Catalina Foothills Watercourse Studies:
Technical Data Notebook for Hydrologic and Hydraulic Mapping of the Unnamed Wash 12, Pima County Arizona.

FEMA FIRM Panel 04019C-1713 and 1715L

Prepared by

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Approved by

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Director

Pima County Regional
FLOOD CONTROL
DISTRICT

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97 E Congress Street
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List of Tables

List of Figures

Exhibit

Section 1 Introduction

1.1 Purpose

The objective of this Technical Data Notebook (TDN) is to provide 100-yr peak discharges at Concentration Points (CPs) for the Unnamed Wash 12, 100-yr floodplain boundary and erosion hazard information, using the most up-to-date topographic, hydrologic, and hydraulic data.

This TDN was prepared in accordance with the "Instructions for Organizing and Submitting Technical Documentation for Flood Studies" prepared by the Arizona Department of Water Resources, Flood Mitigation Section (Arizona State Standard, SSA 1-97) and FEMA Guidelines. This is a local study and has not been submitted to FEMA.

1.2 Project Authority

The State of Arizona has delegated the responsibility to each county flood control district to adopt floodplain regulations designed to promote the public health, safety and general welfare of its citizenry as provided under the Arizona Revised Statutes (ARS), Title 48, Chapter 21, Article 1, Sections 48-3601 through 3627. More specifically, ARS 3609 directs county flood control districts to adopt floodplain regulations that:

A. Regulate all development of land, construction of residential, commercial or industrial structures or uses of any kind which may divert, retard or obstruct flood water and threaten public health or safety or the general welfare; and

B. Establish minimum flood protection elevations and flood damage prevention requirements for uses, structures and facilities which are vulnerable to flood damage; and

C. Comply with state and local land use plans and ordinances, if any. In conformance with ARS 3609, the Pima County Floodplain Management Ordinance 2010 FC-5 (Ordinance) provides for protection of the public health, safety and welfare by regulation of flood and erosion hazard areas to control these hazards and prevent repetitive loss from floods.

D. The flood hazard areas of Pima County are subject to periodic inundation. Erosion hazard areas of Pima County are subject to eventual lateral migration of the low-flow channel of the watercourse. Inundation and/or lateral channel migration may result in loss of life and property, create health and safety hazards, disrupt commerce and governmental services, require extraordinary public expenditures for flood protection and relief, and impair the tax base, all of which adversely affect the public health, safety, and general welfare.

E. These flood and/or erosion losses are caused by the cumulative effect of obstructive development in areas of special flood hazards which increase flood heights, flow velocities, and cause flood and erosion damage. Uses that are inadequately flood-proofed, elevated, or otherwise protected from flood damage, also contribute to the flood loss.

The Ordinance, which is Title 16 of Pima County Code, describes the provisions for floodplain regulation in Pima County.

This study has been prepared by the Pima County Regional Flood Control District (RFCD):

Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

The project was prepared by:

Akitsu Kimoto, Principal Hydrologist
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

1.3 Project Location

The study was performed to provide drainage information for the Unnamed Wash 12. The site includes Sections 24 and 25 of Township 13 South, Range 14 East, Pima County, Arizona. The entire watershed of the Unnamed Wash 12 is in FEMA Zone X, as shown on the current Flood Insurance Rate Map (FIRM) number 04019C-1713 and 1715L.

The study area for the Unnamed Wash 12 is Subbasins U12B, C and D (Fig.1.1). Since the area downstream of River Road has been annexed to the City of Tucson and there is an underground storm sewer located downstream of CP B (Fig. 1.1), this study used CP B as downstream end of the study area. Detail of the underground sewer system is shown in Highland Apartments (Co12-83-105) and River Center Development (Co12-85-111) recorded in Docket 7787, Page 1194. The study watershed is 257 acre and was divided into three sub-basins (Fig.1.2).

1.4 Hydrologic and Hydraulic Methods

A hydrologic analysis was performed to estimate regulatory discharge rates at CPs B, C and D using PC-Hydro Version 5.4.2 (PC-Hydro). The parameters for PC-Hydro, such as soil, vegetation, slope, flow path length and roughness were selected in accordance with the PC-Hydro User Guide (Arroyo Engineering, 2007). The proposed regulatory discharges are flow rates that have a 1-percent chance of being equaled or exceeded each year (“100-year” discharge rates). A hydraulic analysis was performed to determine a 100-yr floodplain boundary using HEC-GeoRAS, Version 10 (HEC-GeoRAS) and HEC-RAS Version 4.1 (HEC-RAS).

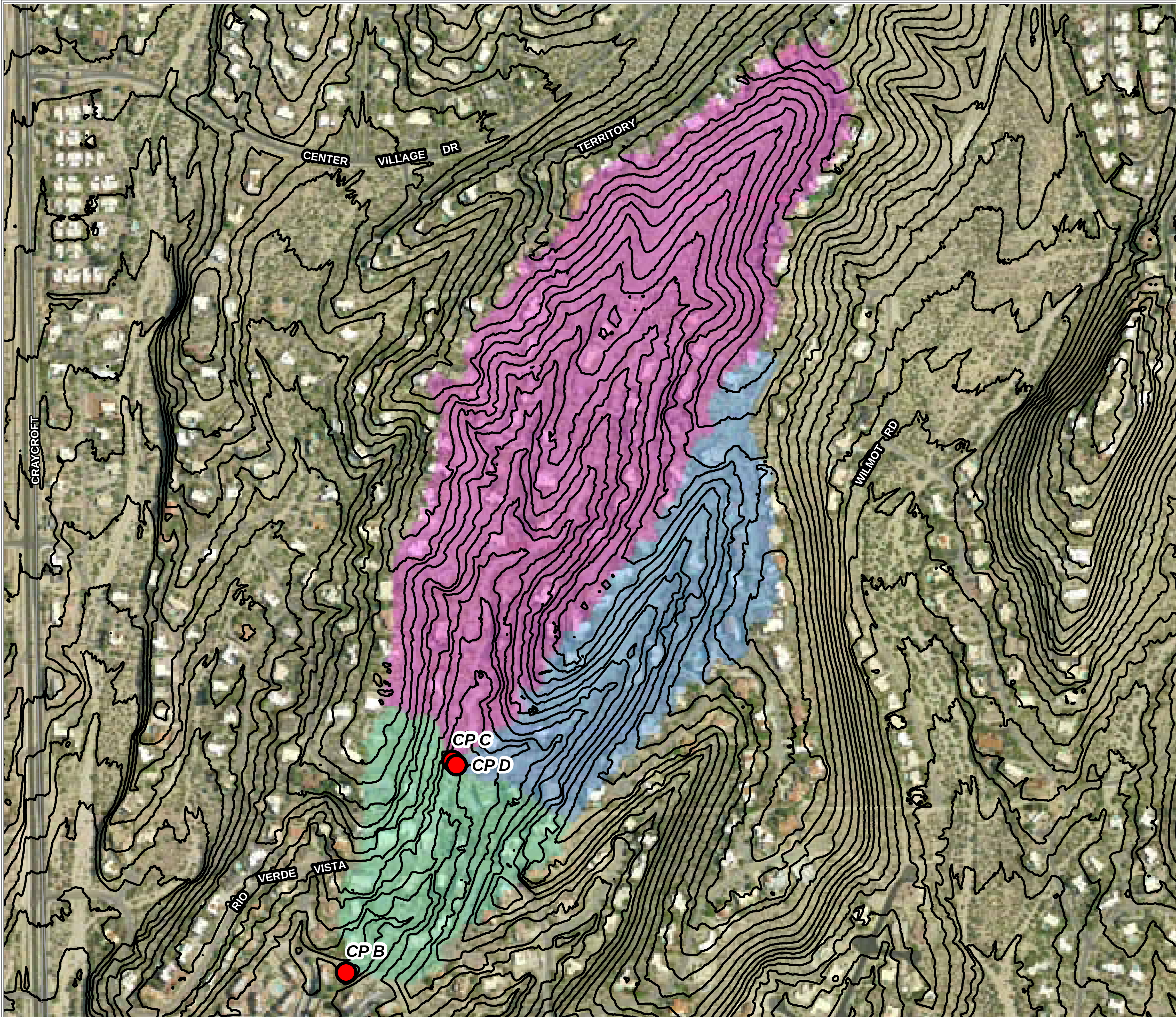
1.5 Acknowledgment

This study relied on assistance from RFCD GIS staff, who were integral to the development of the models and maps.

1.6 Study Results

The 100-yr discharges were calculated for the Unnamed Wash 12. Subbasin boundaries and corresponding CPs are illustrated in Figure 1.2. Hydrologic characteristics for the studied subbasins are presented in Table 2. Calculated discharges are summarized in Table 3. The calculated discharges are compared with the USGS Regional Regression Equation (Table 4). The comparison shows that the peak discharges calculated in this study are reasonable.

Figure 1.1
Watershed Map
Unnamed 12 Wash



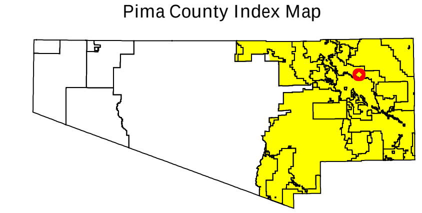
Discharge Point
Contour 10 ft.

Subbasin Name

U12 B
U12 C
U12 D

Aerial : 2010 Pictometry

Pima County Index Map



Index Map Scale 1:5,250,000

The information depicted on this display is the result of digital analyses performed on a variety of databases provided and maintained by several governmental agencies. The accuracy of the information presented is limited to the collective accuracy of these databases on the date of the analysis. The Pima County Regional Flood Control Department makes no claims regarding the accuracy of the information depicted herein.

This product is subject to the Department of Transportation Technical Services Division's Use Restriction Agreement.

Pima County Regional Flood Control District

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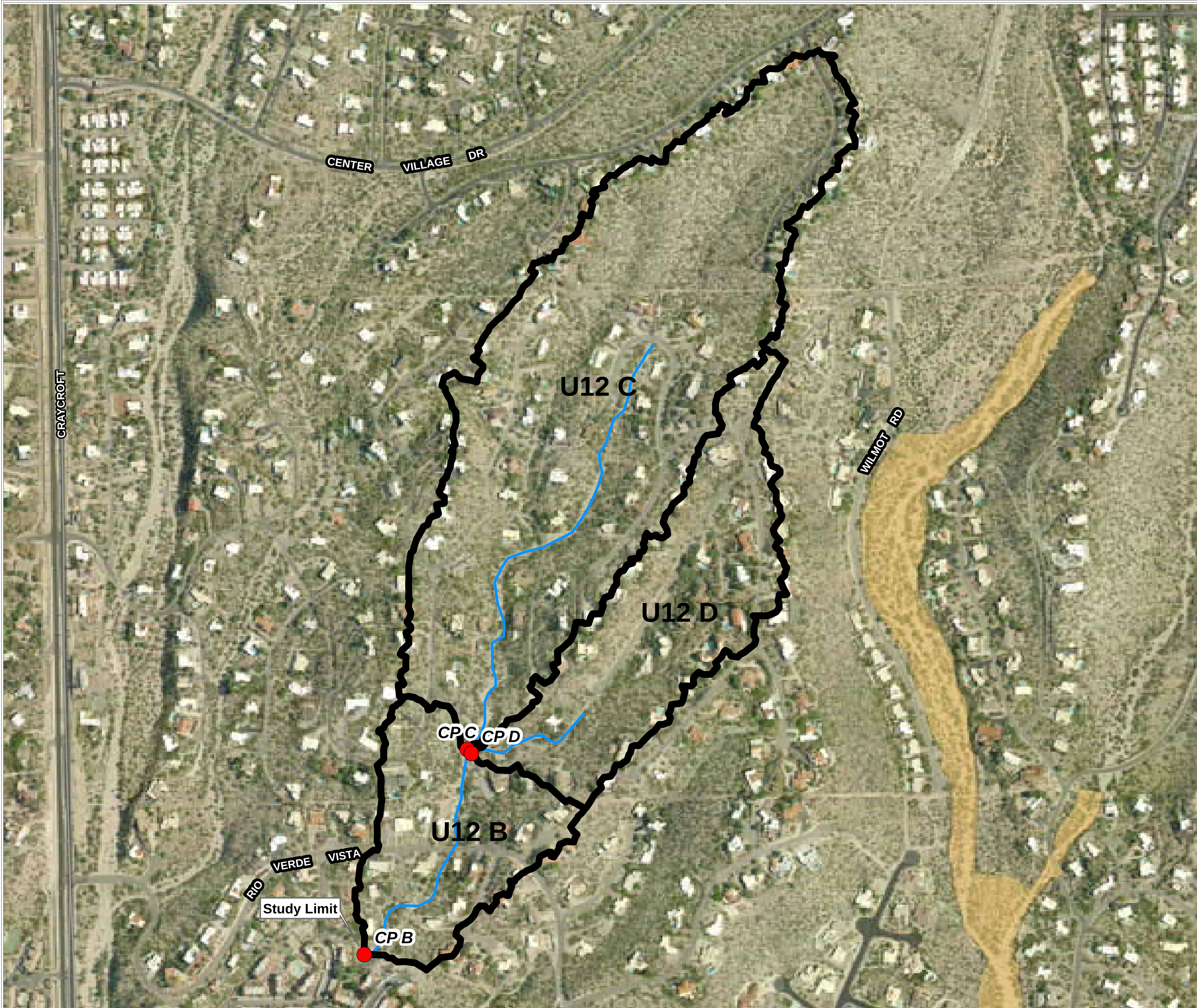
Figure 1.2
Study Limit
Unnamed 12 Wash



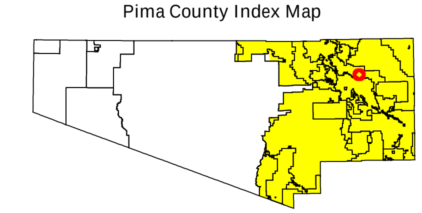
- Discharge Points
- River
- Subbasins

Existing FEMA Floodplain

- ZONE A
- ZONE AE
- ZONE X - SHADED

Aerial : 2010 Pictometry

Pima County Index Map



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Pima County Regional Flood Control District

09/2012

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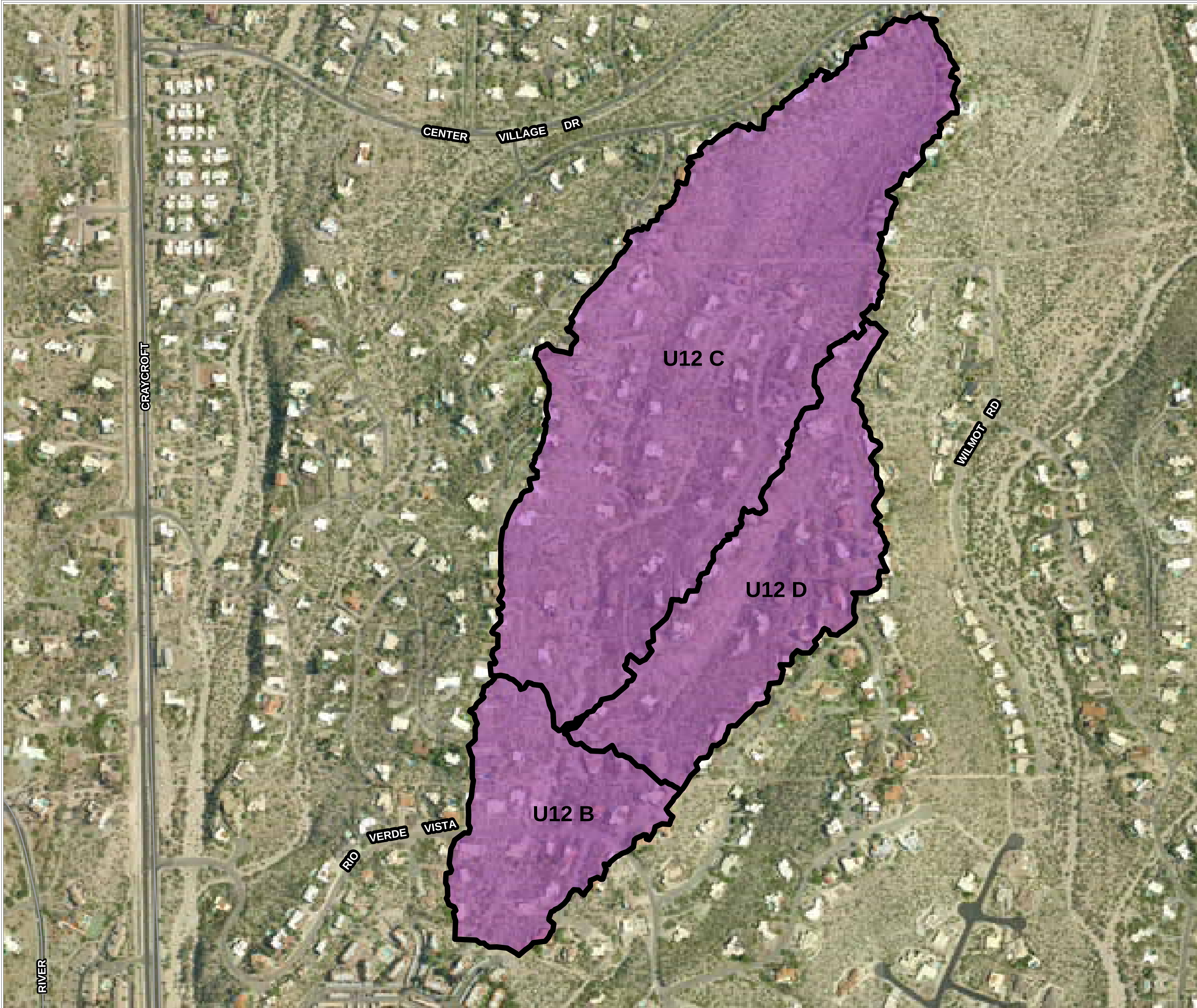
Figure 1.3
Soil Classification
Unnamed 12 Wash



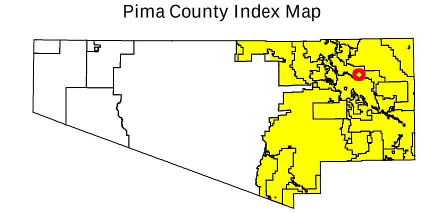
Subbasins

Soil Classification

Soil Group: B (82%) C (18%), PINALENO-STAGECOACH-PALOS VERDES COMPLEX, 10 TO 35 PERCENT SLOPES

Aerial : 2010 Pictometry

Pima County Index Map



Index Map Scale 1:5,250,000

The information depicted on this display is the result of digital analyses performed on a variety of databases provided and maintained by several governmental agencies. The accuracy of the information presented is limited to the collective accuracy of these databases on the date of the analysis. The Pima County Regional Flood Control Department makes no claims regarding the accuracy of the information depicted herein.

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Pima County Regional Flood Control District

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Section 2 Local Government Abstract

2.1 Project Contact Information

<u>Contact Information:</u>
Akitsu Kimoto
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<u>Local Technical Reviewer</u>:
Terry Hendricks
Pima County Regional Flood Control District
97E Congress, Tucson, AZ 85705
Terry.Hendricks@pima.gov

Date Study Submitted: ___________________________

Date Study Approved: ____________________________

2.2 General Information

Community: Pima County Regional Flood Control
County: Pima County
River or Stream Name: Unnamed Wash 12
Reach Description: Wash in Catalina Foothills
Study Type: Hydrology and Hydraulics study of a Riverine System
Purpose of the Study: To provide regulatory discharges and map floodplain boundaries
Summary of Hydrology and Hydraulic Methods:
Brief Summary Description of the Study Results:
Acknowledgements:

2.3 Survey and Mapping Information

Digital Projection Information: NAD 1983 HARN State Plane Arizona Central
USGS Quad Sheets if available:
Mapping for Hydrologic Study: LiDAR based on 2008 flight used to derive 2-ft contour interval maps using ArcGIS 10.0, PAG 2011 orthophotos
Mapping for Hydraulic Study: LiDAR based on 2008 flight used to derive a DEM (5-ft cell size) for use with HEC-GeoRAS, PAG 2011 orthophotos

2.4 Hydrology

Model or Method Used: PC-Hydro Version 5.4.2
Storm Duration: Based on 1-hr Rainfall Depth
Hydrograph Type: NA
Frequencies Determined: 100 yr
List of Gages used in Frequency Analysis or Calibration: None
Rainfall Amounts and Reference: NOAA 14 Upper 90% Confidence Interval
Unique Conditions and Problems: None
Coordination of Q's: Comparison with a USGS Regression Equation

2.5 Hydraulics

Model or Method Used: HEC-GeoRAS, Version 10 (HEC-GeoRAS) and HEC-RAS Version 4.1 (HEC-RAS)
Regime: Modeled as subcritical
Frequencies for which Profiles were computed: 100 yr
Method of Floodway Calculation: Floodway Not Determined in this Study
Unique Conditions and Problems: None

2.6 Erosion, Sediment Transport and Geomorphic Analysis

Summary of Method: NA
Issues Encountered During Study: NA
Summary of Findings: NA

2.7 Additional Study Information

None

Section 3 Survey and Mapping Information

3.1 Digital Projection Information

The data below are included in this TDN (see "GIS" folder)
Projection: State Plane, Arizona Central Zone
Horizontal Datum: NAD 83 HARN
Vertical Datum: NAVD 88
Units: International Feet
Aerial Photo: PAG 2011 Orthophotos
Contour: 2 feet interval
Topographic Data: 5-ft DEM

3.2 Field Survey Information

A survey was not necessary for this study.

3.3 Mapping

A Digital Elevation Model (DEM) derived from 2008 Light Detection and Ranging (LiDAR) data was used for the HEC-RAS analysis. The contour interval of the topographic map is 2 feet.

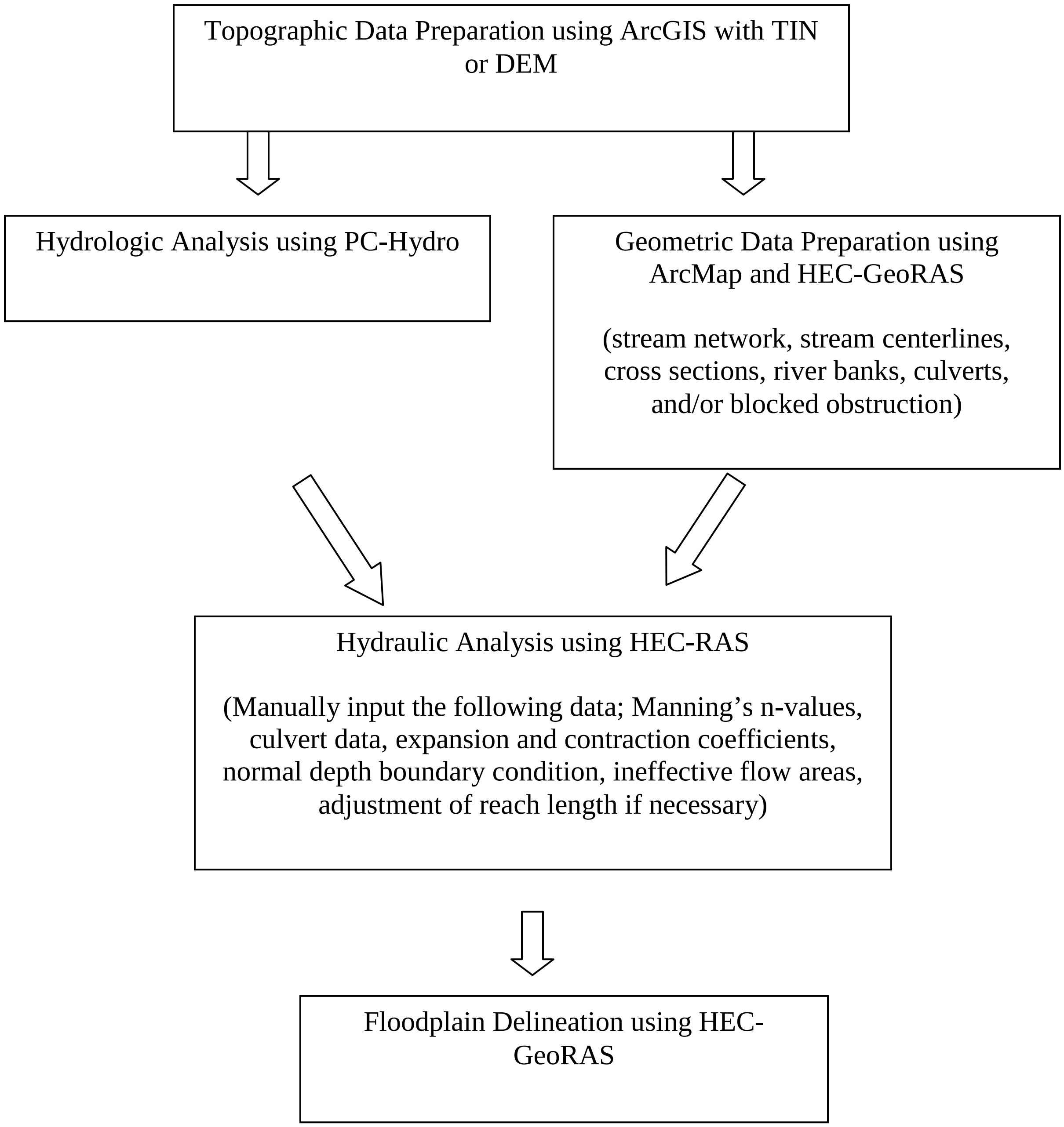
Following data are included in this TDN (see “GIS” folder):
Aerial Photo: PAG 2011 Orthophotos
Contour: 2 feet interval
Topographic Data: 5-ft DEM

Section 4 Hydrology

4.1 Method Description

Hydrologic analysis was performed using PC-Hydro Version 5.4.3 (PC-Hydro). The PC-Hydro uses a semi-empirical method, which is similar to the Rational Formula. The method is unique to Pima County. Pima County has been using the Pima County Hydrology Procedures (PC-Hydro method) for over 30 years for a floodplain management. The PC-Hydro method has been accepted by FEMA for prediction of 100-yr peak discharges in Pima County (i.e. Friendly Village LOMR, Case # 08-09-0473P). The PC-Hydro method produces conservative discharge on smaller watersheds and PC-Hydro is the accepted method for watersheds less than one square mile in Pima County Regional Flood Control District Technical Policy 018 (Tech-018, Appendix A). The PC-Hydro model requires the parameters regarding rainfall, topography, soil, and vegetation to determine peak discharge. Those parameters were determined following the PC-Hydro User Guide (Arroyo Engineering, 2007). The PC-Hydro output is included in Appendix D.

Figure 4.1 Flow Chart of Mapping Process



4.2 Parameter Estimation

4.2.1 Drainage Area Boundaries

The Unnamed Wash 12 watershed is located in FEMA Zone X. The downstream limit of the study area is CP B (Fig.1.1). The study watershed is 257 acre and was divided into three sub-basins (Fig.1.2).

4.2.2 Watershed Work Maps

A watershed work map is included in Exhibit 1. The work map includes subbasin boundaries, concentration points, flow center lines and cross sections with station numbers and water surface elevations. Soil group boundaries are shown for the drainage area in Figure 1.3. Concentration points were named using the Prefix U12 for the Unnamed Wash 12 followed by a letter assigned to each concentration point.

4.2.3 Gage Data

No gage data were used in this TDN.

4.2.4 Spatial Parameters

No spatial parameters were used in this TDN.

4.2.5 Precipitation

The NOAA 14 Atlas 90% upper confidence rainfall data was used. Rainfall depth was selected from the NOAA 14 Upper 90% rainfall data used in PC Hydro. No area reduction factor was applied.

4.2.6 Physical Parameters

The methods used in this study are summarized in Table 1. The PC-Hydro model calculates runoff coefficients using an adjusted Curve Number (CN) method, which has been developed based on the results of the USDA-ARS research. This procedure assumes that high intensity, short duration storms result in raindrop impacts causing the surface of soils to seal up, resulting in reducing infiltration (Caliche Effect). The CN in the PC-Hydro model increases with increasing rainfall depth and intensity. The detail of the method is described in PC-Hydro User Guide (Arroyo Engineering, 2007).

Table 1 Methods used for a PC-Hydro analysis

	Selected Method
Rainfall Depth	NOAA 14, upper 90% Confidence Interval
Rainfall Loss	Adjusted SCS Curve number
Time of Concentration	Pima County Hydrology Procedure

Table 2 Watershed Characteristics

CP Name	Area (Acre)	Impervious Area (%)	Vegetation Cover (%)	Weighted Runoff Coefficient
CP B	139	13	30	0.6
CP C	86	10	30	0.6
CP D	32	10	30	0.6

4.3 Issues Encountered During the Study

4.3.1 Special Problems and Solutions

There were no problems with the hydrologic modeling.

4.3.2 Modeling Warning and Error Messages

None

4.4 Calibration

No calibration was conducted in this study.

4.5 Final Results

4.5.1 Hydrologic Analysis Results

The 100-year peak discharge at CPs B, C and D was determined using the PC-Hydro. The result is summarized Table 3.

Table 3 Summary of the Hydrologic Analysis

CP Name	Location	Area (acre)	Rainfall Intensity at Tc (in/hr)	Time of Concentration (min)	Q100 (cfs)
CP B	**~1300 ft north of River Rd.**	139	7.12	13.3	621
CP C	**~500 ft north of Verde Vista Dr.**	86	8.15	10.0	428
CP D	**~500 ft north of Verde Vista Dr.**	32	9.74	6.1	198

4.5.2 Verification of results

The estimated peak discharge at CP A was also compared with the peak discharge obtained from USGS Regression Equation 13 (Thomas et al., 1997) (Table 4). The comparison showed that the PC-Hydro-derived peak discharge is 12.5% higher than the one derived from the Regression Equation.

Table 4 Comparison of a peak discharge

CP Name	Location	Area (sq mile)	Q100 PC-Hydro(cfs)	Q100 RRE (cfs)
CP B	~1300 ft north of River Rd.	0.22	621	411
CP C	~500 ft north of Verde Vista Dr.	0.13	428	276
CP D	~500 ft north of Verde Vista Dr.	0.05	198	113

RRE: USGS Regression Equation 13

Section 5 Hydraulics

5.1 Method Description

Steady flow analysis with HEC-RAS, Version 4.1 was performed to delineate a 100-year floodplain of the Unnamed Wash 12. Normal depth was used as a downstream boundary condition. Parameters for the hydraulic analysis were selected following the District Tech Policy 019.

The physical attributes of the wash were digitized in ArcGIS using the HEC-GeoRAS extension and exported to HEC-RAS to create geospatially referenced geometric data (cross section, reach profile). Other parameters for the steady-state analysis, such as Manning's n-values, expansion and contraction coefficients, boundary condition, and ineffective flow areas were manually input into HEC-RAS. Normal-depth with a slope of 0.022 was assumed for the downstream boundary condition. The hydraulic data obtained from HEC-RAS were imported into HEC-GeoRAS to delineate a floodplain boundary for the Unnamed Wash 12.

5.2 Work Study Maps

A work study map is shown in Exhibit 1. This study mapped a floodplain upstream of CP B.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

Manning's n values were determined by a combination of a site visit and 2008 PAG aerial photo. There are many reaches that are wide with several flow paths. Rather than assign a channel and overbank Manning's n, an average n for the whole cross-section of 0.045 was assigned.

5.3.2 Expansion and Contraction Coefficients

The expansion coefficient of 0.30 and contraction coefficient of 0.10 were used for the entire study reach. The expansion coefficient of 0.5 and contraction coefficient of 0.3 were used for the cross sections immediately upstream or downstream of culverts.

5.4 Cross-Section Description

A 2-foot interval contour map was used to select the location of cross sections. Cross-section locations were determined primarily based on the channel topography. The cross-section lines were drawn to be perpendicular to flow paths in HEC-GeoRAS. The locations of cross sections and channels used for this study are shown in Exhibit 1.

5.5 Modeling Consideration

5.5.1 Hydraulic Jump and Drop Analysis

No hydraulic, drop analyses or adjustment of the floodplain was conducted in this study.

5.5.2. Bridges and Culverts

None.

5.5.3 Levees and Dikes

There are no levees or dikes located within the study limit.

5.5.4 Non-Levee Embankments

None.

5.5.5 Island and Flow Splits

There were no islands or flow splits modeled.

5.5.5 Ineffective Flow Areas

In general these ineffective flow areas were disconnected overbank areas that would not convey flow to the next downstream cross-section or immediately upstream or downstream of culverts. Contraction rate of 1:1 and expansion rate of 1:3 were used to determine ineffective areas immediately upstream and downstream of road crossings.

5.6 Floodway Modeling

No floodway modeling was performed in this study.

5.7 Problems Encountered

5.7.1 Special Problems and Solutions

There are no special problems in the study limit.

5.7.2 Model Warnings and Errors

No errors occurred. The following warning messages occurred:

Divided flow
Energy loss greater than 1.0
Energy equation could not be balanced and defaulted to critical.
Cross-section extended vertically.
Multiple critical depths calculated.
Conveyance ratio is less than 0.7 or greater than 1.4.

5.8 Calibration

The model was not calibrated in this study.

5.9 Final Results

5.9.1 Hydraulic Analysis Results

The HEC-RAS model is included in Appendix E.

5.9.2 Verification of Results

The proposed floodplain limit tends to follow the existing floodplain limit. The results suggest that the proposed floodplain limit is reasonable based on the topography.

Section 6 Erosion and Sediment Transport

No erosion or sediment transport analysis was conducted in this study.

Section 7 Draft FIS Report Data

7.1 Summary of Discharges

Peak discharges at CPs B, C and D were used for the hydraulic analysis in this study. The estimated regulatory discharge rates are summarized in Table 3.

7.2 Floodway Data

Not applicable.

7.3 Annotated Flood Insurance Rate Map

Not applicable.

7.4 Flood Profiles

Flood profiles are included in the HEC-RAS model in Appendix E.

Exhibit 1.1
Watershed Map
Unnamed 12 Wash

Discharge Point

gdblib.GISDATA.stcl_maj

Cross Section

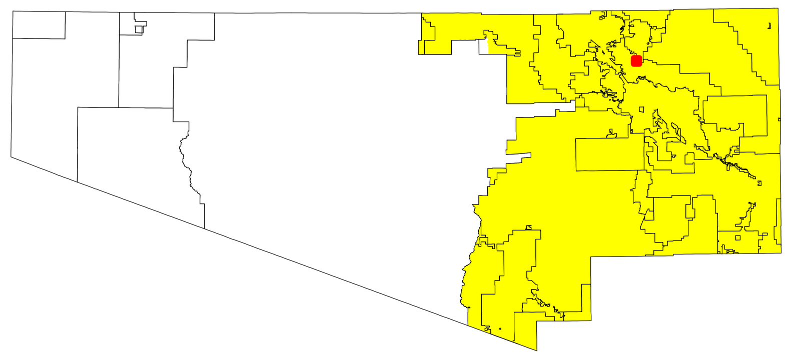
Contours 2ft

Contours 10ft

Proposed 100-yr Floodplain

Aerial : 2011 Picometry Tucson
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:1,500,000

Pima County Regional FLOOD CONTROL DISTRICT

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THE SEAL OF PIMA COUNTY ARIZONA

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Appendix A: References

A.1 Data collection summary.

Include a list of previous studies, other applicable studies, published and unpublished historical
flood information, and research contacts.

A.2 Referenced documents.

Arizona Department of Water Resources, Flood Mitigation Section
"Requirements for Flood Study Technical Documentation" SS1-97, November 1997

Arroyo Engineering. 2007. *PC-Hydro User Guide*. Pima County Regional Flood Control District

Eychaner, J.H., 1984. *Estimation of magnitude and frequency of floods in Pima County, Arizona, with comparisons of alternative methods*: U.S. Geological Survey Water-Resources Investigations Report 84-4142, 69 p.

Haan, C.T., Barfield, B.J., Hayes, J.C. 1994. *Design Hydrology and Sedimentology for Small Catchments*, Academic Press.

National Weather Service. 1984. *Depth-Area Ratios in the Semi-Arid Southwest United States*, NOAA Technical Memorandum NWS Hydro-40

NOAA, 2006. NOAA Atlas 14, Precipitation Frequency Atlas for the United States: Volume 1 - Version 4.0 The Semiarid Southwest. National Weather Service, Hydrometeorological Design Studies Center. Available on the internet at: http://hdsc.nws.noaa.gov/ hdsc/pfds/sa/az_pfds.html

Phillips, J., and S. Tadayon. 2006. *Selection of Manning's roughness coefficient for natural and constructed vegetated and non-vegetated channels, and vegetation maintenance plan guidelines for vegetated channels in central Arizona*: U.S. Geological Survey Scientific Investigations Report 2006–5108, 41 p.

Thomas, B.E., H.W. Hjalmarson, and S.D. Waltemeyer. 1997. *Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States*. USGS Water Supply Paper 2433. 195 p.

U.S. Army Corps of Engineers (COE). 1998. *HEC-1 Flood Hydrograph Package, Users Manual*, CPD-1A, Hydraulic Engineering Center, Davis, CA.

U.S. Army Corps of Engineers (COE). 2001. *HEC-RAS, River Analysis System, Hydraulic Reference Manual*, CPD-69, Hydraulic Engineering Center, Davis, CA.

U.S. Army Corps of Engineers (COE). 2006. *HEC-HMS, Hydrologic Modeling System User's Manual*, (v. 3.1.0) CPD-74A, Hydraulic Engineering Center, Davis, CA.

U.S. Department of Agriculture Natural Resources Conservation Service (NRCS), 1986. *Urban Hydrology for Small Watersheds,* Technical Release 55. Washington, DC.

Appendix B: General Documentation & Correspondence

B.1 Special Problem Reports.

B.2 Contact (telephone) reports.

Provide copies of correspondence documenting notification of the client and the methods of addressing any special problems described in Sections 4.4.1, 5.5 and 6.5.

B.3 Meeting minutes or reports.

B.4 General Correspondence.

B.5 Contract Documents.

Provide a copy of the contract Scope of Work, not financial documents.

Appendix C: Survey Field Notes

C.1 Survey field notes for aerial mapping control.
C.2 Survey field notes for hydrologic modeling.
C.3 Survey field notes for hydraulic modeling.

Appendix D: Hydrologic Analysis Supporting Documentation

(models, spreadsheets and supporting information is provided digitally in the TDN disk)

Appendix E: Hydraulic Analysis and As-Built Drawings for Hydraulic Structures

(models, spreadsheets and supporting information is provided digitally in the TDN disk)

Appendix F: Erosion and Sediment Transport Analysis Supporting Documentation

None