# Gillespie Area Drainage Master Study

## *Maricopa Mountains Alluvial Fan #1*
## *FEMA Stage 1 Analysis*

Flood Control District of Maricopa County

October 2013

**Submitted by:**
Stantec Consulting Services Inc.
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Stantec

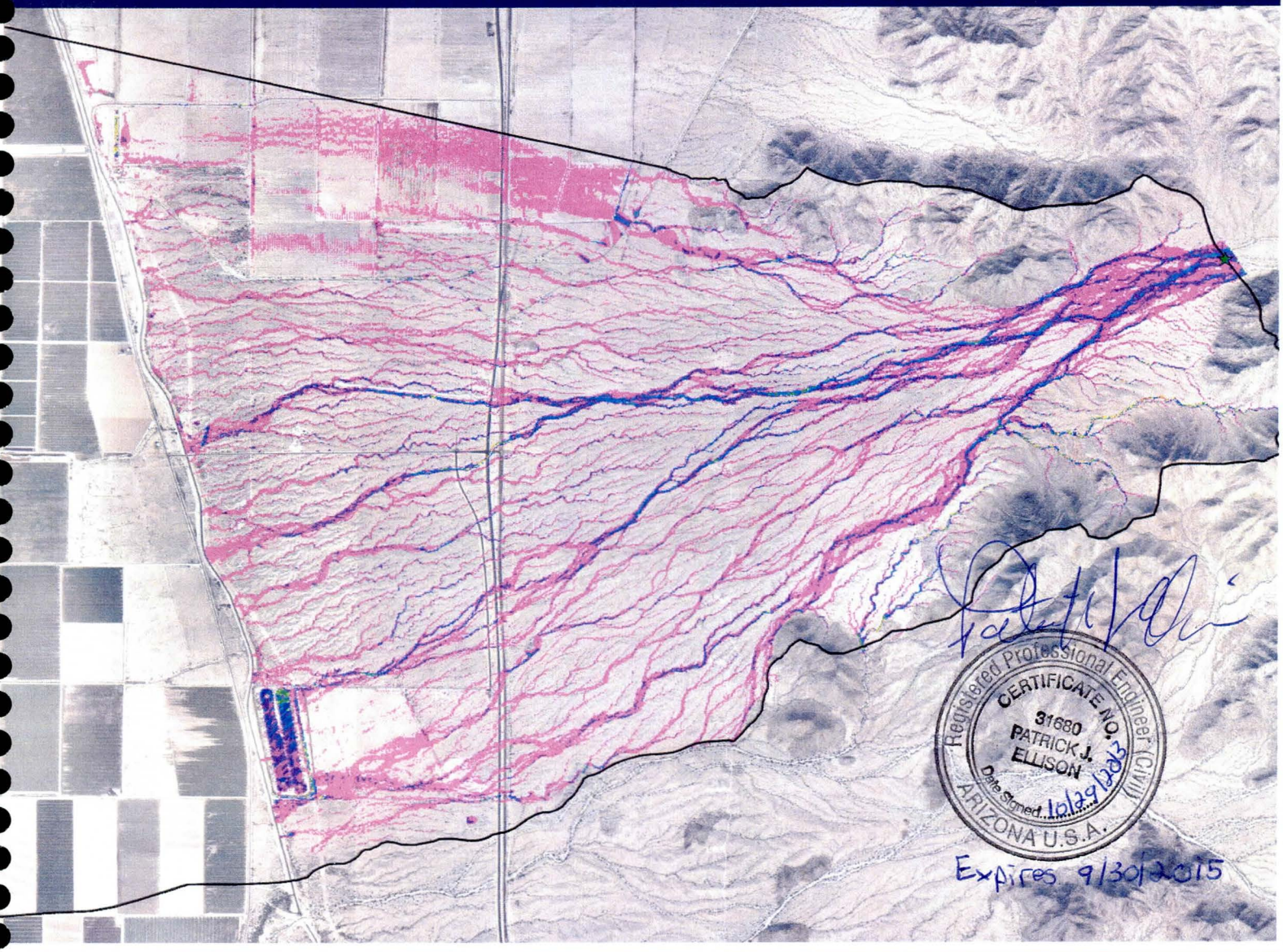
Flood Control District of Maricopa County

A326.106

# Gillespie Area Drainage Master Study

## Maricopa Mountains Alluvial Fan #1

## FEMA Stage 1 Analysis




October 2013

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# 1.0 Introduction

This report describes the evaluations conducted for a Federal Emergency Management Agency (FEMA), Stage 1 Alluvial Fan Analyses that was conducted for a portion of the Maricopa Mountains located within the Gillespie ADMS project area. The Gillespie ADMS project area is approximately 150 square miles in size lies within the Town of Buckeye, Town of Gila Bend, unincorporated Maricopa County and the Woolsey Flood Protection District. The document presents qualitative and quantitative assessments for a Stage 1 Alluvial Fan Analyses.

The Gillespie ADMS project was initiated by the District at the request of the Woolsey Flood Protection District. The Woolsey Flood Protection District is an agency that operates and maintains agricultural drainage facilities within the study area. The project was conducted by Stantec Consulting Services Inc. under District CONTRACT FCD 2009C039.

## 1.1 GILLESPIE ADMS PROJECT DESCRIPTION

The Gillespie ADMS project area approximately 150 square miles in size, lies within the Town of Buckeye, Town of Gila Bend, unincorporated Maricopa County and the Woolsey Flood Protection District. The study watersheds are characterized by three major landforms; mountain, piedmont and alluvial plain.

The mountainous areas of the Buckeye Hills and Maricopa Mountains form the northern and eastern boundaries of the watershed, respectively. These areas are characterized by steep, rocky slopes and small, incised washes that form a tributary network. Typically the conveyance capacity of the tributary network is great enough to convey runoff draining to the channels.

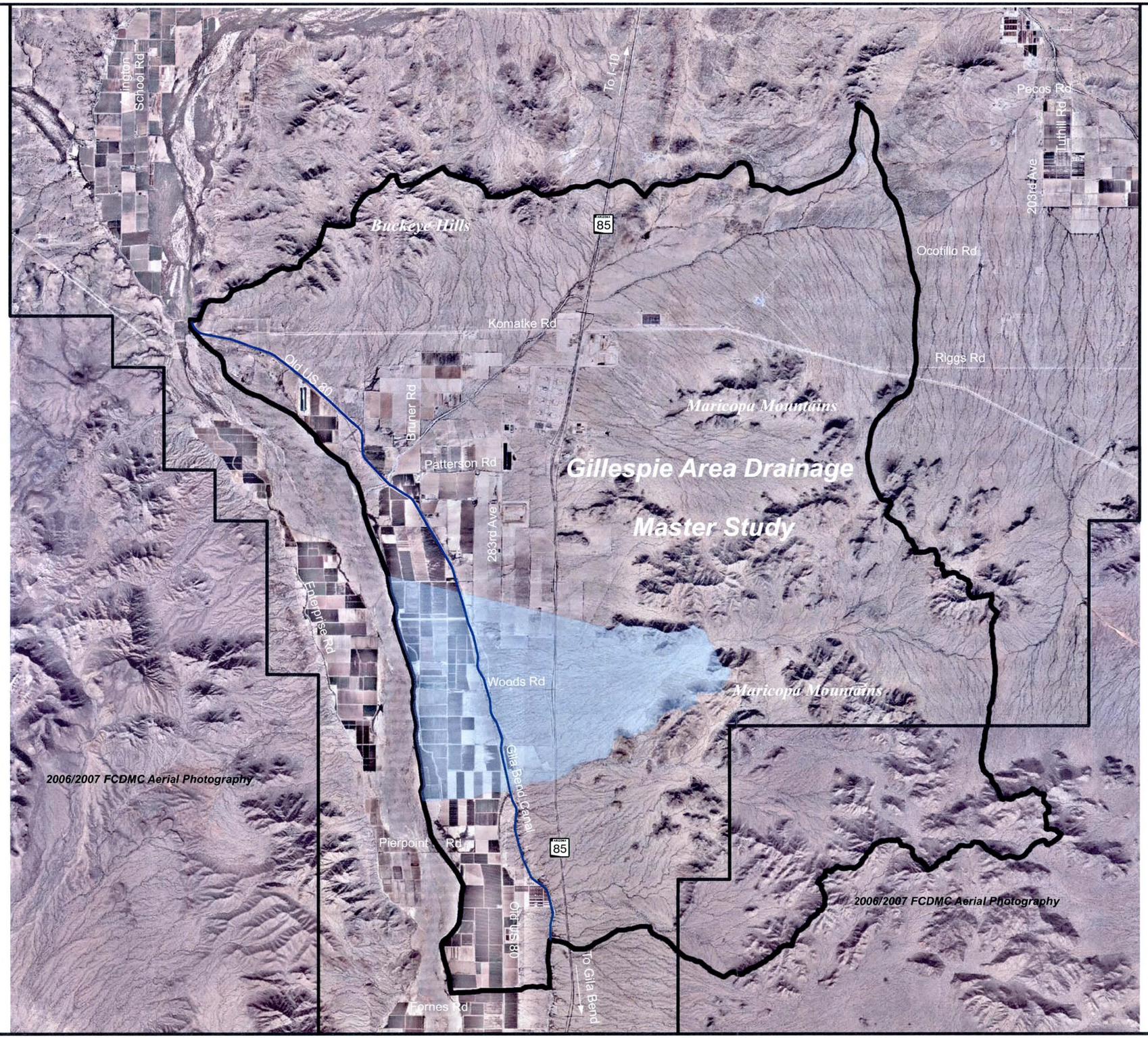
On the piedmont at locations the topography has characteristics similar to alluvial fan landforms.

The piedmont landform is moderately sloping (1 - 5%) and composed of poorly consolidated alluvial deposits that are bisected by channels with ill-defined banks. The piedmont drainage network is a combination of tributary and distributive channels, with distributive channels dominating. In general, the conveyance capacity of the piedmont drainage system diminishes in the downstream direction as channel definition becomes less defined, ultimately giving way to sheet flow. At locations on the piedmont the topography has characteristics similar to alluvial fan landforms. The piedmont is also dissected by numerous manmade features that, in general, redirect flow from historic paths. These manmade features consist of SR-85 and various combinations of culverts, channels and embankments. Many of the channel and embankment features are non-engineered structures that direct flow around agricultural fields.

The alluvial plain is comprised of flat, uniform terrain that terminates at the Gila River, which forms the western watershed boundary. The majority of land use is located within this landform with agricultural as the predominant use. Runoff occurs as sheet flow or is concentrated in very small parallel washes with the exception of Rainbow Wash, the major drainage way within the watershed. This alluvial plain landform is bisected by the Gila Bend Canal. The Gila Bend Canal traverses from north to south across the watershed and is elevated above the natural ground. Runoff reaching the canal ponds against the embankment and is funneled through 6 crossings, at siphons for the Gila Bend Canal.

## 1.2 PURPOSE

The purpose of the FEMA Stage 1 analyses is to evaluate an area adjacent to the Maricopa Mountains to determine if the landform is an alluvial fan landform. Figure 1.1 depicts the location of the Gillespie ADMS project area and the Maricopa Mountains study area subject to this alluvial fan landform determination. Inset to the figure is a vicinity figure depicting the proximity of the project to communities within Maricopa County.




GILLESPIE AREA DRAINAGE
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LEGEND

- Study Area
- Gillespie ADMS Boundary
- Gila Bend Canal

NOTES

Aerial imagery flight dates Oct 2009 and Nov 2006

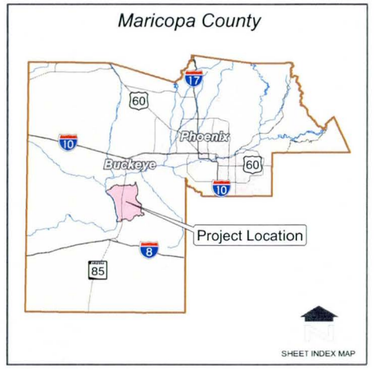


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**Figure 1.1**
**Location of Maricopa Mountains Alluvial Fan Project**

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FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

*Figure1-1_Mar_Mnt_Fan_Loc.mxd*

# 2.0 Geomorphology

This section describes the geomorphic and analytical methods used to determine the type and extent of Alluvial Fan Landforms in a study area at the base and within an intermountain valley of the Maricopa Mountains. Procedures and guidance outlined in the *Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix G: Guidance for Alluvial Fan Flooding Analyses and Mapping by the Federal Emergency Management Agency (FEMA, April 2003)*, was utilized and forms the basis for the structure of this section. The referenced document describes a three stage process for identifying and delineating alluvial fan flood hazards. The three stage process includes:

- Stage 1: Recognizing and Characterizing Alluvial Fan Landforms
- Stage 2: Defining Active and Inactive Areas
- Stage 3: Defining the 100-year Flood within Defined Areas

The focus of this document is Stage 1. Stage 2 and Stage 3 will be conducted at a later date if needed.

Other references utilized in the alluvial fan landform evaluation include *Refinement of Methodology: Alluvial Fan Flood Hazard Identification & Mitigation Methods (JE Fuller/Hydrology & Geomorphology, Inc. August 25, 2010)* and *Flood Hazards of Distributary – Flow Areas in Southwestern Arizona by H.W. Hjalmarson and S.P. Kemna (Hjalmarson and Kemna, December 1991*).

## 2.1 PREVIOUS STUDIES

Previous or concurrent studies of the geomorphology/geology of the project area include:

- *Surficial Geology and Flood Hazards on the Western Piedmont of the Maricopa Mountains and the Southern Piedmont of the Buckeye Hills, Maricopa County, Arizona* (AZGS OFR-12-07/DGM-75, 2012) by Jeri J. Young, Joseph P. Cook and Philip A. Pearthree. This document depicts the surficial geology for portions of the Buckeye Hills and Maricopa Mountains within the Gillespie ADMS project area.

## 2.2 DATA SOURCES

This section of the report describes the type, source and details of data utilized in the three stage process for identifying and delineating alluvial fan flood hazards.

### 2.2.1 NRCS Soils Survey

Soils surveys for the project area are obtained from the Natural Resources Conservation Service (NRCS). The specific soil survey of the alluvial fan landform study area within the Maricopa Mountains is the *AZ 653-Gila Bend-Ajo Area, Arizona, Parts of Maricopa and Pinal Counties (NRCS, 1997)*. This detail soil survey provides map unit descriptions that support the conclusion regarding the composition of the alluvial fan landform. Map unit descriptions include soil composition, setting (which includes a landform interpretation), soil properties and typical profile (soil profile). Soil data was obtained from the NRCS Soil Data Mart website.

### 2.2.2 Arizona Geological Survey

The Arizona Geologic Survey's (AZGS) Open File Report (AZGS OFR-12-07/DGM-75; June 2012) covers portions of the Maricopa Mountains. Details of the mapping area:

- Surficial geology of portions of the Gillespie ADMS
  - Format: Digital Format
  - Map Scale: 1:24,000
  - Year Published : 2012
  - Authors: Pearthree, P.A., Young, J.J. and Cook, J.P.

### 2.2.3 Aerial Photography

Aerial photography collected for the alluvial fan landform study was obtained from multiple sources and included historic and recent aerial photography. The formats of the aerials are digital or photographic prints. Photographic prints were scanned to a digital format, seamed and then rectified. Table 2.1 lists the aerial photography date and format.

**Table 2.1,**
**Summary of Aerial Photographic Data**

| Photo year | Format |
|---|---|
| 1947 | B&W scanned (see Appendix C) |
| 1954 | B&W scanned (see Appendix C) |
| 1978 | Color scanned (see Appendix C) |
| 2009/2010 | Color digital |

### 2.2.4 Topographic Mapping

Table 2.2 list a summary of the topographic data utilized in the study for analytical evaluations and/or as a base for presentation of analytical results.

**Table 2.2,**
**Summary of Topographic Data**

| Contour Interval (feet) | Mapping Year | Source |
|---|---|---|
| 2 | June and July of 2008 | Flood Control District of Maricopa County, Contract Number FCD 07-45 |
| 10 | December 2000 | Flood Control District of Maricopa |

## 2.3 STAGE 1: RECOGNIZING AND CHARACTERIZING PIEDMONT LANDFORMS

### 2.3.1 Introduction

The study area lies within the Maricopa Mountains and the valley plain defining the piedmont located between the mountain front and the Gila River. Storm water runoff from the study area is conveyed to the Gila River within tributary and distributary channel networks. Tributary channels are typically incised and have well defined banks whereas the distributary channels are shallow and banks are ill-defined. The topographic gradient across the study area ranges from greater than 10 % in the mountains to approximately 1.5 % across the valley plain.

A Stage 1 Alluvial fan landform analyses was conducted for the subject piedmont area within and adjacent to the Maricopa Mountains. Hjalmarson (Draft, May 2003) defines a piedmont as a surface that is part of an erosion-depositional system where sediment from the mountains is transported by streams across the piedmont.

The intent of Stage 1 is to determine if the landform is an alluvial fan landform. FEMA describes an alluvial fan landform as follows: "An Alluvial fan landform is a sedimentary deposit located at a topographic break such as at the base of a mountain front, escarpment of valley side that is composed of stream flow and or debris flow sediments and has the shape of a fan either fully or partially extended". FEMA (April, 2003) categorizes an alluvial fan landform by the following physical characteristics:

- Composition
  - An accumulation of loose, unconsolidated to weakly consolidated sediments that are transported by stream flow or debris flow.
- Morphology
  - Alluvial Fan Landforms have the shape of a fan, either partly or fully extended.
- Location
  - Alluvial fan landforms are located at a topographic break where long-term channel migration and sediment accumulation become markedly less confined than upstream of the break.
  - Topographic Apex - The topographic apex is at the extreme upstream extent of the alluvial fan landform.
  - Hydrographic Apex - The hydrographic apex is the highest point on the alluvial fan where there exists physical evidence of channel bifurcation and/or significant flow outside the defined channel.

The last step in the Stage 1 process is to define the toe and lateral boundaries of the alluvial fan. The toe is located at the downstream end of the alluvial fan and may be characterized by the location of an axial stream (a stream that transports sediment away from a fan), an alluvial plain or smoother, gentle slopes of the piedmont plain. The lateral boundaries may be defined by mountains, a trough, channel, or swale.

Should the Stage 1 determination result in an Alluvial Fan Landform classification, the alluvial fan floodplain delineation process will continue with Stage 2 and Stage 3 of the analyses.

### 2.3.2 Composition

The composition of the subject portion of the Maricopa Mountains piedmont is determined from the Gila Bend-Ajo Area, Arizona, Parts of Maricopa and Pima Counties (NRCS, 1997) soil

survey, the AZGS Open File Report (OFR-12-07/DGM-75; June, 2012) and recent aerial photography. These data sources document that the subject piedmont is composed of alluvial sediment.

#### 2.3.2.1 NRCS Soils Data

Figure 2.1 depicts detail soil units on the piedmont surface. Table 2.3 list a summary of soil unit characteristics. Appendix A contains output files (Map Unit Descriptions) from a query of the NRCS Soil Data Mart website. The soil units depicted in Figure 2.3 have been color coded by landform type that is listed in the NRCS Map Unit Descriptions. Land form types include Floodplain, Alluvial Fan, Fan Terrace and Mountains. A review of the typical profiles (soil profile, see Appendix A) for the units underlying the piedmont that are listed in Table 2.3 shows that the piedmont is composed of alluvium. .

#### 2.3.2.2 Surficial Geology Developed for Gillespie ADMS

A portion of the surficial geology developed by Pearthree et. al. (OFR-12-07/DGM-75; June, 2012), for the study area is depicted in Figure 2.2, Surficial geologic mapping was prepared at a 1:24000 scale. There are areas on the piedmont surface that have been disturbed by agricultural activity. These areas were not included in the surficial geologic mapping. In the mountainous areas where alluvium deposits were not observed, the surface is mapped as rock. Unit descriptions for Holocene and Pleistocene deposits indicated the composition of the piedmont is predominately alluvium. There are inselberg located along the northern boundary of the piedmont. Geologic unit descriptions provided by Pearthree et. al. includes discussions concerning composition, drainage network (as applicable), presence or absence of vegetation and vegetation type, surface roughness and infiltration potential. Geologic Unit descriptions are presented in Sections 2.3.2.2.1 and 2.3.2.2.2. Photographs of geologic units are presented in Figures 2.3 through 2.11. The locations of where the photographs were taken are presented in Appendix B. A summary of geologic units and acreage of each unit within the alluvial fan study area are listed in Table 2.4.

GILLESPIE AREA DRAINAGE
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LEGEND

Study Area

**Soil Type**

| | |
|---|---|
| 21 | 65% Fan Terraces<br>15% Floodplains |
| 37 | 80% Fan Terraces<br>20% Floodplains |
| 29, 41, 42, 63 | 75% to 100% Floodplains |
| 54 | Mountain |
| 17 | 70% Fan Terraces |
| 37 | Soil Unit Identifier |

NOTES

Aerial imagery flight dates Oct 2009 and Nov 2006

Soil or landform data source: NRCS Soil Survey Gila Bend - Ajo Area, Arizona. Parts of Maricopa and Pima Counties. 1997

*Maricopa County*

SHEET INDEX MAP

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**Figure 2.1**
**NRCS Detail Soil Mapping**

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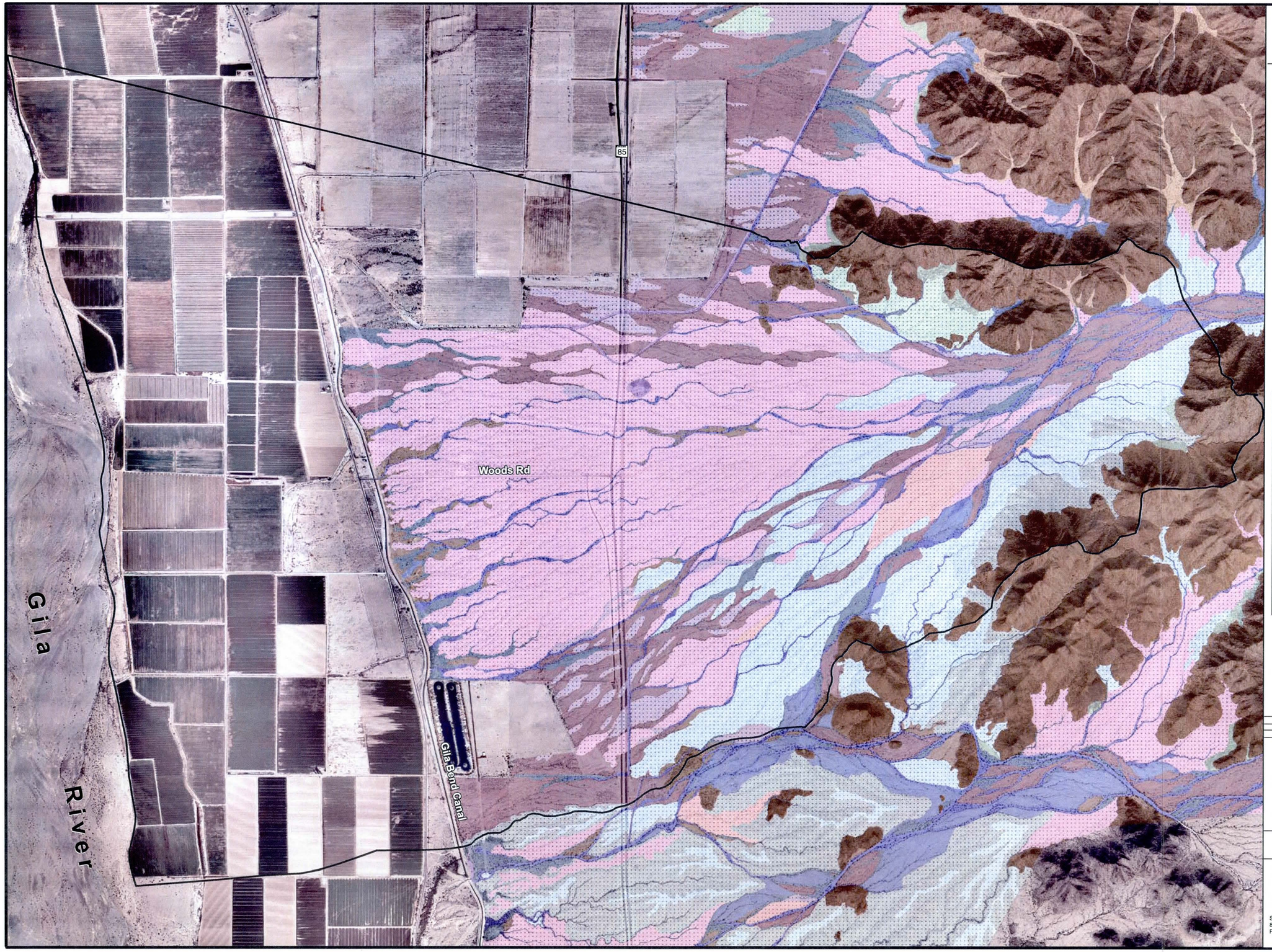
*Figure2-1_NRCS_Soil.mxd*

*2006/2007 FCDMC Aerial Photography*

**Table 2.3,**
**Soil Data Summary**

| Map Symbol | Soil Unit Name | Geomorphic Position | Slope | Soil Profile [1] | Parent Material |
|---|---|---|---|---|---|
| 1 | Agualt-Ripley | 100% Floodplains | 0-1% | very fine sandy loam | Alluvium |
| 2 | Agualt-Ripley (saline-sodic) | 100% Floodplains | 0-1% | very fine sandy loam | Alluvium |
| 6 | Carrizo-Momoli | 65% Floodplains and 25% Alluvial fans & fan terraces | 0-3% | extremely gravelly sandy loam | Alluvium |
| 10 | Cipriano-Momoli | 75% Fan terraces | 1-7% | extremely gravelly sandy loam | Alluvium |
| 13 | Dateland | 77% Stream terraces | 0-1% | very fine sandy loam | Alluvium |
| 14 | Dateland-Cuerda | 60% Fan terraces and 30% Flood plains | 0-3% | Very fine to fine sandy loam | Alluvium |
| 17 | Denure | 70% Fan terraces | 1-3% | gravelly fine sandy loam | Alluvium |
| 21 | Denure-Rillito-Why | 65% Fan terraces and 15% Floodplains | 1-5% | very gravelly sandy loam | Alluvium |
| 29 | Glenbar | 80% Floodplains | 0-1% | silty clay loam | Alluvium |
| 30 | Glenbar (saline-sodic) | 80% Floodplains | 0-1% | silty clay loam | Alluvium |
| 33 | Gunsight-Ajolito | 90% Stream terraces | 1-15% | gravelly sandy loams | Alluvium |
| 37 | Gunsight-Rillito-Carrizo | 80% Fan terraces and 15% Floodplains | 1-15% | extremely gravelly sandy loam | Alluvium |
| 41 | Indio | 75% Floodplains | 0-1% | silt loam | Alluvium |
| 42 | Indio (saline-sodic) | 75% Floodplains | 0-1% | silt loam | Alluvium |
| 43 | Lagunita-Vint | 85% Floodplains | 0-1% | loamy sands | Alluvium |
| 49 | Momoli-Carrizo | 50% Fan terraces and 25% Floodplains | 1-10% | extremely gravelly sandy loam | Alluvium |
| 51 | Momoli-Comobabi | 75% Fan terraces | 5-15% | extremely cobbly loam | Alluvium |
| 53 | Quilotosa-Momoli-Carrizo | 40% Hills, 20% Fan Terraces and 15% Floodplains | 1-15% | extremely gravelly coarse sandy loam | Alluvium |
| 54 | Quilotosa-Rock Outcrop | 60% Mountains and 25% Rock outcrop | 15-55% | rock | Rock |
| 55 | Riverwash | 100% Floodplains | | | Alluvium |
| 63 | Vint | 100%-Floodplains | 0-1% | Very fine sandy loam | Alluvium |
| 67 | Why-Carrizo | 50% Alluvial fans and 25% Floodplains | 0-3% | sandy loam | Alluvium |

1. For Map Unit Description see (Appendix A)

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LEGEND

Study Area

| Holocene <10,000 Years in Age | Pleistocene >10,000 Years in Age | Other |
|---|---|---|
| Qyc | Qiy | Qtc |
| Qy3 | Qi3 | d |
| Qy2 | Qi2 | R |
| Qya | Qi1 | |
| Qy1 | Qi | |
| Qyd | QTa | |

Listed from Youngest to Oldest

NOTES

Aerial imagery flight date: Oct 2009

Soil or landform data source:
AZGS OFR-12-07/DGM-75, 2012

*Maricopa County*

SHEET INDEX MAP

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**Figure 2.2**
**AGS Surficial Geologic Map**

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FLOOD CONTROL DISTRICT
OF MARICOPA COUNTY

*Figure2-2_AGS_Geologic_Map.mxd*

#### *2.3.2.2.1 Holocene Deposits*

**Qyc** – Active channel deposits; light gray, moderately to poorly sorted, unconsolidated sand, pebbles and cobbles, locally with small boulders in channels and bars of larger washes; lightly vegetated except along channel margins; both tributary and distributary channels are mapped separately from surrounding deposits where large enough to delineate at mapping scale.

*Surface roughness: low to moderate; generally low vegetation size and density except along margins, channels relatively smooth, but bed roughness varies with particle size*

*Infiltration potential: moderate to high.*

Figure 2.3, Photograph of Qyc deposits

**Qy3** – Smaller channel, bar, and low terrace deposits that are part of the active drainage system; channel and bar deposits typically consist of light gray, poorly sorted sand and pebbles, with some cobbles and boulders; terraces typically are less than 3 feet above adjacent active channels and consist of similar deposits, but typically are partially or totally mantled by sand and silt; deposits of this unit have no soil development and the associated vegetation consists of bursage, creosote, palo verde, iron wood, and mesquite.

*Surface roughness: moderate to high; relatively high vegetation density outside channels; variable local topography*

*Infiltration potential: moderate to high.*

Figure 2.4, Photograph of Qy3 deposits

**Qy2** – Low terrace deposits along larger channels; typically at least 3 feet above active channels and not laterally extensive; deposits consist of moderately sorted sand, pebbles and cobbles, and are commonly capped by sand and silt deposits; surface gravel is not varnished and soil development is very weak, with no clay accumulation and weak carbonate accumulation; associated vegetation includes mostly creosote with some palo verde, iron wood and mesquite.

*Surface roughness: moderate; vegetation generally small, medium density; variable particle size*

*Infiltration potential: moderate to high.*

Figure 2.5, Photograph of Qy2 deposits

**Qya** – Laterally extensive young alluvial fan or sheet flood deposits; surfaces are light gray to brown in color; deposits are very poorly to poorly sorted sand, pebbles, cobbles and rare boulders; channels are incised less than 5 feet and typically much less than that; weakly integrated networks of very small distributary channels are common; soil development is very weak with no clay accumulation and minimal carbonate accumulation; Qya units are dominated by creosote with some small shrubs and desert trees such as palo verde and mesquite.

*Surface roughness: moderate; vegetation generally small, low to medium density, coppice mounds around bushes; variable particle size, but surface gravel generally limited*

*Infiltration potential: moderate.*

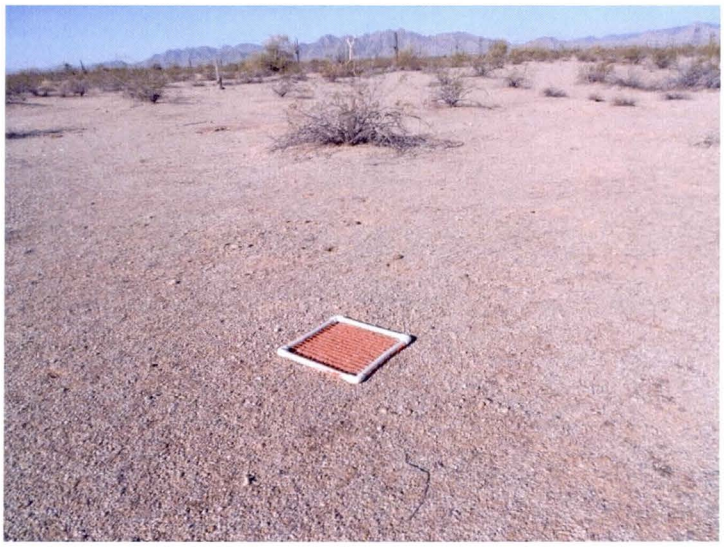


Figure 2.6, Photograph of Qya deposits

**Qy1** – Intermediate terrace deposits along channels and inactive portions of alluvial fans; surfaces are at least 3 feet above adjacent channels; deposits consist of poorly to moderately sorted silt, sand, pebbles, and cobbles, with some small boulders; gravel clasts on Qy1 surfaces are generally unvarnished or weakly varnished; gravel bar and swale deposits are about 1 foot high; soil development is weak, with incipient calcium carbonate accumulation; Qy1 surfaces are dominated by creosote.

*Surface roughness: medium; vegetation generally small, medium density; variable particle size; smooth to gently undulating local topography*

*Infiltration potential: moderate.*

Figure 2.7, Photograph of Qy1 deposits

#### *2.3.2.2.2 Pleistocene Deposits*

**Qiy** – Pleistocene alluvial fan deposits that have been substantially eroded or partially buried by younger deposits; some areas retain characteristics of Pleistocene relict surfaces, such as gravel surface lags and moderate soil development, but in other areas these characteristics have been modified by erosion or partially obscured by younger deposits; this unit designation is applied to areas where the spatial relationships between Pleistocene and younger deposits are complex, and topographic relief between surfaces of different ages is a few feet or less.

*Surface roughness: medium; vegetation generally small, low density; areas partially covered by gravel; gently undulating local topography*

*Infiltration potential: moderate to low.*

Figure 2.8, Photograph of Qiy deposits

**Qi3** – Lightly to moderately dissected relict alluvial fan and terrace deposits; deposits consist of poorly sorted sand, pebbles, cobbles, and silt, with some small boulders and clay; gravel clasts on Qi3 surfaces are weakly to moderately varnished; pavements, where present, vary from weak to moderate; surfaces are generally fairly smooth between incised drainages, which are up to about 6 ft deep; soil development is weak to moderate, with visible calcium carbonate accumulation; Qi3 surfaces are typically lightly vegetated, with small trees along incised drainages and sparse creosote bushes on planar surfaces.

*Surface roughness: medium; vegetation generally small, low density; surfaces typically partially covered by gravel; smooth local topography*

*Infiltration potential: low.*

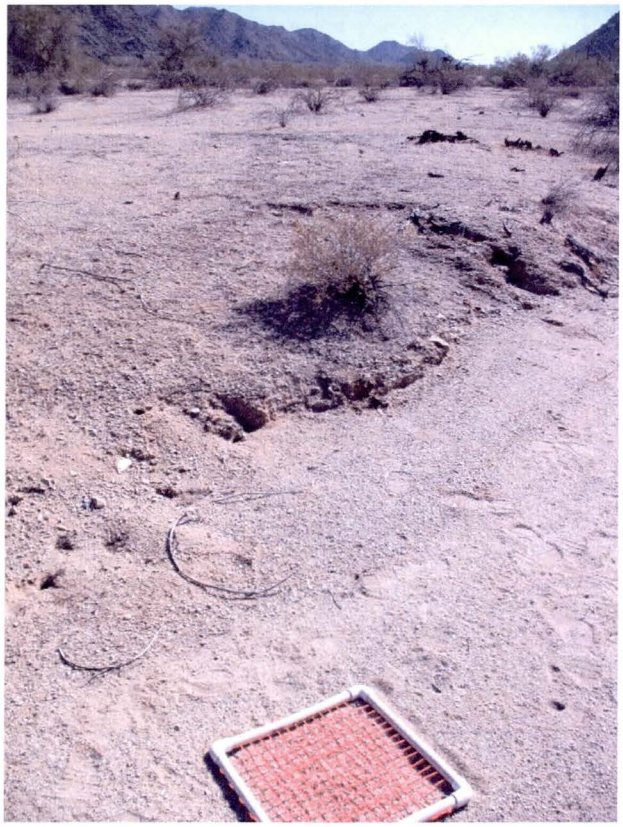


Figure 2.9, Photograph of Qi3 deposits

**Qi2** – Moderately dissected relict alluvial fan and terrace deposits; deposits consist of poorly sorted sand, pebbles, cobbles, and silt, with some small boulders and clay; gravel clasts on Qi2 surfaces are vary from darkly to lightly varnished; pavements vary from weak to moderately strong; surfaces are generally fairly smooth between incised drainages, which are up to about 10 ft deep; soil development is moderate, with visible calcium carbonate accumulation; Qi2 surfaces are typically lightly vegetated, with small trees along incised drainages and sparse creosote bushes on planar surfaces.

*Surface roughness: medium; vegetation generally small, low density; surfaces typically partially covered by gravel; smooth local topography*

*Infiltration potential: low.*

Figure 2.10, Photograph of Qi2 deposits

**Qi1** – Eroded relict alluvial fans; deposits consist of poorly sorted pebbles, cobbles, sand and silt, with some small boulders and clay; varnish on gravel clasts is variable, from darkly varnished to weakly varnished; pavements vary from weak to strong depending on preservation; surfaces are generally rounded, and planar remnants between incised drainages up to 30 ft deep; soil development is strong, with abundant calcium carbonate accumulation and some cementation; Qi1 surfaces are typically lightly vegetated, with small trees along incised drainages and sparse creosote bushes on rounded surfaces.

*Surface roughness: medium; vegetation generally small, low density; surfaces typically covered by gravel*

*Infiltration potential: low.*

Figure 2.11, Photograph of Qi1 deposits

**Qi** – Undifferentiated Pleistocene alluvial fan and terrace deposits;

**QTa** – Deeply dissected relict alluvial fans deposits; consist of moderately cohesive sand and gravel with no preservation of the original surface capping alluvial surface; soil development is variable as a result of erosion;

**Other units**

**Qtc** – Hillslope colluvium; designated only near bedrock hills.
**R** – Bedrock, undivided; this unit includes granitic rocks and metamorphic rocks such as gneiss; also includes areas covered by colluvium.
**D** – Disturbed ground.

**Table 2.4, Summary of Surficial Geologic Units**

| Symbol | Deposit Description | Acreage[1] | Relative Age |
|---|---|---|---|
| Qyc | Active channel deposits | 239.6 | Holocene |
| Qy3 | Smaller channel, bar, and low terrace deposits | 160.1 | Holocene |
| Qy2 | Deposits in low terraces and infrequently active drainage ways | 92.0 | Holocene |
| Qya | Laterally extensive young alluvial fan or sheet flood deposits | 819.0 | Holocene |
| Qy1 | Low to intermediate terrace and inactive alluvial fan deposits | 49.2 | Holocene |
| Qyd | Holocene to late Pleistocene debris flow deposits | 8.4 | Holocene |
| Qiy | Eroded or partially buried Qi surfaces and deposits | 259.8 | Pleistocene |
| Qi3 | Slightly to moderately dissected relict alluvial fan and terrace deposits | 92.9 | Pleistocene |
| Qi2 | Moderately dissected relict alluvial fan and terrace deposits | 1,925.5 | Pleistocene |
| Qi1 | Deeply dissected relict alluvial fans | 785.5 | Pleistocene |
| Qi | Undifferentiated Pleistocene alluvial fan and terrace deposits | 76.0 | Pleistocene |
| QTa | Deeply dissected, strongly cemented alluvial fan deposits | 121.8 | Pleistocene |
| Qtc | Hillslope talus and colluvium | 22.3 | |
| d | Disturbed ground | 29.1 | |
| R | Bedrock, undivided | 655.4 | |

[1]*Acreage is of Deposits within the Study Area Boundary*

### 2.3.2.3 Morphology

The morphology of the piedmont surface can be defined by topography, drainage patterns (tributary, distributary, bifurcations, radiating etc.), slope, and contour pattern. FEMA (FEMA, April 2003) defines the shape of alluvial fans as "landforms that have the shape of a fan either partly or fully extended" and that "modern and old flow paths radiate outward from the fan apex to the perimeter of the fan toe". As an aid in the characterization of the piedmont surface, NRCS's Geomorphic Position for soil units, descriptions of surficial geologic units, topographic data and aerial photography are used to identify key characteristics of alluvial fan landforms.

The Geomorphic Position of soil units within the study area are listed in Table 2.3. The Geomorphic Positions are landforms recognized by the NRCS in their soil surveys. Landforms identified in the study area are Floodplain, Alluvial Fans, Fan Terraces, Stream Terraces, and

Mountains. These landform classifications aid in the characterization of an Alluvial Fan. Figure 2.12 depicts soil units with an alluvial fan or fan terraces landform based on NRCS data.

Descriptions of surficial geologic units presented in the previous section include an alluvial fan landform designation for specific surficial geologic units. Figure 2.13 depicts the surficial geologic units that have an alluvial fan land form designation based on the Surficial Geology provided by AZGS.

Figure 2.14A depicts a combination of alluvial fan landforms determined by AZGS surficial geology and NRCS soil data. The figure shows that there is a strong correlation between the two mapping sets. All of the surficial geologic units with alluvial fan landform classifications with the exception of:

- Areas not mapped by AZGS because the ground surface has been disturbed by agricultural activity
- Areas along washes. These washes are pronounced as green ribbons of NRCS alluvial fan landforms nested within the blue AZGS Alluvial Fan Landforms. AZGS has classified the washes as active channel deposits, smaller channel, bar, and low terrace deposits and deposits in low terraces and infrequently active drainage ways. The AZGS's mapping effort is of greater detail than the NRCS's mapping effort and is the primary reason why the NRCS did not distinguish these areas as separate soil units. Given that these washes occur on alluvial fan landforms an arguments that they are part of the alluvial fan process could be made.
- In the eastern most portion of the study area NRCS Soil Unit 6 has a floodplain landform classification whereas AZGS has mapped the same area as alluvial fan or sheet flow deposits along with washes described in the bullet above. Again this difference is due to the greater level of mapping detail conducted by AZGS.

Figure 2.14B is a union of AZGS fan land forms and NRCS fan land forms.

Figure 2.15 depicts the topography of the piedmont. The topographic surface depicted in the figure shows the piedmont surface has a partially extended fan shape. The fan shape along the northern and southern boundaries are either truncated by mountain landforms, a trough (southern boundary away from mountain front) between coalescing fan shapes and an agricultural disturbed area (along the northern boundary located down slope from the mountains). Contour crenulations indicate that, in certain locations, channels that display radiating channel patterns are incised channels, whereas in other areas crenulations are not as well pronounced indicating poorly incised channels. Through the central part of piedmont contours are typically convex down slope. Contour alignments transition from convex down slope to convex up slope in the piedmont area closer to the Gila River. The slope across the piedmont is approximately 1.5 %. Many stream bifurcations can be inferred from the distribution of stream flow paths depicted in the figure. This indicates a distributary flow pattern.

Another data type used to determine drainage patterns and morphology is aerial photography. The distribution of vegetation and aerial photography color hues can be used to identify channel patterns. Figure 2.16 depicts aerial photography for the piedmont area. Review of the photo indicates a radiating drainage pattern, channels with bifurcations, and distributary flow patterns within the study area.

Stream bifurcation occurs in a drainage network when a single channel separate into two or more channels forming a distributary network. Figure 2.17 depicts on an aerial photo base the locations where stream bifurcations have been identified. Figure 2.18 depicts the stream channel network on an aerial photo base for the subject piedmont area. The figure depicts tributary and distributary patterns.

GILLESPIE AREA DRAINAGE
MASTER STUDY
F.C.D. CONTRACT NO. 2009C039

LEGEND

Study Area

NRCS Alluvial Fan Landform

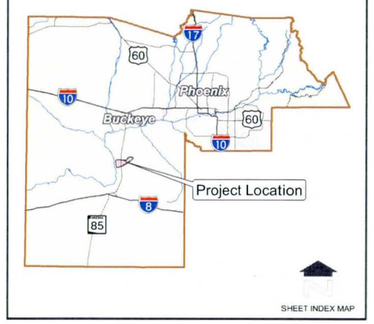
37 Soil Unit Identifier

NOTES

Aerial imagery flight date: October 2009

Soil or landform data source: NRCS Soil Survey Gila Bend - Ajo Area, Arizona. Parts of Maricopa and Pima Counties. 1997

*Maricopa County*

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***Flood Control District of Maricopa County***
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**Figure 2.12**
**Alluvial Fan Landforms NRCS Data**

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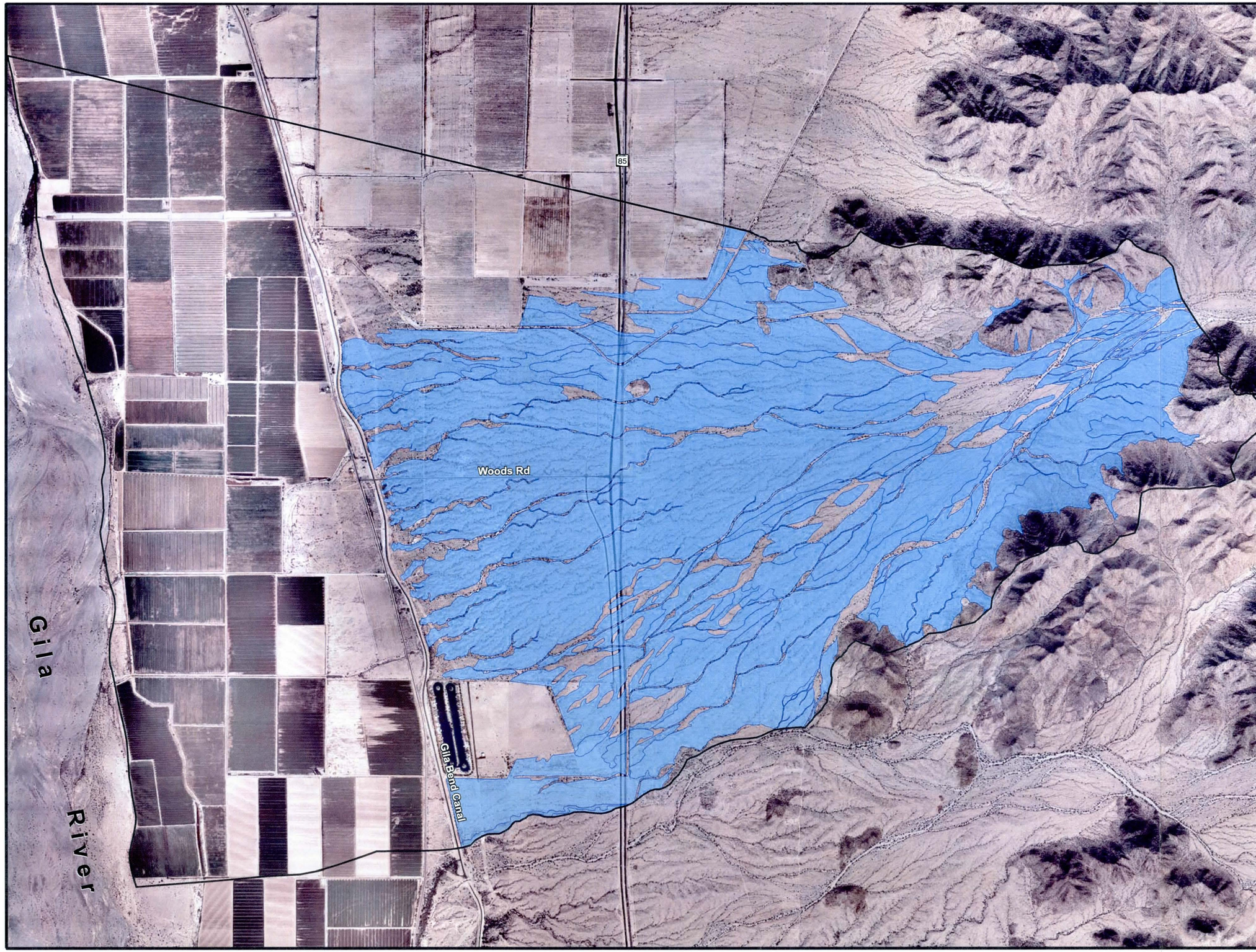
***Figure2-12_AF landforms & NRCS Data.mxd***




GILLESPIE AREA DRAINAGE
MASTER STUDY
F.C.D. CONTRACT NO. 2009C039

LEGEND

Study Area

AZGS Alluvial Fan Landform

NOTES

Aerial imagery flight date: October 2009

Soil or landform data source:
AZGS OFR-12-07/DGM-75, 2012

*Maricopa County*

SHEET INDEX MAP

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***2801 W. Durango St. Phoenix, AZ 85009***

**Figure 2.13**
**Alluvial Fan Landforms AZGS Data**

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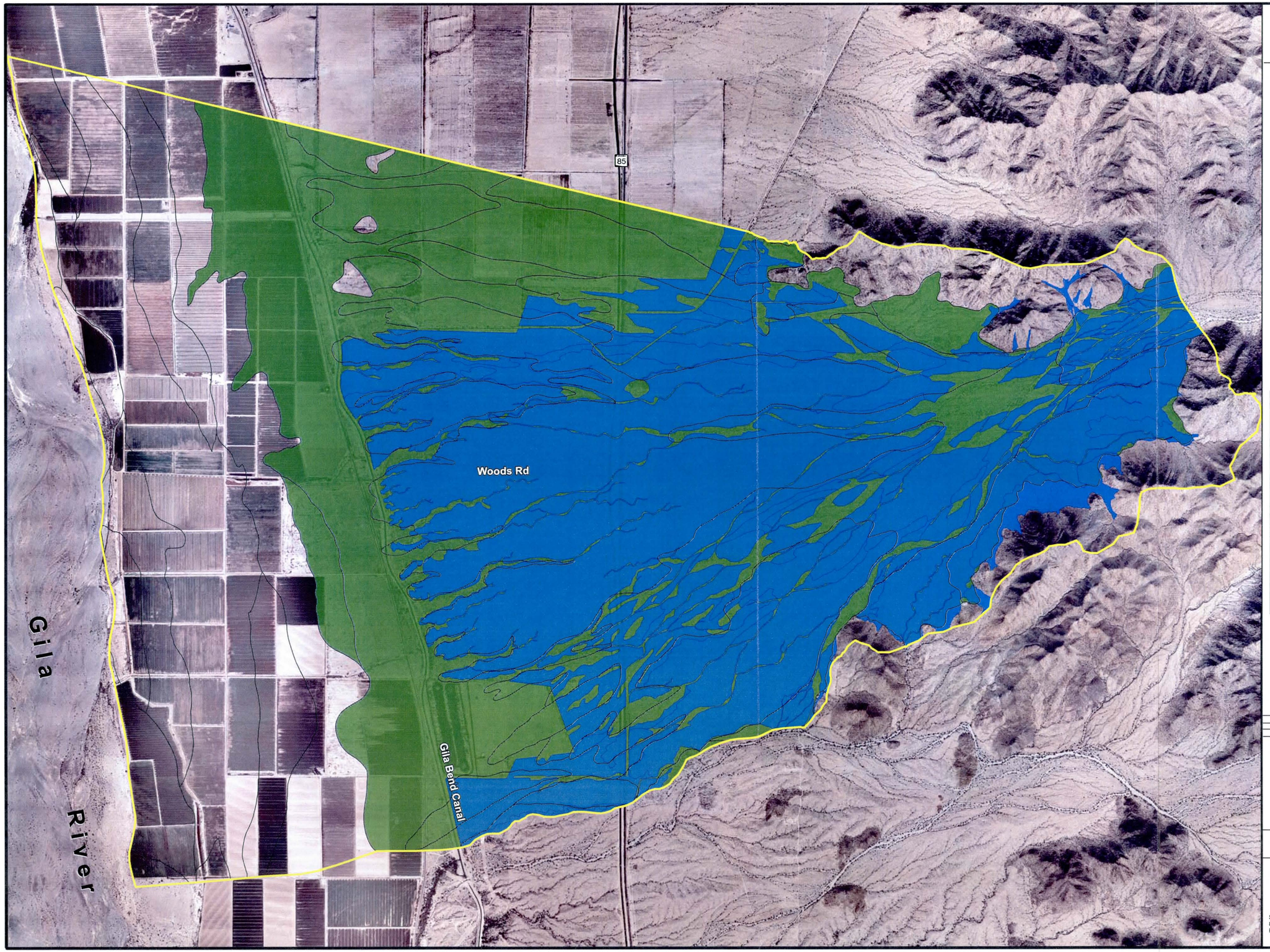
***Figure2-13_AF landforms & AGS Data.mxd***




GILLESPIE AREA DRAINAGE
MASTER STUDY
F.C.D. CONTRACT NO. 2009C039

LEGEND

- Study Area
- NRCS Alluvial Fan Landform
- AZGS Alluvial Fan Landform

NOTES

Aerial imagery flight date: October 2009

Soil or landform data sources:
AZGS OFR-12-07/DGM-75, 2012
&
NRCS Soil Survey, Gila Bend - Ajo Area, Arizona. Parts of Maricopa and Pima Counties. 1997

*Maricopa County*

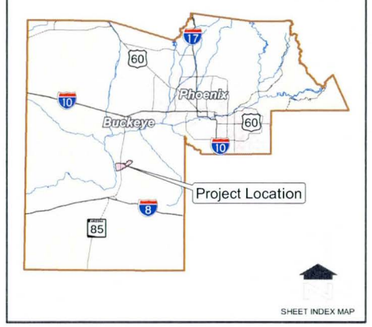



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**Figure 2.14A**
**Alluvial Fan Landforms, AZGS & NRCS Data**

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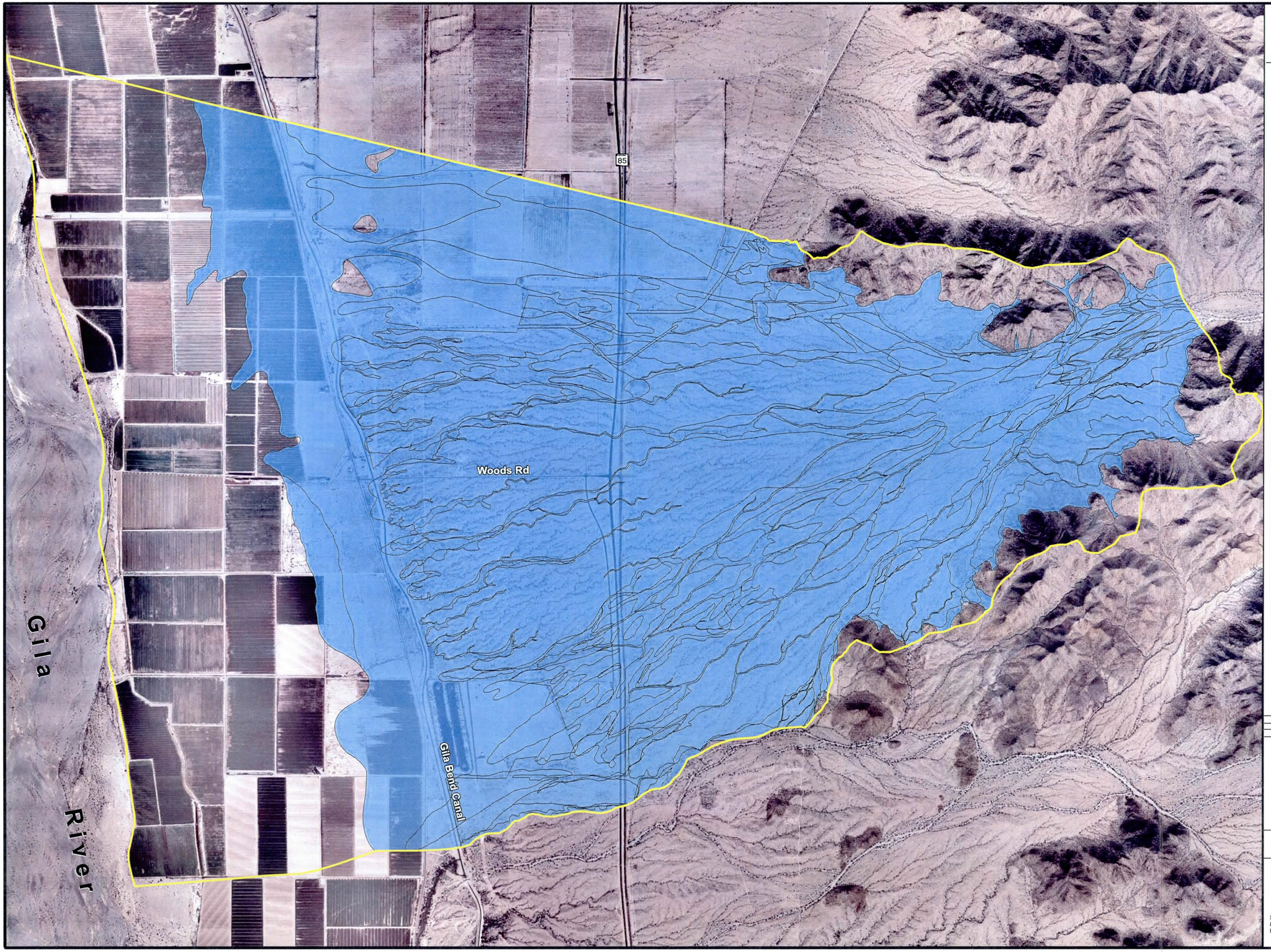
*Figure2-14_AF landforms AGS & NRCS Data.mxd*




GILLESPIE AREA DRAINAGE
MASTER STUDY
F.C.D. CONTRACT NO. 2009C039

LEGEND

Study Area

Union of AZGS and NRCS Fan Land Forms

NOTES

Aerial imagery flight date: October 2009

Soil or landform data sources:
AZGS OFR-12-07/DGM-75, 2012
&
NRCS Soil Survey, Gila Bend - Ajo Area, Arizona. Parts of Maricopa and Pima Counties. 1997

*Maricopa County*

SHEET INDEX MAP

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**Figure 2.14B**
**Union of AZGS Fan Land Forms and NRCS Fan Land Forms**

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***Figure2-14_AF landforms AGS & NRCS Data.mxd***

GILLESPIE AREA DRAINAGE
MASTER STUDY
F.C.D. CONTRACT NO. 2009C039

LEGEND

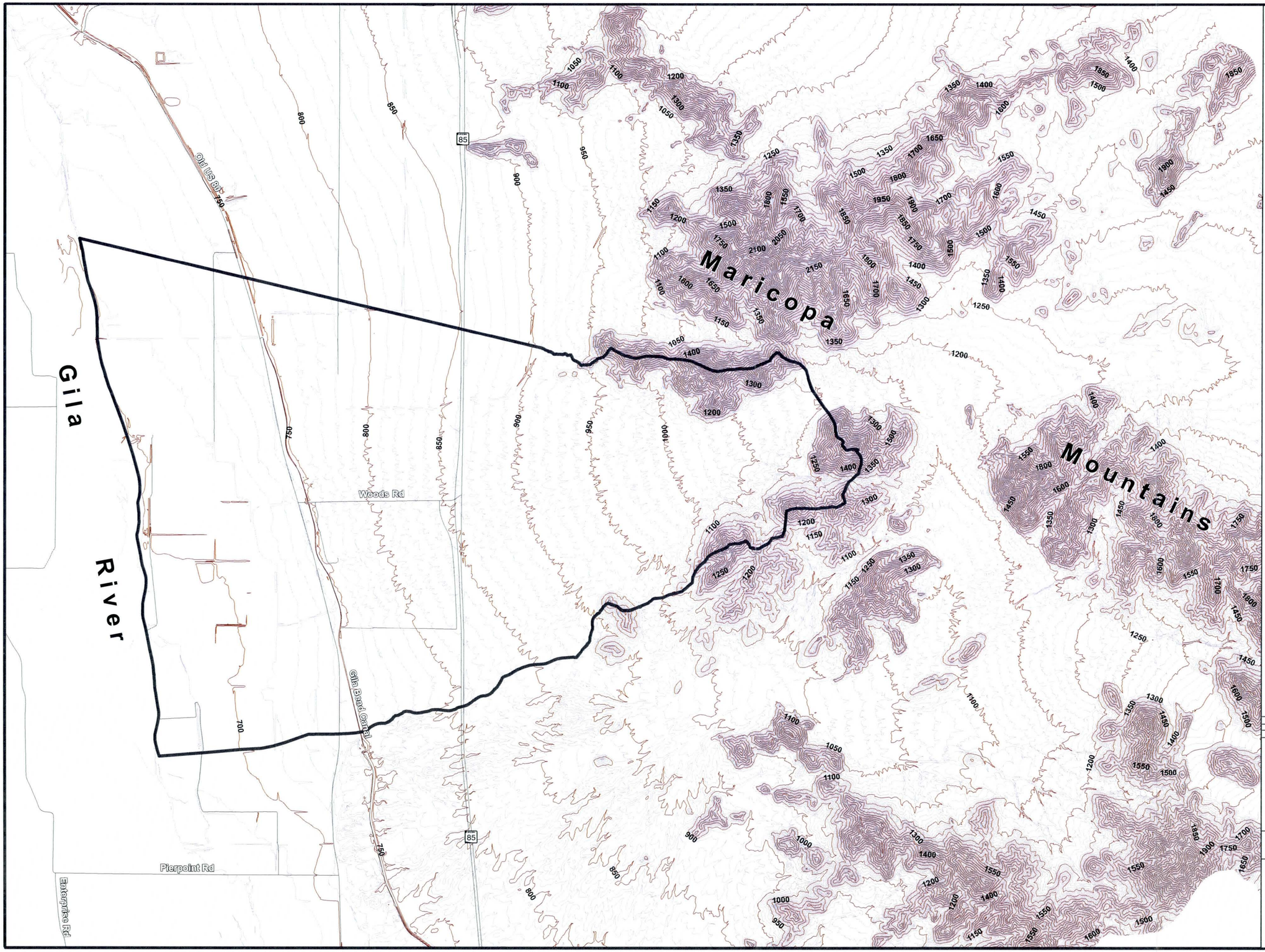
Study Area

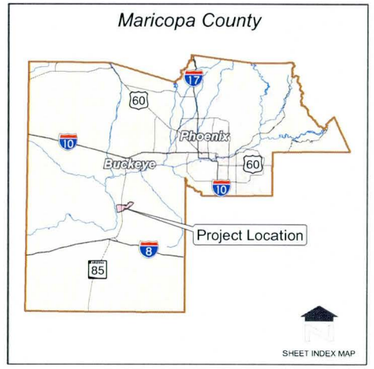
Index (50') Contours

Intermediate (10') Contours

NOTES

Contour information provided by the Flood Control District of Maricopa County. 10 foot contour interval.

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Flood Control District of Maricopa County
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**Figure 2.15**
**10-foot Topographic Mapping**

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*Figure2-15_TOPO_Map.mxd*

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MASTER STUDY
F.C.D. CONTRACT NO. 2009C039

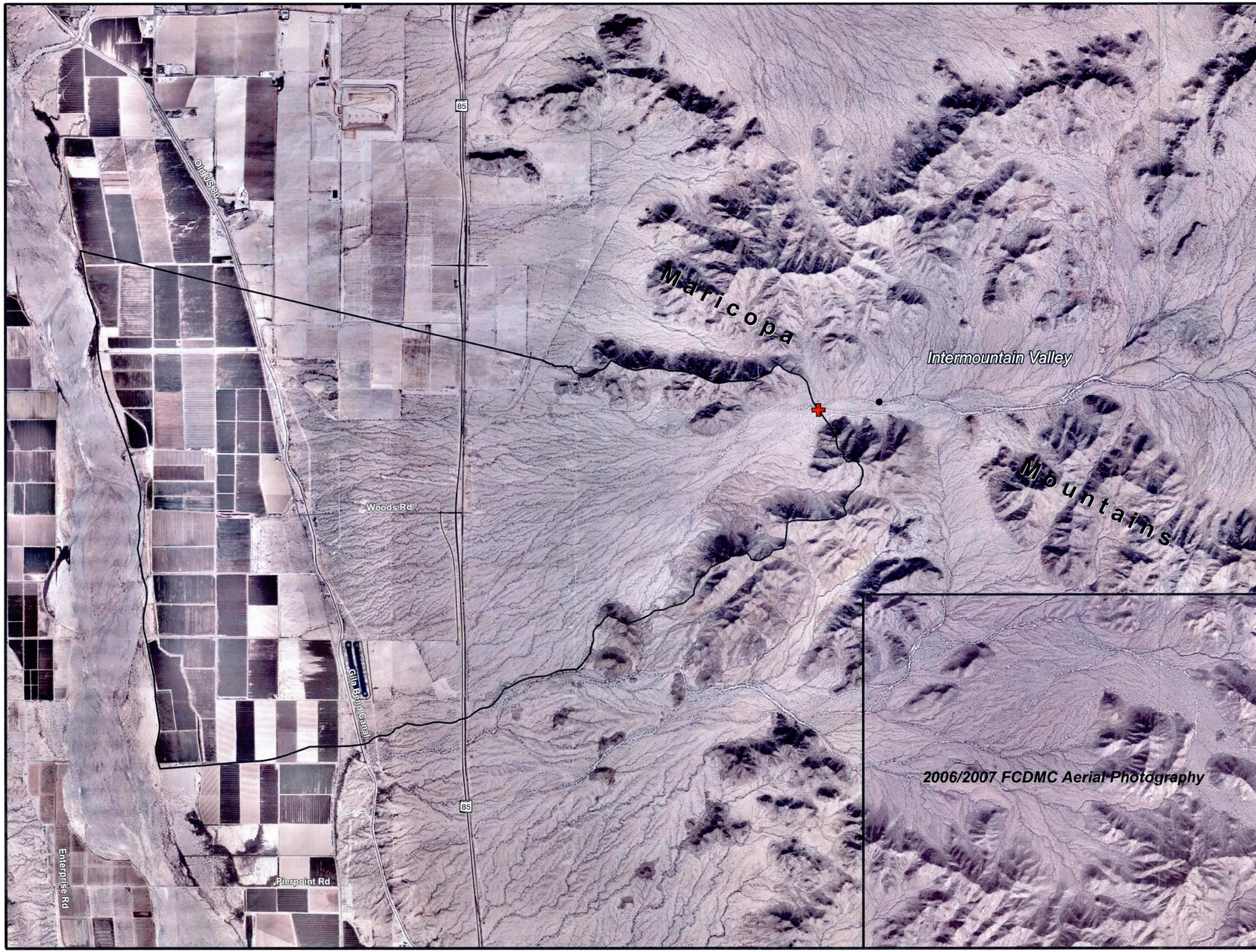
LEGEND

Topographic Apex Location

Study Area

NOTES

Aerial imagery flight dates Oct 2009 and Nov 2006



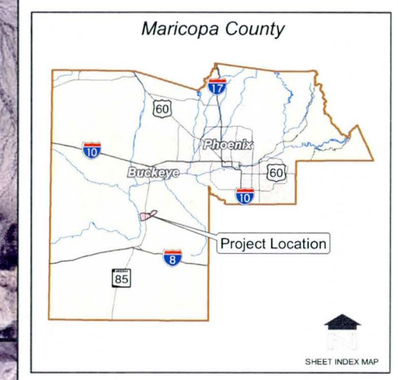




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**Figure 2.16**
**2009/2010 Aerial Photography**

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OF MARICOPA COUNTY

Figure2-16_09_10_Aerials.mxd

GILLESPIE AREA DRAINAGE
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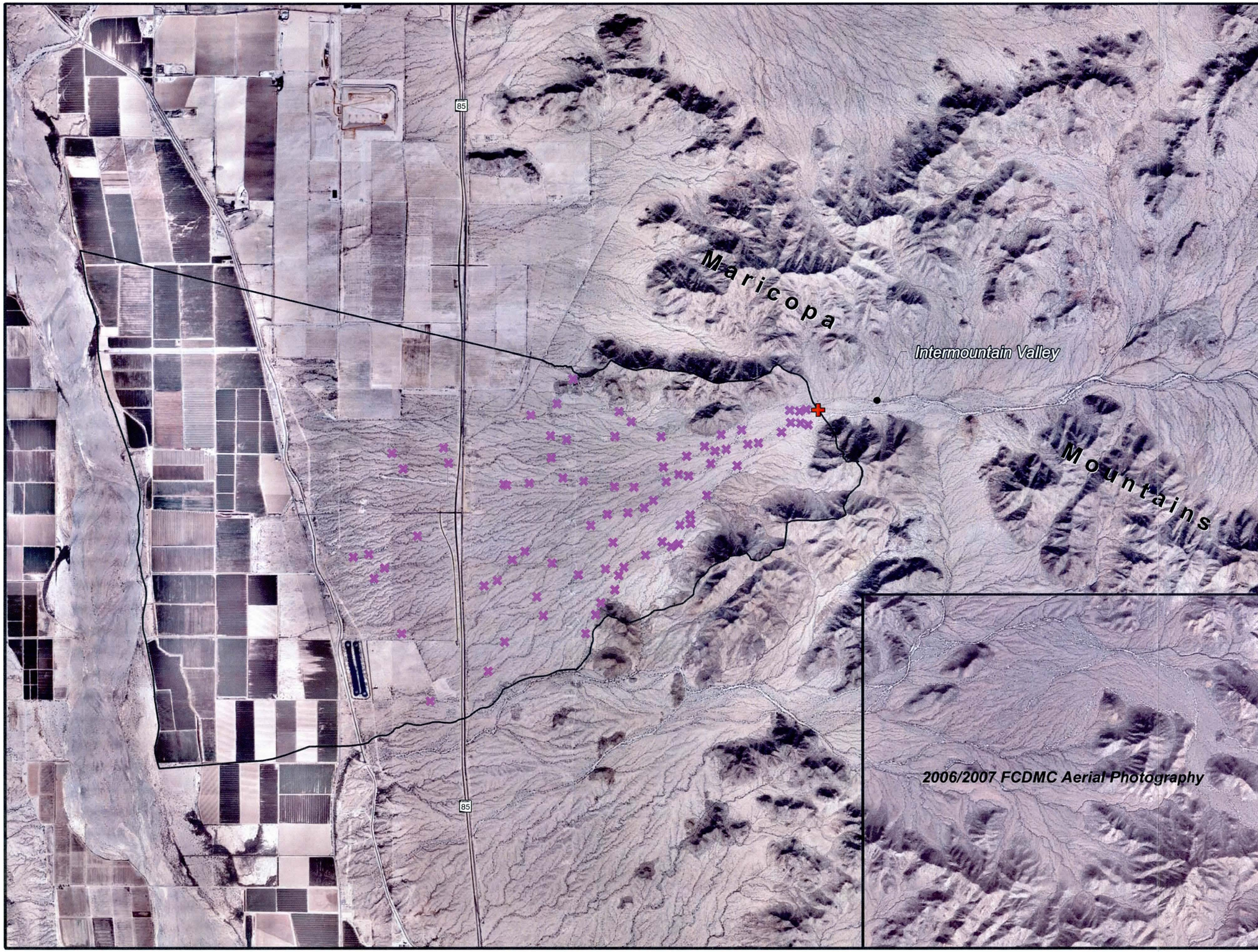
F.C.D. CONTRACT NO. 2009C039

LEGEND

- Topographic Apex Location
- Bifurcation Point
- Study Area

NOTES

Aerial imagery flight dates Oct 2009 and Nov 2006



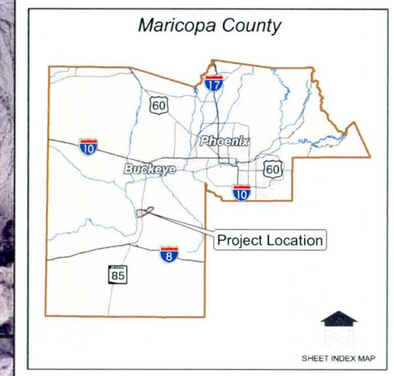




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**Figure 2.17**
**Channel Bifurcation Points**

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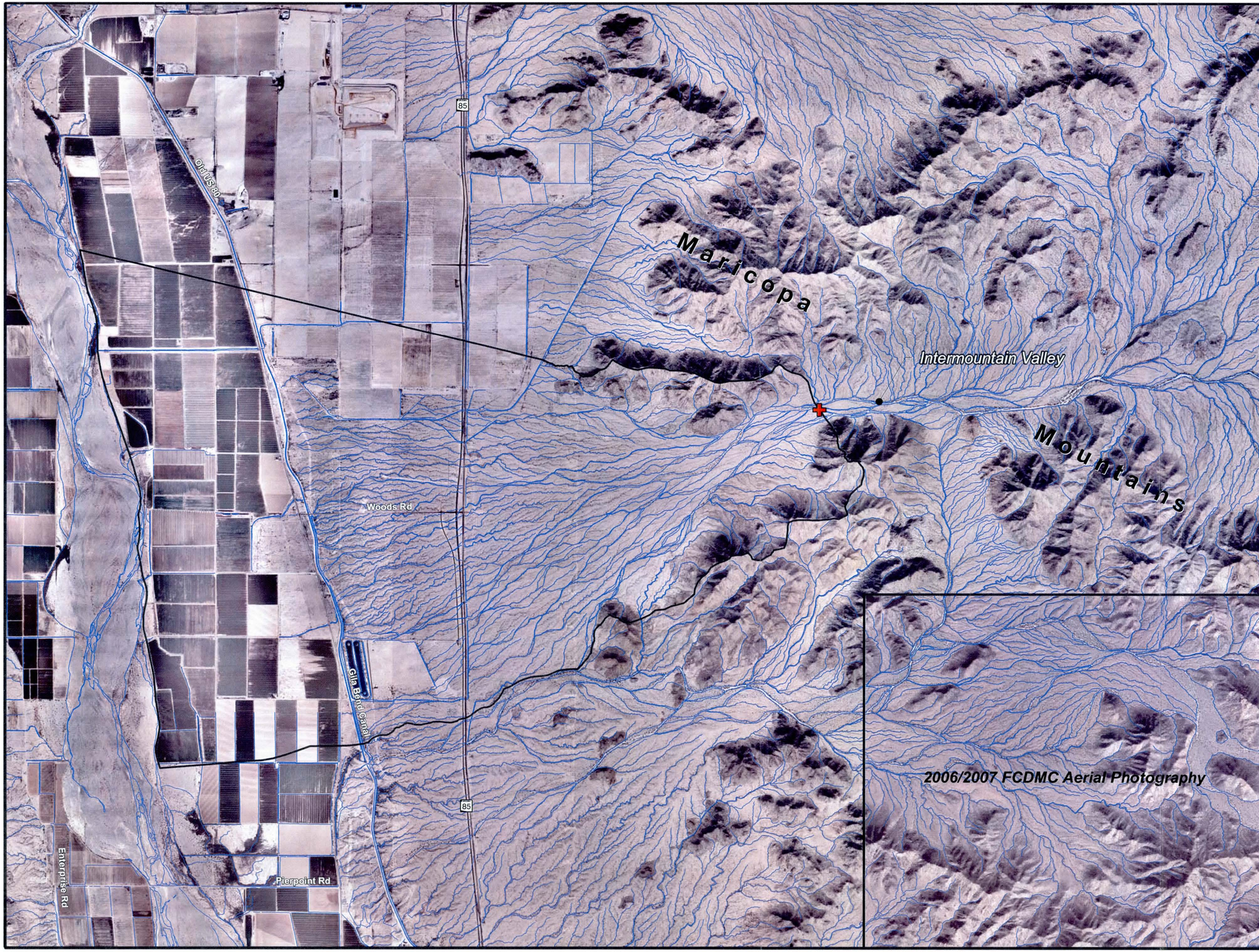
Figure2-17_Bifurcation.mxd




GILLESPIE AREA DRAINAGE
MASTER STUDY
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LEGEND

- Topographic Apex Location
- Stream Channel Network
- Study Area

NOTES

Aerial imagery flight date Oct 2009 and Nov 2006

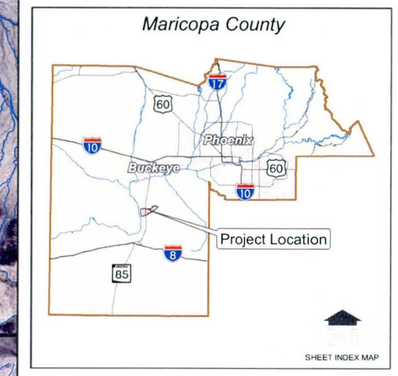


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**Figure 2.18**
**Stream Channel Networks**

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OF MARICOPA COUNTY

*Figure2-18_Stream_Channel_Networks.mxd*

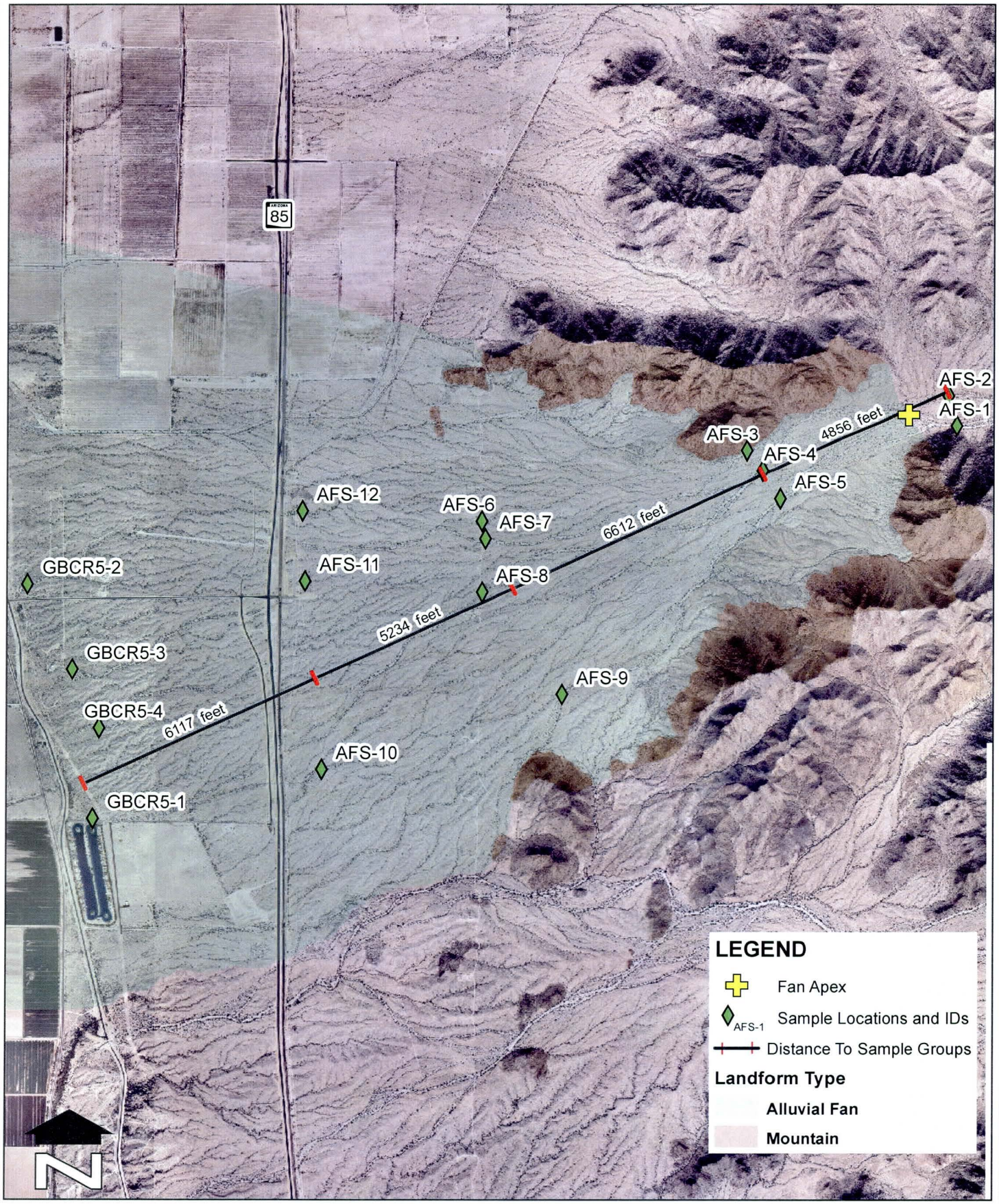
#### *2.3.2.3.1 Sediment Samples*

Sediment samples were obtained within washes that bisect the alluvial fan landform to determine the grain size distribution of the bed load material. Figure 2-19 depicts sediment sample locations. Table 2.5 lists the results of sieve analyses for each of the collected samples and presents the $D_{50}$ grain size. A plot of the average $D_{50}$ size for five sample groupings is presented in Figure 2.20. Grouping of samples are based on the location of samples. Table 2.6 list the Sample Group number and the Samples included in each group.

#### *2.3.2.3.2 Transverse Cross Sections and Longitudinal Profiles*

Transverse cross section and longitude profiles of the subject alluvial fan landform were developed to document the physical shape of the landform and to determine if the landform manifested alluvial fan landform characteristics. Topographic mapping with a 2-foot contour interval was used to develop the transverse cross sections and longitudinal and landform profiles. Figure 2.21 depicts the location of transverse cross sections, a longitudinal profile (following invert of a channel) and a landform profile (straight profile across the landform). Figure 2.22 through Figure 2.26 depicts five transverse cross sections (looking downstream). In cross section view perched channels are manifested by a U or V shapes along the cross section. All transverse cross sections display evidence of perched channels. Transverse Cross Sections 2 through 5 have a very pronounced convex upward shape. Transverse Cross Section 1 has a slight convex upward shape. Cross Section 1 is located immediately downstream of the topographic and hydrographic apexes. Figure 2.27 depicts a straight landform profile across the alluvial fan landform. Figure 2.28 depicts a longitudinal profile (following the invert of a prominent channel from the topographic apex to the toe of the alluvial fan as defined by NRCS landform data. The Landform Profile (Figure 2.27) shows a slight concave upwards shape near the toe of the profile. The Longitudinal Profile (Figure 2.28) does not show the same concave upwards shape near the toe. This is because the profile ended on the alluvial fan landform, if it was extended in to the floodplain landform (depicted as Riverine on Figure 2.21) of the Gila River a concave upwards shape would be realized.

Observations made from the topographic and aerial photography data sets, transverse cross-sections and longitudinal profiles concerning the morphology of the piedmont surface are consistent with key alluvial fan landform characteristics identified in the FEMA Appendix G document.




| | | | |
|---|---|---|---|
| FLOOD CONTROL DISTRICT OF MARICOPA COUNTY | | **Figure 2.19**<br>**Sediment Sample Locations** | GILLESPIE ADMS<br>F.C.D. CONTRACT NO. 2009C039 |
| DATE: | 03/23/2013 | | Stantec<br>Stantec Consulting Inc<br>8211 S. 48th Street<br>Phoenix, AZ U.S.A. 85044 |
| SCALE: | N.T.S. | | |
| DRAWN BY: | AML | | |

## Table 2.5, Sieve Analyses Results

| Sieve | Opening (mm) | Sieve Opening (inch) | AFS-1 (%) | AFS-2 (%) | AFS-3 (%) | AFS-4 (%) | AFS-5 (%) | AFS-6 (%) | AFS-7 (%) | AFS-8 (%) | AFS-9 (%) | AFS-10 (%) | AFS-11 (%) | AFS-12 (%) | GBCR5-1 (%) | GBCR5-2 (%) | GBCR5-3 (%) | GBCR5-4 (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #200 | 0.075 | 0.003 | 2.4 | 2.5 | 2 | 2.5 | 1.8 | 2.5 | 4 | 2.4 | 2.8 | 1.5 | 1.8 | 2.1 | 3 | 2.1 | 4 | 3.5 |
| #100 | 0.149 | 0.006 | 6 | 4 | 4 | 4 | 3 | 5 | 7 | 5 | 4 | 4 | 3 | 3 | 6 | 5 | 6 | 5 |
| #50 | 0.297 | 0.012 | 16 | 7 | 8 | 9 | 6 | 12 | 14 | 13 | 8 | 8 | 8 | 9 | 13 | 12 | 13 | 10 |
| #40 | 0.42 | 0.017 | 25 | 10 | 14 | 14 | 8 | 19 | 18 | 20 | 11 | 12 | 12 | 15 | 18 | 18 | 19 | 15 |
| #30 | 0.595 | 0.023 | 36 | 15 | 21 | 19 | 11 | 25 | 21 | 29 | 15 | 15 | 16 | 20 | 25 | 23 | 25 | 20 |
| #16 | 1.18 | 0.05 | 57 | 32 | 45 | 37 | 18 | 42 | 30 | 47 | 25 | 27 | 30 | 35 | 41 | 37 | 42 | 33 |
| #10 | 2 | 0.08 | 77 | 52 | 67 | 59 | 29 | 58 | 42 | 64 | 40 | 46 | 45 | 55 | 59 | 53 | 60 | 50 |
| #8 | 2.36 | 0.09 | 85 | 59 | 74 | 66 | 34 | 64 | 47 | 70 | 47 | 55 | 52 | 62 | 66 | 60 | 66 | 57 |
| #4 | 4.75 | 0.19 | 99 | 83 | 93 | 89 | 61 | 87 | 78 | 90 | 82 | 90 | 82 | 89 | 92 | 86 | 90 | 83 |
| | 6.35 | 0.25 | 99 | 89 | 96 | 93 | 70 | 93 | 88 | 95 | 90 | 96 | 91 | 93 | 97 | 91 | 95 | 89 |
| | 9.52 | 0.375 | 99 | 97 | 99 | 97 | 85 | 98 | 97 | 99 | 97 | 100 | 97 | 98 | 99 | 95 | 99 | 97 |
| | 12.70 | 0.5 | 100 | 99 | 100 | 98 | 93 | 99 | 99 | 100 | 99 | 100 | 99 | 100 | 100 | 96 | 100 | 99 |
| | 19.05 | 0.75 | 100 | 100 | 100 | 99 | 98 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 96 | 100 | 100 |
| | 25.40 | 1 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | 31.75 | 1.25 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | 38.10 | 1.5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | 50.80 | 2 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | 76.20 | 3 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | 101.60 | 4 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | 152.39 | 6 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| | | $D_{50\ (mm)}$ | 0.985 | 1.92 | 1.37 | 1.6645 | 3.78 | 1.59 | 2.59 | 1.32 | 2.56 | 2.16 | 2.26 | 1.80 | 1.59 | 1.85 | 1.54 | 2.00 |

*Note: All sediment samples were collected from washes for bed material load modeling purposes*

Figure 2.20, Sediment Sample Groups, Average D50 from Upstream to Downstream

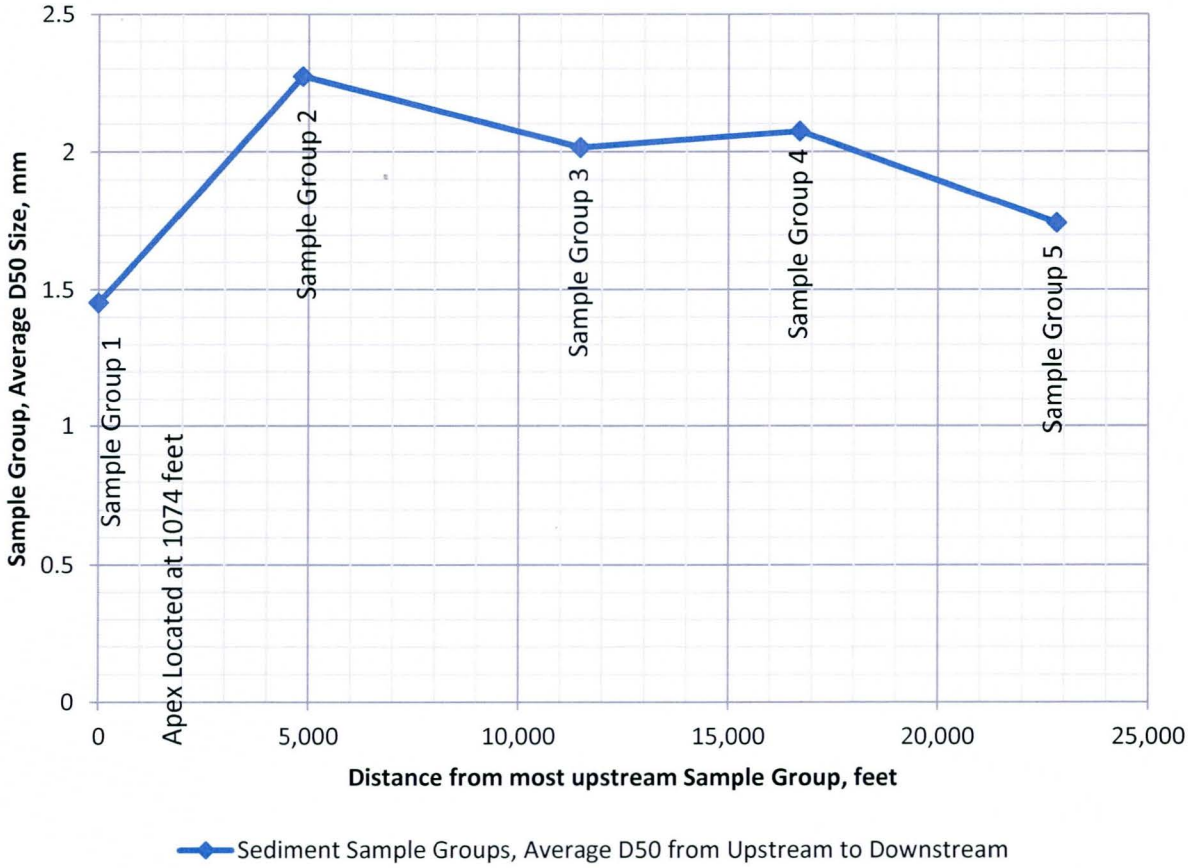



**Table 2.6,**
**Sediment Sample Groupings**

| | Sediment Sample Groups | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| **Samples Included in a Group** | AFS-1<br>AFS-2 | AFS-3<br>AFS-4<br>AFS-5 | AFS-6<br>AFS-7<br>AFS-8<br>AFS-9 | AFS 10<br>AFS 11<br>AFS 12 | GBCR5-1<br>GBCR5-2<br>GBCR5-3<br>GBCR5-4 |
| **Average $D_{50}$ Size (mm)** | 1.45 | 2.27 | 2.02 | 2.07 | 1.75 |

GILLESPIE AREA DRAINAGE
MASTER STUDY
F.C.D. CONTRACT NO. 2009C039

LEGEND

**Profile Type**

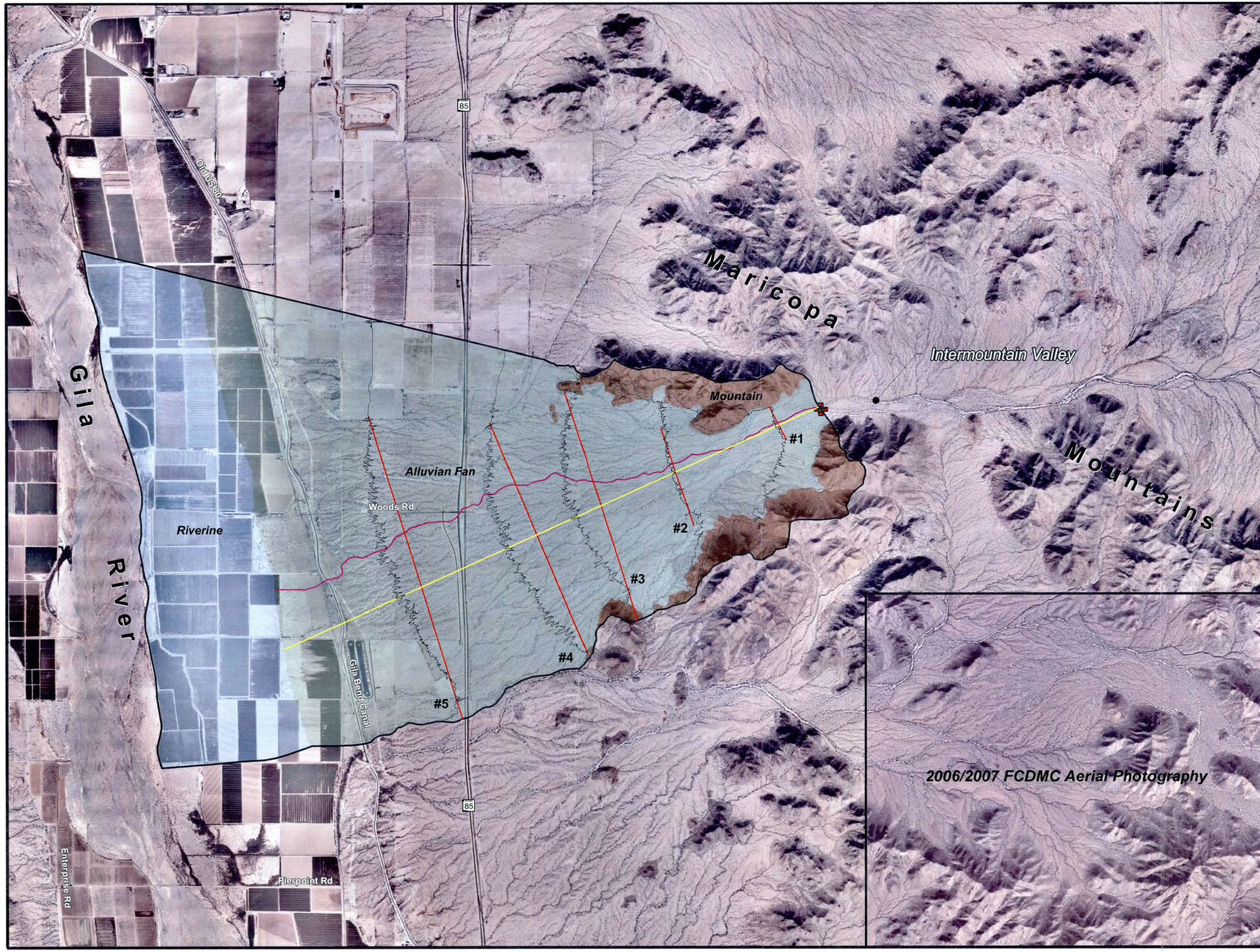
- Landform
- Longitudinal
- #1 Transverse Cross Sections w/ ID
- Select Contours
- Study Area
- Topographic Apex Location
- Hydrographic Apex Location

**Landform Type**

- Alluvial Fan
- Riverine
- Mountain

NOTES

Aerial imagery flight dates Oct 2009 and Nov 2006




*Maricopa County*

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**Figure 2.21**
**Profiles and Transverse Cross Sections Locations**

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*Figure2-21_MM_Profiles.mxd*

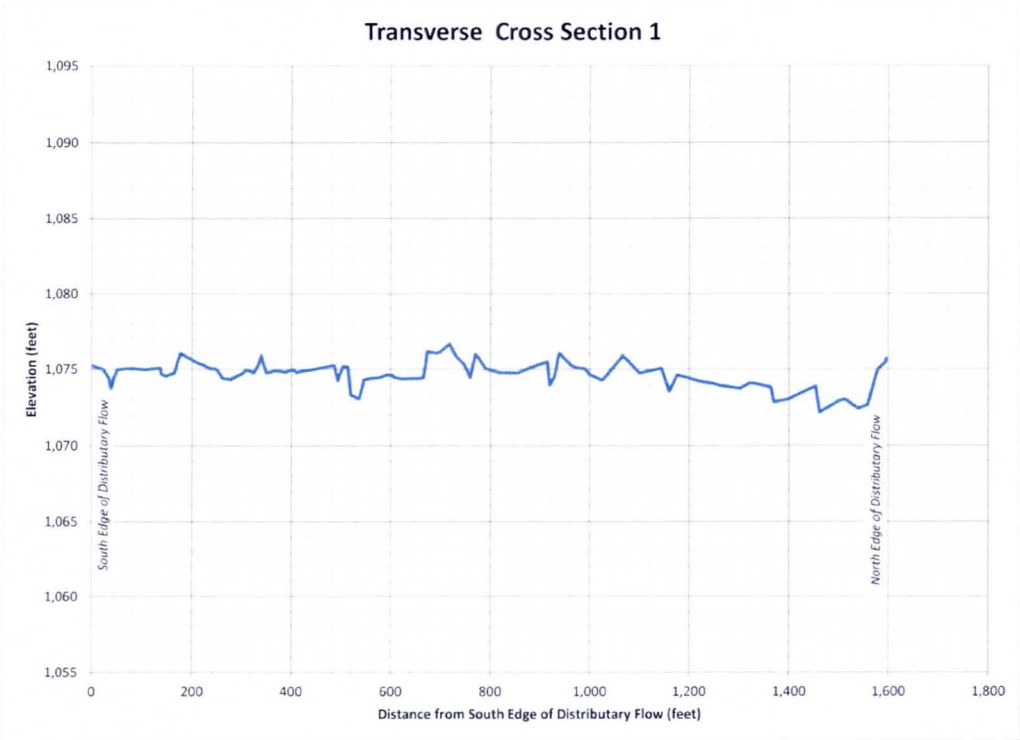



Figure 2.22, Transverse Cross Section 1

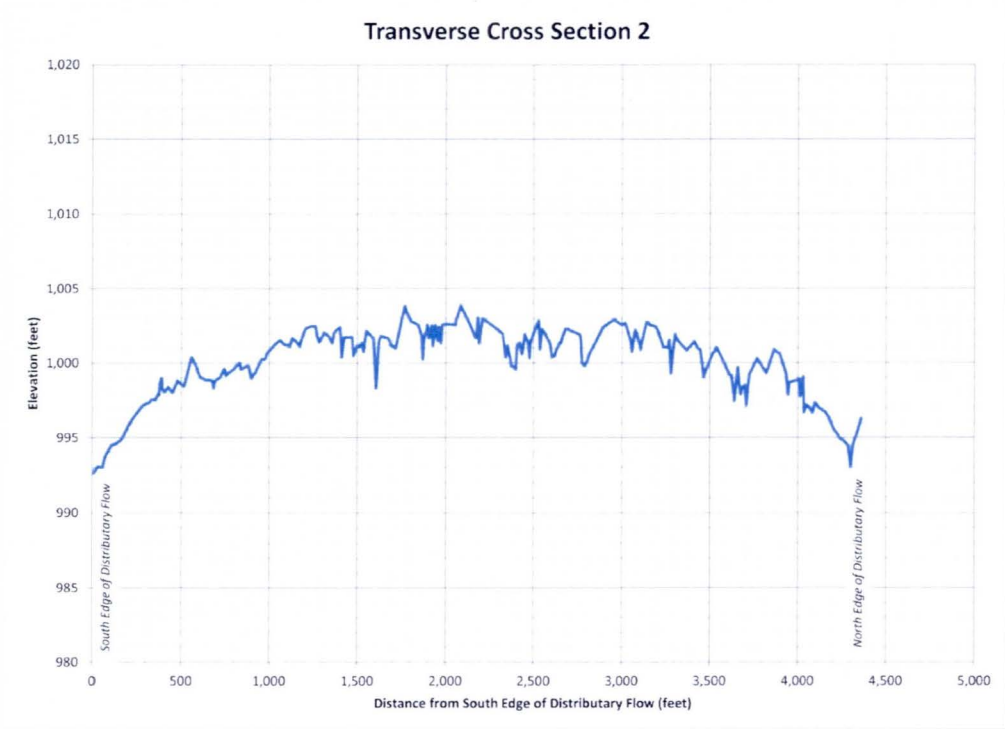



Figure 2.23, Transverse Cross Section 2

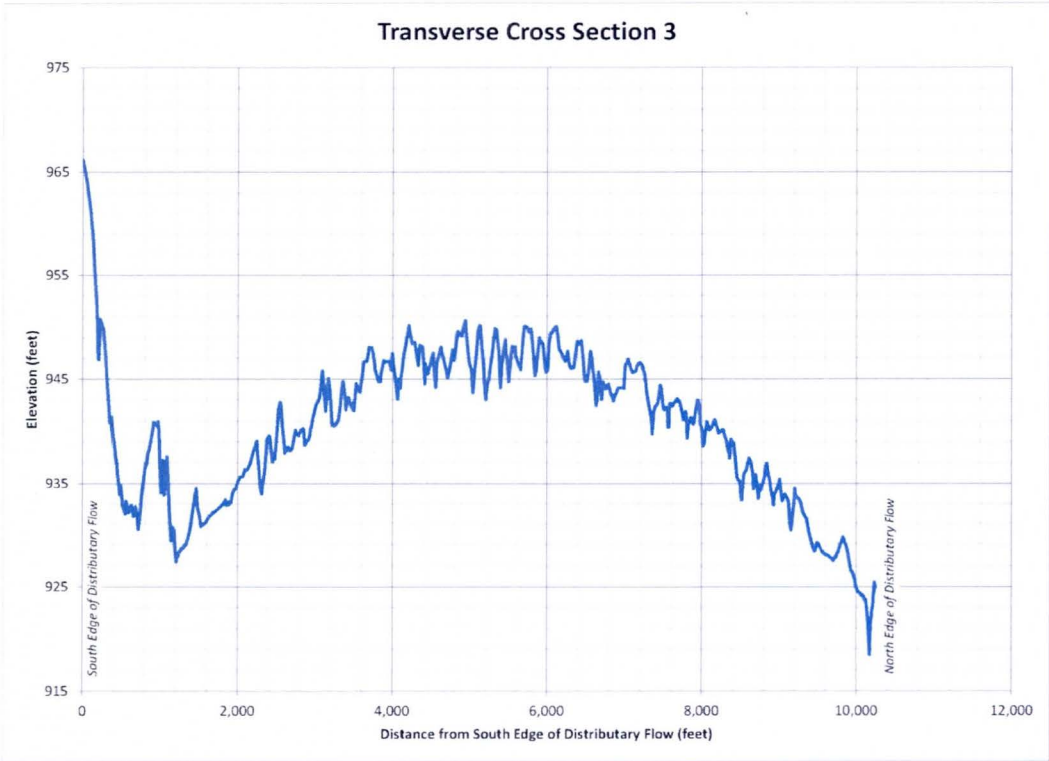



Figure 2.24, Transverse Cross Section 3

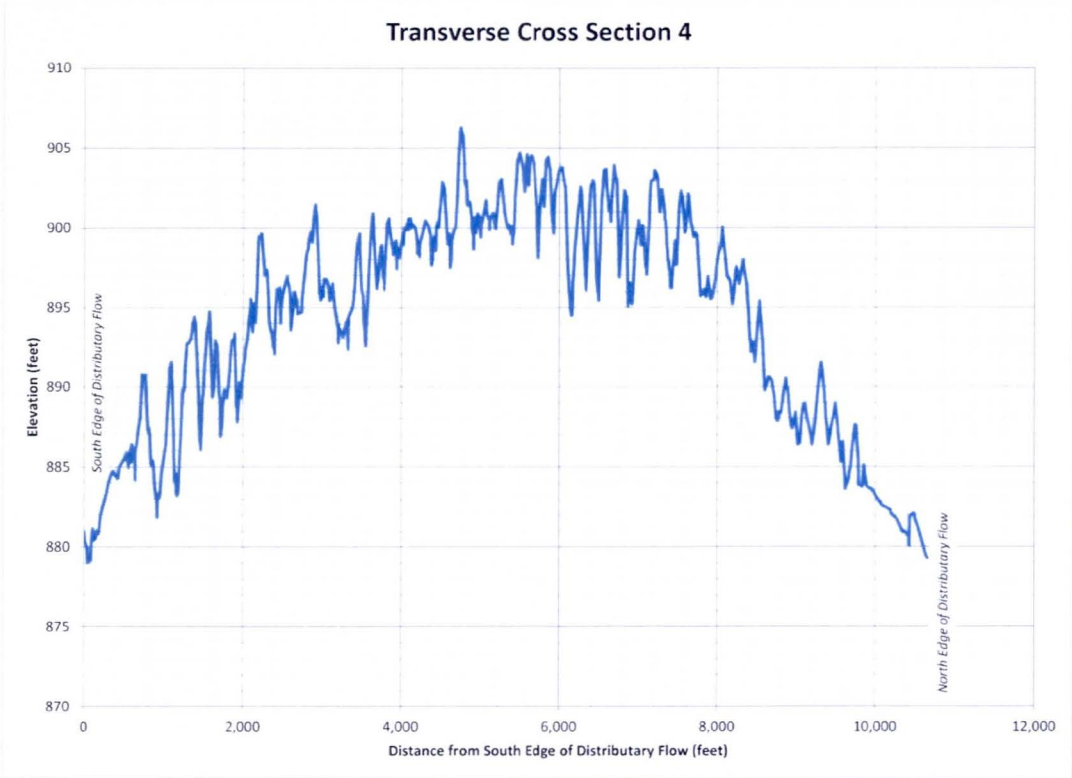



Figure 2.25, Transverse Cross Section 4

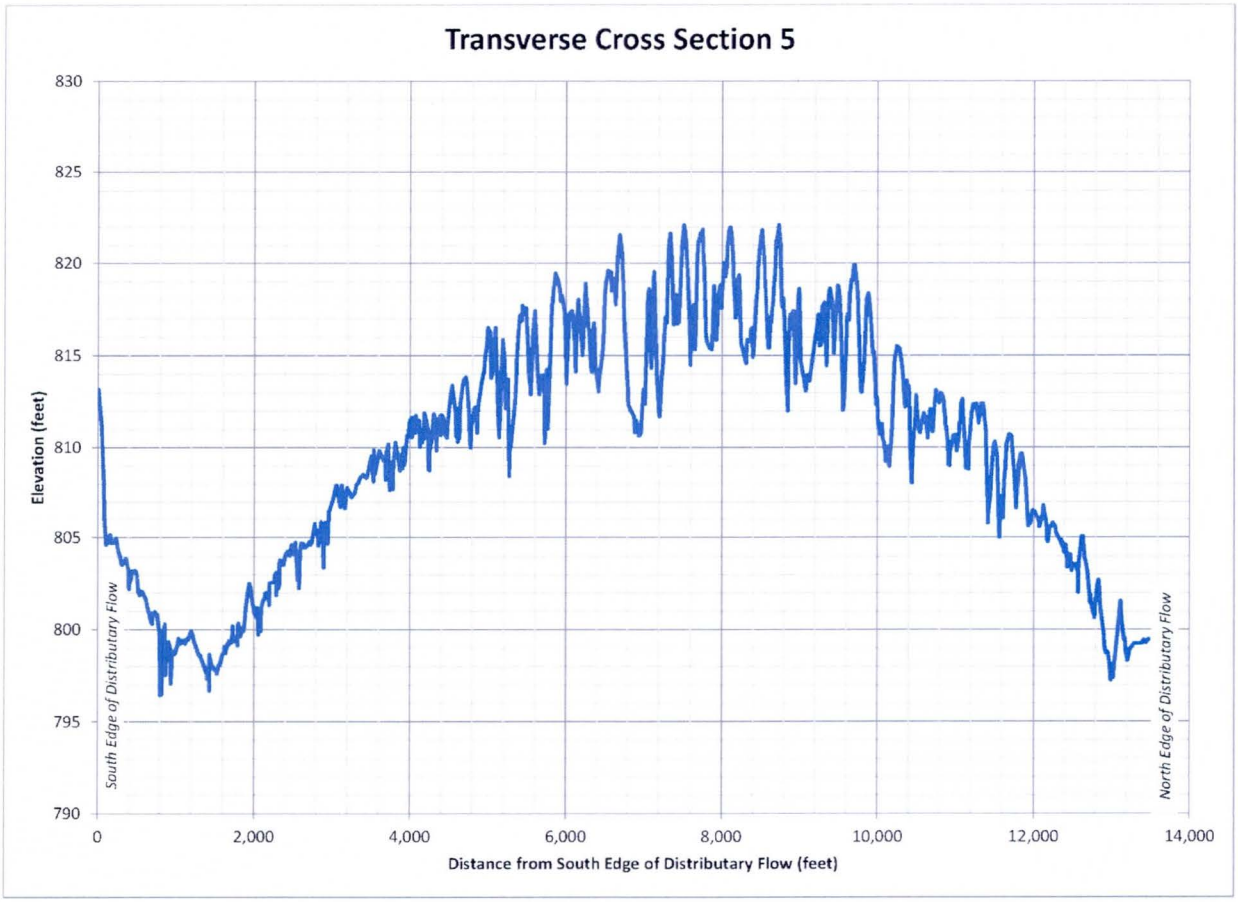



Figure 2.26, Transverse Cross Section 5

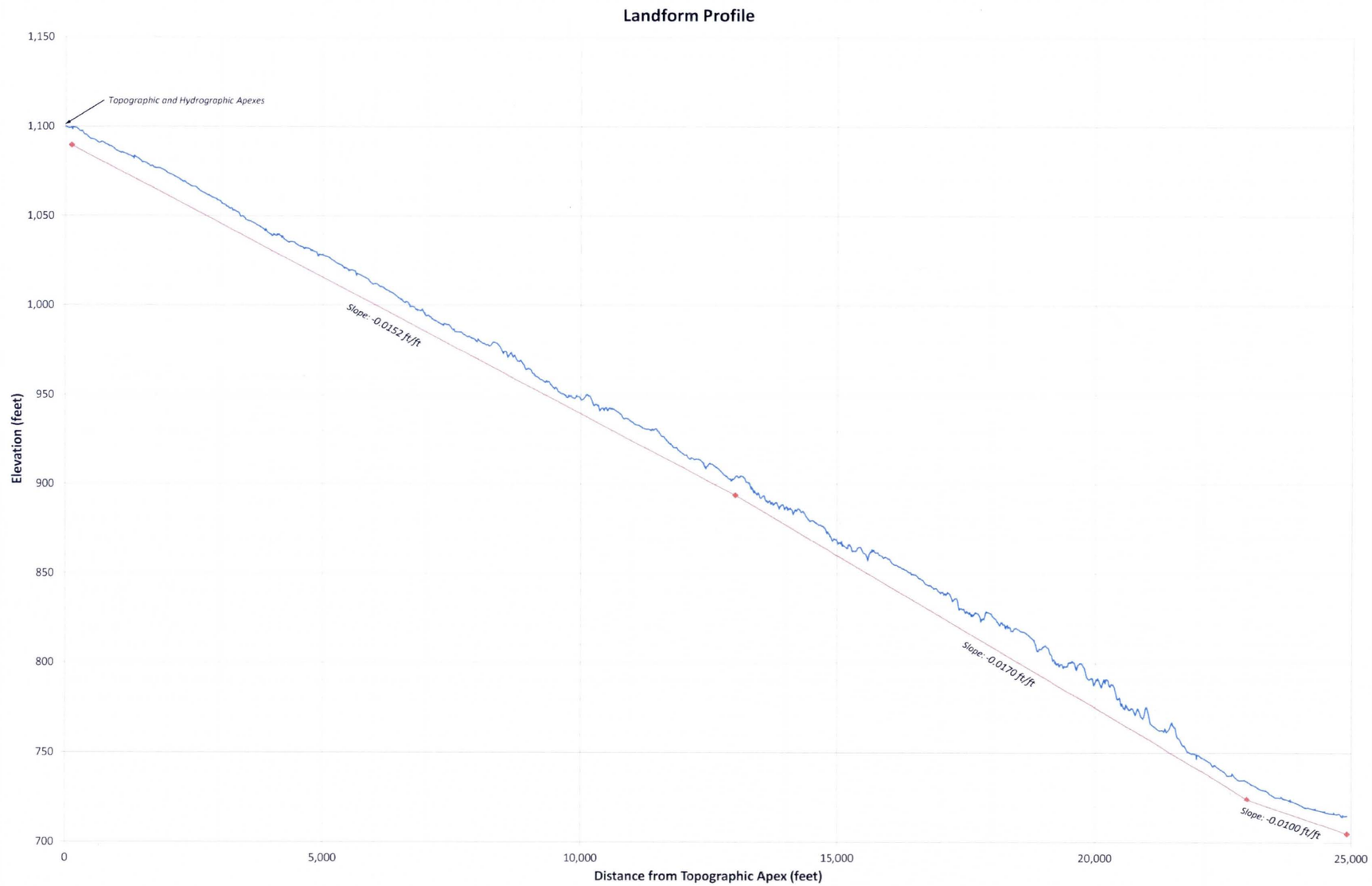



Figure 2.27, Landform Longitudinal Profile

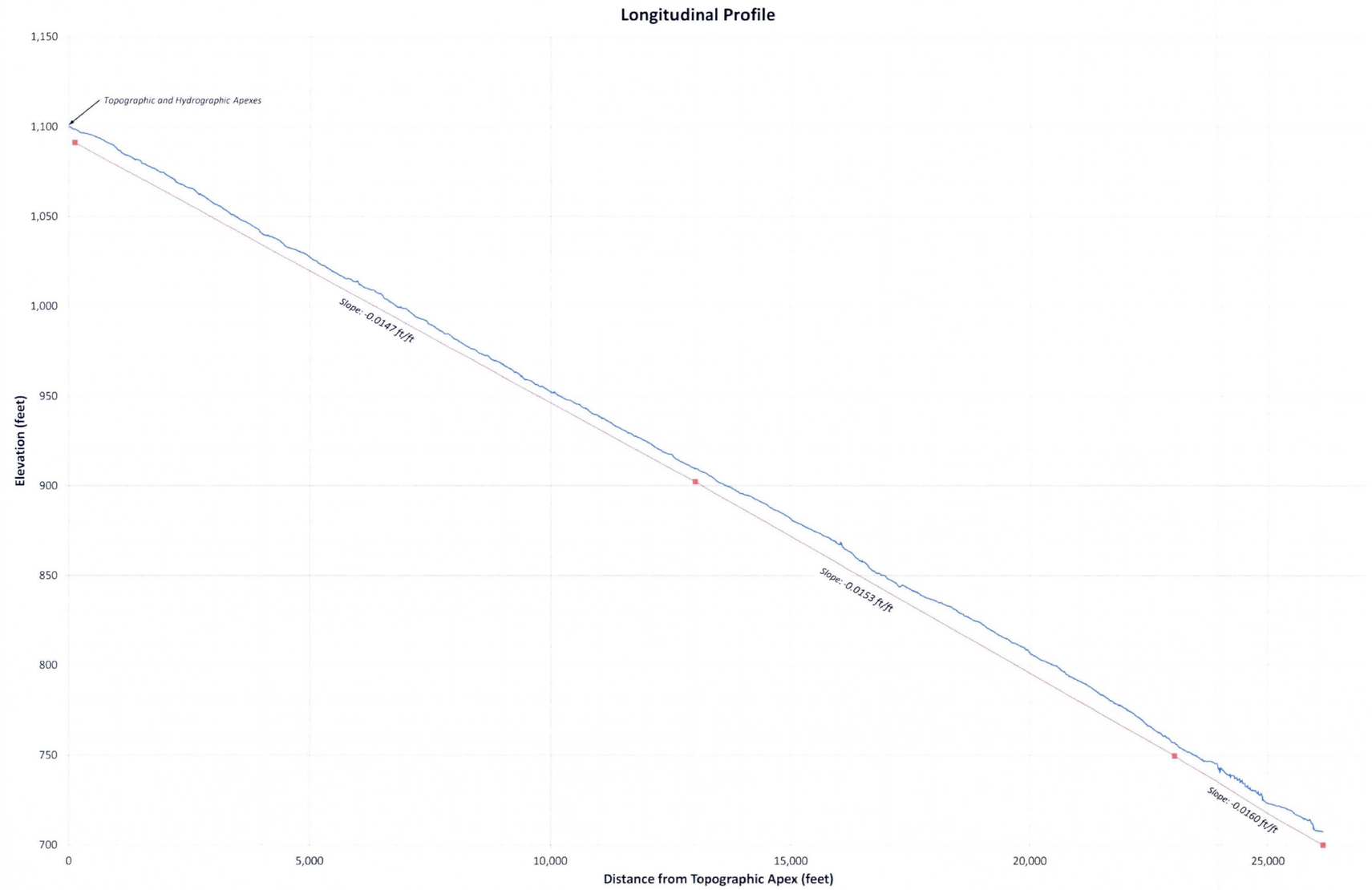



Figure 2.28, Longitudinal Profile along major flow path

### 2.3.3 Location

FEMA Appendix G defines an alluvial fan as a landform located at the topographic break where long term channel migration and sediment accumulation become markedly less confined than upstream of the break. Key elements of the alluvial fan landform are the location of the topographic and hydrographic apex locations. The extreme upstream extent of the alluvial fan landform is referred to as the topographic apex, whereas the location of the highest point where there exists evidence of channel bifurcations and unconfined flow is referred to as the hydrographic apex. Previously presented figures depict the location of the topographic apex.

#### 2.3.3.1 Topographic/Hydrographic Apex Location

The piedmont surface extends from the front of the Maricopa Mountains to the Gila River and also occupies an intermountain valley that is approximately 1000 to 1500 feet in width. The location of the topographic apex is down slope of the intermountain valley. The drainage patterns in the intermountain valley are somewhat complex, displaying a braided/distributary pattern. The intermountain valley channel drains flow and transports sediment to the west from adjacent mountain valleys and slopes. Adjacent mountain valleys and slopes typically drain due south or north and out fall to the subject piedmont surface where the predominant channel trend is to the west. Two channels have formed along the margins of the intermountain valley from runoff draining from adjacent mountain valleys and slopes. The intermountain valley channels trend parallel to the valley and at locations stream bifurcations are evident. The topographic apex location was chosen at the highest point on the piedmont surface where the intermountain valley begins to widen and channels within the valley bifurcate. Due to the channel bifurcation the hydrographic apex was located coincidental with the topographic apex.

Figures 2.17 and 2.18 and 2.29 show the channel characteristic discussed above. Figure 2.29 is a detail figure of the topographic apex location.

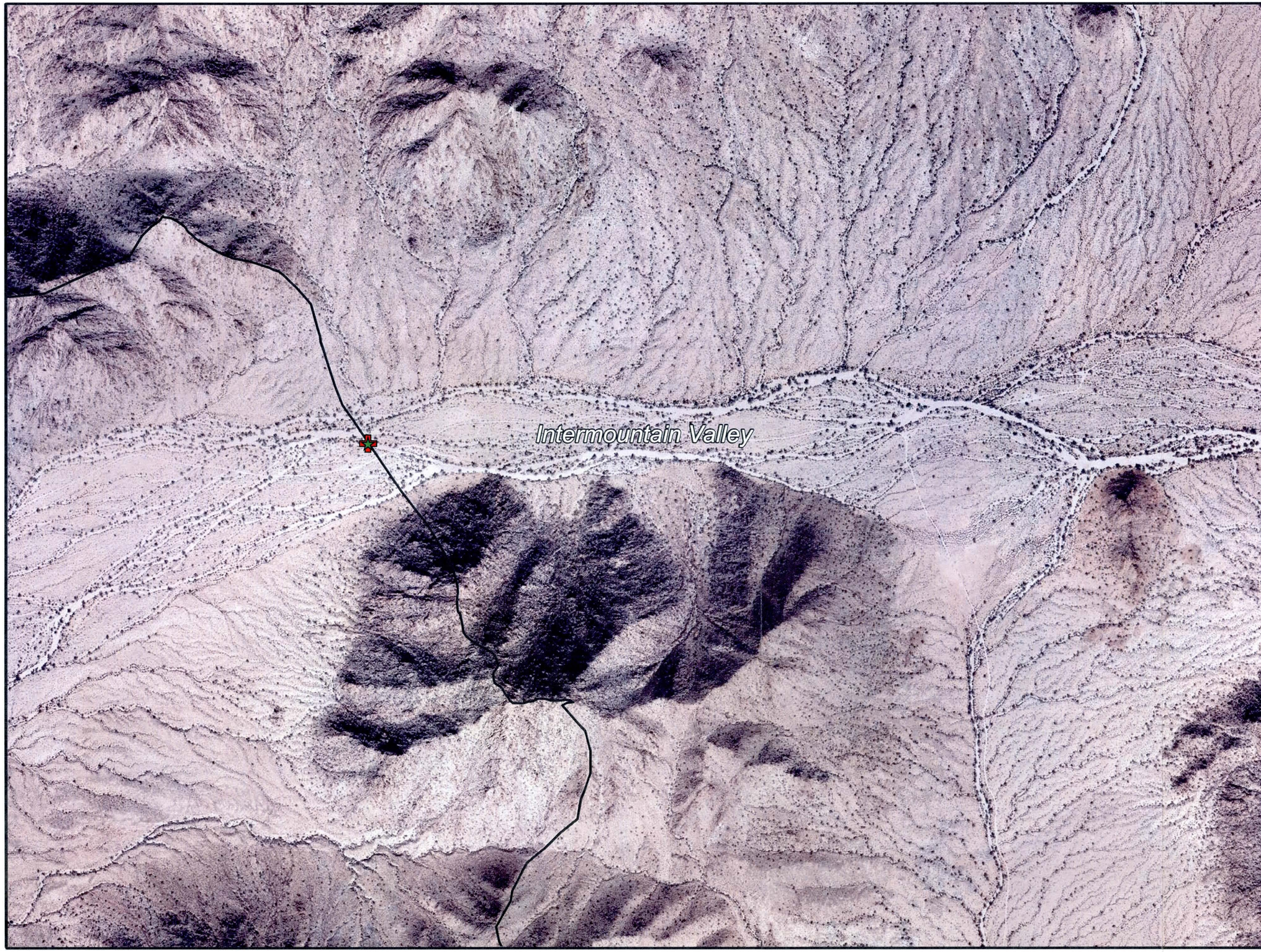
### 2.3.4 Toe and Lateral Boundaries

The toe and lateral boundaries of an alluvial fan define the limits of the fan. Physical characteristics that are used to identify the toe and lateral boundaries of the fan are presented in the PFHAM and FEMA Appendix G documents. The toe of the fan can be defined by the presence of:

- an axial stream (a stream intersects the fan and transports sediments away from the fan),
- a playa lake,
- alluvial plain,
- gentler slopes of a piedmont plain,
- the extent of distributary flow patterns

Lateral boundaries of the fan can be defined by:

- Trough, channel or swale formed at the lateral limits of deposition
- Confining mountain side
- Topographic ridge or trough in areas where fans coalesce




GILLESPIE AREA DRAINAGE
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LEGEND

- Topographic Apex Location
- Hydrographic Apex Location
- Subject Piedmont Area

NOTES

Aerial imagery flight dates Oct 2009 and Nov 2006

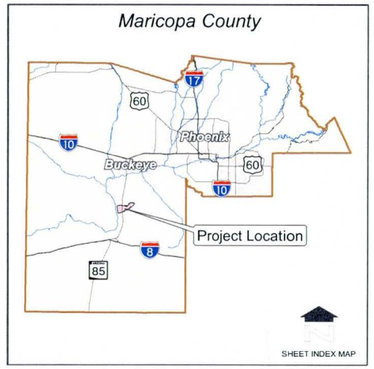


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**Figure 2.29**
**Apex Locations Detail**

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*Figure2-29_apex.mxd*

GILLESPIE AREA DRAINAGE
MASTER STUDY
F.C.D. CONTRACT NO. 2009C039

LEGEND

Topographic Apex Location

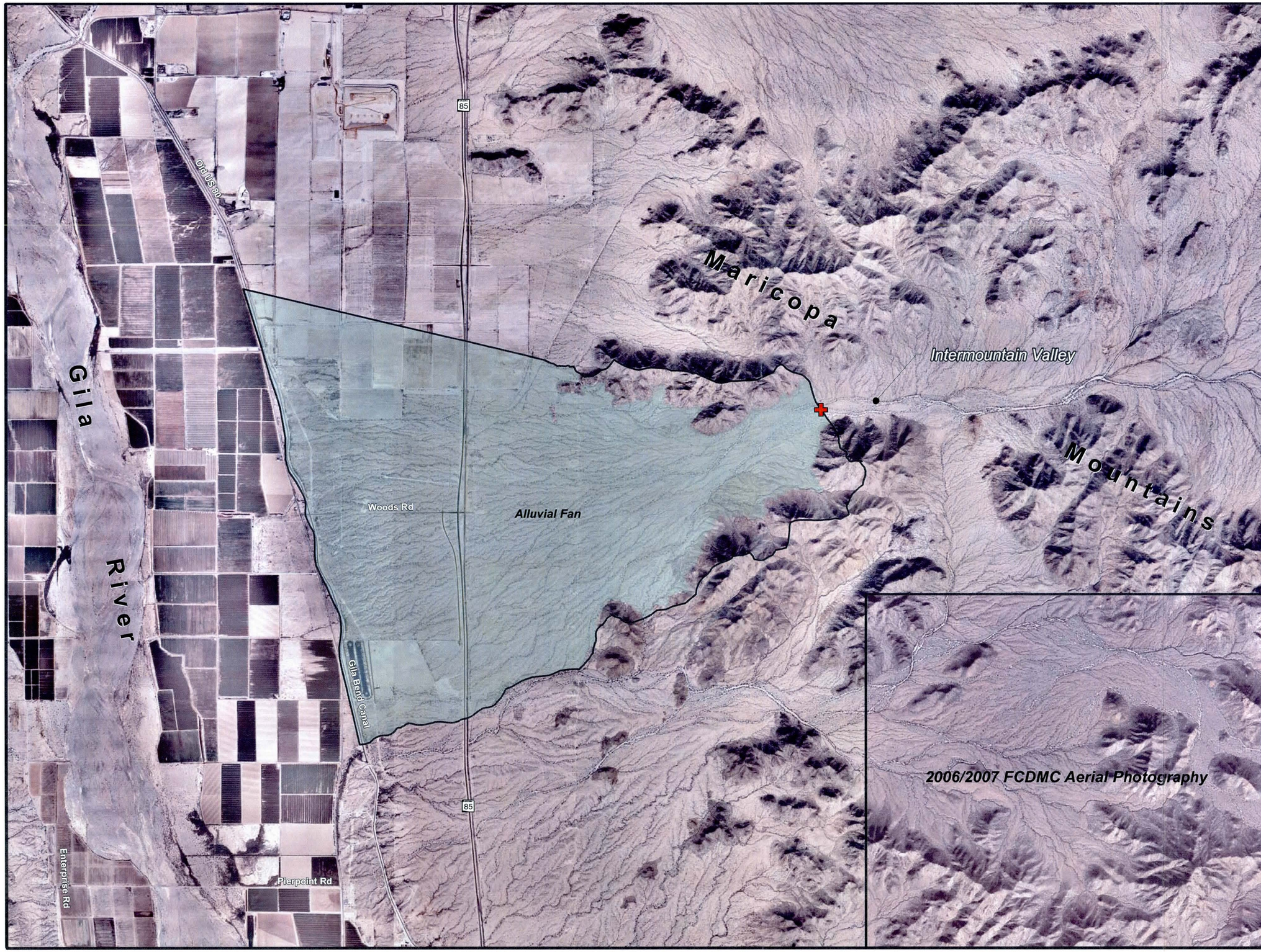
Study Area

**Landform Type**

Alluvial Fan

NOTES

Aerial imagery flight dates Oct 2009 and Nov 2006



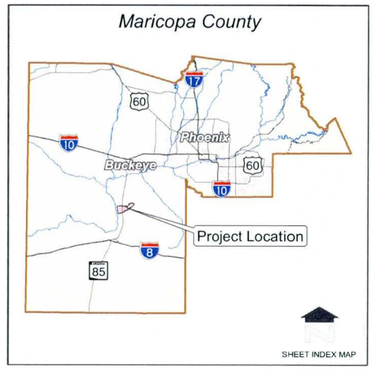




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**Figure 2.30**
**Stage 1 Landform Delineations**

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*Figure2-30_Stage1_Landform_Delineations.mxd*

Toe and lateral boundaries of the fan are depicted in Figure 2.30. At locations the fan boundaries are coincident with the boundaries of the piedmont area of interest. Topographic maps, aerial photography and soil maps were used to define the toe of the fan. The Gila River is the axial river to the piedmont surface that transports sediment away from the fan. The Gila River geomorphic floodplain is a very large floodplain and can be defined in part by soil units. NRCS soil units were used to help define the location of the toe. Soil units with a landform designation of floodplain (we have included stream terrace in this landform category) where the long axis of the soil unit polygon parallels the rivers flow direction were used to define the limit of the fan toe. Topographic mapping shows that in the vicinity of the toe contours are no longer convex in the downstream direction. In profile (Figure 2.27) there is a decrease in slope at the location where the alluvial fan landform transitions to riverine floodplain.

Aerial photography, surficial geologic maps, topography and soil surveys were used to define lateral boundaries. The lateral boundaries are either defined by the mountain front or by channels that divide the study area from adjacent alluvial fan landforms. The northern boundary, away from the mountain front is difficult to define because the area has been disturbed by agricultural activities. NRCS soil maps (Figure 2.1), 10 foot Contour Mapping (Figure 2.15), and projections of geologic units (Figure 2.2) to disturbed areas are the data sets used to help determine the location of the northern fan boundary limit. The boundary in the disturbed area was delineated based on a broad trough inferred from topographic data and assumed projections of geologic units.

### 2.3.5 Watershed and Alluvial Fan Characterization Using Geomorphic and Engineering Parameters.

This section of the report summarizes geomorphic and engineering parameters described in the scope of work for the watershed draining to the alluvial fan landform and the alluvial fan landform itself. Many of the parameters listed in the scope of work are based on parameters listed in "Flood Hazards of Distributary –Flow Areas in Southwestern Arizona" by H.W. Hjalmarson and S.P. Kemna. Hjalmarson (December, 1991), and Kemna develop a procedure for identifying and categorizing distributary flow areas downstream of a hydrographic apex. The procedure utilizes geomorphic and engineering parameters.

Watershed characteristics to be defined include:

- Drainage area at the topographic and hydrographic apexes.
  - Area in square miles of the drainage basin contributing flow to the topographic and hydrographic apexes (See Figure 2.31).
- Drainage basin shape.
  - Geometric shape of the drainage basin, elongated, tear drop, circular, etc.
- Drainage basin topographic relief (at both topographic and hydrographic apexes)
  - The vertical distance in feet, between the highest elevation in the drainage basin and the elevation at either the topographic or hydrographic apexes.
- Drainage basin slopes (at both topographic and hydrographic apexes).
  - The slope of the basin in feet/feet, calculated by dividing the change in elevation between the end points of the major flow path draining to either the topographic or hydrographic apexes by the length of the flow path.
- General geologic and soil make-up of the drainage basin.
  - Composition and texture of soil or bedrock within drainage basin.

- Mean-relief ratio of drainage basin (MRDA).
    - MRDA = RB/LB -Where RB is the relief of the drainage basin, in feet, and LB is the length of the drainage basin axis, in feet.
- Mean Basin Elevation (MBE).
    - Average elevation of the drainage basin measured in feet.
- Mountain-Area Factor (MAF)
    - Defined as the ratio of the drainage-basin area that is not on the piedmont plain (typically composed of bedrock mountains) and the total drainage-basin area (Hjalmarson and Kemna, 1991). The ratio is multiplied by 10 and rounded to one significant figure so that the values range from 1 to 10. An inverse relation exists between the mountain-area factor and the flood-hazard degree. The mountain-area factor may be a surrogate for the effects of geology on the flood-hazard degree (including lithology and geologic structure).
- Distance from the hydrographic apex to the topographic apex.
    - Distance measured in feet along the major flow path connecting the hydrographic and topographic apexes.

Alluvial Fan Landform Characteristics to be defined include the following.

- Alluvial fan type.
    - Singular or coalescing with other fans.
- Alluvial fan surface area.
    - Alluvial fan landform surface area measured in square miles. The area from the Fan Apex to Fan Toe ( area shaded in green on Figure 2.31)
- Alluvial fan channel slope profile and the value of the slope.
    - See Longitudinal Profile (Figure 2.28) in Morphology section above. Slope is measured in feet/feet.
- Alluvial fan surface slope profile and the value of the slope.
    - See Landform profile (Figure 2.27) in Morphology section above. Slope is measured in feet/feet.
- Alluvial fan surface slope profile near the toe.
    - See Alluvial Fan Toe Determination section (Figure 2.27). Slope is measured in feet/feet.
- Ratio of alluvial fan surface area to drainage basin area.
- Mean-relief ratio of alluvial fan (MRDFA).
    - MRDFA is related roughly to the mean elevation of the drainage basin (MBE) as: MRDFA = 0.009(MBE/1000)^0.7 (Hjalmarson and Kemna, 1991).
- Average contour sinuosity of alluvial fan (Figure 2.32).
    - Contour sinuosity defined as the ratio of the length of the contour, in miles, and the length of straight lines, in miles that approximately splits the distance between the largest and smallest crenulations. Contour lengths were determined using ArcView. If a contour was segmented the segments were joined and ArcView was queried for a length.
- Channel characteristics on the alluvial fan.

- Types of channels that occur on the fan surface; incised or shallow, multiple or singular, parallel or radiating, decrease in size/increase in size. See Section 2.3.2.3.

- General sediment description.
  - General description of the sediments located on the alluvial fan and in its channels. See Section 2.3.2.2.

#### 2.3.5.1 Summary of Geomorphic and Engineering Parameters

Summaries of watershed and alluvial fan landform characteristics are listed in Tables 2.7 and 2.8, respectively. Watershed and landform values listed in Tables 2.7 and 2.8 were determined from topographic data (2 foot contour interval) provided by the District, shape files developed to depict watershed and alluvial fan boundaries and the ArcView program to determine areas, lengths, and mean elevations of specific features. Data listed in tables will be utilized during Stage 3 evaluations.

**Table 2.7,**
**Summary of Watershed Characteristics**

| Characteristics/Parameter | Value/Response | Comment |
|---|---|---|
| Drainage Basin Area (drainage area upstream of Fan Apex, Mountainous Area): | 16.8 mile $^2$ | See Figure 2.31 |
| Drainage Basin Shape: | Oblong with a narrowing width to the southeast. | See Figure 2.31 |
| Drainage Length (LB - major flow path): | 49,112 ft | See Figure 2.31 |
| Top Elevation (highest point in the basin): | 2,444 ft | See Figure 2.31 |
| Bottom Elevation: | 1,102 ft | See Figure 2.31 |
| Drainage Basin topographic relief (RB): | 1,342 ft | |
| Drainage Basin Slope: | 0.0273 ft/ft | |
| Watershed composition: | The watershed is underlain by bedrock and poorly sorted sand, pebbles, cobbles, silts and clays | See figure 2.31 and Table 2.3. |
| Mean-relief ratio of drainage basin (MRDA): | 0.0273 ft/ft | |
| Mean Basin Elevation (MBE, average of point elevations within the basin): | 1,466 ft | |
| Mountain Area Factor (MAF= (Drainage Basin Area / Total Drainage Basin Area) x10)): | 6.5 | |
| Distance between topographic apex and hydrographic apex | 0 ft | See Figure 2.31 |
| Total drainage basin area (Piedmont to fan toe and basin area upstream of apex) | 25.83 mile $^2$ | |

**Table 2.8,**
**Summary of Alluvial Fan Landform Characteristics**

| Characteristics/Parameter | Value/Response | Comment |
|---|---|---|
| Alluvial Fan Type | Single | |
| Alluvial Fan Surface Area (area from Fan Apex to Fan toe) | 9.03 mile $^2$ | See Figure 2.31 |
| Alluvial Fan Channel Profile Slope | 0.015 ft/ft | |
| Alluvial Fan Surface Profile Slope | 0.016 ft/ft | |
| Alluvial Fan Surface Profile Slope (near toe) | 0.010 ft/ft | |
| Ratio of Alluvial Fan surface area to drainage basin area | 0.537 | |
| Mean-relief ratio of alluvial fan (MRDFA) | 0.0118 | |
| Average Contour Sinuosity | 3.82 | See Figure 2.32 |
| Channel characteristics on the alluvial fan | Channels range from poorly incised ill-defined to well defined incised channels. | |
| General sediment description | See Section 2.3.2.2 | |

### 2.3.6 Conclusions

Results of the Alluvial Fan Stage 1 analyses shows that the subject Maricopa Mountain piedmont area meets FEMA and PFHAM criteria for characterizing the piedmont surface as an Alluvial Fan Landform. The NRCS soil survey and AZGS geologic maps demonstrate that the fan composition is alluvium. Morphologic characteristics determined from topography and aerial photographs demonstrates that the shape of the fan is partially extended, there is a distributary drainage network defined by bifurcating and coalescing channels, that radiate out from the top of the fan.

## 2.4 REFERENCES

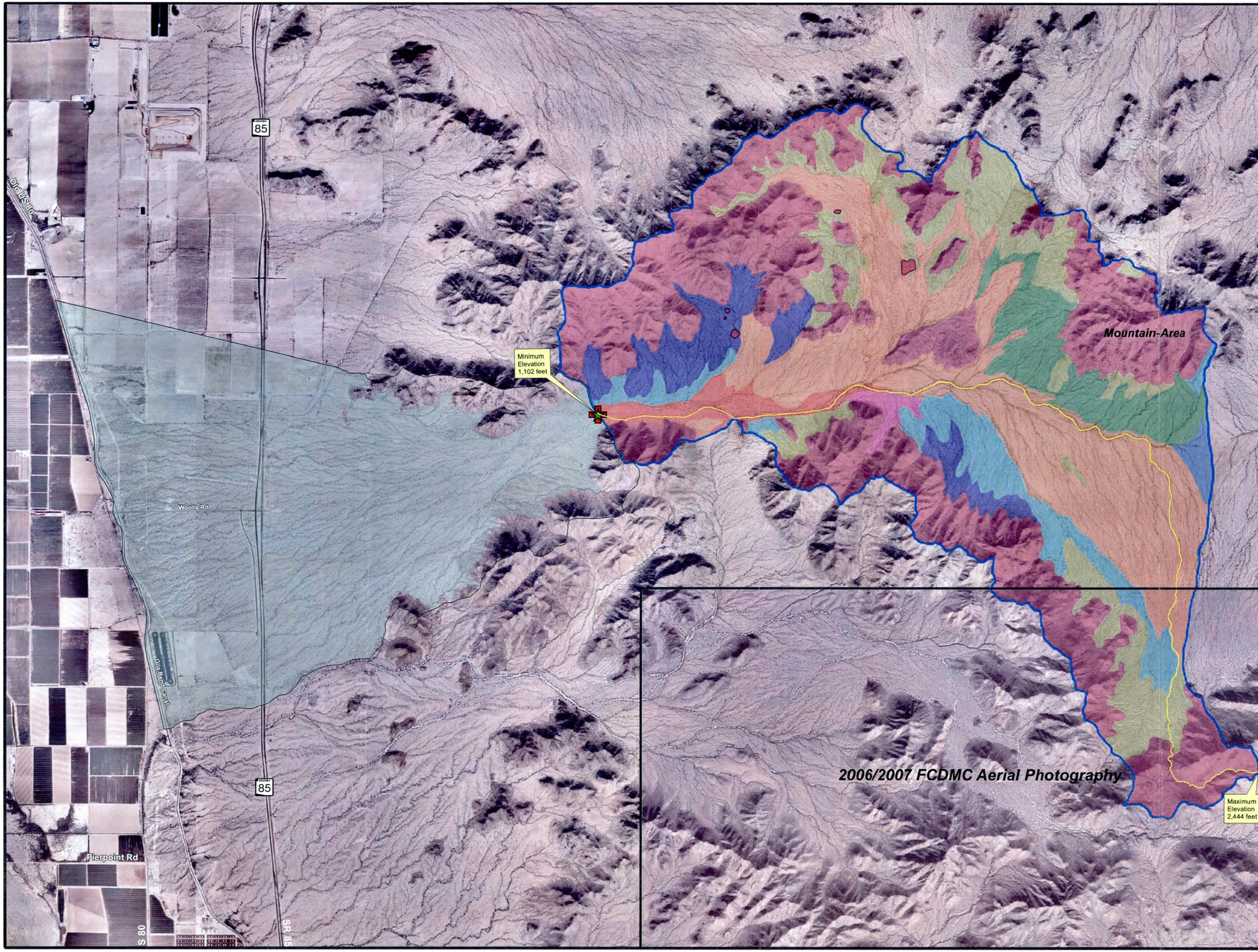
AZGS OFR-12-07/DGM-75, 2012, Surficial Geology and Flood Hazards on the Western Piedmont of the Maricopa Mountains and the Southern Piedmont of the Buckeye Hills, Maricopa County, Arizona by Jeri J. Young, Joseph P. Cook and Philip A. Pearthree.

FEMA, April 2003, Specifications for Flood Hazard Mapping Partners, Appendix G: Guidance for Alluvial Fan Flooding Analyses and Mapping by the Federal Emergency Management Agency.

Hjalmarso & Kemna, December, 1991, Flood Hazards of Distributary – Flow Areas in Southwestern Arizona.

JE Fuller/Hydrology & Geomorphology, Inc. August 25, 2010, Refinement of Methodology: Alluvial Fan Flood Hazard Identification & Mitigation Methods.

NRCS, 1997, AZ 653-Gila Bend-Ajo Area, Arizona, Parts of Maricopa and Pinal Counties.




# GILLESPIE AREA DRAINAGE MASTER STUDY
## F.C.D. CONTRACT NO. 2009C039

LEGEND

- Topographic Apex Location
- Hydrographic Apex Location
- Alluvial Fan Study Area
- Stantec Identified Rock Outcrop (0.02 sq. miles)
- Apex Drainage Area (16.80 sq. miles)
- Drainage Flow Path (49,112 ft)

**Landform Type**

- Alluvial Fan (9.03 sq. miles)

**Soil Description**

- Carrizo-Momoli complex (0.44 sq. miles)
- Cipriano-Momoli complex (1.00 sq. miles)
- Dateland-Cuerda complex (0.12 sq. miles)
- Denure-Rillito-Why complex (4.14 sq. miles)
- Gunsight-Rillito-Carrizo complex (1.02 sq. miles)
- Momoli-Carrizo extremely gravelly sandy loams (0.12 sq. miles)
- Momoli-Comobabi association (0.96 sq. miles)
- Quilotosa-Momoli-Carrizo complex (2.31 sq. miles)
- Quilotosa-Rock outcrop complex (6.68 sq.miles)

NOTES

Aerial imagery flight dates Oct 2009 and Nov 2006

*Maricopa County*

SHEET INDEX MAP

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**Figure 2.31**
**Drainage Basin / Alluvial Fan Landform Map**

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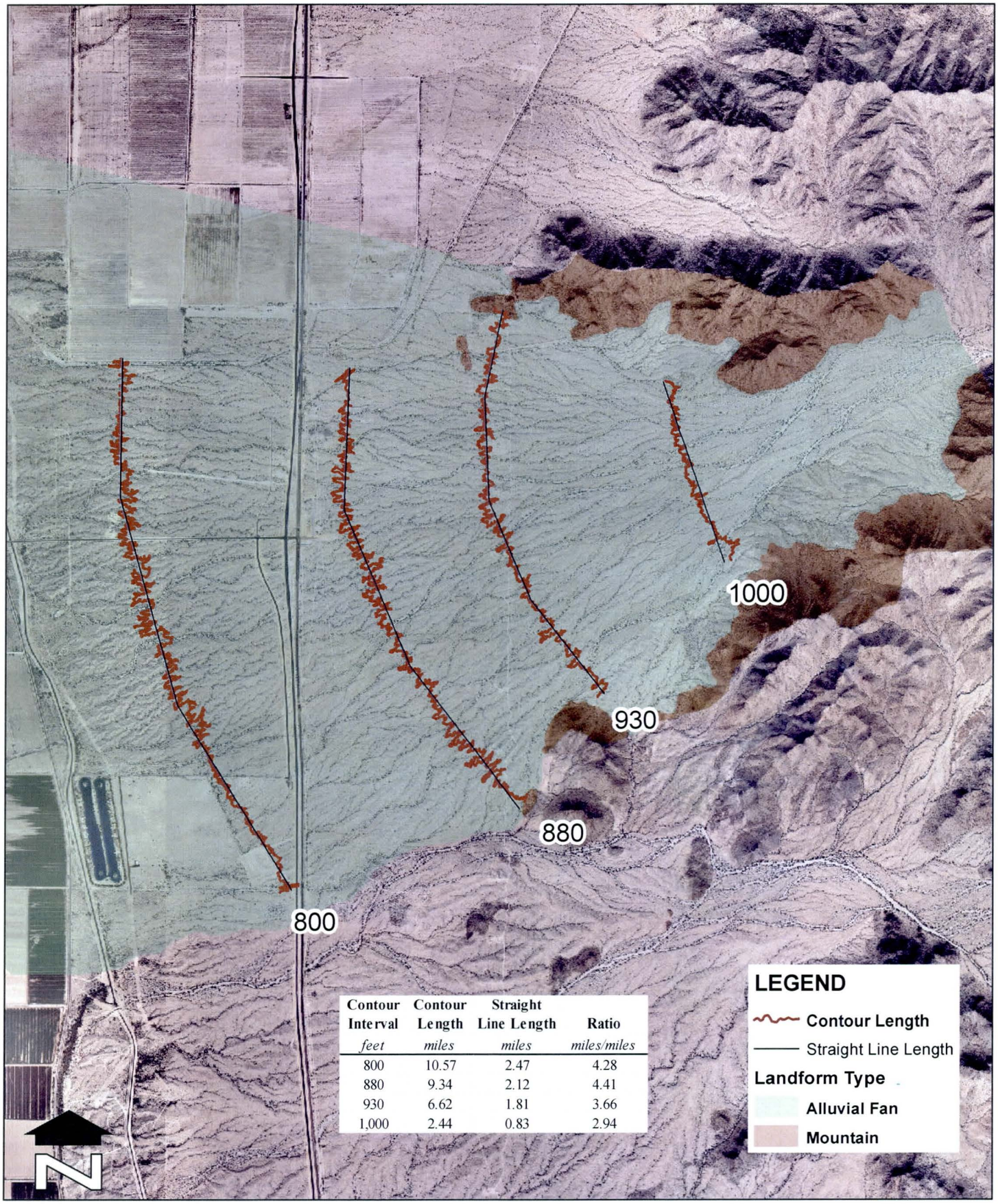
*Figure2-31_Landform_Map.mxd*




| Contour Interval | Contour Length | Straight Line Length | Ratio |
|---|---|---|---|
| *feet* | *miles* | *miles* | *miles/miles* |
| 800 | 10.57 | 2.47 | 4.28 |
| 880 | 9.34 | 2.12 | 4.41 |
| 930 | 6.62 | 1.81 | 3.66 |
| 1,000 | 2.44 | 0.83 | 2.94 |

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| DATE: | 04-13-2012 |
| SCALE: | 1" = 3000' |
| DRAWN BY: | AML |

**FIGURE 2.32**
**Contour Sinousity for Alluvial Fan Landform**

GILLESPIE ADMS
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# Appendix A

# Appendix B

# Appendix C