Camino De Oeste Wash Letter of Map Revision Technical Data Notebook

Prepared by:

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Approved by

Suzanne Shields, PE
Director

CERTIFICATE NO. 15610 SUZANNE J. SHIELDS DATE SIGNED 6/21/2010 ARIZONA U.S.A.

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Exhibit 1 100-yr Floodplain limits for the Camino De Oeste Wash
Exhibit 2 Annotated Flood Insurance Rate Map for the Camino De Oeste Wash

Section 1 Introduction

1.1 Purpose

This Technical Data notebook (TDN) has been prepared for a Letter of Map Revision (LOMR) application for a portion of the Camino De Oeste Wash (CMNO) located in Pima County, Arizona. The objective of the TDN and LOMR submission is provide regulatory discharge rates and floodplain limits along the Camino De Oeste 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:

Evan Canfield, PE, Chief Hydrologist
Planning & Development Division
Pima County Regional Flood Control District
97 East Congress, Tucson, AZ 85701

1.3 Project Location

The study reach of the Camino De Oeste Wash (CMNO) is located within a Federal Emergency Management Agency (FEMA)-designated "Zone A" flood-hazard area, as depicted on FIRM Map Panel Numbers 04019C1618K, and 1619K (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 to provide regulatory discharge rates and floodplain limits along the Camino De Oeste Wash using better topographic, hydrologic, and hydraulic data.

The study reach of the Camino De Oeste Wash is located primarily west of Silverbell Rd. and extends to Sections 28, 29, 32 & 33, Township 13 South, Range 13 East, Pima County, Arizona (Fig. 1.1). The upstream study limit for the Camino De Oeste Wash begins immediately downstream of West Goret Rd. The Camino De Oeste Wash enters study limit from the west, where it is mapped as an AE Zone and flows east until it converges with the Santa Cruz River.

1.4 Hydrologic and Hydraulic Methods

Hydrologic analysis was preformed to determine proposed regulatory discharge rate at Silverbell Rd 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 limit along the study reach of the Camino De Oeste Wash using U.S. Army Corps of Engineers Computer Backwater Model, HEC-

RAS. Because the floodplain of the Camino De Oeste Wash is not confined when it enters the geologic floodplain of the Santa Cruz River, the FLO-2D model was used to determine the direction of flow east of Silverbell Rd.

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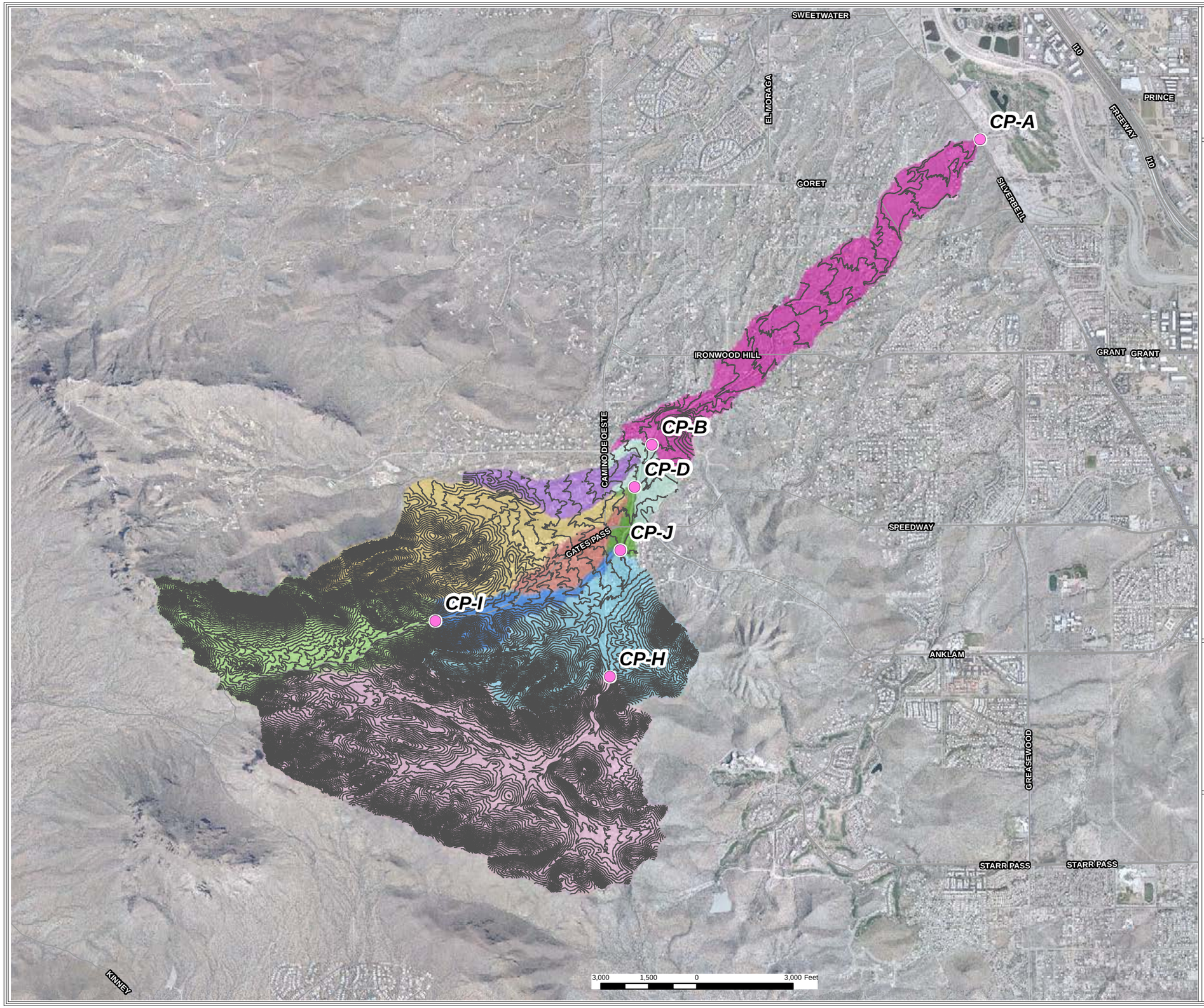
1.5 Acknowledgment

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 rate was calculated at Silverbell Rd (CP_A; Fig. 1.3). The estimated regulatory discharge rate is 6432 cubic feet per second (cfs) with a drainage area of 5.69 square mile at CP_A where the watercourse crosses Silverbell Rd. The new mapping removed some structures from the floodplain west of Silverbell Rd, but did not add any structures. To the east of Silverbell Rd, the flow is basically unconfined and the floodplain expands greatly. Fortunately, most of this land is golf course.

Figure 1.1
Watershed Map
Camino De Oeste Wash



Discharge Points

20 Foot Contour

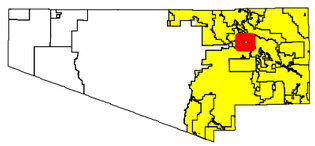
Subbasins

Name

- CMN_A
- CMN_B
- CMN_C
- CMN_D
- CMN_E
- CMN_F
- CMN_G
- CMN_H
- CMN_I
- CMN_J

Aerial : 2008 Pima Association of Governments
Topo : 2008 Pima Association of Governments

Pima County Index Map



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Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

Scale 1:3000

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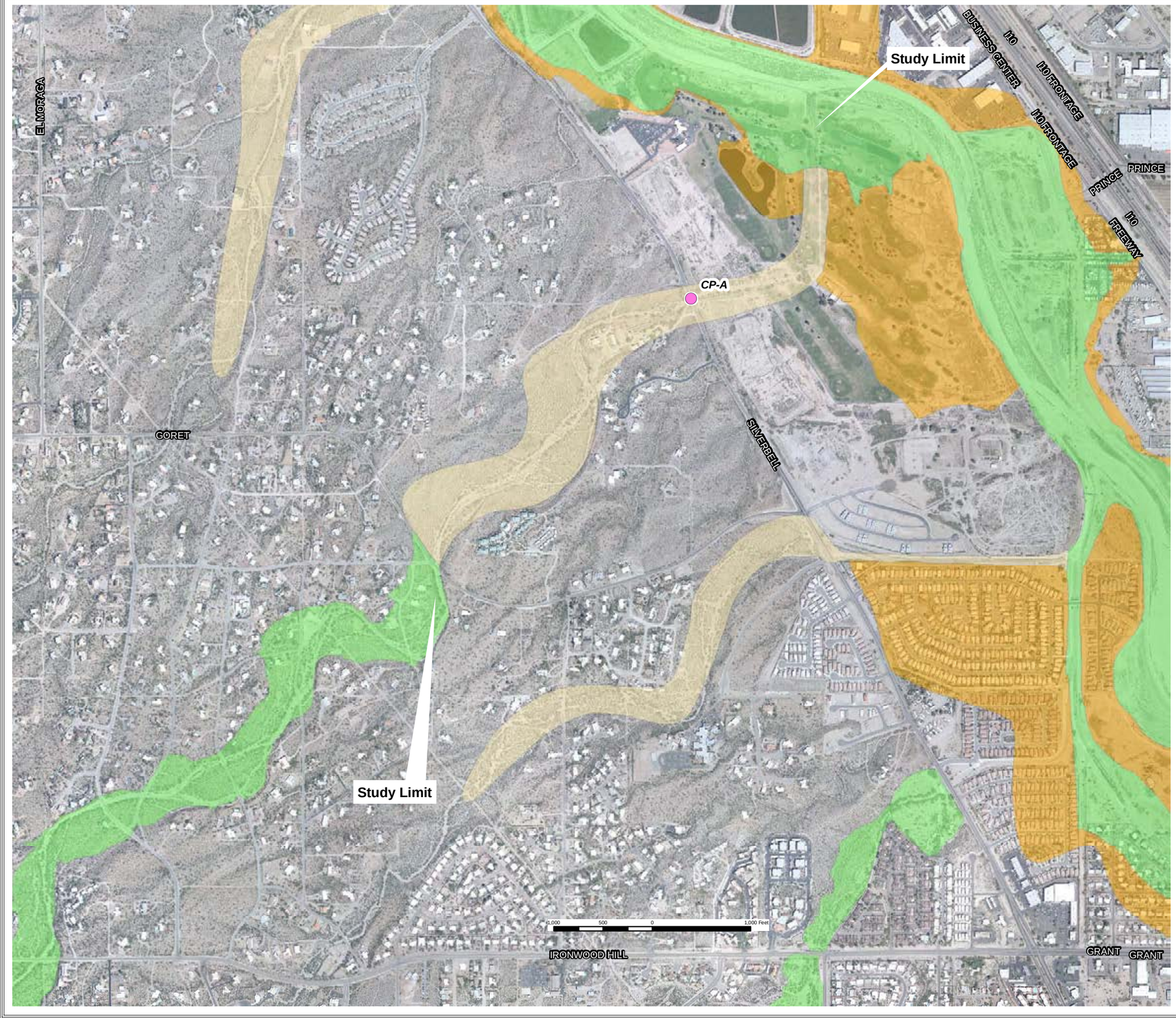
Figure 1.2
Study Limit Map
Camino De Oeste Wash



Discharge Points

Existing Floodplain

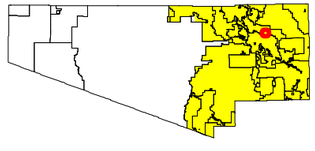
ZONE A

ZONE AE

ZONE X - SHADED

Aerial: 2008 Pima Arizona 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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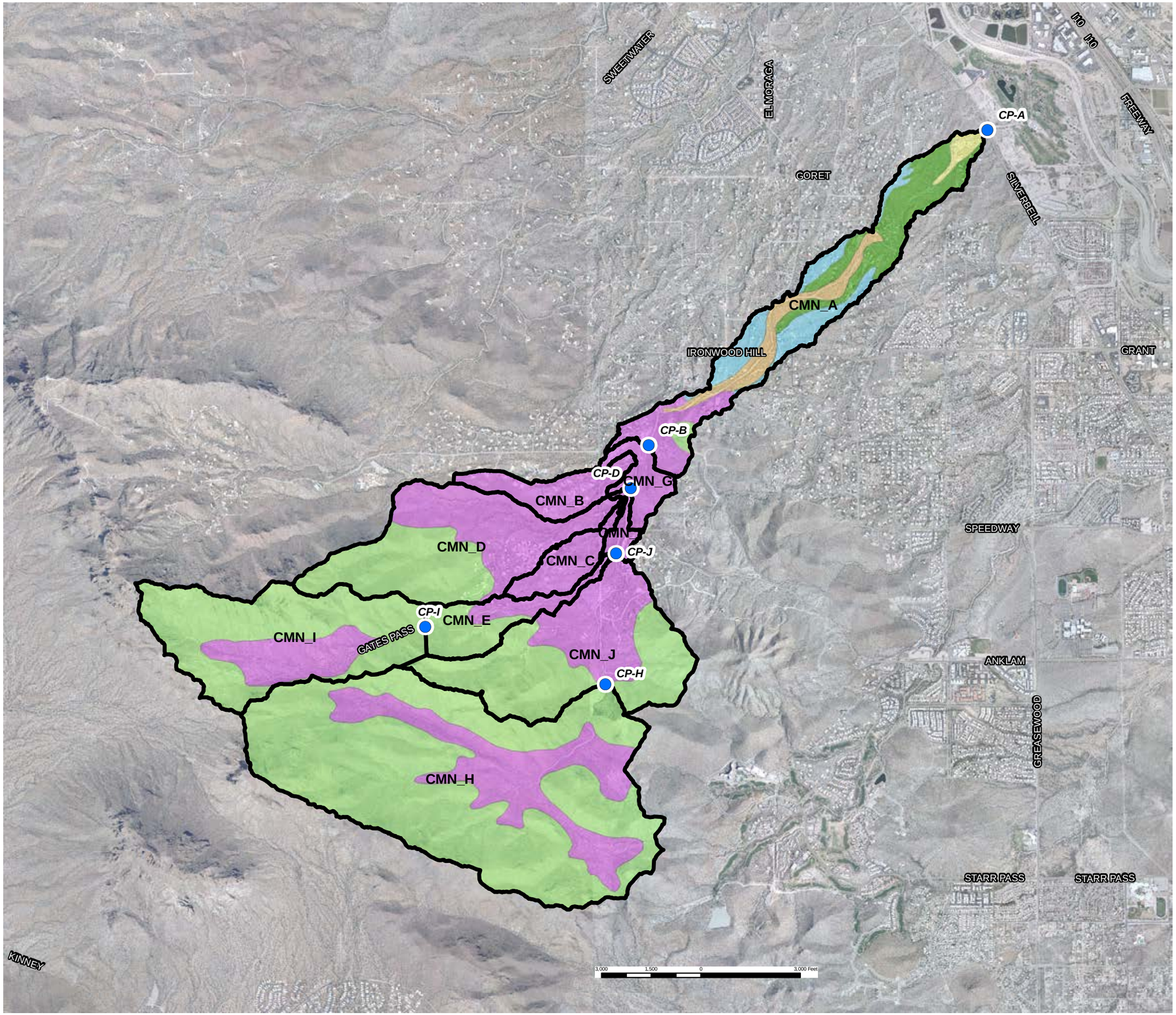
Figure 1.3
Soil Classification
Camino De Oeste Wash



Discharge Point

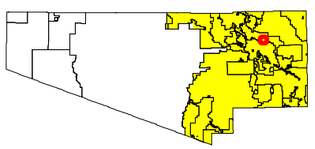
Subbasins

Soil Classification

- Soil Group: A (100%), ARIZO-RIVERWASH COMPLEX, 0 TO 3 PERCENT SLOPES
- Soil Group: B (100%), GLENDALE SILT LOAM, 0 TO 3 PERCENT SLOPES
- Soil Group: B (100%), GRABE GRAVELLY LOAM, 1 TO 3 PERCENT SLOPES
- Soil Group: B (100%), PINALENO VERY COBBLY SANDY LOAM, 1 TO 8 PERCENT SLOPES
- Soil Group: B (100%), PINALENO-STAGECOACH COMPLEX, 5 TO 16 PERCENT SLOPES
- Soil Group: C (47%) D (53%), PANTANO-GRANOLITE COMPLEX, 5 TO 25 PERCENT SLOPES
- Soil Group: D (100%), ANKLAM-CELLAR-ROCK OUTCROP COMPLEX, 15 TO 55 PERCENT SLOPES

Aerial: 2008 Pima Arizona Government

Pima County Index Map



Index Map Scale 1:5,250,000

Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

Scale 1:3000'

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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 Evan Canfield, PE, Chief 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 Camino De Oeste Wash is located within a Federal Emergency Management Agency (FEMA)-designated "Zone A", as depicted on FIRM Map Panel Numbers 04019C1618K, and 1619K (February 8, 1999). The study reach of the Camino De Oeste Wash is located primarily west of Silverbell Rd., Pima County, Arizona (Fig. 1.1). The study reach of the Camino De Oeste Wash is primarily composed of sand channel and the bottom of the reach is relatively clean with vegetation cover. The overbank of the reach is covered with desert brush.

2.1.5 Unique Conditions and Problems

None.

2.1.6 Coordination of Peak Discharges

The 100-year regulatory discharge rate at the Silverbell Rd. was computed using HEC-HMS, assuming no base flow in the watersheds and no transmission loss within the

reaches. The hydraulic data used to derive parameters for HEC-HMS was obtained using HEC-RAS. The discharge rate was acceptable per Suzanne Shields, Director of the Pima County Regional Flood Control District and Andy Dinauer of the City of Tucson

2.2 FEMA Forms

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

Section 3 Survey and Mapping Information

3.1 Field Survey Information

Field Survey was done to supplement the topographic mapping in areas of known change since the topographic data were collected in 2005. These data were prepared by a Registered Land Surveyor. Notes on this data are included in Appendix C.

3.2 Mapping

The topographic data was obtained using HEC-GeoRas and ArcGIS. Digital Terrain Model (DTM) derived from 2005 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: 2005 PAG aerial photo
Projection: UTM, Zone 12
Units: International feet
The contour interval of the topographic map is 2 feet.

This data set has been shown to be FEMA-compliant in an area of similar cover and topography. Notes are included in Appendix C.

In addition, the field survey described in section 3.1 was used to replace topography in these areas of change, so that both 2005 LiDAR and field survey were used to characterize the topographic surface.

Section 4 Hydrology

4.1 Method Description

The 100-year peak discharges for the ten subbasins of the Camino De Oeste Wash (CMNO A, to J; 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 2008 Lidar Data. A 2-ft contour map was used to make sure that the subbasin delineation was reasonable.

4.2.2 Watershed Work Map

A watershed work map is included in Exhibit 1. Ten subbasins were delineated for HEC-HMS hydrologic analysis. Five concentration points were included in the study watershed (CP_A, CP_B, CP_H, CP_J, CP_I). A 100-year peak discharge at Silverbell Rd. (CP A) was used for HEC-RAS and FLO-2D 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 for a peak discharge calculation for the Camino De Oeste Wash, 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 Camino De Oeste Wash watershed is 3.23 inches at the upper part of the watershed and 3.14 inches in the lower part of the watershed. The aerial reduction factor of 0.85 was applied to CP_A.

4.2.6 Physical Parameters

The physical parameters for the subbasins 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 following 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 table associated with the PC Hydro User Guide (Arroyo Engineering, 2007) and a Hydrologic Soils Group map. 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 the 2008 PAG aerial photograph and Table 3 in the PC Hydro User Guide (Arroyo Engineering, 2007). The combination of the kinematic wave method and the U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (Tc) calculation method (USDA-NRCS, 1986) was used to determine Tc, following 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). HEC-GeoRAS and HEC RAS were used to estimate average velocity of channels. 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)
CMN_A	0.7	72.6	10.0	30	29.4
CMN_B	0.16	90.2	15.0	30	14.3
CMN_C	0.13	89.6	10.0	30	12.1
CMN_D	0.7	89.8	5.0	30	16.0
CMN_E	0.19	89.9	5.0	30	10.8
CMN_F	0.05	91.7	30.0	30	8.1
CMN_G	0.1	89.1	5.0	30	6.1
CMN_H	2.1	89.7	0.0	30	17.3
CMN_I	0.8	90.1	5.0	30	14.8
CMN_J	0.76	90.0	5.0	30	10.0

Runoff from subbasins was routed using the Modified-Puls method. Storage discharge tables for the channel routing were developed using HEC-GeoRAS and HEC-RAS. Six different discharges were used for storage-discharge relations. The number of subreaches was calculated using the following method:

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

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

Therefore,

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

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 for the Camino De Oeste Wash subbasins and at CP A were determined using the HEC-HMS. The results are summarized 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)
CMN_A	0.70	3.14	0.92	395.7
CMN_B	0.16	3.23	2.21	375.4
CMN_C	0.13	3.23	2.16	325.0
CMN_D	0.70	3.23	2.18	1519.6
CMN_E	0.19	3.23	2.19	506.5
CMN_F	0.05	3.23	2.35	158.0
CMN_G	0.10	3.23	2.12	314.7
CMN_H	2.10	3.23	2.17	4329.4
CMN_I	0.80	3.23	2.21	1837.6
CMN_J	0.76	3.23	2.20	2102.5

Table 4. Summary of Discharges at Relevant Concentration Points

Concentration Point	Location	Area (sq mile)	Rainfall Depth (in)	Runoff Volume (in)	Q100 HMS (cfs)
CP_A	**at Silverbell Rd**	5.69	2.74	1.6	6,432

4.5.2 Verification of results

The existing 100-year regulatory discharge for Camino De Oeste Wash in the AE zone immediately upstream is 6,418 cfs (99-09-434P), which is nearly the same as the discharge determined in this study (6,432 cfs) shown in Table 5. The comparison shows that the 100-year peak discharges estimated in this study is very close to the existing value. The peak discharge was also compared with the peak discharge obtained from USGS Regression Equation 13 (Thomas et al., 1997) (Table 5). The comparison showed that the HMS-derived peak discharge was much higher than the ones derived from the Regression Equation. This is to be expected, because the watershed is steep, and has a shape that is conducive to routing sub-basins with similar travel times to the same downstream location.

Table 5 Comparison of a peak discharge

Concentration Point	Location	Area (sq mile)	Rainfall Depth (in)	Runoff Volume (in)	Q100 HMS (cfs)	Q100 RRE (cfs)	Time to Peak
CP_A	**at Silverbell Rd**	5.69	2.74	1.6	6,432	3,595	2:18
CP_B	**at Speedway Blvd**	4.99	2.74	1.73	6,606	3,347	1:48

Section 5 Hydraulics

5.1 Method Description

The hydraulic modeling for the Sweetwater was performed using FLO-2D (version 2007.06), and compared to the results of Hec-Ras, Version 4.1 (HEC-RAS), which also used 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.

The DTM derived was from 2005 LiDAR data, which was augmented with field survey data in areas where topography had changed since 2005. Two earthen pads have been started on the eastern side of Silverbell Rd on either side of the excavated channel of the Camino De Oeste wash in preparation for a subdivision that is currently on hold. The field survey data in the area of the pad was used to replace the data in the 2005 LiDAR dataset, so that the topographic dataset in this analysis more accurately reflected existing conditions.

Both the HEC-RAS and FLO-2D model were used to determine the limits of the floodplain. In the confined portions of the wash the two model can be expected to produce similar floodplains, but as the flow crosses Silverbell, it enters the geologic floodplain of the Santa Cruz River the constructed channel is too small to contain the 100-yr discharge. For this reason, FLO-2D is more useful in determining flow patterns in this area where flow direction is undefined.

FLO-2D was used throughout the mapping area in order to provide a single model for the study area. However, the model is most important in the downstream distributary area east of Silverbell Rd to a confluence with the Santa Cruz River. The HEC-RAS model is used to validate the results of the FLO-2D model in the reach west of Silverbell Rd, where flow is confined, and flow can be approximated as one-dimensional and modeled with HEC-RAS.

Geometric data for the FLO-2D model were derived from the 2005 Lidar data. Grid cell size of 20 feet was used to map a floodplain in the distributary area. The time interval used for the computation was 5 minutes. The FLO-2D model includes floodplain cross sections at immediately upstream of Silverbell Rd to estimate discharge crossing the road. The model does not include infiltration or rainfall. A hydrograph from the HMS at CP A (at Silverbell Rd.) was used as inflow data at a cell located at the upstream limits of the mapping at Goret Rd.

For the HEC-RAS mapping, the locations of the stream centerline, cross-sections, and bank of the Camino De Oeste Wash were determined using the contour map and 2005 PAG aerial photos. The physical attributes of the wash were digitized in ArcGIS using the HEC-GeoRAS extension and then 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. The hydraulic data obtained from HEC-RAS were then imported into HEC-GeoRAS to delineate a floodplain boundary in the study area.

Steady flow analysis was performed to determine 100-year water surface elevations in the study area by using HEC-RAS. As described above, geometric data for HEC-RAS including stream centerline, flow paths and cross-sections were obtained using HEC-GeoRAS.

5.2 Work Study Maps

The work study map for the Camino De Oeste Wash is included in Exhibit 1.

5.3 Parameter Estimation

5.3.1 Roughness Coefficients

Within FLO-2D, Manning's n values were determined by a combination of a site visit and 2008 PAG aerial photo. Manning's n value of 0.06 was assigned for the overbank with desert brush along the Camino De Oeste Wash. A value of 0.035 was used in the unvegetated portion of channels and in the constructed reach downstream of Silverbell Rd.

5.3.2 Expansion and Contraction Coefficients

The channel of the Camino De Oeste Wash 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 entire study reach.

5.4 Cross-Section Description

The FLO-2D model is a grid-based model. Upstream of Silverbell the watercourse is riverine and the HEC-RAS model can also be used as a basis for comparing mapping. 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

No bridges and culverts are found in the mapping area.

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

In general these ineffective flow areas were disconnected overbank areas that would not convey flow to the next downstream cross-section.

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 in FLO-2D. In HEC-RAS 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 channel conditions. In most cases, a subcritical solution was found. However, in some cases the errors require a critical solution which is reasonable in steeper portions of this watercourse. A summary of errors is available in Appendix E.

5.8 Calibration

The model was not calibrated in this study.

5.9 Final Results

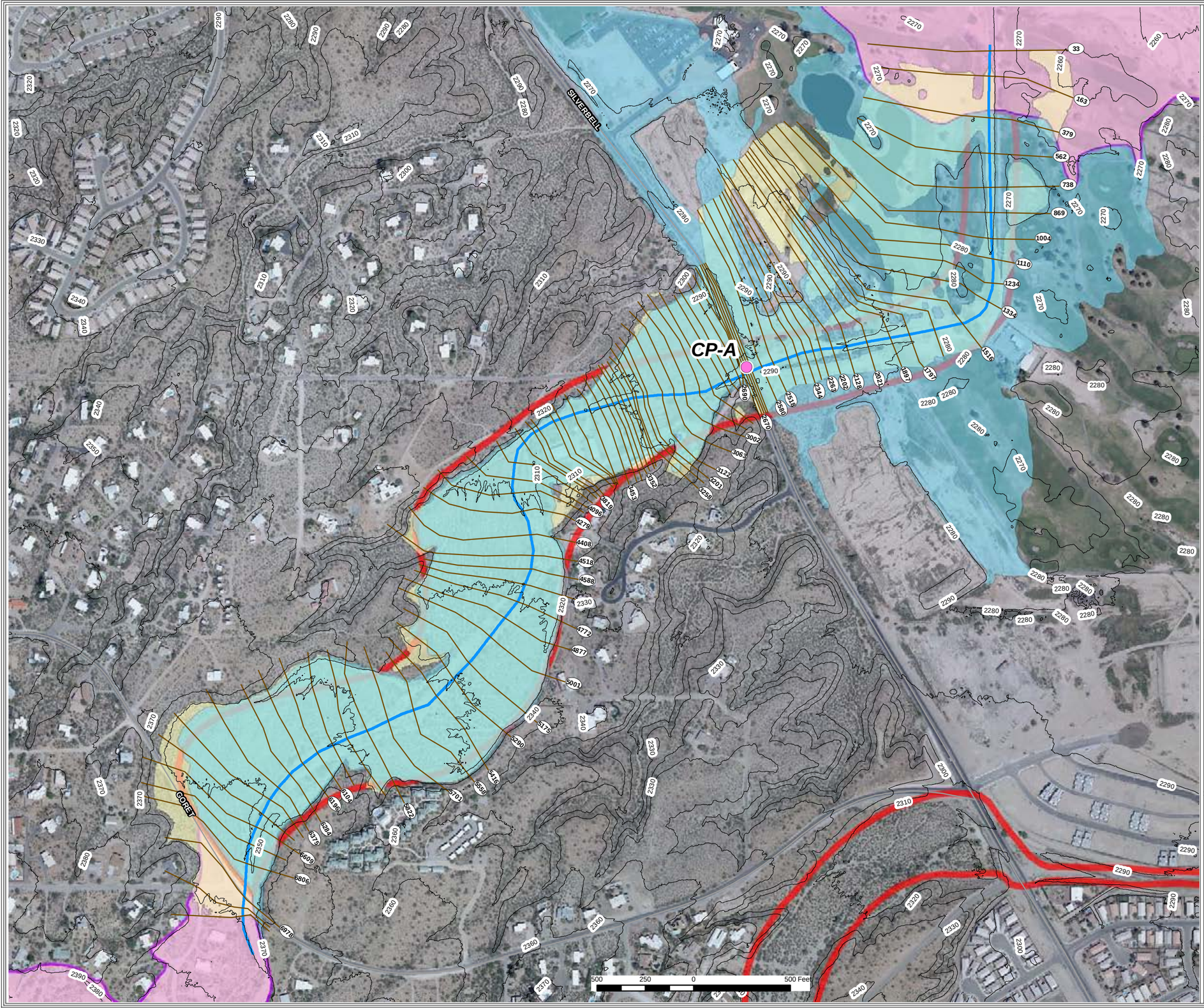
5.9.1 Hydraulic Analysis Results

The FLO-2D and HEC-RAS modeling results are summarized in Appendix E.

5.9.2 Verification of Results

The floodplain limit produced in this Camino De Oeste Wash LOMR study was compared to the results of the HEC-RAS 4.1 simulation (Figure 5.1). Where the flow is confined in the area west of Silverbell Rd, the proposed floodplain limit tends to follow the existing floodplain limit. The results suggest that the proposed floodplain limit created in FLO-2D is reasonable compared to the more commonly-used one dimensional hydraulic model. East of Silverbell, where the flow enters the geologic floodplain of the Santa Cruz River, the results are very different. The FLO-2D model shows great divergence indicating the dominance of two-dimensional flow, which could not be adequately be simulated with HEC-RAS.

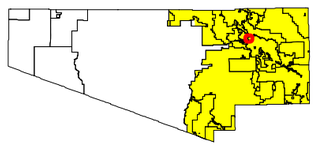
Figure 5.1
Comparison of
FLO-2D and HEC-RAS
Camino De Oeste Wash



- Discharge Points
- 10 Foot Contour
- XS Cutlines
- River
- Proposed FLO-2D AZone
- HECRAS AZone for Comparison
- ZONE AE
- ZONE A

Aerial : 2008 Pima Association of Governments
Topo : 2008 Pima Association of Governments

Pima County Index Map



Index Map Scale 1:5,250,000

Pima County Regional Flood Control District

Pima County Regional FLOOD CONTROL DISTRICT

Scale 1:500

06/2010

\\gislib\rfcd\projects\imd\xavi\mxd\AKITSU\Camino_De_Oeste_wash_Watershed_Fig5_1.mxd

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

The estimated regulatory discharge rate is 6432 cubic feet per second (cfs) with a drainage area of 5.69 square mile at CMN_Outlet.

7.2 Floodway Data

Not applicable.

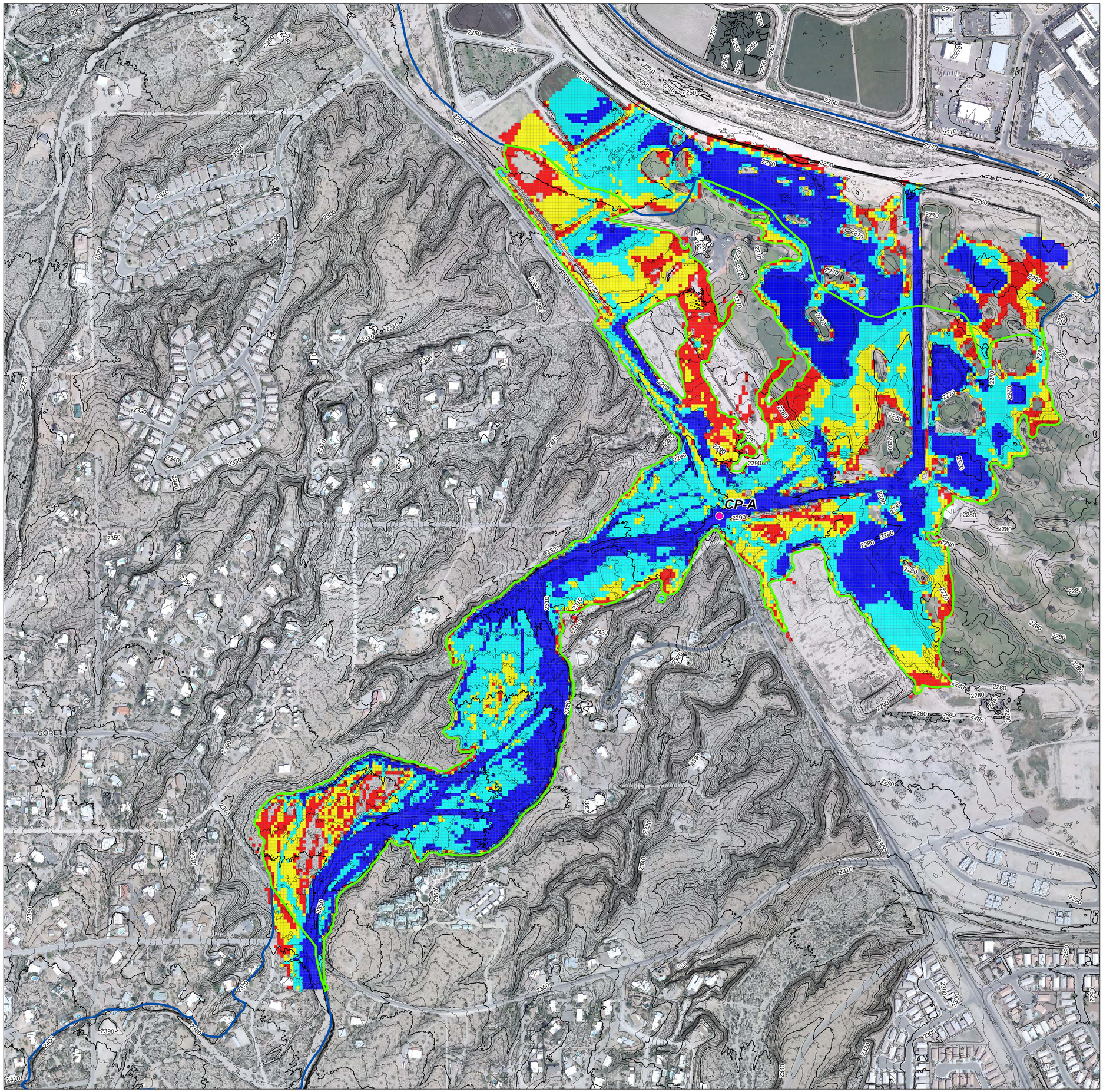
7.3 Annotated Flood Insurance Rate Map

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

7.4 Flood Profiles

Flood profiles are included in Appendix E.

Exhibit 1
100-year Floodplain
Camino De Oeste Wash



- Discharge Point
- 2 Foot Contour
- 10 Foot Contour
- Proposed Floodplain FLO 2D AZone
- Existing ZONE AE

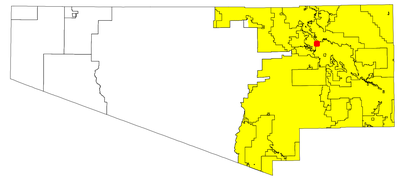
Flow Depth at Cell

Feet

- =>0.200
- => 0.500
- =>1.000
- =>2.000

Aerial : 2008 Pima Association of Governments
Topo: 2008 Pima Association of Governments
Datum: NAVD 1988

Pima County Index Map



Index Map Scale 1:1,500,000

N

200 100 0 200 Feet

Pima County Regional FLOOD CONTROL DISTRICT

THE SEAL OF PIMA COUNTY ARIZONA

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

05/2010

\\gislib\rfcd\projects\imd\xavi\mxd\AKITSU\CaminoDeOeste\CaminoDeOeste_watershed_100yr_exh1.mxd

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.

PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NAME: Acceptable Model Parameterization for Determining Peak Discharges

POLICY NUMBER: Technical Policy, TECH-018

EFFECTIVE DATE: July 1, 2010

PURPOSE

The purpose of this technical policy is to standardize the parameterization of hydrologic models.

BACKGROUND

When determining peak discharges, a computer-based hydrologic model or previously-accepted discharge value may be used. Technical Policy *TECH-015, Hydrologic Model Selection for Peak Discharge Determination,* describes which models are acceptable for determining peak discharges. Pima County Hydrology Procedures (PC-Hydro) shall be used for riverine watersheds with an area less than 1 square mile, and it may be used for watersheds up to 10 square miles. However, the use of PC-Hydro shall be limited to riverine watersheds with little impact of detention basins, reservoirs, or channel storage and attenuation. HEC-HMS or HEC-1 may be applied to riverine watersheds with an area larger than 1 square mile, and is useful for evaluating watersheds that have detention basins and where channel routing or storage is important. This policy describes which parameterization shall be used for submittals to the Pima County Regional Flood Control District (District).

POLICY

A. **Watershed Delineation:** The accuracy of watershed delineation and flow path identification is critical in hydrologic modeling. The District requires the use of 2-foot contour interval (or finer where available) maps, such as the Pima Association of Governments (PAG) contour maps for delineation of basin boundaries and flow paths in all areas other than steep terrain. In areas of steep terrain, or where 2-foot or finer contour interval maps are not available, U.S. Geologic Survey (USGS) contour maps (7.5 minute series) may be accepted. At the discretion of the District, it may be a requirement that topographic data be sealed by an Arizona registered civil engineer (PE), or land surveyor (RLS). In regulatory sheetflood areas, both 2-foot or finer contour interval maps and aerial photos shall be used with a resolution sufficient to determine flow paths and watershed boundaries. If Geo-HMS (COE, 2003) is used, Digital Elevation

Models (DEMs) or Digital Terrain Models (DTMs) or DEMs derived from Lidar data from PAG or other reputable vendors, may be used. With the approval of the District, alternative topographic data, such as stereo photography, may be used.

B. **Pima County Hydrology Procedures:** Peak-discharge calculations performed using the Pima County Hydrology Procedures (PC-Hydro) shall follow the guidance for parameterization provided in the PC- Hydro User Guide (Arroyo Engineering, 2007).

C. **HEC-1 and HEC-HMS:** Peak discharges calculated using HEC-HMS (COE, 2006) or HEC-1 (COE, 1998) shall employ the following parameterization:

a. ***Rainfall Loss Method:*** Models shall employ the U.S Soil Conservation Service (SCS) Curve Number method using the Curve Number tables, Vegetation map and Hydrologic Soils Group map associated with the PC Hydro User Guide (Arroyo Engineering, 2007), shall be used. The default vegetation cover percent provided in the PC- Hydro User Guide (Arroyo Engineering, 2007) shall be used unless additional justification is provided. The Curve Number shall not be adjusted for rainfall intensity or antecedent moisture conditions.

b. ***Time of Concentration Calculation:*** The modified U.S. Natural Resources Conservation Service (NRCS) segmented Time of Concentration (T_c) calculation shall be employed (USDA-NRCS, 1986). The Tc shall be calculated by summing the travel time for sheet flow, shallow concentrated flow and channel flow, along the primary flow path.

i. For sheet flow segment:

1. Manning's roughness coefficient for sheet flow shall be obtained using Table 3-1 in Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).
2. Maximum slope length for sheet flow shall be 100 feet unless additional justification is provided.
3. The Kinematic wave method shall be used to estimate the travel time for sheet flow.

ii. For shallow concentrated flow segment:

1. The travel time for shallow concentrated flow shall be obtained using the velocity determined from Figure 3-1 of Technical Release 55, Urban Hydrology for Small Watersheds (USDA-NRCS, 1986).

iii. *For channel flow*

1. Manning's roughness coefficient for channel flow shall be determined using the method described in the District's

Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*.

2. HEC-RAS velocity or the Manning's equation may be used to estimate the travel time for channel flow.
3. The discharge for upstream sub-basins shall be 2/3 times the 100-yr discharge value calculated with Regional Regression Equation 13 (Thomas et al., 1997). Sub-basins with channel flow from an upstream basin shall use the 100-yr discharge value calculated with Regional Regression Equation 13.

c. ***Transform:*** The SCS Unit Hydrograph method shall be used.

d. ***Channel Routing:***

1.) ***Routing in Natural Channels:*** Runoff shall be routed using the Modified-Puls method for natural channels with the slope less than 1.5%. It may also be used for steeper channels. A storage discharge table is required if HEC-HMS is used. Such a table can be developed using cross-sections and slopes derived from a Manning normal depth analysis or HEC-RAS (COE, 2001). The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manual. Initial discharge to estimate HEC-RAS velocity for channel flow should be determined using discharge calculated with USGS Regression Equation 13 (Thomas et al., 1997).

2.) ***Routing in Constructed Channels and Steep Channel:*** The Kinematic Wave Method may be used for constructed channels and natural channels with slopes greater than 1%. Reach length, slope, bottom width and side slope may be obtained using the data utilized for watershed delineation (e.g. 2-foot contour interval contour maps, Digital Elevation Models (DEMs) or Digital Terrain Models (DTMs), or DEMs). Selection of Manning's n values shall conform to the guidance in Technical Policy *TECH-019, Standards for Floodplain Hydraulic Modeling*.. The number of sub-reaches shall be calculated using the methods described in the HEC-HMS User's Manuals.

e. ***Rainfall:*** The NOAA 14 Upper 90% rainfall shall be used as described in the District's Technical Policy *TECH-010, Rainfall Input for Hydrologic Modeling*. Point rainfall depth shall be evaluated for a watershed, based on the latitude and longitude of the centroid of the watershed. If appreciable elevation change occurs on a watershed, users should use different values for higher and lower elevations.

f. ***Rainfall Aereal Reduction:*** Aereal reduction shall be applied to watersheds larger than 1 square mile. Aereal reduction shall be estimated

using Hydro-40 (National Weather Service, 1984) for the watershed and event of interest (i.e. same tables as contained in Arizona State Standard [SS10-07]).

g. ***Rainfall Distribution:*** The following rainfall distributions shall be used, with the highest peak discharge selected in order to determine the critical storm (i.e. the storm that produces the highest discharge) :

1. **SCS Type II 3-hr Storm:** The 3-hr distribution shall be used as the local storm. In general, this includes watersheds with a time of concentration (T_c) equal to or less than three hours (Haan et al 1994).

3. **SCS Type I (24 hr):** The SCS Type I rainfall (NRCS, 1986) may apply for general storms on watersheds with times of concentration (T_c) greater than three hours.

D. **Comparison of peak discharge**: Peak discharges shall be compared with the peak discharges obtained from USGS Regression Equation 13 (Thomas et al., 1997) and/or the equations (both urban and rural) developed by Eychaner (1984) (See Appendix), and existing regulatory discharge estimates. Appropriate Basin Development Factors (BDFs) shall be used for urban areas.

REFERENCES

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

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.

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

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.

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.

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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.

APPROVED BY:

_____ _____

Suzanne Shields, P.E. **Date**
Director and Chief Engineer

Appendix

1.) USGS Regression Equation 13: The current regional regression relationship for southern Arizona is Regression Equation 13 from Thomas et al (1997). This method predicts peak discharge in cfs (Q_p) as a function of watershed Area (square miles) only. It has the form:

$$Q_{p100} = 10^{(5.52-2.42*A^{-0.12})}$$

2.) Eychaner 1984 (rural): This is a USGS publication that was prepared in cooperation with the City of Tucson and Pima County. It presents a series of regression equations that rely on watershed area (sq. miles), main channel slope (%), channel length (miles) and a shape factor to account for the differences in runoff noted between long watersheds and more traditionally-shaped watersheds. The equation for the 100 year peak discharge is:

$$Q_{p100}rural = 10^{(3.044+0.646(\log A)-0.49(\log A)^2+0.706(\log S)-0.367(\log S)^2-0.614(\log S)(LogSh))}$$

The shape factor (Sh) is calculated as the channel length squared divided by the contributing watershed area (i.e. L^2/A).

3.) Eychaner 1984 (urban): This equation adjusts Eychaner's rural equation to account for the amount of impervious area, channel lining and channel modification. It is:

$$Q_{p100}urban = 7.7A^{0.15}(13-BDF)^{-0.32}Q_{p100}rural^{0.82}$$

The Basin Development Factor (BDF) is a scoring factor to account for the degree of urbanization within a watershed. The specific scoring is based on four factors described in pages 10-13 of the USGS publication by Eychaner. The lower, middle and upper portions of a watershed are scored separately, and the results are summed. The maximum BDF score is 12, and a score of 0 indicates that the rural equation should be used. (The Q_{p100} *rural* in the equation is the value calculated using Eychaner's rural method described in section 2 above.)

Appendix B General Documentation and Correspondence

U.S. DEPARTMENT OF HOMELAND SECURITY - FEDERAL EMERGENCY MANAGEMENT AGENCY

OVERVIEW & CONCURRENCE FORM

O.M.B No. 1660-0016
Expires: 12/31/2010

PAPERWORK BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 1 hour per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, U.S. Department of Homeland Security, Federal Emergency Management Agency, 500 C Street, SW, Washington DC 20472, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

A. REQUESTED RESPONSE FROM DHS-FEMA

This request is for a (check one):

☐ CLOMR: A letter from DHS-FEMA commenting on whether a proposed project, if built as proposed, would justify a map revision, or proposed hydrology changes (See 44 CFR Ch. 1, Parts 60, 65 & 72).

☒ LOMR: A letter from DHS-FEMA officially revising the current NFIP map to show the changes to floodplains, regulatory floodway or flood elevations. (See 44 CFR Ch. 1, Parts 60, 65 & 72)

B. OVERVIEW

1. The NFIP map panel(s) affected for all impacted communities is (are):

Community No.	Community Name	State	Map No.	Panel No.	Effective Date
Ex: 480301 480287	City of Katy Harris County	TX TX	480301 48201C	0005D 0220G	02/08/83 09/28/90
040078	City of Tucson	AZ	04019C	1619K	02/08/99
040078	City of Tucson	AZ	04019C	1618K	02/08/99

2. a. Flooding Source: Camino De Oeste Wash

b. Types of Flooding: ☒ Riverine ☐ Coastal ☐ Shallow Flooding (e.g., Zones AO and AH)
☐ Alluvial fan ☐ Lakes ☐ Other (Attach Description)

3. Project Name/Identifier: Camino De Oeste A-Zone

4. FEMA zone designations affected: A (choices: A, AH, AO, A1-A30, A99, AE, AR, V, V1-V30, VE, B, C, D, X)

5. Basis for Request and Type of Revision:

a. The basis for this revision request is (check all that apply)

☐ Physical Change ☒ Improved Methodology/Data ☐ Regulatory Floodway Revision ☐ Base Map Changes
☐ Coastal Analysis ☐ Hydraulic Analysis ☒ Hydrologic Analysis ☒ Corrections
☐ Weir-Dam Changes ☐ Levee Certification ☐ Alluvial Fan Analysis ☐ Natural Changes
☒ New Topographic Data ☐ Other (Attach Description)

Note: A photograph and narrative description of the area of concern is not required, but is very helpful during review.

b. The area of revision encompasses the following structures (check all that apply)

Structures: ☐ Channelization ☐ Levee/Floodwall ☐ Bridge/Culvert
☐ Dam ☐ Fill ☐ Other (Attach Description)

C. REVIEW FEE

Has the review fee for the appropriate request category been included? ☐ Yes Fee amount: $_____

☒ No, Attach Explanation

Please see the DHS-FEMA Web site at http://www.fema.gov/plan/prevent/fhm/frm_fees.shtm **for Fee Amounts and Exemptions.**

D. SIGNATURE

All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Evan Canfield	Company: Pima County Regional Flood Control	
Mailing Address: 97 E. Congress, Tucson AZ, 85701	Daytime Telephone No.: 520 243 1800	Fax No.: 520 243-1821
	E-Mail Address: evan.canfield@rfcd.pima.gov	
Signature of Requester (required):	Date: 6/18/10	

As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision (LOMR) or conditional LOMR request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirement that no fill be placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a conditional LOMR, will be obtained. In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44CFR 65.2(c), and that we have available upon request by FEMA, all analyses and documentation used to make this determination.

Community Official's Name and Title: Andrew Dinauer, Administrator	Community Name: City of Tucson	
Mailing Address: P.O. Box 27210 Tucson, AZ 85726	Daytime Telephone No.: 520 791-4251	Fax No.:
	E-Mail Address: adinaue1@ci.tucson.az.us	
Community Official's Signature (required):	Date: 6/17/10	

CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR

This certification is to be signed and sealed by a licensed land surveyor, registered professional engineer, or architect authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.2(b) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: Howard Evan Canfield.	License No.: 41917	Expiration Date: 3/31/2011
Company Name: Pima County Regional Flood Control	Telephone No.: 520 243 1800	Fax No.:
Signature:		Date: 6/18/10

Ensure the forms that are appropriate to your revision request are included in your submittal.

Form Name and (Number)	Required if ...
☒ Riverine Hydrology and Hydraulics Form (Form 2)	New or revised discharges or water-surface elevations
☐ Riverine Structures Form (Form 3)	Channel is modified, addition/revision of bridge/culverts, addition/revision of levee/floodwall, addition/revision of dam
☐ Coastal Analysis Form (Form 4)	New or revised coastal elevations
☐ Coastal Structures Form (Form 5)	Addition/revision of coastal structure
☐ Alluvial Fan Flooding Form (Form 6)	Flood control measures on alluvial fans

Registered Professional Engineer (Civil) CERTIFICATE NO. 41917 HOWARD EVAN CANFIELD Date Signed 6/18/10 (Optional) ARIZONA U.S.A.

Expires 3-31-11

U.S. DEPARTMENT OF HOMELAND SECURITY - FEDERAL EMERGENCY MANAGEMENT AGENCY

RIVERINE HYDROLOGY & HYDRAULICS FORM

O.M.B No. 1660-0016
Expires: 12/31/2010

PAPERWORK REDUCTION ACT

Public reporting burden for this form is estimated to average 3.25 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing, reviewing, and submitting the form. You are not required to respond to this collection of information unless a valid OMB control number appears in the upper right corner of this form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, U.S. Department of Homeland Security, Federal Emergency Management Agency, 500 C Street, SW, Washington DC 20472, Paperwork Reduction Project (1660-0016). Submission of the form is required to obtain or retain benefits under the National Flood Insurance Program. **Please do not send your completed survey to the above address.**

Flooding Source: Camino De Oeste Wash
Note: Fill out one form for each flooding source studied

A. HYDROLOGY

1. Reason for New Hydrologic Analysis (check all that apply)

☐ Not revised (skip to section B) ☐ No existing analysis ☒ Improved data
☐ Alternative methodology ☐ Proposed Conditions (CLOMR) ☐ Changed physical condition of watershed

2. Comparison of Representative 1%-Annual-Chance Discharges

Location	Drainage Area (Sq. Mi.)	Effective/FIS (cfs)	Revised (cfs)
at Silverbell Rdi	5.69	6418 (upstream AE)	6432

3. Methodology for New Hydrologic Analysis (check all that apply)

☐ Statistical Analysis of Gage Records ☒ Precipitation/Runoff Model HEC-HMS
☐ Regional Regression Equations ☐ Other (please attach description)

Please enclose all relevant models in digital format, maps, computations (including computation of parameters) and documentation to support the new analysis.

4. Review/Approval of Analysis

If your community requires a regional, state, or federal agency to review the hydrologic analysis, please attach evidence of approval/review.

5. Impacts of Sediment Transport on Hydrology

Was sediment transport considered? ☐ Yes ☒ No If yes, then fill out Section F (Sediment Transport) of Form 3. If No, then attach your explanation for why sediment transport was not considered.

B. HYDRAULICS

1. Reach to be Revised

	Description	Cross Section	Water-Surface Elevations (ft.) Effective	Proposed/Revised
Downstream Limit	Atthe confluence with the Santa Cruz Riv			
Upstream Limit	Goret Rd at transition to upstream AE			

2. Hydraulic Method/Model Used

FLO-2D (v 2007- 06)

B. HYDRAULICS (CONTINUED)

3. Pre-Submittal Review of Hydraulic Models

DHS-FEMA has developed two review programs, CHECK-2 and CHECK-RAS, to aid in the review of HEC-2 and HEC-RAS hydraulic models, respectively. These review programs may help verify that the hydraulic estimates and assumptions in the model data are in accordance with NFIP requirements, and that the data are comparable with the assumptions and limitations of HEC-2/HEC-RAS. CHECK-2 and CHECK-RAS identify areas of potential error or concern. **These tools do not replace engineering judgment.** CHECK-2 and CHECK-RAS can be downloaded from http://www.fema.gov/plan/prevent/fhm/frm_soft.shtm. We recommend that you review your HEC-2 and HEC-RAS models with CHECK-2 and CHECK-RAS. Review of your submittal and resolution of valid modeling discrepancies may result in reduced review time.

4. Models Submitted

Models Submitted	Natural Run		Floodway Run		Datum
Duplicate Effective Model*	File Name: N/A	Plan Name: N/A	File Name: N/A	Plan Name:	_____
Corrected Effective Model*	File Name: N/A	Plan Name:	File Name:	Plan Name:	_____
Existing or Pre-Project Conditions Model	File Name: N/A	Plan Name:	File Name:	Plan Name:	_____
Revised or Post-Project Conditions Model	File Name: N/A	Plan Name:	File Name:	Plan Name:	_____
Other - (attach description)	File Name: N/A	Plan Name:	File Name:	Plan Name:	_____

* For details, refer to the corresponding section of the instructions.

☒ Digital Models Submitted? (Required)

C. MAPPING REQUIREMENTS

A **certified topographic map** must be submitted showing the following information (where applicable): the boundaries of the effective, existing, and proposed conditions 1%-annual-chance floodplain (for approximate Zone A revisions) or the boundaries of the 1%- and 0.2%-annual-chance floodplains and regulatory floodway (for detailed Zone AE, AO, and AH revisions); location and alignment of all cross sections with stationing control indicated; stream, road, and other alignments (e.g., dams, levees, etc.); current community easements and boundaries; boundaries of the requester's property; certification of a registered professional engineer registered in the subject State; location and description of reference marks; and the referenced vertical datum (NGVD, NAVD, etc.).

☒ Digital Mapping (GIS/CADD) Data Submitted

Note that the boundaries of the existing or proposed conditions floodplains and regulatory floodway to be shown on the revised FIRM and/or FBFM must tie-in with the effective floodplain and regulatory floodway boundaries. Please attach **a copy of the effective FIRM and/or FBFM,** annotated to show the boundaries of the revised 1%- and 0.2%-annual-chance floodplains and regulatory floodway that tie-in with the boundaries of the effective 1%- and 0.2%-annual-chance floodplain and regulatory floodway at the upstream and downstream limits of the area of revision.

☒ Annotated FIRM and/or FBFM (Required)

D. COMMON REGULATORY REQUIREMENTS*

1. For LOMR/CLOMR requests, do Base Flood Elevations (BFEs) increase? ☐ Yes ☒ No

   a. For CLOMR requests, if either of the following is true, please submit **evidence of compliance with Section 65.12 of the NFIP regulations**:
   - The proposed project encroaches upon a regulatory floodway and would result in increases above 0.00 foot.
   - The proposed project encroaches upon a SFHA with or without BFEs established and would result in increases above 1.00 foot.

   b. For LOMR requests, does this request require property owner notification and acceptance of BFE increases? ☐ Yes ☒ No
   If Yes, please attach **proof of property owner notification and acceptance (if available)**. Elements of and examples of property owner notification can be found in the MT-2 Form 2 Instructions.

2. Does the request involve the placement or proposed placement of fill? ☐ Yes ☒ No

   If Yes, the community must be able to certify that the area to be removed from the special flood hazard area, to include any structures or proposed structures, meets all of the standards of the local floodplain ordinances, and is reasonably safe from flooding in accordance with the NFIP regulations set forth at 44 CFR 60.3(a)(3), 65.5(a)(4), and 65.6(a)(14). Please see the MT-2 instructions for more information.

3. For LOMR requests, is the regulatory floodway being revised? ☐ Yes ☒ No

   If Yes, attach **evidence of regulatory floodway revision notification**. As per Paragraph 65.7(b)(1) of the NFIP Regulations, notification is required for requests involving revisions to the regulatory floodway. (Not required for revisions to approximate 1%-annual-chance floodplains [studied Zone A designation] unless a regulatory floodway is being added. Elements and examples of regulatory floodway revision notification can be found in the MT-2 Form 2 Instructions.)

4. For LOMR/CLOMR requests, does this request have the potential to impact an endangered species? ☐ Yes ☒ No

   If Yes, please submit documentation to the community to show that you have complied with Sections 9 and 10 of the Endangered Species Act (ESA). Section 9 of the ESA prohibits anyone from "taking" or harming an endangered species. If an action might harm an endangered species, a permit is required from U.S. Fish and Wildlife Service or National Marine Fisheries Service under Section 10 of the ESA.

   For actions authorized, funded, or being carried out by Federal or State agencies, please submit documentation from the agency showing its compliance with Section 7(a)(2) of the ESA.

* Not inclusive of all applicable regulatory requirements. For details, see 44 CFR parts 60 and 65.

Appendix C: Survey Field Notes

PIMA COUNTY
REGIONAL FLOOD CONTROL DISTRICT
97 EAST CONGRESS STREET, THIRD FLOOR
TUCSON, ARIZONA 85701-1797

SUZANNE SHIELDS, P.E.
DIRECTOR

(520) 243-1800
FAX (520) 243-1821

January 2, 2009

Craig S. Kennedy, CFM, Program Specialist
Engineering Management Branch
Mitigation Directorate
FEMA
500C Street SW
Washington, DC 20472

Re: Re: Acceptability of LiDAR

Dear Mr. Kennedy:

The Pima Association of Governments (PAG) has contracted with Sanborn to generate ortho rectified aerial photography and LiDAR. Figure 1 shows the extent of the LiDAR coverage for Pima County and the FIRM Special Flood Hazard Areas. The next version of Flood Insurance Rate Maps for Pima County will be converted to the North American Vertical Datum of 1988 (NAVD88). Attached to this letter you will find a draft letter from Sanborn indicating the vertical accuracy of the LiDAR meets FEMA's Map Modernization requirements.

The Pima County Regional Flood Control District (District) requests that the documentation in the draft letter be examined by FEMA to verify the LiDAR and topography created from this data would meet FEMA's vertical requirements for mapping to the NAVD88 Datum. If acceptable, the District will request PAG to have Sanborn seal the documentation so that it may be used in FEMA re-mapping processes. The District understands the digital maps generated from the LiDAR would need to be re-projected to FEMA's UTM coordinate system for LOMR applications.

Please call me at 520-243-1800, should you have any questions with this request.

Sincerely,

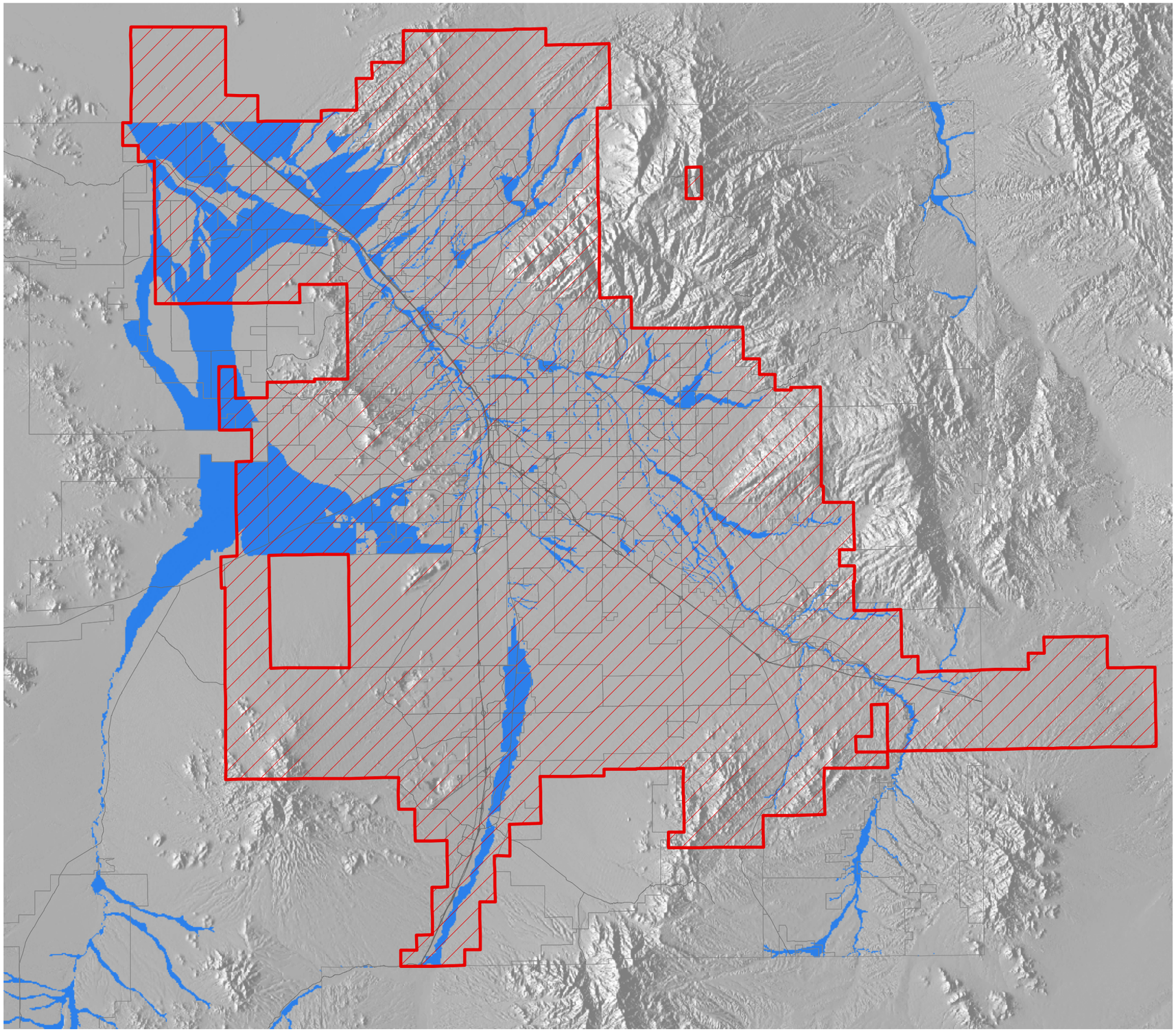
R. "Terry" Hendricks, CFM, Chief Hydrologist
Planning and Development Division

RTH/cd

Cc: Steve Whitney, GIS Manager, Pima County Department of Transportation
Kenneth Maits, Senior GIS Analyst, PC Regional Flood Control District
Manny M. Rosas, GIS Administrator, Pima Association of Governments.

Enclosures

Exhibit 1:
2008 LiDAR Coverage and FEMA Special Flood Hazard Areas



2008 LiDAR Coverage

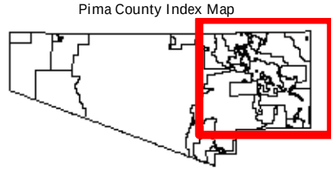
FEMA Floodplains

Major Streets

Jurisdiction Lines

Not Shown: Western Pima County, including Ajo and LiDAR coverage on Tohono O'dham Nation.

Pima County Index Map



Index Map Scale 1:5,250,000

Pima County Regional Flood Control District

Scale 1:415,000

\\gislib\rfcd\projects\imd\ken\lidar08\fema_08cov.mxd km

Corporate Headquarters:
Colorado Springs
Colorado

Ann Arbor
Michigan

Charlotte
North Carolina

Ft. Collins
Colorado

Pelham
New York

Portland
Oregon

Sacramento
California

St. Louis
Missouri

Sanborn
Middle East

Mumbai
India

30 December 2008

Manny Rosas, GIS Administrator
Pima Association of Governments
177 N. Church Ave.
Suite 405
Tucson, AZ 85701

Re: FEMA Results for the PAG 2008 Ortho Project (Contract – 08-5951-01)

Dear Mr. Rosas,

Attached you will find the results of the FEMA checkpoints for PAG 2008 LiDAR data. Sanborn's contracted Arizona State Registered Land-Surveyor, Greg Thompson, performed a review of the report and is in agreement with the results.

Background

To ensure the accuracy of the PAG 2008 LiDAR data, Sanborn was contracted to implement a project plan that included the integration of FEMA checkpoints as part of the QA/QC process. To support this initiative, Sanborn collected 69 checkpoints as part of the control survey effort. This meets the minimum standards for vertical accuracy testing and reporting as defined in FEMA's map modernization requirements. FEMA recommends 20 checkpoints in each of the major land cover categories representative of floodplains being mapped; this normally requires a minimum of 60 checkpoints for at least three land cover categories. The three categories surveyed were:

1. Bare Earth and Low Grass
2. High Grass, Weeds, and Crops
3. Brush lands/low trees

Field data was acquired using GPS equipment and static surveying methods. Sanborn team surveyed all checkpoint following the procedures in NOAA Technical Memorandum NOS NGS-58, "Guidelines for Establishing GPS-Derived Ellipsoid Heights (Standards: 2 cm and 5 cm)" and use NGS' latest Geoid Model to compute NAVD88 orthometric heights accurate to 5-cm at the 95% confidence level. (The x and y coordinates of checkpoints will be accurate to 2-cm at the 95% confidence level.)

Final adjusted results were adjusted to Arizona State Plane Coordinates, Central Zone NAD83-92 (HARN), NAVD88, in units of International Foot.

Testing Methodology

As stated in the Guidelines and Specifications for Flood Hazard Mapping Partners (April 2003), Section A.87.6.1, "The Root Mean Square Error (RMSE) is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points…TINs (and DEMs derived therefrom) should normally have a maximum RMSE of 18.5 centimeters, equivalent to

2-foot contours, in flat terrain. The following are the results from the PAG 2008 Ortho Program.

Bare Earth:

Number	Easting	Northing	Known Z	Laser Z	Dz ----------
1	1001837.162	410093.611	2587.031	2587.530	+0.499
7	999345.782	449442.944	2441.401	2441.640	+0.239
20	933721.166	412981.849	2439.091	2439.310	+0.219
17	933650.558	412993.658	2438.451	2438.660	+0.209
15	897369.501	552863.803	1937.257	1937.430	+0.173
3	1159921.689	349431.234	4294.062	4294.210	+0.148
8	1005806.086	434836.185	2509.196	2509.340	+0.144
9	1000927.946	448200.185	2446.309	2446.400	+0.091
13	994444.372	503631.914	2655.984	2656.070	+0.086
11	994513.846	503595.055	2658.012	2658.090	+0.078
18	955798.751	425094.504	2540.814	2540.880	+0.066
2	906521.919	540616.247	1946.585	1946.640	+0.055
12	987338.200	503575.338	2542.972	2542.930	-0.042
14	965580.705	519074.819	2667.182	2667.120	-0.062
21	955893.647	425085.496	2541.302	2541.240	-0.062
5	1021871.892	457772.536	2472.149	2472.080	-0.069
6	1033139.499	445741.877	2610.656	2610.580	-0.076
16	939704.593	416728.203	2432.726	2432.640	-0.086
10	985754.835	454784.703	2313.130	2312.980	-0.150
19	939508.793	416651.451	2432.802	2432.630	-0.172
22	1027485.930	416573.872	2740.833	2740.650	-0.183
4	1156429.917	365109.827	4055.003	outside	*

Average dz	+0.053
Minimum dz	-0.183
Maximum dz	+0.499
Average magnitude	0.139
Root mean square	**0.171 (foot)**
Std deviation	0.166

Medium Vegetation:

Number	Easting	Northing	Known Z	Laser Z	Dz ----------
1	1187028.525	351518.925	4080.561	4080.540	-0.021
2	1117108.620	363592.785	3587.077	3586.940	-0.137
3	1073972.909	383419.761	3240.515	3240.590	+0.075
4	1010832.502	410849.441	2643.786	2643.990	+0.204
5	1005445.314	419156.617	2579.495	2579.880	+0.385
6	1045092.088	435136.157	2724.009	2724.050	+0.041

7	1069748.640	446273.392	2760.125	2760.050	-0.075
8	1033371.126	464364.855	2518.606	2518.310	-0.296
9	1054207.161	418935.174	2886.854	2886.950	+0.096
10	955203.805	487660.945	2178.734	2179.130	+0.396
11	997532.713	434803.804	2460.164	2460.250	+0.086
12	979509.921	492673.940	2417.792	2418.190	+0.398
13	995655.491	465569.990	2344.777	2344.690	-0.087
14	997550.935	482620.376	2598.648	2598.550	-0.098
15	1001334.429	474026.061	2493.153	2493.240	+0.087
16	990196.690	487542.780	2546.083	outside	*
17	990519.334	490352.801	2559.039	2559.110	+0.071
18	998219.739	493708.248	2936.804	2937.080	+0.276
19	996795.607	504234.682	2727.497	2727.370	-0.127
20	988245.902	501104.027	2560.988	2560.870	-0.118
21	985960.009	501595.086	2553.169	2553.130	-0.039
22	997446.853	506178.000	2694.613	2695.140	+0.527
23	987398.768	503506.302	2546.335	2546.410	+0.075
24	985971.797	501493.493	2552.516	2552.570	+0.054
25	997540.656	506124.929	2707.864	2708.230	+0.366
26	991206.370	506306.455	2518.406	2518.250	-0.156
27	978945.698	519233.465	2782.405	2782.330	-0.075
28	978935.642	519272.398	2784.006	2784.080	+0.074
29	965555.375	519044.382	2666.260	2666.260	+0.000
30	897298.425	552978.606	1937.352	1937.730	+0.378
31	910066.011	514280.384	2003.658	2003.840	+0.182

Average dz	+0.085
Minimum dz	-0.296
Maximum dz	+0.527
Average magnitude	0.167
Root mean square	**0.217 (foot)**
Std deviation	0.203

High Vegetation:

Number	Easting	Northing	Known Z	Laser Z	Dz
1	1041505.790	408998.331	2868.881	2869.410	+0.529
4	1007421.616	441240.211	2501.880	2502.270	+0.390
9	988302.547	500937.045	2557.959	2558.170	+0.211
10	993323.041	504876.742	2616.818	2616.900	+0.082
3	944799.536	483176.205	2406.404	2406.480	+0.076
6	993338.640	505132.410	2616.096	2616.130	+0.034
13	995168.385	519848.931	2773.051	2773.040	-0.011
8	996811.199	504124.980	2733.504	2733.470	-0.034
14	995094.857	519807.072	2771.624	2771.590	-0.034
5	995053.089	492295.493	2741.552	2741.500	-0.052
7	986911.443	504348.439	2463.848	2463.780	-0.068

11	986965.447	504425.310	2458.159	2458.090	-0.069
12	993296.411	506167.522	2598.730	2598.640	-0.090
16	919968.908	521623.590	2003.520	2003.130	-0.390
15	909979.986	514314.158	2004.186	2003.740	-0.446
2	988498.629	488163.006	2506.243	outside	*

Average dz	+0.009
Minimum dz	-0.446
Maximum dz	+0.529
Average magnitude	0.168
Root mean square	**0.240 (foot)**
Std deviation	0.248

Sanborn concludes that the overall RMSE of the LiDAR data is within PAG 2008 Ortho project requirements, as it meets the +/- 15.0 cm (0.492 foot) RMSE at 95% confidence for all three categories. RMSE is an indicator of overall accuracy of the product and is not used for individual point accuracy.

Please contact me at (719) 593-0093 extension 5645 or Jamie Young (General Manager – ext. 5602) if you have any question regarding the report.

Sincerely,

Andrew Lucero
Sanborn
Senior Project Manager

Evan Canfield

From: Kenneth Maits
Sent: Monday, May 03, 2010 12:20 PM
To: Evan Canfield
Subject: FW: PAG 2008 Orthos/Lidar

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
(510) 627-7207 - office
(510) 295-5249 - mobile

From: Manny M. Rosas [mailto:MRosas@pagnet.org]
Sent: Tuesday, November 10, 2009 7:29 AM
To: 'Lucero, Andrew'; 'Caldwell, Jason'
Cc: 'Terry Hendricks'; Curtis, Edward
Subject: PAG 2008 Orthos/Lidar

Hi Andy,
I resent Sanborn's Version 3 document produced in July 2009 and yet to receive any comments from FEMA, Pima County and Michael Baker Inc. therefore
please proceed with direct communications with Michael Baker Inc (Pascal Akl) to resolve all issues regarding the FEMA guidelines

Thank You
Manny

Manny M. Rosas Jr.
GIS Administrator

Pima Association of Governments

177 N Church Ave. Suite 405
Tucson, Arizona 85701

520-792-1093 (tel)
520-620-6981 (fax)

Property of HDR ENG. INC.

5210 E. WILLIAMS CIR.

Address STE. 530

TUCSON, AZ. 85711

Phone 520-584-7611

INDEX PAGE

JOB NO.	PROJECT	PAGE NUMBER
112279	SILVERBELL RD, GRANT RD TO INA RD. (C.O.T.) (REF. COT JO. 15794 IN HDR F.B. 201)	ALL
	COT FB # 2255	
	I HEREBY CERTIFY THAT THE SURVEY	

CONTAINED HEREIN WAS CONDUCTED UNDER MY DIRECT SUPERVISION BETWEEN MAY, 2009 AND MAY, 2010. I FURTHER CERTIFY THAT THIS SURVEY WAS CONDUCTED AS A CONTROL AND DESIGN SURVEY FOR SILVERBELL RD. FROM GRANT RD. TO INA RD. THE INFORMATION CONTAINED HEREIN IS TRUE, ACCURATE AND SUFFICIENT TO RETRACE THIS SURVEY. THIS SURVEY MEETS OR EXCEEDS THE MINIMUM STANDARDS FOR SURVEYS IN ARIZONA.

REGISTERED LAND SURVEYOR CERTIFICATE NO. 18211 FRANK D. ABELL Date Signed 5-6-10 ARIZONA, U.S.A.

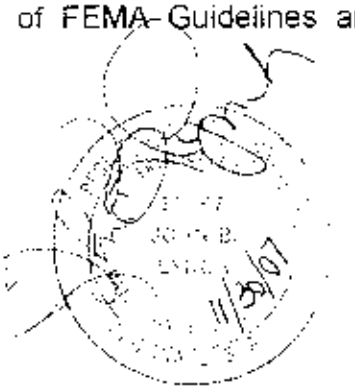
TETRA TECH, INC.

The accuracy of the lidar data was verified using the methods described in sections A.3. A.4 and A.8 of the *FEMA Guidelines and Specifications for Flood Hazard Mapping Partners* (April, 2003). Ground cover categories (1) bare-earth and low grass and (5) urban area, roadways were evaluated. A total of 493 points were compared. The difference was determined to be 0.2 feet (median value).

A total of 506 points were collected throughout the area defined by the 100yr flood limit (TetraTech Job 0939-FVW-LOMR) plus an additional 300 feet, from Stone Loop northeasterly to North 1st Avenue, all within Section 13, T13S, R13E and Section 18, T13S, R14E. The survey utilized a GPS/RTK base and receiver localized on survey monuments with Arizona State Plane, Central Zone NAD83 coordinates (horizontal) and orthometric heights relative to NAVD88, published by the Pima Association of Governments (PAG). The field survey was conducted in October and November of 2007. A total of 13 points were discarded due to man-made changes in the ground surface or insufficient satellite reception.

The surface used for this survey was provided by Pima County Flood Control as lidar point file (13S13E13) using LAS format and a XYZ point cloud covering the approximate same area. A TIN was created using ArcGIS 9.2 3D Analyst and elevations extracted at locations as determined per the field survey and differences between the two were calculated.

It was found that accuracy of the lidar surface was within the two-foot equivalent contour interval (accuracy$_z$ = 1.2 foot at the 95-percent confidence level) criteria specified by FEMA. The actual ground elevation was higher then the lidar surface by an average of 0.2 feet, with a min/max range of 1.1 feet. The verification demonstrates that the lidar surface meets the criteria for lidar compliance specified in sections A.3, A.4 and A.8 of FEMA Guidelines and Specifications for Flood Hazard Mapping Partners.



Tetra Tech Job Number: 0939 Friendly Village Wash LOMR

Appendix D: Hydrologic Analysis

(in digital form on DVD)

Appendix E: Hydraulic Analysis

(in digital form on DVD)

Appendix F: Erosion and Sediment Transport Analysis Supporting Documentation

None