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

Prepared by:

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97 East Congress, Tucson, AZ 85701

Approved by

Suzanne Shields

Suzanne Shields, PE
Director

Registered Professional Engineer (Civil)
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SHIELDS
DATE SIGNED 11/29/2012
ARIZONA U.S.A.
expires 6/30/2013

Pima County Regional Flood Control District
97 E Congress Street
Tucson Arizona, 85701

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Section 1 Introduction

1.1 Propose

This Technical Data notebook (TDN) has been prepared to study a portion of the Pegler Wash (PGR) located in Pima County, Arizona. The objective of the TDN is provide regulatory discharge rates and floodplain limits along the Pegler 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. 2010 FC-5 (part), 2010).

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 Pegler Wash (PGR) is located upstream of a Federal Emergency Management Agency (FEMA)-designated “Zone A” flood-hazard area, as depicted on FIRM Map Panel Number 04019C1660L and 1680L (June 16, 2011). The site includes Sections 25, 26, 34, 35, and 36 of Township 12 South, Range 13 East, Section 30 and 31 of Township 12, Range 14, and Section 03, 04, and 09 of Township 13, Range 13, Pima County, Arizona. The objective of the TDN is provide regulatory discharge rates and floodplain limits along the Pegler Wash using better topographic, hydrologic, and hydraulic data.

The study reach of the Pegler Wash is located primarily east of La Cholla Bld (Fig. 1.1). The Pegler Wash enters study limit from the east and flows west. The study limit for the Pegler Wash is from La Cholla Bld. to Northern Ave.

LOMR Case# 08-09-1616P (Effective Date 12-19-2008) re-mapped the Pegler Wash between La Cholla Blvd. and Orange Grove Rd. LOMR Case# 09-09-0020P (Effective Date 11-20-2009) re-mapped the wash from the Sotomayor Ranch Subdivision (including a levee) to Orange Grove Rd. Case# 04-09-0465X (Effective Date 04-22-2004) re-mapped near the downstream of the wash from the Rillito River. All three LOMRs were incorporated into FIRM panels 04019C1660L and 1667L.

1.4 Hydrologic and Hydraulic Methods

The 100-year return interval peak discharge rates were obtained by using HEC-1 and PC-Hydro, Version 5.4.2 (PC-Hydro). The HEC-1 peak discharges for the Pegler Wash were provided by JE Fuller. The watershed was subdivided into 6 sub-basins for the HEC-1 analysis. There are four concentration points (CP 103,104,105 and 106) for the HEC-1 analysis (Fig. 1). CP 103 is located at La Canada Dr. and CP 105 is located at La Cholla Bld. Vegetation cover of 20% and impervious cover of 25% were used for the analysis.

Upstream of the Pegler watershed was further subdivided for PC-Hydro analysis (CP C, E, G, H, I and J). The parameters for PC-Hydro, such as rainfall intensity and subbasin characteristics (e.g. soil, vegetation, slope, flow distance, roughness), were selected using 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). Hydraulic analysis was performed to delineate floodplain limit along the study reach of the Pegler Wash using U.S. Army Corps of Engineers Computer Backwater Model, HEC-RAS, Version 4.1 and FLO-2D, Version 2007.
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1.5 Acknowledgment

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

1.6 Study Results

The regulatory peak discharge rates were calculated at concentration points A to J (Fig. 1.3).

Table 0 Summary of Results

Concentration Point	Location	Area (sq mile)	Q100 HEC-1 or PC-Hydro (cfs)	Q100 RRE (cfs)
CP 103	**La Canada**	1.60	2050	1709
CP 104	**Ina**	2.03	2392	1982
CP 105	**La Cholla**	2.43	2615	2211
CP C	**La Cholla**	0.11	367	230
CP E	**Ina**	0.19	817	368
CP G	**Upstream of La Canada**	0.55	1808	832
CP H	**Upstream of La Canada**	0.36	1253	609
CP I	**Magee**	0.15	673	303
CP J	**Magee**	0.42	1603	683

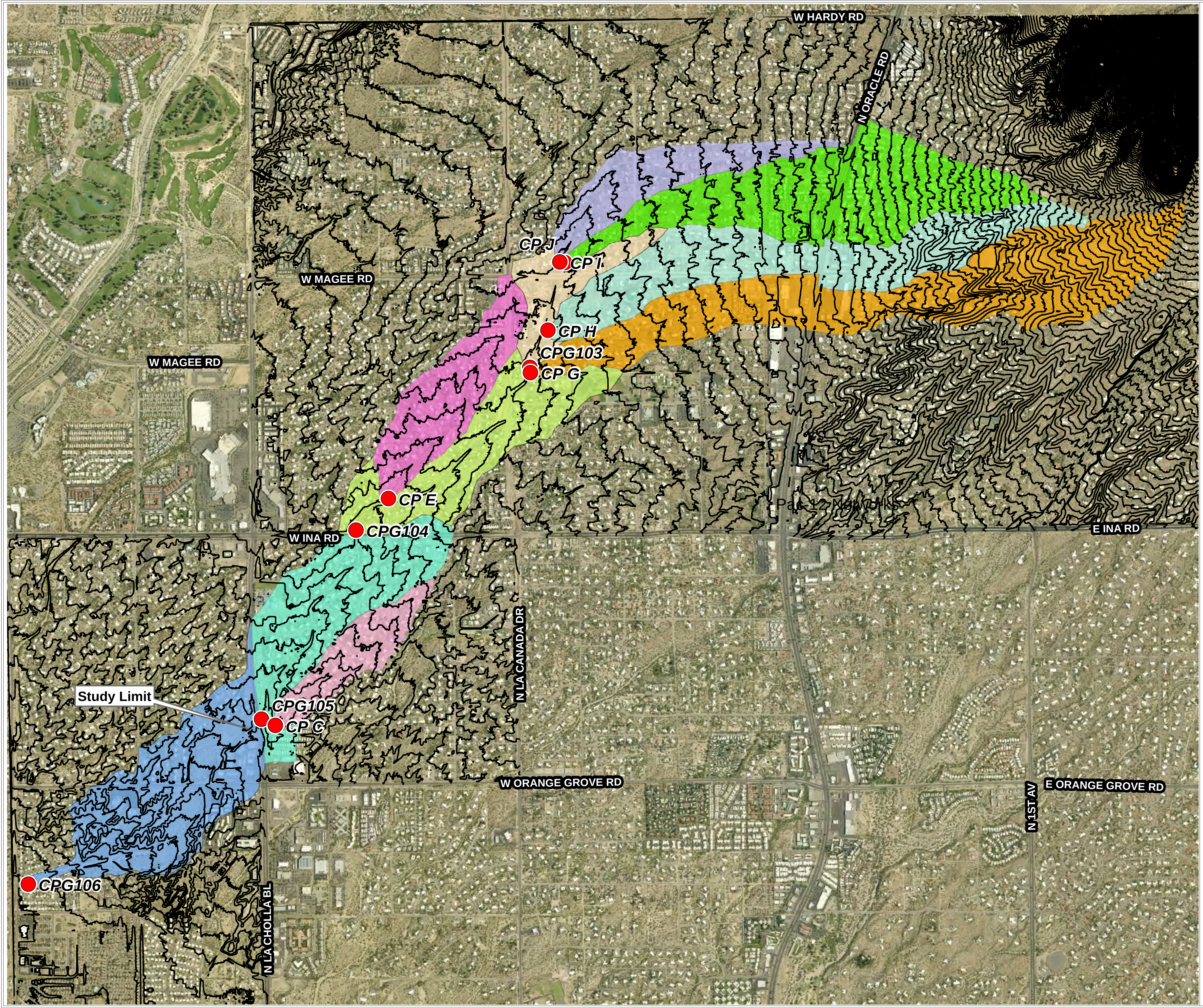


Figure 1.1
Watershed Map
Pegler Wash

Discharge Point

Contours 10ft

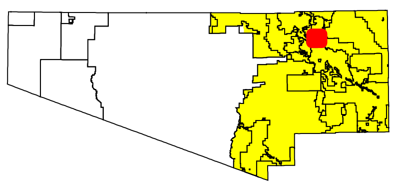
Subbasins

- A
- B
- C
- D
- E
- F
- G
- H
- I
- J

Aerial : 2010 Pictometry

Datum: NAVD 1988

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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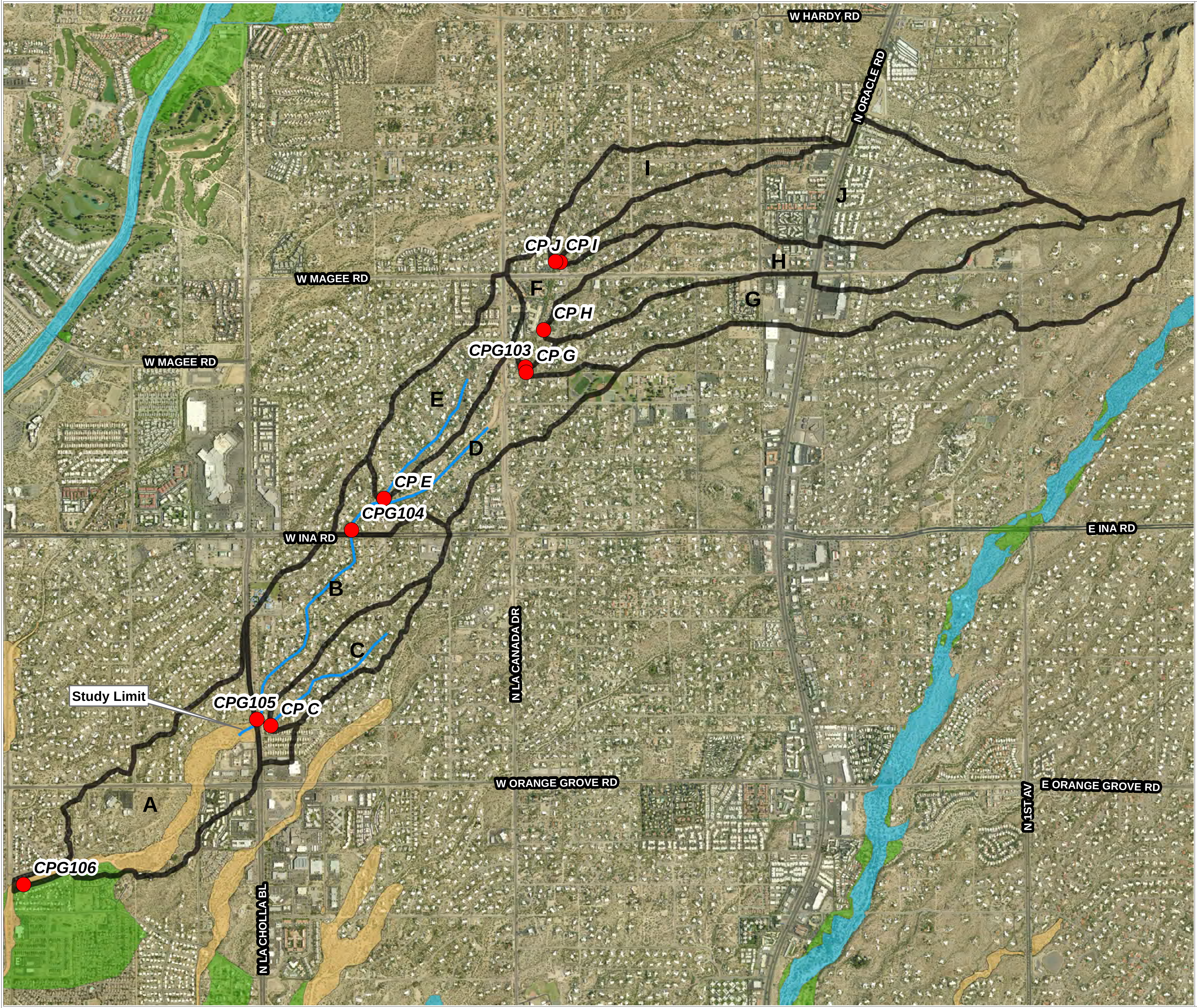
Figure 1.2
Study Limit
Pegler Wash



Discharge Points

River

Subbasins

Existing FEMA Floodplain

ZONE A

ZONE AE

ZONE X - SHADED

Aerial : 2010 Pictometry

Pima County Index Map

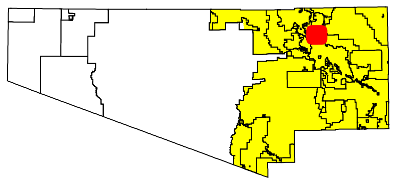


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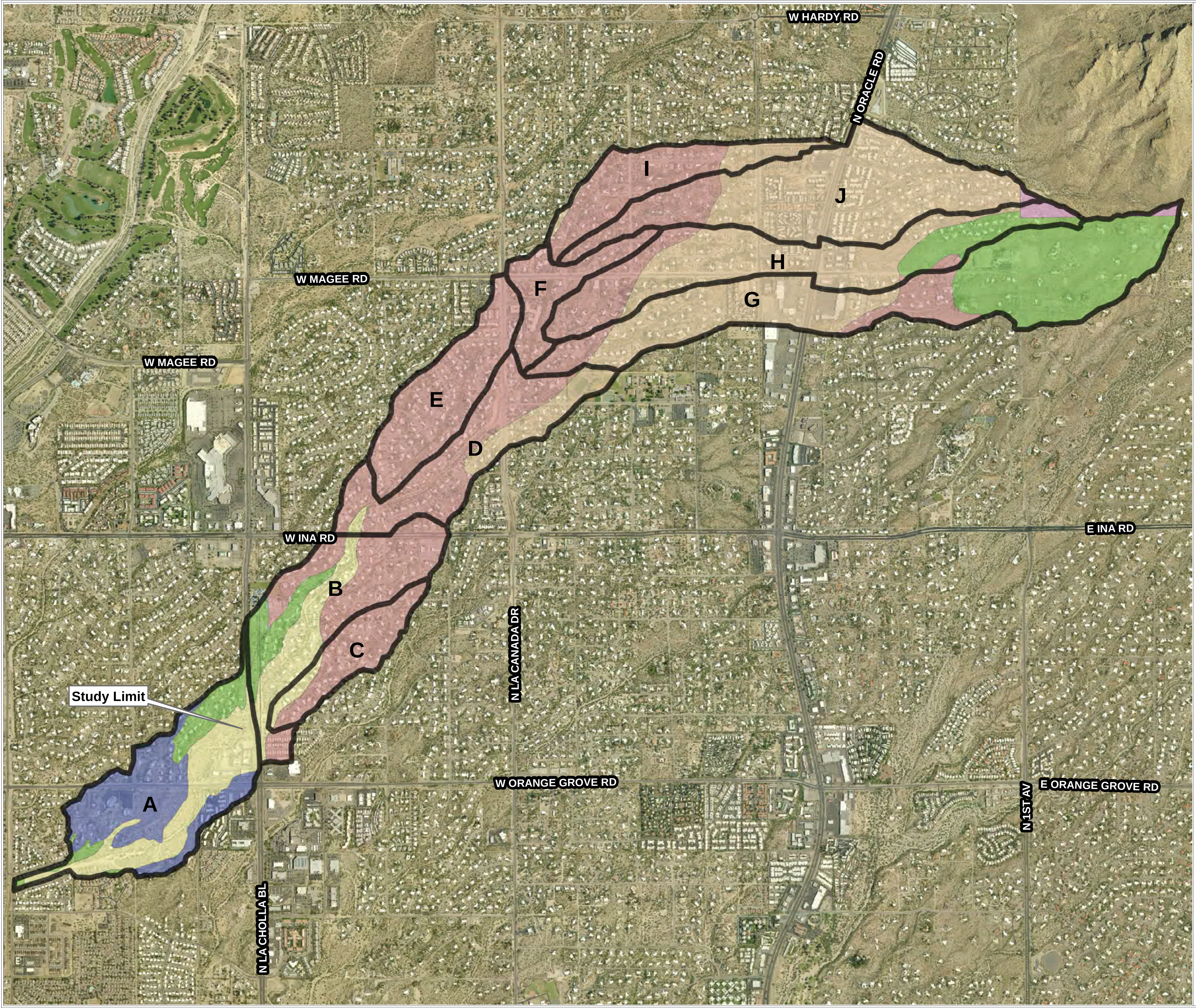
Figure 1.3
Soil Classification
Pegler Wash



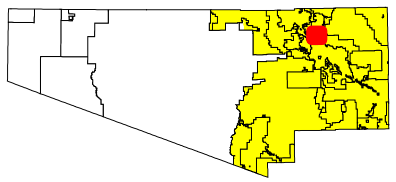
Subbasins

Soil Classification

- Soil Group: A (100%)
- Soil Group: B (100%)
- Soil Group: B (50%) C (50%)
- Soil Group: C (100%)
- Soil Group: C (53%) D (47%)
- Soil Group: D (100%)

Aerial : 2010 Pictometry

Pima County Index Map



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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

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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Akitsu.Kimoto@pima.gov

<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: Pegler Wash
Reach Description: Wash in Catalina Foothills
Study Type: Hydrology and Hydraulics study of a Riverene System
Purpose of the Study: Estimate regulatory discharge and map a floodplain boundary

2.3: Mapping Information

Digital Projection Information: PAG 2011 orthophoto
USGS Quad Sheets if available:
Mapping for Hydrologic Study: LiDAR based on 2008 flight used to derive 2' contour interval maps using ARC-GIS 10.0
Mapping for Hydraulic Study: LiDAR based on 2008 flight used to derive a DEM (5-ft cell size) for use with HEC-GeoRAS

2.3: Hydrology

Model or Method Used: PC-Hydro, version 5.4.2, HEC-1
Storm Duration:
Hydrograph Type:
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

2.4: Hydraulics

Model or Method Used: HEC-RAS 4.1, HEC-GeoRAS, FLO-2D
Regime: Modeled as subcritical
Frequencies for which Profiles were computed: 100 yr
Method of Floodway Calculation: No Floodway
Unique Conditions and Problems: Boundary set at normal depth.

Section 3 Survey and Mapping Information

3.1 Digital Projection Information

Projection: State Plane, Arizona central Zone
Horizontal Datum: NAD83-92 (HARN)
Vertical Datum: NAVD88
Units: International Feet

3.2 Mapping

The topographic data was obtained using ArcGIS. Digital Elevation Model (DEM) derived from 2008 Light Detection and Ranging (LiDAR) data was used to create 2-foot interval contour map.

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 Pegler Wash were estimated using HEC-1 for downstream CPs and PC-Hydro for upstream subbasins. HEC-1 peak discharges were obtained by JE Fuller. 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 method has been deemed as a FEMA-accepted hydrologic method for prediction of 100-yr peak discharge in Pima County. The method was used for the Friendly Village LOMR (case# 08-09-0473P) and it was approved by FEMA. The PC-Hydro method generally produces higher discharge values compared to HEC-1 or HEC-HMS or USGS Regression equations. Peak discharge values produced by the PC-Hydro would be conservative, compared to using HEC-HMS or USGS Regression equations. 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 model is included in Appendix D. Data for HEC-1 provided by JE Fuller is also included in Appendix D.

4.2 Parameter Estimation

4.2.1 Drainage Area

Subbasin boundaries were delineated using the hydrology function of ArcGIS with 2008 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.

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

One-hour rainfall was used to estimate 100-year peak discharge for the upstream PC-Hydro subbasins (CPs C, E, G, H, I and J). No area reduction factor was applied. Summary of the HEC-1 analysis is included in Appendix D.

4.2.6 Physical Parameters

Methods are summarized in Table 1. The PC-Hydro model calculates runoff coefficients using adjusted Curve Number (CN), 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 was 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 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

Table 2 Watershed Characteristics

Sub-Basin	Area (sq mile)	Impervious Area (%)	Vegetation Cover (%)
PGR C	0.11	20.0	20.0
PGR E	0.19	20.0	20.0
PGR G	0.55	20.0	20.0
PGR H	0.36	20.0	20.0
PGR I	0.15	20.0	20.0
PGR J	0.42	20.0	20.0

4.3 Issues Encountered During the Study

4.3.1 Special Problems and Solutions

None

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 discharges at CPs were determined using HEC-1 (provided by JE-Fuller) and PC-Hydro. The results are summarized Tables 3.

Table 3 Summary of the Hydrologic Analysis

Concentration Point	Location	Area (sq mile)	Rainfall Depth at Tc (in)	Q100 (cfs)	Time of Concentration (min)
CP 103	**La Canada**	1.60	-	2050	-
CP 104	**Ina**	2.03	-	2392	-
CP 105	**La Cholla**	2.43	-	2615	-
CP 106	**Shannon**	2.78	-	2770	-
CP C	**La Cholla**	0.11	6.99	367	13.1
CP E	**Ina**	0.19	8.22	817	14.5
CP G	**Upstream of La Canada**	0.55	6.84	1808	20.4
CP H	**Upstream of La Canada**	0.36	7.09	1253	19.2
CP I	**Magee**	0.15	8.14	673	15.4
CP J	**Magee**	0.42	7.75	1603	16.6

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

Concentration Point	Location	Area (sq mile)	Rainfall Depth at Tc (in)	Q100 (cfs)	Time of Concentration (min)
CP 103	**La Canada**	1.60	-	2050	-
CP 104	**Ina**	2.03	-	2392	-
CP 105	**La Cholla**	2.43	-	2615	-
CP C	**La Cholla**	0.11	6.99	367	13.1
CP E	**Ina**	0.19	8.22	817	14.5
CP G	**Upstream of La Canada**	0.55	6.84	1808	20.4
CP H	**Upstream of La Canada**	0.36	7.09	1253	19.2
CP I	**Magee**	0.15	8.14	673	15.4
CP J	**Magee**	0.42	7.75	1603	16.6

RRE: USGS Regression Equation 13

Section 5 Hydraulics

5.1 Method Description

The hydraulic modeling for the Pegler Wash was performed using HEC-RAS, Version 4.1 (HEC-RAS), HEC-GeoRAS, Version 10 (HEC-GeoRAS), ArcGIS, Version 10, and FLO-2D (Version 2007-6).

Steady flow analysis was performed to determine 100-year water surface elevations for downstream of La Cholla by using HEC-RAS. The model name is PGR, and the plan name is Plan 01. The locations of the stream centerline, cross-sections, and bank of the Campbell 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. 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 Pegler Wash. Normal depth was assumed for a downstream boundary condition. The hydraulic data obtained from HEC-RAS were imported into HEC-GeoRAS to delineate a floodplain boundary of the Pegler Wash for downstream of La Cholla Bld.

FLO-2D was used for upstream of La Cholla Bld. Geometric data for the FLO-2D model were derived from the 2008 LiDAR data. Grid cell size of 20 feet was used to map a floodplain in the downstream area. The time interval used for the computation was 1 minutes. Hydrographs at CPs G, H, I and J, obtained by using PC-Hydro, were used as inflow.

5.2 Work Study Maps

The work study map for the Pegler Wash is included in Exhibit 2.

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.

5.3.2 Expansion and Contraction Coefficients

The channel of the Pegler is assumed to have generally gradual transitions with minimum curvature. The expansion coefficient of 0.30 and contraction coefficient of 0.10 were used for the study reach except for immediately upstream and downstream of a culvert (expansion 0.5, contraction 0.3).

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.

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

There are culverts at La Cholla Bld., Ina Rd. and La Canada Dr.

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.

5.5.6 Ineffective Flow Areas

Ineffective flow option was modeled in the situation that overbank areas are disconnected and would not convey flow to the next downstream cross-section.

5.6 Floodway Modeling

No floodway modeling was performed in this study.

5.7 Issues Encountered

5.7.1 Special Problems and Solutions

The upstream area of the Pegler Wash is a distributary-flow area with flat topography. Therefore, FLO-2D was applied to delineate a 100-yr floodplain for the upstream area of the Pegler Wash. There is a recent road improvement at La Canada Dr. LiDAR 2008 used in this study does not reflect the changes along the road. Therefore, a floodplain was not mapped around La Canada Dr. A floodplain around La Canada Dr. will be added when a new topography is obtained.

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.

Inspection indicated that the modeling is accurate given the steep channel conditions. Most of these errors force a critical solution which is reasonable for these steep watercourses.

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 and FLO-2D model are included in Appendix E.

5.9.2 Verification of Results

NA

Section 6 Erosion and Sediment Transport

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

A.1 Data Collection Summary

Aldridge, B. and J. Garrett. 1973. Roughness Coefficients for Stream Channels in Arizona. US Department of the Interior Geological Survey. Tucson, AZ.

Arizona Department of Water Resources, Flood Mitigation Section
"Instruction for Organization and Submitting Technical Document for Flood Studies" SSA1-97, November 1997

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

City of Tucson (COT), Department of Transportation, 1989. Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona. Revised in 1998.

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

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.

Phillips, J., and T. Ingersoll. 1998. Verification of Roughness Coefficients for Selected Natural and Constructed Stream Channels in Arizona. U.S. Geological Survey Professional Paper 1584.

Pima County Regional Flood Control District
"Pima County Mapguide Map", 2008

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). 2003. Geospatial Hydrologic Modeling Extension HEC-GeoHMS, (v 1.1) CPD-77, 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.

A 2. Referenced Documents

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.

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

Appendix B FEMA MT-2 Form, General Documentation and Correspondence

Appendix C: Survey Field Notes

Terry Hendricks

From: Curtis, Edward [mailto:Edward.Curtis@dhs.gov]
Sent: Tuesday, November 10, 2009 2:44 PM
To: Manny M. Rosas
Cc: Terry Hendricks; Lucero, Andrew; Caldwell, Jason; Akl, Pascal
Subject: RE: PAG 2008 Orthos/Lidar

Mr. Rosas –

I apologize for the delay in responding to you regarding the Sanborn LiDAR report. Pascal Akl of Michael Baker, Jr. reviewed the updated July 2009 report on behalf of FEMA and advised me that all of the concerns raised in his May 18, 2009 memorandum titled "Pima County, CA [sic] Sanborn LiDAR Report Items" were addressed in the updated report except the comment that the original report lacked a sufficient number of checkpoints in urban areas and dense vegetation areas. No additional checkpoints were surveyed in such arease to permit analysis of data accuracy in these land cover categories. However, in the data voids analysis section of the updated report (p. 16), Sanborn states the following: "*Specific areas, dense vegetation or undergrowth near small streams, for example, prevents the LiDAR pulses to fully penetrate to the true ground surface. Thus, for mapping products such as floodplain or contour mapping, LiDAR data must often be manually supplemented with breaklines and mass-points to accurately model the terrain surface.*" As long as the data is used with caution and supplemented with additional ground survey data where necessary in accordance with this statement, I am satisfied that the terrain data meets FEMA standards for use in detailed flood studies.

Please contact me if you have any questions regarding our review and comments.

Ed Curtis, P.E., CFM
Risk Analysis Branch
FEMA Region IX
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(510) 295-5249 - mobile

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