number of steps is as follows:

Step 1: An initial estimate of the number of steps (NSTPS) for each reach is made assuming an average velocity of 10 feet per second. The HEC-1 models are run using the assumed values.

Step 2: The reach travel time is calculated by subtracting the time-to-peak (T_p) at the beginning of the routing operation from the T_p at the end of the routing operation.

Step 3: The travel time from Step 2 is then divided by the computational time interval (NMIN), to obtain a check NSTPS value.

Step 4: The result from Step 3 is compared with the NSTPS value currently coded in HEC-1 model. If the two values are not equal, the check NSTPS value is re-coded into the HEC-1 model as the new NSTPS value and the model is rerun.

Step 5: Repeat Steps 2 through 5 until the current NSTPS value and the check NSTPS value are equal. Convergence normally occurs within three iterations.

Summary of Routing Results – Tables D-1 through D-24 of Appendix D, summarize reach route hydraulic data and checking calculations for both existing and future watershed conditions for all modeled storm frequencies and durations. Data represented in those tables include average physical parameters, normal depth calculation results, minimum and maximum check velocities that are based on the HEC-1 calculated wave celerity and numerics relating flood wave velocity to normal depth velocity, travel time through the reaches in increments of NMIN, and final NSTPS values. A summary describing the calculations performed to obtain those values for each column of those tables, is provided in Appendix D following the tables. Examination of the data summarized in those tables provides confirmation of the reasonableness of each reach route.

3.2.2.6 Reservoir Route Parameters

There are numerous locations within the study watershed both at culvert crossings and stock tanks where there is a potential for some degree of ponding to occur. The significance of the potential ponding in regard to the overall modeling results has been evaluated on a case by case basis. The results of that evaluation are summarized into the following categories:

- Storage routing is not justified due to the combination of channel slope and geometry resulting in insignificant storage volume in comparison to the inflow volume. Moreover, the best available source for estimation of storage volume is from 20-foot contour interval (CI) mapping. This category is typified by many of the culvert crossings of State Route (SR) 74.
- Storage routing is justified in that the culvert does not have sufficient capacity to convey the inflow volume and there is sufficient storage volume in comparison to the inflow volume. However, there is insufficient data to develop a stage-storage-discharge relation, particularly a state-storage relation. This category is typified by culvert crossings of the Beardsley Canal, west of the Agua Fria River and at select locations along the Waddell and Hayden-Rhodes reaches of the CAP.
- Storage routing at the stock tanks is not justified given the uncertainty associated with the structural stability and long term maintenance program.
- Storage routing is justified and there is sufficient data to develop stage-storage-

discharge relations. This category is typified by culvert crossings of the Waddell and Hayden-Rhodes reaches of the CAP and the Beardsley Canal east of the Agua Fria River.

The evaluation of each potential storage routing location was based on a hydraulic analysis of the culvert using the HY-8 computer program and inspection of any available mapping. Input data to HY-8 was obtained from various as-built plan sets and field reconnaissance. The locations where storage routing is warranted are listed both by HEC-1 operational identifiers and structure number in Table 3-15. Stage-storage and stage-discharge rating curves input into the HEC-1 models are included for reference in Appendix E, along with the HY-8 program output.

Table 3-15

Storage routing locations

HEC-1 ID	Structure No.
(1)	(2)
S400	78
C502	81
S503	94
S504	93
S506	84
S507	82
C705	63
S709	95
C710	58
S711	71
C712	60
C713	59
S716	74
S721	75

3.2.2.7 Future Condition Retention

General

Both Maricopa County and the City of Peoria require retention/detention for all new developments. While the specifies of the respective ordinances are similar, only the City of Peoria's ordinances are addressed for this study as it is anticipated that over time the entire

study area will be incorporated.

The specifics of the city's retention/detention requirements are covered in the Hillside Development Overlay District (Zoning Ordinance) and the Grading and Drainage Ordinance. These ordinances describe the land use classes for which on-site and off-site retention is required as well as a table of maximum allowable densities for various ranges of land slope. This table is particularly important as it relates to a waiver for the on-site retention requirement. The maximum residential density that can occur on slopes greater than 10 percent is greater than the maximum density of the residential category that qualifies for on-site retention. Because of the possibility for waiving the retention requirements for this category of development, only the land use classes occurring on slopes less than 10 percent will be considered in the retention volume calculations.

According to the City of Peoria Infrastructure Guidelines, the design event for all retention/detention facilities is the 100-year, 2-hour storm. Retention volumes are computed for this storm using Equation 3.4 of the Design Manual. That equation is:

$$V = C\frac{P}{12}A$$

Where:

V = Runoff volume, in acre-ft;

C = Runoff coefficient;

P = 100-year, 2-hour rainfall depth; and

A = Developed area, in acres

The calculated volume is then reduced by 20 percent to account for potential waivers (beyond what is previously discussed) or alternative methods of post-development mitigation that may be allowed.

Developed Area

Developed area calculations apply to all land use classes, other than OPEN, H2O and DESERT, that have more than 50 percent of its occurring on natural terrain slopes less than 10 percent. These land use classes were identified by overlaying the Future Condition Land Use Map (Plate 9) on a slope map of the watershed. The slope map was generated from a mosaic of 30 meter USGS digital elevation models for the watershed using ArcView. The areas of these land use classes as they occur within each subbasin were taken from the worksheets of Table A-5 of Appendix A. The total developed area for each subbasin is shown in Table A-6 of Appendix A.

Runoff Coefficient

The runoff coefficient, (C) is a representation of the rainfall losses and is primarily associated with land use. Table 3.2 of the Design Manual is used for guidance in the selection of appropriate values for C for the land use classes that are identified as requiring retention. Table 3-16 lists the land use classes and the assigned value of C.

Weighted runoff coefficients are computed for each subbasin based on the development area. These calculations are provided in the worksheets of Appendix H, Tables H-1 and H-2. The weighted value of C for each subbasin is listed in Table 3-17 and 3-18 for the HEC-1 and Rational Method subbasins, respectively.

Rainfall Depth

The 100-year, 2-hour rainfall depth used for the retention volume calculations for all subbasins is 2.80 inches. This value is taken from Table 3-19 as discussed in Section 3.2.4.2.

Retention Volume

Calculated retention volumes for each HEC-1 subbasin are shown in Table 3-17. These values are coded into the future condition HEC-1 model on the DT card of the diversion record set. Calculated retention volumes for each Rational Method subbasin are listed in Table 3-18.

Table 3-16
Runoff coefficients for each future condition land use classification

Land Use Class (1)	Runoff Coefficients 100 Year (2)	50 Year (3)	25 Year (4)	2-10 Year (5)
ARP	0.95	0.95	0.94	0.85
COMM	0.88	0.84	0.77	0.70
DESERT	0.50	0.48	0.44	0.40
H20	1.00	1.00	1.00	1.00
IND	0.88	0.84	0.77	0.70
LDR	0.60	0.58	0.54	0.49
MDR	0.69	0.66	0.61	0.55
MFR1	0.75	0.72	0.66	0.60
MFR2	0.80	0.77	0.71	0.65
MFR3	0.81	0.78	0.72	0.66
MFR4	0.81	0.78	0.72	0.66
OPEN	0.50	0.48	0.44	0.40
P	0.95	0.95	0.94	0.85
PF	0.88	0.84	0.77	0.70
VLDR	0.56	0.54	0.50	0.45

Land-use Class	Description
VLDR	Very low density and low density residential = < 2.0 dwelling units per acre
LDR	Low density residential = 2.0 - 5.0 dwelling units per acre
MDR	Medium density residential = 5.0 - 8.0 dwelling units per acre
MFR_1	Multiple family residential = 8.0 - 15.0 dwelling units per acre
MFR_2	Multiple family residential = 15+ dwelling units per acre
MFR_3	Mixed use
MFR_4	Resort development, multiple family residential
PF	Public Facilities/Quasi-public (Community Centers/Ball Park)
COMM	Neighborhood/Community Commercial
IND	Business Park, industrial
OPEN	Natural Desert Park/Open space
ARP	Airport
H2O	Water
DESERT	Unincorporated/undeveloped natural desert
P	Pavement

Table 3-17

Summary of 100-year, 2-hour retention volumes for the HEC-1 subbasins

Subbasin ID (1)	Developed Area acres (2)	Weighted Runoff Coefficient (3)	100-Year, 2-Hour Retention Volume acre-ft (4)
S100	57.0	0.59	6.3
S101	0.0	0.00	0.0
S102	137.6	0.56	14.4
S103	0.0	0.00	0.0
S104	150.1	0.72	20.2
S105	154.0	0.56	16.1
S106	0.0	0.00	0.0
S107	0.0	0.00	0.0
S200	0.0	0.00	0.0
S201	0.0	0.00	0.0
S202	0.0	0.00	0.0
S203	145.0	0.56	15.2
S204	14.1	0.56	1.5
S205	106.8	0.71	14.2
S206	404.0	0.56	42.2
S207	191.0	0.56	20.0
S208	85.2	0.81	12.9
S209	0.0	0.00	0.0
S210	0.0	0.00	0.0
S211	0.0	0.00	0.0
S300	292.5	0.60	32.6
S301	332.8	0.61	37.9
S302	76.7	0.58	8.3
S303	0.0	0.00	0.0
S304	317.5	0.56	33.2
S400	398.2	0.74	55.3
S401	345.3	0.56	36.2
S402	366.3	0.76	51.8
S403	345.8	0.77	49.4
S404	27.5	0.57	2.9
S500	434.1	0.58	46.6
S501	233.8	0.58	25.1
S502	123.6	0.57	13.3
S503	224.7	0.61	25.5
S504	204.4	0.68	26.1

Table 3-17 (continued)

Summary of 100-year, 2-hour retention volumes for the HEC-1 subbasins

Subbasin ID (1)	Developed Area acres (2)	Weighted Runoff Coefficient (3)	100-Year, 2-Hour Retention Volume acre-ft (4)
S505	14.9	0.65	1.8
S506	38.7	0.84	6.0
S507	416.5	0.59	45.5
S508	168.1	0.66	20.7
S509	42.2	0.66	5.2
S510	78.3	0.75	11.0
S511	154.0	0.61	17.6
S512	132.3	0.80	19.6
S513	497.6	0.61	57.1
S514	383.8	0.72	51.8
S515	650.6	0.70	84.7
S516	254.7	0.83	39.4
S600	0.0	0.00	0.0
S601	0.0	0.00	0.0
S602	0.0	0.00	0.0
S603	0.0	0.00	0.0
S604	0.0	0.00	0.0
S605	0.0	0.00	0.0
S606	0.0	0.00	0.0
S607	51.4	0.56	5.4
S608	86.3	0.56	9.0
S609	97.6	0.56	10.2
S610	0.0	0.00	0.0
S611	0.0	0.00	0.0
S612	0.0	0.00	0.0
S613	0.0	0.00	0.0
S614	0.0	0.00	0.0
S615	0.0	0.00	0.0
S616	120.3	0.56	12.6
S617	0.0	0.00	0.0
S618	0.0	0.00	0.0
S619	0.0	0.00	0.0
S620	0.0	0.00	0.0
S621	0.0	0.00	0.0
S622	0.0	0.00	0.0
S700	0.0	0.00	0.0

Table 3-17 (continued)

Summary of 100-year, 2-hour retention volumes for the HEC-1 subbasins

Subbasin ID (1)	Developed Area acres (2)	Weighted Runoff Coefficient (3)	100-Year, 2-Hour Retention Volume acre-ft (4)
S701	2.3	0.88	0.4
S702	135.6	0.65	16.5
S703	48.9	0.56	5.1
S704	0.0	0.00	0.0
S705	0.0	0.00	0.0
S705AF	50.2	0.58	5.4
S706	355.7	0.76	50.4
S707	331.4	0.85	52.4
S708	396.6	0.57	42.4
S709	199.7	0.58	21.6
S710	42.1	0.60	4.7
S711	93.4	0.60	10.5
S712	37.4	0.60	4.2
S713	25.5	0.60	2.9
S714	0.0	0.00	0.0
S715	37.0	0.60	4.1
S716	633.4	0.66	77.8
S717	72.0	0.60	8.1
S718	118.2	0.60	13.2
S719	76.9	0.60	8.6
S720	204.8	0.61	23.2
S721	201.2	0.80	30.1
S722	504.4	0.67	63.0
S723	27.3	0.88	4.5
S724	624.4	0.86	100.4
S725	660.5	0.86	106.2
S726	165.3	0.69	21.2
S727	221.1	0.81	33.4
S728	107.1	0.87	17.4

Table 3-18

Summary of 100-year, 2-hour retention volumes for the Rational Method subbasins

Subbasin ID (1)	Developed Area acres (2)	Weighted Runoff Coefficient (3)	100-Year, 2-Hour Retention Volume acre-ft (4)
R100	0.0	0.00	0.0
R101	0.0	0.00	0.0
R102	0.0	0.00	0.0
R103	108.1	0.72	14.6
R104	86.1	0.78	12.5
R105	25.9	0.88	4.2
R106	62.8	0.65	7.6
R107	188.2	0.60	21.2
R108	85.0	0.62	9.9
R109	57.8	0.88	9.5
R110	1.0	0.88	0.2
R111	119.3	0.81	18.0
R112	58.9	0.70	7.7
R113	24.5	0.69	3.2
R114	62.0	0.69	8.0
R115	43.4	0.69	5.6
R116	0.0	0.00	0.0
R117	0.9	0.56	0.1
R118	0.0	0.00	0.0
R119	0.0	0.00	0.0
R120	56.2	0.61	6.4
R121	83.2	0.60	9.3
R122	0.3	0.60	0.0
R123	19.6	0.88	3.2
R124	34.5	0.88	5.6
R125	41.5	0.60	4.6

3.2.3 Statistical Parameters

3.2.3.1 Precipitation Statistics

There are no statistical data of significant record available for this watershed other than the regional precipitation data published by the National Oceanic and Atmospheric Administration (NOAA). The precipitation depth-duration-frequency statistics used for this study are derived from the NOAA Atlas 2 for Arizona.

3.2.3.2 Discharge Statistics

There are no statistical data available for the study watershed.

3.2.4 Precipitation Data

3.2.4.1 Rainfall Distributions

Both the 6- and 24-hour storm durations are specified for analysis in this study. The rainfall distributions for the 6-hour duration storm are based on watershed area. Those distributions are listed in the Design Manual with each precipitation pattern valid for a certain watershed area and are automatically coded into the model by the modified version of the MCUHP1 program. The 24-hour rainfall distribution used for this study is the SCS Type II.

3.2.4.2 Point Precipitation Data

Point precipitation values used for this study are derived from the isopluvial maps in the Design Manual. The precipitation values from those maps are analyzed to develop the rainfall depth-duration-frequency table using the PREFRE computer program. The results of that analysis are shown in Table 3-19.

Table 3-19
Depth-duration-frequency table

Output Data

Revised June 1988 to update computation of short-duration values
Precipitation frequency values for North Peoria Area Drainage Master

Primary zone number = 7
Short-duration zone number = 8

Point Values

Return Period

Duration	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR	500-YR
5-Min	.34	.44	.51	.60	.68	.75	.92
10-Min	.52	.67	.78	.92	1.04	1.16	1.42
15-Min	.63	.84	.98	1.18	1.33	1.48	1.83
30-Min	.83	1.12	1.32	1.59	1.80	2.01	2.49
1-Hr	1.01	1.38	1.63	1.98	2.25	2.51	3.13
2-Hr	1.13	1.54	1.82	2.20	2.50	2.80	3.48
3-Hr	1.21	1.65	1.94	2.35	2.67	2.99	3.72
6-Hr	1.36	1.85	2.18	2.64	3.00	3.35	4.17
12-Hr	1.53	2.08	2.46	2.97	3.38	3.77	4.70
24-Hr	1.70	2.32	2.73	3.31	3.76	4.20	5.23

NOTE: If your site is in Arizona or New Mexico, please consult the following paper or revised depth-area values: Depth-Area Ratios In The Semi-Arid Southwest United States NOAA Technical Memorandum NWS Hydro-40 Zehr and Myers, August 1984.

Input Data

Project Name	=	North Peoria Area Drainage Master
Zone	=	7
Short-Duration Zone	=	8
Elevation	=	0
Latitude	=	.00
Longitude	=	100.00
2-yr, 6-hr pcpn	=	1.36
100-yr, 6-hr pcpn	=	3.35
2-yr, 24-hr pcpn	=	1.70
100-yr, 24-hr pcpn	=	4.20

3.2.4.3 Areal Precipitation Reduction

Precipitation reduction for the 6-hour storm is based upon the depth-area curve developed for the historic storm of 1954 over the Queen Creek, Arizona area, as developed by the U.S. Army Corps of Engineers in 1974. That depth-area curve is listed in the Design Manual. The precipitation patterns and corresponding areal reduction factors are selected automatically by the enhanced version of the MCUHP1 program.

The precipitation reduction factors used for the 24-hour storms are listed in the Design Manual and those values were derived from information contained in the NOAA Technical Memorandum NWS HYDRO-40 (NWS, 1984). Appropriate depth-area reduction for all storms and accumulated drainage areas is simulated in HEC-1 using the JD record option. Table 3-20 summarizes the basin areas, reduction factors and areally reduced point precipitation values used for the 24-hour HEC-1 model.

Table 3-20

Summary of 100-year, 24-hour JD areal reduction factors and corresponding drainage areas

Basin Area sq. miles (1)	Areal Reduction Factor (2)	Areally Reduced Point Precip. inches (3)
0.01	1.00	4.20
1	0.994	4.17
5	0.97	4.07
10	0.94	3.95
25	0.905	3.80
70	0.856	3.59

3.2.5 Gage Data

3.2.5.1 Streamflow Gaging Stations

There are no stream gages located within or sufficiently close to the study watershed to be of use.

3.2.5.2 Precipitation Gages

There are six continuous recording precipitation gages located in or near the study watershed. All six gages are owned, operated, and monitored by the District and are located as follows:

Chrysler Proving Grounds: Established 31 October 1990. Located 3.0 miles ESE Circle City, 1.5 miles N. of Whittmann in Section 7, Township 5 N., Range 2 W., at Latitude 33° 47' 04" and Longitude 112° 30' 03". The gage is at elevation 1,720 feet.

Castle Hot Springs: Established 20 October 1981. Located 6.1 miles NE from US 60/93 on Castle Hot Springs Road in Section 24, Township 7 N., Range 3 W., at Latitude 33° 55' 42" and Longitude 112° 31' 42". The gage is at elevation 2,683 feet.

Sun City West: Established 30 March 1995. Located 0.25 miles SE of the Beardsley Rd. and Litchfield Rd. alignments in Section 27, Township 4 N., Range 1 W., at Latitude 33° 39' 54" and Longitude 112° 21' 25". The gage is at elevation 1,335 feet.

New River Dam: Established 01 May 1986. Located 0.5 miles NE of Jomax Rd. and 83rd Ave. in Section 35, Township 5 N., Range 1 E., at Latitude 33° 44' 09" and Longitude 112° 13' 31". The gage is at elevation 1,498 feet.

Lake Pleasant: Established 10 December 1991. Located on New Waddell Dam at Lake Pleasant in Section 21, Township 6 N., Range 1 E., at Latitude 33° 51' 10" and Longitude 112° 16' 31". The gage is at elevation 1,820 feet.

Garfias Mountain: Established 14 April 1981. Located 6.0 miles WSW of Castle Hot Springs off Castle Hot Springs Rd. in Section 1, Township 7 N., Range 2 W., at Latitude 33° 57' 55" and Longitude 112° 25' 42". The gage is at elevation 2,645 feet.

All six gages have an insufficient period of record for statistical analysis of a 100-year recurrence interval precipitation depth, therefore, data from these gages are not used in this study.

3.3 Calibration

3.3.1 General

Calibration of the HEC-1 models is not possible because of the lack of available physical data. In lieu of calibration, indirect methods of model verification are performed and compared to the modeling results. The indirect verification methods used are:

1. Comparison of HEC-1 results with regional data;
2. Comparison of HEC-1 results with USGS data and;
3. Comparison of HEC-1 results with estimates made using a USGS regional regression equation.

In general, these methods of model verification are based on data or the analysis of data for non-urbanized watersheds. Therefore, these methods are used for comparison of the existing condition model results only.

3.3.2 Comparison with Regional Data

The Arizona Department of Water Resources (ADWR) has adopted State Standard SS2-96 which includes ten envelope curves of various data sets from the entire State of Arizona as well as surrounding regions. That data is adopted from the Arizona Department of Transportation Drainage Design Manual (1994). The envelope curves are shown in Figure 10-1 of the ADOT Manual, and that figure is included in Appendix F. Seven of the curves shown in Figure 10-1 represent envelopes of maximum observed flood discharges (Curves A, B, D, E, F, I and J), one is a 100-year discharge envelope (Curve H), and two are 100-year discharge relations (Curves C and G).

Existing condition 100-year discharge results of this study at several locations within the watershed are selected for comparison and are listed in Table F-1 of Appendix F. The results listed in this table are the larger of the 6- or 24-hour storm and are plotted for comparison on Figure 10-1. The curves of most interest in evaluating 100-year peak discharges in Arizona are C, G and H. Inspection of this figure shows that, in general, the modeled results plot favorably with curves C, G and H.

3.3.3 Comparison with USGS Data

Representative watersheds and their corresponding data are selected from the USGS report entitled Basin Characteristics and Streamflow Statistics in Arizona as of 1989 (WR, 91-4041) and are summarized in Table F-2 of Appendix F. The locations of those watersheds are shown in relation to the study watershed in Figure F-7 of Appendix F. The HEC-1 modeling results that are selected for comparison are summarized in Table F-1 of Appendix F. Data from Tables F-1 and F-2 are plotted in Figures F-1 through F-6 of Appendix F. The USGS data selected are for watersheds ranging in size from 0.5 to 144.0 square miles. The HEC-1 model results selected for comparison range in size from 0.71 to 22.90 square miles. As can be seen from Figures F-1 through F-6, the HEC-1 model data points plot favorably within the scatter limits of the USGS gage data. In addition, gage data (Log-Pearson Type III (LP3) peak discharge analyses and maximum recorded discharge (Q_{max})) for 240 gages throughout the state have been tabulated in the ADOT Manual. A regression analysis was performed for both the LP3 and Q_{max} data sets. Plots of this data along with 75% tolerance limits lines about the 100-year discharge line are shown in Figures 10-3 through 10-5 of the ADOT Manual and have been included in Appendix F. These data sets have also been adopted by ADWR in the State Standards SS2-96. Existing condition 100-year discharge data from Table F-1 is plotted for comparison in Figures 10-3 through 10-5. Inspection of these figures shows that, in general, the modeled results plot within the tolerance limits.

3.3.4 Comparison with USGS Regional Regression Equation

Table F-3 provides a comparison of selected HEC-1 modeling results to peak discharge estimates calculated using regional regression equations developed for Arizona, and published in the USGS Open-File Report 93-419 entitled Methods for estimating Magnitude and Frequency of Floods in the Southwestern United States. According to that report, Arizona is characterized by flood regions, with the study watershed being located in Flood Region 12. Applicable excerpts from that report for Flood Region 12, that are used for this comparison are provided in Appendix F. Included in those excerpts are a map (Figure F-8) showing the regional flood boundaries of the state in relation to the study watershed, a Flood Region 12 scatter diagram taken from the ADOT Manual of mean basin elevation versus drainage area for gage sites used

to perform regression analysis, a tabulation taken from the ADOT Manual of regional regression equations for estimation of peak discharges and the corresponding error percentages, and a scatter diagram and envelope curve taken from the ADOT Manual of 100-year peak discharges versus drainage area for gaged sites used for regression analysis.

In general, the HEC-1 model results are lower than the regression equation results for the 100-, 50- and 25-year return periods and higher than the regression equation results for the 10-, 5- and 2-year return periods, yet the results for all return periods are within the error ranges of the equations.

In summary, the existing conditions watershed model results compare favorable with the indirect methods of verification. Based on this the existing condition model results for all return periods are considered to be reasonable.

3.4 Special Problems and Solutions

3.4.1 HEC-1 Warnings and Errors

The only warning messages encountered in either of the two hydrologic models summarized in this report are as follows:

1. *** WARNING *** MODIFIED PULS ROUTING MAY BE NUMERICALLY UNSTABLE FOR OUTFLOWS BETWEEN XXXX. TO XXXX.

2. XXXX * WARNING EXCESS AT PONDING LESS THAN ZERO FOR PERIOD EXCESS SET TO ZERO

The first warning listed above specifies a range of peak flows for which the routing numerics may be unstable. Each routing reach for which a warning message is issued was checked for the following:

1. The routed peak discharge was compared to the range listed in the warning message;

2. The routed peak discharge was compared with the inflow peak discharge to determine if an increase resulted due to the routing computations; and

3. The routed hydrograph was plotted and checked for oscillations if either item 1 or 2 above was a concern.

Hydrograph plots for the reaches that required analyzing by the third step are provided in Appendix D. Examination of those plots does not give any cause to suspect the routing calculations, therefore the warning messages are considered inconsequential.

The second warning message listed above is in regard to the rainfall loss calculations performed by HEC-1 using the Green and Ampt methodology. After satisfying the surface retention loss requirement, HEC-1 then performs check calculations for each modeling time period to determine when a combination of accumulated rainfall and sufficient rainfall intensity occur to begin ponding (rainfall excess generation). All rainfall is infiltrated to that point and accounted for in the calculations. Once the program determines that ponding has occurred, an infiltration rate is then calculated for each time period and subtracted from the rainfall intensity for that same period to obtain the rate of rainfall excess. Due to imperfect numerics, it is possible to have a rainfall intensity for the modeling time period that results in the calculation of a ponding condition, yet that ponded depth is less than the calculated infiltration capacity of the soil for that time period. This results in a negative value for the rainfall excess calculation. HEC-1 issues its message and sets the loss to zero. This message is not an indication of model instability and can be disregarded.

3.5 Rational Method

3.5.1 General

The Rational Method is used for determination of peak discharges for subbasins that are less than 160 acres in size and that drain directly to the Agua Fria River or that drain to or are impounded by the Beardsley Canal. The Rational Method equation is as follows:

$$Q = CiA$$

where:
- Q = peak discharge for a selected recurrence interval, in cfs;
- C = coefficient relating rainfall to runoff;
- i = average rainfall intensity, in inches/hour, of calculated rainfall duration, T_c;
- T_c = time of concentration, in hours; and
- A = contributing drainage area, in acres.

In general, the physical parameters required for the estimation of peak discharge are the same as those for rainfall-runoff (HEC-1) modeling.

3.5.2. Rational Method Runoff Coefficient

The runoff coefficient, (C) is a representation of rainfall losses and is primarily associated with land use. Table 3.2 of the Design Manual is used for guidance in the selection of appropriate values of C. That table lists by land use class ranges of coefficients for various return periods, where the ranges for the 25-, 50- and 100-year return periods are derived using frequency adjustment factors of 1.10, 1.20 and 1.25, respectively to the 2- to 10-year ranges. The C values selected for this study are summarized in Table 3-21 and 3-16 for existing and future watershed conditions, respectively.

Table 3-21

Summary of existing condition land use classifications for the Rational Method

Land Use Classification (1)	Runoff Coefficients 2- to 10-Year (2)	25-Year (3)	50-Year (4)	100-Year (5)
COMM	0.70	0.77	0.84	0.88
DESERT	0.40	0.44	0.48	0.50
LDR	0.55	0.61	0.66	0.69
OPEN	0.40	0.44	0.48	0.50
PF	0.70	0.77	0.84	0.88

Where:
- DESERT = Undeveloped Desert
- LDR = Residential Areas, Single Family
- OPEN = Lake Pleasant Regional Park
- COMM = Commercial Areas
- PF = Public Facilities (APS Substation)

Weighted runoff coefficients are computed for the 2- to 10-year return period(s) based on the area of each unique land use class as it occurs within the subbasin. These calculations are provided in the worksheets of Tables G-1 and G-3 of Appendix G for existing and future watershed conditions respectively. Weighted values for the 25-, 50- and 100-year return periods are determined by multiplying the 2- to 10-year weighted value by the appropriate frequency adjustment factors. The resulting area weighted C values for both existing and future watershed conditions are shown in Tables 3-22 and 3-23, respectively.

3.5.3. Average Intensity

The peak discharge corresponding to a given intensity occurs only if the rainfall duration is at least equal to T_c. The equation that describes the relation of intensity to T_c is the same as that used for the Clark unit hydrograph. Refer to Section 3.2.2.4. for a detailed discussion of this relation. The physical characteristics of each Rational Method subbasin (length, slope and K_b) required for the calculation of T_c are summarized in Tables G-2 and G-4 of Appendix G for existing and future watershed conditions, respectively. Solution of the T_c equation is an iterative process that requires the use of an Intensity-Duration-Frequency (IDF) graph. An IDF graph appropriate for use in Maricopa County is provided in the Design Manual. The procedure involves making an initial estimate of the duration for which the corresponding intensity is determined from the IDF graph. The intensity is then used to calculate the actual T_c. This process is repeated until the estimated duration and the calculated T_c are equivalent. The resulting average intensity for each Rational Method Subbasin, for each return period is summarized in Tables 3-22 and 3-23 for existing and future watershed conditions, respectively.

3.5.4. Contributing Drainage Area

The drainage area of each Rational Method subbasin is calculated by the same approach as described for the HEC-1 modeled subbasins. These areas are summarized in Table 3-22, and 3-23. A generally accepted maximum drainage area limit for the application of the Rational Method is 160 acres. Four Rational Method subbasins (R107, R108, R112 and R115) delineated for this study, exceed this limit. However, the use of the Rational Method for these subbasins is considered appropriate for the purposes of this study.

Table 3-22

Summary of Rational Method input parameters for existing watershed conditions

Subbasin ID	Drainage Area Acres	Weighted Runoff Coefficient	Intensity, in inches/hour					
			100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
R100	61.4	0.40	7.3	6.6	5.8	4.7	3.9	2.7
R101	53.9	0.40	7.3	6.6	5.8	4.8	4.0	2.8
R102	64.0	0.40	6.9	6.1	5.2	4.0	3.4	2.4
R103	114.3	0.40	6.4	5.6	4.8	3.7	3.1	2.1
R104	86.1	0.40	6.5	5.8	4.9	3.8	3.2	2.2
R105	26.0	0.40	7.3	6.6	5.8	4.8	4.1	3.1
R106	84.0	0.40	6.9	6.1	5.2	4.0	3.4	2.4
R107	191.7	0.40	5.6	4.9	4.0	3.1	2.5	1.7
R108	196.6	0.40	6.5	5.7	4.9	3.8	3.1	2.2
R109	84.4	0.40	5.9	5.2	4.3	3.4	2.7	1.9
R110	63.1	0.40	7.3	6.5	5.7	4.5	3.8	2.6
R111	151.2	0.44	4.6	3.8	3.2	2.5	2.1	1.4
R112	165.5	0.40	4.3	3.7	3.2	2.5	2.1	1.4
R113	47.8	0.40	6.4	5.4	4.6	3.6	2.9	2.0
R114	145.7	0.40	4.2	3.6	3.1	2.4	2.0	1.2
R115	181.7	0.40	4.3	3.7	3.1	2.4	2.1	1.3
R116	37.1	0.40	7.3	6.4	5.6	4.4	3.7	2.5
R117	16.9	0.40	7.3	6.6	5.8	4.8	4.1	3.1
R118	26.4	0.40	7.3	6.6	5.8	4.7	3.9	2.8
R119	31.0	0.40	7.3	6.6	5.8	4.8	4.1	3.1
R120	58.6	0.40	7.0	6.2	5.3	4.1	3.5	2.4
R121	87.9	0.40	7.3	6.5	5.7	4.5	3.8	2.6
R122	71.1	0.40	6.1	5.4	4.6	3.6	2.9	2.0
R123	31.0	0.40	7.3	6.6	5.8	4.8	4.1	3.0
R124	37.3	0.40	7.0	6.2	5.4	4.2	3.5	2.4
R125	47.5	0.40	7.3	6.6	5.7	4.5	3.8	2.6

Table 3-23

Summary of Rational Method input parameters for future watershed conditions

Subbasin ID	Drainage Area acres	Weighted Runoff Coefficient	Intensity, in inches/hour					
			100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
R100	61.4	0.40	7.3	6.6	5.9	4.7	3.9	2.7
R101	53.9	0.40	7.3	6.6	6.1	4.8	4.0	2.8
R102	64.0	0.43	6.9	6.1	5.2	4.0	3.4	2.4
R103	114.3	0.58	7.3	6.6	5.7	4.5	3.8	2.6
R104	86.1	0.63	7.3	6.6	5.8	4.6	3.9	2.7
R105	26.0	0.70	7.3	6.6	5.8	4.8	4.1	3.1
R106	84.0	0.49	6.9	6.1	5.2	4.0	3.4	2.4
R107	191.7	0.49	6.7	5.9	5.1	3.9	3.3	2.3
R108	196.6	0.44	6.5	5.7	4.9	3.8	3.1	2.2
R109	84.4	0.61	7.1	6.2	5.4	4.2	3.5	2.4
R110	63.1	0.41	7.3	6.6	5.8	4.6	3.9	2.7
R111	151.2	0.59	5.7	5.0	4.1	3.2	2.6	1.8
R112	165.6	0.55	5.8	5.1	4.2	3.3	2.7	1.8
R113	47.8	0.55	7.3	6.5	5.7	4.5	3.8	2.6
R114	145.7	0.55	5.7	5.0	4.1	3.2	2.6	1.8
R115	181.7	0.55	5.9	5.2	4.3	3.4	2.7	1.9
R116	37.1	0.40	7.3	6.4	5.6	4.4	3.7	2.5
R117	16.9	0.40	7.3	6.6	5.8	4.8	4.1	3.1
R118	26.4	0.40	7.3	6.6	5.8	4.7	3.9	2.8
R119	31.0	0.43	7.3	6.6	5.8	4.8	4.1	3.1
R120	58.6	0.49	7.3	6.6	5.8	4.8	4.1	2.9
R121	87.9	0.49	7.3	6.6	5.8	4.8	4.1	3.1
R122	71.1	0.40	6.1	5.4	4.6	3.6	2.9	2.0
R123	31.0	0.59	7.3	6.6	5.8	4.8	4.1	3.1
R124	37.3	0.68	7.3	6.6	5.8	4.8	4.1	3.0
R125	47.5	0.48	7.3	6.6	5.8	4.8	4.1	3.1

3.6 Final Results

3.6.1 General

HEC-1 models are developed for multiple frequencies, storm durations and watershed conditions for this study. For each watershed condition (exiting, future without retention and future with retention), input data is initially developed in consideration of the anticipated magnitude for the 100-year event. Several key assumptions were then made in regard to specific elements of the input data to facilitate the development of the HEC-1 models for all other return periods. Those assumptions are:

1. The watershed delineation, particularly the size of individual subbasins, is appropriate for all return periods,
2. The rainfall distribution patterns and aerial reduction curves specified in the Design Manual are appropriate for all return periods,
3. Input data to the Green and Ampt infiltration equation, particularly the XKSAT and RTIMP variables, are appropriate for all return periods,
4. The watershed resistance coefficient, (K_b) is appropriate for all return periods, and
5. Manning's n-values used for hydrologic routing are appropriate for all return periods.

The HEC-1 model results are organized for comparison purposes into three sets of tables, one for each watershed condition. Each set is composed of four tables, two summarizing peak discharges at all concentration points for the 6- and 24- hour storm durations, respectively, and two tables summarizing peak discharges at each subbasin. Summary output for each model is provided in the back of this report. HEC-1 input and output files are also provided digitally on CD as Appendix O).

Rational Method results for each return period for both existing and future without retention watershed conditions are summarized in Tables 3-36 and 3-37, respectively. The required 100-year, 2-hour retention volume for these subbasins are listed in Table 3-18.

The results, in general, follow what is expected given the watershed conditions considered for this study. Under proposed conditions, the watershed can be divided into four regions. The first

region is north of State Route 74, which includes all of the Morgan City Wash sub-watershed and the upper portions of the sub-watersheds for Unnamed Washes 1 and 2. This area is to remain mostly undeveloped. What development is planned is very low density residential as can be seen from Plate 9. Locally, the development has the effect of increasing peak discharges and runoff volumes. For example, the 100-year, 6-hour peak discharge for subbasin S609 increases from 564 cfs to 622 cfs and the runoff volume increases from 56 acre-feet to 58 acre-feet due to the proposed development. The required retention volume estimated for this subbasin is 10.2 acre-feet. This volume is not sufficient to impact the 100-year peak discharge and is only effective for the more frequent runoff events (10-, 5- and 2-year). From a regional perspective, the proposed development has a negligible effect on the runoff characteristics as can be seen by inspection of the results for the Morgan City Wash sub-watershed (represented in HEC-1 as concentration point C615). The 100-year, 24-hour peak discharge at this location decreases from 11,824 cfs to 11,339 cfs and the runoff volume increases from 1,971 acre-feet to 1,998 acre-feet due to the proposed development. The total estimated required retention volume for this sub-watershed is only 37.2 acre-feet and the resulting peak discharge and runoff volume after retention is 11,320 cfs and 1,962 acre-feet, respectively.

The second region is north of the CAP, south of State Route 74 and west of the Agua Fria River. The area primarily includes the three Unnamed Wash sub-watersheds. Approximately half of this area is target for future development with the other half remaining undeveloped. The majority of the proposed land use consists of very low density residential with the remaining development consisting of various other residential densities as well as isolated areas of commercial development. This proposed land use has the effect of increasing peak discharges and runoff volumes at both the local and regional levels. Inspection of the results for the future condition with 100-year, 2-hour retention shows that the peak discharges and runoff volumes are decreased. For example, for the Unnamed Wash 1 and 2 sub-watersheds (represented in HEC-1 as concentration point C105), the 100-year, 24-hour future condition peak discharge and runoff volume decrease due to modeling the total estimated required retention volume of 163 acre-feet from 7,609 cfs and 1,199 acre-feet, respectively to 6,906 cfs and 1,036 acre-feet, respectively. These results compare to a 100-year, 24-hour peak discharge and runoff of 7,297 cfs and 1,128 acre-feet, respectively for existing conditions. Similarly, for the Unnamed Wash 3 sub-

watershed (represented in HEC-1 as concentration point C303) the 100-year, 6-hour future condition peak discharge and runoff volume decrease due to modeling the total estimated required retention volume of 112 acre-feet from 3,489 cfs and 331 acre-feet, respectively to 2,848 cfs and 219 acre-feet, respectively. These results compare to a 100-year, 6-hour peak discharge and runoff volume of 2,567 cfs and 303 acre-feet, respectively for existing conditions.

The third region is located south of the CAP and west of the Agua Fria River and includes the Twin Buttes Wash and Caterpillar Tank Wash sub-watersheds. It is proposed that this area be essentially fully developed with the development consisting of a variety of land uses. Like the previous region, results of hydrologic modeling of proposed land uses indicate that there is an increase to the peak discharges and runoff volumes from both the local and regional perspective. More notable is the impact of modeling the 100-year, 2-hour retention requirement on peak discharge and runoff volume, particularly for the Caterpillar Tank wash sub-watershed. For this entire sub-watershed (represented in HEC-1 as concentration point C404), the 100-year, 6-hour future condition peak discharge and runoff volume are reduced due to modeling a total estimated required retention volume of 195.6 acre-feet from 2,140 cfs and 356 acre-feet, respectively to 845 cfs and 161 acre-feet, respectively. This is compared to existing condition peak discharge and runoff volume results of 1,556 cfs and 281 acre-feet, respectively. For the Twin Buttes Wash sub-watershed (represented in HEC-1 as concentration point C512), the future condition 100-year, 6-hour peak discharge and runoff volume decrease due to modeling a total estimated required retention volume of 497 acre-feet from 3,997 cfs and 837 acre-feet, respectively to 2,187 cfs and 497 acre-feet, respectively. This is compared to existing condition peak discharge and runoff volume results of 3,775 cfs and 643 acre-feet, respectively. Additionally, at a number of locations within this region, 100-year, 2-hour retention model results for frequent events (10-, 5- and 2-year) demonstrate that entire runoff hydrograph is retained.

The forth region lies to the east of the Agua Fria River. This region is very similar in both the proposed land use conditions and the resulting runoff characteristics to region three. Future condition peak discharges increase over existing condition and consideration of 100-year, 2-hour retention requirements result in a reduction of future condition discharges to magnitudes similar to those for existing conditions.

Table 3-24
Summary of results for the 6-hour storm with existing watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C102	2.05	1769	1409	1054	662	417	175
C102L	0.84	856	683	516	332	225	107
C102R	1.20	1185	945	719	472	309	127
C103	3.54	2671	2127	1501	957	576	207
C103R	2.95	2330	1864	1401	859	517	187
C104	4.11	2892	2296	1614	1011	598	212
C105	12.75	6840	5290	3687	2232	1408	703
C105L	5.05	3193	2504	1734	1044	602	208
C105R	7.70	4567	3565	2569	1590	1087	586
C201	1.31	1669	1354	1033	682	467	225
C203	2.76	2627	2112	1593	997	654	345
C203R	1.81	1954	1582	1201	775	525	264
C204	3.17	2913	2336	1754	1091	708	368
C205	4.98	3870	3075	2274	1384	935	520
C205L	4.03	3345	2664	1980	1206	805	428
C206	6.09	4325	3409	2481	1527	1043	572
C207	7.22	4528	3534	2553	1575	1081	588
C207R	6.74	4471	3499	2540	1567	1076	588
C300	1.61	1665	1324	756	635	420	209
C301	2.07	1985	1578	960	744	481	238
C302	2.78	2203	1775	1147	814	502	233
C303	3.60	2567	2054	1344	901	540	234
C400O	1.05	500	456	406	315	243	132
C401	1.69	913	759	609	436	301	122
C402	2.43	1292	1034	790	504	312	116
C403	2.99	1572	1240	920	561	339	102
C404	3.26	1556	1224	910	556	336	101
C501	1.67	1250	980	722	453	336	202
C502I	3.07	2246	1767	1296	775	506	257
C502L	2.07	1392	1077	786	481	348	206
C502O	3.07	1982	1648	1255	775	505	257
C503O	0.14	97	93	88	81	72	40
C504O	0.15	93	90	81	71	59	31
C505	4.35	2513	2070	1536	930	564	233
C505L	3.39	2057	1695	1263	762	487	237
C505R	0.96	876	700	532	342	222	90

Table 3-24 (continued)
Summary of results for the 6-hour storm with existing watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C506O	0.17	93	90	86	79	72	50
C507O	0.38	98	97	93	86	82	64
C508	0.90	601	513	426	315	237	121
C508L	0.60	372	313	256	187	144	87
C508R	0.30	279	241	202	153	120	66
C509	6.32	3191	2581	1928	1082	642	225
C509L	4.65	2509	2055	1520	868	526	203
C509R	1.67	945	768	607	431	287	112
C510	6.97	3486	2809	2105	1168	682	233
C511	8.07	3779	3052	2304	1297	737	239
C512	8.61	3775	3050	2300	1231	718	223
C601	2.92	2625	2056	1493	856	539	330
C602	5.47	4393	3455	2500	1466	984	610
C602L	3.58	3040	2378	1716	964	670	404
C603	9.87	6527	5096	3665	2258	1577	996
C603L	6.13	4628	3629	2620	1550	1036	624
C604	11.25	6994	5461	3925	2375	1657	1032
C604R	10.43	6592	5147	3692	2231	1555	970
C605	11.76	7133	5584	4014	2431	1703	1067
C606	13.17	7694	6046	4367	2652	1870	1159
C606L	12.36	7321	5752	4145	2514	1768	1106
C608	15.53	8797	6915	5006	3047	2172	1357
C609	16.61	9109	7166	5183	3168	2260	1415
C611	18.85	9785	7728	5581	3440	2488	1536
C611L	1.56	1491	1220	976	702	513	287
C611R	17.29	9093	7165	5162	3160	2250	1398
C613	21.08	10389	8171	5901	3685	2692	1645
C613L	1.27	1716	1435	1141	781	555	264
C613R	19.81	9959	7838	5661	3496	2529	1550
C614	22.00	10339	8111	5843	3662	2672	1621
C615	22.90	10371	8111	5833	3651	2649	1587
C705	1.16	1418	1141	864	530	253	110
C705AF	1.34	772	687	581	415	231	109
C705O	1.16	689	619	530	383	218	101
C709O	0.44	411	385	355	293	244	136

Table 3-24 (continued)
Summary of results for the 6-hour storm with existing watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C710I	0.55	524	456	402	327	270	149
C710O	0.55	408	383	356	295	250	139
C711O	0.16	181	172	159	144	131	113
C712I	0.23	371	336	299	250	206	126
C712O	0.23	245	228	211	186	163	119
C713O	0.11	179	160	140	114	91	53
C714	0.39	543	493	438	361	297	182
C716O	1.13	618	579	537	471	387	224
C717	1.41	881	755	629	473	385	223
C718	1.86	1158	998	837	624	489	268
C721O	0.34	253	238	206	167	130	79
C722	1.29	1384	1157	928	649	462	216
C727	0.71	1132	910	738	491	218	136

Table 3-25
Summary of results for the 24-hour storm with existing watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C102	2.05	1464	1185	919	595	383	148
C102L	0.84	627	508	390	249	164	67
C102R	1.20	967	790	612	385	245	84
C103	3.54	2424	1958	1510	964	616	215
C103R	2.95	2058	1668	1290	829	529	188
C104	4.11	2682	2168	1665	1056	669	227
C105	12.75	7297	5845	4423	2827	1828	729
C105L	5.05	3031	2432	1860	1168	724	233
C105R	7.70	4684	3780	2868	1849	1257	563
C201	1.31	1396	1133	874	569	369	166
C203	2.76	2589	2098	1603	1023	656	301
C203R	1.81	1746	1417	1085	699	454	209
C204	3.17	2913	2354	1797	1145	727	326
C205	4.98	3995	3224	2464	1572	1022	477
C205L	4.03	3378	2723	2083	1328	856	389
C206	6.09	4421	3561	2709	1730	1156	533
C207	7.22	4651	3736	2833	1818	1234	559
C207R	6.74	4573	3676	2790	1792	1210	554
C300	1.61	1433	1158	887	561	308	157
C301	2.07	1787	1449	1107	699	378	190
C302	2.78	2042	1699	1313	830	442	208
C303	3.60	2414	2003	1547	968	511	222
C400O	1.05	453	417	370	294	232	96
C401	1.69	808	686	568	427	310	108
C402	2.43	1115	921	740	512	350	115
C403	2.99	1362	1102	864	578	393	126
C404	3.26	1352	1091	855	573	390	125
C501	1.67	1041	839	640	406	291	151
C502I	3.07	2088	1677	1273	799	513	241
C502L	2.07	1174	944	718	453	322	163
C502O	3.07	1829	1577	1221	798	513	241
C503O	0.14	89	85	78	68	51	13
C504O	0.15	84	78	72	59	51	14
C505	4.35	2420	2044	1598	1044	617	233
C505L	3.39	1927	1616	1257	801	509	217

Table 3-25 (continued)
Summary of results for the 24-hour storm with existing watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C505R	0.96	712	587	465	312	191	47
C506O	0.17	87	85	78	70	63	24
C507O	0.38	95	92	88	82	74	44
C508	0.90	493	429	364	279	215	93
C508L	0.60	286	248	210	160	124	62
C508R	0.30	214	187	158	124	98	36
C509	6.32	3160	2616	2084	1363	754	240
C509L	4.65	2425	2029	1598	1030	592	210
C509R	1.67	830	684	560	412	285	96
C510	6.97	3455	2842	2263	1464	804	253
C511	8.07	3737	3055	2537	1594	861	263
C512	8.61	3744	3057	2545	1556	849	258
C601	2.92	2687	2150	1618	990	588	293
C602	5.47	4746	3603	2904	1766	1111	568
C602L	3.58	3097	2289	1873	1117	686	369
C603	9.87	7308	5609	4426	2757	1827	934
C603L	6.13	4966	3754	3016	1855	1172	579
C604	11.25	7817	6018	4689	2947	1931	971
C604R	10.43	7372	5668	4472	2768	1805	905
C605	11.76	7954	6121	4783	3007	1983	1010
C606	13.17	8535	6588	5172	3251	2174	1115
C606L	12.36	8146	6284	4923	3092	2055	1050
C608	15.53	9840	7608	5996	3767	2556	1308
C609	16.61	10248	7913	6248	3908	2666	1359
C611	18.85	11048	8532	6739	4239	2928	1495
C611L	1.56	1210	1003	825	602	447	237
C611R	17.29	10241	7906	6235	3908	2665	1346
C613	21.08	11746	9056	7179	4567	3170	1629
C613L	1.27	1389	1152	929	652	475	220
C613R	19.81	11263	8699	6889	4352	2989	1518
C614	22.00	11709	9018	7162	4539	3164	1612
C615	22.90	11824	9101	7224	4568	3178	1582
C705	1.16	1146	937	723	299	280	69
C705AF	1.34	712	632	533	288	253	79
C705O	1.16	622	557	475	263	230	69

Table 3-25 (continued)
Summary of results for the 24-hour storm with existing watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C709O	0.44	362	331	294	245	199	118
C710I	0.55	433	390	345	286	229	133
C710O	0.55	376	352	313	262	216	124
C711O	0.16	156	148	138	126	117	83
C712I	0.23	259	239	219	191	166	107
C712O	0.23	206	195	182	161	145	97
C713O	0.11	131	118	102	81	61	39
C714	0.39	416	379	337	279	232	146
C716O	1.13	572	541	498	434	357	223
C717	1.41	739	641	545	457	375	226
C718	1.86	989	877	730	584	474	279
C721O	0.34	214	192	170	137	109	59
C722	1.29	1123	952	781	573	433	209
C727	0.71	796	661	531	363	259	99

Table 3-26
Summary of results for the 6-hour storm with existing watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S100	0.57	746	596	447	292	200	88
S101	0.63	1034	828	621	390	255	97
S102	0.45	540	429	328	218	152	75
S103	0.40	455	358	266	165	110	58
S104	0.90	1137	897	662	397	246	120
S105	0.59	547	427	233	186	132	73
S106	0.57	686	537	387	230	145	63
S107	0.94	789	600	415	220	147	62
S200	0.96	1379	1110	851	566	391	184
S201	0.35	603	490	378	258	181	83
S202	0.13	274	230	181	126	89	41
S203	0.37	417	331	254	172	120	54
S204	0.95	1126	894	673	439	296	146
S205	0.41	561	443	330	214	146	60
S206	0.85	760	596	442	264	202	116
S207	0.96	863	681	510	331	241	145
S208	1.10	1004	795	590	376	283	156
S209	0.65	888	699	516	318	206	93
S210	0.48	774	607	443	267	168	56
S211	0.49	650	508	365	218	136	58
S300	0.62	710	558	257	268	181	87
S301	0.99	1216	973	736	486	333	163
S302	0.47	742	589	447	295	201	84
S303	0.71	901	700	503	299	186	77
S304	0.82	791	603	426	236	147	68
S400	1.05	1212	962	719	438	278	145
S401	0.65	769	590	420	244	154	73
S402	0.74	951	739	524	295	174	74
S403	0.56	617	491	368	230	155	85
S404	0.26	651	544	433	293	194	73
S500	1.05	914	721	540	350	263	160
S501	0.61	844	665	496	321	215	90
S502	0.40	704	558	419	266	174	61
S503	0.99	1285	1036	780	485	307	141
S504	0.33	219	157	108	64	44	23

Table 3-26 (continued)
Summary of results for the 6-hour storm with existing watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S505	0.14	382	326	260	179	122	45
S506	0.15	318	260	203	132	87	32
S507	0.67	811	618	433	240	142	60
S508	0.29	418	323	229	133	80	25
S509	0.17	420	353	282	193	136	58
S510	0.13	195	157	121	77	49	19
S511	0.38	777	640	499	329	225	95
S512	0.21	306	247	190	119	74	29
S513	0.78	487	364	267	184	130	82
S514	0.65	626	494	367	227	156	84
S515	1.10	1268	1027	785	500	350	183
S516	0.54	429	315	213	130	93	270
S600	2.02	1843	1415	1003	558	345	195
S601	0.90	1460	1215	965	673	482	251
S602	1.88	1882	1505	1136	717	473	270
S603	0.67	1467	1229	994	708	518	268
S604	2.66	1924	1526	1137	755	547	338
S605	1.09	1250	1000	759	497	340	170
S606	0.66	910	735	563	380	267	124
S607	0.82	947	763	584	386	267	127
S608	0.51	976	804	636	436	313	159
S609	0.56	564	442	332	218	145	65
S610	0.60	730	587	453	307	218	113
S611	0.57	1068	873	679	465	326	153
S612	0.81	954	779	602	397	270	131
S613	1.80	1579	1261	950	630	468	276
S614	1.08	1033	821	618	398	279	168
S615	1.05	1313	1095	878	619	451	268
S616	0.50	360	280	212	159	123	71
S617	0.68	896	708	531	338	227	113
S618	0.96	1048	832	624	387	251	127
S619	0.83	1395	1163	928	641	455	231
S620	0.44	613	502	395	267	190	97
S621	0.92	1316	1038	755	426	246	89
S622	0.90	808	616	431	242	172	78

Table 3-26 (continued)
Summary of results for the 6-hour storm with existing watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S700	0.61	716	556	401	234	145	63
S701	0.72	518	401	291	182	137	74
S702	0.26	335	264	192	115	73	26
S703	0.26	400	318	232	139	86	28
S704	0.41	757	609	459	289	189	67
S705	0.75	980	786	592	358	163	88
S705AF	0.18	351	295	240	171	123	57
S706	0.71	825	645	464	268	163	71
S707	0.64	728	575	422	251	155	69
S708	0.71	1336	1123	913	656	476	219
S709	0.44	903	766	628	459	339	168
S710	0.11	298	257	214	163	127	74
S711	0.16	483	417	353	273	213	126
S712	0.07	238	211	182	144	117	77
S713	0.11	326	285	243	190	150	92
S714	0.06	163	140	117	86	63	29
S715	0.22	450	382	314	228	169	84
S716	1.13	1625	1373	1110	786	561	255
S717	0.29	867	752	637	494	389	231
S718	0.44	476	397	318	222	157	91
S719	0.15	242	205	168	125	95	54
S720	0.37	652	547	444	322	238	118
S721	0.34	866	735	594	419	290	120
S722	0.95	1279	1065	846	573	387	170
S723	0.09	216	185	153	114	86	45
S724	1.16	1788	1516	1244	907	665	330
S725	1.16	1153	638	725	469	316	171
S726	0.33	860	723	579	392	265	100
S727	0.38	519	428	340	233	100	68
S728	0.28	286	219	153	86	52	19

Table 3-27
Summary of results for the 24-hour storm with existing watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S100	0.57	512	414	320	204	132	47
S101	0.63	717	581	449	284	178	51
S102	0.45	360	291	224	144	94	41
S103	0.40	307	246	188	119	76	31
S104	0.90	870	701	538	341	216	75
S105	0.59	387	307	232	145	97	39
S106	0.57	470	374	282	171	102	28
S107	0.94	618	484	355	204	119	28
S200	0.96	1067	873	675	438	286	127
S201	0.35	387	316	245	158	103	46
S202	0.13	159	133	106	72	49	21
S203	0.37	280	226	172	110	71	33
S204	0.95	880	710	543	342	217	95
S205	0.41	369	297	226	141	88	28
S206	0.85	581	466	355	224	153	72
S207	0.96	674	543	415	265	183	96
S208	1.10	804	649	500	322	236	110
S209	0.65	624	504	382	238	146	47
S210	0.48	496	396	298	180	104	18
S211	0.49	428	341	254	153	90	22
S300	0.62	499	401	305	190	119	48
S301	0.99	959	778	599	384	199	111
S302	0.47	481	390	299	188	118	41
S303	0.71	651	515	384	226	128	32
S304	0.82	596	470	349	207	119	33
S400	1.05	967	779	601	390	256	105
S401	0.65	549	435	324	191	108	31
S402	0.74	705	559	419	248	142	34
S403	0.56	444	360	278	180	124	63
S404	0.26	383	322	261	182	126	38
S500	1.05	731	587	448	284	201	109
S501	0.61	582	469	356	220	135	47
S502	0.40	449	360	273	165	97	24
S503	0.99	1009	819	638	416	213	97
S504	0.33	154	85	78	40	21	1

Table 3-27 (continued)
Summary of results for the 24-hour storm with existing watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S505	0.14	202	168	133	88	56	14
S506	0.15	190	159	126	84	54	14
S507	0.67	590	464	343	198	108	24
S508	0.29	279	220	162	92	49	7
S509	0.17	235	197	158	108	74	26
S510	0.13	133	109	85	56	38	13
S511	0.38	484	405	325	219	144	48
S512	0.21	211	173	136	90	60	21
S513	0.78	376	288	223	151	99	35
S514	0.65	462	373	284	180	128	63
S515	1.10	1040	855	516	449	311	168
S516	0.54	303	233	165	94	57	8
S600	2.02	1804	1426	1057	615	349	147
S601	0.90	1116	935	753	530	383	185
S602	1.88	1738	1411	1092	702	457	211
S603	0.67	972	355	688	499	364	174
S604	2.66	1851	1493	1144	736	535	288
S605	1.09	1008	820	635	409	267	117
S606	0.66	651	530	412	270	178	76
S607	0.82	713	584	278	305	207	88
S608	0.51	638	532	427	297	211	95
S609	0.56	393	310	232	138	83	37
S610	0.60	510	419	331	223	154	73
S611	0.57	699	578	451	297	197	85
S612	0.81	719	592	467	318	222	96
S613	1.80	1406	1139	879	569	419	216
S614	1.08	831	670	515	330	218	114
S615	1.05	1027	860	696	500	372	209
S616	0.50	248	197	163	118	86	37
S617	0.68	635	514	395	252	162	64
S618	0.96	818	662	511	245	215	84
S619	0.83	1040	871	704	500	364	175
S620	0.44	414	342	273	189	135	63
S621	0.92	1009	812	612	369	214	41
S622	0.90	628	492	364	212	135	37

Table 3-27 (continued)
Summary of results for the 24-hour storm with existing watershed conditions by subbasin

HEC-1 ID	Drainage Area Sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S700	0.61	497	395	297	179	106	28
S701	0.72	382	301	228	146	106	44
S702	0.26	222	177	132	80	47	10
S703	0.26	257	206	155	92	53	8
S704	0.41	472	387	299	185	111	26
S705	0.75	733	593	455	179	189	56
S705AF	0.18	237	203	168	123	93	48
S706	0.71	610	485	365	222	132	37
S707	0.64	528	422	320	201	127	40
S708	0.71	969	828	684	499	376	194
S709	0.44	609	524	435	327	252	142
S710	0.11	179	156	133	103	83	52
S711	0.16	282	248	213	169	137	87
S712	0.07	132	117	101	81	66	43
S713	0.11	189	166	143	113	91	58
S714	0.06	96	83	69	52	39	19
S715	0.22	302	262	218	163	126	71
S716	1.13	1328	1129	926	674	505	259
S717	0.29	511	448	386	305	249	160
S718	0.44	333	282	229	165	124	73
S719	0.15	165	141	118	90	71	43
S720	0.37	443	378	314	233	178	99
S721	0.34	521	447	369	268	197	81
S722	0.95	1019	856	689	487	353	161
S723	0.09	131	114	97	74	58	34
S724	1.16	1462	1253	1040	773	594	330
S725	1.16	946	782	616	416	290	158
S726	0.33	484	408	329	227	154	46
S727	0.38	361	301	243	171	125	58
S728	0.28	196	153	112	64	34	6

Table 3-28
Summary of results for the 6-hour storm with future watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C102	2.05	1972	1586	1211	765	485	193
C102L	0.84	1061	849	643	416	280	127
C102R	1.20	1209	964	734	482	320	132
C103	3.54	3017	2444	1855	1157	726	275
C103R	2.95	2630	2133	1627	1019	641	241
C104	4.11	3190	2579	1948	1204	748	283
C105	12.75	7255	5365	4089	2559	1669	837
C105L	5.05	3500	2792	2072	1256	764	283
C105R	7.70	4802	3502	2754	1743	1192	642
C201	1.31	1669	1354	1033	682	467	225
C203	2.76	2648	1996	1602	1003	659	348
C203R	1.81	1965	1449	1208	778	529	267
C204	3.17	2980	2249	1795	1118	739	390
C205	4.98	4106	3138	2437	1517	1008	549
C205L	4.03	3485	2639	2074	1291	857	452
C206	6.09	4633	3423	2724	1704	1154	623
C207	7.22	4821	3516	2776	1743	1191	642
C207R	6.74	4789	3508	2778	1745	1189	642
C300	1.61	2560	2128	1689	1152	800	395
C301	2.07	2879	2403	1894	1277	869	425
C302	2.78	3129	2603	2048	1345	869	414
C303	3.60	3489	2882	2242	1454	922	409
C400O	1.05	557	528	489	430	375	263
C401	1.69	1243	1038	837	600	453	286
C402	2.43	1830	1527	1195	772	516	283
C403	2.99	2055	1707	1329	941	684	328
C404	3.26	2140	1778	1444	1045	757	341
C501	1.67	1780	1450	1103	719	487	234
C502I	3.07	3055	2486	1905	1216	708	354
C502L	2.07	2157	1749	1336	860	491	261
C502O	3.07	2290	2079	1716	1174	708	354
C503O	0.14	98	94	89	84	74	51
C504O	0.15	97	94	90	79	72	55
C505	4.35	2804	2457	2005	1353	850	420
C505L	3.39	2409	2160	1778	1200	730	365

Table 3-28 (continued)
Summary of results for the 6-hour storm with future watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C505R	0.96	1351	1129	894	605	402	164
C506O	0.17	95	93	89	85	80	68
C507O	0.38	100	98	96	91	86	77
C508	0.90	897	784	670	526	423	274
C508L	0.60	578	501	426	330	262	165
C508R	0.30	403	355	302	239	194	130
C509	6.32	3588	3032	2434	1670	1005	486
C509L	4.65	2777	2417	1958	1316	786	382
C509R	1.67	1486	1254	1023	757	580	323
C510	6.97	3865	3222	2574	1744	1034	497
C511	8.07	3995	3324	2623	1744	1185	571
C512	8.61	3997	3327	2620	1797	1257	630
C601	2.92	2625	2056	1493	856	539	330
C602	5.47	4393	3455	2500	1466	984	610
C602L	3.58	3040	2378	1716	964	670	404
C603	9.87	6527	5096	3665	2258	1577	996
C603L	6.13	4628	3629	2620	1550	1036	624
C604	11.25	7002	5469	3935	2382	1663	1036
C604R	10.43	6593	5149	3696	2234	1558	971
C605	11.76	7106	5561	3999	2423	1699	1064
C606	13.17	7469	5862	4231	2568	1820	1139
C606L	12.36	7174	5632	4058	2459	1733	1087
C608	15.53	8609	6783	4920	3005	2158	1349
C609	16.61	8945	7057	5109	3138	2254	1412
C611	18.85	9479	7491	5420	3369	2451	1523
C611L	1.56	1581	1299	1033	726	523	291
C611R	17.29	8839	6965	5026	3092	2217	1383
C613	21.08	10153	7995	5796	3639	2665	1636
C613L	1.27	1716	1435	1141	781	555	264
C613R	19.81	9676	7622	5526	3436	2493	1538
C614	22.00	10097	7944	5756	3620	2646	1614
C615	22.90	10136	7935	5757	3612	2623	1585
C705	1.16	1852	1549	1244	858	595	290
C705AF	1.34	954	871	779	634	503	275
C705O	1.16	782	723	654	543	437	241

Table 3-28 (continued)
Summary of results for the 6-hour storm with future watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C709O	0.44	436	412	384	341	292	200
C710I	0.55	646	583	502	389	314	207
C710O	0.55	427	399	372	329	282	194
C711O	0.16	183	180	169	154	143	125
C712I	0.23	395	374	337	289	255	198
C712O	0.23	259	244	228	205	188	153
C713O	0.11	185	177	155	128	107	68
C714	0.39	561	541	483	411	349	246
C716O	1.13	654	622	582	527	478	349
C717	1.41	1143	1033	903	723	587	392
C718	1.86	1470	1300	1123	890	733	456
C721O	0.34	277	262	248	219	191	147
C722	1.29	1776	1523	1265	950	729	426
C727	0.71	1512	1303	1088	806	608	332

Table 3-29
Summary of results for the 24-hour storm with future watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C102	2.05	1729	1417	1100	704	427	163
C102L	0.84	784	640	495	320	179	81
C102R	1.20	974	801	623	396	257	89
C103	3.54	2781	2281	1781	1165	724	276
C103R	2.95	2383	1963	1532	999	615	234
C104	4.11	2971	2428	1902	1243	772	293
C105	12.75	7609	6084	4703	3023	2031	866
C105L	5.05	3244	2654	2078	1349	857	309
C105R	7.70	4900	3905	3031	1935	1322	620
C201	1.31	1396	1133	874	569	369	166
C203	2.76	2592	2099	1607	1028	661	305
C203R	1.81	1753	1420	1089	703	459	213
C204	3.17	2923	2362	1804	1153	748	348
C205	4.98	4175	3375	2585	1654	1078	507
C205L	4.03	3432	2772	2121	1359	887	414
C206	6.09	4699	3782	2906	1857	1241	584
C207	7.22	4897	3928	3023	1925	1309	615
C207R	6.74	4850	3896	2999	1913	1294	609
C300	1.61	2181	1839	1487	1041	723	320
C301	2.07	2639	2234	1786	1226	837	360
C302	2.78	3042	2594	2078	1425	940	375
C303	3.60	3387	2883	2324	1581	1044	404
C400O	1.05	518	489	452	294	344	238
C401	1.69	1070	906	733	424	433	273
C402	2.43	1582	1307	1035	674	502	286
C403	2.99	1823	1523	1223	888	680	316
C404	3.26	1919	1639	1340	985	748	338
C501	1.67	1536	1253	965	636	425	172
C502I	3.07	3012	2453	1909	1242	817	305
C502L	2.07	1985	1604	1245	809	531	204
C502O	3.07	2246	2013	1696	1193	816	305
C503O	0.14	89	86	81	70	61	21
C504O	0.15	90	84	78	70	60	41
C505	4.35	2698	2394	2029	1420	995	374

Table 3-29 (continued)
Summary of results for the 24-hour storm with future watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C505L	3.39	2358	2105	1777	1228	839	314
C505R	0.96	986	837	681	485	342	126
C506O	0.17	89	87	84	76	70	46
C507O	0.38	97	95	91	85	81	64
C508	0.90	667	591	517	419	349	215
C508L	0.60	393	348	303	243	202	129
C508R	0.30	275	245	215	177	147	87
C509	6.32	3374	2919	2454	1756	1227	429
C509L	4.65	2687	2363	1990	1392	960	333
C509R	1.67	1107	937	790	616	492	268
C510	6.97	3555	3064	2544	1828	1244	478
C511	8.07	3642	3109	2554	1825	1220	591
C512	8.61	3644	3113	2555	1825	1288	656
C601	2.92	2687	2150	1618	990	588	293
C602	5.47	4746	3603	2904	1766	1111	568
C602L	3.58	3097	2289	1873	1117	686	369
C603	9.87	7308	5609	4426	2757	1827	934
C603L	6.13	4966	3754	3016	1855	1172	579
C604	11.25	7844	6021	4763	2954	1937	975
C604R	10.43	7398	5667	4474	2772	1809	906
C605	11.76	7950	6094	4843	2993	1976	1008
C606	13.17	8294	6375	5127	3142	2107	1094
C606L	12.36	8003	6147	4906	3024	2013	1035
C608	15.53	9534	7340	5953	3645	2512	1306
C609	16.61	9914	7635	6212	3793	2633	1362
C611	18.85	10509	8112	6581	4053	2890	1489
C611L	1.56	1264	1054	857	616	454	241
C611R	17.29	9791	7550	6117	3745	2637	1338
C613	21.08	11241	8647	7035	4366	3141	1627
C613L	1.27	1389	1152	929	652	475	220
C613R	19.81	10741	8284	6729	4142	2954	1512
C614	22.00	11199	8593	7000	4337	3127	1611
C615	22.90	11339	8676	7074	4378	3144	1585
C705	1.16	1477	1254	1022	709	490	260
C705AF	1.34	841	775	697	560	455	241

Table 3-29 (continued)
Summary of results for the 24-hour storm with future watershed conditions by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C705O	1.16	698	647	587	478	390	200
C709O	0.44	379	358	326	279	244	164
C710I	0.55	488	442	392	321	274	179
C710O	0.55	384	364	334	286	254	167
C711O	0.16	165	156	147	134	125	109
C712I	0.23	283	261	239	210	190	148
C712O	0.23	223	208	196	178	162	129
C713O	0.11	142	129	115	93	76	47
C714	0.39	445	413	375	316	271	190
C716O	1.13	605	575	545	491	451	327
C717	1.41	986	904	810	676	563	386
C718	1.86	1314	1166	1012	832	691	462
C721O	0.34	243	226	203	175	156	113
C722	1.29	1462	1274	1076	820	639	378
C727	0.71	1023	878	737	556	419	220

Table 3-30
Summary of results for the 6-hour storm with future watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S100	0.57	765	612	462	301	208	93
S101	0.63	1034	828	621	390	255	97
S102	0.45	701	565	432	290	204	97
S103	0.40	521	413	307	194	129	58
S104	0.90	1359	1104	859	554	367	160
S105	0.59	712	570	428	273	183	83
S106	0.57	862	687	513	314	204	78
S107	0.94	1153	912	670	385	220	73
S200	0.96	1379	1110	851	566	391	184
S201	0.35	603	490	378	258	181	83
S202	0.13	274	230	181	126	89	41
S203	0.37	468	161	287	195	138	65
S204	0.95	1126	894	673	439	296	146
S205	0.41	784	648	513	351	251	124
S206	0.85	878	701	526	337	228	120
S207	0.96	1007	804	609	398	273	150
S208	1.10	1064	643	647	413	310	179
S209	0.65	1011	810	607	380	251	99
S210	0.48	855	681	512	311	197	69
S211	0.49	808	648	479	292	188	69
S300	0.62	1195	988	773	525	366	170
S301	0.99	1883	1570	1253	873	625	317
S302	0.47	936	768	597	405	285	130
S303	0.71	1024	809	592	358	226	82
S304	0.82	1080	856	634	372	224	74
S400	1.05	1999	1689	1371	971	694	348
S401	0.65	1316	1085	843	547	358	142
S402	0.74	1696	1427	1164	831	593	299
S403	0.56	1440	1234	1031	779	593	338
S404	0.26	672	565	453	318	219	96
S500	1.05	1236	1001	765	509	355	174
S501	0.61	1118	916	703	463	319	140
S502	0.40	819	663	513	340	113	98
S503	0.99	1459	1190	919	602	410	189

Table 3-30 (continued)
Summary of results for the 6-hour storm with future watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S504	0.33	513	420	324	218	154	75
S505	0.14	395	336	272	192	135	58
S506	0.15	394	333	274	198	144	73
S507	0.67	1460	1216	963	653	434	180
S508	0.29	786	667	537	383	273	127
S509	0.17	520	448	372	279	215	111
S510	0.13	329	284	237	180	139	80
S511	0.38	1018	856	699	505	364	177
S512	0.21	536	458	383	292	227	135
S513	0.78	1317	1090	848	551	364	155
S514	0.65	1427	1226	1014	748	562	301
S515	1.10	2390	2060	1734	1319	1015	574
S516	0.54	1115	934	758	539	397	217
S600	2.02	1843	1415	1003	558	345	195
S601	0.90	1460	1215	965	673	482	251
S602	1.88	1882	1505	1136	717	473	270
S603	0.67	1467	1229	994	708	518	268
S604	2.66	1924	1526	1137	755	547	338
S605	1.09	1250	1000	759	497	340	170
S606	0.66	910	735	563	380	267	124
S607	0.82	952	772	592	391	272	129
S608	0.51	1072	896	716	497	360	182
S609	0.56	622	489	368	243	164	68
S610	0.60	952	780	611	417	298	152
S611	0.57	1068	873	679	465	326	153
S612	0.81	1082	889	706	480	331	163
S613	1.80	1854	1499	1151	747	508	298
S614	1.08	1126	900	684	443	303	174
S615	1.05	1313	1095	878	619	451	268
S616	0.50	803	648	492	318	218	95
S617	0.68	1206	976	746	488	332	144
S618	0.96	1055	838	626	389	253	127
S619	0.83	1395	1163	928	641	455	231
S620	0.44	613	502	395	267	190	97
S621	0.92	1493	1197	890	528	312	94

Table 3-30 (continued)
Summary of results for the 6-hour storm with future watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S622	0.90	806	614	429	241	171	77
S700	0.61	1197	985	760	491	317	119
S701	0.72	740	590	440	272	175	78
S702	0.26	556	463	372	255	178	84
S703	0.26	451	365	271	167	105	35
S704	0.41	945	787	617	408	275	110
S705	0.75	1657	1402	1153	838	617	320
S705AF	0.18	351	295	240	171	123	57
S706	0.71	1656	1419	1161	842	613	323
S707	0.64	1524	1310	1088	812	617	356
S708	0.71	1828	1575	1326	991	758	399
S709	0.44	1142	984	818	622	482	271
S710	0.11	369	337	290	230	186	120
S711	0.16	565	516	446	361	297	202
S712	0.07	238	230	201	163	135	93
S713	0.11	362	338	290	233	193	128
S714	0.06	188	166	140	105	81	44
S715	0.22	510	436	357	268	201	106
S716	1.13	2132	1844	1528	1153	876	490
S717	0.29	936	822	701	553	445	282
S718	0.44	586	490	396	284	205	90
S719	0.15	329	284	234	177	137	79
S720	0.37	935	805	666	508	391	223
S721	0.34	1140	1003	856	680	553	354
S722	0.95	1779	1518	1251	925	692	368
S723	0.09	279	246	211	167	134	89
S724	1.16	2345	2035	1734	1342	1071	679
S725	1.16	1780	1518	1264	950	732	428
S726	0.33	1036	888	746	569	436	227
S727	0.38	736	628	521	391	302	179
S728	0.28	496	416	335	236	172	94

Table 3-31
Summary of results for the 24-hour storm with future watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S100	0.57	522	425	329	213	140	52
S101	0.63	717	581	449	284	178	51
S102	0.45	470	383	299	196	130	52
S103	0.40	348	280	216	137	70	31
S104	0.90	1040	853	674	452	309	117
S105	0.59	507	408	317	207	139	52
S106	0.57	602	487	374	238	150	42
S107	0.94	918	737	560	344	132	43
S200	0.96	1067	873	675	438	286	127
S201	0.35	387	316	245	158	103	46
S202	0.13	159	133	106	72	49	21
S203	0.37	321	259	201	130	86	38
S204	0.95	880	710	543	342	217	95
S205	0.41	497	417	336	229	159	67
S206	0.85	671	544	421	274	182	81
S207	0.96	787	639	494	318	209	101
S208	1.10	849	688	537	357	260	132
S209	0.65	704	573	443	283	180	54
S210	0.48	561	457	348	215	130	28
S211	0.49	542	438	333	208	128	32
S300	0.62	790	664	533	366	246	98
S301	0.99	1413	1196	971	691	492	229
S302	0.47	588	489	386	256	170	66
S303	0.71	733	589	443	269	159	37
S304	0.82	844	682	519	321	197	48
S400	1.05	1533	1315	1088	367	582	278
S401	0.65	886	742	599	404	267	83
S402	0.74	1152	985	815	597	447	210
S403	0.56	906	788	670	517	413	254
S404	0.26	394	335	276	197	143	56
S500	1.05	1007	823	639	419	281	116
S501	0.61	761	633	499	324	211	77
S502	0.40	500	418	328	212	137	46
S503	0.99	1178	968	762	507	344	110

Table 3-31 (continued)
Summary of results for the 24-hour storm with future watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S504	0.33	343	285	225	149	101	42
S505	0.14	210	177	142	98	67	23
S506	0.15	225	194	159	117	87	42
S507	0.67	967	822	669	476	334	121
S508	0.29	446	379	311	223	161	69
S509	0.17	281	241	200	147	109	52
S510	0.13	197	172	147	113	90	56
S511	0.38	588	501	413	299	221	102
S512	0.21	332	289	245	191	154	99
S513	0.78	966	813	657	449	303	108
S514	0.65	971	837	706	538	423	246
S515	1.10	1868	1634	1393	1082	869	531
S516	0.54	725	619	511	376	277	139
S600	2.02	1804	1426	1057	615	349	147
S601	0.90	1116	935	753	530	383	185
S602	1.88	1738	1411	1092	702	457	211
S603	0.67	972	355	688	499	364	174
S604	2.66	1851	1493	1144	736	535	288
S605	1.09	1008	820	635	409	267	117
S606	0.66	651	530	412	270	178	76
S607	0.82	720	588	463	311	212	91
S608	0.51	683	579	474	333	238	109
S609	0.56	429	342	257	157	96	39
S610	0.60	678	563	446	306	215	98
S611	0.57	699	578	451	297	197	85
S612	0.81	832	691	277	383	276	128
S613	1.80	1643	1354	1061	708	482	242
S614	1.08	900	733	568	370	228	121
S615	1.05	1027	860	696	500	372	209
S616	0.50	530	433	337	221	145	51
S617	0.68	858	707	552	364	133	84
S618	0.96	820	665	514	332	217	85
S619	0.83	1040	871	704	500	364	175
S620	0.44	414	342	273	189	135	63
S621	0.92	1141	928	713	443	267	53

Table 3-31 (continued)
Summary of results for the 24-hour storm with future watershed conditions by subbasin

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S622	0.90	625	492	362	210	134	36
S700	0.61	778	648	519	351	232	65
S701	0.72	558	447	343	221	145	52
S702	0.26	331	280	227	163	117	48
S703	0.26	278	229	178	109	65	11
S704	0.41	554	466	373	253	170	51
S705	0.75	1141	984	825	617	478	257
S705AF	0.18	237	203	168	123	93	48
S706	0.71	1103	945	788	584	445	232
S707	0.64	981	854	721	549	433	258
S708	0.71	1222	1068	908	700	557	330
S709	0.44	715	624	534	418	338	213
S710	0.11	214	190	164	130	107	70
S711	0.16	318	282	246	200	167	114
S712	0.07	135	120	105	85	71	49
S713	0.11	210	187	163	131	108	72
S714	0.06	107	94	79	60	46	24
S715	0.22	330	287	244	188	150	87
S716	1.13	1733	1514	1286	988	775	460
S717	0.29	535	473	410	328	270	180
S718	0.44	408	346	285	210	159	88
S719	0.15	209	183	157	122	99	64
S720	0.37	581	506	431	337	272	172
S721	0.34	638	564	488	388	317	208
S722	0.95	1392	1210	1017	768	594	336
S723	0.09	160	141	122	98	80	53
S724	1.16	1877	1643	1412	1119	913	594
S725	1.16	1467	1256	1045	783	610	368
S726	0.33	569	493	411	305	231	116
S727	0.38	489	424	360	276	216	133
S728	0.28	324	278	230	166	122	62

Table 3-32
Summary of results for the 6-hour storm with future watershed conditions with retention by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C102	2.05	1954	1530	1093	561	299	84
C102L	0.84	1026	776	541	287	146	48
C102R	1.20	1201	956	715	443	256	79
C103	3.54	2813	2164	1511	823	386	83
C103R	2.95	2476	1912	1336	712	390	83
C104	4.11	2920	2244	1569	807	347	72
C105	12.75	6310	4468	3169	1634	822	393
C105L	5.05	3135	2380	1627	806	347	75
C105R	7.70	4258	2944	2135	1210	704	369
C201	1.31	1669	1354	1033	682	467	225
C203	2.76	2648	1879	1558	885	580	308
C203R	1.81	1965	1327	1145	661	455	223
C204	3.17	2978	2139	1676	992	579	308
C205	4.98	3909	2753	1923	1073	556	300
C205L	4.03	3352	2305	1634	965	559	300
C206	6.09	4238	2955	2146	1219	670	354
C207	7.22	4306	2977	2167	1226	704	371
C207R	6.74	4311	2988	2174	1234	701	370
C300	1.61	2161	1569	1027	505	153	0
C301	2.07	2499	1764	1147	558	186	22
C302	2.78	2651	1956	1311	608	160	31
C303	3.60	2848	1911	1371	971	151	348
C400O	1.05	478	528	358	171	23	0
C401	1.69	761	832	380	142	21	0
C402	2.43	926	861	361	105	11	0
C403	2.99	868	826	354	100	25	0
C404	3.26	845	809	333	176	109	9
C501	1.67	1390	925	540	164	61	0
C502I	3.07	2069	1514	920	429	205	0
C502L	2.07	1485	953	544	150	34	0
C502O	3.07	1832	1383	914	407	183	0
C503O	0.14	98	93	88	81	71	32
C504O	0.15	92	86	77	61	45	0
C505	4.35	2025	1404	857	307	106	2

Table 3-32 (continued)
Summary of results for the 6-hour storm with future watershed conditions with retention by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C505L	3.39	1863	1293	828	297	113	0
C505R	0.96	682	436	207	105	67	24
C506O	0.17	93	89	86	76	69	7
C507O	0.38	96	92	85	73	44	36
C508	0.90	571	402	275	108	67	36
C508L	0.60	354	249	158	61	36	36
C508R	0.30	326	255	177	76	67	4
C509	6.32	2295	1501	751	232	61	36
C509L	4.65	1970	1306	714	254	75	0
C509R	1.67	645	446	248	62	36	36
C510	6.97	2327	1490	743	214	58	36
C511	8.07	2244	1465	714	195	46	36
C512	8.61	2187	1299	671	165	36	36
C601	2.92	2625	2056	1493	856	539	330
C602	5.47	4393	3455	2500	1466	984	610
C602L	3.58	3040	2378	1716	964	670	404
C603	9.87	6527	5096	3665	2258	1577	996
C603L	6.13	4628	3629	2620	1550	1036	624
C604	11.25	7002	5469	3935	2382	1604	998
C604R	10.43	6593	5149	3696	2234	1510	939
C605	11.76	7106	5561	3999	2421	1638	1027
C606	13.17	7469	5862	4231	2557	1758	1101
C606L	12.36	7174	5632	4058	2451	1672	1050
C608	15.53	8609	6783	4919	2977	2092	1311
C609	16.61	8945	7057	5107	3096	2188	1373
C611	18.85	9478	7489	5409	3296	2356	1455
C611L	1.56	1581	1299	1033	726	462	257
C611R	17.29	8839	6964	5022	3041	2152	1339
C613	21.08	10151	7985	5772	3549	2568	1560
C613L	1.27	1716	1435	1141	781	555	264
C613R	19.81	9675	7617	5509	3355	2398	1468
C614	22.00	10093	7925	5729	3532	2549	1536
C615	22.90	10130	7910	5720	3521	2526	1507
C705	1.16	1853	1549	1244	868	595	289
C705AF	1.34	954	871	779	635	487	241

Table 3-32 (continued)
Summary of results for the 6-hour storm with future watershed conditions with retention by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C705O	1.16	783	723	654	544	437	241
C709O	0.44	387	355	298	210	112	0
C710I	0.55	440	367	304	210	122	0
C710O	0.55	362	321	269	182	97	0
C711O	0.16	163	150	134	112	10	0
C712I	0.23	321	266	200	115	12	0
C712O	0.23	205	175	148	92	9	0
C713O	0.11	173	158	135	101	71	27
C714	0.39	428	392	299	188	118	45
C716O	1.13	540	487	398	197	0	0
C717	1.41	692	610	522	414	327	104
C718	1.86	1000	832	689	420	216	38
C721O	0.34	183	146	93	0	0	0
C722	1.29	1505	1108	709	196	0	0
C727	0.71	915	566	296	40	0	0

Table 3-33
Summary of results for the 24-hour storm with future watershed conditions with retention by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C102	2.05	1706	1365	1006	550	303	78
C102L	0.84	774	615	440	238	103	30
C102R	1.20	974	800	620	390	242	62
C103	3.54	2623	2067	1515	915	477	74
C103R	2.95	2256	1785	1305	751	426	74
C104	4.11	2779	2194	1627	943	477	86
C105	12.75	6906	5188	3822	2326	1226	404
C105L	5.05	3028	2374	1760	992	530	96
C105R	7.70	4515	3369	2447	1535	853	364
C201	1.31	1396	1133	874	569	369	166
C203	2.76	2592	2099	1597	917	588	270
C203R	1.81	1753	1420	1080	591	385	178
C204	3.17	2923	2360	1753	1039	607	269
C205	4.98	4167	3150	2130	1301	756	265
C205L	4.03	3425	2589	1697	1016	592	265
C206	6.09	4439	3340	2375	1477	836	335
C207	7.22	4546	3409	2450	1535	857	361
C207R	6.74	4520	3399	2438	1525	855	355
C300	1.61	2047	1411	961	582	206	4
C301	2.07	2352	1671	1145	665	214	27
C302	2.78	2587	1968	1397	736	254	35
C303	3.60	2837	2182	1450	682	245	34
C400O	1.05	442	400	318	97	15	0
C401	1.69	588	453	340	92	15	0
C402	2.43	836	498	341	85	13	0
C403	2.99	752	480	347	80	12	0
C404	3.26	761	470	340	191	137	27
C501	1.67	1236	865	557	216	41	0
C502I	3.07	2089	1531	967	484	271	11
C502L	2.07	1395	937	583	214	28	0
C502O	3.07	1799	1378	952	465	241	11
C503O	0.14	89	86	80	70	57	7
C504O	0.15	82	75	67	52	20	0
C505	4.35	2106	1498	961	422	171	4
C505L	3.39	1874	1303	861	355	153	1

Table 3-33 (continued)
Summary of results for the 24-hour storm with future watershed conditions with retention by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C505R	0.96	487	256	134	83	38	5
C506O	0.17	88	85	79	70	51	1
C507O	0.38	91	86	81	62	36	36
C508	0.90	458	349	249	92	46	36
C508L	0.60	240	188	142	46	36	36
C508R	0.30	219	173	110	69	46	1
C509	6.32	2421	1651	938	361	138	36
C509L	4.65	2038	1449	867	353	135	0
C509R	1.67	523	338	200	48	36	36
C510	6.97	2491	1681	950	357	133	36
C511	8.07	2461	1669	940	323	121	36
C512	8.61	2412	1568	903	288	98	36
C601	2.92	2675	2150	1618	990	588	293
C602	5.47	4738	3603	2904	1766	1111	568
C602L	3.58	3089	2289	1873	1117	686	369
C603	9.87	7300	5609	4426	2757	1827	934
C603L	6.13	4958	3754	3016	1855	1172	579
C604	11.25	7810	6021	4763	2954	1924	940
C604R	10.43	7364	5667	4474	2772	1805	875
C605	11.76	7917	6094	4843	2993	1946	972
C606	13.17	8257	6375	5127	3142	2057	1059
C606L	12.36	7965	6147	4906	3024	1971	999
C608	15.53	9506	7340	5953	3644	2443	1270
C609	16.61	9888	7635	6212	3791	2565	1329
C611	18.85	10486	8112	6581	4043	2818	1433
C611L	1.56	1264	1054	857	616	437	205
C611R	17.29	9766	7550	6116	3739	2570	1304
C613	21.08	11221	8647	7033	4350	3066	1562
C613L	1.27	1389	1152	929	652	475	220
C613R	19.81	10719	8284	6728	4130	2882	1453
C614	22.00	11179	8592	6997	4318	3052	1541
C615	22.90	11320	8674	7068	4349	3067	1513
C705	1.16	1480	1254	1022	714	490	269
C705AF	1.34	841	775	697	561	419	207
C705O	1.16	699	647	587	479	390	209

Table 3-33 (continued)
Summary of results for the 24-hour storm with future watershed conditions with retention by concentration point

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
C709O	0.44	330	286	235	139	66	0
C710I	0.55	371	319	258	148	66	0
C710O	0.55	324	279	231	131	61	0
C711O	0.16	143	130	117	40	2	0
C712I	0.23	246	183	135	47	2	0
C712O	0.23	177	145	118	42	2	0
C713O	0.11	133	117	96	64	43	13
C714	0.39	358	280	197	105	71	24
C716O	1.13	493	433	329	123	0	0
C717	1.41	580	482	407	325	267	82
C718	1.86	878	714	580	306	172	28
C721O	0.34	138	99	53	6	0	0
C722	1.29	1195	864	510	92	0	0
C727	0.71	707	415	208	22	0	0

Table 3-34
Summary of results for the 6-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S100	0.57	765	612	462	301	208	93
S100O	0.57	765	612	462	301	208	83
S101	0.63	1034	828	621	390	255	97
S102	0.45	701	565	432	290	204	97
S102O	0.45	701	565	419	247	132	0
S103	0.40	521	413	307	194	129	58
S104	0.90	1359	1104	859	554	367	160
S104O	0.90	1359	1104	859	509	248	51
S105	0.59	712	570	428	273	183	83
S105O	0.59	712	566	407	222	121	11
S106	0.57	862	687	513	314	204	78
S107	0.94	1153	912	670	385	220	73
S200	0.96	1379	1110	851	566	391	184
S201	0.35	603	490	378	258	181	83
S202	0.13	274	230	181	126	89	41
S203	0.37	468	161	287	195	138	65
S203O	0.37	463	147	245	127	54	0
S204	0.95	1126	894	673	439	296	146
S204O	0.95	1126	894	673	439	296	146
S205	0.41	784	648	513	351	251	124
S205O	0.41	784	648	498	282	142	0
S206	0.85	878	701	526	337	228	120
S206O	0.85	755	519	277	93	5	0
S207	0.96	1007	804	609	398	273	150
S207O	0.96	1007	804	609	379	205	61
S208	1.10	1064	643	647	413	310	179
S208O	1.10	1064	643	647	413	310	142
S209	0.65	1011	810	607	380	251	99
S210	0.48	855	681	512	311	197	69
S211	0.49	808	648	479	292	188	69
S300	0.62	1195	988	773	525	366	170
S300O	0.62	1016	762	480	129	0	0
S301	0.99	1883	1570	1253	873	625	317
S301O	0.99	1883	1570	1161	538	286	0

Table 3-34 (continued)
Summary of results for the 6-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S302	0.47	936	768	597	405	285	130
S302O	0.47	936	768	597	405	285	90
S303	0.71	1024	809	592	358	226	82
S304	0.82	1080	856	634	372	224	74
S304O	0.82	931	601	337	78	0	0
S400	1.05	1999	1689	928	302	694	0
S400O	0.82	1937	0	3459	1741	51	400
S401	0.65	1316	1085	843	547	358	142
S401O	0.65	1002	668	344	0	0	0
S402	0.74	1696	1427	1164	831	593	299
S402O	0.74	1191	864	420	0	0	0
S403	0.56	1440	1234	1031	779	593	338
S403O	0.56	1022	684	300	0	0	0
S404	0.26	672	565	453	318	219	96
S404O	0.26	672	565	453	318	219	83
S500	1.05	1236	1001	765	509	355	174
S500O	1.05	1186	894	576	206	81	0
S501	0.61	1118	916	703	463	319	140
S501O	0.61	1083	798	526	247	67	0
S502	0.40	819	663	513	340	113	98
S502O	0.40	819	663	474	234	46	0
S503	0.99	1459	1190	919	602	410	189
S503O	0.99	1459	1190	919	547	256	51
S504	0.33	513	420	324	218	154	75
S504O	0.33	283	142	25	0	0	0
S505	0.14	395	336	272	192	135	58
S505O	0.14	395	336	272	192	135	51
S506	0.15	394	333	274	198	144	73
S506O	0.15	394	333	267	146	55	0
S507	0.67	1460	1216	963	653	434	180
S507O	0.67	912	579	163	0	0	0
S508	0.29	786	667	537	383	273	127
S508O	0.29	604	353	127	0	0	0
S509	0.17	520	448	372	279	215	111

Table 3-34 (continued)
Summary of results for the 6-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S509O	0.17	520	448	372	279	184	13
S510	0.13	329	284	237	180	139	80
S510O	0.13	261	176	92	0	0	0
S511	0.38	1018	856	699	505	364	177
S511O	0.38	1018	848	613	285	66	0
S512	0.21	536	458	383	292	227	135
S512O	0.21	395	274	133	0	0	0
S513	0.78	1317	1090	848	551	364	155
S513O	0.78	692	360	67	0	0	0
S514	0.65	1427	1226	1014	748	562	301
S514O	0.65	1002	697	346	0	0	0
S515	1.10	2390	2060	1734	1319	1015	574
S515O	1.10	1871	1339	662	91	0	0
S516	0.54	1115	934	758	539	397	217
S516O	0.54	906	644	341	47	0	0
S600	2.02	1843	1415	1003	558	345	195
S601	0.90	1460	1215	965	673	482	251
S602	1.88	1882	1505	1136	717	473	270
S603	0.67	1467	1229	994	708	518	268
S604	2.66	1924	1526	1137	755	547	338
S605	1.09	1250	1000	759	497	340	170
S606	0.66	910	735	563	380	267	124
S607	0.82	952	772	592	391	272	129
S607O	0.82	952	772	592	391	272	129
S608	0.51	1072	896	716	497	360	182
S608O	0.51	1072	896	716	497	359	160
S609	0.56	622	489	368	243	164	68
S609O	0.56	622	489	368	229	141	32
S610	0.60	952	780	611	417	298	152
S611	0.57	1068	873	679	465	326	153
S612	0.81	1082	889	706	480	331	163
S613	1.8	1854	1499	1151	747	508	298
S614	1.08	1126	900	684	443	303	174
S615	1.05	1313	1095	878	619	451	268

Table 3-34 (continued)
Summary of results for the 6-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S616	0.5	803	648	492	318	218	95
S616O	0.5	803	648	490	275	151	13
S617	0.68	1206	976	746	488	332	144
S618	0.96	1055	838	626	389	253	127
S619	0.83	1395	1163	928	641	455	231
S620	0.44	613	502	395	267	190	97
S621	0.92	1493	1197	890	528	312	94
S622	0.90	806	614	429	241	171	77
S700	0.61	1197	985	760	491	317	119
S701	0.72	740	590	440	272	175	78
S701O	0.72	740	590	440	272	175	78
S702	0.26	556	463	372	255	178	84
S702O	0.26	451	291	139	0	0	0
S703	0.26	740	365	271	167	105	35
S703O	0.26	451	365	262	129	56	0
S704	0.41	945	787	617	408	275	110
S705	0.75	1657	1402	1153	838	617	320
S705AF	0.18	351	295	240	171	123	57
705AFO	0.18	351	295	239	155	90	7
S706	0.71	1656	1419	1161	842	613	323
S706O	0.71	1253	913	460	22	0	0
S707	0.64	1524	1310	1088	812	617	356
S707O	0.64	1128	764	448	31	0	0
S708	0.71	1828	1575	1326	991	758	399
S708O	0.71	1708	1191	853	310	0	0
S709	0.44	1142	984	818	622	482	271
S709O	0.44	1142	975	751	468	236	0
S710	0.11	369	337	290	230	186	120
S710O	0.11	369	337	290	219	133	0
S711	0.16	565	516	446	361	297	202
S711O	0.16	565	516	394	187	12	0
S712	0.07	238	230	201	163	135	93
S712O	0.07	238	230	201	111	14	0
S713	0.11	362	338	290	233	193	128

Table 3-34 (continued)
Summary of results for the 6-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S713O	0.11	362	338	290	233	193	93
S714	0.06	188	166	140	105	81	44
S715	0.22	510	436	357	268	201	106
S715O	0.22	510	436	357	268	199	87
S716	1.13	2132	1844	1528	1153	876	490
S716O	1.13	1865	1419	885	260	0	0
S717	0.29	936	822	701	553	445	282
S717O	0.29	936	822	701	553	445	181
S718	0.44	586	490	396	284	205	90
S718O	0.44	586	490	393	261	158	34
S719	0.15	329	284	234	177	137	79
S719O	0.15	320	259	194	111	52	0
S720	0.37	935	805	666	508	391	223
S720O	0.37	911	709	499	245	42	0
S721	0.34	1140	1003	856	680	553	354
S721O	0.34	1091	715	365	0	0	0
S722	0.95	1779	1518	1251	925	692	368
S722O	0.95	1576	1129	700	203	0	0
S723	0.09	279	246	211	167	134	89
S723O	0.09	279	246	211	133	66	0
S724	1.16	2345	2035	1734	1342	1071	679
S724O	1.16	1970	1389	855	199	0	0
S725	1.16	1780	1518	1264	950	732	428
S725O	1.16	1253	826	427	18	0	0
S726	0.33	1036	888	746	569	436	227
S726O	0.33	999	786	398	15	0	0
S727	0.38	736	628	521	391	302	179
S727O	0.38	590	410	230	44	0	0
S728	0.28	496	416	335	236	172	94
S728O	0.28	453	340	215	76	4	0

Table 3-35
Summary of results for the 24-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S100	0.57	522	425	329	213	140	52
S100O	0.57	522	425	329	213	140	47
S101	0.63	717	581	449	284	178	51
S102	0.45	470	383	299	196	130	52
S102O	0.45	470	383	297	164	69	0
S103	0.40	348	280	216	137	70	31
S104	0.90	1040	853	674	452	309	117
S104O	0.90	1040	853	674	452	262	10
S105	0.59	507	408	317	207	139	52
S105O	0.59	507	408	313	182	89	0
S106	0.57	602	487	374	238	150	42
S107	0.94	918	737	560	344	132	43
S200	0.96	1067	873	675	438	286	127
S201	0.35	387	316	245	158	103	46
S202	0.13	159	133	106	72	49	21
S203	0.37	321	259	201	130	86	38
S203O	0.37	321	249	175	79	24	0
S204	0.95	880	710	543	342	217	95
S204O	0.95	880	710	543	342	217	95
S205	0.41	497	417	336	229	159	67
S205O	0.41	497	417	336	183	80	0
S206	0.85	671	544	421	274	182	81
S206O	0.85	614	443	270	72	4	0
S207	0.96	787	639	494	318	209	101
S207O	0.96	787	639	494	318	199	49
S208	1.10	849	688	537	357	260	132
S208O	1.10	849	688	537	357	260	128
S209	0.65	704	573	443	283	180	54
S210	0.48	561	457	348	215	130	28
S211	0.49	542	438	333	208	128	32
S300	0.62	790	664	533	366	246	98
S300O	0.62	762	545	322	40	0	0
S301	0.99	1413	1196	971	691	492	229
S301O	0.99	1413	1196	971	588	256	5
S302	0.47	588	489	386	256	170	66
S302O	0.47	588	489	386	256	170	31
S303	0.71	733	589	443	269	159	37
S304	0.82	844	682	519	321	197	48

Table 3-35 (continued)
Summary of results for the 24-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S304O	0.82	713	458	227	1	0	0
S400	1.05	1533	1315	1088	367	582	278
S400O	1.05	1533	1301	864	139	20	0
S401	0.65	886	742	599	404	267	83
S401O	0.65	658	351	75	0	0	0
S402	0.74	1152	985	815	597	447	210
S402O	0.74	941	540	183	6	0	0
S403	0.56	906	788	670	517	413	254
S403O	0.56	595	326	88	0	0	0
S404	0.26	394	335	276	197	143	56
S404O	0.26	394	335	276	197	143	33
S500	1.05	1007	823	639	419	281	116
S500O	1.05	1007	787	542	227	58	0
S501	0.61	761	633	499	324	211	77
S501O	0.61	761	612	403	129	6	0
S502	0.40	500	418	328	212	137	46
S502O	0.40	500	418	316	128	18	0
S503	0.99	1178	968	762	507	344	110
S503O	0.99	1178	968	762	505	290	16
S504	0.33	343	285	225	149	101	42
S504O	0.33	144	56	6	0	0	0
S505	0.14	210	177	142	98	67	23
S505O	0.14	210	177	142	98	67	10
S506	0.15	225	194	159	117	87	42
S506O	0.15	225	194	159	78	22	0
S507	0.67	967	822	669	476	334	121
S507O	0.67	444	140	0	0	0	0
S508	0.29	446	379	311	223	161	69
S508O	0.29	264	100	5	0	0	0
S509	0.17	281	241	200	147	109	52
S509O	0.17	281	241	200	147	91	1
S510	0.13	197	172	147	113	90	56
S510O	0.13	137	88	36	2	0	0
S511	0.38	588	501	413	299	221	102
S511O	0.38	588	497	372	135	8	0
S512	0.21	332	289	245	191	154	99
S512O	0.21	240	143	66	3	0	0
S513	0.78	966	813	657	449	303	108

Table 3-35 (continued)
Summary of results for the 24-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S513O	0.78	401	98	0	0	0	0
S514	0.65	971	837	706	538	423	246
S514O	0.65	662	414	158	0	0	0
S515	1.10	1868	1634	1393	1082	869	531
S515O	1.10	1554	1019	479	12	0	0
S516	0.54	725	619	511	376	277	139
S516O	0.54	602	406	208	18	0	0
S600	2.02	1804	1426	1057	615	349	147
S601	0.90	1116	935	753	530	383	185
S602	1.88	1738	1411	1092	702	457	211
S603	0.67	972	355	688	499	364	174
S604	2.66	1851	1493	1144	736	535	288
S605	1.09	1008	820	635	409	267	117
S606	0.66	651	530	412	270	178	76
S607	0.82	720	588	463	311	212	91
S607O	0.82	720	588	463	311	212	91
S608	0.51	683	579	474	333	238	109
S608O	0.51	683	579	474	333	238	92
S609	0.56	429	342	257	157	96	39
S609O	0.56	429	342	257	157	84	14
S610	0.60	678	563	446	306	215	98
S611	0.57	699	578	451	297	197	85
S612	0.81	832	691	277	383	276	128
S613	1.80	1643	1354	1061	708	482	242
S614	1.08	900	733	568	370	228	121
S615	1.05	1027	860	696	500	372	209
S616	0.50	530	433	337	221	145	51
S616O	0.50	530	433	337	194	88	0
S617	0.68	858	707	552	364	133	84
S618	0.96	820	665	514	332	217	85
S619	0.83	1040	871	704	500	364	175
S620	0.44	414	342	273	189	135	63
S621	0.92	1141	928	713	443	267	53
S622	0.90	625	492	362	210	134	36
S700	0.61	778	648	519	351	232	65
S701	0.72	558	447	343	221	145	52
S701O	0.72	558	447	343	221	145	52
S702	0.26	331	280	227	163	117	48
S702O	0.26	217	126	37	0	0	0

Table 3-35 (continued)
Summary of results for the 24-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S703	0.26	278	229	178	109	65	11
S703O	0.26	278	229	176	71	9	0
S704	0.41	554	466	373	253	170	51
S705	0.75	1141	984	825	617	478	257
S705AF	0.18	237	203	168	123	93	48
705AFO	0.18	237	203	163	100	56	0
S706	0.71	1103	945	788	584	445	232
S706O	0.71	914	590	258	13	0	0
S707	0.64	981	854	721	549	433	258
S707O	0.64	771	536	256	18	0	0
S708	0.71	1222	1068	908	700	557	330
S708O	0.71	1141	781	450	16	0	0
S709	0.44	715	624	534	418	338	213
S709O	0.44	715	624	489	254	113	0
S710	0.11	214	190	164	130	107	70
S710O	0.11	214	190	164	116	49	0
S711	0.16	318	282	246	200	167	114
S711O	0.16	318	282	226	48	2	0
S712	0.07	135	120	105	85	71	49
S712O	0.07	135	120	100	18	0	0
S713	0.11	210	187	163	131	108	72
S713O	0.11	210	187	163	131	108	41
S714	0.06	107	94	79	60	46	24
S715	0.22	330	287	244	188	150	87
S715O	0.22	330	287	244	188	150	66
S716	1.13	1733	1514	1286	988	775	460
S716O	1.13	1534	1113	661	138	0	0
S717	0.29	535	473	410	328	270	180
S717O	0.29	535	473	410	328	269	90
S718	0.44	408	346	285	210	159	88
S718O	0.44	408	346	280	185	122	24
S719	0.15	209	183	157	122	99	64
S719O	0.15	209	176	131	74	36	0
S720	0.37	581	506	431	337	272	172
S720O	0.37	570	431	292	113	4	0
S721	0.34	638	564	488	388	317	208
S721O	0.34	568	324	115	8	0	0
S722	0.95	1392	1210	1017	768	594	336
S722O	0.95	1200	894	545	109	0	0

Table 3-35 (continued)
Summary of results for the 24-hour storm with future watershed conditions with retention by subbasin

Note: HEC-1 ID's with the suffix "O" represent the runoff after retention.

HEC-1 ID	Drainage Area sq. miles	Peak Discharges, in cfs					
		100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
S723	0.09	160	141	122	98	80	53
S723O	0.09	160	141	122	66	27	0
S724	1.16	1877	1643	1412	1119	913	594
S724O	1.16	1692	1180	667	147	12	0
S725	1.16	1467	1256	1045	783	610	368
S725O	1.16	1016	663	322	24	0	0
S726	0.33	569	493	411	305	231	116
S726O	0.33	557	396	159	4	0	0
S727	0.38	489	424	360	276	216	133
S727O	0.38	379	270	149	22	0	0
S728	0.28	324	278	230	166	122	62
S728O	0.28	294	223	142	47	5	0

Table 3-36
Summary of Rational Method results for existing watershed conditions

Subbasin ID	Drainage Area acres	Weighted Runoff Coefficient	Peak Discharge, in cfs					
			100-Year	50-Year	25-Year	10-Year	5-Year	2-Year
(1)	(4)	(2)	(5)	(6)	(7)	(8)	(9)	(10)
R100	61.4	0.40	158	194	158	114	97	67
R101	53.9	0.40	198	170	139	103	87	61
R102	64.0	0.40	220	186	146	103	86	60
R103	114.3	0.40	363	307	240	171	139	98
R104	86.1	0.40	282	239	185	132	109	76
R105	26.0	0.40	95	82	67	50	43	32
R106	84.0	0.40	288	244	193	135	113	79
R107	191.7	0.40	427	376	305	238	193	131
R108	196.6	0.40	638	542	422	300	247	173
R109	84.4	0.40	249	212	160	114	92	63
R110	63.1	0.40	231	198	158	114	96	66
R111	151.2	0.44	378	302	235	166	141	91
R112	165.5	0.40	352	296	230	165	141	95
R113	47.8	0.40	152	125	97	69	55	39
R114	145.7	0.40	304	253	196	138	115	71
R115	181.7	0.40	391	325	252	178	150	95
R116	37.1	0.40	135	115	91	65	55	38
R117	16.9	0.40	62	54	44	32	28	21
R118	26.4	0.40	97	84	68	49	42	29
R119	31.0	0.40	114	98	80	59	51	38
R120	58.6	0.40	205	174	137	97	81	57
R121	87.9	0.40	322	275	219	157	133	91
R122	71.1	0.40	217	185	143	102	82	57
R123	31.0	0.40	114	98	80	59	51	37
R124	37.3	0.40	131	112	88	63	52	36
R125	47.5	0.40	174	150	119	86	72	50

Table 3-37
Summary of Rational Method results for <u>future watershed conditions</u>

Subbasin ID (1)	Drainage Area (4)	Weighted Runoff Coefficient (2)	Peak Discharge, in cfs 100-Year (5)	50-Year (6)	25-Year (7)	10-Year (8)	5-Year (9)	2-Year (10)
R100	61.4	0.40	225	194	159	114	97	67
R101	53.9	0.40	198	171	146	103	88	62
R102	64.0	0.43	237	201	158	111	93	65
R103	114.3	0.58	603	520	416	299	252	173
R104	86.1	0.63	496	428	348	251	212	148
R105	26.0	0.70	167	144	117	87	75	56
R106	84.0	0.49	352	298	235	165	139	97
R107	191.7	0.49	630	555	476	369	308	215
R108	196.6	0.44	709	602	468	333	275	192
R109	84.4	0.61	451	382	303	214	179	125
R110	63.1	0.41	235	203	164	118	99	69
R111	151.2	0.59	638	540	402	287	231	159
R112	165.6	0.55	664	564	421	302	244	167
R113	47.8	0.55	241	206	164	118	99	68
R114	145.7	0.55	567	479	358	254	206	141
R115	181.7	0.55	735	624	470	337	273	187
R116	37.1	0.40	135	115	91	65	55	38
R117	16.9	0.40	62	54	44	33	28	21
R118	26.4	0.40	97	84	68	49	42	29
R119	31.0	0.43	123	106	86	64	56	41
R120	58.6	0.49	266	229	186	139	120	85
R121	87.9	0.49	391	337	274	204	177	131
R122	71.1	0.40	217	185	143	102	82	57
R123	31.0	0.59	168	145	118	87	76	56
R124	37.3	0.68	231	199	162	121	104	75
R125	47.5	0.48	208	180	146	109	94	70

3.6.2 Comparison with Previous Studies within the Watershed

Two studies establishing the current FIS peak discharges along Morgan City Wash, Caterpillar Tank Wash and Twin Buttes Wash including tributaries are briefly summarized as follows:

1. Morgan City Wash FDS, FCD 89-15, conducted by Michael Baker Jr, Inc. 1989. Peak discharges were computed for the 100-year, 2-, 6- and 24-hour storms using the SCS Type II rainfall distribution, with rainfall depths for the 6- and 24-hour durations of 3.4 and 4.5 inches, respectively. The SCS dimensionless hydrograph in combination with the initial loss and uniform loss rate method was used for runoff hydrograph development. Runoff hydrographs were routed using the Muskingum method.

2. C.A.P. Overchutes, Agua Fria River Floodplain Delineation Study; Maricopa County, Arizona, FCD 90-09, conducted by AGK Engineers, Inc., 1991. Peak discharges were computed for the 100-year, 6- and 24-hour storms. Rainfall depths of 3.32 and 4.14 inches for the 6- and 24-hour durations, respectively were modeled with the distributions prescribed by the Design Manual. The Clark Unit Hydrograph in combination with the Green and Ampt infiltration equation were used for runoff hydrograph development. Runoff hydrographs were routed using the normal depth option of the Modified Puls channel storage routing method.

The extents of these studies are shown in relation to the NPADMP watershed limits in Figure 3-1. Also shown on this figure are the floodplain limits established as part of those studies. Table 3-38 summarizes and compares the 100-year peak discharges estimated as part of the previous studies to the results of this study at common locations. Column 1of Table 3-38 is the HEC-1 identifier for this study. Column 2 is the corresponding identifier from either the Morgan City Wash FDS or the C.A.P. Overchutes, Agua Fria River FDS. HEC-1 identifiers relating to the Morgan City Wash FDS are within the S600 series alpha-numeric range. The remaining identifiers correspond to the C.A.P. Overchutes, Agua Fria River FDS. In general, the 100-year peak discharges estimated for this study are less than those for the Morgan City Wash study and greater than those for the C.A.P. Overchutes study. The following discussion summarizes reasons for these differences.

Figure 3-1

Watershed Map

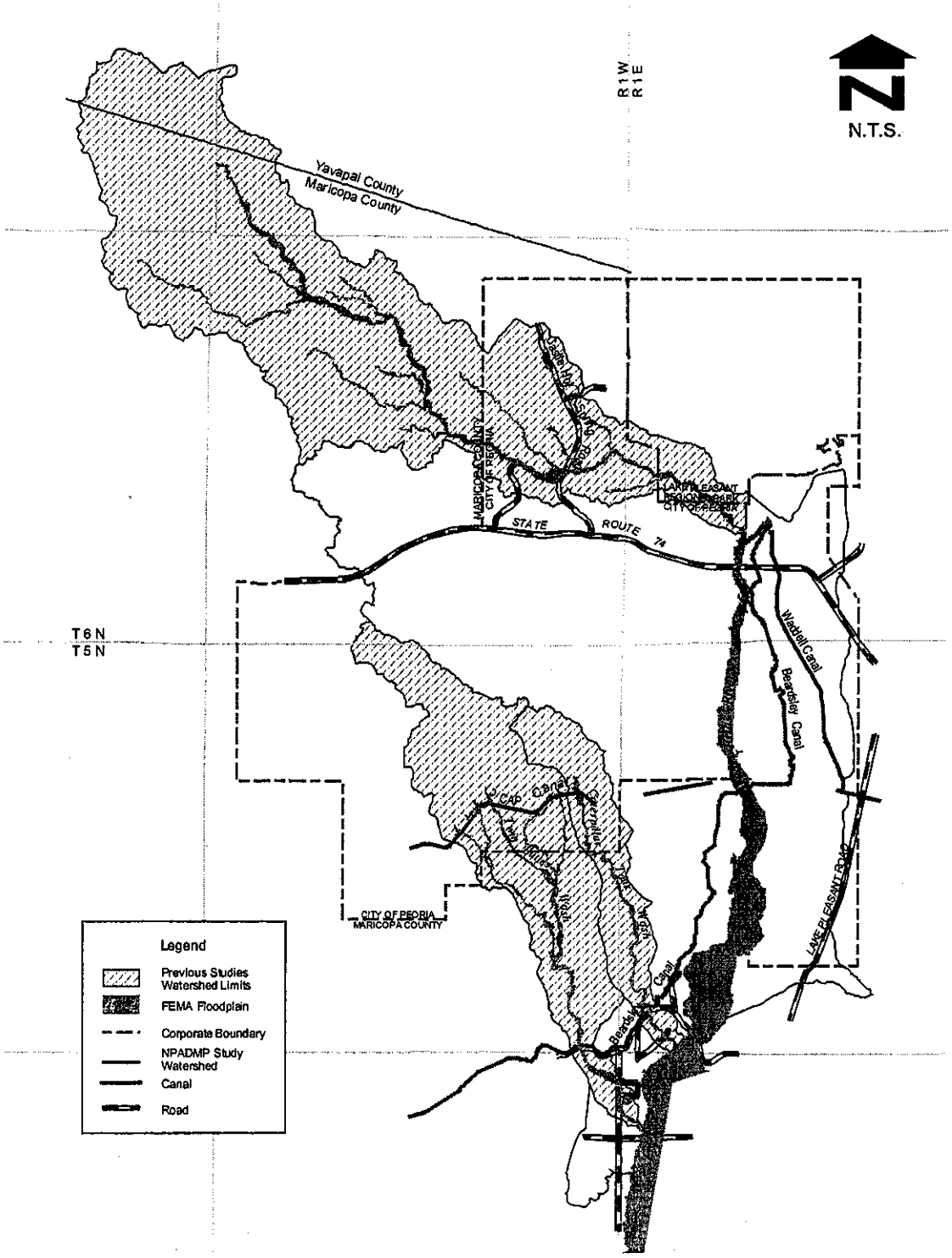


Table 3-38

Comparison with previous studies

HEC-1 ID		100-Year Peak Discharges, in cfs	
This Study (1)	Previous Study (2)	This Study (3)	Previous Study (4)
S400	SA19	1,212	1,446
C400O	EACAP	500	489
C401	EB	913	970
C402	EC	1,292	1,295
C403	ED	1,572	1,375
C404	EE	1,556	1,315
S500	SA01	914	1,176
C501	B	1,250	1,752
C502I	C	2,246	2,659
C502O	CCAP	1,982	2,154
C505	E	2,513	2,462
C509	J	3,191	2,776
C510	K	3,486	2,826
C511	M	3,779	2,779
C512	N	3,775	2,746
S600	M1	1,804	3,173
C602	CO-2	4,746	4,817
C603	CO-4	7,308	10,868
C608	CO-7	9,840	13,863
C611	CO-9	11,048	14,155
C613	CO-11	11,746	14,441
C614	CO-12	11,709	14,168

The reductions in the 100-year peak discharges estimated by this study, as compared to those of the Morgan City Wash study, are due to differences in modeling techniques. The increases in the 100-year peak discharges estimated by this study, as compared to those of the C.A.P. Overchutes FIS, are primarily due to differences in the interpretation of the soils report, particularly in regard to the XKSAT variable. In the previous study, selection of the XKSAT variable is primarily based on the general description of the individual soil map units without consideration for the horizon depth of the separate sub units. For example, soil map unit 45 has a general description of gravelly loam, however, the soil description for the first 10 inches of the horizon is a clay soil.

3.6.3 Conclusion

In general, the modeled results compare favorably to the various indirect verification methods. The results are also considered reasonable in comparison to the two previous studies given the changes in modeling techniques and data interpretation. Therefore, there is no reason to doubt the results of this study.

The purpose of the hydrologic phase of this study is to compute discharges and runoff volumes at key locations in the watershed for floodplain/floodway delineation, alternative analyses and to provide general baseline data for the anticipation of potential flooding problems that can be expected as a result of future development within the watershed.

3.7 Final Modeling Results on Diskette

The CD containing the HEC-1 files for this project is provided in Appendix O. An ASCII text file named README.DOC is included on the CD and summarizes the files and filenames provided.

SECTION 4: HYDRAULIC ANALYSIS

4.1 Method Description

Hydraulic analysis is performed in accordance with the guidelines and specifications set forth in FEMA 37, Flood Insurance Study Guidelines and Specifications for study contractors and State Standards 2-91, Requirement for Floodplain Delineation in Riverine Environmentalists. Detailed floodplain and floodway limits are determined for three separate unnamed watercourses totaling approximately 18 miles. The flooding limits for these watercourses are determined using the COE HEC-RAS Computer Program, version 3.0, dated January 2001. Approximate method floodplains are determined for several unnamed watercourses totaling approximately 18 miles. The flooding limits for these watercourses are based on a normal depth analysis using the Manning's equation. Re-delineation is not performed for the existing Flood Insurance Study limits, Twin Buttes Wash, Caterpillar Wash and Morgan City Wash.

The hydraulic analyses documented in this report are for existing watershed conditions only. Hydraulic analyses for future watershed conditions and related alternative analyses are discussed in the Alternatives Formulation Section of the North Peoria Area Drainage Master Plan Technical Data Notebook (Stantec 2001).

With the exception of Morgan City Wash, Twin Buttes Wash and Caterpillar Tank Wash all of the study watercourses are currently unnamed, therefore arbitrary names are assigned for documentation purposes. The location of these watercourses and the assigned names are shown in Figure 1-3.

Starting water surface elevations for the detailed study reaches of Unnamed Washes 2 and 3 are computed using the normal depth option of HEC-RAS. This method requires the input of the energy slope downstream of the first cross section. The input values for these two watercourses was determined by first running the model with the starting water surface elevation set to critical depth. The resulting slope of the energy grade line for the first three cross sections of each wash were averaged to obtain the input values for the normal depth option. Starting water surface elevations determined utilizing the normal

depth option are compared with water surface elevations associated with the Agua Fria River at the confluence with Unnamed Washes 2 and 3 to determine the most realistic starting water surface elevation. The comparison demonstrated that normal depth calculation is the most realistic. The starting water surface elevation for Unnamed Wash 1 is interpolated from of Unnamed Wash 2 immediately upstream and downstream of the confluence with Unnamed Wash 1.

Floodway limits are initially determined using the Method 4, equal conveyance encroachment option of HEC-RAS. Those floodway limits are converted to the Method 1 encroachment option and refined as necessary.

4.2 Parameter Estimation

4.2.1 Manning's n-Value

4.2.1.1 General

Detailed and approximate method hydraulic analyses are conducted for several washes within the project area. Each wash is divided into reaches that have similar hydraulic characteristics, and therefore have similar Manning's n-values. The "Manning's n-Value Photo Location Map for Detailed and Zone A Delineations" (located in Appendix J) shows the location and limit of each wash, wash reach and locations of photographs representing typical reach characteristics. Photographs, and Manning's n-value calculation sheets are also provided in Appendix J.

4.2.1.2 Methodology

In order to estimate Mannings n-values for the study watercourses physical characteristics for each watercourse are identified through field observations and examination of ground and aerial photographs as well as examination of topographic mapping. The discerning characteristics recorded are channel size and shape, bed material, vegetation density, presence of meanders or channel bends and the presence or absence of channel obstructions. Detail and approximate method study watercourses were viewed on foot during field reconnaissance and each reach was photographed at representative locations.

Manning's n-values are estimated using the methods set forth in the U.S. Geological Survey (USGS) publication Estimated Manning's n-Values for Stream Channels and Flood Plains in Maricopa County Arizona (USGS, 1991) and Channel Subdivision and Bank Selection In Open Channels (draft April 23, 1999). The method cited in the USGS publication and the method used for this study involves the selection of an initial value of Manning's n-value based upon the channel bed material and then adjusting that value for channel irregularities, effects of obstructions, vegetation and channel cross sectional variations. If the channel has sufficient meander to increase roughness, then the sum of the base n-value plus subsequent adjustments is multiplied by a meander value, m.

4.2.1.3 Manning's n-Value Determination

The base n-value for the bed material roughness is estimated from field investigations. A 1-foot square grid (grid on 1-inch centers) is utilized for the estimation of the average size of bed material. Adjustment of the base n-value is then made based on vegetation present in the channel and the overbanks, field assessment of the channel bank conditions and the impact of any obstructions as well as a review of the cross sectional plots for variations in channel geometry.

The study watercourses are characterized by channels with little or no vegetation within the bottom width of the channel. Bottom width dimensions range from 20 to 50 feet for the detailed study reaches and 15 to 25 feet for the approximate method reaches. The study watercourses are also characterized by steep channel side slopes (2:1 (horizontal to vertical) or greater) that typically are lined with vegetation. The average channel bed material size ranges from gravel to cobbles. At some locations bed material will also consist of a boulder component. In general, the watercourses are deeply incised with well defined banks. Overbank areas are either ill defined or are nonexistent. Where overbank areas are present, the area can be characterized as having bed material ranging in size from firm soil to course sand and in some cases a gravel and cobble component exists. Overbank areas are typically vegetated with the canopy of the larger trees and bushes extending to the ground.

Base n-values for each watercourse and/or reach of each watercourse are estimated from the average size of the channel bed and overbank bed material. Adjustments to the channel base n-value are then made to account for channel irregularity, effects of obstruction, effects of vegetation, variations in channel cross section and degree of meandering. The greatest adjustment to the base n-value is from the effect of vegetation. For overbank areas an adjustment of 0.025 is made to the base n-value to account for the effects of vegetation. Vegetation within the channel generally occurs along the side slopes, therefore a composite n-value is estimated for channel segment that is representative of the vegetated side slopes and the non-vegetated bottom width. The difference between the composite n-value and the base n-value is then coded as the channel vegetation adjustment in the calculation sheets. Composite n-values are estimated for a typical channel section using Equation 6-17 from Open Channel Hydraulics (1959). That equation is:

$$n = \left[\frac{(P_1 n_1 + P_2 n_2 + P_3 n_3)^{1.5}}{P} \right]^{2/3}$$

where: P = total wetted perimeter of the channel;

P_1 = wetted perimeter of the channel bottom;

$P_{2,3}$ = wetted perimeter of the channel side slopes;

n_1 = Manning's n-value of the channel bottom; and

$P_{2,3}$ = Manning's n-value of the channel side slopes.

The typical channel section is estimated for both the detailed and approximate method reaches based on an inspection of the cross section plots. The typical section is determined to be trapezoidal with 2:1 (horizontal to vertical) side slopes with average channel bottom widths of 35 feet for the detailed method reaches and 20 feet for the approximate method reaches. Average depths of flow for the estimation of the wetted perimeter are assumed to be 5 feet for the detail study reaches and 3 feet for the approximate method study reaches. A channel side slope n-value of 0.050 is used

along with the base n-value estimated for each watercourse reach to determine a composite n-value.

The degree of channel irregularity (physical characteristics of the side slopes) ranges between smooth and moderate, adjustments of 0.001 and 0.005 are made for the smooth and moderate reaches, respectively. The effects of obstructions category is used to adjust the base n-value for the presence of boulders in the channel. An adjustment value of 0.005 is used for all reaches that are characterized with a bolder component to the channel bed material size. Variations in channel cross section are typically gradual therefore no adjustment is made. At a number of locations for each wash appreciable and severe meanders occur. The sum of the base n-value plus subsequent n-value adjustments is multiplied by a value of 1.15 or 1.3 for appreciable and severe meanders, respectively.

Calculation sheets listing the estimated base n-values and adjustments to that value for each reach of each study watercourse are provided in Appendix J. Manning's n-values determined for Unnamed Washes 1, 2 and 3 are listed in Tables 4-1, 4-2 and 4-3, receptively. Manning's n-values for the approximate method study reaches are listed in Table 4-4.

Table 4-1

Manning's n-values for Unnamed Wash 1

Reach	River Station miles	Manning's n-Value Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
Reach 3	6.311	0.050	0.040	0.060	
	6.216	0.050	0.040	0.060	
	6.100	0.050	0.040	0.060	
	6.015	0.050	0.040	0.060	
	5.969	0.060	0.045	0.070	Appreciable Meander
	5.917	0.060	0.045	0.070	Appreciable Meander
	5.862	0.050	0.040	0.060	
	5.746	0.050	0.040	0.060	
	5.632	0.050	0.040	0.060	
	5.505	0.050	0.040	0.060	
	5.439	0.060	0.045	0.070	Appreciable Meander
	5.380	0.050	0.040	0.060	
	5.310	0.050	0.040	0.060	
	5.227	0.060	0.045	0.070	Appreciable Meander
	5.207	0.060	0.045	0.070	Appreciable Meander
	5.176	0.050	0.040	0.060	
	5.096	0.050	0.040	0.060	
	5.007	0.050	0.040	0.060	
	4.920	0.050	0.040	0.060	
	4.879	0.060	0.045	0.070	
	4.839	0.050	0.040	0.060	
	4.725	0.050	0.040	0.060	
	4.628	0.050	0.040	0.060	
	4.613	0.050	0.040	0.060	
	4.536	0.060	0.040	0.060	
	4.436	0.050	0.040	0.060	
	4.412	0.050	0.040	0.060	
	4.361	0.050	0.040	0.060	
	4.256	0.050	0.040	0.060	
	3.671	0.050	0.040	0.060	
	3.643	0.050	0.040	0.060	
	3.631	N/A	N/A	N/A	Inline Weir
	3.617	0.050	0.040	0.060	
	3.577	0.050	0.040	0.060	

Table 4-1 (continued)
Manning's n-values for Unnamed Wash 1

Reach	River Station miles	Manning's n-Value: Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
	3.515	0.050	0.040	0.060	
	3.453	0.050	0.040	0.060	
	3.366	0.050	0.040	0.060	
	3.274	0.050	0.040	0.060	
	3.186	0.050	0.040	0.060	
Reach 2	3.121	0.060	0.065	0.070	Appreciable Meander
	3.073	0.060	0.065	0.070	Appreciable Meander
	3.015	0.055	0.055	0.055	
	2.923	0.055	0.055	0.055	
	2.880	0.060	0.060	0.060	Appreciable Meander
	2.848	0.060	0.060	0.060	Appreciable Meander
	2.813	0.060	0.060	0.060	Appreciable Meander
	2.770	0.055	0.055	0.055	
	2.674	0.060	0.060	0.060	Appreciable Meander
	2.611	0.060	0.060	0.060	Appreciable Meander
	2.557	0.055	0.055	0.055	
	2.467	0.055	0.055	0.055	
	2.390	0.070	0.070	0.070	Severe Meander
	2.347	0.070	0.070	0.070	Severe Meander
	2.312	0.050	0.055	0.060	
	2.230	0.050	0.055	0.060	
	2.134	0.055	0.055	0.055	
	2.047	0.055	0.055	0.055	
	1.992	0.060	0.060	0.060	Appreciable Meander
	1.928	0.060	0.060	0.060	Appreciable Meander
	1.862	0.060	0.060	0.060	Appreciable Meander
	1.768	0.060	0.060	0.060	Appreciable Meander
	1.709	0.060	0.060	0.060	Appreciable Meander
	1.675	0.060	0.060	0.060	Appreciable Meander
	1.637	0.060	0.060	0.060	Appreciable Meander
	1.621	0.055	0.055	0.055	
	1.590	0.055	0.055	0.055	
	1.479	0.055	0.055	0.055	
	1.398	0.055	0.055	0.055	
	1.374	0.055	0.055	0.055	
	1.367	0.055	0.055	0.055	

Table 4-1 (continued)
Manning's n-values for Unnamed Wash 1

Reach	River Station miles	Manning's n-Value Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
	1.286	0.055	0.055	0.055	
	1.208	0.055	0.055	0.055	
	1.116	0.055	0.055	0.055	
	1.010	0.055	0.055	0.055	
	0.914	0.055	0.055	0.055	
	0.850	0.055	0.055	0.055	
	0.819	0.055	0.055	0.055	
	0.724	0.055	0.055	0.055	
	0.644	0.055	0.055	0.055	
Reach 1	0.575	0.060	0.045	0.060	Appreciable Meander
	0.547	0.060	0.045	0.060	Appreciable Meander
	0.523	0.060	0.045	0.060	Appreciable Meander
	0.484	0.050	0.040	0.050	
	0.453	0.050	0.040	0.050	
	0.414	0.065	0.050	0.065	Severe Meander
	0.356	0.050	0.040	0.050	
	0.323	0.050	0.040	0.050	
	0.238	0.050	0.040	0.050	
	0.190	0.050	0.040	0.050	
	0.141	0.050	0.040	0.050	
	0.046	0.050	0.040	0.050	

Table 4-2

Manning's n-values for Unnamed Wash 2

Reach	River Station miles	Manning's n-Value: Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
Reach 3	6.789	0.055	0.040	0.055	
	6.765	0.055	0.040	0.055	
	6.714	0.055	0.040	0.055	
	6.669	0.055	0.040	0.055	
	6.643	0.055	0.040	0.055	
	6.595	0.055	0.040	0.055	
	6.570	0.055	0.040	0.055	
	6.501	0.055	0.040	0.055	
	6.451	0.055	0.040	0.055	
	6.418	0.055	0.040	0.055	
	6.392	0.055	0.040	0.055	
	6.318	0.055	0.040	0.055	
	6.271	0.055	0.040	0.055	
	6.218	0.055	0.040	0.055	
	6.161	0.055	0.040	0.055	
	6.058	0.055	0.040	0.055	
	5.974	0.055	0.040	0.055	
	5.927	0.055	0.040	0.055	
	5.865	0.055	0.040	0.055	
	5.845	0.070	0.050	0.070	Severe Meander
	5.759	0.055	0.040	0.055	
	5.702	0.055	0.040	0.055	
	5.624	0.055	0.040	0.055	
Reach 2	5.551	0.050	0.040	0.050	
	5.508	0.050	0.040	0.050	
	5.460	0.050	0.040	0.050	
	5.364	0.050	0.040	0.050	
	5.304	0.050	0.040	0.050	
	5.266	0.050	0.040	0.050	
	5.172	0.050	0.040	0.050	
	5.114	0.050	0.040	0.050	
	5.079	0.050	0.040	0.050	
	4.974	0.060	0.045	0.060	Appreciable Meander
	4.939	0.050	0.040	0.050	
	4.884	0.050	0.040	0.050	
	4.784	0.050	0.040	0.050	

Table 4-2 (continued)

Manning's n-values for Unnamed Wash 2

Reach	River Station miles	Manning's n-Value Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
	4.692	0.050	0.040	0.050	
	4.640	0.050	0.040	0.050	
	4.600	0.050	0.040	0.050	
	4.502	0.065	0.050	0.065	Severe Meander
	4.430	0.065	0.050	0.065	Severe Meander
	4.391	0.065	0.050	0.065	Severe Meander
	4.365	0.065	0.050	0.065	Severe Meander
	4.332	0.050	0.040	0.050	
	4.286	0.050	0.040	0.050	
	4.199	0.050	0.040	0.050	
	4.102	0.050	0.040	0.050	
	4.072	0.050	0.040	0.050	
	4.013	0.050	0.040	0.050	
	3.961	0.050	0.040	0.050	
	3.923	0.050	0.040	0.050	
	3.874	0.050	0.040	0.050	
	3.825	0.050	0.040	0.050	
	3.770	0.050	0.040	0.050	
	3.725	0.065	0.050	0.065	Severe Meander
	3.698	0.065	0.050	0.065	Severe Meander
	3.660	0.065	0.050	0.065	Severe Meander
	3.643	0.065	0.050	0.065	Severe Meander
	3.618	0.050	0.040	0.050	
	3.590	0.050	0.040	0.050	
	3.523	0.050	0.040	0.050	
	3.426	0.050	0.040	0.050	
	3.311	0.050	0.040	0.050	
	3.211	0.050	0.040	0.050	
	3.122	0.050	0.040	0.050	
	3.053	0.050	0.040	0.050	
	3.033	0.050	0.040	0.050	
	3.007	0.050	0.040	0.050	
	2.976	0.050	0.040	0.050	
	2.934	0.050	0.040	0.050	
	2.903	0.050	0.040	0.050	
Reach 1	2.892	0.055	0.040	0.055	

Table 4-2 (continued)

Manning's n-values for Unnamed Wash 2

Reach	River Station miles	Manning's n-Value Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
	2.856	0.055	0.040	0.055	
	2.813	0.055	0.040	0.055	
	2.718	0.055	0.040	0.055	
	2.683	0.060	0.045	0.060	Appreciable Meander
	2.656	0.055	0.040	0.055	
	2.625	0.055	0.040	0.055	
	2.603	0.055	0.040	0.055	
	2.521	0.055	0.040	0.055	
	2.424	0.055	0.040	0.055	
	2.401	0.055	0.040	0.055	
	2.319	0.055	0.040	0.055	
	2.225	0.055	0.040	0.055	
	2.131	0.055	0.040	0.055	
	2.034	0.055	0.040	0.055	
	1.940	0.055	0.040	0.055	
	1.846	0.055	0.040	0.055	
	1.818	0.055	0.040	0.055	
	1.781	0.055	0.040	0.055	
	1.742	0.065	0.045	0.065	Appreciable Meander
	1.677	0.055	0.040	0.055	
	1.629	0.055	0.040	0.055	
	1.535	0.055	0.040	0.055	
	1.481	0.055	0.040	0.055	
	1.438	0.055	0.040	0.055	
	1.419	0.055	0.040	0.055	
	1.363	0.055	0.040	0.055	
	1.261	0.055	0.040	0.055	
	1.168	0.055	0.040	0.055	
	1.092	0.055	0.040	0.055	
	1.052	0.055	0.040	0.055	
	0.995	0.055	0.040	0.055	
	0.957	0.055	0.040	0.055	
	0.916	0.055	0.040	0.055	
	0.864	0.055	0.040	0.055	
	0.769	0.065	0.045	0.065	Appreciable Meander
	0.745	0.065	0.045	0.065	Appreciable Meander

Table 4-2 (continued)

Manning's n-values for Unnamed Wash 2

Reach	River Station miles	Manning's n-Value Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
	0.734	0.065	0.045	0.065	Appreciable Meander
	0.703	0.055	0.040	0.055	
	0.650	0.055	0.040	0.055	
	0.625	0.055	0.040	0.055	
	0.610	0.055	0.040	0.055	
	0.589	0.055	0.040	0.055	
	0.537	0.055	0.040	0.055	
	0.441	0.055	0.040	0.055	
	0.348	0.055	0.040	0.055	
	0.309	0.055	0.040	0.055	
	0.252	0.055	0.040	0.055	
	0.205	0.055	0.040	0.055	

Table 4-3
Manning's n-values for Unnamed Wash 3

Reach	River Station miles	Manning's n-Value: Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
Reach 5	4.540	0.050	0.045	0.050	
	4.464	0.050	0.045	0.050	
	4.428	0.060	0.050	0.060	Appreciable Meander
	4.417	0.060	0.050	0.060	Appreciable Meander
	4.399	0.060	0.050	0.060	Appreciable Meander
	4.379	0.050	0.045	0.050	
	4.338	0.050	0.045	0.050	
	4.289	0.050	0.045	0.050	
	4.229	0.060	0.050	0.060	Appreciable Meander
	4.197	0.060	0.050	0.060	Appreciable Meander
	4.177	0.060	0.050	0.060	Appreciable Meander
	4.145	0.050	0.045	0.050	
	4.110	0.050	0.045	0.050	
	4.013	0.050	0.045	0.050	
	3.921	0.050	0.045	0.050	
	3.826	0.050	0.045	0.050	
	3.731	0.050	0.045	0.050	
	3.649	0.050	0.045	0.050	
	3.561	0.050	0.045	0.050	
Reach 4	3.520	0.065	0.050	0.065	Severe Meander
	3.509	0.065	0.050	0.065	Severe Meander
	3.497	0.065	0.050	0.065	Severe Meander
	3.487	0.065	0.050	0.065	Severe Meander
	3.460	0.050	0.040	0.050	
	3.426	0.050	0.040	0.050	
	3.412	0.060	0.045	0.060	Appreciable Meander
	3.370	0.060	0.045	0.060	Appreciable Meander
	3.351	0.060	0.045	0.060	Appreciable Meander
	3.319	0.060	0.045	0.060	Appreciable Meander
	3.309	0.050	0.040	0.050	
	3.257	0.050	0.040	0.050	
	3.168	0.060	0.045	0.060	Appreciable Meander
	3.144	0.060	0.045	0.060	Appreciable Meander
	3.114	0.050	0.040	0.050	
	3.061	0.065	0.050	0.065	Severe Meander
	3.042	0.065	0.050	0.065	Severe Meander
	3.015	0.065	0.050	0.065	Severe Meander

Table 4-3 (continued)
Manning's n-values for Unnamed Wash 3

Reach	River Station miles	Manning's n-Value: Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
	2.984	0.050	0.040	0.050	
	2.916	0.050	0.040	0.050	
	2.850	0.050	0.040	0.050	
	2.779	0.050	0.040	0.050	
	2.677	0.050	0.040	0.050	
	2.581	0.050	0.040	0.050	
	2.522	0.050	0.040	0.050	
	2.471	0.050	0.040	0.050	
	2.421	0.050	0.040	0.050	
	2.315	0.050	0.040	0.050	
	2.233	0.050	0.040	0.050	
	2.118	0.060	0.045	0.060	Appreciable Meander
	2.050	0.060	0.045	0.060	Appreciable Meander
	2.011	0.060	0.045	0.060	Appreciable Meander
	1.973	0.060	0.045	0.060	Appreciable Meander
	1.944	0.050	0.040	0.050	
	1.872	0.050	0.040	0.050	
	1.784	0.050	0.040	0.050	
	1.690	0.050	0.040	0.050	
	1.641	0.050	0.040	0.050	
	1.600	0.050	0.040	0.050	
	1.563	0.050	0.040	0.050	
	1.537	0.050	0.040	0.050	
	1.519	0.050	0.040	0.050	
	1.497	0.050	0.040	0.050	
	1.481	0.050	0.040	0.050	
Reach 3	1.425	0.070	0.070	0.070	Appreciable Meander
	1.385	0.070	0.070	0.070	Appreciable Meander
	1.356	0.070	0.070	0.070	Appreciable Meander
	1.331	0.070	0.070	0.070	Appreciable Meander
	1.304	0.060	0.060	0.060	
	1.259	0.060	0.060	0.060	
	1.222	0.060	0.060	0.060	
	1.171	0.060	0.060	0.060	
	1.152	0.060	0.060	0.060	
Reach 2	1.088	0.055	0.040	0.055	
	1.008	0.065	0.055	0.065	Appreciable Meander

Table 4-3 (continued)
Manning's n-values for Unnamed Wash 3

Reach	River Station miles	Manning's n-Value: Left Overbank	Channel	Right Overbank	Description
(1)	(2)	(3)	(4)	(5)	(6)
	0.986	0.065	0.055	0.065	Appreciable Meander
	0.960	0.065	0.055	0.065	Appreciable Meander
	0.928	0.055	0.040	0.055	
	0.852	0.055	0.040	0.055	
	0.761	0.065	0.045	0.065	Appreciable Meander
	0.734	0.065	0.045	0.065	Appreciable Meander
	0.716	0.065	0.045	0.065	Appreciable Meander
	0.695	0.065	0.045	0.065	
	0.658	0.055	0.040	0.055	
	0.625	0.070	0.050	0.070	Severe Meander
	0.598	0.070	0.050	0.070	Severe Meander
	0.583	0.070	0.050	0.070	Severe Meander
	0.565	0.055	0.040	0.055	
	0.520	0.055	0.040	0.055	
	0.481	0.055	0.040	0.055	
	0.386	0.055	0.040	0.055	
Reach 1	0.306	0.055	0.040	0.050	
	0.185	0.055	0.040	0.050	
	0.144	0.055	0.040	0.050	

Table 4-4

Mannings n-values for the approximate method study reaches

Wash Identification	Manning's n- Value			Remarks
	Left Overbank[1]	Channel	Right Overbank[1]	
Tributary 1 to Unnamed Wash 1	N/A	0.040	N/A	
Unnamed Wash 2 Approximate Methods Reach	N/A	0.040	N/A	
Tributary 1 to Unnamed Wash 2	N/A	0.050	N/A	
Tributary 2 to Unnamed Wash 2	N/A	0.040	N/A	
Twin Buttes Approximate Methods Reach	N/A	0.040	0.050	Photo location PZA9
Twin Buttes Approximate Methods Reach	N/A	0.050	N/A	Photo location PZA8
Twin Buttes Approximate Methods Reach	N/A	0.040	0.055	Photo location PZA7
Caterpillar Tank Wash Approximate Method Reach	N/A	0.040	N/A	
Unnamed Wash 4 Reach 1	0.035	0.045	N/A	Photo location PZA17
Unnamed Wash 4 Reach 2	N/A	0.040	N/A	Photo location PZA11
Unnamed Wash 5	0.070	0.045	0.070	Photo location PZA12
Unnamed Wash 6	N/A	0.040	N/A	Photo location PZA13
Unnamed Wash 7	N/A	0.040	N/A	
Unnamed Wash 8	N/A	0.040	N/A	
Unnamed Wash 9	N/A	0.040	N/A	

Note:
1. N/A = Overbank is poorly defined, 0.050 is utilized when flow is not contained in the channel.

4.2.2 Expansion and Contraction Coefficients

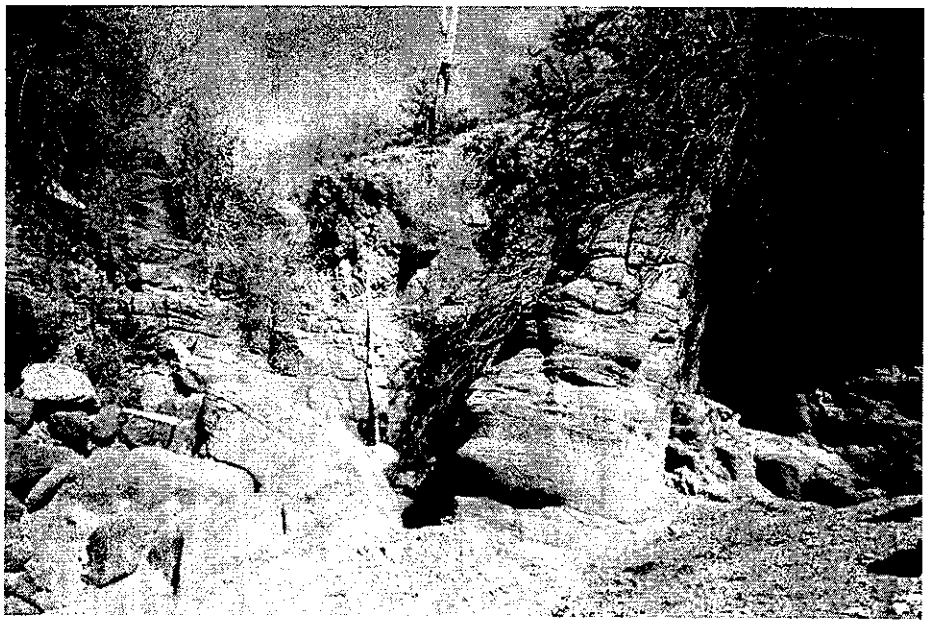
With the exception of a stock tank located at River Mile (R.M.) 3.361 of Unnamed Wash 1, there are no culverts or other hydraulic structures located within the limits of the three detailed study reaches and, in general, the study reaches are relatively free of any abrupt transitions. Therefore, gradual contraction and expansion coefficients of 0.1 and 0.3, respectively, are used for the majority of this study. For the locations where the washes naturally contract and expand more severely, larger coefficients for contraction and expansion are selected. Guidance for the selection of appropriate coefficients is obtained from the HEC-RAS Hydraulic Reference Manual (January 2001). Tables summarizing the contraction and expansion coefficients for all river stations for each wash are included as part of the HEC-RAS model output provided in Appendix L.

4.2.3 Hydraulic Jump Analysis

There are several abrupt changes in channel slope along both the detailed and approximate method study watercourses. Figure 4-1 is a photograph of one of the more severe drops which is located on Unnamed Wash 1. An evaluation was performed at each location where there may be a potential for a hydraulic jump for the detailed study reaches. The evaluation involved modeling the study reaches in a mixed flow regime with interpolated cross sections between the cross sections where there is a potential for a hydraulic jump. The results of this evaluation indicate that the hydraulic conditions are not sufficient to form a hydraulic jump for the flows associated with the 100-year event. The potential for the occurrence of hydraulic jumps along the approximate method study reaches is not warranted for that level of study and is therefore not evaluated.

Figure 4- 1

Vertical drop on Unnamed Wash 1



4.3 Modeling Discharges

The watershed area contributing runoff to the study watercourses is only a portion of the total study watershed area for the NPADMP project. This area is shown in relation to the

total watershed study area on Figure 1-3 and Plate 1. The following tables summarize the peak discharges used in the hydraulic analysis of each study watercourse. A detailed discussion of the development of these discharges is provided in Section 3.

Table 4-5

100-year modeling discharges for Unnamed Wash 1

Flow Change Location	Modeling Peak Discharge cfs	HEC-1 Station Identifier	100-Year Peak Discharge 6-Hour cfs	100-Year Peak Discharge 24-Hour cfs
6.311	750	S100	746	512
5.862	1,190	C102R	1,185	967
4.613	2,330	C103R	2,330	2,058
3.015	2,890	C104	2,892	2,682
1.286	3,190	C105L	3,193	3,031

Table 4-6

100-year modeling discharges for Unnamed Wash 2

Flow Change Location	Modeling Peak Discharge cfs	HEC-1 Station Identifier	100-Year Peak Discharge 6-Hour cfs	100-Year Peak Discharge 24-Hour cfs
6.789	1,750*	C203R	1,954	1,746
6.161	2,910	C204	2,913	2,913
5.927	3,380	C205L	3,345	3,378
4.939	4,420	C206	4,325	4,421
2.625	4,570	C207R	4,471	4,573
1.629	4,680	C105R	4,567	4,687
0.252	7,300	C105	6,847	7,297

Note: * 24-hour peak discharge is used for consistency.

Table 4-7

100-year modeling discharges for Unnamed Wash 3

Flow Change Location	Modeling Peak Discharge cfs	HEC-1 Station Identifier	100-Year Peak Discharge 6-Hour cfs	100-Year Peak Discharge 24-Hour cfs
4.540	1,220	S301	1,216	959
4.197	1,990	C301	1,985	1,787
3.168	2,200	C302	2,203	2,042
1.641	2,570	C303	2,567	2,414

Table 4-8

100-year modeling discharges for the approximate method study reaches

River Reach	Flow Change Location	Modeling Peak Discharge	HEC-1 Station Identifier	100-Year Peak Discharge 6-Hour cfs	100-Year Peak Discharge 24-hour cfs
Tributary 1 to Unnamed Wash 1	A-A	860	C102L	856	627
Unnamed Wash 2	F-F	1380	S200	1379	1067
Unnamed Wash 2	A-A	1670	C201	1669	1396
Tributary 1 to Unnamed Wash 2	A-A	860	S207	863	674
Tributary 2 to Unnamed Wash 2	A-A	1130	S204	1126	880
Twin Buttes Wash	F-F	1250	C501	1250	1041
Twin Buttes Wash	A-A	1390	C502L	1392	1174
Caterpillar Tank Wash	A-A	1210	S400	1212	967
Unnamed Wash 4	A-A	1420	C705	1418	1146
Unnamed Wash 4	F-F	770	C705AF	772	712
Unnamed Wash 4	I-I	690	C705O	689	622
Tributary 1 to Unnamed Wash 4	A-A	770	C705AF	772	712
Unnamed Wash 5	N-N	1630	S716	1625	1328
Unnamed Wash 5	J-J	880	C717	881	739
Unnamed Wash 5	A-A	1160	C718	1158	989
Unnamed Wash 6	A-A	1380	C722	1384	1123
Unnamed Wash 7	A-A	1790	S724	1788	1462
Unnamed Wash 8	A-A	1150	S725	1153	946
Unnamed Wash 9	H-H	860	S726	860	484
Unnamed Wash 9	A-A	1130	C727	1132	796

4.4 Cross Section Description

4.4.1 General

Cross sectional geometry for the detailed study watercourses is determined from a triangulated irregular network (TIN). The TIN is developed from a digital terrain model (DTM) supplied by Cooper using the 3D Analyst extension of ArcView GIS v3.2. Cross sections are located at approximately 500 foot intervals as well at significant changes in channel slope and cross sectional area. Cross section numbering is expressed in river miles above the confluence with the Agua Fria River for Unnamed Washes 2 and 3 and the confluence with Unnamed Wash 2 for Unnamed Wash 1. Cross section stationing is from left to right looking downstream with the location of the hydraulic baseline set to station 10,000.

Cross sectional geometry for the approximate method study watercourses is determined from three sources:

1. Detailed mapping prepared for the Agua Fria River Floodplain Delineation Study Re-Study, FCD 95-5, aerial photography flight date September 1987. Mapping scale is 1 inch = 400 feet with a contour interval of 4 feet.
2. Detailed mapping prepared for CMX from aerial photography ranging from 1993 to 1998 at a contour interval of 2 feet.
3. Field survey

Cross sections are located at approximately 1,000 feet intervals. Cross sections are identified alphabetically starting at the downstream most cross section. Cross section stationing is from left to right looking downstream.

4.4.2 Channel and Overbanks

For the detailed study watercourses, cross section reach lengths and channel bank stations are determined using the HEC-GeoRAS extension for ArcView GIS. The process involves the initial layout of line work representing the hydraulic baseline (channel reach length), flow paths (overbank reach lengths) and bank stations. This data, along with cross sectional geometry is exported into a format required by HEC-RAS to get an initial

estimation of the flooding limits. Based on the initial results, this data is refined to be representative of the hydraulic conditions of the 100-year event.

For both the detailed and approximate method study watercourses, bank stations are located at the natural channel bank or at major grade breaks, in part, based on the 100-year water surface elevation such that the channel area remains relatively consistent throughout the reach. For locations where there is no identifiable overbank area, channel bank stations are located just below the 100-year water surface elevations or where there is a significant change in roughness to warrant a separation in Manning's n-values. The final locations of the channel bank stations are shown on the cross section plots provided in Appendix L and M for the detailed and approximate method reaches, respectively.

Overbank reach lengths for the detailed study watercourses are defined as extending from the centroid of the overbank flow area from the upstream cross section to that of the downstream cross section. The overbank reach lengths are therefore directly effected by the location of the channel bank stations. For the cross sections where there is no identifiable overbank area, overbank reach lengths are measured along the channel bank. Overbank reach lengths are not required for the approximate methods analysis.

4.4.3 Bridges, Culverts and Constrictions

There are no bridges, culverts or other significant constrictions located within the limits of the detailed study watercourses. There are numerous natural constrictions and these are discussed in Section 4.2.2.

Within the approximate method study limits there is a canal overchute and several culverts. The locations of these structures are shown on Plate 7. In general, the flooding limits at the culverts are based on the headwater elevation for the culvert as determined using the HY-8 computer program. Input data to the program are determined from the detailed mapping, as-built drawings or from field survey. That data as well as the program output are included for reference in Appendix K. Some of the culverts do not have the capacity to convey the 100-year discharge without taking into consideration potential storage upstream of a culvert. At locations where storm water storage is taken into

consideration, ponding conditions are modeled using the Modified Puls, level pool storage routing option of the HEC-1 computer program. This analysis is discussed in Section 3.2.2.6. Flooding limits for these locations are based on the ponded water surface elevation as determined by the HEC-1 computer program. Associated technical calculations for these locations are provided in Appendix E.

4.4.4 Grade Control Structures

There are no engineered grade control structures located within the study limits. There are, however, numerous locations of significant change in grade with exposed bedrock that function as natural grade control structures. These locations are discussed in Section 4.2.3.

4.5 Calibration

There are no stream gage data available within the study limits to use for HEC-RAS model calibration. The mapped floodplain limits have been inspected for reasonableness and found to be appropriate.

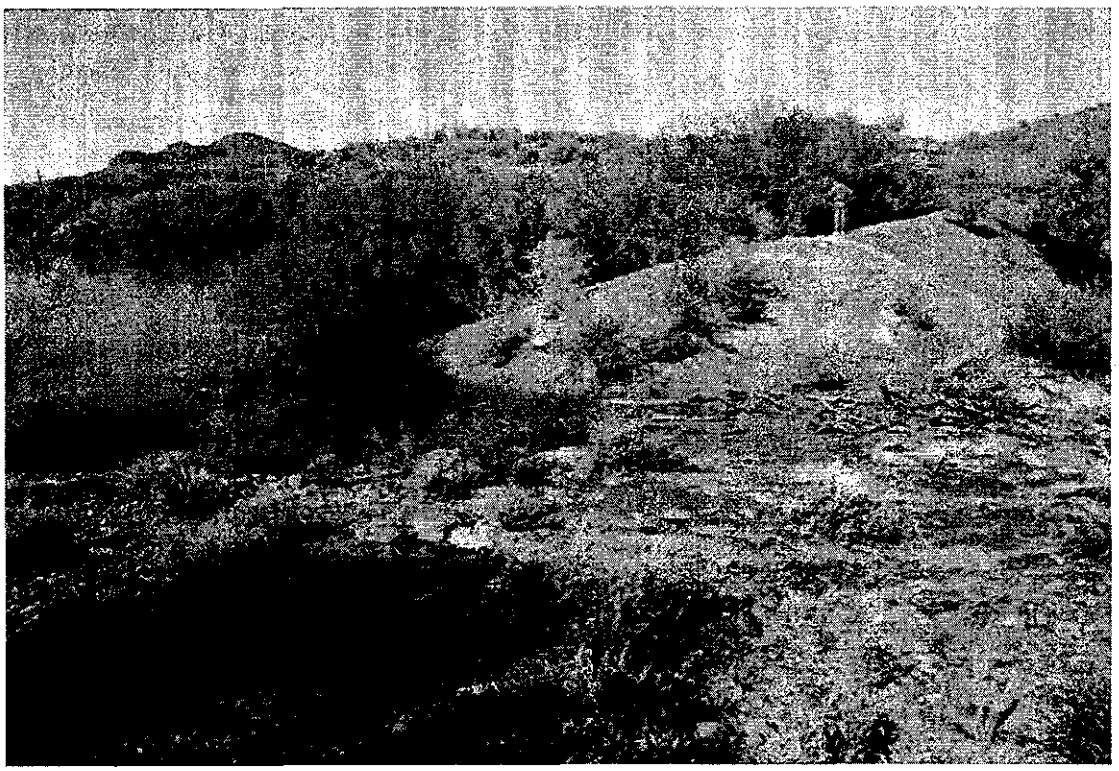
4.6 Special Problems

4.6.1 Stock Tanks

There are four stock tanks located within the hydraulic study limits. One of these is located within the study limits of Unnamed Wash 1 at approximately river station 3.631. The stock tank is an earthen embankment approximately 12 feet in height from the crest of the overflow section to the downstream toe of slope. The upstream face of the embankment is moderately vegetated with Palo Verde and Mesquite Trees and there is exposed bedrock at both the right and left "abutments". Figure 4-2 is a photo of the embankment and impoundment area.

Figure 4- 2

Stock tank on Unnamed Wash 1



At the time of this report, it appears that the area is no longer used for grazing and as a consequence it is more than likely that long term maintenance of the stock tanks will not occur. Despite this, the structural integrity of the embankment during a 100-year event is unknown and therefore, for modeling purposes it is assumed that this structure will remain in tact during such an event. This assumption results in a very conservative estimation for the flooding limits upstream of this structure. For the hydrologic portion of the study, this structure was not considered in the analysis and thus there is no reduction in peak discharge downstream due to storage behind the embankment. The resulting floodplain and floodway limits downstream of this structure are also considered to be conservative.

The second stock tank is located on the approximate method study watercourse Unnamed Wash 7 immediately upstream of river station "F". The stock tank is an earthen embankment approximately 11.5 feet in height. Inspection of the surrounding topography indicates that there is a potential for break-out once the pond is filled. Given the

uncertainty of the structural integrity during the 100-year event, two scenarios where used to map the floodplain limits.

The first scenario assumes that the structure can withstand the 100-year event. Once the stock tank fills, runoff will begin to bypass the impoundment area to be conveyed in a small wash southeast of the stock tank. This bypass wash, identified as Tributary 1 to Unnamed Wash 7, is tributary to Unnamed Wash 7 just downstream of river station "C" as shown on sheet 5 of Plate 7. Storage routing through the stock tank and split flow analyses are not performed for this location, therefore the floodplain limits for this tributary are based on the entire peak discharge entering the stock tank. The second scenario assumes that the stock tank fails during the 100-year event and that the runoff continues downstream without spilling into Tributary 1 of Unnamed Wash 7. Both scenarios are used to map the floodplain limits.

The third stock tank is located on the approximate method watercourse Unnamed Wash 8 between river station F and G. The stock tank is an earthen embankment approximately 6 feet high. The structural integrity during a 100-year event is uncertain, however the worst case scenario concerning flooding depths would be if the structure did not fail and runoff overtopped the crest of the earthen embankment. The worst case scenario was used to map the approximate method flood zone.

The fourth tank is located on the approximate method watercourse Unnamed Wash 5. The stock tank is an earthen embankment approximately 6 feet high. As with the stock tank on Unnamed Wash 8 the worst case scenario was used to map the approximate method flood zone.

4.6.2 Berms

Downstream of the Beardsley Canal crossing of Unnamed Wash 4, a small berm and drainage channel was constructed that diverts flow around a citrus orchard. The construction date of this drainage way is uncertain, however the berm is identified on the U.S.G.S. 7.5 Minute Series Baldy Mountain Quadrangle Map which has a photo revision date of 1978. The berm varies in height and is approximately 2,600 feet in length. The

channel depth ranges from approximately 3 to 5 feet and the bottom width ranges from approximately 5 to 15 feet. Typical photos of the berm and channel are provided in Appendix J.

Starting approximately 650 feet downstream of the Beardsley Canal culvert crossing the berm does not have sufficient conveyance capacity to contain the flow and is overtopped. Because of the uncertainties of long term maintenance and structural stability, two scenarios are used to map the floodplain for this portion of Unnamed Wash 4. The first scenario assumes that the berm fails at the first point of overtopping and all the flow breaks-out through the orchard to the Agua Fria River. The second scenario assumes that the berm does not fail, but is still overtopped. The constructed berm and channel downstream of the point of overtopping is identified as Tributary 1 of Unnamed Wash 4. The area between the berm and the limits of flooding for scenario 1 is included as part of the total flooding limits, but is called out on the map as having flow depths less that 1 foot.

4.6.3 Tie-In to Existing Floodplain Delineations

Detailed study watercourses, Unnamed Washes 2 and 3, are tributary to the Agua Fria River. Floodplain and floodway limits for the Agua Fria River were established in the Agua Fria River Floodplain Delineation Study Re-Study, FCD 95-5. Those delineations were performed on scanned images of 4 foot contour interval mapping prepared in 1987. The geometry at these confluences made it difficult to locate a cross section at the Agua Fria River floodplain limits. Because of this and the differences in mapping resolution between these two studies, the floodplain and floodway limits at the last cross section of Unnamed Washes 2 and 3 were projected at a 4:1 expansion until they intersected with the Agua Fria River floodplain and floodway limits.

4.7 Floodway Modeling

Floodway encroachments for the detailed study watercourses were initially established using the Method 4, equal conveyance encroachment option with a target rise in water surface elevation of 1 foot. The target rise was then adjusted at various river stations as necessary to eliminate all rises greater than 1 foot and to eliminate as much as possible

reductions in water surface elevations. The encroachment stations obtained from the results of the Method 4 option were then converted to the Floodway Method 1 option for the final HEC-RAS model.

Reductions in water surface elevation occurred at numerous locations as a result of encroachment due to either a change in flow regime (subcritical to supercritical) or the failure of the model to determine a valid subcritical answer, thus the model defaults to critical depth. In addition to this, the model defaulted to critical depth at a sufficient number of other river stations such that a floodway based on the rise in energy grade line was warranted as per State Standard 3-94, Floodway Modeling Standards for Supercritical Flow. Therefore, the Method 1 floodway encroachments stations were adjusted were necessary so that there were no rises in on the energy grade line greater than 1 foot. Despite the use of the energy grade line for the floodway, there were still locations at which a reduction in water surface elevation occurs. The locations that this occurs can be seen in Tables 4-12 through 4-14 for Unnamed Washes 1, 2 and 3, respectively. For the mapping, the floodway water surface elevations at these locations are set equal to the floodplain water surface elevation.

4.8 Model Warning and Error Messages

The HEC-RAS models for each of the detailed study watercourses execute without error messages for both the floodplain and floodway profiles. However, the model does report several different warning messages. In general, the majority of these messages are to be expected given the hydraulic characteristics of these watercourses.

The only message that was not expected, occurred only for the Method 1 floodway profile. That message is, "The cross section had to be extended vertically during critical depth computations". This warning message occurs at numerous river stations. The exact cause of this message is due to the fact that encroachment limits are treated as vertical walls within the limits of the cross section and that these walls are extended vertically to whatever height is required to contain the flow.

4.9 Final Results

Printouts from the HEC-RAS models for each detailed study watercourse are provided in Appendix L. Summary output for the floodplain profiles are provided in Tables 4-9 through 4-11. Summary output for the Method 1 floodway profiles are provided in Tables 4-12 through 4-14. The HEC-RAS model data files, both input and output, for each detailed watercourse are provided digitally on CD as Appendix O. The normal depth calculations used for the approximate method floodplains are provided in Appendix M. The results of those calculations are provided in Table 4-15.

Table 4-9

Summary of results for the natural floodplain profile for Unnamed Wash 1

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
6.311	750	1793.8	1797.4	1797.35	1798.65	0.0175	9.2	82.6	34.5	1.00	9986.8	10021.3
6.216	750	1786.4	1789.9	1789.67	1790.47	0.0109	6.2	134.5	96.9	0.77	9943.0	10043.0
6.100	750	1777.3	1780.4	1780.42	1781.27	0.0219	8.4	112.0	66.8	1.07	9978.6	10045.5
6.015	750	1767.6	1771.0	1770.98	1772.09	0.0179	8.5	89.1	42.0	0.99	9976.8	10018.8
5.969	750	1764.4	1768.4	1767.29	1768.61	0.0056	4.4	276.2	214.9	0.50	9804.5	10019.4
5.917	750	1760.8	1765.2	1764.93	1766.23	0.0154	8.4	95.3	40.4	0.85	9987.8	10028.2
5.862	1190	1756.1	1760.1	1760.10	1761.45	0.0172	9.3	127.9	48.6	1.00	9974.8	10023.4
5.746	1190	1748.4	1751.9	1751.56	1752.45	0.0085	6.4	231.0	141.8	0.70	9889.4	10031.2
5.632	1190	1741.0	1745.9	1745.45	1746.89	0.0099	8.0	154.0	58.6	0.78	9966.1	10024.8
5.505	1190	1734.0	1737.6	1737.45	1738.71	0.0152	8.5	139.7	55.7	0.94	9980.0	10035.7
5.439	1190	1726.5	1731.4	1731.41	1732.73	0.0192	9.5	141.2	60.0	0.95	9980.7	10157.7
5.380	1190	1721.9	1725.7	1724.67	1726.03	0.0063	5.8	298.5	120.7	0.60	9987.7	10108.4
5.310	1190	1716.1	1720.7	1720.66	1722.21	0.0159	9.7	122.2	40.6	0.97	9981.8	10022.3
5.227	1190	1711.4	1715.8	1715.59	1716.47	0.0103	7.0	220.2	116.9	0.70	9910.3	10027.2
5.207	1190	1710.4	1715.3	1713.98	1715.70	0.0045	5.4	259.9	99.2	0.48	9952.7	10051.8
5.176	1190	1708.4	1712.9	1712.93	1714.40	0.0143	10.0	132.8	50.2	0.94	9983.5	10033.7
5.096	1190	1702.4	1707.1	1706.76	1708.20	0.0118	8.4	142.2	48.4	0.84	9980.2	10028.7
5.007	1190	1697.4	1702.8	1702.38	1703.74	0.0077	8.3	183.8	82.3	0.71	9975.4	10057.7
4.920	1190	1693.6	1698.2	1698.20	1699.33	0.0121	9.0	156.9	71.1	0.86	9947.2	10018.3
4.879	1190	1692.3	1696.8	1696.05	1697.21	0.0062	6.0	322.0	166.3	0.55	9946.0	10112.3
4.839	1190	1690.2	1694.8	1694.60	1695.69	0.0103	8.1	195.2	102.0	0.79	9978.3	10099.0
4.725	1190	1684.1	1687.6	1687.65	1688.52	0.0140	8.5	185.6	101.4	0.91	9930.2	10031.5
4.628	1190	1676.2	1681.8	1679.57	1682.07	0.0016	3.8	318.8	88.4	0.33	9957.1	10045.5
4.613	2330	1675.0	1680.8	1679.84	1681.72	0.0060	8.1	352.4	114.8	0.66	9952.2	10067.1
4.536	2330	1670.3	1676.2	1676.20	1678.15	0.0130	11.4	222.5	62.6	0.94	9983.3	10045.9

Table 4-9 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 1

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
4.436	2330	1665.7	1669.7	1669.73	1670.76	0.0144	9.5	323.6	149.7	0.95	9880.2	10029.9
4.412	2330	1660.6	1666.7	1665.89	1667.43	0.0062	7.5	387.4	119.3	0.65	9970.3	10089.7
4.361	2330	1658.1	1663.6	1663.63	1665.06	0.0125	10.0	269.1	99.9	0.91	9932.7	10032.6
4.256	2330	1653.7	1659.0	1658.52	1659.76	0.0071	7.9	407.7	152.2	0.69	9974.6	10126.8
4.170	2330	1648.6	1654.0	1654.01	1655.47	0.0127	11.0	291.1	100.3	0.92	9983.6	10083.9
4.077	2330	1644.2	1649.7	1649.36	1650.50	0.0068	8.3	401.7	152.9	0.69	9877.0	10030.0
3.987	2330	1640.1	1645.1	1645.12	1646.34	0.0117	10.0	321.6	131.5	0.89	9952.1	10083.6
3.895	2330	1637.3	1642.9	1641.49	1643.20	0.0029	5.7	599.0	186.4	0.46	9935.8	10122.2
3.803	2330	1634.2	1642.1	1638.67	1642.34	0.0012	4.3	595.8	122.3	0.30	9961.9	10084.2
3.706	2330	1630.6	1642.1	1634.31	1642.17	0.0001	1.5	1923.4	269.9	0.08	9770.8	10040.6
3.671	2330	1629.0	1642.1	1631.23	1642.15	0.0000	0.9	3304.3	368.0	0.04	9752.1	10120.1
3.643	2330	1627.4	1642.1	1629.71	1642.15	0.0000	0.7	4019.3	389.4	0.03	9749.8	10157.3
3.631	Inline Weir											
3.617	2330	1623.9	1626.2	1626.18	1627.09	0.0193	7.6	306.2	174.7	1.00	9838.8	10013.5
3.577	2330	1619.0	1623.6	1623.01	1624.43	0.0084	8.1	356.1	129.7	0.74	9921.0	10050.7
3.515	2330	1614.4	1619.6	1619.61	1621.09	0.0125	10.4	272.3	99.8	0.92	9945.8	10045.6
3.453	2330	1609.8	1616.2	1615.19	1617.09	0.0056	7.9	345.9	111.7	0.63	9973.4	10085.1
3.366	2330	1605.9	1611.3	1611.28	1613.03	0.0154	10.6	220.9	66.3	0.99	9961.7	10028.0
3.274	2330	1597.9	1604.7	1604.28	1606.38	0.0106	10.3	228.9	54.5	0.85	9973.7	10028.3
3.186	2330	1595.4	1601.1	1600.83	1602.05	0.0073	8.5	366.7	152.8	0.71	9895.5	10048.3
3.121	2330	1592.2	1597.8	1597.21	1598.52	0.0154	7.4	373.3	143.6	0.63	9892.1	10035.8
3.015	2890	1581.4	1588.4	1587.77	1589.76	0.0177	9.4	310.9	82.4	0.80	9951.5	10033.8
3.073	2330	1588.3	1594.1	1592.94	1594.62	0.0156	6.4	406.3	152.4	0.61	9969.5	10158.9
2.923	2890	1573.7	1581.8	1580.37	1582.93	0.0114	8.7	334.4	66.2	0.66	9969.1	10035.3
2.880	2890	1570.7	1577.9	1577.34	1579.46	0.0209	10.6	297.5	69.9	0.80	9988.0	10058.0

Table 4-9 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 1

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
2.848	2890	1567.8	1574.8	1573.99	1576.14	0.0180	9.5	313.6	88.6	0.75	9974.1	10082.8
2.813	2890	1563.9	1571.4	1570.72	1572.83	0.0181	10.5	314.9	71.2	0.75	9938.2	10009.4
2.770	2890	1561.9	1568.7	1567.54	1569.71	0.0103	8.5	375.1	84.2	0.64	9967.0	10051.2
2.674	2890	1553.8	1561.8	1560.63	1563.19	0.0163	9.6	303.5	59.7	0.72	9953.2	10012.9
2.611	2890	1547.5	1555.7	1555.36	1557.34	0.0194	10.7	300.8	75.4	0.78	9944.7	10020.1
2.557	2890	1543.2	1550.6	1549.81	1552.38	0.0156	10.9	279.7	54.3	0.77	9977.1	10031.5
2.467	2890	1538.4	1545.4	1543.85	1546.33	0.0098	7.9	368.0	75.0	0.61	9960.1	10035.1
2.390	2890	1534.0	1539.9	1539.09	1540.85	0.0197	8.0	396.4	116.1	0.67	9927.8	10043.9
2.347	2890	1530.1	1537.1	1535.94	1537.59	0.0113	6.2	551.2	168.4	0.50	9994.7	10163.1
2.312	2890	1527.9	1533.5	1533.52	1534.78	0.0237	9.7	336.7	131.1	0.90	9865.9	10035.2
2.230	2890	1521.3	1527.8	1526.51	1528.36	0.0084	6.4	481.5	141.7	0.55	9883.7	10030.3
2.134	2890	1513.5	1520.2	1519.77	1521.86	0.0208	10.5	278.6	67.0	0.86	9945.6	10012.6
2.047	2890	1503.2	1509.8	1509.81	1511.86	0.0227	11.7	262.9	70.0	0.92	9970.4	10040.4
1.992	2890	1493.8	1504.0	1502.16	1504.77	0.0066	7.5	464.1	96.0	0.47	9958.4	10054.5
1.928	2890	1491.5	1499.2	1498.48	1501.00	0.0213	10.6	273.0	52.5	0.80	9981.5	10034.1
1.862	2890	1485.5	1494.4	1492.48	1495.65	0.0113	9.2	321.7	53.1	0.62	9976.4	10029.5
1.768	2890	1479.1	1486.7	1485.86	1488.22	0.0204	10.0	287.8	58.7	0.79	9964.0	10022.7
1.709	2890	1476.0	1484.0	1481.64	1484.75	0.0062	7.4	455.9	86.4	0.47	9968.0	10054.4
1.675	2890	1471.9	1482.4	1479.73	1483.41	0.0087	8.1	368.5	73.1	0.53	9979.7	10052.8
1.637	2890	1466.8	1476.8	1476.83	1480.03	0.0352	14.4	202.1	33.3	0.99	9983.7	10017.0
1.621	2890	1467.3	1474.6	1473.82	1476.26	0.0146	10.9	292.2	57.6	0.76	9967.8	10025.4
1.590	2890	1464.7	1473.3	1471.38	1474.33	0.0084	8.4	358.7	66.1	0.58	9968.5	10034.5
1.479	2890	1459.2	1465.7	1464.98	1467.37	0.0174	10.4	280.2	57.5	0.80	9983.4	10040.8
1.398	2890	1440.9	1454.0	1454.04	1457.57	0.0299	15.2	196.6	30.2	0.95	9988.2	10018.4
1.374	2890	1438.2	1449.4	1449.36	1452.26	0.0287	13.7	213.5	39.8	0.97	9990.8	10030.6

Table 4-9 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 1

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
1.367	2890	1425.1	1441.2	1441.18	1444.39	0.0348	14.8	206.8	31.5	0.88	9981.1	10012.6
1.286	3190	1418.8	1428.4	1426.95	1430.30	0.0145	11.2	287.2	42.0	0.73	9976.4	10018.4
1.208	3190	1413.3	1419.9	1419.87	1422.44	0.0258	12.7	253.8	50.8	0.97	9970.5	10021.4
1.116	3190	1404.1	1414.8	1411.91	1416.06	0.0073	9.0	361.8	47.1	0.54	9982.0	10029.1
1.010	3190	1393.5	1405.9	1404.90	1409.15	0.0236	14.4	225.1	26.4	0.83	9986.8	10013.1
0.914	3190	1388.2	1399.5	1397.32	1401.09	0.0103	10.3	318.4	45.3	0.63	9976.1	10021.4
0.850	3190	1386.8	1396.0	1394.19	1397.41	0.0110	9.7	334.5	54.3	0.65	9978.1	10032.3
0.819	3190	1386.2	1394.7	1392.64	1395.66	0.0088	8.1	396.4	70.5	0.59	9966.2	10036.7
0.724	3190	1382.7	1390.2	1388.58	1391.17	0.0091	7.9	408.8	80.3	0.59	9954.6	10034.9
0.644	3190	1378.9	1386.5	1385.14	1387.43	0.0087	8.2	426.3	88.7	0.59	9976.2	10064.9
0.575	3190	1376.4	1383.8	1382.44	1384.76	0.0063	8.4	454.9	97.6	0.61	9978.3	10075.9
0.547	3190	1374.7	1381.4	1381.04	1383.32	0.0143	11.0	291.0	63.2	0.88	9974.2	10037.4
0.523	3190	1371.9	1379.8	1379.78	1381.64	0.0132	11.9	341.3	92.7	0.86	9976.6	10069.3
0.484	3190	1369.2	1378.9	1377.69	1379.81	0.0044	8.1	479.9	110.7	0.56	9907.0	10017.7
0.453	3190	1370.6	1378.0	1377.00	1379.02	0.0052	8.8	462.7	115.4	0.62	9904.2	10019.6
0.414	3190	1368.2	1377.3	1375.36	1377.90	0.0054	7.6	554.1	117.4	0.51	9895.5	10023.6
0.356	3190	1367.7	1376.0	1374.47	1376.61	0.0034	7.2	613.3	152.3	0.50	9970.0	10122.3
0.323	3190	1366.8	1373.2	1373.18	1375.13	0.0145	12.2	303.7	79.7	1.00	9958.1	10037.9
0.238	3190	1363.1	1370.2	1368.68	1370.53	0.0031	5.8	740.8	199.0	0.46	9985.3	10184.3
0.190	3190	1362.7	1369.7	1367.14	1369.98	0.0018	4.7	782.0	164.6	0.36	9966.4	10131.1
0.141	3190	1361.5	1368.3	1367.60	1369.15	0.0080	9.3	460.5	126.8	0.73	9884.9	10011.7
0.046	3190	1359.5	1367.6	1364.38	1367.82	0.0011	4.4	933.0	176.2	0.30	9868.6	10044.8

Table 4-10

Summary of results for the natural floodplain profile for Unnamed Wash 2

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
6.789	1750	1839.9	1845.2	1844.0	1846.1	0.0079	9.0	248.4	63.1	0.74	9974.7	10037.7
6.765	1750	1837.8	1843.6	1842.8	1845.0	0.0084	9.3	192.6	44.6	0.75	9971.1	10015.7
6.714	1750	1832.0	1839.3	1839.3	1841.9	0.0153	13.0	141.4	30.4	0.97	9984.3	10014.7
6.669	1750	1827.7	1833.2	1833.2	1834.9	0.0155	11.6	187.0	55.3	0.98	9987.5	10042.8
6.643	1750	1825.3	1830.5	1830.5	1831.7	0.0106	9.4	241.2	106.0	0.84	9922.9	10028.9
6.595	1750	1821.4	1826.9	1826.7	1828.0	0.0099	9.4	241.3	84.6	0.80	9984.4	10069.0
6.570	1750	1818.8	1824.0	1824.0	1825.9	0.0170	10.9	160.3	43.6	1.00	9971.0	10014.6
6.501	1750	1813.4	1817.8	1817.8	1819.0	0.0136	9.7	221.8	87.2	0.92	9982.9	10070.1
6.451	1750	1810.0	1813.9	1813.9	1814.9	0.0122	8.9	266.5	131.9	0.87	9886.9	10018.8
6.418	1750	1807.4	1810.5	1810.5	1811.6	0.0189	9.1	218.7	103.5	1.04	9926.4	10029.9
6.392	1750	1805.0	1808.1	1807.9	1809.0	0.0166	8.4	246.7	117.0	0.97	9909.1	10026.1
6.318	1750	1800.0	1803.0	1802.6	1803.5	0.0117	7.3	326.9	162.8	0.82	9851.5	10014.3
6.271	1750	1796.7	1800.6	1799.7	1801.2	0.0076	6.8	307.9	99.5	0.68	9921.1	10020.6
6.218	1750	1792.1	1796.4	1796.4	1798.0	0.0148	10.2	181.0	61.1	0.96	9969.9	10031.0
6.161	2910	1788.5	1792.9	1792.0	1793.5	0.0085	7.7	532.0	220.2	0.74	9792.5	10012.7
6.058	2910	1781.2	1786.3	1786.3	1787.7	0.0145	11.1	358.9	125.8	0.97	9896.2	10022.1
5.974	2910	1775.5	1781.6	1780.8	1782.5	0.0064	8.1	423.0	125.6	0.67	9956.4	10082.0
5.927	3380	1772.8	1778.3	1778.3	1780.2	0.0129	11.5	334.8	93.5	0.94	9984.1	10077.6
5.865	3380	1767.4	1773.6	1773.6	1775.2	0.0114	12.0	403.2	125.2	0.91	9948.8	10074.0
5.845	3380	1758.6	1768.2	1768.2	1770.2	0.0177	12.9	360.4	87.0	0.84	9990.0	10077.0
5.759	3380	1752.4	1758.8	1758.8	1761.1	0.0155	12.2	276.2	60.6	1.01	9972.4	10033.0
5.702	3380	1749.1	1756.0	1754.9	1756.9	0.0055	8.2	495.1	130.1	0.63	9902.9	10033.0
5.624	3380	1745.5	1751.3	1751.3	1753.4	0.0143	12.3	317.0	78.7	0.99	9939.8	10018.5
5.551	3380	1740.9	1746.3	1746.0	1747.4	0.0102	9.9	437.2	135.5	0.83	9892.2	10027.7
5.508	3380	1736.8	1743.2	1743.2	1744.9	0.0108	10.8	357.1	113.4	0.86	9967.1	10080.5

Table 4-10 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 2

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
5.460	3380	1734.0	1740.4	1739.7	1741.5	0.0075	8.8	417.9	133.9	0.72	9945.6	10079.6
5.364	3380	1729.3	1734.4	1734.4	1736.2	0.0155	10.7	317.1	92.3	1.00	9960.9	10053.2
5.304	3380	1725.0	1731.9	1730.4	1732.6	0.0044	7.3	562.6	148.0	0.56	9895.1	10043.1
5.266	3380	1722.8	1729.1	1729.1	1731.1	0.0126	11.9	321.7	85.5	0.94	9930.9	10016.4
5.172	3380	1717.1	1723.1	1723.1	1724.7	0.0123	10.7	355.7	116.0	0.91	9967.9	10083.9
5.114	3380	1713.7	1720.3	1719.5	1721.5	0.0075	9.6	409.0	98.2	0.74	9974.2	10072.3
5.079	3380	1711.6	1717.7	1717.7	1719.7	0.0130	12.1	325.5	84.6	0.95	9976.5	10061.0
4.974	3380	1704.6	1711.3	1708.8	1711.9	0.0032	5.9	575.2	158.2	0.44	9970.6	10128.9
4.939	4420	1701.6	1708.9	1708.9	1710.7	0.0103	11.9	478.1	130.4	0.87	9889.7	10020.1
4.884	4420	1697.1	1703.9	1703.9	1705.9	0.0124	11.9	416.7	106.8	0.93	9909.3	10016.1
4.784	4420	1688.6	1695.6	1695.6	1697.9	0.0131	12.8	390.0	89.5	0.98	9955.1	10044.5
4.692	4420	1681.9	1688.8	1688.8	1691.0	0.0128	12.1	378.8	101.2	0.96	9942.9	10044.1
4.640	4420	1678.9	1686.1	1686.1	1687.9	0.0092	11.4	495.5	151.3	0.83	9880.7	10032.0
4.600	4420	1673.5	1682.7	1682.7	1685.1	0.0103	13.0	416.2	109.4	0.87	9983.8	10093.1
4.502	4420	1667.1	1673.9	1673.1	1675.3	0.0114	10.4	498.7	109.2	0.75	9949.1	10058.4
4.430	4420	1661.7	1668.7	1668.1	1670.4	0.0154	10.3	428.9	96.8	0.83	9923.4	10020.2
4.391	4420	1657.5	1665.0	1664.8	1667.0	0.0159	11.9	416.9	97.6	0.87	9973.4	10071.0
4.365	4420	1656.0	1663.4	1662.8	1665.0	0.0139	10.4	448.7	102.7	0.80	9974.0	10076.7
4.332	4420	1652.7	1660.4	1660.4	1662.6	0.0119	12.9	400.1	93.2	0.95	9948.4	10041.6
4.286	4420	1650.6	1657.0	1656.7	1658.9	0.0104	11.4	419.3	92.0	0.87	9939.8	10031.9
4.199	4420	1645.4	1651.9	1651.9	1653.9	0.0114	11.8	417.8	108.3	0.90	9981.3	10089.6
4.102	4420	1640.3	1646.7	1646.7	1648.1	0.0094	10.1	541.8	197.2	0.81	9973.6	10170.8
4.072	4420	1638.7	1644.9	1644.5	1646.0	0.0080	8.9	572.4	247.7	0.75	9890.8	10138.5
4.013	4420	1634.3	1641.4	1641.4	1643.0	0.0111	10.5	481.4	173.2	0.87	9844.5	10017.7
3.961	4420	1631.7	1637.7	1637.5	1639.2	0.0104	10.0	485.7	161.9	0.85	9864.2	10026.1

Table 4-10 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 2

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
3.923	4420	1629.0	1635.8	1635.2	1637.2	0.0088	9.6	479.9	142.0	0.78	9928.5	10070.5
3.874	4420	1626.7	1634.4	1633.6	1635.2	0.0055	7.1	701.7	209.9	0.61	9968.9	10178.8
3.825	4420	1621.5	1630.7	1629.8	1632.6	0.0092	12.5	419.9	72.0	0.82	9946.0	10018.0
3.770	4420	1618.1	1626.0	1626.0	1629.2	0.0146	14.4	308.4	50.0	1.00	9977.8	10027.9
3.725	4420	1616.1	1622.2	1622.0	1624.1	0.0231	12.2	420.6	101.7	1.00	9922.1	10023.8
3.698	4420	1613.7	1621.7	1619.7	1622.3	0.0072	7.1	725.7	145.8	0.55	9865.6	10011.4
3.660	4420	1609.8	1619.2	1617.0	1620.6	0.0080	9.4	473.7	69.3	0.60	9947.9	10017.2
3.643	4420	1609.4	1616.8	1616.8	1619.4	0.0193	13.4	355.5	69.3	0.94	9950.6	10019.9
3.618	4420	1605.3	1614.6	1614.6	1617.2	0.0100	13.4	385.3	85.0	0.88	9965.9	10050.9
3.590	4420	1602.9	1611.3	1610.0	1612.6	0.0059	9.2	501.7	99.1	0.66	9961.2	10065.8
3.523	4420	1599.7	1606.9	1606.9	1609.5	0.0139	12.8	345.9	72.5	0.99	9949.6	10031.8
3.426	4420	1593.3	1600.4	1599.2	1601.6	0.0065	8.7	509.8	106.8	0.68	9937.0	10043.8
3.311	4420	1585.1	1592.8	1592.8	1595.7	0.0144	13.8	319.4	54.8	1.00	9967.7	10022.5
3.211	4420	1577.8	1584.8	1584.3	1586.4	0.0082	10.6	467.7	112.0	0.78	9945.1	10057.1
3.122	4420	1574.1	1582.7	1580.6	1583.8	0.0037	8.6	607.0	123.4	0.55	9932.3	10055.7
3.053	4420	1567.5	1582.7	1576.3	1583.0	0.0008	5.1	1010.2	117.9	0.26	9964.1	10082.0
3.033	4420	1565.3	1577.1	1577.1	1580.8	0.0156	15.4	287.1	40.3	1.01	9976.0	10016.3
3.007	4420	1563.5	1577.2	1574.1	1578.4	0.0037	8.9	523.6	78.4	0.53	9947.2	10026.3
2.976	4420	1560.6	1572.9	1572.9	1577.0	0.0161	16.3	272.2	34.6	1.00	9984.2	10018.8
2.934	4420	1558.9	1569.3	1569.3	1572.5	0.0131	14.4	313.8	53.8	0.97	9973.0	10026.8
2.903	4420	1556.3	1566.7	1566.7	1569.6	0.0144	13.7	323.2	57.5	1.01	9973.3	10030.8
2.892	4420	1548.8	1564.1	1564.1	1567.0	0.0156	13.8	324.4	59.7	0.99	9967.6	10027.3
2.856	4420	1547.2	1558.0	1558.0	1561.2	0.0152	14.4	309.0	51.4	1.00	9959.0	10010.4
2.813	4420	1545.5	1553.8	1553.5	1555.4	0.0083	11.5	531.8	144.6	0.80	9968.4	10113.0
2.718	4420	1541.9	1549.0	1548.6	1551.0	0.0095	11.7	434.3	95.9	0.84	9963.5	10059.3

Table 4-10 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 2

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
2.683	4420	1538.2	1548.7	1546.2	1549.4	0.0032	7.0	726.2	191.0	0.45	9957.1	10148.2
2.656	4420	1535.7	1545.2	1545.2	1547.9	0.0124	13.4	344.0	102.8	0.95	9967.2	10084.8
2.625	4570	1533.9	1540.5	1539.3	1541.3	0.0055	8.3	710.6	167.2	0.64	9950.0	10117.3
2.603	4570	1532.6	1538.7	1538.3	1540.3	0.0120	11.7	496.2	118.9	0.92	9983.2	10102.1
2.521	4570	1526.2	1533.2	1533.1	1534.9	0.0131	12.9	511.2	138.7	0.97	9885.4	10024.1
2.424	4570	1520.8	1527.9	1527.1	1529.4	0.0088	10.0	459.3	98.0	0.79	9966.9	10064.8
2.401	4570	1519.5	1526.4	1525.9	1528.2	0.0099	10.8	429.6	92.2	0.84	9967.5	10059.7
2.319	4570	1513.5	1522.0	1521.4	1523.9	0.0098	11.1	411.0	78.2	0.84	9947.7	10025.9
2.225	4570	1509.2	1516.2	1516.2	1518.5	0.0118	12.5	395.8	91.0	0.93	9936.3	10027.3
2.131	4570	1503.1	1509.8	1509.8	1512.1	0.0115	13.3	414.6	90.0	0.94	9964.8	10054.9
2.034	4570	1496.7	1503.9	1503.4	1505.9	0.0095	11.5	424.2	93.1	0.85	9951.6	10044.7
1.940	4570	1491.5	1497.9	1497.8	1500.1	0.0140	12.1	379.3	86.0	0.99	9954.5	10040.5
1.846	4570	1485.7	1493.4	1492.4	1495.1	0.0073	10.3	450.0	86.2	0.74	9961.1	10047.3
1.818	4570	1484.9	1491.2	1491.2	1493.5	0.0145	12.4	369.5	80.1	1.00	9963.5	10043.6
1.781	4570	1482.1	1488.3	1488.3	1490.5	0.0121	12.0	417.5	115.0	0.93	9983.0	10098.0
1.742	4570	1479.5	1485.5	1485.5	1487.3	0.0151	11.5	467.1	233.2	0.92	9802.5	10035.6
1.677	4570	1475.5	1481.7	1481.1	1483.0	0.0093	9.2	498.2	121.8	0.79	9942.0	10063.8
1.629	4680	1471.2	1478.2	1478.2	1480.2	0.0124	11.4	436.9	125.2	0.93	9979.2	10104.5
1.535	4680	1464.8	1471.5	1471.5	1473.6	0.0128	12.0	429.4	107.1	0.96	9926.8	10033.9
1.481	4680	1459.3	1466.2	1466.2	1469.0	0.0148	13.3	351.2	65.6	1.00	9989.4	10055.0
1.438	4680	1457.9	1463.1	1463.1	1465.3	0.0146	11.9	395.0	91.9	1.00	9968.7	10060.6
1.419	4680	1445.6	1458.4	1458.4	1461.6	0.0104	14.6	366.9	73.7	0.83	9958.1	10031.7
1.363	4680	1442.9	1451.4	1451.4	1454.3	0.0141	13.6	343.3	60.9	1.00	9955.3	10016.3
1.261	4680	1431.1	1439.0	1438.7	1441.0	0.0118	11.4	413.0	88.8	0.91	9965.2	10054.0
1.168	4680	1425.1	1433.3	1433.3	1435.6	0.0101	12.6	446.7	119.1	0.87	9915.6	10034.7

Table 4-10 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 2

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
1.092	4680	1420.6	1433.2	1426.8	1433.4	0.0006	4.4	1191.0	147.5	0.24	9938.2	10085.8
1.052	4680	1412.5	1428.2	1428.2	1432.0	0.0146	16.1	326.4	64.3	0.83	9925.8	10009.3
0.995	4680	1409.6	1417.7	1417.4	1420.1	0.0109	12.3	383.9	69.8	0.90	9962.0	10031.9
0.957	4680	1405.6	1414.3	1414.3	1417.5	0.0139	14.3	326.9	53.0	1.00	9981.3	10034.2
0.916	4680	1402.6	1411.1	1411.1	1414.1	0.0138	13.7	344.0	61.3	0.99	9979.5	10040.8
0.864	4680	1398.1	1405.7	1405.7	1408.4	0.0140	13.2	354.7	67.1	1.00	9969.1	10036.2
0.769	4680	1387.9	1400.6	1399.3	1402.4	0.0087	11.7	496.2	81.8	0.70	9980.2	10062.0
0.745	4680	1388.0	1401.0	1395.2	1401.7	0.0015	6.4	777.3	115.2	0.33	9946.2	10061.3
0.734	4680	1387.0	1397.0	1397.0	1401.1	0.0202	16.2	288.4	36.0	1.00	9982.7	10018.7
0.703	4680	1382.9	1394.0	1390.6	1394.8	0.0026	7.9	676.8	90.4	0.46	9943.3	10033.7
0.650	4680	1375.2	1389.9	1388.3	1392.9	0.0100	13.9	338.5	37.2	0.78	9981.5	10018.7
0.625	4680	1373.6	1389.5	1386.6	1391.6	0.0063	11.7	402.7	41.7	0.64	9984.7	10026.4
0.610	4680	1373.2	1386.4	1386.4	1390.6	0.0162	16.5	283.9	35.2	1.00	9984.6	10019.8
0.589	4680	1371.0	1379.7	1379.7	1382.4	0.0142	13.0	360.5	70.5	1.00	9951.7	10022.2
0.537	4680	1368.7	1377.3	1376.2	1379.0	0.0075	10.6	447.5	76.8	0.75	9974.3	10051.1
0.441	4680	1365.4	1371.8	1371.8	1373.8	0.0148	12.5	448.1	111.4	1.02	9966.8	10078.2
0.348	4680	1362.0	1368.6	1367.3	1369.4	0.0047	8.0	725.8	162.9	0.59	9882.3	10045.1
0.309	4680	1360.7	1367.0	1366.0	1368.2	0.0070	9.3	553.8	118.7	0.72	9929.1	10047.8
0.252	7300	1357.8	1363.9	1363.9	1365.4	0.0106	11.3	940.3	304.4	0.88	9810.5	10114.9
0.205	7300	1356.6	1360.4	1360.2	1361.3	0.0106	7.9	1111.1	545.2	0.81	9801.6	10376.7

Table 4-11

Summary of results for the natural floodplain profile for Unnamed Wash 3

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
4.540	1220	1636.7	1641.1	1640.7	1642.2	0.0129	8.5	147.2	48.8	0.80	9976.8	10025.5
4.464	1220	1631.9	1636.6	1636.2	1637.4	0.0105	7.7	181.5	75.7	0.72	9979.4	10055.1
4.428	1220	1630.7	1635.3	1634.4	1635.7	0.0068	5.5	251.1	92.0	0.53	9932.2	10024.2
4.417	1220	1629.3	1634.1	1634.1	1635.1	0.0173	8.3	181.7	96.1	0.82	9918.4	10014.5
4.399	1220	1626.7	1631.8	1631.7	1633.0	0.0185	8.7	154.6	70.4	0.85	9932.3	10014.9
4.379	1220	1625.7	1629.6	1629.6	1631.0	0.0200	9.4	130.7	46.8	0.97	9976.1	10022.9
4.338	1220	1621.4	1626.1	1625.9	1627.3	0.0144	8.7	145.9	52.8	0.84	9978.6	10031.5
4.289	1220	1617.7	1622.4	1622.0	1623.7	0.0132	8.9	141.1	43.5	0.81	9980.1	10023.6
4.229	1220	1613.1	1618.2	1617.9	1619.3	0.0146	8.2	164.8	75.7	0.77	9979.6	10055.3
4.197	1990	1611.3	1616.8	1615.7	1617.5	0.0081	7.1	319.5	116.1	0.60	9965.0	10081.0
4.177	1990	1609.3	1615.8	1614.8	1616.6	0.0086	7.9	291.7	98.0	0.62	9981.4	10143.3
4.145	1990	1606.3	1612.4	1612.4	1614.4	0.0192	11.5	174.1	44.5	0.99	9972.3	10016.8
4.110	1990	1602.4	1608.1	1607.9	1610.0	0.0163	10.9	185.0	47.0	0.92	9972.8	10019.7
4.013	1990	1594.8	1599.3	1599.2	1600.9	0.0193	10.2	197.7	63.8	0.98	9972.1	10035.9
3.921	1990	1585.1	1591.1	1590.6	1592.9	0.0139	10.8	185.8	40.9	0.86	9982.5	10023.4
3.826	1990	1579.5	1585.3	1584.9	1586.3	0.0117	8.7	261.6	88.6	0.77	9991.6	10080.3
3.731	1990	1573.7	1579.0	1579.0	1580.2	0.0128	9.5	276.6	151.5	0.82	9964.2	10115.8
3.649	1990	1569.5	1574.8	1574.0	1575.5	0.0066	7.1	335.2	115.2	0.60	9955.0	10070.2
3.561	1990	1565.2	1570.5	1570.4	1571.4	0.0119	9.0	293.7	138.3	0.79	9936.0	10074.4
3.520	1990	1562.8	1569.3	1568.1	1569.7	0.0050	5.8	478.3	174.1	0.47	9913.1	10087.2
3.509	1990	1562.0	1569.1	1567.3	1569.4	0.0037	5.1	463.8	198.6	0.41	9895.3	10093.9
3.497	1990	1561.2	1567.6	1567.2	1568.7	0.0115	9.2	288.0	91.7	0.71	9987.8	10079.5
3.487	1990	1560.1	1567.4	1565.2	1568.0	0.0046	6.5	339.4	133.2	0.47	9967.1	10100.3
3.460	1990	1559.1	1565.0	1564.6	1566.5	0.0118	10.0	200.0	49.3	0.86	9986.6	10035.8
3.426	1990	1558.3	1563.9	1562.9	1564.7	0.0068	7.3	274.2	81.5	0.67	9959.0	10040.5

Table 4-11 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 3

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
3.412	1990	1557.8	1562.6	1562.6	1563.9	0.0155	9.6	249.2	101.0	0.89	9929.6	10030.7
3.370	1990	1554.2	1559.4	1559.1	1560.2	0.0104	7.2	332.1	172.8	0.71	9849.5	10022.3
3.351	1990	1553.2	1559.1	1557.2	1559.5	0.0029	5.4	453.6	109.5	0.41	9942.5	10052.0
3.319	1990	1550.8	1558.2	1557.0	1558.8	0.0051	6.9	357.1	103.7	0.52	9990.0	10093.7
3.309	1990	1551.2	1556.5	1556.5	1558.3	0.0138	10.7	193.9	69.5	0.93	9985.0	10054.5
3.257	1990	1547.5	1553.0	1552.9	1554.0	0.0078	8.7	299.3	121.2	0.73	9903.9	10025.1
3.168	2200	1544.1	1548.4	1548.3	1549.2	0.0132	8.3	361.1	166.2	0.81	9973.3	10139.5
3.144	2200	1541.7	1547.4	1547.0	1548.0	0.0073	7.6	456.4	188.4	0.62	9981.8	10170.1
3.114	2200	1540.0	1545.2	1545.2	1546.5	0.0124	9.4	260.6	107.2	0.89	9954.9	10062.1
3.061	2200	1537.6	1543.4	1542.5	1543.8	0.0063	5.9	483.7	177.0	0.52	9861.3	10038.2
3.042	2200	1537.0	1542.9	1541.7	1543.3	0.0052	5.1	518.7	176.4	0.46	9850.7	10027.2
3.015	2200	1535.3	1542.6	1540.3	1542.9	0.0026	4.9	648.9	241.0	0.35	9853.0	10094.0
2.984	2200	1534.3	1539.1	1539.1	1541.0	0.0155	11.2	197.1	51.8	1.00	9975.7	10027.5
2.916	2200	1530.5	1535.1	1535.0	1535.9	0.0101	8.4	393.3	208.6	0.79	9982.2	10190.8
2.850	2200	1527.0	1532.5	1531.7	1533.2	0.0060	7.7	363.0	109.5	0.65	9925.8	10035.3
2.779	2200	1522.7	1529.1	1529.1	1530.4	0.0091	9.7	277.4	117.2	0.79	9928.8	10046.0
2.677	2200	1517.6	1523.7	1523.7	1524.8	0.0082	8.7	314.4	197.0	0.74	9926.8	10123.8
2.581	2200	1513.3	1519.1	1519.1	1520.3	0.0096	9.2	305.4	168.1	0.79	9882.4	10050.6
2.522	2200	1510.9	1516.4	1515.8	1517.3	0.0077	7.6	322.4	147.5	0.71	9974.0	10121.5
2.471	2200	1508.3	1513.6	1513.6	1514.8	0.0111	8.9	301.2	157.0	0.84	9855.6	10012.6
2.421	2200	1505.8	1510.9	1510.3	1511.6	0.0062	7.3	365.4	142.7	0.65	9897.2	10039.9
2.315	2200	1499.8	1506.0	1506.0	1507.3	0.0098	9.8	282.8	185.3	0.81	9981.5	10166.8
2.233	2200	1495.4	1501.2	1501.0	1502.4	0.0102	9.0	276.5	130.1	0.81	9889.7	10019.7
2.118	2200	1488.6	1495.3	1495.3	1496.4	0.0097	8.9	342.3	179.6	0.71	9984.1	10163.7
2.050	2200	1487.1	1491.8	1491.3	1492.5	0.0096	7.8	357.0	175.7	0.71	9915.4	10091.2

Table 4-11 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 3

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
2.011	2200	1482.5	1488.8	1488.5	1490.2	0.0127	9.6	263.8	92.8	0.82	9937.1	10029.9
1.973	2200	1480.3	1487.2	1486.4	1488.1	0.0076	7.8	323.7	97.1	0.64	9980.9	10077.9
1.944	2200	1480.0	1484.7	1484.7	1486.5	0.0150	10.5	210.1	62.0	0.98	9979.0	10041.1
1.872	2200	1475.7	1480.9	1480.2	1482.0	0.0087	8.5	258.8	67.1	0.76	9962.8	10029.9
1.784	2200	1470.7	1475.9	1475.5	1477.3	0.0116	9.6	228.7	60.6	0.87	9960.5	10021.1
1.690	2200	1465.9	1472.4	1470.9	1473.3	0.0055	7.8	284.2	61.2	0.62	9954.7	10015.9
1.641	2570	1464.3	1469.6	1469.6	1471.2	0.0120	10.6	293.1	107.7	0.90	9914.4	10022.1
1.600	2570	1463.0	1467.2	1466.8	1468.2	0.0092	8.0	355.2	148.5	0.76	9868.7	10017.2
1.563	2570	1460.5	1464.3	1464.3	1465.7	0.0222	10.4	283.8	119.7	1.14	9917.4	10037.1
1.537	2570	1452.8	1460.3	1460.3	1462.4	0.0129	12.0	232.0	60.5	0.94	9977.9	10038.4
1.519	2570	1449.9	1457.7	1457.7	1460.1	0.0152	12.5	206.0	44.2	1.00	9984.8	10029.0
1.497	2570	1448.8	1456.4	1455.7	1458.1	0.0093	10.4	250.0	51.8	0.80	9977.3	10029.0
1.481	2570	1447.7	1454.8	1454.8	1457.1	0.0142	12.3	214.7	48.2	0.98	9963.0	10011.2
1.425	2570	1440.7	1449.1	1447.8	1450.5	0.0221	9.7	266.2	48.4	0.71	9977.8	10026.3
1.385	2570	1433.0	1441.7	1441.7	1444.3	0.0400	13.1	203.9	43.6	0.94	9988.9	10032.6
1.356	2570	1429.8	1437.5	1435.6	1438.3	0.0109	7.4	369.2	73.5	0.53	9973.7	10047.2
1.331	2570	1427.7	1436.0	1434.4	1436.8	0.0126	7.5	371.4	77.2	0.55	9942.0	10019.2
1.304	2570	1426.1	1433.1	1432.0	1434.6	0.0173	9.6	267.2	50.8	0.73	9982.1	10032.9
1.259	2570	1417.9	1426.8	1426.8	1429.1	0.0306	12.7	219.4	50.2	0.96	9978.6	10028.7
1.222	2570	1405.2	1416.3	1416.3	1418.8	0.0310	13.2	207.7	41.6	0.93	9975.3	10016.9
1.171	2570	1404.8	1413.3	1410.4	1413.9	0.0058	6.3	411.7	68.1	0.44	9966.7	10034.9
1.152	2570	1402.7	1411.4	1409.9	1412.9	0.0155	9.9	261.3	43.6	0.69	9971.6	10015.2
1.088	2570	1400.2	1407.2	1406.5	1408.8	0.0098	10.2	255.8	54.4	0.80	9985.8	10040.2
1.008	2570	1392.7	1401.4	1400.6	1403.2	0.0185	10.8	238.5	43.9	0.80	9983.8	10027.7
0.986	2570	1392.6	1400.3	1398.7	1401.4	0.0106	8.6	303.3	56.5	0.63	9973.7	10030.2

Table 4-11 (continued)

Summary of results for the natural floodplain profile for Unnamed Wash 3

River Station miles	100-Year Peak Discharge cfs	Minimum Channel Elevation feet	Water Surface Elevation feet	Critical W.S. Elevation feet	Energy Gradeline Elevation feet	Energy Gradeline Slope ft/ft	Channel Velocity fps	Flow Area sq. feet	Top Width feet	Froude # Channel	Water Surface Start and End Stations Left feet	Water Surface Start and End Stations Right feet
0.960	2570	1390.6	1397.2	1397.2	1399.3	0.0232	12.2	242.8	59.3	0.91	9950.5	10009.8
0.928	2570	1387.4	1394.4	1392.9	1395.4	0.0054	7.9	326.1	63.6	0.61	9983.1	10046.7
0.852	2570	1383.9	1389.8	1389.8	1391.9	0.0151	11.7	221.0	53.7	1.00	9972.3	10026.0
0.761	2570	1378.4	1384.8	1384.3	1385.8	0.0095	8.9	357.3	106.8	0.72	9911.3	10018.1
0.734	2570	1376.2	1382.8	1382.3	1384.3	0.0114	10.2	281.7	68.0	0.79	9956.6	10024.6
0.716	2570	1375.6	1382.3	1381.0	1383.3	0.0076	8.2	317.3	72.2	0.65	9957.1	10029.3
0.695	2570	1370.8	1379.2	1379.2	1382.0	0.0182	13.4	195.5	37.7	0.98	9977.5	10015.2
0.658	2570	1368.5	1376.2	1375.5	1377.8	0.0091	10.0	262.6	57.3	0.79	9952.5	10009.9
0.625	2570	1367.1	1373.8	1373.8	1375.6	0.0178	11.4	267.7	76.8	0.88	9941.3	10018.1
0.598	2570	1365.2	1372.1	1370.3	1373.0	0.0076	7.6	338.2	65.1	0.58	9967.9	10033.0
0.583	2570	1364.3	1371.7	1369.6	1372.4	0.0054	6.5	394.8	75.9	0.50	9974.9	10050.8
0.565	2570	1363.3	1369.2	1369.2	1371.5	0.0146	12.0	217.6	53.1	0.99	9980.9	10034.0
0.520	2570	1359.4	1365.5	1365.5	1367.5	0.0157	11.5	223.9	56.2	1.01	9971.5	10027.7
0.481	2570	1357.1	1363.6	1362.6	1364.8	0.0078	8.8	292.5	65.9	0.73	9973.8	10039.7
0.386	2570	1351.9	1358.1	1357.9	1360.0	0.0116	11.2	250.3	68.6	0.90	9978.9	10047.6
0.306	2570	1348.0	1353.4	1353.4	1354.7	0.0124	9.8	314.8	138.4	0.90	9886.2	10024.7
0.240	2570	1343.6	1349.3	1348.7	1349.8	0.0080	6.8	493.5	296.3	0.70	9815.6	10111.9
0.185	2570	1337.3	1344.2	1344.2	1345.8	0.0161	10.4	246.8	76.2	1.01	9968.0	10044.2
0.144	2570	1335.0	1340.7	1340.5	1342.6	0.0134	11.1	236.2	58.6	0.94	9982.9	10041.5

Table 4-12

Summary of results for the floodway profile for Unnamed Wash 1

River Station miles	Water Surface Elevation (WSEL) Floodplain feet	Water Surface Elevation (WSEL) Floodway feet	Energy Grade Line Elevation (EGL) Floodplain feet	Energy Grade Line Elevation (EGL) Floodway feet	Surcharge WSEL feet	Surcharge EGL feet	Floodway Encroachment Station Left feet	Floodway Encroachment Station Right feet
6.311	1797.4	1797.4	1798.7	1798.7	0.0	0.0	9986.5	10021.6
6.216	1789.9	1789.9	1790.5	1790.5	0.0	0.0	9944.2	10042.0
6.100	1780.4	1780.4	1781.3	1781.3	0.0	0.0	9979.2	10045.2
6.015	1771.0	1771.0	1772.1	1772.1	0.0	0.0	9976.8	10018.8
5.969	1768.4	1768.7	1768.6	1769.0	0.3	0.4	9922.0	10019.4
5.917	1765.2	1765.1	1766.2	1766.2	-0.1	0.0	9987.8	10028.2
5.862	1760.1	1760.1	1761.5	1761.5	0.0	0.0	9974.8	10023.4
5.746	1751.9	1752.0	1752.5	1752.6	0.1	0.1	9940.0	10023.5
5.632	1745.9	1746.0	1746.9	1746.9	0.1	0.0	9966.1	10015.5
5.505	1737.6	1737.6	1738.7	1738.7	0.0	0.0	9980.0	10035.7
5.439	1731.4	1731.5	1732.7	1732.7	0.1	0.0	9980.7	10157.7
5.380	1725.7	1725.8	1726.0	1726.3	0.1	0.3	9987.7	10062.4
5.310	1720.7	1721.1	1722.2	1722.3	0.4	0.1	9981.8	10022.3
5.227	1715.8	1715.8	1716.5	1716.7	0.0	0.2	9955.0	10027.2
5.207	1715.3	1715.3	1715.7	1715.7	0.0	0.0	9968.1	10051.8
5.176	1712.9	1713.0	1714.4	1714.4	0.1	0.0	9983.6	10033.7
5.096	1707.1	1707.1	1708.2	1708.2	0.0	0.0	9980.2	10028.7
5.007	1702.8	1702.8	1703.7	1703.7	0.0	0.0	9975.4	10057.7
4.920	1698.2	1698.8	1699.3	1699.9	0.6	0.6	9980.3	10018.3
4.879	1696.8	1697.0	1697.2	1697.8	0.2	0.6	9979.8	10075.0
4.839	1694.8	1695.2	1695.7	1696.1	0.4	0.4	9978.3	10070.0
4.725	1687.7	1687.9	1688.5	1689.2	0.2	0.7	9966.8	10020.0
4.628	1681.9	1681.9	1682.1	1682.1	0.0	0.0	9957.1	10045.5
4.613	1680.8	1680.9	1681.7	1681.8	0.1	0.1	9952.2	10067.1
4.536	1676.2	1676.5	1678.2	1678.4	0.3	0.2	9983.3	10027.1

Table 4-12 (continued)

Summary of results for the floodway profile for Unnamed Wash 1

River Station miles	Water Surface Elevation (WSEL) Floodplain feet	Water Surface Elevation (WSEL) Floodway feet	Energy Grade Line Elevation (EGL) Floodplain feet	Energy Grade Line Elevation (EGL) Floodway feet	Surcharge WSEL feet	Surcharge EGL feet	Floodway Encroachment Station Left feet	Floodway Encroachment Station Right feet
4.170	1654.0	1654.2	1655.5	1655.5	0.2	0.0	9983.6	10083.9
4.077	1649.8	1650.1	1650.5	1651.1	0.3	0.6	9925.0	10021.4
3.987	1645.1	1646.1	1646.3	1647.3	1.0	1.0	9977.4	10050.0
3.895	1642.9	1642.9	1643.2	1643.7	0.0	0.5	9973.5	10062.2
3.803	1642.1	1642.1	1642.3	1642.4	0.0	0.1	9961.9	10053.6
3.706	1642.1	1642.1	1642.2	1642.2	0.0	0.0	9770.8	10040.6
3.671	1642.1	1642.1	1642.2	1642.2	0.0	0.0	9752.1	10120.1
3.643	1642.1	1642.1	1642.2	1642.2	0.0	0.0	9749.8	10157.3
3.631	Inline Weir							
3.617	1626.2	1626.2	1627.1	1627.1	0.0	0.0	9838.8	10013.5
3.577	1623.6	1624.1	1624.4	1624.7	0.5	0.3	9921.0	10050.7
3.515	1619.6	1619.8	1621.1	1621.9	0.2	0.8	9967.6	10016.0
3.453	1616.2	1616.3	1617.1	1617.3	0.1	0.2	9973.4	10034.5
3.366	1611.3	1611.3	1613.0	1613.0	0.0	0.0	9961.7	10028.0
3.274	1604.7	1605.3	1606.4	1606.6	0.6	0.2	9973.7	10028.3
3.186	1601.1	1601.5	1602.1	1602.8	0.4	0.7	9967.4	10048.3
3.121	1597.8	1598.7	1598.5	1599.4	0.9	0.9	9945.0	10024.9
3.073	1594.1	1594.6	1594.6	1595.6	0.5	1.0	9969.5	10047.3
3.015	1588.4	1588.4	1589.8	1589.8	0.0	0.0	9951.5	10033.8
2.923	1581.8	1581.8	1582.9	1582.9	0.0	0.0	9969.1	10035.3
2.880	1577.9	1577.9	1579.5	1579.5	0.0	0.0	9988.0	10058.0
2.848	1574.8	1574.8	1576.1	1576.1	0.0	0.0	9974.1	10082.8
2.813	1571.4	1571.4	1572.8	1572.8	0.0	0.0	9938.2	10009.4
2.770	1568.7	1568.7	1569.7	1569.7	0.0	0.0	9967.0	10051.2
2.674	1561.8	1561.9	1563.2	1563.3	0.1	0.1	9953.2	10012.9

Table 4-12 (continued)

Summary of results for the floodway profile for Unnamed Wash 1

River Station miles	Water Surface Elevation (WSEL) Floodplain feet	Water Surface Elevation (WSEL) Floodway feet	Energy Grade Line Elevation (EGL) Floodplain feet	Energy Grade Line Elevation (EGL) Floodway feet	Surcharge WSEL feet	Surcharge EGL feet	Floodway Encroachment Station Left feet	Floodway Encroachment Station Right feet
2.347	1537.1	1537.5	1537.6	1537.9	0.4	0.3	9994.7	10163.1
2.312	1533.5	1534.2	1534.8	1535.7	0.7	0.9	9911.6	10035.2
2.230	1527.8	1528.5	1528.4	1529.3	0.7	0.9	9931.9	10030.3
2.134	1520.2	1520.1	1521.9	1521.8	-0.1	-0.1	9945.7	10012.6
2.047	1509.8	1509.9	1511.9	1511.9	0.1	0.0	9970.4	10040.4
1.992	1504.1	1504.1	1504.8	1504.8	0.0	0.0	9958.4	10054.5
1.928	1499.3	1499.3	1501.0	1501.0	0.0	0.0	9981.5	10034.1
1.862	1494.4	1494.4	1495.7	1495.7	0.0	0.0	9976.4	10029.5
1.768	1486.7	1486.7	1488.2	1488.2	0.0	0.0	9964.0	10022.7
1.709	1484.0	1484.0	1484.8	1484.8	0.0	0.0	9968.0	10054.4
1.675	1482.4	1482.4	1483.4	1483.4	0.0	0.0	9979.7	10052.8
1.637	1476.8	1476.8	1480.0	1480.0	0.0	0.0	9983.7	10017.0
1.621	1474.6	1474.6	1476.3	1476.3	0.0	0.0	9967.8	10025.4
1.590	1473.3	1473.3	1474.3	1474.3	0.0	0.0	9968.5	10034.5
1.479	1465.7	1465.7	1467.4	1467.4	0.0	0.0	9983.4	10040.8
1.398	1454.0	1454.1	1457.6	1457.6	0.1	0.0	9988.2	10018.4
1.374	1449.4	1449.4	1452.3	1452.3	0.0	0.0	9990.8	10030.6
1.367	1441.2	1441.2	1444.4	1444.4	0.0	0.0	9981.1	10012.6
1.286	1428.4	1428.4	1430.3	1430.3	0.0	0.0	9976.4	10018.4
1.208	1419.9	1419.9	1422.4	1422.4	0.0	0.0	9970.6	10021.4
1.116	1414.8	1414.8	1416.1	1416.1	0.0	0.0	9982.0	10029.1
1.010	1405.9	1405.9	1409.2	1409.2	0.0	0.0	9986.8	10013.1
0.914	1399.5	1399.5	1401.1	1401.1	0.0	0.0	9976.1	10021.4
0.850	1396.0	1396.0	1397.4	1397.4	0.0	0.0	9978.1	10032.3
0.819	1394.7	1394.7	1395.7	1395.7	0.0	0.0	9966.2	10036.7

Table 4-12 (continued)

Summary of results for the floodway profile for Unnamed Wash 1

River Station miles	Water Surface Elevation (WSEL) Floodplain feet	Water Surface Elevation (WSEL) Floodway feet	Energy Grade Line Elevation (EGL) Floodplain feet	Energy Grade Line Elevation (EGL) Floodway feet	Surcharge WSEL feet	Surcharge EGL feet	Floodway Encroachment Station Left feet	Floodway Encroachment Station Right feet
0.523	1379.8	1380.7	1381.6	1381.9	0.9	0.3	9976.6	10069.3
0.484	1379.0	1379.6	1379.8	1380.8	0.6	1.0	9959.1	10017.7
0.453	1378.0	1378.4	1379.0	1379.9	0.4	0.9	9961.2	10019.6
0.414	1377.3	1377.6	1377.9	1378.5	0.3	0.6	9952.8	10023.6
0.356	1376.1	1377.0	1376.6	1377.4	0.9	0.8	9970.0	10107.7
0.323	1373.2	1373.6	1375.1	1376.0	0.4	0.9	9980.5	10037.9
0.238	1370.2	1371.0	1370.5	1371.3	0.8	0.8	9985.3	10140.2
0.190	1369.7	1370.5	1370.0	1370.9	0.8	0.9	9966.4	10090.4
0.141	1368.3	1369.2	1369.2	1370.1	0.9	0.9	9930.0	10011.7
0.046	1367.6	1368.5	1367.8	1368.8	0.9	1.0	9932.0	10044.8

Table 4-13

Summary of results for the floodway profile for Unnamed Wash 2

River	Water Surface Elevation (WSEL)		Energy Grade Line Elevation (EGL)		Surcharge		Floodway Encroachment Station	
Station miles	Floodplain feet	Floodway feet	Floodplain feet	Floodway feet	WSEL feet	EGL feet	Left feet	Right feet
6.789	1845.2	1845.2	1846.1	1846.1	0.0	0.0	9974.7	10037.7
6.765	1843.6	1843.6	1845.0	1845.0	0.0	0.0	9971.1	10015.7
6.714	1839.3	1839.4	1841.9	1841.9	0.1	0.0	9984.3	10014.7
6.669	1833.2	1833.3	1834.9	1834.9	0.1	0.0	9987.5	10042.8
6.643	1830.5	1831.3	1831.7	1831.9	0.8	0.2	9922.9	10028.9
6.595	1826.9	1826.9	1828.0	1829.0	0.0	1.0	9984.4	10023.6
6.570	1824.0	1824.1	1825.9	1825.9	0.1	0.0	9971.1	10014.6
6.501	1817.8	1818.2	1819.0	1820.0	0.4	1.0	9982.9	10024.6
6.451	1813.9	1814.2	1814.9	1815.9	0.3	1.0	9966.3	10018.8
6.418	1810.5	1811.0	1811.6	1812.3	0.5	0.7	9960.1	10029.9
6.392	1808.1	1808.6	1809.0	1809.9	0.5	0.9	9953.4	10026.1
6.318	1803.0	1804.0	1803.5	1804.4	1.0	0.9	9911.3	10014.3
6.271	1800.6	1800.9	1801.2	1802.2	0.3	1.0	9959.7	10020.6
6.218	1796.5	1796.5	1798.0	1798.0	0.0	0.0	9969.9	10031.0
6.161	1792.9	1792.9	1793.5	1793.5	0.0	0.0	9792.5	10012.7
6.058	1786.3	1786.4	1787.7	1787.7	0.1	0.0	9896.2	10022.1
5.974	1781.6	1782.2	1782.5	1783.2	0.6	0.7	9956.4	10032.6
5.927	1778.3	1778.4	1780.2	1780.8	0.1	0.6	9984.1	10041.9
5.865	1773.6	1773.7	1775.2	1775.7	0.1	0.5	9948.8	10036.7
5.845	1768.2	1767.9	1770.2	1770.2	-0.3	0.0	9990.0	10055.0
5.759	1758.8	1758.8	1761.1	1761.1	0.0	0.0	9972.4	10033.0
5.702	1756.0	1756.1	1756.9	1757.5	0.1	0.6	9964.7	10033.0
5.624	1751.3	1751.4	1753.4	1753.4	0.1	0.0	9939.8	10018.5
5.551	1746.3	1746.2	1747.4	1747.4	-0.1	0.0	9892.2	10027.7
5.508	1743.2	1743.3	1744.9	1744.9	0.1	0.0	9967.1	10080.5
5.172	1723.1	1723.4	1724.7	1725.2	0.3	0.5	9967.9	10036.6

Table 4-13 (continued)

Summary of results for the floodway profile for Unnamed Wash 2

River	Water Surface Elevation (WSEL)		Energy Grade Line Elevation (EGL)		Surcharge		Floodway Encroachment Station	
Station miles	Floodplain feet	Floodway feet	Floodplain feet	Floodway feet	WSEL feet	EGL feet	Left feet	Right feet
5.114	1720.3	1721.1	1721.5	1722.5	0.8	1.0	9974.2	10036.0
5.079	1717.7	1718.1	1719.7	1720.7	0.4	1.0	9976.5	10026.3
4.974	1711.3	1712.3	1711.9	1712.7	1.0	0.8	9970.6	10072.8
4.939	1709.0	1709.0	1710.7	1711.6	0.0	0.9	9951.7	10020.1
4.884	1703.9	1704.0	1705.9	1706.6	0.1	0.7	9949.6	10016.1
4.784	1695.7	1696.1	1697.9	1699.0	0.4	1.1	9984.5	10044.5
4.692	1688.8	1688.7	1691.0	1691.1	-0.1	0.1	9970.4	10044.1
4.640	1686.1	1686.2	1687.9	1687.9	0.1	0.0	9880.7	10032.0
4.600	1682.7	1683.0	1685.1	1685.1	0.3	0.0	9983.8	10093.1
4.502	1673.9	1673.8	1675.3	1676.2	-0.1	0.9	9979.1	10039.0
4.430	1668.7	1669.3	1670.4	1670.6	0.6	0.2	9923.4	10020.2
4.391	1665.0	1665.2	1667.0	1667.6	0.2	0.6	9973.4	10039.0
4.365	1663.4	1663.2	1665.0	1665.1	-0.2	0.1	9974.0	10053.7
4.332	1660.4	1660.4	1662.6	1662.6	0.0	0.0	9948.4	10041.6
4.286	1657.0	1657.5	1658.9	1659.6	0.5	0.7	9965.2	10031.9
4.199	1651.9	1652.1	1653.9	1654.4	0.2	0.5	9981.3	10047.4
4.102	1646.7	1646.7	1648.1	1648.3	0.0	0.2	9973.6	10117.9
4.072	1644.9	1645.1	1646.0	1646.2	0.2	0.2	9938.8	10075.0
4.013	1641.4	1641.3	1643.0	1643.1	-0.1	0.1	9888.0	10017.7
3.961	1637.7	1637.7	1639.2	1639.4	0.0	0.2	9928.1	10026.1
3.923	1635.8	1636.2	1637.3	1637.4	0.4	0.1	9968.9	10070.5
3.874	1634.4	1634.3	1635.2	1635.4	-0.1	0.2	9968.9	10099.3
3.825	1630.7	1630.6	1632.6	1632.6	-0.1	0.0	9946.0	10018.0
3.770	1626.0	1626.0	1629.2	1629.2	0.0	0.0	9977.8	10027.9
3.725	1622.2	1622.2	1624.1	1624.1	0.0	0.0	9922.1	10023.8
3.590	1611.3	1611.3	1612.6	1612.6	0.0	0.0	9961.2	10065.8

Table 4-13 (continued)

Summary of results for the floodway profile for Unnamed Wash 2

River	Water Surface Elevation (WSEL)		Energy Grade Line Elevation (EGL)		Surcharge		Floodway Encroachment Station	
Station miles	Floodplain feet	Floodway feet	Floodplain feet	Floodway feet	WSEL feet	EGL feet	Left feet	Right feet
3.523	1606.9	1606.9	1609.5	1609.5	0.0	0.0	9949.6	10031.8
3.426	1600.4	1600.4	1601.6	1601.6	0.0	0.0	9937.0	10043.8
3.311	1592.8	1592.8	1595.7	1595.7	0.0	0.0	9967.7	10022.5
3.211	1584.8	1584.8	1586.4	1586.7	0.0	0.3	9945.1	10026.6
3.122	1582.7	1582.7	1583.8	1583.8	0.0	0.0	9932.3	10026.5
3.053	1582.7	1582.6	1583.0	1583.0	-0.1	0.0	9964.2	10061.0
3.033	1577.1	1577.2	1580.8	1580.8	0.1	0.0	9976.0	10016.3
3.007	1577.2	1577.2	1578.4	1578.4	0.0	0.0	9947.2	10026.3
2.976	1572.9	1572.9	1577.0	1577.0	0.0	0.0	9984.2	10018.8
2.934	1569.3	1569.4	1572.5	1572.5	0.1	0.0	9973.0	10026.8
2.903	1566.7	1566.7	1569.6	1569.6	0.0	0.0	9973.3	10030.8
2.892	1564.1	1564.1	1567.0	1567.0	0.0	0.0	9967.6	10027.3
2.856	1558.0	1558.1	1561.2	1561.2	0.1	0.0	9959.0	10010.4
2.813	1553.8	1554.0	1555.4	1556.3	0.2	0.9	9968.5	10034.9
2.718	1549.0	1548.9	1551.0	1551.2	-0.1	0.2	9963.5	10034.8
2.683	1548.7	1548.6	1549.4	1549.4	-0.1	0.0	9957.2	10070.1
2.656	1545.2	1545.2	1547.9	1547.9	0.0	0.0	9967.2	10084.8
2.625	1540.5	1541.3	1541.3	1542.1	0.8	0.8	9950.0	10080.1
2.603	1538.7	1538.8	1540.3	1541.1	0.1	0.8	9983.2	10071.0
2.521	1533.2	1533.2	1534.9	1534.9	0.0	0.0	9885.4	10024.1
2.424	1527.9	1527.9	1529.4	1529.4	0.0	0.0	9966.9	10064.8
2.401	1526.4	1526.5	1528.2	1528.2	0.1	0.0	9967.5	10059.7
2.319	1522.0	1522.0	1523.9	1523.9	0.0	0.0	9947.7	10025.9
2.225	1516.2	1516.2	1518.5	1518.5	0.0	0.0	9936.3	10027.3
1.818	1491.2	1491.2	1493.5	1493.5	0.0	0.0	9963.5	10043.6
1.781	1488.3	1488.3	1490.5	1490.7	0.0	0.2	9983.0	10054.5

Table 4-13 (continued)

Summary of results for the floodway profile for Unnamed Wash 2

River	Water Surface Elevation (WSEL)		Energy Grade Line Elevation (EGL)		Surcharge		Floodway Encroachment Station	
Station miles	Floodplain feet	Floodway feet	Floodplain feet	Floodway feet	WSEL feet	EGL feet	Left feet	Right feet
1.742	1485.5	1485.5	1487.3	1487.3	0.0	0.0	9920.0	10035.6
1.677	1481.7	1481.8	1483.0	1483.0	0.1	0.0	9942.0	10063.8
1.629	1478.2	1478.3	1480.2	1480.3	0.1	0.1	9979.3	10066.0
1.535	1471.5	1471.7	1473.6	1473.9	0.2	0.3	9926.8	10018.3
1.481	1466.2	1466.3	1469.0	1469.0	0.1	0.0	9989.4	10055.0
1.438	1463.1	1463.1	1465.3	1465.3	0.0	0.0	9968.7	10060.6
1.419	1458.4	1458.5	1461.6	1461.6	0.1	0.0	9958.1	10031.7
1.363	1451.4	1451.4	1454.3	1454.3	0.0	0.0	9955.3	10016.3
1.261	1439.0	1438.8	1441.0	1441.0	-0.2	0.0	9965.2	10054.0
1.168	1433.3	1433.5	1435.6	1435.5	0.2	-0.1	9915.6	10034.7
1.092	1433.2	1433.2	1433.4	1433.5	0.0	0.1	9938.2	10085.8
1.052	1428.2	1428.2	1432.0	1432.0	0.0	0.0	9925.8	10009.3
0.995	1417.7	1417.7	1420.1	1420.1	0.0	0.0	9962.0	10031.9
0.957	1414.3	1414.3	1417.5	1417.5	0.0	0.0	9981.3	10034.2
0.916	1411.2	1411.2	1414.1	1414.1	0.0	0.0	9979.5	10040.8
0.864	1405.7	1405.9	1408.4	1408.4	0.2	0.0	9969.1	10036.2
0.769	1400.6	1400.5	1402.4	1402.6	-0.1	0.2	9980.2	10037.3
0.745	1401.0	1401.1	1401.7	1401.7	0.1	0.0	9946.2	10027.5
0.734	1397.0	1397.0	1401.1	1401.1	0.0	0.0	9982.7	10018.7
0.703	1394.0	1393.8	1394.8	1395.1	-0.2	0.3	9976.7	10033.7
0.650	1389.9	1389.9	1392.9	1392.9	0.0	0.0	9981.5	10018.7
0.625	1389.5	1389.5	1391.6	1391.6	0.0	0.0	9984.7	10026.4
0.610	1386.4	1386.4	1390.6	1390.6	0.0	0.0	9984.6	10019.8
0.589	1379.7	1379.8	1382.4	1382.4	0.1	0.0	9951.7	10022.2
0.252	1363.9	1364.2	1365.4	1366.1	0.3	0.7	9884.4	10069.8
0.205	1360.4	1360.7	1361.3	1361.7	0.3	0.4	9835.2	10117.8

Table 4-14

Summary of results for the floodway profile for Unnamed Wash 3

River Station miles	Water Surface Elevation (WSEL) Floodplain feet	Water Surface Elevation (WSEL) Floodway feet	Energy Grade Line Elevation (EGL) Floodplain feet	Energy Grade Line Elevation (EGL) Floodway feet	Surcharge WSEL feet	Surcharge EGL feet	Floodway Encroachment Station Left feet	Floodway Encroachment Station Right feet
4.540	1641.1	1641.3	1642.2	1642.3	0.2	0.1	9976.8	10025.5
4.464	1636.6	1636.9	1637.4	1637.9	0.3	0.5	9979.4	10019.7
4.428	1635.3	1635.6	1635.7	1636.1	0.3	0.4	9960.0	10024.2
4.417	1634.1	1634.3	1635.1	1635.4	0.2	0.3	9945.0	10014.5
4.399	1631.8	1631.8	1633.0	1633.1	0.0	0.1	9940.0	10014.9
4.379	1629.7	1629.7	1631.0	1631.0	0.0	0.0	9976.1	10022.9
4.338	1626.1	1626.1	1627.3	1627.3	0.0	0.0	9978.6	10031.5
4.289	1622.5	1622.5	1623.7	1623.7	0.0	0.0	9980.1	10023.6
4.229	1618.3	1618.6	1619.3	1619.6	0.3	0.3	9984.4	10025.2
4.197	1616.8	1617.5	1617.5	1618.2	0.7	0.7	9971.9	10032.6
4.177	1615.8	1615.8	1616.6	1617.2	0.0	0.6	9981.4	10027.5
4.145	1612.4	1612.4	1614.4	1614.4	0.0	0.0	9972.3	10016.8
4.110	1608.1	1608.1	1610.0	1610.0	0.0	0.0	9972.8	10019.7
4.013	1599.3	1599.3	1600.9	1600.9	0.0	0.0	9972.1	10035.9
3.921	1591.1	1591.4	1592.9	1593.0	0.3	0.1	9982.5	10023.4
3.826	1585.3	1586.0	1586.3	1587.2	0.7	0.9	9991.6	10040.0
3.731	1579.0	1579.4	1580.2	1581.0	0.4	0.8	9982.2	10028.0
3.649	1574.8	1575.5	1575.5	1576.4	0.7	0.9	9981.1	10032.2
3.561	1570.5	1570.9	1571.5	1572.2	0.4	0.7	9975.0	10045.0
3.520	1569.3	1569.9	1569.7	1570.4	0.6	0.7	9970.0	10065.0
3.509	1569.1	1569.7	1569.4	1570.1	0.6	0.7	9976.5	10060.0
3.497	1567.6	1567.6	1568.7	1569.1	0.0	0.4	9987.8	10058.0
3.487	1567.4	1567.4	1568.0	1568.2	0.0	0.2	9978.5	10025.6
3.460	1565.0	1565.0	1566.5	1566.5	0.0	0.0	9986.6	10035.8
3.426	1563.9	1564.3	1564.7	1565.0	0.4	0.3	9959.0	10040.5

Table 4-14 (continued)

Summary of results for the floodway profile for Unnamed Wash 3

River Station miles	Water Surface Elevation (WSEL) Floodplain feet	Water Surface Elevation (WSEL) Floodway feet	Energy Grade Line Elevation (EGL) Floodplain feet	Energy Grade Line Elevation (EGL) Floodway feet	Surcharge WSEL feet	Surcharge EGL feet	Floodway Encroachment Station Left feet	Floodway Encroachment Station Right feet
3.309	1556.5	1556.6	1558.3	1558.3	0.1	0.0	9985.0	10054.5
3.257	1553.0	1553.7	1554.0	1554.9	0.7	0.9	9970.0	10016.4
3.168	1548.4	1548.7	1549.2	1549.9	0.3	0.7	9973.3	10090.0
3.144	1547.4	1547.4	1548.0	1548.3	-0.1	0.3	9981.8	10125.0
3.114	1545.2	1545.6	1546.5	1546.8	0.4	0.3	9954.9	10022.7
3.061	1543.4	1543.5	1543.8	1544.1	0.1	0.3	9900.0	10015.9
3.042	1542.9	1543.0	1543.3	1543.4	0.1	0.1	9870.0	10027.2
3.015	1542.6	1542.6	1542.9	1542.9	0.0	0.0	9870.0	10011.2
2.984	1539.1	1539.1	1541.1	1541.0	0.0	-0.1	9975.7	10027.5
2.916	1535.1	1535.9	1535.9	1536.8	0.8	0.9	9982.2	10070.0
2.850	1532.5	1532.6	1533.2	1533.8	0.1	0.6	9950.0	10015.3
2.779	1529.1	1529.1	1530.5	1530.8	0.0	-0.1	9928.7	10046.0
2.677	1523.7	1524.4	1524.8	1525.8	0.7	0.6	9975.5	10030.2
2.581	1519.1	1519.1	1520.3	1520.8	0.0	0.5	9970.2	10019.4
2.522	1516.4	1516.4	1517.3	1517.4	0.0	0.1	9974.0	10053.8
2.471	1513.6	1513.6	1514.8	1514.8	0.0	0.0	9880.0	10012.6
2.421	1510.9	1511.7	1511.6	1512.3	0.8	0.7	9955.0	10039.9
2.315	1506.1	1506.0	1507.3	1508.2	-0.1	0.9	9981.5	10022.9
2.233	1501.2	1501.5	1502.4	1502.6	0.3	0.2	9956.5	10019.7
2.118	1495.3	1496.0	1496.4	1497.3	0.7	0.9	9984.1	10029.3
2.050	1491.8	1491.7	1492.5	1493.1	-0.1	0.6	9955.0	10025.0
2.011	1488.8	1488.8	1490.2	1490.2	0.0	0.0	9937.1	10029.9
1.973	1487.2	1487.2	1488.1	1488.1	0.0	0.0	9980.9	10077.9
1.944	1484.7	1484.8	1486.5	1486.5	0.1	0.0	9979.0	10041.1
1.872	1480.9	1480.9	1482.1	1482.0	0.0	-0.1	9962.8	10029.9

Table 4-14 (continued)

Summary of results for the floodway profile for Unnamed Wash 3

River	Water Surface Elevation (WSEL)		Energy Grade Line Elevation (EGL)		Surcharge		Floodway Encroachment Station	
Station miles	Floodplain feet	Floodway feet	Floodplain feet	Floodway feet	WSEL feet	EGL feet	Left feet	Right feet
1.784	1475.9	1475.9	1477.3	1477.3	0.0	0.0	9960.5	10021.1
1.690	1472.4	1472.3	1473.3	1473.3	-0.1	0.0	9954.7	10015.9
1.641	1469.6	1469.7	1471.2	1471.1	0.1	-0.1	9922.0	10022.1
1.600	1467.2	1467.7	1468.2	1468.6	0.5	0.4	9925.8	10017.2
1.563	1464.3	1465.1	1465.7	1466.6	0.8	0.9	9950.0	10037.1
1.537	1460.3	1460.4	1462.4	1462.4	0.1	0.0	9977.9	10038.4
1.519	1457.7	1457.7	1460.1	1460.1	0.0	0.0	9984.8	10029.0
1.497	1456.4	1456.4	1458.1	1458.1	0.0	0.0	9977.3	10029.0
1.481	1454.8	1454.8	1457.1	1457.1	0.0	0.0	9963.0	10011.2
1.425	1449.1	1449.0	1450.5	1450.5	-0.1	0.0	9977.8	10026.3
1.385	1441.7	1441.7	1444.3	1444.3	0.0	0.0	9988.9	10032.6
1.356	1437.5	1437.5	1438.3	1438.3	0.0	0.0	9973.7	10047.2
1.331	1436.0	1436.0	1436.8	1436.8	0.0	0.0	9942.0	10019.2
1.304	1433.1	1433.1	1434.6	1434.6	0.0	0.0	9982.1	10032.9
1.259	1426.8	1426.9	1429.1	1429.1	0.1	0.0	9978.6	10028.7
1.222	1416.3	1416.3	1418.8	1418.8	0.0	0.0	9975.3	10016.9
1.171	1413.3	1413.3	1413.9	1413.9	0.0	0.0	9966.7	10034.9
1.152	1411.4	1411.4	1412.9	1412.9	0.0	0.0	9971.6	10015.2
1.088	1407.2	1407.2	1408.8	1408.8	0.0	0.0	9985.8	10040.2
1.008	1401.4	1401.4	1403.2	1403.2	0.0	0.0	9983.8	10027.7
0.986	1400.3	1400.3	1401.4	1401.4	0.0	0.0	9973.7	10030.2
0.960	1397.2	1397.3	1399.3	1399.3	0.1	0.0	9950.6	10009.8
0.928	1394.4	1394.4	1395.4	1395.4	0.0	0.0	9983.1	10046.7
0.852	1389.8	1389.8	1391.9	1391.9	0.0	0.0	9972.3	10026.0
0.761	1384.8	1384.8	1385.8	1385.9	0.0	0.1	9918.0	10018.1
0.734	1382.8	1382.8	1384.3	1384.4	0.0	0.1	9960.0	10024.6

Table 4-14 (continued)

Summary of results for the floodway profile for Unnamed Wash 3

River Station miles	Water Surface Elevation (WSEL) Floodplain feet	Water Surface Elevation (WSEL) Floodway feet	Energy Grade Line Elevation (EGL) Floodplain feet	Energy Grade Line Elevation (EGL) Floodway feet	Surcharge WSEL feet	Surcharge EGL feet	Floodway Encroachment Station Left feet	Floodway Encroachment Station Right feet
0.716	1382.3	1382.3	1383.3	1383.3	0.0	0.0	9957.1	10029.3
0.695	1379.2	1379.2	1382.0	1382.0	0.0	0.0	9977.5	10015.2
0.658	1376.2	1376.2	1377.8	1377.8	0.0	0.0	9952.5	10009.9
0.625	1373.8	1373.8	1375.6	1375.6	0.0	0.0	9941.3	10018.1
0.481	1363.6	1363.7	1364.8	1364.8	0.1	0.0	9973.8	10039.7
0.386	1358.1	1358.4	1360.0	1360.3	0.3	0.3	9978.9	10025.4
0.306	1353.4	1353.5	1354.7	1355.1	0.1	0.4	9935.0	10025.2
0.240	1349.3	1349.6	1349.8	1350.6	0.3	0.8	9860.0	10060.0
0.185	1344.2	1344.2	1345.9	1345.9	0.0	0.0	9968.0	10044.2
0.144	1340.7	1340.7	1342.6	1342.6	0.0	0.0	9982.9	10041.5

Table 4-15
Summary of normal depth calculations for the approximate method study watercourses

Wash Identification	Cross-section Identifer cfs	Discharge feet	Depth of flow feet	Top Width
Tributary 1 to Unnamed Wash 1	A-A	860	3.09	59.11
Tributary 1 to Unnamed Wash 1	B-B	860	4.08	94.97
Tributary 1 to Unnamed Wash 1	C-C	860	3.90	101.87
Unnamed Wash 2	Structure #7	1670	14.50	----
Unnamed Wash 2	A-A	1670	3.59	55.66
Unnamed Wash 2	B-B	1670	3.78	52.39
Unnamed Wash 2	C-C	1670	4.37	43.87
Unnamed Wash 2	D-D	1670	4.68	39.66
Unnamed Wash 2	E-E	1670	5.80	42.52
Unnamed Wash 2	F-F	1380	4.51	48.58
Unnamed Wash 2	G-G	1380	3.66	44.53
Unnamed Wash 2	H-H	1380	5.02	34.33
Tributary 1 to Unnamed Wash 2	A-A	860	3.82	34.01
Tributary 1 to Unnamed Wash 2	B-B	860	3.52	41.72
Tributary 1 to Unnamed Wash 2	C-C	860	4.62	61.25
Tributary 1 to Unnamed Wash 2	D-D	860	4.10	48.73
Tributary 1 to Unnamed Wash 2	E-E	860	4.60	37.80
Tributary 1 to Unnamed Wash 2	F-F	860	3.44	47.45
Tributary 1 to Unnamed Wash 2	G-G	860	5.23	47.15
Tributary 2 to Unnamed Wash 2	A-A	1130	1.95	173.90
Tributary 2 to Unnamed Wash 2	B-B	1130	3.44	53.28
Tributary 2 to Unnamed Wash 2	Structure #13	1130	11.69	----
Tributary 2 to Unnamed Wash 2	C-C	1130	2.55	61.42
Tributary 2 to Unnamed Wash 2	D-D	1130	3.52	60.27
Tributary 2 to Unnamed Wash 2	E-E	1130	4.17	37.29
Twin Buttes Wash	A-A	1390	4.95	108.87
Twin Buttes Wash	B-B	1390	4.38	59.88
Twin Buttes Wash	C-C	1390	9.68	24.93
Twin Buttes Wash	D-D	1390	4.64	92.63
Twin Buttes Wash	E-E	1390	4.86	34.40
Twin Buttes Wash	F-F	1250	5.07	35.15

Table 4-15 (continued)
Summary of normal depth calculations for the approximate method study watercourses

Wash Identification	Cross-section Identifer	Discharge cfs	Depth of flow feet	Top Width feet
Twin Buttes Wash	G-G	1250	4.65	99.16
Twin Buttes Wash	H-H	1250	3.30	71.32
Twin Buttes Wash	I-I	1250	3.71	53.91
Twin Buttes Wash	J-J	1250	2.29	218.38
Twin Buttes Wash	K-K	1250	3.50	97.73
Twin Buttes Wash	L-L	1250	2.85	122.34
Caterpillar Tank Wash	A-A	1210	5.49	43.79
Caterpillar Tank Wash	B-B	1210	3.43	53.29
Unnamed Wash 4	F-F	770	3.25	487.15
Unnamed Wash 4	G-G	770	1.16	426.38
Unnamed Wash 4	H-H	770	1.97	332.76
Unnamed Wash 4	I-I	690	3.29	238.45
Unnamed Wash 4	J-J	690	3.80	41.79
Tributary 1 to Unnamed Wash 4	A-A	770	5.40	190.28
Tributary 1 to Unnamed Wash 4	B-B	770	4.07	168.45
Unnamed Wash 4	K-K	690	3.91	62.67
Unnamed Wash 4	Structure # 63	1420	13.76	----
Unnamed Wash 4	A-A	1420	1.68	214.53
Unnamed Wash 4	B-B	1420	3.41	80.65
Unnamed Wash 4	C-C	1420	3.88	94.32
Unnamed Wash 4	D-D	1420	3.00	70.25
Unnamed Wash 4	E-E	1420	4.27	53.62
Unnamed Wash 5	A-A	1160	4.37	145.24
Unnamed Wash 5	B-B	1160	2.46	136.09
Unnamed Wash 5	C-C	1160	2.62	247.99
Unnamed Wash 5	D-D	1160	3.71	107.59
Unnamed Wash 5	E-E	1160	3.26	190.57
Unnamed Wash 5	F-F	1160	4.18	112.84
Unnamed Wash 5	G-G	1160	4.40	45.54
Unnamed Wash 5	H-H	1160	4.94	268.76
Unnamed Wash 5	I-I	1160	2.92	95.44

Table 4-15 (continued)
Summary of normal depth calculations for the approximate method study watercourses

Wash Identification	Cross-section Identifer cfs	Depth of Discharge feet	Top flow feet	Width
Unnamed Wash 5	Structure # 62	1160	2.00	33.00
Unnamed Wash 5	J-J	880	3.47	82.00
Unnamed Wash 5	K-K	880	3.27	77.36
Unnamed Wash 5	L-L	880	2.74	106.45
Unnamed Wash 5	M-M	880	4.93	116.69
Unnamed Wash 5	Structure # 74	880	18.37	124.57
Unnamed Wash 5	N-N	1630	4.11	114.53
Unnamed Wash 5	O-O	1630	3.24	166.40
Unnamed Wash 5	Structure # 73	1630	5.88	----
Unnamed Wash 5	P-P	1630	3.17	369.71
Unnamed Wash 5	Q-Q	1630	3.28	272.64
Unnamed Wash 5	R-R	1630	2.35	424.01
Unnamed Wash 6	A-A	1380	4.03	93.50
Unnamed Wash 6	B-B	1380	3.21	119.86
Unnamed Wash 6	C-C	1380	2.85	124.01
Unnamed Wash 6	D-D	1380	3.50	99.26
Unnamed Wash 6	E-E	1380	4.16	55.98
Unnamed Wash 6	F-F	1380	1.83	317.77
Unnamed Wash 6	G-G	1380	3.30	144.87
Unnamed Wash 6	Structure # 106	1380	6.63	----
Unnamed Wash 6	H-H	1380	3.65	165.04
Unnamed Wash 6	I-I	1380	1.79	428.53
Unnamed Wash 6	J-J	1380	3.46	94.54
Unnamed Wash 7	A-A	1790	5.14	133.04
Unnamed Wash 7	B-B	1790	4.40	85.58
Unnamed Wash 7	C-C	1790	4.76	90.86
Unnamed Wash 7	D-D	1790	5.41	53.15
Unnamed Wash 7	E-E	1790	2.07	411.73
Unnamed Wash 7	F-F	1790	2.33	297.28

Table 4-15 (continued)
Summary of normal depth calculations for the approximate method study watercourses

Wash Identification	Cross-section Identifer cfs	Depth of Discharge feet	Top flow feet	Width
Unnamed Wash 7	Structure # 76	1790	11.49	----
Unnamed Wash 7	G-G	1790	3.42	181.14
Unnamed Wash 7	H-H	1790	3.17	195.35
Tributary 1 to Unnamed 7	A-A	1790	5.60	58.62
Tributary 1 to Unnamed 7	B-B	1790	2.08	269.74
Tributary 1 to Unnamed 7	C-C	1790	4.26	143.54
Unnamed Wash 8	A-A	1150	2.62	123.00
Unnamed Wash 8	B-B	1150	3.68	81.20
Unnamed Wash 8	C-C	1150	4.03	73.28
Unnamed Wash 8	D-D	1150	3.97	72.79
Unnamed Wash 8	E-E	1150	3.42	86.93
Unnamed Wash 8	F-F	1150	1.96	311.50
Unnamed Wash 8	Structure # 104	1150	5.57	----
Unnamed Wash 8	G-G	1150	2.55	233.05
Unnamed Wash 8	H-H	1150	1.84	453.68
Unnamed Wash 8	I-I	1150	1.77	527.49
Unnamed Wash 9	A-A	1130	3.34	69.50
Unnamed Wash 9	B-B	1130	2.72	113.40
Unnamed Wash 9	C-C	1130	3.50	108.07
Unnamed Wash 9	D-D	1130	2.36	161.12
Unnamed Wash 9	E-E	1130	3.42	96.69
Unnamed Wash 9	F-F	1130	3.12	84.93
Unnamed Wash 9	G-G	1130	3.48	82.83
Unnamed Wash 9	Structure # 86	1130	8.10	----
Unnamed Wash 9	H-H	860	3.41	96.01

SECTION 5: EROSION/SEDIMENT TRANSPORT ANALYSIS

Erosion/sediment transport analyses are not conducted as part of watershed modeling and floodplain delineation phase of the North Peoria Area Drainage Master Plan. However, the potential for lateral migration along the study watercourses is of interest for planning purposes as part of the overall study. The limits of lateral migration are used in conjunction with the floodplain/floodway limits as well as other data to establish policies and guidelines for future development along the watercourses. A complete discussion of the data, interpretations and conclusions of the lateral migration analysis are provided in a separate report entitled North Peoria Area Drainage Master Plan, Attachment 3, Sedimentation Engineering and Geomorphic Evaluation Technical Memorandums.

SECTION 6: REFERENCE MATERIALS

6.1 Other Published Flood Studies

See discussion in Section 3.6.2 pertaining to previous studies.

6.2 Previous FEMA Studies

Same as Section 6.1

6.3 Other Applicable Studies

No other studies are referenced in this report.

6.4 Published and Unpublished Historical Flood Information

See discussion in Section 3.2.5.1 and Section 3.2.3.2 of this report.

6.5 Bibliography

Arizona Department of Transportation, 1994, Drainage Design Manual.

Arizona Department of Water Resources, Engineering Division, Flood Management Section, September 1991, Instructions for Organizing and Submitting Technical Documentation for Flood Study (SS A-97).

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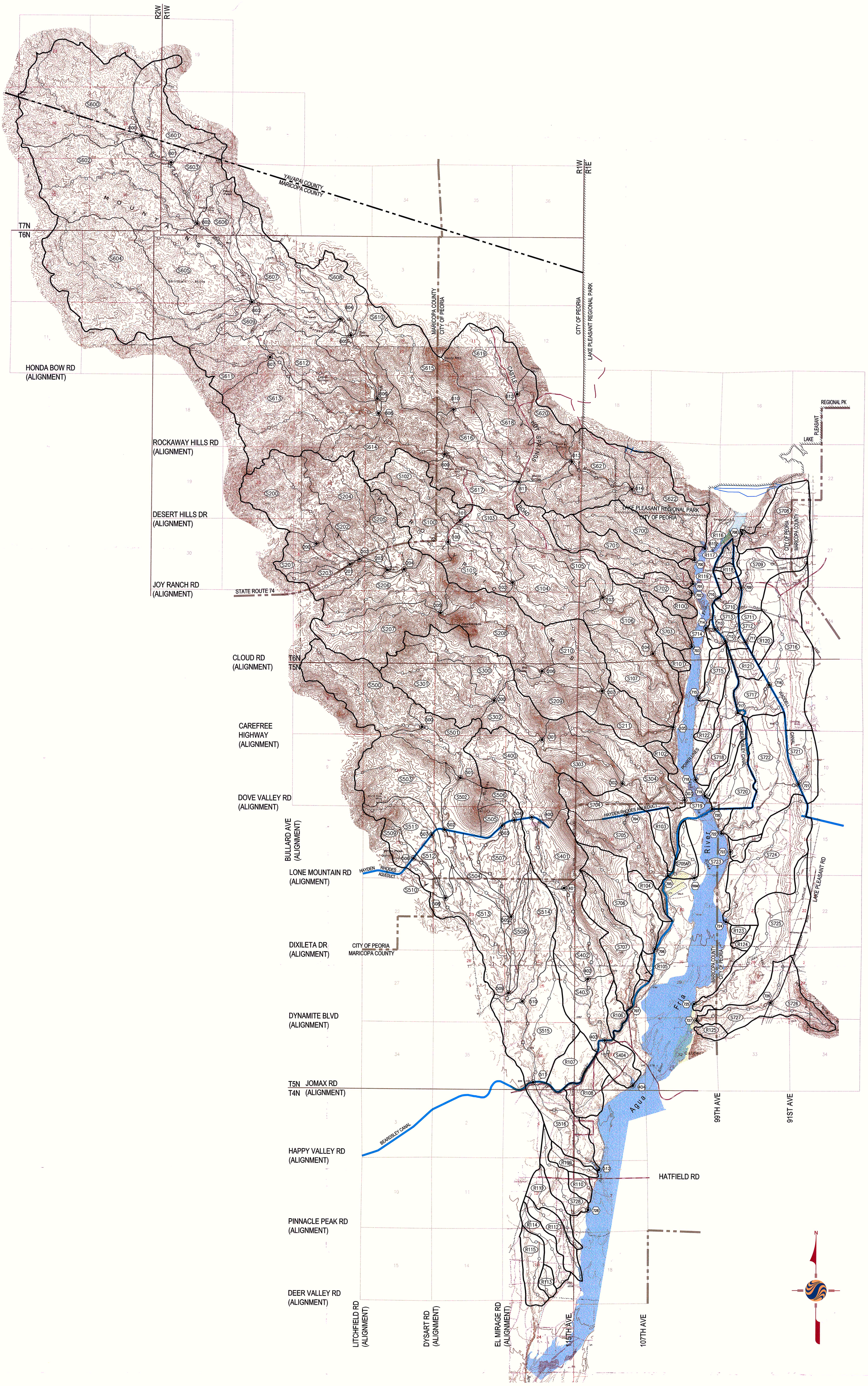

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File Name: 01wwm146.dwg	HAR	MCG	MCG	04.13.00
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Legend

- Basin Boundary
- Subbasin Boundary
- Basin Identifier (S504)
- Concentration Point and Identifier (504)
- Time of Concentration Flowpath
- Routing Reach
- Routing Reach and Hydraulic Study Reach
- Canal
- Existing Road
- Corporate Limits
- Park Boundary
- Effective FEMA Floodplain

Prepared for:

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

In conjunction with:

CITY OF PEORIA

Client/Project

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
NORTH PEORIA

AREA DRAINAGE MASTER PLAN
FCD NO. 99-45

Peoria, Arizona

Title

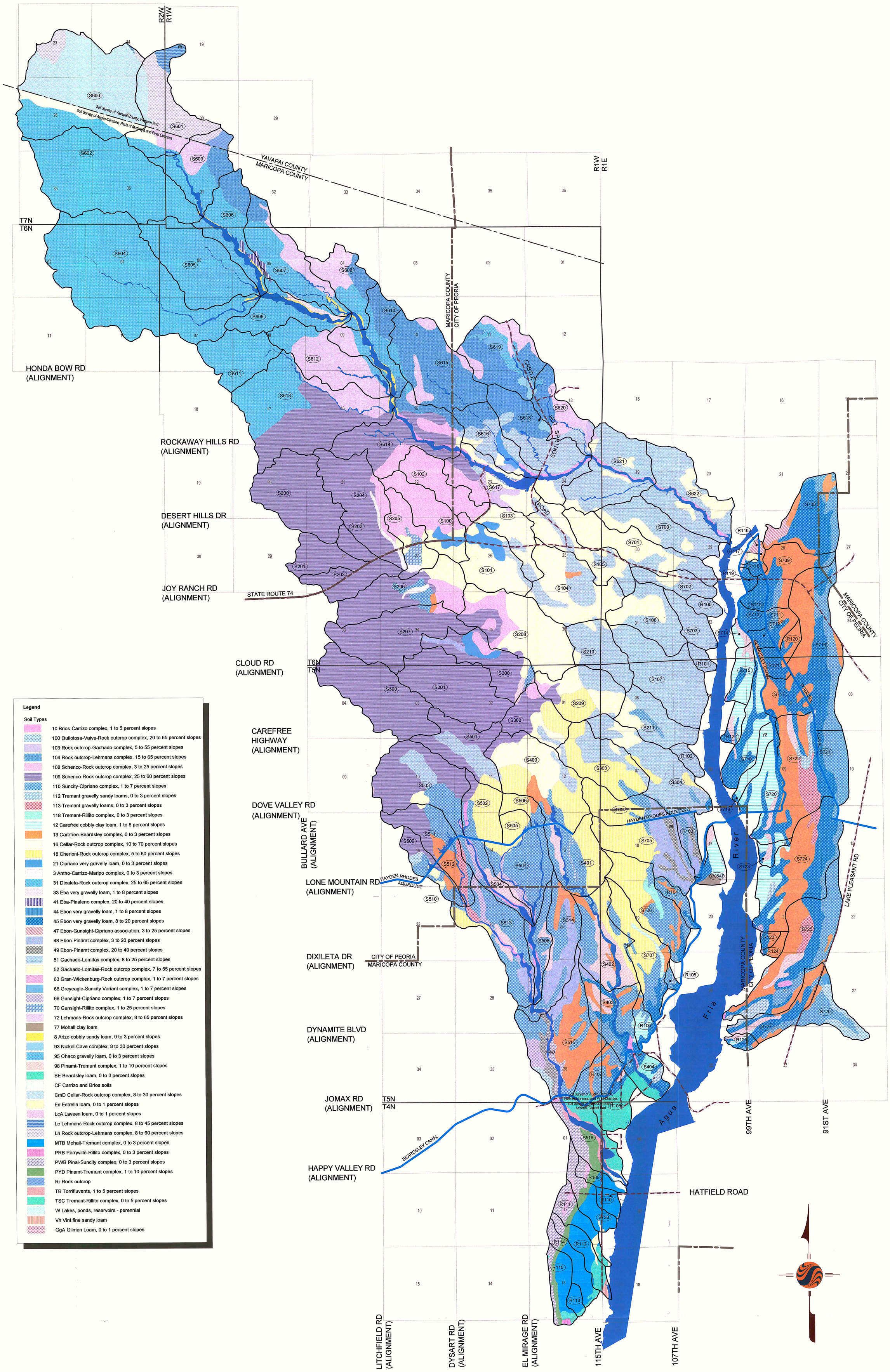
PLATE 1
WATERSHED MAP

Project No. 82000146

Scale 1"=2000' (0, 2000', 3000', 4000')

Drawing No.

Sheet 1 of 1



Legend

Soil Types

- 10 Brios-Carrizo complex, 1 to 5 percent slopes
- 100 Quilotosa-Vaiva-Rock outcrop complex, 20 to 65 percent slopes
- 103 Rock outcrop-Gachado complex, 5 to 55 percent slopes
- 104 Rock outcrop-Lehmans complex, 15 to 65 percent slopes
- 108 Schenco-Rock outcrop complex, 3 to 25 percent slopes
- 109 Schenco-Rock outcrop complex, 25 to 60 percent slopes
- 110 Suncity-Cipriano complex, 1 to 7 percent slopes
- 112 Tremant gravelly sandy loams, 0 to 3 percent slopes
- 113 Tremant gravelly loams, 0 to 3 percent slopes
- 118 Tremant-Rillito complex, 0 to 3 percent slopes
- 12 Carefree cobbly clay loam, 1 to 8 percent slopes
- 13 Carefree-Beardsley complex, 0 to 3 percent slopes
- 16 Cellar-Rock outcrop complex, 10 to 70 percent slopes
- 18 Cherioni-Rock outcrop complex, 5 to 60 percent slopes
- 21 Cipriano very gravelly loam, 0 to 3 percent slopes
- 3 Antho-Carrizo-Maripo complex, 0 to 3 percent slopes
- 31 Dixaleta-Rock outcrop complex, 25 to 65 percent slopes
- 33 Eba very gravelly loam, 1 to 8 percent slopes
- 41 Eba-Pinaleno complex, 20 to 40 percent slopes
- 44 Ebon very gravelly loam, 1 to 8 percent slopes
- 45 Ebon very gravelly loam, 8 to 20 percent slopes
- 47 Ebon-Gunsight-Cipriano association, 3 to 25 percent slopes
- 48 Ebon-Pinamt complex, 3 to 20 percent slopes
- 49 Ebon-Pinamt complex, 20 to 40 percent slopes
- 51 Gachado-Lomitas complex, 8 to 25 percent slopes
- 52 Gachado-Lomitas-Rock outcrop complex, 7 to 55 percent slopes
- 63 Gran-Wickenburg-Rock outcrop complex, 1 to 7 percent slopes
- 66 Greyeagle-Suncity Variant complex, 1 to 7 percent slopes
- 68 Gunsight-Cipriano complex, 1 to 7 percent slopes
- 70 Gunsight-Rillito complex, 1 to 25 percent slopes
- 72 Lehmans-Rock outcrop complex, 8 to 65 percent slopes
- 77 Mohall clay loam
- 8 Arizo cobbly sandy loam, 0 to 3 percent slopes
- 93 Nickel-Cave complex, 8 to 30 percent slopes
- 95 Ohaco gravelly loam, 0 to 3 percent slopes
- 98 Pinamt-Tremant complex, 1 to 10 percent slopes
- BE Beardsley loam, 0 to 3 percent slopes
- CF Carrizo and Brios soils
- CmD Cellar-Rock outcrop complex, 8 to 30 percent slopes
- Es Estrella loam, 0 to 1 percent slopes
- LcA Laveen loam, 0 to 1 percent slopes
- Le Lehmans-Rock outcrop complex, 8 to 45 percent slopes
- Lh Rock outcrop-Lehmans complex, 8 to 60 percent slopes
- MTB Mohall-Tremant complex, 0 to 3 percent slopes
- PRB Perryville-Rillito complex, 0 to 3 percent slopes
- PWB Pinal-Suncity complex, 0 to 3 percent slopes
- PYD Pinamt-Tremant complex, 1 to 10 percent slopes
- Rr Rock outcrop
- TB Torrifluvents, 1 to 5 percent slopes
- TSC Tremant-Rillito complex, 0 to 5 percent slopes
- W Lakes, ponds, reservoirs - perennial
- Vh Vint fine sandy loam
- GgA Gilman Loam, 0 to 1 percent slopes

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File Name: excon146.apr | NKD Dwn. | PJE Chkd. | MCG Dsgn. | 11.06.00 Date

Legend

Subbasin Boundary	
Subbasin Identifier	S101
Section Number	17
Canal	
Existing Road	
Corporate Limits	
Fema Floodplain	

Prepared for:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

In conjunction with:

CITY OF PEORIA

Client/Project

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FCD NO. 99-45
Peoria, Arizona

Title

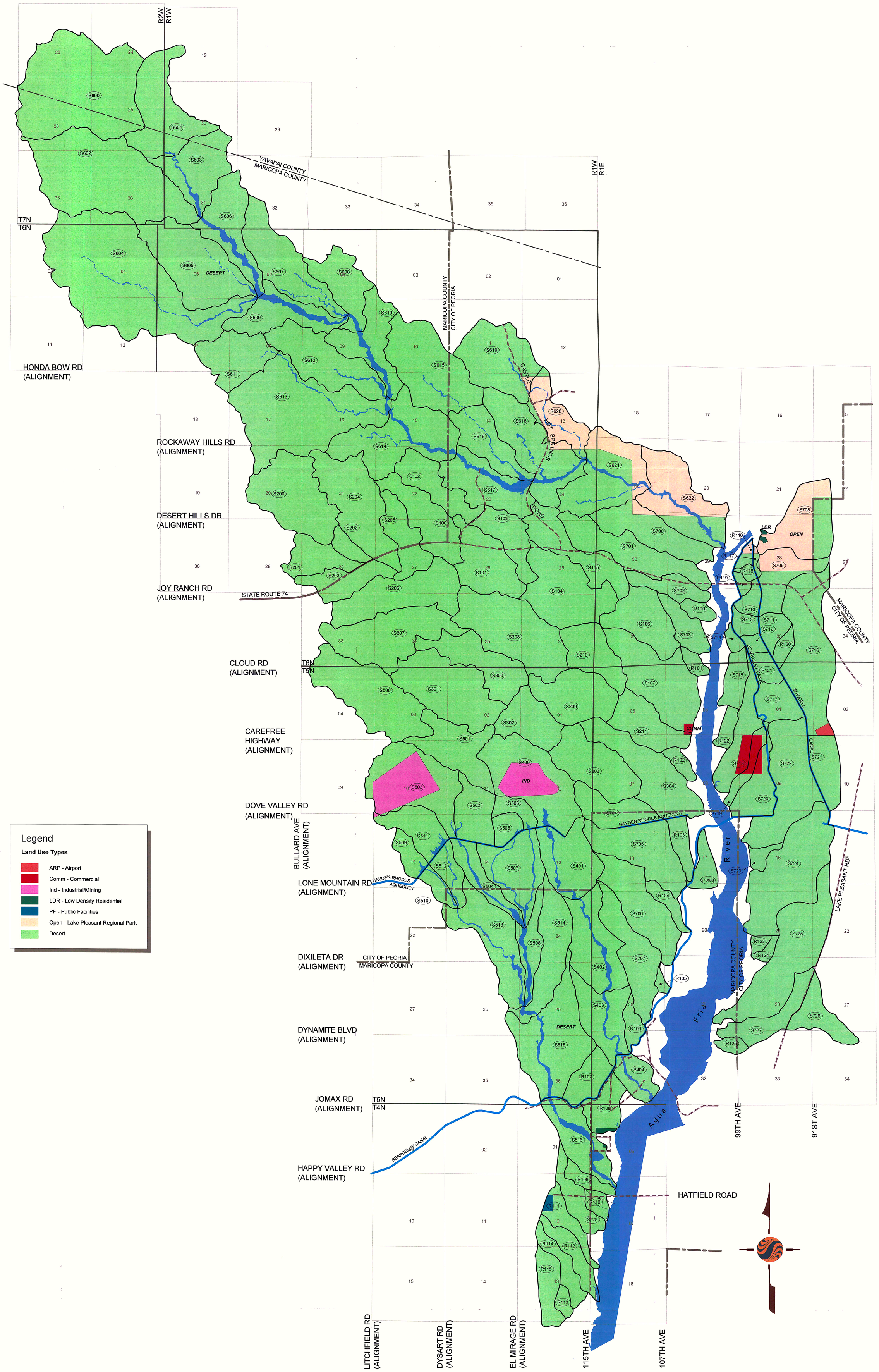
PLATE 2
SOILS MAP

Project No. 82000146

Scale 1"=2000' (0, 2000', 3000', 4000')

Drawing No.

Sheet 1 of 1



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May 07, 2001

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File Name: fucon146.apr	HAR	PJE	MCG	02.05.01
	Dwn.	Chkd.	Dsgn.	Date

Legend

Subbasin Boundary	
Subbasin Identifier	S101
Section Number	17
Canal	
Existing Road	
Corporate Limits	
Fema Floodplain	

Notes

1. Land use boundaries are approximated based on the City of Peoria General Plan, dated October 2000.
2. Proposed road alignments are approximated based on the City of Peoria General Plan.

Prepared for:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

In conjunction with:

CITY OF PEORIA

Client/Project

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FCD NO. 99-45
Peoria, Arizona

Title

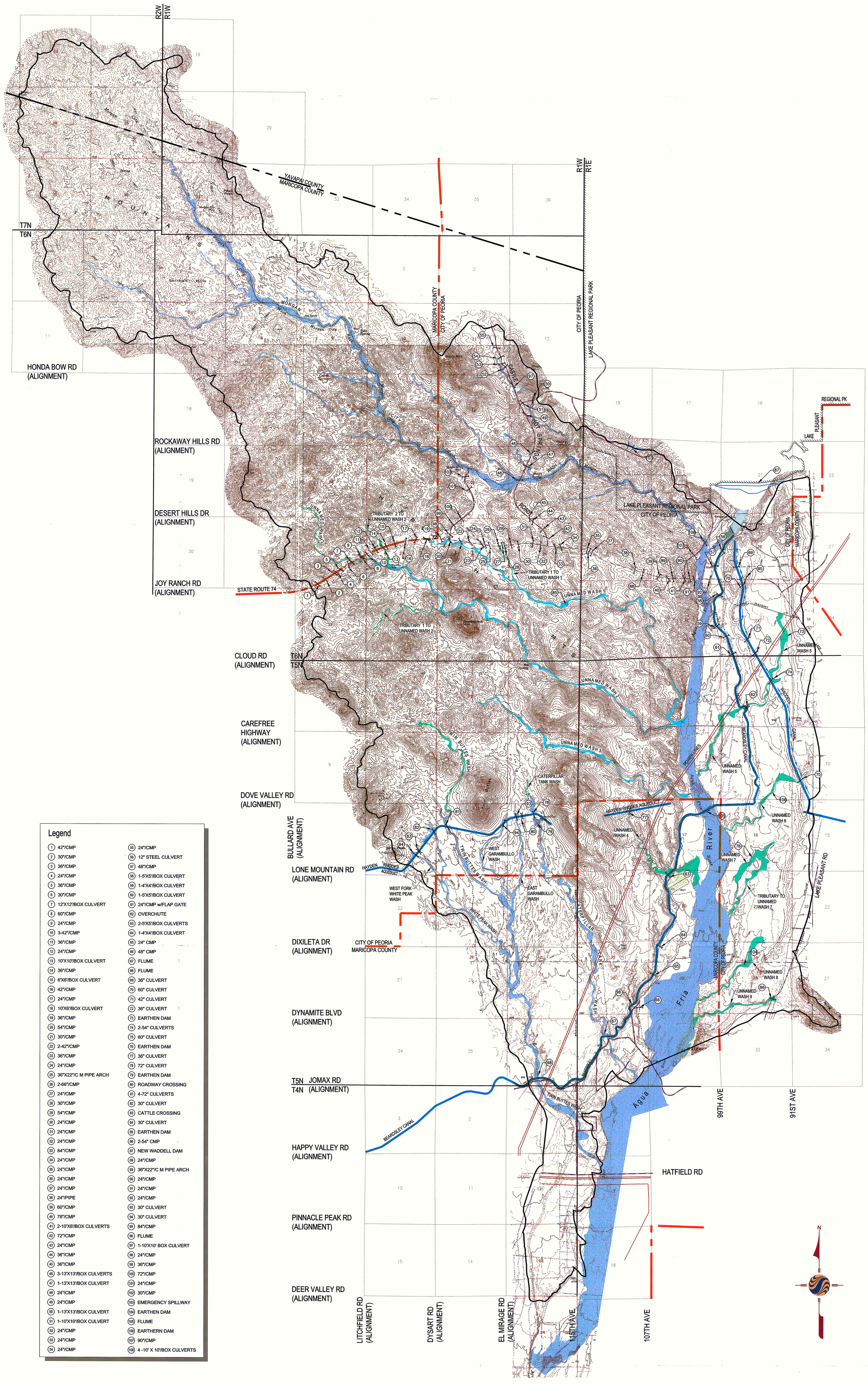
PLATE 3
EXISTING CONDITION LAND USE MAP

Project No. 82000146

Scale 1"=2000' (0, 2000', 3000', 4000')

Drawing No.

Sheet 1 of 1



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File Name: 01efm146.dwg	HAR	MCG	MCG	08.30.01
	Dwn.	Chkd.	Dsgn.	Date

Legend

- Canal
- Existing Road
- Corporate Limits
- Park Boundary
- Power Lines
- Project Boundary
- Effective FEMA Floodplain
- Zone A Floodplain (New FEMA Submittal)
- Detainled Delineation Floodplain (New FEMA Submittal)

Prepared for:

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In conjunction with:

CITY OF PEORIA

Client/Project

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
NORTH PEORIA

AREA DRAINAGE MASTER PLAN
FCD NO. 99-45

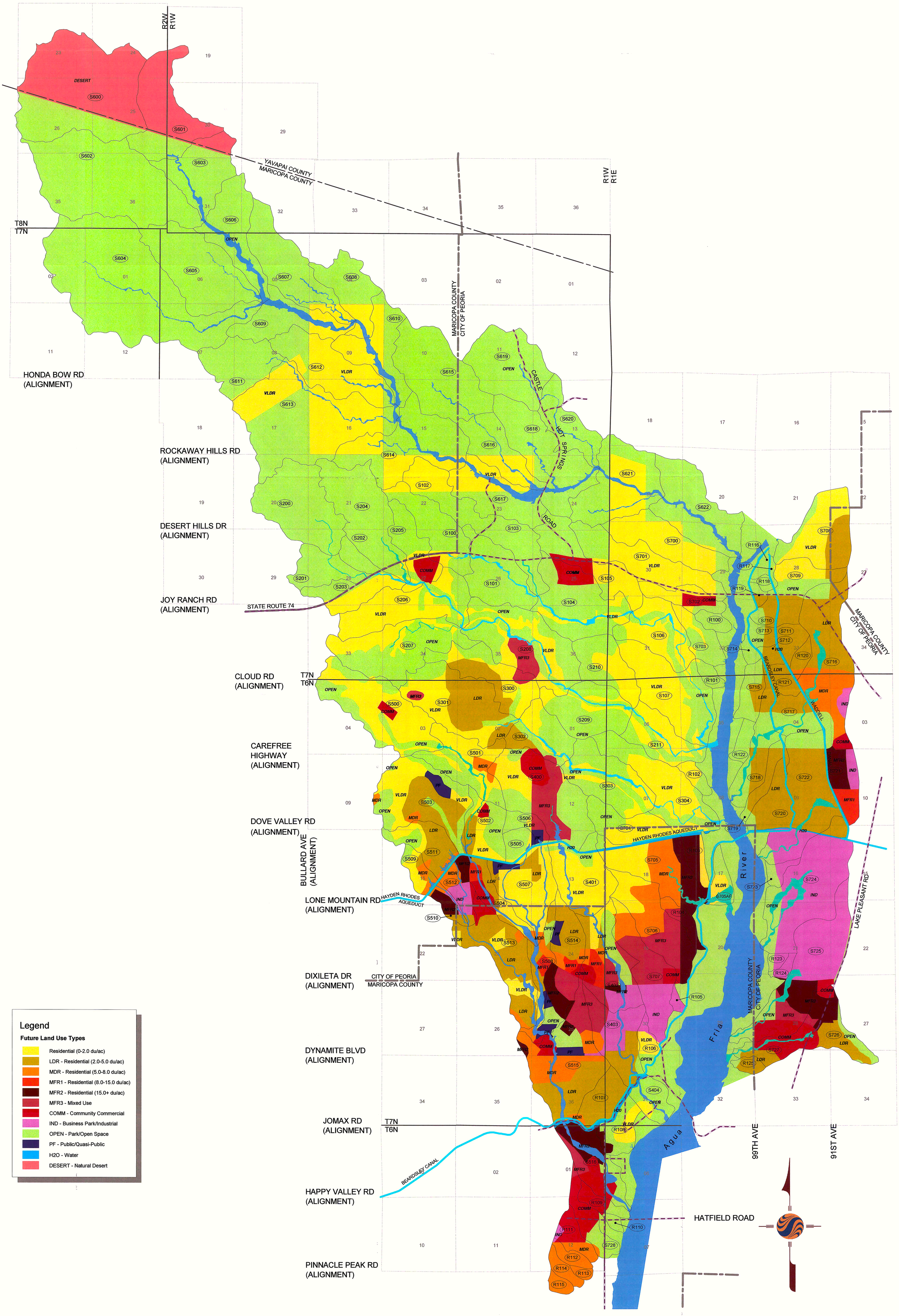
Peoria, Arizona

Title

PLATE 8
EXISTING FACILITIES MAP

Project No.	Scale
82000146	1"=2000' (0, 2000', 3000', 4000')
Drawing No.	Sheet

1 of 1



Legend

Future Land Use Types

- Residential (0-2.0 du/ac)
- LDR - Residential (2.0-5.0 du/ac)
- MDR - Residential (5.0-8.0 du/ac)
- MFR1 - Residential (8.0-15.0 du/ac)
- MFR2 - Residential (15.0+ du/ac)
- MFR3 - Mixed Use
- COMM - Community Commercial
- IND - Business Park/Industrial
- OPEN - Park/Open Space
- PF - Public/Quasi-Public
- H2O - Water
- DESERT - Natural Desert

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August 30, 2001

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File Name: fucon146.apr	HAR	PJE	MCG	02.05.01
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Legend

- Section Number — 17
- Canal
- Existing Road
- Corporate Limits
- Effective FEMA Floodplain
- Zone A Floodplain (New FEMA Submittal)
- Detailed Delineation Floodplain (New FEMA Submittal)
- Proposed Road

Notes

1. Land use boundaries are approximated based on the City of Peoria General Plan, dated October 2000.
2. Proposed road alignments are approximated based on the City of Peoria General Plan.

Prepared for:

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In conjunction with:

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NORTH PEORIA
AREA DRAINAGE MASTER PLAN
FCD NO. 99-45
Peoria, Arizona

Title

PLATE 9
FUTURE CONDITION LAND USE

Project No. 82000146

Scale 1"=2000' (0, 2000', 3000', 4000')

Drawing No.

Sheet 1 of 1