Flecha Caida Wash Letter of Map Revision Technical Data Notebook

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Approved by

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Director

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Exhibit 1 100-yr floodplain limits for the Flecha Caida Wash
Exhibit 2 Annotated Flood Insurance Rate Map for the Flecha Caida Wash

Section 1 Introduction

1.1 Propose

This Technical Data notebook (TDN) has been prepared for a Letter of Map Revision (LOMR) application for a portion of the Flecha Caida Wash (FCW) located in Pima County, Arizona. The objective of the TDN and LOMR submission is provide regulatory discharge rates and floodplain limits along the Flecha Caida Wash using better 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 Guideline. FEMA LOMR forms are included in this TDN.

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, Title 48, Chapter 21, Article 1, Sections 48-3601 through 3627. More specifically, A.R.S. 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 A.R.S. 3609, this ordinance provides for protection of the public health safety and welfare by regulation of flood and erosion hazard areas to control flood hazards and prevent repetitive loss from flood damage.
> D. The flood hazard areas of Pima County are subject to periodic inundation which 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 losses are caused by the cumulative effect of obstructions 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. (Ord. 2005 FC-2 § 2 (part), 2005).

Section 16 of the Pima County Ordinance 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, Ph.D., C.F.M., Principal Hydrologist.
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

1.3 Project Location

The study reach of the Flecha Caida Wash (FCW) is located within a Federal Emergency Management Agency (FEMA)-designated "Zone A" flood-hazard area, as depicted on FIRM Map Panel Numbers 04019C1644K and 04019C1645K (February 8, 1999). No documented hydraulic analyses were found to determine the "Zone A", and the existing "Zone A" depiction is not consistent with current topography. The objective of the TDN and LOMR submission is provide regulatory discharge rates and floodplain limits along the Flecha Caida Wash using better topographic, hydrologic, and hydraulic data.

The study reach of the Flecha Caida Wash is located primarily east of Swan Rd. and extends to Sections 23, 26, and 27 of Township 13 South, Range 14 East, Pima County, Arizona (Fig. 1.1). The study reach was divided into three segments in the study limit for the Flecha Caida Wash LOMR (Fig. 1.1). The western branch of the Flecha Caida Wash enters study limit from the northeast and flows southwest until it converges with the eastern branch. The eastern branch of the Flecha Caida Wash enters the study limit from the northwest and flows southeast until it converges with the western branch. The eastern and western branches converge immediately south of River Road. The Flecha Caida Wash LOMR study limit for the western branch extends from a junction with western branch to Paseo del Bac, in Section 23 of Township 13 South, Range 14 East. The study limit for the eastern branch extends from the junction with the eastern branch to Avenida del Cazador, in Section 23 of Township 13 South, Range 14 East. After the junction of the western and eastern branches, the wash flows down until it converges with Rillito Creek, in Section 27 of Township 13 South, Range 14 East.

1.3 Hydrologic and Hydraulic Methods

Hydrologic analysis was preformed to determine proposed regulatory discharge rates at concentration points along the Flecha Caida Wash using U.S. Army Corps of Engineers Computer Hydrologic Modeling System, HEC-HMS. Parameterization followed guidelines developed by Pima County Regional Flood Control District and described in technical Policy 018 (Tech 018, Appendix A). The proposed regulatory discharges are flow rates that have a 1-percent chance of being equaled or exceeded each year ("100-year" discharge rates). Hydraulic analysis was performed to delineate floodplain limits along the study reach of the Flecha Caida Wash using U.S. Army Corps of Engineers Computer Backwater Model, HEC-RAS.

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Three culverts exist within the study limit of the Flecha Caida Wash. Two culverts are located along the western branch of the study reach. A Corrugated Metal Pipe (CMP) culvert is located on Camino Cardenal, and on Calle de Las Chacras. A reinforced Concrete Box (RCB) culvert is located along the downstream segment, on Swan Road, just north of Avenida del Cazador.

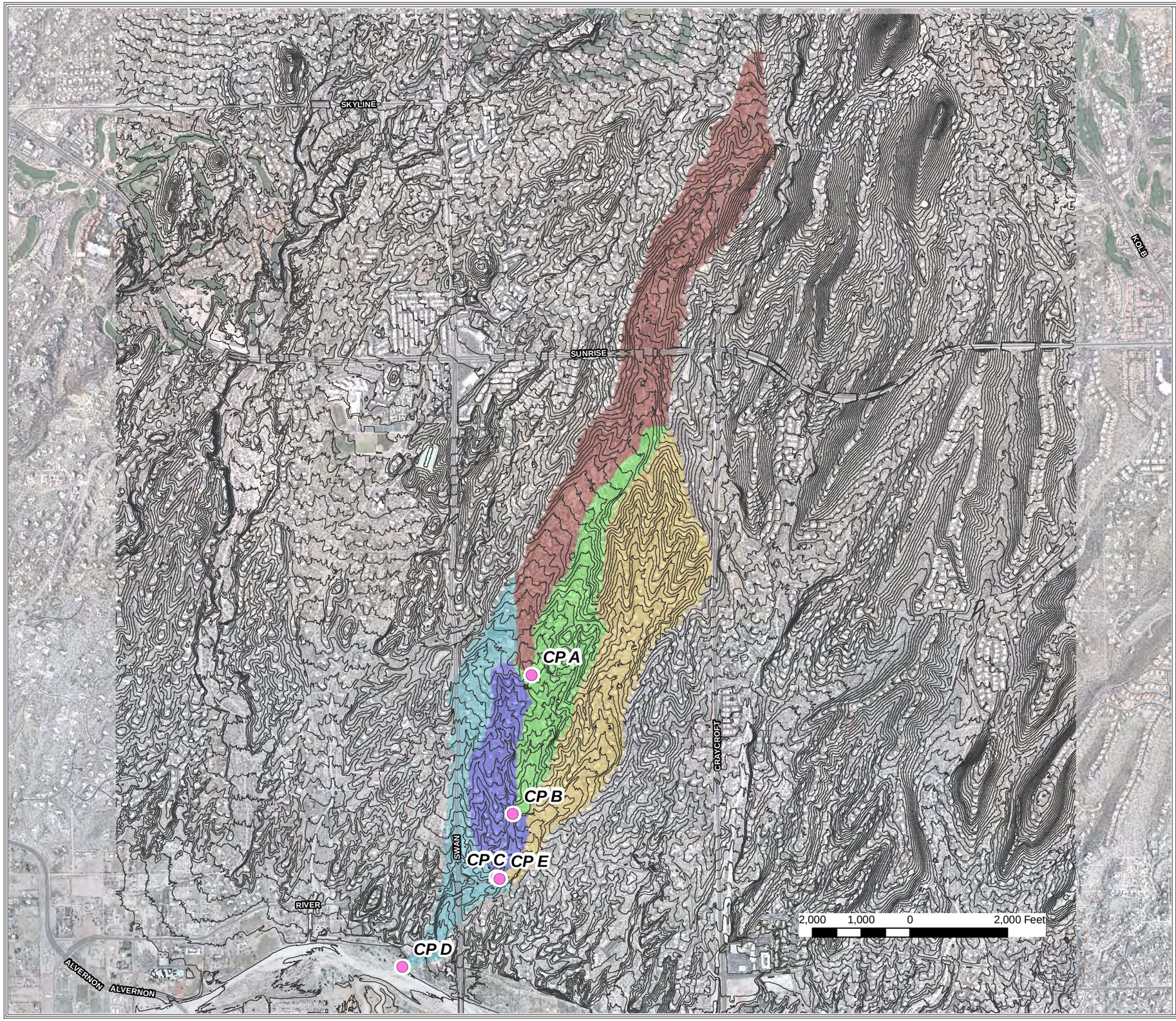
1.4 Acknowledgment

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

1.5 Study Results

The regulatory discharge rates were calculated at five concentration points along the Flecha Caida Wash (Fig. 1.3). Peak discharges at three concentration points (CP B, C, D) were used for the hydraulic analysis in this study. The estimated regulatory discharge rates are 604 cubic feet per second (cfs) with a drainage area of 0.7 square mile at the Concentration Point B (CP B), 781 cfs at CP C with a drainage area of 0.83 square mile, and 1370 cfs with a drainage area of 1.42 square mile at CP D.

Figure 1.1
Watershed Map
Flecha Caida Wash



Concentration Point

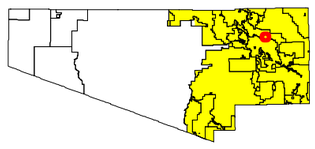
10 Foot Contour

Flecha Caida Subbasins

- FCW-1
- FCW-2
- FCW-3
- FCW-4
- FCW-5

Aerial Photo:2008 Pima Association of Government
Topo: 2005 Pima Association of Government
Vertical Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:5,250,000

Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

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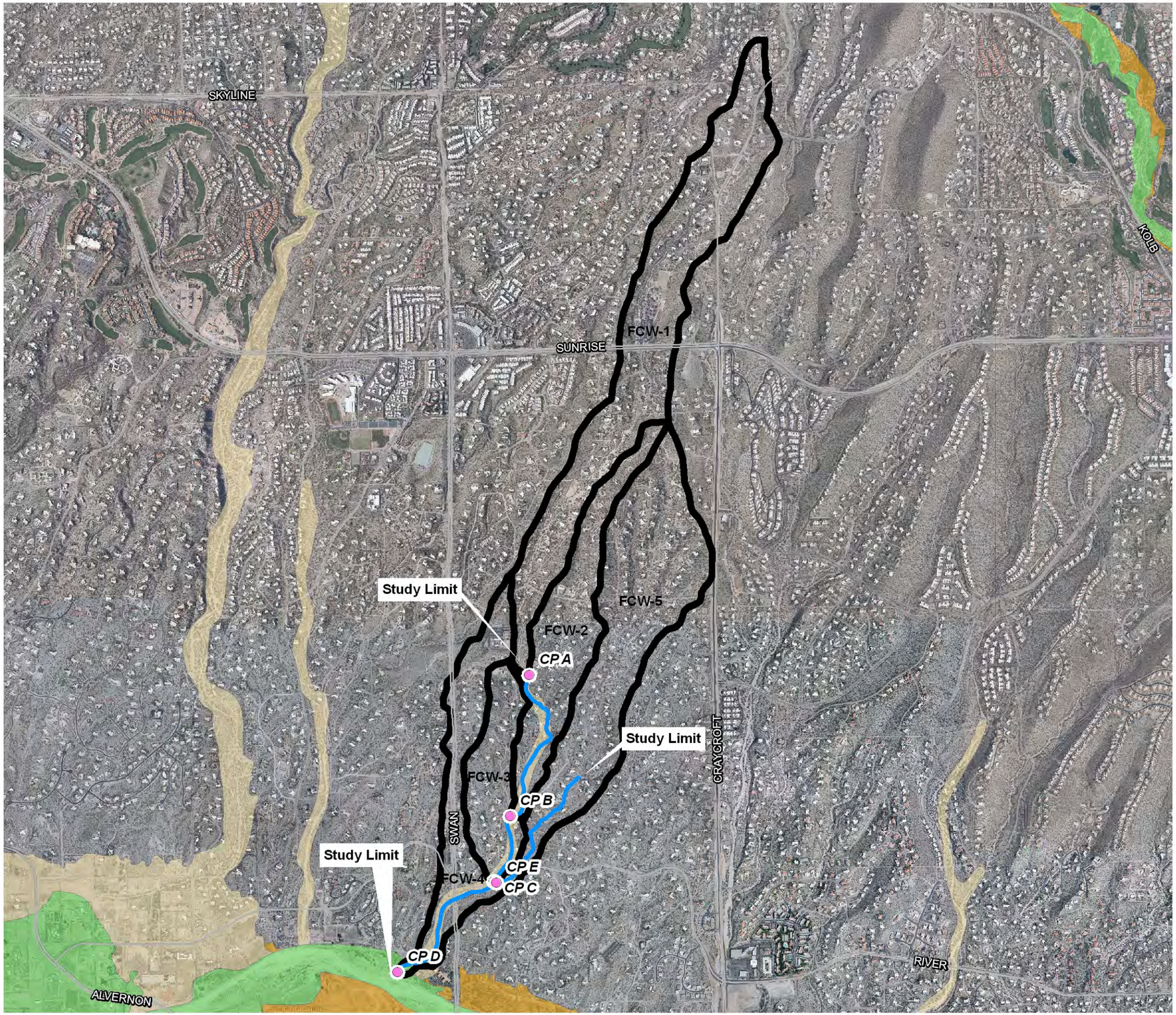
Figure 1.2
Study Limit Map
Flecha Caida Wash



Concentration Point

Channel

Flecha Caida Subbasins

Existing FEMA Floodplain

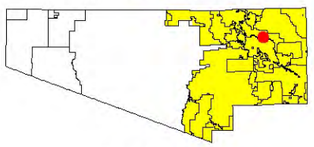
ZONE A

ZONE AE

ZONE X - SHADED

Aerial Photo:2008 Pima Association of Government

Pima County Index Map



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Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

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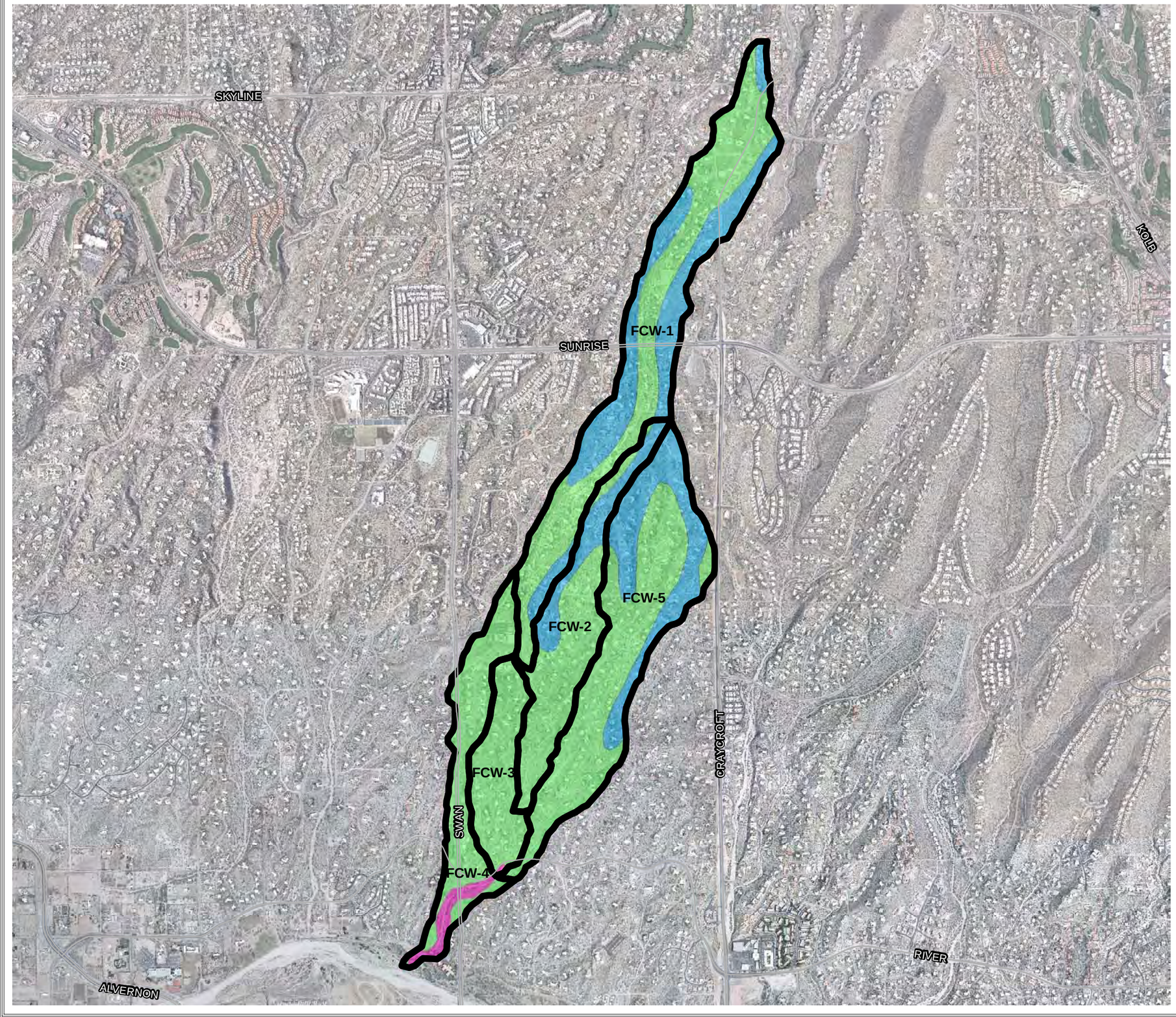
Figure 1.3
Soil Classification Map
Flecha Caida Wash



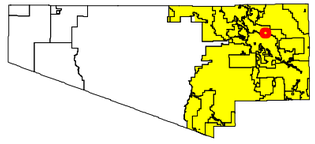
Flecha Caida Subbasins

Soil Classification

- Soil Group: A (100%)
- Soil Group: B (100%)
- Soil Group: B (82%) C (18%)

Aerial Photo:2008 Pima Association of Government

Pima County Index Map



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Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

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Section 2 FEMA Forms

2.1 Study Documentation Abstract for FEMA submittals

2.1.1 Date Study Accepted: _____

2.1.2 Study Contractor:

Planning and Development Division,
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701
(520) 243-1800

Prepared by Akitsu Kimoto, Ph.D, C.F.M., Principal Hydrologist.

2.1.3 Local Technical Reviewer:

Terry Hendricks, C.F.M, Chief Hydrologist
Planning and Development Division,
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701
(520) 243-1800

2.1.4 Reach Description

The study reach of the Flecha Caida Wash is located within a Federal Emergency Management Agency (FEMA)-designated “Zone A” and “Zone AE” flood-hazard area, as depicted on FIRM Map Panel Numbers 04019C1644K and 04019C1645K (February 8, 1999). The study reach of the Flecha Caida Wash is located primarily east of Swan Rd. and extends to Sections 123, 26, and 27 of Township 13 South, Range 14 East, Pima County, Arizona (Fig. 1.1). As previously mentioned, the study reach was divided into three segments in the study limit for the Flecha Caida Wash LOMR (Fig. 1.1). The western branch within the Flecha Caida Wash LOMR study limit extends from a junction with western branch to Paseo del Bac in Section 23 of Township 13 South, Range 14 East, while the eastern branch extends from the junction with the eastern branch to Avenida del Cazador, in Section 23 of Township 13 South, Range 14 East. After the junction of the western and eastern branches, the downstream segment flows downgrade until it converges with Rillito Creek, in Section 27 of Township 13 South, Range 14 East. The reach becomes wider after the junction. The length of each reach segment is 5034 feet for the western branch, 3066 feet for the eastern branch, and 3066 feet for the downstream segment.

The study reach of the Flecha Caida Wash are primarily composed of sand channels and the bottom of the reach is clean with no significant vegetation cover. The overbank of the reach is covered with scattered desert brush.

2.1.8 USGS Quad Sheets

Not available for this study

2.1.9 Unique Conditions and Problems

Approximately half of the CMP culvert, located on Camino Cardenal along the western Branch, was clogged with sand at the inlet. This might create backwater problems that might lead to higher flood elevation upstream of the CMP.

2.1.10 Coordination of Peak Discharges

The 100-year regulatory discharge rates at the concentration points along the study reach were computed using HEC-HMS, assuming no base flow in the watersheds or no transmission loss within the reaches. All reaches were modeled with HEC-RAS. The discharge rates were acceptable per Suzanne Shield, Director of the Pima County Regional Flood Control District.

2.2 FEMA Forms

The FEMA MT-2 forms are included in Appendix B.

Section 3 Survey and Mapping Information

3.1 Field Survey Information

The survey of the culverts was conducted between November 20-24, 2008 under direct contract with the Pima County Regional Flood Control. A signed and sealed copy of the survey is included in Appendix C.

The site survey was performed by:

Michael C. McCredie
Arizona Registered Land Surveyor, Certificate Number. 32792

3.2 Mapping

The topographic data was obtained using GeoRAS and ArcGIS. A triangular Irregular Network (TIN) derived from 2005 Light Detection and Ranging (LiDAR) data was used to create 2-foot interval contour map. The 2005 LiDAR data was accepted by FEMA for the LOMR revision of the Friendly Village Wash ("Friendly Village Wash LOMR TDN", Case No. 08-09-0473P, effective on October 23, 2008), located approximately 5 miles west of the Flecha Caida Wash.

The following data was used in this TDN;

The aerial photo: 2008 PAG aerial photo
Projection: UTM, Zone 12
Units: International feet
The contour interval of the topographic map is 2 feet.

Section 4 Hydrology

4.1 Method Description

The 100-year peak discharges for the five sub-basins of the Flecha Caida Wash (FCW-1, FCW-2, FCW-3, FCW-4, FCW-5; Fig. 1.3) were calculated using U.S. Army Corps of Engineers Computer Hydrologic Modeling System, (HEC-HMS) version 3.4. The HEC-HMS model requires the parameters regarding rainfall, topography, soil, vegetation, and channel characteristics to determine runoff volume and peak discharge. Those parameters were determined according to the Pima County Regional Flood Control District Technical Policy 018 (Tech-018). Tech-018 is included in Appendix A. The HEC-HMS model is included in Appendix D.

4.2 Parameter Estimation

4.2.1 Drainage Area

Subbasin boundaries were delineated using the hydrology function of ArcGIS with 2005 Lidar Data. A 2-ft contour map was used to make sure if the subbasin delineation was reasonable.

4.2.2 Watershed Work Map

A watershed work map is included in Exhibit 1. Nine subbasins were delineated for HEC-HMS hydrologic analysis. Five sub-basins were delineated for HEC-HMS hydrologic analysis. Five concentration points were included in the study watershed (CP A, B, C, D, and E). A junction was used to connect the eastern branch of the Flecha Caida Wash and western branch. The 100-year peak discharges at the three concentration points (CP B, C, and D) were used for HEC-RAS hydraulic analysis.

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

According to the Tech-018, the 3-hour storm shall be used as rainfall data in the HEC-HMS model in the case that a time of concentration (Tc) is equal or less than three hours. A 3-hour storm was selected, since Tc was less than 3 hours in all the sub-basins.

A point 3-hour rainfall depth at the coordinates of the centroid of the watershed was obtained from NOAA Atlas 14, upper 90% confidence interval precipitation frequency estimate (NOAA 14 rainfall). Areal reduction factor was applied to watersheds larger than 1 square mile, as described in Tech-018. The 3-hour rainfall depth for the Flecha Caida Wash watershed is 3.3 inches. The areal reduction factor of 0.96 was applied to CP D.

4.2.6 Physical Parameters

The physical parameters for the sub-basins and reaches of the HEC-HMS model were summarized in Tables 1 and 2. As mentioned in 4.1, all the methods and parameters were determined based on Tech-018. Table 1 summarizes the method used for a HEC-HMS analysis.

Table 1 Methods used for a HEC-HMS analysis

	Selected Method
Rainfall Depth	NOAA 14, upper 90% Confidence Interval
Rainfall Distribution	3-hr SCS Type II Storm
Rainfall Loss	SCS Curve number
Time of Concentration	SCS Segmental Method
Transform	SCS Unit Hydrograph
Routing	Modified-Puls

The SCS Curve Number (CN) method was utilized as a rainfall loss method in the HEC-HMS model. The CN was determined using the Curve Number tables and Hydrologic Soils Group maps associated with the PC Hydro User Guide (Arroyo Engineering, 2007). The CN was not adjusted for rainfall intensity or antecedent moisture conditions. The SCS Unit Hydrograph method was used as a transform method. Impervious cover was determined using 2008 PAG aerial photograph. The combination of the kinematic wave time of concentration method and the U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (Tc) calculation (USDA-NRCS, 1986) was used to determine Tc, based on the recommendation on Tech-018. The Tc was calculated by summing the travel time for sheet flow, shallow concentrated flow and channel flow. The Tc for sheet flow was estimated using the kinematic wave equation. Manning's roughness coefficient for sheet flow was obtained using Table 3-1 in Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986). The velocity for channel was calculated using Manning's equation. The detail of the Tc calculation is included in Appendix D.

Table 2 Physical Parameters for the Sub-Basins

Sub-Basin	Area (sq mi)	CN	Impervious Area (%)	Vegetation Cover (%)	Lag Time (min)
FCW1	0.47	84.0	10.0	30	25.5
FCW2	0.22	84.0	10.0	30	16.1
FCW3	0.14	83.7	10.0	30	8.7
FCW4	0.18	83.7	10.0	30	14.1
FCW5	0.41	83.9	10.0	30	22.3

Runoff from sub-basins was routed using the Modified-Puls method. A storage discharge table for the channel routing was developed using the cross sections and slopes derived from HEC-HMS. The number of subreaches was calculated using the following method:

$$V_w = 1.5 * V_{ave} .....eq.1$$

$$K = \frac{L}{V_w} .....eq.2$$

Therefore,

$$N = \frac{K}{\Delta t} .....eq.3$$

where V_{ave} is average flow velocity, L is reach length, V_w is velocity of flood wave (a conversion factor of 1.5 is used for natural channels), K is hydrograph travel time, Δt is the time interval for computations in the model, and N is the number of steps in the reach routing. Eq.4 was obtained from eq.1, 2, and 3. The detail of the calculation of the number of subreach is included in Appendix D.

4.3 Problems 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

The time interval of the rainfall data used in this study is 5 minutes, while the simulation time interval is 1 minute. The HEC-HMS model interpolated the 5-minute time interval of the rainfall data to 1-minute time interval.

4.4 Calibration

No calibration was conducted in this study.

4.5 Final Results

4.5.1 Hydrologic Analysis Results

The 100-year peak discharges at the concentration points along the Flecha Caida Wash were determined using the HEC-HMS. The results are summarized in Tables 3 and 4.

Table 3 Summary of the Hydrologic Analysis Results for Sub-Basins

Sub-Basin	Area (sq mi)	Rainfall Depth (in)	Runoff Volume (in)	Peak Discharge (cfs)
FCW1	0.47	3.30	1.77	603.6
FCW2	0.22	3.30	1.77	385.4
FCW3	0.14	3.30	1.74	330.7
FCW4	0.18	3.30	1.74	336.9
FCW5	0.41	3.30	1.76	574.2

Table 4 Summary of the Hydrologic Analysis Results at the Concentration Points

Concentration Point	Location	Area (sq mile)	Rainfall Depth (in)	Runoff Volume (in)	Q100 HMS (cfs)	Time to Peak
CP A	**at Paseo del Bac**	0.47	3.30	1.77	604	1:50
CP B	**at Via Ra Posa**	0.69	3.30	1.77	781	1:53
CP C	**at River Rd**	0.83	3.30	1.74	846	1:54
CP D	**Confulence with Rillito River**	1.42	3.17	1.65	1370	2:00
CP E	**at River Rd**	0.41	3.30	1.76	574	1:47

4.5.2 Verification results

There were comparable 100-year peak discharges available near the concentration points A, C and E in a previous study (prepared by Simons, Li and Associates, Inc. 1986). The peak discharges in the previous study were determined based on Hydrology Manual for Engineering Design and Flood Plain Management within Pima County, Arizona (Pima County Department of Transportation and Flood Control District, 1979). The 100-year discharge near the CP A, B, and E were shown in Table 5. The comparison shows that the 100-year peak discharges estimated in this study is lower than the values from the previous study.

The calculated 100-year peak discharge was also compared with the peak discharge obtained from USGS Regression Equation 13 (Thomas et al., 1997) (Table 6). The comparison showed that the peak discharge from the HMS-derived peak discharge was lower than the one derived from the regression equation.

Table 5 Comparison of a peak discharge

Concentration Point	Concentration Point Location	Area	Q_{100}
		(sq mile)	Peak Discharge (cfs)
CP #20	Near CP A in this TDN	0.5	766
CP #21	Near CP C in this TDN	0.81	1046
CP #24	Near CP D in this TDN	1.33	1604

Table 6 Comparison of a peak discharge

Concentration Point	Location	Area (sq mile)	Q100 HMS (cfs)	Q100 RRE (cfs)
CP A	at Paseo del Bac	0.47	604	742
CP B	at Via Ra Posa	0.69	781	977
CP C	at River Rd	0.83	846	1110
CP D	Confulence with Rillito River	1.42	1370	1584
CP E	at River Rd	0.41	574.2	671

Section 5 Hydraulics

5.1 Method Description

The hydraulic modeling for the Flecha Caida Wash was performed using Hec-RAS, Version 4.0 (HEC-RAS), HEC-GeoRAS, Version 4.1.1 (HEC-GeoRAS), and ArcGIS, Version 9.3.

Hydraulic analysis was performed in the area currently mapped as FEMA Zone A. Steady flow analysis was performed to determine a 100-year floodplain limit for the Flecha Caida Wash by using HEC-RAS. Normal-depth with a slope of 0.027 was assumed for a downstream boundary condition. Corrected model is proposed in this study. The model name is FC, and the plan name is Plan 01.

The locations of the stream centerline, cross-sections, and bank of the Flecha Caida Wash were determined using the 2-ft contour map and 2008 PAG aerial photos. The geometric data, including stream centerline, flow paths and cross-sections, were digitized in HEC-GeoRAS. The digitized data was exported to create geospatially referenced geometric data (cross section, reach profile) in HEC-RAS. As previously mentioned, the DTM derived from 2005 LiDAR data was used. Other parameters for the steady-state analysis in HEC-RAS, such as Manning's n-values, expansion and contraction coefficients, boundary condition, and ineffective flow areas were manually input into HEC-RAS. The hydraulic data obtained from HEC-RAS were imported into HEC-GeoRAS to delineate a floodplain boundary for the Flecha Caida Wash.

5.2 Work Study Maps

The work study map is included in Exhibit 2.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

Manning's n values were determined using 2008 PAG aerial photo. Manning's n value of 0.06 was assigned for the overbank with scattered desert brush along the all reaches including western, eastern, and downstream branches. The value of 0.04-0.045 was assigned for the channel.

5.3.2 Expansion and Contraction Coefficients

The channel of the Flecha Caida Wash is assumed to have generally gradual transitions with minimum curvature, except for the upstream and downstream of the culverts. The expansion coefficient of 0.30 and contraction coefficient of 0.10 were used for the entire study reaches of the FC except the upstream and downstream of the culverts. The expansion coefficient of 0.50 and contraction coefficient of 0.30 were used for the upstream and downstream of the culverts.

5.4 Cross-Section Description

A 2-foot interval contour map derived from 2005 LiDAR data 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 Geo-RAS and ArcGIS.

5.5 Modeling Consideration

5.5.1 Hydraulic Jump and Drop Analysis

The HEC-RAS profile showed a drop of the 100-year flood elevation over the two upstream culverts (Culverts #1 and 2) along the Flecha Caida Wash. No hydraulic, drop analyses or adjustment of the floodplain for the Flecha Caida Wash was conducted in this study.

5.5.2. Bridges and Culverts

There are three culverts in the study limit. Two corrugated metal pipe (CMP) culverts are located along the western branch of the study reach. A 4-cell, arch (3.5-ft span and 2.4-fe rise) CMP is located on Camino Cardenal, and a 4-cell, circular culvert with a diameter of 3 feet CMP is located on Calle de Las Chacras. A 2-cell, 9-ft wide by 6-ft high reinforced concrete box (RCB) culvert is located along the downstream segment, on Swan Road, just north of Avenida del Cazador. All the culvers were surveyed by Michael C. McCredie, Arizona registered land surveyor.

5.5.3 Levees and Dikes

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

5.5.4 Island and Flow Splits

There were no islands or flow splits modeled.

5.5.5 Ineffective Flow Areas

Ineffective flow option was modeled in the following situations;

- Floodplain areas are not hydraulically connected (Cross Section # 860.9661)
- A contraction and expansion of flow through the culvert openings occurs at the upstream and downstream of the Culvert #3 (Cross Section#.2344.541, 2199.356, and 1992.327). 4:1 expansion and 1:1 contraction ratios were used.

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

The FEMA guidelines state that it is required to run hydraulic models under subcritical flow conditions. Since the study area of the Flecha Caida Wash has steep slopes, the flow regime of the Flecha Caida Wash is expected to be critical or supercritical. The HEC-RAS modeling produced warnings stating “During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program defaulted to critical depth at many cross-sections along the Flecha Caida Wash. Most of the errors force a critical solution which is reasonable for these steep watercourses.

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.

The warnings stating that "The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations", "The energy loss was greater than 1.0 ft (0.3 m) between the current and previous cross section. This may indicate the need for additional cross sections", and "The conveyance ratio (upstream conveyance divided by downstream conveyance) is less than 0.7 or greater than 1.4. This may indicate the need for additional cross sections" are produced at many cross sections through the Flecha Caida Wash. These warming messages were produced mainly due to the steepness of the slope of the Flecha Caida Wash and the subcritical flow requirement of FEMA.

5.8 Calibration

The model was not calibrated in this study.

5.9 Final Results

5.9.1 Hydraulic Analysis Results

The HEC-RAS modeling results are included in Appendix E.

5.9.2 Verification of Results

The floodplain limit produced in this Flecha Caida Wash LOMR study was compared to the existing FEMA floodplain limit. The floodplain limit of this study was extended to the Calle dos Cabezas. The proposed floodplain limit tends to follow the existing floodplain limit, although the proposed limit tends to be narrower than the exiting limit. The results suggest that the proposed floodplain limit is reasonable based on the topography of the Flecha Caida Wash.

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 three concentration points (CP B, C, E) were used for the hydraulic analysis in this study. The estimated regulatory discharge rates are 604 cubic feet per second (cfs) with a drainage area of 0.7 square mile at the Concentration Point B (CP B), 781 cfs at CP C with a drainage area of 0.83 square mile, and 1370 cfs with a drainage area of 1.42 square mile at CP E.

7.2 Floodway Data

Not applicable.

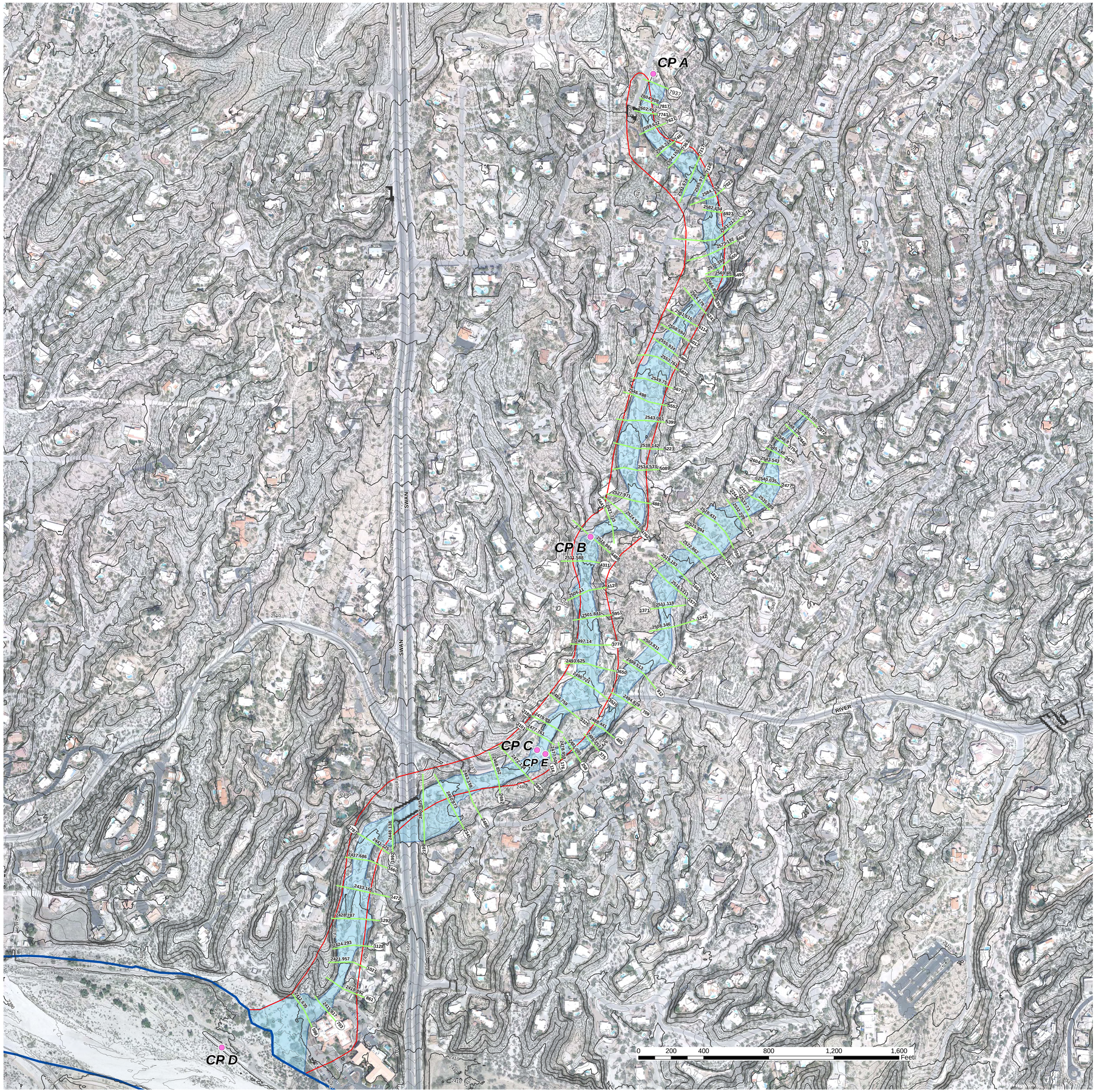
7.3 Annotated Flood Insurance Rate Map

An annotated Flood Insurance Rate Map (FIRM) is included in Exhibit 2.

7.4 Flood Profiles

Flood profiles are available in HECRAS model included in Appendix E.

Exhibit 1
100-year Floodplain
with cross sections
Flecha Caida Wash



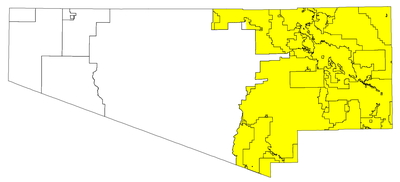
- Discharge Point
- Cross Sections
- 2 Foot contour
- 10 Foot contour
- Proposed Zone A

Existing FEMA Floodplain

- ZONE A
- ZONE AE

Aerial: 2008 Pima Arizona Government
Topo: 2005 Pima Arizona Government
Vertical Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:1,500,000

Pima County Regional Flood Control District

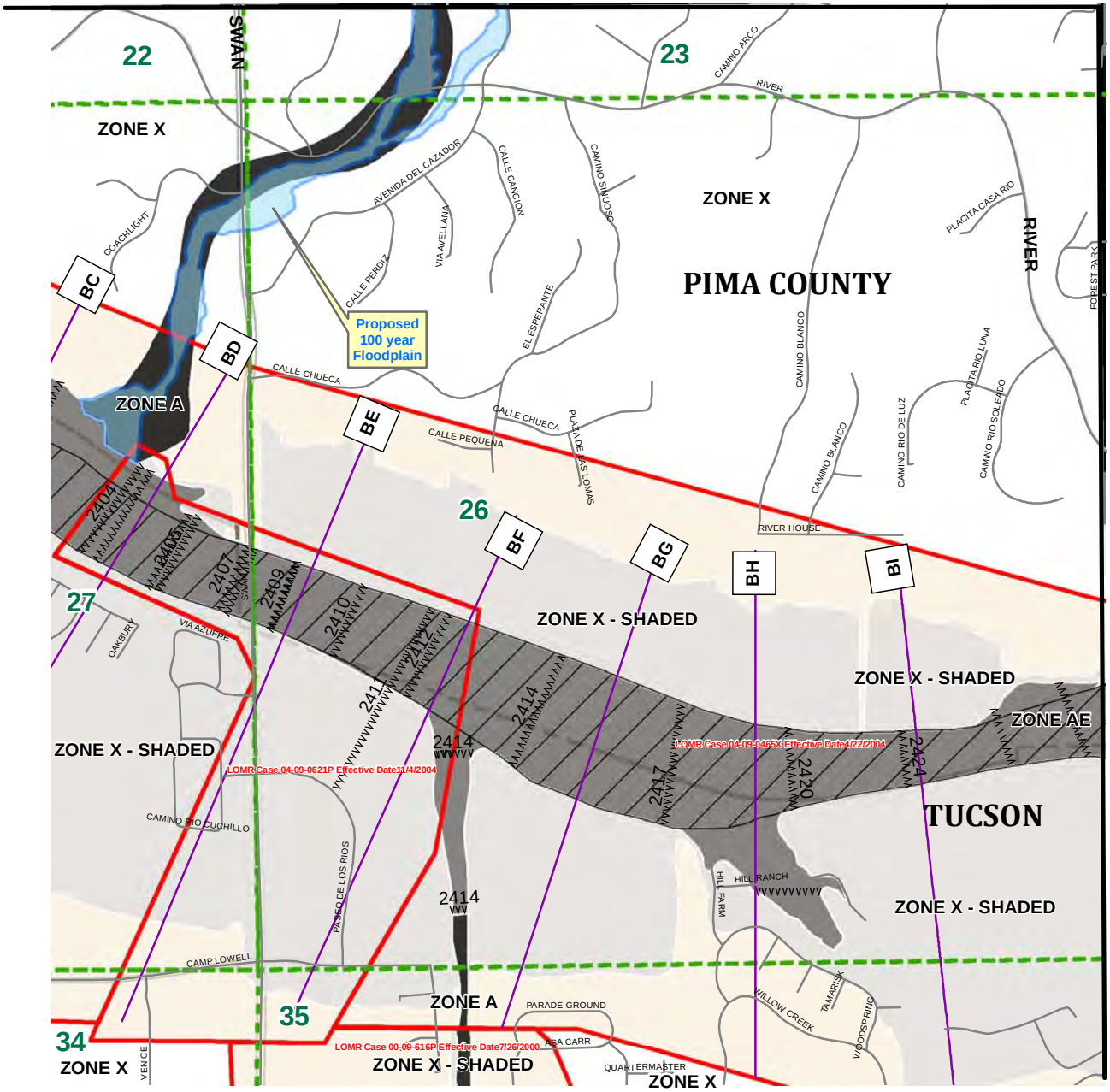
Scale 1:200'

Pima County Regional Flood Control
97 East Congress Street - 3rd Floor
Tucson, Arizona 85701-1207
(520)243-1800 - FAX (520)243-1821
http://www.rfcd.pima.gov

01/2010

gislib\rfcd\projects\iimd\xavi\mdx\akitsu\Flecha Caida wash_100yr_exh1.mxd

Exhibit 2
Annotated Flood Insurance Rate Map
04019C1644 K
Flecha Caida Wash



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 Department of Transportation Technical Services Division makes no claims regarding the accuracy of the information depicted herein.

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http://www.rfcd.pima.gov

- Streets
- FIRM X-Sections
- Base Flood Elevations
- Proposed Floodplain
- LOMRs
- FIRM - Flood Insurance Rate Map
- Sections
- Jurisdictions
- Floodway

Existing Floodplain Zone

- ZONE A
- ZONE AE
- ZONE AO 1
- ZONE AO 2
- ZONE X
- ZONE X - SHADED

0 250 500 1,000 Feet

N

Pima County Index Map

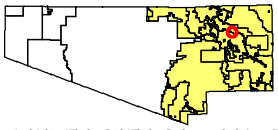

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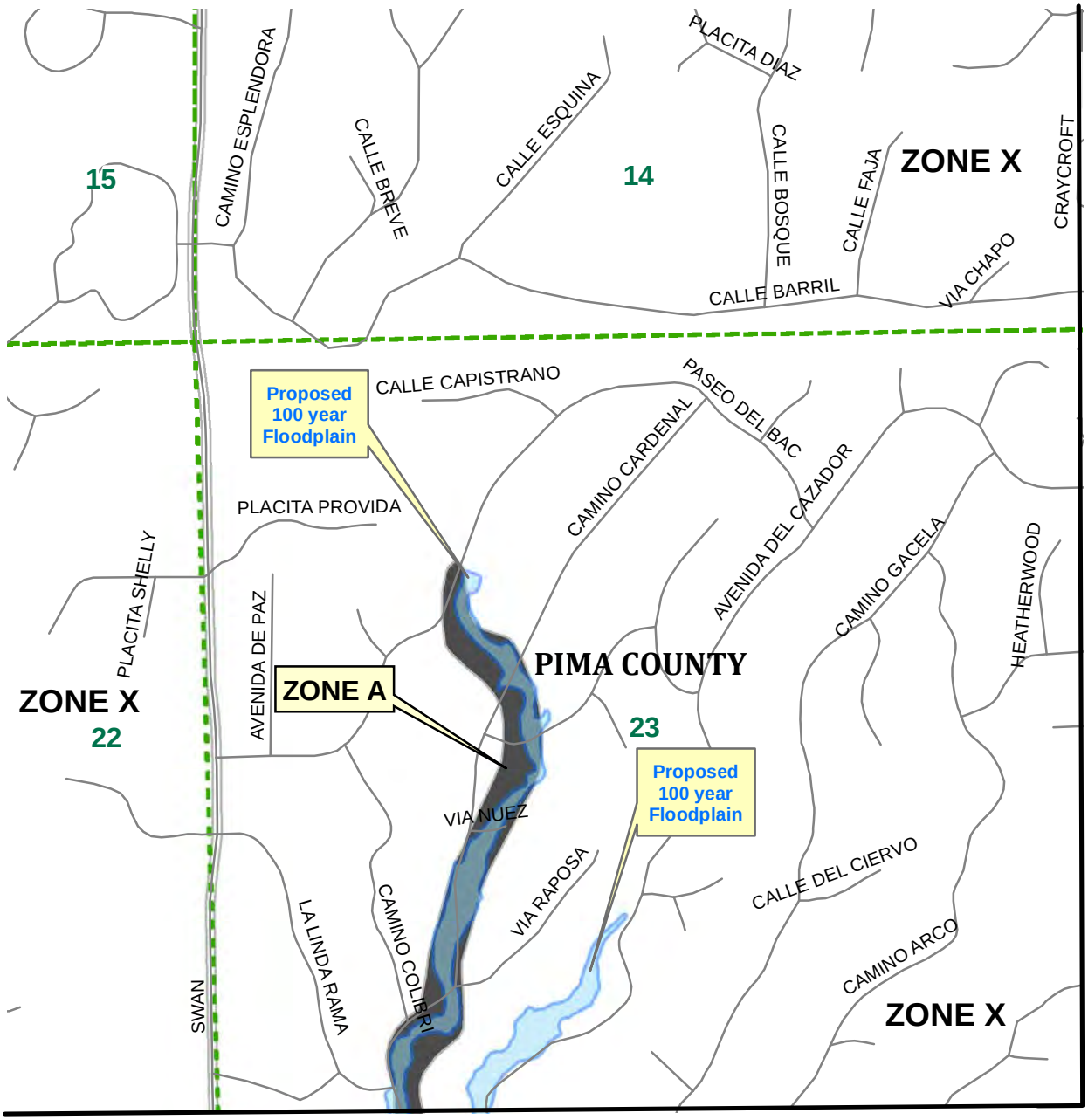
Exhibit 2
Annotated Flood Insurance Rate Map
04019C1645 K
Flecha Caida Wash



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- Streets
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- Proposed Floodplain
- LOMRs
- FIRM - Flood Insurance Rate Map
- Sections
- Jurisdictions

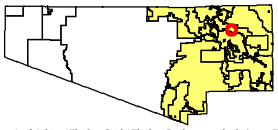
Existing Floodplain Zone

- A
- AE
- AO
- X
- X (SHADED)

0 250 500 1,000 Feet

N

Pima County Index Map



g:\lib\rfcd\projects\imd\xavi\mdx\akitsu\Flecha_Caida\Flecha_Caida_watershed_Anno_FIRM8x11_1645K.mxd