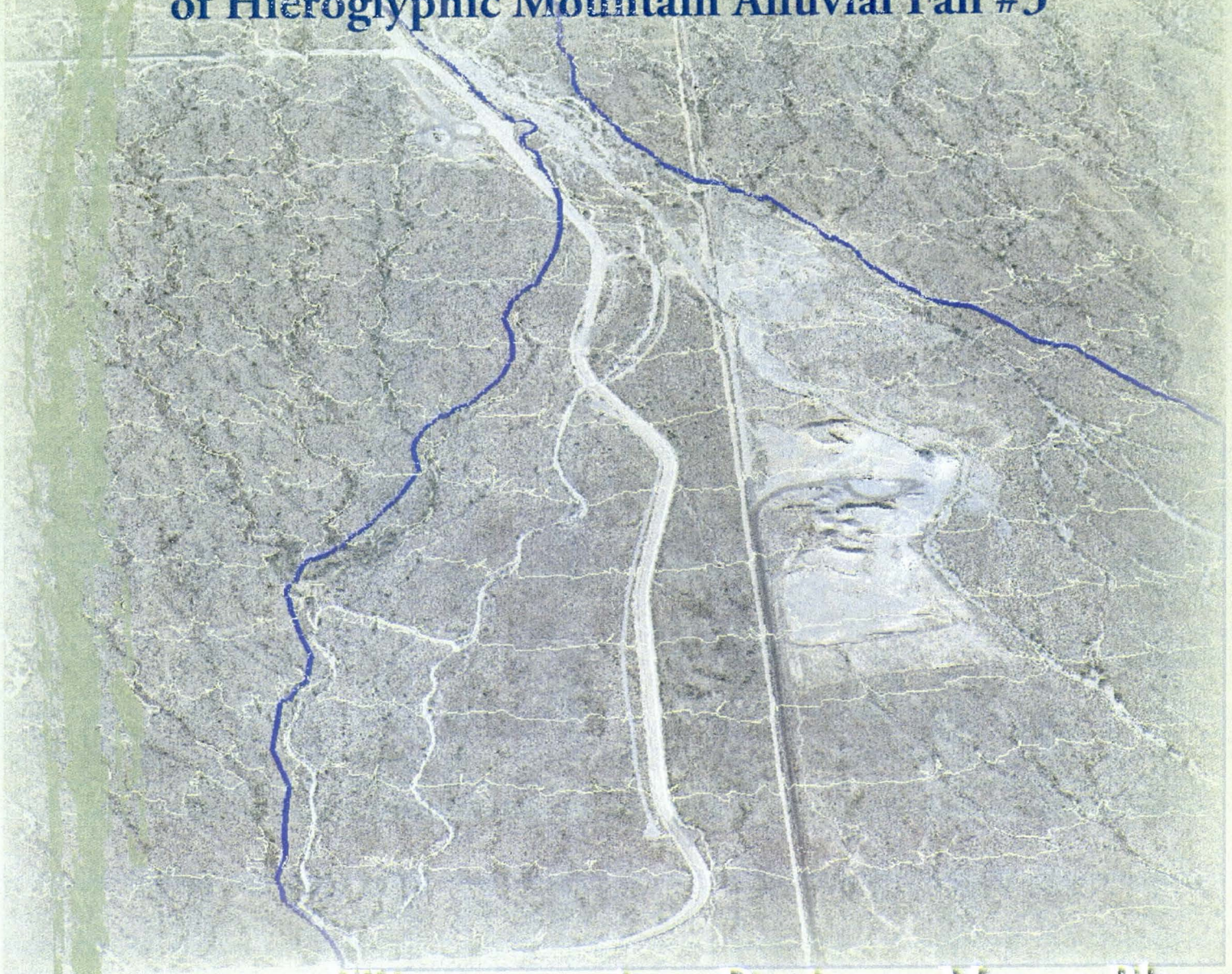
TECHNICAL DATA NOTEBOOK

Approximate Zone A Floodplain Delineation Study of Hieroglyphic Mountain Alluvial Fan #3



Wittmann Area Drainage Master Plan

Flood Control District of Maricopa County

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

TECHNICAL DATA NOTBOOK:

APPROXIMATE ZONE A
FLOODPLAIN DELINEATION STUDY
of
HIEROGLYPHIC MOUNTAIN
ALLUVIAL FAN #3

WITTMANN AREA DRAINAGE MASTER PLAN

FCD CONTRACT NO. 2004 C060

Task 2.8.5

April 2007

Prepared for:

Flood Control District of Maricopa County

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Appendix G: Geomorphology Analyses Supporting Documentation

DISKETTES

Digital data files on CD with a copy of the "readme" file

EXHIBITS

A. Hydrology Plates
- **Hydrologic Subbasins**
- **NRCS Soils and XKSAT**
- **Existing Land Use**

B. Geomorphology Exhibit Maps
- **Stage 1 - Landform Map**
- **Stage 2 - Stability Map**
- **Stage 3 – Floodplain Map**

C. Floodplain Study Work Maps

SECTION 1: INTRODUCTION

1.1 Study Purpose

The purpose of this floodplain delineation study is to delineate an approximate method 100-year floodplain for the Hieroglyphic Mountain Alluvial Fan #3 as identified in the Wittmann Area Drainage Master Study (Entellus, 2005). This study incorporates the assessment methods for piedmont flood hazards as outlined in Piedmont Flood Hazard Assessment Manual for Maricopa County (PFHAM) (Hjalmarson, 2003) and for alluvial fans in the Guidelines and Specifications for Flood Hazard Mapping Partners, Appendix G: Guidance for Alluvial Fan Flooding Analyses and Mapping (FEMA Guidelines) (FEMA, 2002), as well as approximate method riverine floodplain delineations for reaches upstream of the alluvial fan apex.

1.2 Study Authority

The current study was authorized by the Flood Control District of Maricopa County (District) for the Wittmann Area Drainage Master Plan Update (ADMP) under contract FCD 2004 C060, Task 2.8.5. The study was performed by JE Fuller/Hydrology & Geomorphology, Inc. (JEF) as a subconsultant to Entellus, Inc. on behalf of the District. The JEF project manager is Jonathan E. Fuller, P.E., R.G., CFM. The District's project manager is Kelli Sertich. The Entellus project manager is Hernan Aristizabal, P.E.

1.3 Study Location

Figure 1.1 shows the location of the Hieroglyphic Mountain Alluvial Fan #3 study area. Figure 1.2 shows the alluvial fan and its watershed. The study area is located in western Maricopa County, Arizona, within unincorporated Maricopa County near the Town of Surprise. The watershed heads in the Hieroglyphic Mountains and generally drains south toward McMicken Dam. The floodplain delineation extends from approximately the Cloud Road alignment to the Central Arizona Project (CAP) canal.

The study area has a semi-arid desert climate with an average annual precipitation of generally less than 10 inches. Precipitation is typically divided between two seasons with comparable rainfall amounts: summer and winter. Summer storms are associated with warm, moist tropical air masses that enter the state from the Gulf of Mexico and Gulf of California, producing moderate to intense localized thundershowers. Winter precipitation usually originates from the Pacific Ocean and produces light to moderate precipitation over relatively large areas. A third source of precipitation is from dissipating tropical storm and/or hurricane remnants, which typically occur in fall, and which generate moderate to high rainfall intensities of moderate to long duration.

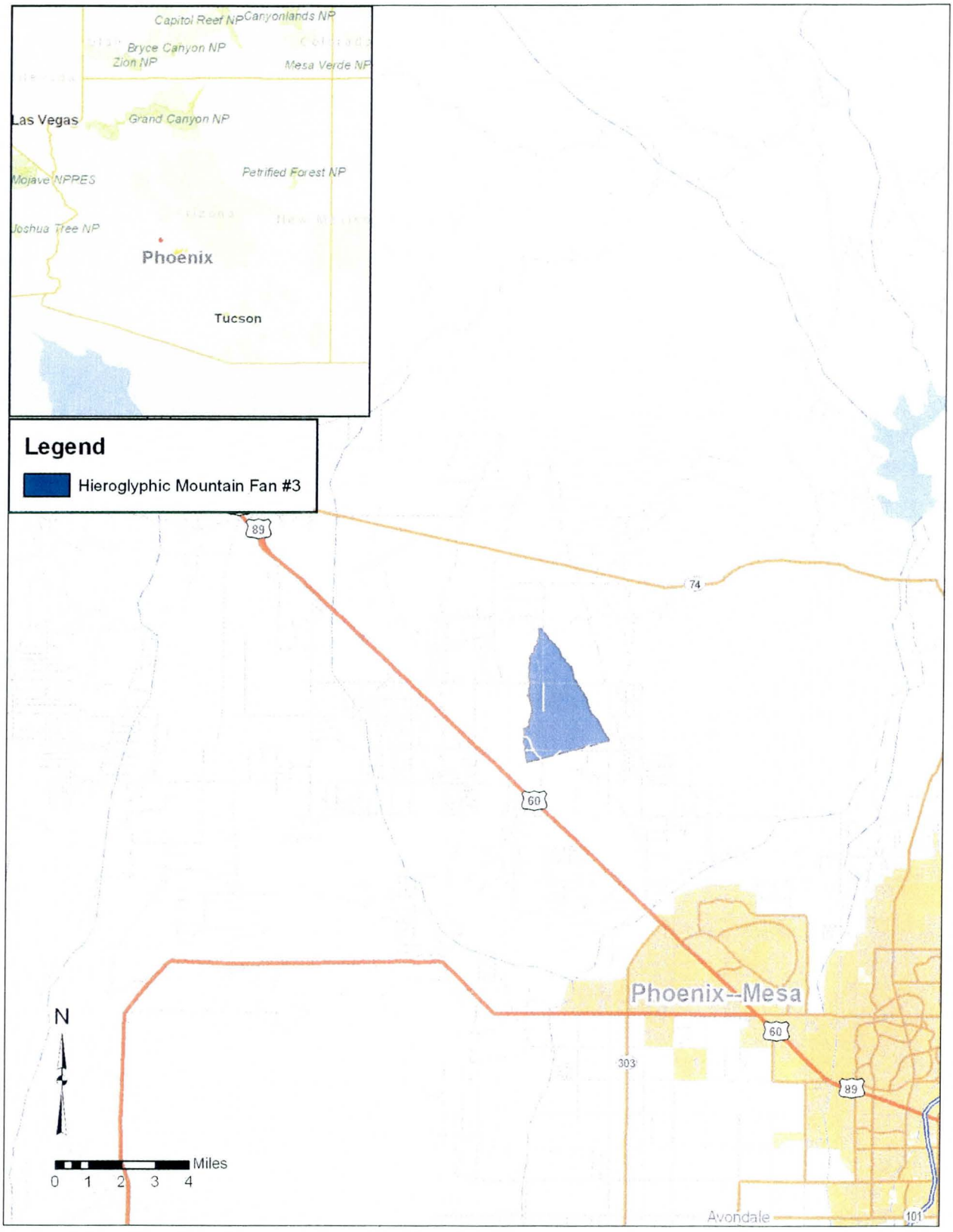


Figure 1.1 General Location of Study Area

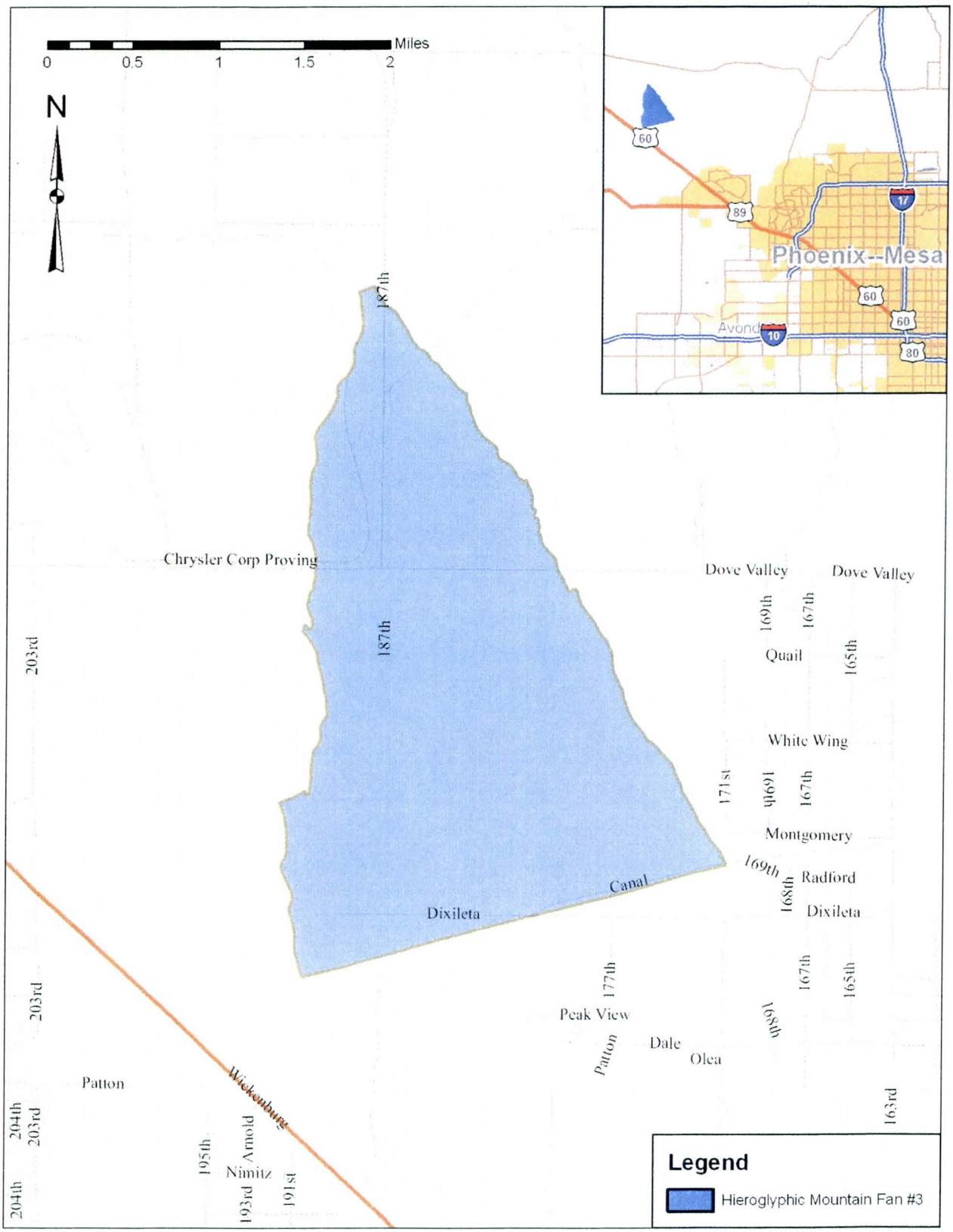


Figure 1.2 Location of Hieroglyphic Mountain Alluvial Fan #3 Study Limits

1.4 Methodology

This study used methods outlined in the Drainage Design Manuals for Maricopa County. In addition, the study uses piedmont flood hazard assessment methods outlined in the District's PFHAM and in the FEMA Guidelines. These two documents were published in response to the National Research Council's Alluvial Fan Flooding report (NRC, 1996). The FEMA Guidelines are targeted at determination of flood hazards on alluvial fan landforms. The PFHAM, which is recommended for use in Maricopa County, Arizona, is applicable to the entire piedmont, not just alluvial fans. The PFHAM methodology incorporates geomorphic methods into the flood hazard assessment of piedmont surfaces. According to the FEMA Guidelines, the geomorphic approach is considered an "approximate method" (p. G-12, Table G-1) because no base flood elevations are calculated in the geomorphic approach.

1.4.1 Hydrology

The U.S. Army Corps of Engineers HEC-1 model (version 4.1) was used to compute runoff hydrographs and peak discharges. Parameters were processed into HEC-1 through the DDMSW version 3.2.8 software from the FCDMC. Documentation of the hydrologic modeling for this study is provided in Section 4.0 of this Technical Documentation Notebook (TDN).

1.4.2 Hydraulics

The U.S Army Corps of Engineers HEC-RAS model (version 3.1.3) was used to compute the water surface profiles used for the riverine approximate floodplain delineations upstream of the alluvial fan hydrographic apexes. A description of the approximate method riverine floodplain delineation is provided in Section 5.0 of this TDN.

1.4.3 Geomorphology

Geomorphic methods that incorporate landform characteristics, surficial geologic mapping, soils mapping, field observations and aerial photograph interpretation as described in the PFHAM and FEMA Guidelines were used to delineate floodplains on alluvial fan surfaces. A description of the geomorphic method floodplain delineation is provided in Section 6B of this TDN.

1.5 Acknowledgements

This study was funded entirely by the Flood Control District of Maricopa County. Assistance and review from their staff was critical to the success of this project.

1.6 Study results

The study resulted in the delineation of 0.7 miles of approximate riverine 100-year floodplain and 5.7 square miles of alluvial fan floodplain. The inundation areas for the newly delineated floodplains are shown on the maps in Section 6B and 7 and the Exhibit Maps at the end of this notebook. The floodplain mapping also includes administrative flood hazard zones defined by the Flood Control District of Maricopa County for the local management of flood hazards on the alluvial fan.

SECTION 2: ADWR/FEMA FORMS

2.1 Study Documentation Abstract for FEMA Submittals

Study Documentation Abstract For FEMA Submittals		Initial Study	Restudy	CLOMR	LOMR	X	Other
2.1.1	Date Study Accepted						
2.1.2	Study Prime Contractor	JE Fuller / Hydrology and Geomorphology, Inc.					
	Contact(s)	Jonathan E. Fuller, P.E., R.G., CFM					
	Address	8400 S. Kyrene Rd., Suite 201 Tempe, AZ 85284					
	Phone	(480) 752-2124					
	Internal Reference Number	Entellus Wittmann ADMP					
2.1.2	Study Sub-Contractor	None					
	Contact(s)						
	Address						
	Phone						
	Internal Reference Number						
2.1.2	Sub Study Sub-Contractor						
	Contact(s)						
	Address						
	Phone						
	Internal Reference Number						
2.1.3	FEMA Technical Review						
	Contractor	Michael Baker, Jr.					
	Contact(s)	Mounir Boudjemaa					
	Address	3600 Eisenhower Ave. Suite 600 Alexandria, VA 22304					
	Phone	703-960-8800					
	Internal Reference Number						
2.1.4	FEMA Regional Reviewer	Michael Baker, Jr. Engineering					
	Phone	(703) 960-8800					
2.1.5	State Technical Reviewer	None					
	Phone						
2.1.6	Local Technical Reviewer	Flood Control District of Maricopa County (FCDMC) Kathryn Gross, CFM					
	Phone	(602) 506-1501					
2.1.7	Reach Description	Hieroglyphic Mountain Alluvial Fan #3					
2.1.8	USGS Quad Sheet(s) with original photo date & latest photo revision date	Hieroglyphic Mountains SW, Arizona, 1982					
2.1.9	Unique Conditions and Problems	Alluvial Fan Flooding					
2.1.10	Coordination of Peak Discharges (Agency, Date, Comments)	FCDMC – Wittmann ADMSU (2005) Existing Conditions HEC-1 Model Results					

2.2 FEMA Forms

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

OVERVIEW & CONCURRENCE FORM

O.M.B No. 1660-0016
Expires: August 31, 2007

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 Parts 60 & 65 of the NFIP Regulations.)

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
040037	Maricopa County, Arizona and Unincorporated Areas	AZ	04013C	0705G 0715G 0720G 1130G	9/30/2005

2. Flooding Source: Hieroglyphic Mountain Alluvial Fan #3

3. Project Name/Identifier: Approximate Zone A Floodplain Delineation Study of Hieroglyphic Mountain Alluvial Fan #3

4. FEMA zone designations affected: A, X (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 ☐ 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 types of flooding and structures (check all that apply)

Types of Flooding:	☒ Riverine	☐ Coastal	☐ Shallow Flooding (e.g., Zones AO and AH)
	☒ Alluvial fan	☐ Lakes	☐ Other (Attach Description)
Structures:	☐ Channelization	☐ Levee/Floodwall	☐ Bridge/Culvert
	☐ Dam	☐ Fill	☐ Other, Attach Description

C. REVIEW FEE

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

☒ No, Attach Explanation: New Delineation by Agency

Map changes based on flood hazard information meant to improve upon that shown on the flood map or within the flood study.

Please see the DHS-FEMA Web site at http://www.fema.gov/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: Kathryn Gross, CFM, Project Manager	Company: Flood Control District of Maricopa County	
Mailing Address: 2801 West Durango Street Phoenix, AZ 85009	Daytime Telephone No.: (602) 506 1501	Fax No.: 602-506-4601
	E-Mail Address: kag@mail.maricopa.gov	
Signature of Requester (required):		Date:

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.

ommunity Official's Name and Title: Timothy S. Phillips, P.E., Chief Engineer & General Manager		Telephone No.: 602-506-1501
Community Name: Maricopa County, AZ	Community Official's Signature (required):	Date:

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. 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: Jonathan Fuller, PE	License No.: 26846	Expiration Date: March 31, 2008
Company Name: JE Fuller/Hydrology & Geomorphology, Inc.	Telephone No.: 480-752-2124	Fax No.: 480-839-2193
Signature:		Date: 4-25-07

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

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

RIVERINE HYDROLOGY & HYDRAULICS FORM

O.M.B No. 1660-0016

Expires: August 31, 2007

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: Hieroglyphic Mountain Alluvial Fan #3

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 2) ☐ 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.)	FIS (cfs)	Revised (cfs)

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

☐ Statistical Analysis of Gage Records ☐ Precipitation/Runoff Model [TR-20, HEC-1, HEC-HMS etc.]
☐ 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. The document, "Numerical Models Accepted by FEMA for NFIP Usage" lists the models accepted by DHS-FEMA. This document can be found at: http://www.fema.gov/fhm/en_modl.shtm.

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	See attached annotated FIRMs			
Upstream Limit	See attached annotated FIRMs			

2. Hydraulic Method Used

Hydraulic Analysis HEC-RAS [HEC-2 , HEC-RAS, Other (Attach description)]

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 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/fhm/frm_soft.shtm. We recommend that you review your HEC-2 and HEC-RAS models with CHECK-2 and CHECK-RAS. If you disagree with a message, please attach an explanation of why the message is not valid in this case. Review of your submittal and resolution of valid modeling discrepancies will result in reduced review time.

HEC-2/HEC-RAS models reviewed with CHECK-2/CHECK-RAS? ☐ Yes ☐ No

4. Models Submitted ☐ Diskette Submitted

	Natural Run		Floodway Run		Datum
Duplicate Effective Model*	File Name:	Plan Name:	File Name:	Plan Name:	_____
Corrected Effective Model*	File Name:	Plan Name:	File Name:	Plan Name:	_____
Existing or Pre-Project Conditions Model	File Name: zonea	Plan Name: 100yr	File Name:	Plan Name:	NAVD88
Revised or Post-Project Conditions Model	File Name:	Plan Name:	File Name:	Plan Name:	_____
Other - (attach description)	File Name:	Plan Name:	File Name:	Plan Name:	_____

*Not required for revisions to approximate 1%-annual-chance floodplains (Zone A) – for details, refer to the corresponding section of the instructions.

The document "Numerical Models Accepted by FEMA for NFIP Usage" lists the models accepted by DHS-FEMA. This document can be found at: http://www.fema.gov/fhm/en_modl.shtm.

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.).

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 Included ☒ Digital Mapping (GIS/CADD) Data Submitted (Recommended)

D. COMMON REGULATORY REQUIREMENTS*

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

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.

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/CLOMR 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 from the community to show that they 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.

5. 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.

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

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

ALLUVIAL FAN FLOODING FORM

O.M.B No. 1660-0016
Expires: August 31, 2007

PAPERWORK REDUCTION ACT

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.**

Flooding Source: Hieroglyphic Mountain Alluvial Fan #3
Note: Fill out one form for each flooding source studied

A. THREE-STAGE ANALYSIS (Based on FEMA Guidelines dated February 23, 2000)

1. Stage 1 Analysis

   a. The landform is composed of (check one) ☒ alluvial ☐ debris flow deposits.

   b. Source of data used to determine composition, morphology, and location of the landform:

   NRCS Soils Maps, AZ Geological Survey Geologic Maps, USGS Topographic Maps, Aerial Photos, Field Observation

   c. Is there an NRCS soils survey and soil survey map available? ☒ Yes ☐ No
   If Yes, please include a copy of the map and any pertinent sections of the soil survey

2. Stage 2 Analysis

   a. The alluvial fan exhibits ☐ active ☐ inactive ☒ a combination of active and inactive alluvial fan flooding.

   b. Approximate age of inactive fan surfaces (thousands of years): > 10,000 yrs.

   c. Is there an opportunity for avulsions that could lead channels or sheetfloods across the older fan surfaces?
   ☐ Yes ☒ No

   d. Is there evidence of headcutting that could lead to stream piracy? ☒ Yes ☐ No

   e. Is there geomorphic evidence of past avulsions during the Holocene epoch? ☒ Yes ☐ No

   f. The fan exhibits the following types of flooding (check one):

   ☒ Flooding along stable channels
   ☒ Sheetflow
   ☐ Debris flow
   ☒ Unstable flow path flooding

3. Stage 3 Analysis

   The boundaries of the 1%-annual-chance floodplain have been determined using (check one):

   ☐ Risk-Based Analysis
   ☐ FEMA FAN program (if discharge at the apex is different than that given in the effective FIS, then attach MT-2, Form 2 along with a plot of the flood frequency curve on log-normal probability paper and include the drainage area above the hydrographic apex, and the mean, standard deviation, and skew coefficient of the curve)
   ☐ Sheetflow Methods
   ☐ Hydraulic Analytical Methods
   ☒ Geomorphic Data, Post-Flood Hazard Verification, and Historical Information
   ☐ Composite Methods

B. STRUCTURAL FLOOD CONTROL MEASURES

1. The following structural flood control measures are proposed or built (check one): **No Structural Measures are Proposed**

☐ Channelization ☐ Levee/Floodwall ☐ Dam ☐ Sedimentation Basin

2. Do the constructed or proposed structural measures affect flood hazards (including velocity, scour, and sediment deposition) on other areas of the fan? ☐ Yes ☐ No

3. Attach completed Form 3 (Riverine Structures Form).

4. Sediment Transport Considerations:

Was sediment transport considered? ☐ Yes ☒ No If Yes, then fill out Form 3, Section F (Sediment Transport).

If No, then attach your explanation for why sediment transport was not considered.

Delineation was performed using approximate geomorphic methods. Sediment yield is reported from other studies.

5. Please attach a copy of the formal Operations and Maintenance Plan.

C. MAPPING REQUIREMENTS

Attach a certified topographic work map showing the following:

- The boundaries of the alluvial fan including: toe, topographic and hydrologic apexes, and lateral boundaries
- The delineation of the active and inactive portions of the fan as determined by the Stage 2 analysis
- The revised 1%-annual-chance floodplain boundaries, as determined by the Stage 3 Analysis, that tie into the effective floodplain boundaries
- The correct alignment of all structural features
- The map scale

SECTION 2: ADWR/FEMA FORMS

2.1 Study Documentation Abstract for FEMA Submittals

Study Documentation Abstract For FEMA Submittals		Initial Study	Restudy	CLOMR	LOMR	X	Other
2.1.1	Date Study Accepted						
2.1.2	Study Prime Contractor	JE Fuller / Hydrology and Geomorphology, Inc.					
	Contact(s)	Jonathan E. Fuller, P.E., R.G., CFM					
	Address	8400 S. Kyrene Rd., Suite 201 Tempe, AZ 85284					
	Phone	(480) 752-2124					
	Internal Reference Number	Entellus Wittmann ADMP					
2.1.2	Study Sub-Contractor	None					
	Contact(s)						
	Address						
	Phone						
	Internal Reference Number						
2.1.2	Sub Study Sub-Contractor						
	Contact(s)						
	Address						
	Phone						
	Internal Reference Number						
2.1.3	FEMA Technical Review Contractor	Michael Baker, Jr.					
	Contact(s)	Mounir Boudjemaa					
	Address	3600 Eisenhower Ave. Suite 600 Alexandria, VA 22304					
	Phone	703-960-8800					
	Internal Reference Number						
2.1.4	FEMA Regional Reviewer	Michael Baker, Jr. Engineering					
	Phone	(703) 960-8800					
2.1.5	State Technical Reviewer	None					
	Phone						
2.1.6	Local Technical Reviewer	Flood Control District of Maricopa County (FCDMC) Kathryn Gross, CFM					
	Phone	(602) 506-1501					
2.1.7	Reach Description	Hieroglyphic Mountain Alluvial Fan #3					
2.1.8	USGS Quad Sheet(s) with original photo date & latest photo revision date	Hieroglyphic Mountains SW, Arizona, 1982					
2.1.9	Unique Conditions and Problems	Alluvial Fan Flooding					
2.1.10	Coordination of Peak Discharges (Agency, Date, Comments)	FCDMC – Wittmann ADMSU (2005) Existing Conditions HEC-1 Model Results					

2.2 FEMA Forms

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

OVERVIEW & CONCURRENCE FORM

O.M.B No. 1660-0016
Expires: August 31, 2007

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 Parts 60 & 65 of the NFIP Regulations.)

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
040037	Maricopa County, Arizona and Unincorporated Areas	AZ	04013C	0705G 0715G 0720G 1130G	9/30/2005

2. Flooding Source: Hieroglyphic Mountain Alluvial Fan #3

3. Project Name/Identifier: Approximate Zone A Floodplain Delineation Study of Hieroglyphic Mountain Alluvial Fan #3

4. FEMA zone designations affected: A, X (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 ☐ 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 types of flooding and structures (check all that apply)

Types of Flooding:	☒ Riverine	☐ Coastal	☐ Shallow Flooding (e.g., Zones AO and AH)
	☒ Alluvial fan	☐ Lakes	☐ Other (Attach Description)
Structures:	☐ Channelization	☐ Levee/Floodwall	☐ Bridge/Culvert
	☐ Dam	☐ Fill	☐ Other, Attach Description

C. REVIEW FEE

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

☒ No, Attach Explanation: New Delineation by Agency

Map changes based on flood hazard information meant to improve upon that shown on the flood map or within the flood study.

Please see the DHS-FEMA Web site at http://www.fema.gov/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: Kathryn Gross, CFM, Project Manager	Company: Flood Control District of Maricopa County	
Mailing Address: 2801 West Durango Street Phoenix, AZ 85009	Daytime Telephone No.: (602) 506 1501	Fax No.: 602-506-4601
	E-Mail Address: kag@mail.maricopa.gov	
Signature of Requester (required):		Date:

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.

ɔmmunity Official's Name and Title: Timothy S. Phillips, P.E., Chief Engineer & General Manager		Telephone No.: 602-506-1501
Community Name: Maricopa County, AZ	Community Official's Signature (required):	Date:

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. 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: Jonathan Fuller, PE	License No.: 26846	Expiration Date: March 31, 2008
Company Name: JE Fuller/Hydrology & Geomorphology, Inc.	Telephone No.: 480-752-2124	Fax No.: 480-839-2193
Signature:		Date: 4-25-07

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

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

RIVERINE HYDROLOGY & HYDRAULICS FORM

O.M.B No. 1660-0016

Expires: August 31, 2007

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: Hieroglyphic Mountain Alluvial Fan #3

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 2) ☐ 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.)	FIS (cfs)	Revised (cfs)

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

☐ Statistical Analysis of Gage Records ☐ Precipitation/Runoff Model [TR-20, HEC-1, HEC-HMS etc.]

☐ 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. The document, "Numerical Models Accepted by FEMA for NFIP Usage" lists the models accepted by DHS-FEMA. This document can be found at: http://www.fema.gov/fhm/en_modl.shtm.

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	See attached annotated FIRMs			
Upstream Limit	See attached annotated FIRMs			

2. Hydraulic Method Used

Hydraulic Analysis HEC-RAS [HEC-2 , HEC-RAS, Other (Attach description)]

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 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/fhm/frm_soft.shtm. We recommend that you review your HEC-2 and HEC-RAS models with CHECK-2 and CHECK-RAS. If you disagree with a message, please attach an explanation of why the message is not valid in this case. Review of your submittal and resolution of valid modeling discrepancies will result in reduced review time.

HEC-2/HEC-RAS models reviewed with CHECK-2/CHECK-RAS? ☐ Yes ☐ No

4. Models Submitted ☐ Diskette Submitted

	Natural Run		Floodway Run		Datum
Duplicate Effective Model*	File Name:	Plan Name:	File Name:	Plan Name:	_____
Corrected Effective Model*	File Name:	Plan Name:	File Name:	Plan Name:	_____
Existing or Pre-Project Conditions Model	File Name: zonea	Plan Name: 100yr	File Name:	Plan Name:	NAVD88
Revised or Post-Project Conditions Model	File Name:	Plan Name:	File Name:	Plan Name:	_____
Other - (attach description)	File Name:	Plan Name:	File Name:	Plan Name:	_____

*Not required for revisions to approximate 1%-annual-chance floodplains (Zone A) – for details, refer to the corresponding section of the instructions.

The document "Numerical Models Accepted by FEMA for NFIP Usage" lists the models accepted by DHS-FEMA. This document can be found at: http://www.fema.gov/fhm/en_modl.shtm.

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.).

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 Included ☒ Digital Mapping (GIS/CADD) Data Submitted (Recommended)

D. COMMON REGULATORY REQUIREMENTS*

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

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.

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/CLOMR 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 from the community to show that they 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.

5. 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.

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

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

ALLUVIAL FAN FLOODING FORM

O.M.B No. 1660-0016
Expires: August 31, 2007

PAPERWORK REDUCTION ACT

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.**

Flooding Source: Hieroglyphic Mountain Alluvial Fan #3
Note: Fill out one form for each flooding source studied

A. THREE-STAGE ANALYSIS (Based on FEMA Guidelines dated February 23, 2000)

1. Stage 1 Analysis

   a. The landform is composed of (check one) ☒ alluvial ☐ debris flow deposits.

   b. Source of data used to determine composition, morphology, and location of the landform:

   NRCS Soils Maps, AZ Geological Survey Geologic Maps, USGS Topographic Maps, Aerial Photos, Field Observation

   c. Is there an NRCS soils survey and soil survey map available? ☒ Yes ☐ No
   If Yes, please include a copy of the map and any pertinent sections of the soil survey

2. Stage 2 Analysis

   a. The alluvial fan exhibits ☐ active ☐ inactive ☒ a combination of active and inactive alluvial fan flooding.

   b. Approximate age of inactive fan surfaces (thousands of years): > 10,000 yrs.

   c. Is there an opportunity for avulsions that could lead channels or sheetfloods across the older fan surfaces?
   ☐ Yes ☒ No

   d. Is there evidence of headcutting that could lead to stream piracy? ☒ Yes ☐ No

   e. Is there geomorphic evidence of past avulsions during the Holocene epoch? ☒ Yes ☐ No

   f. The fan exhibits the following types of flooding (check one):

   ☒ Flooding along stable channels
   ☒ Sheetflow
   ☐ Debris flow
   ☒ Unstable flow path flooding

3. Stage 3 Analysis

   The boundaries of the 1%-annual-chance floodplain have been determined using (check one):

   ☐ Risk-Based Analysis
   ☐ FEMA FAN program (if discharge at the apex is different than that given in the effective FIS, then attach MT-2, Form 2 along with a plot of the flood frequency curve on log-normal probability paper and include the drainage area above the hydrographic apex, and the mean, standard deviation, and skew coefficient of the curve)
   ☐ Sheetflow Methods
   ☐ Hydraulic Analytical Methods
   ☒ Geomorphic Data, Post-Flood Hazard Verification, and Historical Information
   ☐ Composite Methods

B. STRUCTURAL FLOOD CONTROL MEASURES

1. The following structural flood control measures are proposed or built (check one): **No Structural Measures are Proposed**

   ☐ Channelization ☐ Levee/Floodwall ☐ Dam ☐ Sedimentation Basin

2. Do the constructed or proposed structural measures affect flood hazards (including velocity, scour, and sediment deposition) on other areas of the fan? ☐ Yes ☐ No

3. Attach completed Form 3 (Riverine Structures Form).

4. Sediment Transport Considerations:

   Was sediment transport considered? ☐ Yes ☒ No If Yes, then fill out Form 3, Section F (Sediment Transport).

   If No, then attach your explanation for why sediment transport was not considered.

   Delineation was performed using approximate geomorphic methods. Sediment yield is reported from other studies.

5. Please attach a copy of the formal Operations and Maintenance Plan.

C. MAPPING REQUIREMENTS

Attach a certified topographic work map showing the following:

- The boundaries of the alluvial fan including: toe, topographic and hydrologic apexes, and lateral boundaries
- The delineation of the active and inactive portions of the fan as determined by the Stage 2 analysis
- The revised 1%-annual-chance floodplain boundaries, as determined by the Stage 3 Analysis, that tie into the effective floodplain boundaries
- The correct alignment of all structural features
- The map scale

SECTION 3: MAPPING AND SURVEY INFORMATION

3.1 Field Survey Information

Ground control survey work associated with the topographic mapping was performed previously by others under separate contract with the FCDMC, in conjunction with the District's topographic mapping program. The survey data for this project is presented in the North American Datum of 1983 (NAD 83), 1992 Central Zone of Arizona State Plane Coordinate System. Elevations are referenced to the North American Vertical Datum of 1988 (NAVD88).

3.2 Mapping

The topographic mapping was prepared by Stewart Geo Technologies in 2002, under FCDMC contract FCD 01-21. The topographic mapping was prepared by photogrammetric methods to two separate national map accuracy standards of 1-inch equals 100 feet with a 2-foot contour interval and 1-inch equals 200 feet with a 4-foot contour interval. The aerial photography flight dates were April 18, 2002 for the 2-foot mapping and April 22, 2002 for the 4-foot mapping.

SECTION 4: HYDROLOGY

4.1 Method Description

All hydrologic data used in this floodplain delineation study were obtained from the Wittmann ADMP Update Technical Data Notebook ADMSU Hydrology, Volume HY-1 of 3 Addendum prepared by Entellus Inc. (2005). No new hydrologic modeling was performed. The methods employed by Entellus are described in the Drainage Design Manual for Maricopa County, Volume I, Hydrology (1995) which uses the U.S. Army Corps of Engineers HEC-1 model (version 4.1) to compute runoff hydrographs and peak discharges. Rainfall losses were calculated by use of the Green and Ampt infiltration equation with an allowance for surface retention loss within HEC-1. The Clark Unit Hydrograph was used to generate unit hydrographs. Channel routing was performed using the normal depth methods. Peak discharges were estimated at various concentration points for the 100-year return period for the 6- and 24-hour durations. The larger estimate is recommended for use in the floodplain delineation. The watershed boundaries are shown in Figure 1.2.

4.2 Parameter Estimation

The Entellus Hydrology Data Notebook which includes descriptions of all modeling parameters, methodologies, assumptions and results, as well as HEC-1 input and output files is provided on the DVD. The Wittmann ADMSU HEC-1 modeling was approved by the District and was provided by the District for use in this study.

4.3 Problems Encountered During the Study

4.3.1 Special problems and solutions

No special problems with the hydrologic modeling were encountered.

4.3.2 Modeling warning and error messages

No warnings or error messages that relate to the Hieroglyphic Mountain Alluvial Fan #3 watershed occur in the HEC-1 models.

4.4 Calibration

No calibration of the models was performed as part of this study. However, the results were compared to previous studies and regional regression equations and found to be reasonable. In addition, the methods used in this study have been designed for application to the area and have been found to produce reasonable results in hundreds of studies throughout Maricopa County.

4.5 Final Results

4.5.1 Hydrologic analysis results

Table 4.2 shows the peak discharges and total runoff volumes results. The 24-hour storm produces higher peak discharges the concentration point at the fan apex.

Table 4.1
HEC-1 Hydrologic Modeling Results from the Wittmann ADMSU (Entellus, 2005)

Concentration Point	100-Year 24-Hour (cfs)	100-Year 6-Hour (cfs)	Drainage Area (sq. mi.)
CPI681	9,687	9,152	18.72

4.5.2 Verification of results

HEC-1 model result verification is discussed in the Wittmann ADMSU Hydrology Data Notebook provided on DVD with this report.

4.5.3 Comparison with Previous Studies

HEC-1 model result comparisons are discussed in the Wittmann ADMSU Hydrology Data Notebook provided on DVD with this report.

4.6 References

1. FCDMC, 2003, Drainage Design Manual for Maricopa County – Hydrology.

2. Entellus, 2005, Wittmann ADMP Update Technical Data Notebook ADMSU Hydrology, Volume HY-1 of 3 Addendum. Report prepared for the Flood Control District of Maricopa County.

SECTION 5: HYDRAULIC ANALYSIS

5.1 Method Description

The 100-year floodplain was delineated using approximate methods upstream of the hydrographic apex on the Hieroglyphic Mountain Alluvial Fan #3. The U.S. Army Corp of Engineers HEC-RAS v. 3.1.3[1] was used to perform hydraulic rating calculations to estimate the depth and width of inundation from the 100-year flood. The resultant width was applied to the stream reach at each cross section. Cross section locations along the study reaches were selected depending on the variability of the channel geometry. On average, the cross section spacing is approximately 1,000 feet. Cross section data were collected from the base map using various software tools available in AutoCAD Land Development Desktop 2005. The base map used included that described in Section 5.2 (below). An emphasis was placed on interpretation of surficial geology observed from the aerial base mapping and during field visits to augment the floodplain delineation. In some cases, adjustments to the computed floodplain widths were made based on aerial photograph interpretation and application of geomorphic principles. Appendix E includes the HEC-RAS cross sections, summary tables and detailed input/output files.

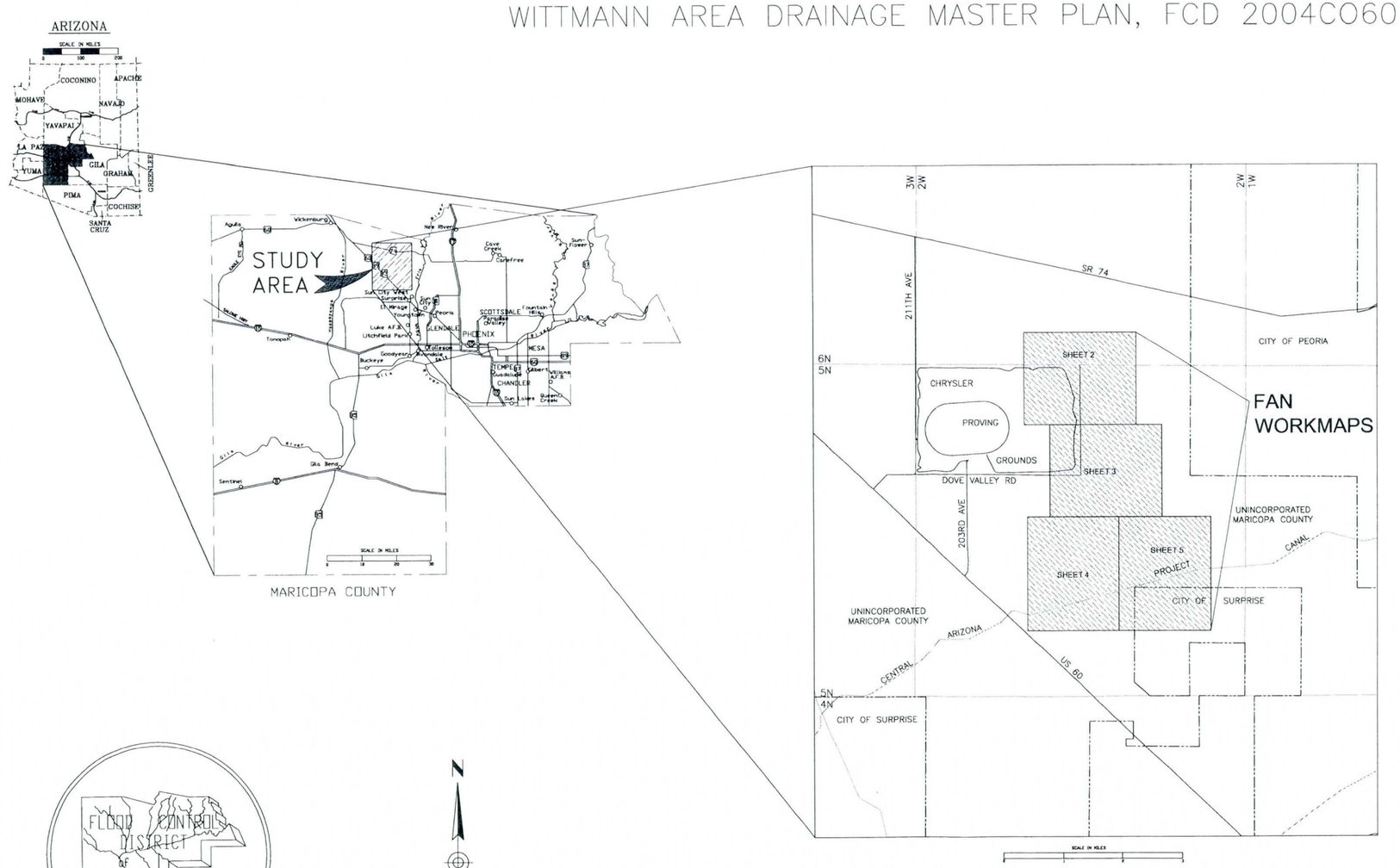
5.2 Work Study Maps

The Zone A delineation for the Hieroglyphic Mountain Alluvial Fan #3 is shown on 1"= 400', 2- or 4-foot contour interval base mapping with orthographic aerial photography. The work study maps and index sheet are presented in Exhibit Maps C of this Technical Data Notebook (TDN) on 24"x36" sheets. Reduced-scale copies of the work study maps are included on Figure 5.1.

The work study maps include cross-section locations, floodplain boundaries, zone designations, road names, state-plane coordinate grid, section lines, corporate boundaries and stream names/numbers. The flood zone delineated using approximate method hydraulic modeling of the reach upstream of the alluvial fan apex is shown as a Zone A administrative floodway on the work maps and annotated FIRM panels.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

APPROXIMATE ZONE A FLOODPLAIN DELINEATION STUDY OF HIEROGLYPHIC MOUNTAIN ALLUVIAL FAN #3 WITTMANN AREA DRAINAGE MASTER PLAN, FCD 2004C060



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

N

NOTES

1. HORIZONTAL PROJECTION IS ARIZONA STATE PLANE, CENTRAL ZONE, NORTH AMERICAN DATUM OF 1983.
2. ALL ELEVATIONS ARE BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.

STATEMENTS OF PROFESSIONAL REGISTRANT

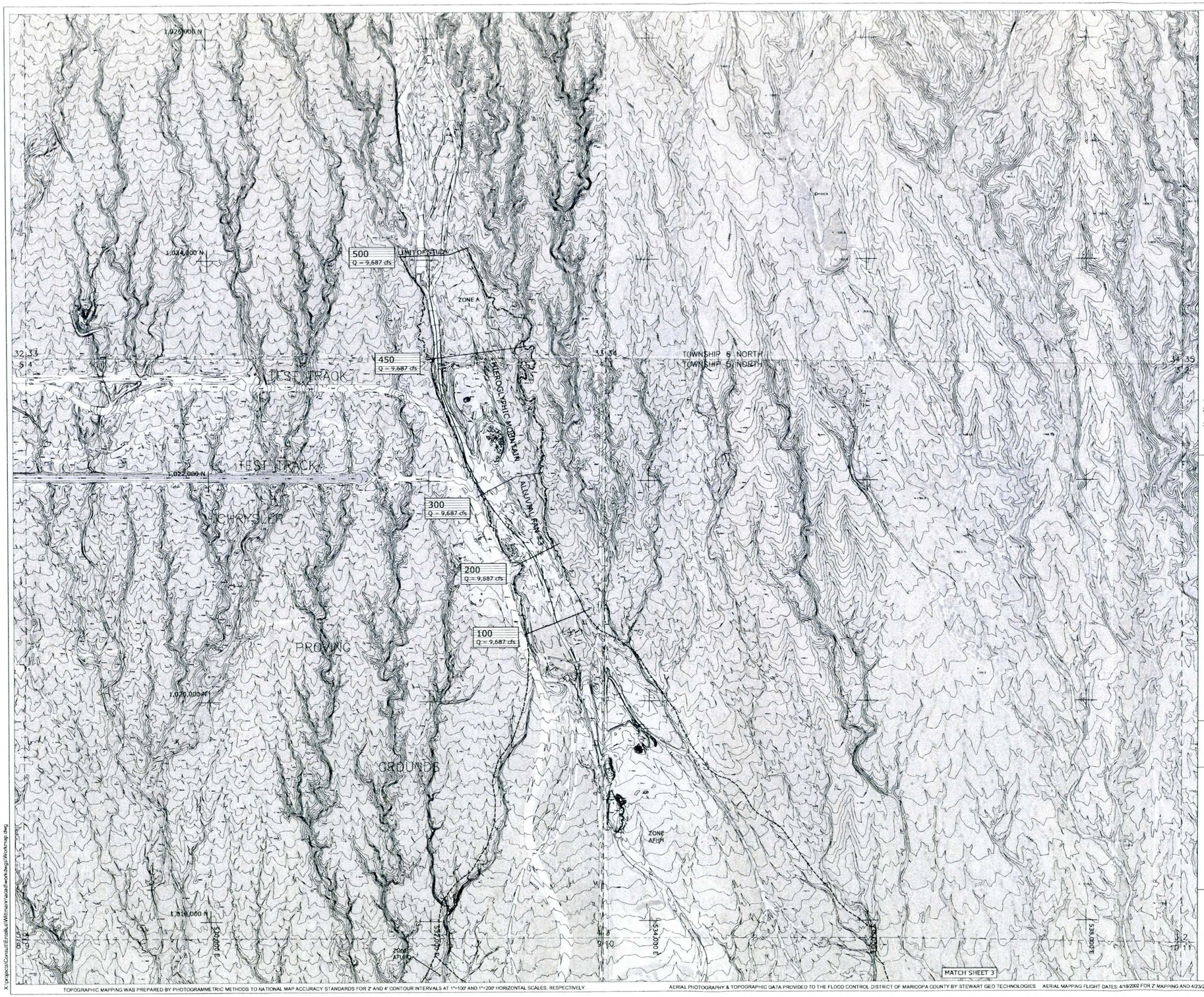
THE FLOODPLAIN DELINEATIONS PRESENTED ON THE FOLLOWING SHEETS WERE PREPARED UNDER MY DIRECT SUPERVISION.

Registered Professional Engineer
CERTIFICATE NO.
25846
JONATHAN E. FULLER
Date Signed 4-27-07
ARIZONA, U.S.A.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.
5400 S. KYRENE ROAD, SUITE 301
TEMPE, ARIZONA 85284
PHONE: 480-752-2134
FAX: 480-820-3163

INDEX SHEET

APRIL, 2007



LEGEND

100-YR FLOODPLAIN	
100-YR ADMINISTRATIVE FLOODWAY	
EFFECTIVE 100-YR FLOODPLAIN BOUNDARY	
EFFECTIVE 100-YR FLOODWAY	
SECTION BOUNDARY	
CROSS SECTION	200 Q = 9,687 cfs
CORPORATE LIMITS	Corporate Limits
COUNTY BOUNDARY	County Boundary
STATE PLANE COORDINATES	1,046,800 N / 646,800 E

ZONE DESIGNATIONS

ZONE A	Approximate 100-year administrative floodway; riverine reaches upstream of hydrologic apex.
ZONE A	Approximate 100-year floodplain.
ZONE AFHH	Alluvial Fan High Hazard administrative floodway
ZONE AFUFD	Alluvial Fan Uncertain Flow Distribution Area administrative floodway
ZONE AAFF	Approximate Alluvial Fan Floodway administrative floodway
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ZONE X (SHADED)	Areas flooded between 100- and 500-yr discharge, areas of 100-yr flooding depth less than 1 foot, or drainage area less than 1 square mile
ZONE X	Areas outside the 500-yr floodplain
ZONE D	Area not studied

NOTES

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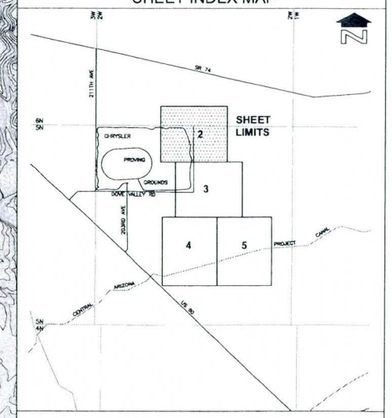
SHEET INDEX MAP



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

APPROXIMATE ZONE A FLOODPLAIN DELINEATION STUDY OF HIEROGLYPHIC MOUNTAIN ALLUVIAL

FAN #3

FCD 2004CO60
WITTMANN
AREA DRAINAGE MASTER PLAN
APRIL, 2007

SCALE IN FEET
400' 0' 400' 800'
CONTOUR INTERVAL = 2' AND 4' FEET

Registered Professional Engineer Certificate
25848
JONATHAN E. FULLER
Date Signed 4-23-07
ARIZONA U.S.A.

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.
PHONE: 480-752-2134
FAX: 480-839-2165

SHEET 2 OF 5

TOPOGRAPHIC MAPPING WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 2' AND 4' CONTOUR INTERVALS AT 1"=100' AND 1"=200' HORIZONTAL SCALES, RESPECTIVELY.

AERIAL PHOTOGRAPHY & TOPOGRAPHIC DATA PROVIDED TO THE FLOOD CONTROL DISTRICT OF MARICOPA COUNTY BY STEWART GEO TECHNOLOGIES. AERIAL MAPPING FLIGHT DATES: 4/16/2002 FOR 2' MAPPING AND 4/23/2002 FOR 4' MAPPING.

AERIAL UPDATE: NOVEMBER 2004.

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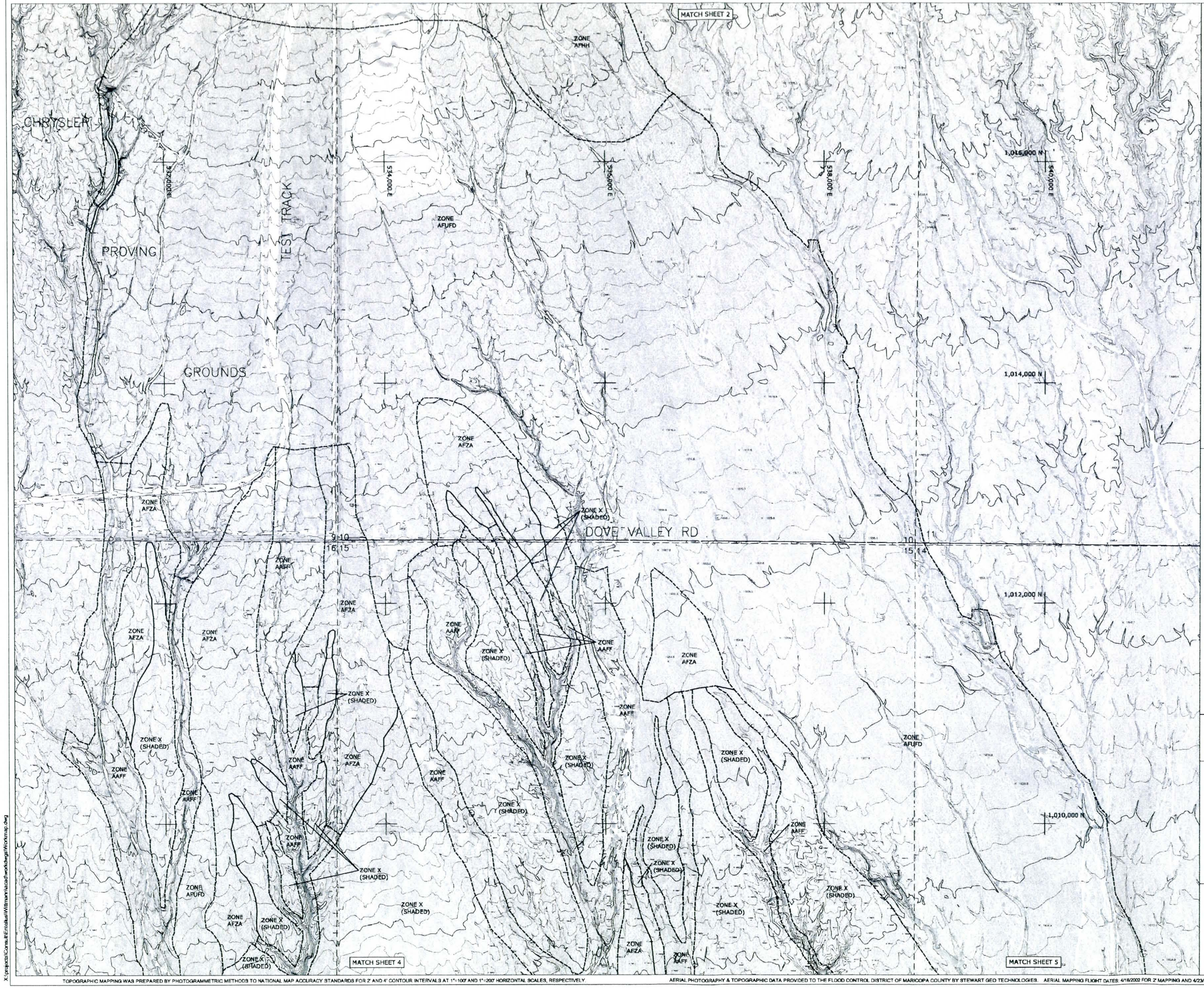

LEGEND

100-YR FLOODPLAIN
100-YR ADMINISTRATIVE FLOODWAY
EFFECTIVE 100-YR FLOODPLAIN BOUNDARY
EFFECTIVE 100-YR FLOODWAY
SECTION BOUNDARY
CROSS SECTION — 200, Q = 9,687 cfs
CORPORATE LIMITS — Corporate Limits
COUNTY BOUNDARY — County Boundary
STATE PLANE COORDINATES — 1,046,800 N, 648,800 E

ZONE DESIGNATIONS

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ZONE A	Approximate 100-year floodplain.
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ZONE D	Area not studied

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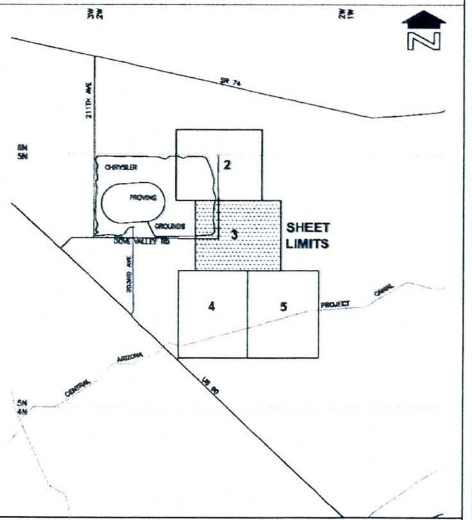
SHEET INDEX MAP



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

APPROXIMATE ZONE A FLOODPLAIN DELINEATION STUDY OF HIEROGLYPHIC MOUNTAIN ALLUVIAL

FAN #3

FCD 2004CO60
WITTMANN
AREA DRAINAGE MASTER PLAN
APRIL, 2007

Registered Professional Engineer (Civil) CERTIFICATE NO. 26846 JONATHAN E. FULLER Date Signed ARIZONA, U. S. A.

SCALE IN FEET
400' 0' 400' 800'
CONTOUR INTERVAL = 2 AND 4 FEET

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

SHEET 3 OF 5

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AERIAL UPDATE: NOVEMBER 2004.

LEGEND

- 100-YR FLOODPLAIN
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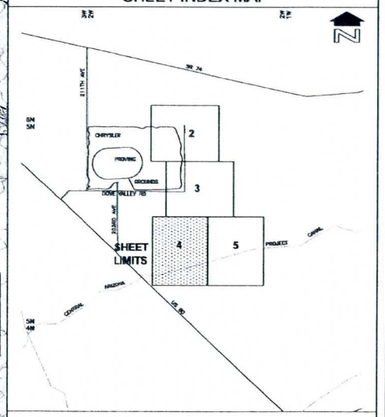

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

APPROXIMATE ZONE A FLOODPLAIN DELINEATION STUDY OF HIEROGLYPHIC MOUNTAIN ALLUVIAL

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WITTMANN
AREA DRAINAGE MASTER PLAN
APRIL, 2007

ARIZONA Professional Engineer CERTIFICATE NO. 26845 JONATHAN E. FULLER Date Signed ARIZONA, U.S.A.

SCALE IN FEET
400' 0' 400' 800'
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JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

SHEET 4 OF 5

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AERIAL UPDATE: NOVEMBER 2004.

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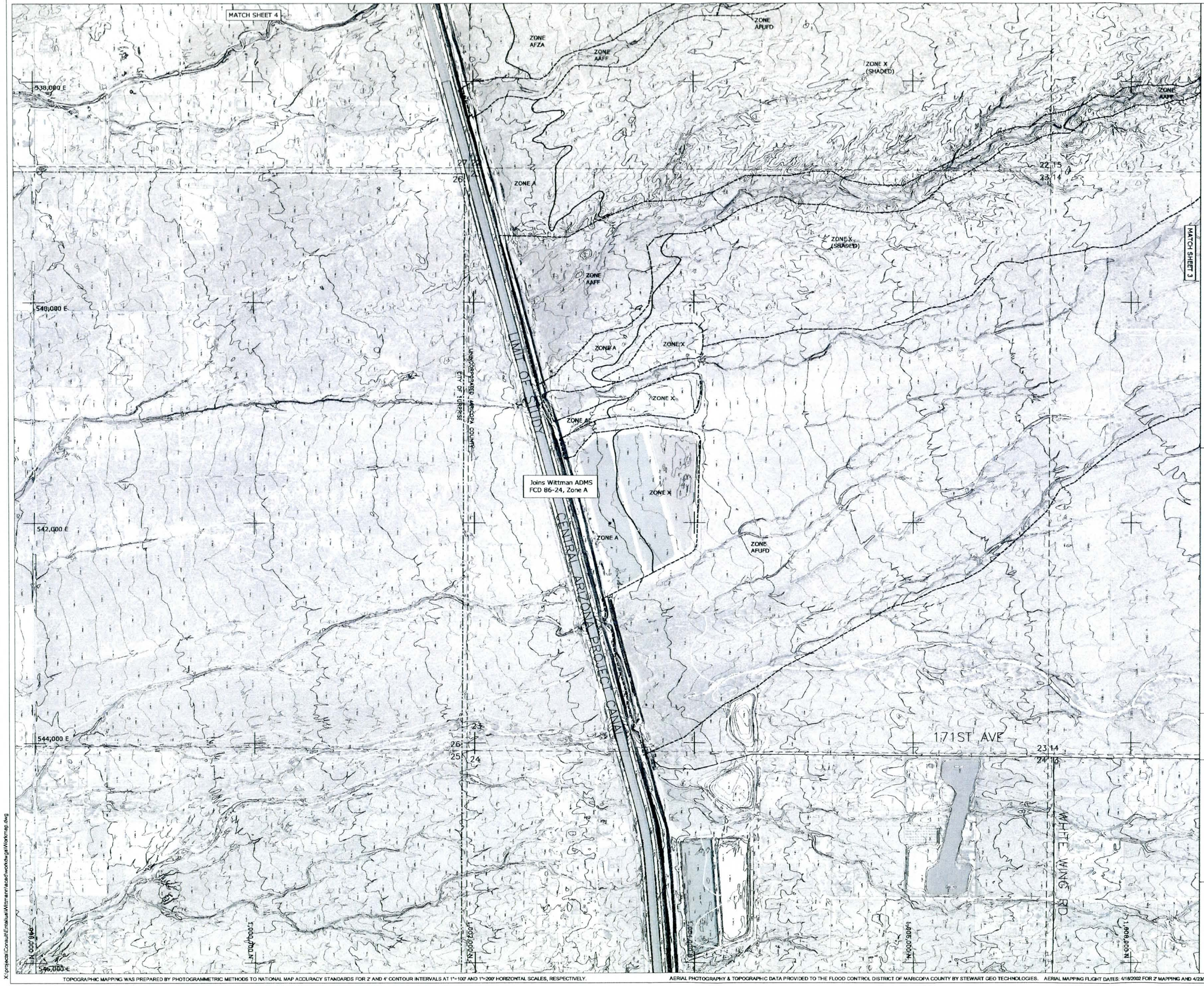

LEGEND

100-YR FLOODPLAIN		
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ZONE DESIGNATIONS

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ZONE A	Approximate 100-year floodplain.
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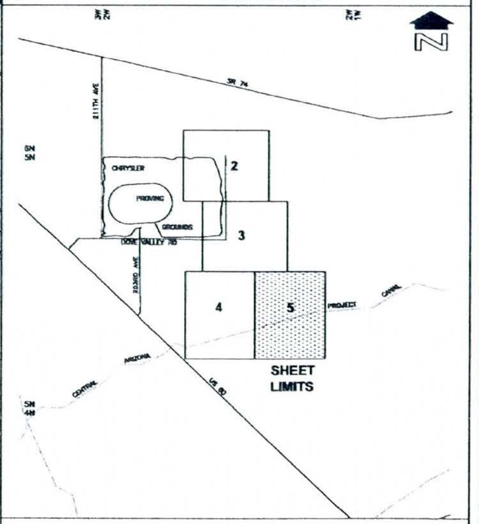
SHEET INDEX MAP



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

APPROXIMATE ZONE A FLOODPLAIN DELINEATION STUDY OF HIEROGLYPHIC MOUNTAIN ALLUVIAL

FAN #3

FCD 2004CO60
WITTMANN
AREA DRAINAGE MASTER PLAN
APRIL, 2007

Registered Professional Engineer (Civil) CERTIFICATE NO. 26846 JONATHAN E FULLER Date Signed ARIZONA, U.S.A.

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CONTOUR INTERVAL = 2 AND 4 FEET

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SHEET 5 OF 5

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AERIAL UPDATE: NOVEMBER 2004.

5.3 Parameter Estimation

HEC-RAS v3.1.3 was used to determine the hydraulic profile calculations for each cross section. The containment reach was modeled in the sub-critical flow regime and the downstream boundary conditions were set at normal depth.

5.3.1 Roughness Coefficients

Manning's roughness coefficient (n value) describes the friction attributable to the channel, banks and overbank areas. The n value generally varies with depth of flow, so it is determined assuming a flow depth associated with the 100-year discharge. Manning's "n" values were determined using the methodology outlined in the USGS report titled, "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" by Jeff V. Phillips and Saeid Tadayon, (2006)[2]. Field reconnaissance was undertaken to photograph the reach and to document channel and overbank conditions. Photographs of the containment reach and a field reconnaissance photo location map are provided in Appendix E.1.

The containment reach generally consists of sandy to gravelly channel bottom and overbank areas. The main channel is moderately well defined. In general, the study area is covered by the Upper Sonoran plant community. Vegetation throughout the study reaches include trees such as mesquite, little leaf Palo verde, creosote and ocotillo, cacti including saguaro, barrel, staghorn, and teddy bear cholla, and various shrubs such as desert broom, jojoba, brittle bush and hackberry.

The worksheet shown in Table 5.1 was prepared to estimate the Manning's roughness coefficients that were used for this approximate study.

5.3.2 Expansion and Contraction Coefficients

The expansion and contraction coefficients used throughout the study were 0.3 and 0.1, respectively. No abrupt changes in the floodplain width were encountered that would warrant modification of these coefficients.

5.4 Cross-section descriptions

Cross section geometry was developed from the elevation contours. Cross sections are labeled numerically in intervals of 100 increasing in the upstream direction. Cross section stationing is from left to right as viewed in the downstream direction. Cross section plots are located in Appendix E.2

Table 5.1. Manning's Roughness Coefficient Worksheet

Channel Conditions		Manning's n Adjustment		Left Overbank	Main Channel	Right Overbank
Channel Bed Material	Concrete	n0	0.012-0.018			
	Rock Cut		0.025			
	Firm Soil		0.025-0.032			
	Fine Sand		0.023-0.036			
	Coarse Sand		0.026-0.035	0.03	0.03	0.03
	Gravel		0.028-0.035			
	Cobble		0.030-0.050			
	Boulder		0.040-0.070			
Degree of Irregularity	Smooth	n1	0.000			
	Minor		0.001-0.005	0.003	0.003	0.003
	Moderate		0.006-0.010			
	Severe		0.011-0.020			
Effects of Obstructions	Negligible	n2	0.000-0.004			
	Minor		0.005-0.015	0.01	0.01	0.01
	Appreciable		0.020-0.030			
	Severe		0.040-0.060			
Vegetation	Small	n3	0.002-0.010		0.002	
	Medium		0.010-0.025	0.02		0.020
	Large		0.025-0.050			
	Very Large		0.050-0.100			
Variations in the Channel Cross	Gradual	n4	0.000	0.000	0.000	0.000
	Alternating		0.001-0.005			
	Alternating (frequently)		0.010-0.015			
Degree of Meandering	Minor	m	1.00	1	1	1
	Appreciable		1.15			
	Severe		1.30			
n=(n0+n1+n2+n3+n4)m				0.063	0.045	0.063
			Use	**0.065**	**0.045**	**0.065**

5.5 Modeling Considerations

5.5.1 Hydraulic Jump and drop analysis

No hydraulic jump or drop analyses were conducted in this study.

5.5.2 Bridge or Culverts

No bridge or culvert analyses were conducted in this study.

5.5.3 Levees and Dikes

There are no levees or dikes within the project area.

5.5.4 Islands and Flow Splits

In general, small islands were not delineated on the work maps. No split flows occur in the reach upstream of the hydrographic apex.

5.5.5 Ineffective Flow Areas

No significant ineffective flow areas exist in the natural channels in this study.

5.5.6 Supercritical Flow

Supercritical flow does not occur for significant lengths along any reach in this study.

5.6 Floodway modeling

Floodway modeling was not conducted for this study. The Flood Control District of Maricopa County (FCDMC) manages the approximate floodplain delineations as administrative floodways and shows them as such on the floodplain workmaps (i.e. floodplain = floodway). In addition, the FCDMC administers certain approximate method alluvial fan zone designations as administrative floodways. The alluvial fan delineations are described in Section 6B.

5.7 Special problems encountered during the study

No special problems were encountered during this study.

5.8 Calibration

No hydraulic calibration was performed during this study.

5.9 Final Results

5.9.1 Hydraulic analysis results

This portion of this study resulted in 100-year Zone A riverine delineations for 0.68 miles of the Hieroglyphic Mountain Alluvial Fan #3. The hydraulic analysis results are provided in the HEC-RAS summary Table 5.2. Appendix E.3 contains the HEC-RAS model detailed input and output.

Table 5.2. HEC-RAS Summary

River Station	Q Total (cfs)	W.S. Elev'n (ft)	Crit WSEL (ft)	Vel Total (ft/s)	Top Width (ft)	Max Chl Depth (ft)	Froude # XS	Sta W.S. Left (ft)	Sta W.S. Right (ft)
500	9687	1836.31	1836.31	6.12	617.9	5.31	0.67	21.65	639.56
450	9687	1821.15	1821.05	7.12	573.88	7.15	0.81	19.7	869.21
300	9687	1802.27		7.88	395.13	5.27	0.79	27.41	603.49
200	9687	1791.81	1791.33	8.39	317.43	4.81	0.78	62.55	401.73
100	9687	1783.81	1783.12	5.83	567.18	4.31	0.6	50.43	617.61

5.10 References

1. U.S. Army Corps of Engineers, HEC-RAS River Analysis System, Version 3.1.3, May, 2005.

2. Phillips, J.V., and Tadayon, S., 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.

SECTION 6: SEDIMENT TRANSPORT/EROSION

SECTION 6A: EROSION AND SEDIMENT TRANSPORT

No specific erosion or sediment transport analyses were conducted as part of this study. However, sedimentary processes were implicitly considered in the geomorphic assessment of alluvial fan. Therefore, areas of erosion hazards associated with the active alluvial fan flooding have been included in the floodplain delineation.

Sediment yield estimates were performed for the Wittmann ADMSU (WEST, 2004) and are used without modification for this study. The WEST sedimentation report is provided in Appendix G.

SECTION 6B: GEOMORPHOLOGY

This section of the Technical Data Notebook describes the geomorphic methods used to delineate the flood hazards on the Hieroglyphic Mountain Alluvial Fan #3. Section 6B is organized to follow the outline of the Piedmont Flood Hazard Assessment Manual (PFHAM) (Hjalmarson, 2003) format, as well as the FEMA Guidelines (FEMA, 2002). Hydrology and hydraulic data used in the delineation are described in Sections 4 and 5 of this TDN. Both the PFHAM and the FEMA Guidelines describe a three stage delineation process. The FEMA Guidelines are intended only for alluvial fans, whereas the PFHAM is applicable to a wider range of piedmont surfaces. The three stage delineation process includes the following steps:

- Stage 1: Recognizing and Characterizing Alluvial Fan Landforms
- Stage 2: Defining Active and Inactive Areas of Erosion and Deposition
- Stage 3: Defining the 100-Year Floodplain

Downstream of the hydrographic apex, geomorphic methods, historical data, and limited post-flood hazard verification data were used to delineate the flood hazard zones, as specified in Table G-1 of the FEMA Guidelines. Upstream of the hydrographic apex, geomorphic methods were used to complement and refine conventional approximate normal-depth hydraulic methods, as described in Section 5 of the TDN.

6B.1 Previous Studies

Several previous studies of the geomorphology and relative flood hazards have been conducted in and around the study area. These studies include the following:

- Huckleberry, Gary (1994), *Surficial Geology of the Wittmann and Hieroglyphic Mountains Southwest 7.5' Quadrangles, Northern Maricopa County, Arizona.*

  This mapping project is the most recent AZGS geologic and surficial mapping of the study area.

- WEST Consultants (2005), Wittmann ADMS Update Geomorphic and Sedimentation Analysis. Report Volume GR Final Report. Report to the Flood Control District of Maricopa County.

  This report includes a sediment yield analysis and landform mapping, as well as some Stage 1 alluvial delineations outside the current study limits.

6B.2 Data Sources

6B.2.1 NRCS Soils Map Unit Interpretation

The soils data used in this study were derived from a Natural Resource Conservation Service (NRCS) soil survey report entitled *Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona* (Camp, 1986). This detailed soil survey was developed for use by land planners, farmers, ranchers, agronomists, rangeland managers, community officials, geologists, engineers, developers, builders, home buyers, and watershed and wildlife managers. The Camp (1986) soil survey data was converted to a digital format in 2001. Digital versions of the NRCS soils data obtained from the NRCS web site were used for this study.

6B.2.2 AZGS Map Unit Interpretation

The Arizona Geological Survey (AZGS) published multiple surficial geologic maps at varying scales within the SVADMP study area. Table 6B.1 lists the AZGS maps available for the SVADMP study area.

Table 6B.1. Collected AZGS Geology Maps

Map Name	Map Format	Scale	Year	Authors
Surficial Geology of the Wittmann and Hieroglyphic Mountains Southwest 7.5' Quadrangles, Northern Maricopa County, Arizona	Scanned raster	1:24,000	1994	Gary Huckleberry
Geologic Map of the Phoenix North 30' x 60' Quadrangle, Central Arizona	Digital GIS	1:100,000	1997	S.J. Reynolds, M.J. Grubensky

6B.2.3 Aerial Photography

Modern Orthophotography

Color, digital, orthophotography covering the entire SVADMP study area was provided by the Flood Control District of Maricopa County. Over 400 image tiles were collected, each covering approximately 0.90 square miles at a resolution of 1-foot/pixel.

Historical Aerial Photography

Limited historical aerial photography was collected from the Flood Control District of Maricopa County. The photos were provided as digital image files scanned from the original photo prints. Table 6B.2 lists the years of historical photos coverage used in this study.

Table 6B.2. Collected historical aerial photography		
Photo Year	**Original Photo Print Scale**	**Format**
1949	1:20,000	B&W scanned
1986	1:7,200	B&W scanned

6B.2.4 Topographic Mapping

The primary mapping source used in this study was 10-foot contour interval, digital topography provided by the Flood Control District of Maricopa County. The mapping was performed county-wide scale in December 2000. Additional 2- to 4-foot digital topography was provided by the District for the Wittmann ADMP study area including most of the area of the Hieroglyphic Mountain Alluvial Fan #3.

6B.3 Method Description

The PFHAM alluvial fan floodplain delineation methodology is based on the three stage process outlined in the National Research Council's (NRC, 1996) report, *Alluvial Fan Flooding*. Both the PFHAM and NRC documents describe a three stage method used to identify alluvial fan flood hazards, which was later adapted for the FEMA Guidelines Appendix G (2002). The PFHAM broadens the three-stage delineation approach to cover a variety of piedmont landforms.

Stage 1 of the PFHAM/FEMA alluvial fan methodology is the recognition and characterization of piedmont landforms. The intent of the Stage 1 analysis is to distinguish alluvial fan landforms from riverine, sheet flow, ponding, or coastal landforms.[1] If the landform in question is identified as an alluvial fan, then the delineation may proceed using the PFHAM/FEMA Stage 2 and 3 procedures. If the landform is not an alluvial fan, then more traditional floodplain delineation procedures should be applied. The Stage 1 delineation relies on the following types of information:

- Composition. Alluvial fans are composed of loose, unconsolidated materials transported by fluvial or debris flow processes (a.k.a., "alluvium").
- Morphology. Alluvial fans have the shape of a partially or fully extended fan as observed on topographic maps or aerial photographs.
- Location. Alluvial fans are usually found at a topographic break where stream channels become less confined than upstream of the break.

[1] FEMA Guidelines, p. G-6, 1st paragraph.

- Boundaries. The downstream boundary of an alluvial fan is called the "toe," which is located at an axial stream, lake or landform not dominated by alluvial fan flooding processes. The lateral boundaries of the fan are defined by a transition from alluvial fan flooding processes to riverine processes, although an alluvial fan may also coalesce into adjacent alluvial fans to form a bajada.[1]

Data sources for the Stage 1 delineation included topographic maps, NRCS soil surveys, geologic mapping, aerial photographs, and field observations. These data were used to differentiate piedmont landforms which included mountains, inselbergs, alluvial fans, pediments, and riverine floodplains. The locations of the topographic and hydrographic apexes on the alluvial fan were also identified in Stage 1. The topographic apex is the extreme upstream extent of the alluvial fan landform, which is often located at the mountain front or within a mountain front embayment. The hydrographic apex is the location at which flow of water and sediment becomes unconfined and spreads out rapidly. Sudden expansion of flow at the hydrographic apex causes sediment deposition, uncertain flood flow paths, and uncertain flow distribution below the apex. The complex hydraulics associated with this flow expansion and sediment deposition can create significant uncertainties (unpredictability) that "cannot be set aside in the realistic assessment of the flood hazard" (FEMA, 2002), which is the defining characteristic for alluvial fan flooding.

The piedmont on which the Chrysler Proving Ground is located consists of an extensive landform surface that links the Hieroglyphic Mountains with the historical Trilby Wash alignment. There are a number of individual active alluvial fans located on this piedmont that are hydrologically, hydraulically and geomorphically separated from one another. The active fan areas on this piedmont are located well away from the mountain front, and are inset within the original alluvial fans, sometimes with two or more hydrographic apexes on what was once (in geologic time) a single alluvial fan landform. This piedmont landform, in conjunction with the complicated hydrographic apex locations, makes the Stage 1 alluvial fan landform delineation somewhat problematic. Therefore, the Stage 1 delineation incorporates an area much larger than the Hieroglyphic Mountain Alluvial Fan #3 study limits. Enough of the Stage 1 landform is shown to demonstrate that it meets the FEMA alluvial fan landform definition criteria.

Stage 2 of the PFHAM/FEMA alluvial fan methodology consists of defining active and inactive[2] areas portions of the alluvial fan landform. Active areas are those locations where uncertainties about channel geometry and hydraulic conditions of water and sediment discharge cannot be set aside in the realistic assessment of flood hazard. Active areas on alluvial fans experience sediment deposition, erosion and

[1] A bajada is "a low-lying area of confluent pediment slopes and alluvial fans at the base of mountains around a desert" (The New Penguin Dictionary of Geology, 1996).

[2] FEMA uses the terms "active" and "inactive." The PFHAM uses "stable" and "unstable," respectively, for the same concept, although most geomorphologists attached different meanings to the terms.

unstable flow paths in addition to flood inundation. Generally, active alluvial fans have experienced these processes within the past 10,000 years (the Holocene Epoch). Inactive alluvial fan areas are the portions of the alluvial fan where active fan processes do not occur. Generally, inactive alluvial fans have not experienced such processes within the past 10,000 years, but may have done so during much older geologic periods (the Pleistocene Epoch or Tertiary Period). Stage 2 also identifies portions of the piedmont subject to various types of flooding such as stable riverine flooding, active alluvial fan flooding, inactive alluvial fan flooding, and/or sheet flooding.

According to FEMA Guidelines, Stage 2 delineations may be completed using a geomorphic-based approach, if the alluvial fan has little or no urbanization (Table G-1, FEMA, 2002). In the geomorphic approach, the following surficial stability characteristics are compiled and evaluated:

- Detailed Soils Mapping. Detailed soils maps prepared by the USDA Natural Resource Conservation Service (NRCS) are available for the entire study area. NRCS soils maps describe soil composition, as well as provide some degree of landform interpretation.
- Surficial Geologic Mapping. The Arizona Geological Survey (AZGS) has prepared several types of surficial geology and flood hazard assessment maps for the entire study area. The AZGS maps indicate surface age, degree of flood hazard, and landform type.
- Topographic Mapping. Topographic data to be considered include the fan profile, crenulation index (degree of incision), fan shape, and slope. 2- and 4-foot contour interval topographic data are available for the study area. Topographic data are also used to estimate flow containment when defining fan boundaries. The topographic data were also used to construct longitudinal profiles of the alluvial fans.
- Vegetation. Vegetation patterns can be used to identify flow paths or areas of more frequent inundation (dense vegetation), sheet flow (uniform vegetation), the degree of soil development (e.g., ocotillo are a marker species for carbonate soil horizons), soil material (e.g., saguaro cacti prefer rocky, well drained soils), surface age (e.g., old surfaces have more slow growing species, creosote clone rings are wider on older surfaces), and surface boundaries (e.g., vegetation suites change with soil types and landform).
- Surficial Characteristics. Older, inactive surfaces tend to have well developed surficial features such as desert varnish, desert pavement, soil reddening, and incised, well-defined drainage patterns.
- Sediment Delivery Potential Sediment yield estimates can be used to estimate fan aggradation rates and define a zone of aggradation more likely to experience active fan processes.

- Drainage Pattern. Inactive fans tend to have tributary drainage patterns with well defined divides. Active fans tend to have distributary drainage patterns with poorly defined divides and/or perched flow paths.
- Historical Aerial Photographs. Channel positions from historical 1949 aerial photographs were compared with channel positions on 2005 aerial photographs to identify areas of known channel movement and changes in channel pattern.

The piedmont landform described in this TDN included active and inactive alluvial fan areas, but also included extensive flow corridors located downstream of the primary active alluvial fan areas in which flow distribution uncertainty exists. These flow paths downstream of the active fan areas are often relatively stable, at least within an engineering time scale of several hundred years, and are typically separated by stable, older, topographically-higher surfaces. Because of the flow path uncertainty in the active, unstable area upstream, accurate determination of a peak discharge for the downstream (more stable) flow corridors is not possible. Also, because these downstream flow corridors often have complicated distributary channel patterns, and because the study area has "little or no urbanization" (FEMA Guidelines, Table G-1), the downstream flow corridor floodplains were delineated using geomorphic methods.

Stage 3 of the PFHAM/FEMA alluvial fan methodology involves identifying the areas subject to flooding in a 100-year flood event. Stage 3 methodologies range from conventional detailed or approximate hydraulic methods using fixed-bed hydraulic models, such as Manning's equation, to geomorphic interpretation based field observations and aerial photographs. For this study, geomorphic methods were used for all of the alluvial fan reaches downstream of the hydrographic apex, including the "stable" reaches downstream of unstable, active alluvial fan areas.

6B.4 Stage 1: Recognizing and Characterizing Piedmont Landforms

Stage 1 of the PFHAM/FEMA alluvial fan methodology consists of recognizing and characterizing piedmont landforms. The primary objective of the Stage 1 analysis is to distinguish alluvial fan landforms from riverine, sheet flow, ponding, or coastal landforms. If an alluvial fan landform is identified, the location of the topographic and hydrographic apexes also must be determined. The Stage 1 assessment uses geomorphic characteristics obtained from soils maps, surficial geology maps, topographic maps, and aerial photographs, as well as field observations. As described above, a Stage 1 delineation was performed for the piedmont area surrounding the Hieroglyphic Mountain Alluvial Fan #3.

The Hieroglyphic Mountain Piedmont consists of a broad geomorphic surface that slopes from the mountains to Trilby Wash, which served as the axial stream. Although a number of inselbergs crop out within the upper piedmont, well upstream of the Hieroglyphic Mountain Alluvial Fan #3, the vast majority of the

piedmont is composed of alluvium deposited below the mountain front in a radiating (albeit coalesced) pattern. The piedmont area is bounded by the Hassayampa River to the west and the Agua Fria River to the east. To the south, the piedmont transitions gradually to a sheet flow area before reaching the axial drainage system at the Trilby Wash historical alignment. Today, the lower piedmont is truncated by the CAP which creates a depositional and ponding environment which interrupts the natural geomorphic processes to some degree.

6B.4.1 Composition

NRCS soils maps (Figure 6B.1; adapted from Camp, 1986; Hartman, 1977) and AZGS surficial geology maps (Figure 6B.2; adapted from Field and Pearthree, 1991) show that the entire piedmont area is composed of alluvial sediments, with the exception of a few inselbergs.

6B.4.1.1 Soils Data

Figure 6B.1 shows the NRCS soil map units overlain on the USGS topographic quadrangles. The soil unit polygons were obtained from the Soil Survey of Aguila-Carefree Area (Camp, 1986). Table 6B.4 gives a list and description of the NRCS soil units within the study area. In addition to showing the map unit boundaries and designations, Figure 6B.1 shows by color the setting or type of landforms generally associated with each of the various map units as distinguished by the NRCS. The three main categories of landforms distinguished by the NRCS map unit descriptions are: 1) drainageways, floodplains, and alluvial fans, 2) alluvial fan terraces, and 3) mountains and hillslopes. Complete soil unit descriptions for the study area are provided in Camp (1986).

The NRCS soils map units are grouped into broad soil associations as shown on the General Soils Maps provided in the NRCS soils reports. On the General Soils Maps, the bedrock areas of the Hieroglyphic Mountains are mapped as the Gran-Rock Outcrop-Lehman Association (Camp, 1986), which consist of shallow gravelly and non-gravelly soils and rock outcrop on hill slopes and mountain slopes. The majority of the piedmont bounding the mountain bedrock core is mapped as Tremant-Ebon-Pinamt Association (Camp, 1986), which is found on gently to moderately steep slopes of fan terraces and consists of gravelly and very gravelly loamy soils. To the south, the General Soils Map indicates an area underlain by the Momoli-Carrizo-Denure Association, which is described as nearly level, non-gravelly to gravelly loamy and sandy soils on fan terraces.

Table 6B.4 also shows the relationship between the detailed NRCS soil map units and the various piedmont landforms. As can be seen from the table, each soil map unit is actually comprised of several soil series. Each series has its own associated position or landform which is identified in the table. Characteristics important to the soil series age, stability, and flood history are also presented in Table 6B.4. These characteristics help identify the landform type, as well as the stability and the flood history and flood potential of the unit, as described in the Stage 2 analysis.

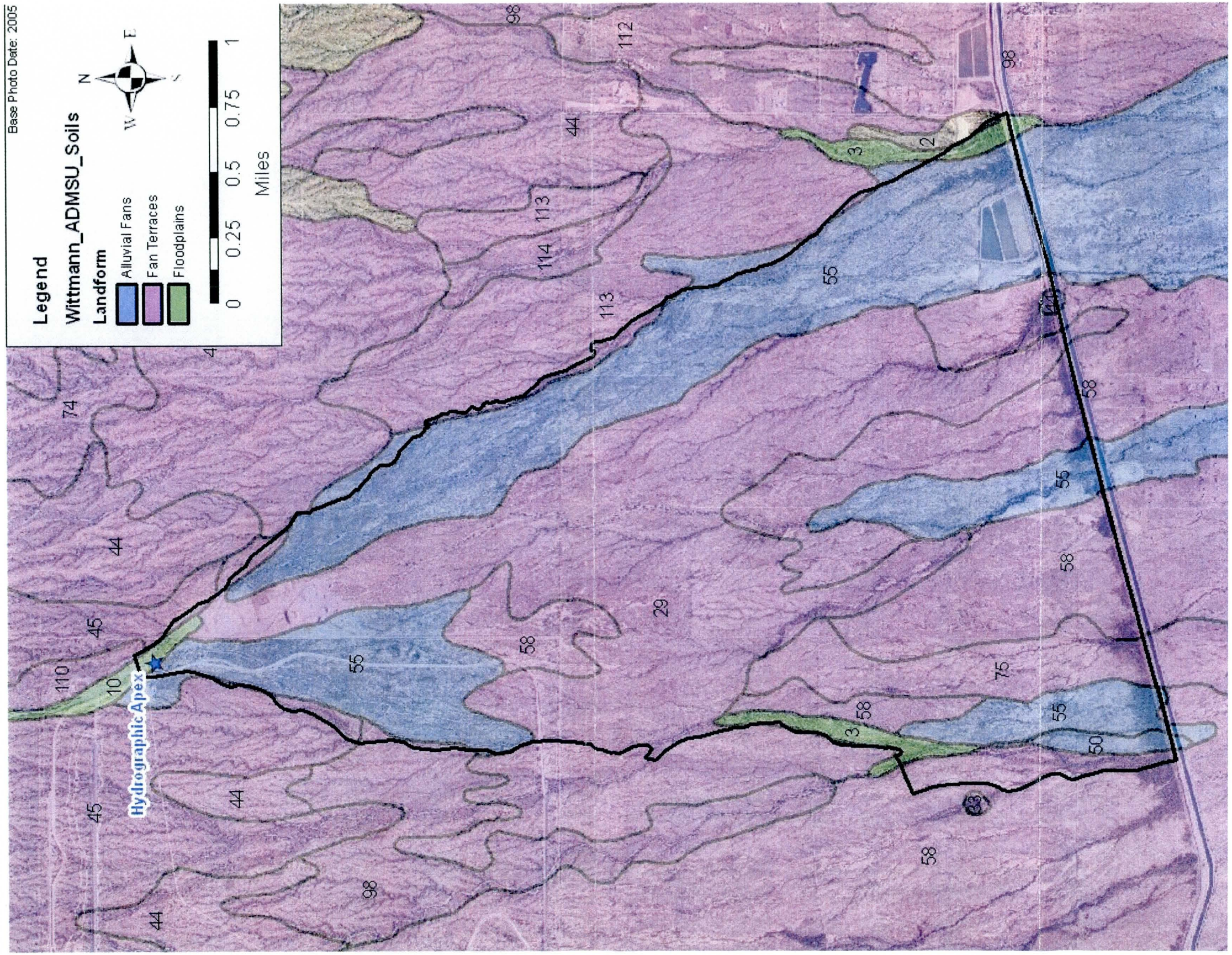


Figure 6B.1. NRCS soils mapping with landform interpretations – the entire area is shown as alluvial fan or fan terrace

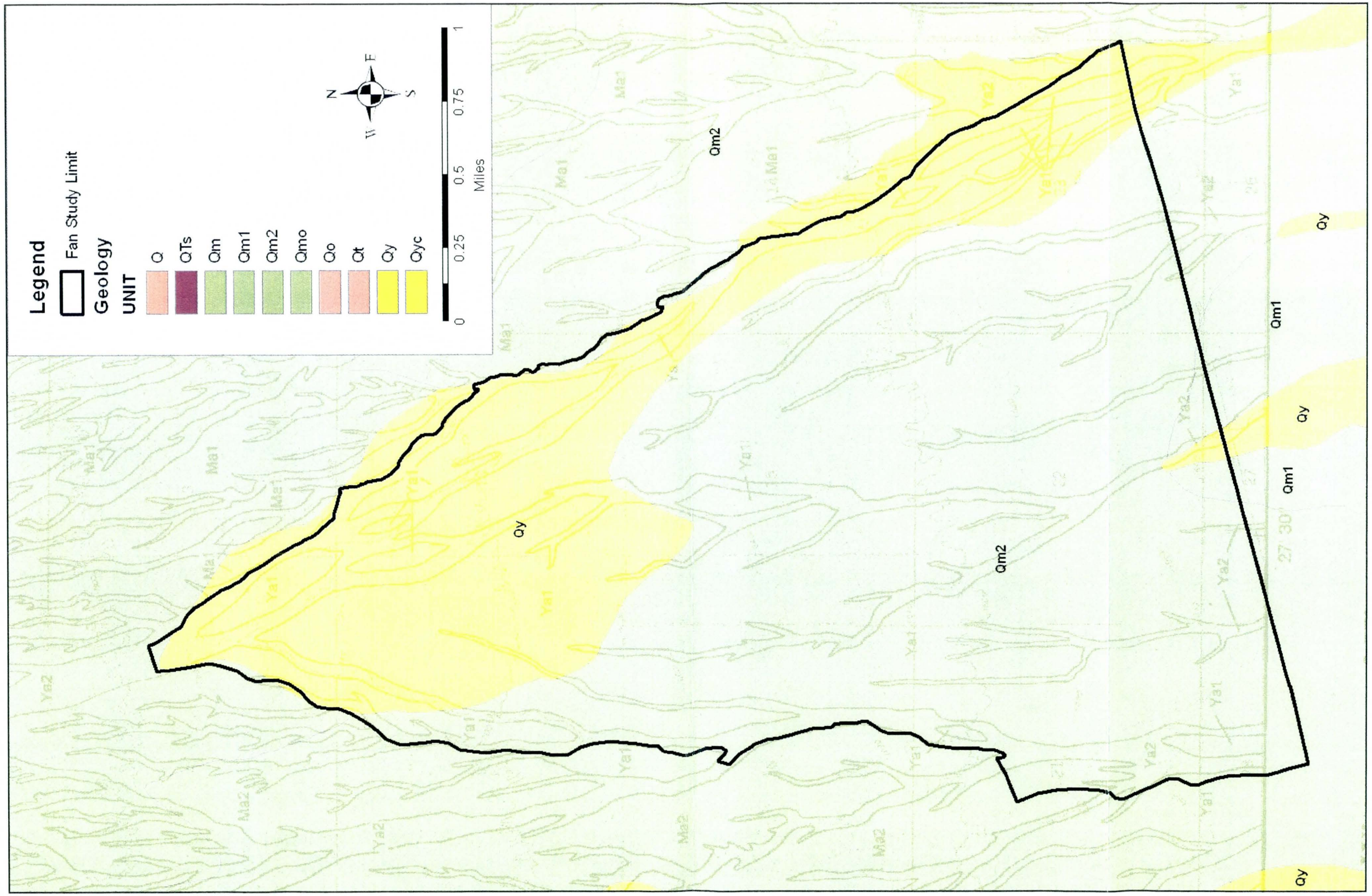


Figure 6B.2. AZGS geologic mapping (Mapping source references given in Table 6B.1)

The key facts derived from the NRCS soils mapping with respect to the Stage 1 delineation are that the piedmont area is underlain by alluvium and that soils are associated with alluvial fans, fan terraces (inactive alluvial fans), and alluvial plains. The NRCS soil descriptions provided in Table 6B.4 are consistent with the common soil types for alluvial fans shown in Table 2.1 of the PFHAM.

6B.4.1.2 Surficial Geology

Figure 6B.2 shows the 1:24,000 scale surficial geologic mapping of the piedmont by Huckleberry (1994) of the Arizona Geological Survey (AZGS). Figure 6B.2 shows the entire piedmont area surrounding the Hieroglyphic Mountain Alluvial Fan #3 is composed of alluvium of either Pleistocene or Holocene in age. Complete descriptions of the surficial geologic units are provided in Huckleberry (1994). The following units in the study area were mapped by the AZGS:

- Modern Stream Channels (Ya2). These surfaces experience frequent flood inundation and active sedimentation and erosion. The Ya2 unit is the youngest unit and is found along modern stream channels.
- Holocene Alluvial Fans & Drainageways (Ya1). These surfaces have experienced active deposition and erosion during the last 10,000 years. The Ya1 unit is found on relatively young alluvial fans.
- Younger Pleistocene Alluvial Fans (Ma2). The Ma2 units are of Pleistocene age (10,000 to 200,000 years), and have been subject to erosion and transport in recent geologic time.
- Pleistocene Alluvial Fans (Ma1). The Ma1 units represent Pleistocene age (200,000 to 500,000 years) surfaces of relict and inactive alluvial fans.
- Bedrock Units (X and T). Bedrock units occur within the Hieroglyphic Mountains and as inselbergs that crop out on the piedmont.

The surficial geology as mapped by the AZGS shows a general pattern of decreasing alluvial surface age moving downslope from the Hieroglyphic Mountains, and generally broader extent of younger surfaces with distance from the mountain front. Elsewhere in Maricopa County, Field and Pearthree (1991) hypothesized that the location of active alluvial fan and distributary flow areas on the piedmont has not shifted significantly since the Pleistocene, and that the younger Ya1, and Ya2 surfaces in the middle and lower piedmont were derived primarily by erosion of the Ma1 and Ma2 surfaces on the upper piedmont. That is, most of the sediment deposited on the lower piedmont is being eroded from older upstream piedmont surfaces, rather than from the upper mountainous watersheds. The differing sediment source areas may be responsible for the contrast in sediment size and surface texture between the gravelly active alluvial fan areas on the piedmont immediately below the hydrographic apexes and the silty-sand younger surfaces near the toe of portions of the piedmont.

6B.4.1.3 Field Observations

Field investigations were completed as part of the alluvial fan floodplain delineation study performed by JE Fuller/Hydrology & Geomorphology, Inc. In addition, aerial photography was inspected to identify features consistent with alluvial deposits. Field observations made throughout the piedmont area and aerial photographic interpretation confirm that the piedmont is composed of alluvial materials, except where inselbergs crop out.

6B.4.1.4 Summary

The NRCS soils mapping, AZGS surficial geologic mapping, and field observations all have similar findings regarding the alluvial composition of the piedmont surrounding the Hieroglyphic Mountain Alluvial Fan #3. Therefore, it is concluded that the piedmont is composed of non-consolidated alluvium deposited by fluvial processes, which meets the composition criteria for classification as an alluvial fan specified in the PFHAM and FEMA Guidelines.

6B.4.2 Morphology

According to the National Research Council definition (1996), "alluvial fans are landforms that have the shape of a fan, either partly or fully extended." The piedmont area surrounding the Hieroglyphic Mountain Alluvial Fan #3 consists of a series of coalescing landforms each with the shape of a partially extended alluvial fan. These coalescing alluvial fans comprise a bajada which also shows a somewhat distorted, partially extended fan shape oriented perpendicular to the Hieroglyphic Mountain front. The fan shape is readily visible on aerial photographs of the study area (Figure 6B.3) and USGS topographic mapping (Figure 6B.6).

Topographic contour data also support the morphological definition of an alluvial fan. The USGS 7.5-minute quadrangle topographic maps, as well as the District's 2- and 4-foot contour interval mapping (Figures 6B.4 and 6B.6), show slightly radial patterns across the piedmont surface. The contour crenulations, which range from highly crenulated to smooth radial lines, indicate the degree of fan incision and channel confinement, but uniformly depict an extended fan shape.

Other morphologic features which support delineation of the piedmont as an alluvial fan landform include the slope, drainage patterns, and surficial characteristics. The piedmont slope ranges from less than one percent to almost four percent (1-4%), which is much steeper than nearly all valley riverine drainage systems in central Arizona, which typically have slopes of less than one percent. Steep slopes are characteristic of alluvial fan landforms, which provide a transition from steep mountain slopes to flatter axial valley streams. The drainage pattern on the piedmont includes vast areas of distributary channels, as illustrated by the plot of flow bifurcations in Figure 6B.5. Surficial characteristics indicative of an alluvial fan landform observed in the study area, on aerial photographs, and in the field included non-linear (i.e., non-riverine) and radial distributions of geomorphic surfaces, low divides between adjacent flow paths, small poorly integrated

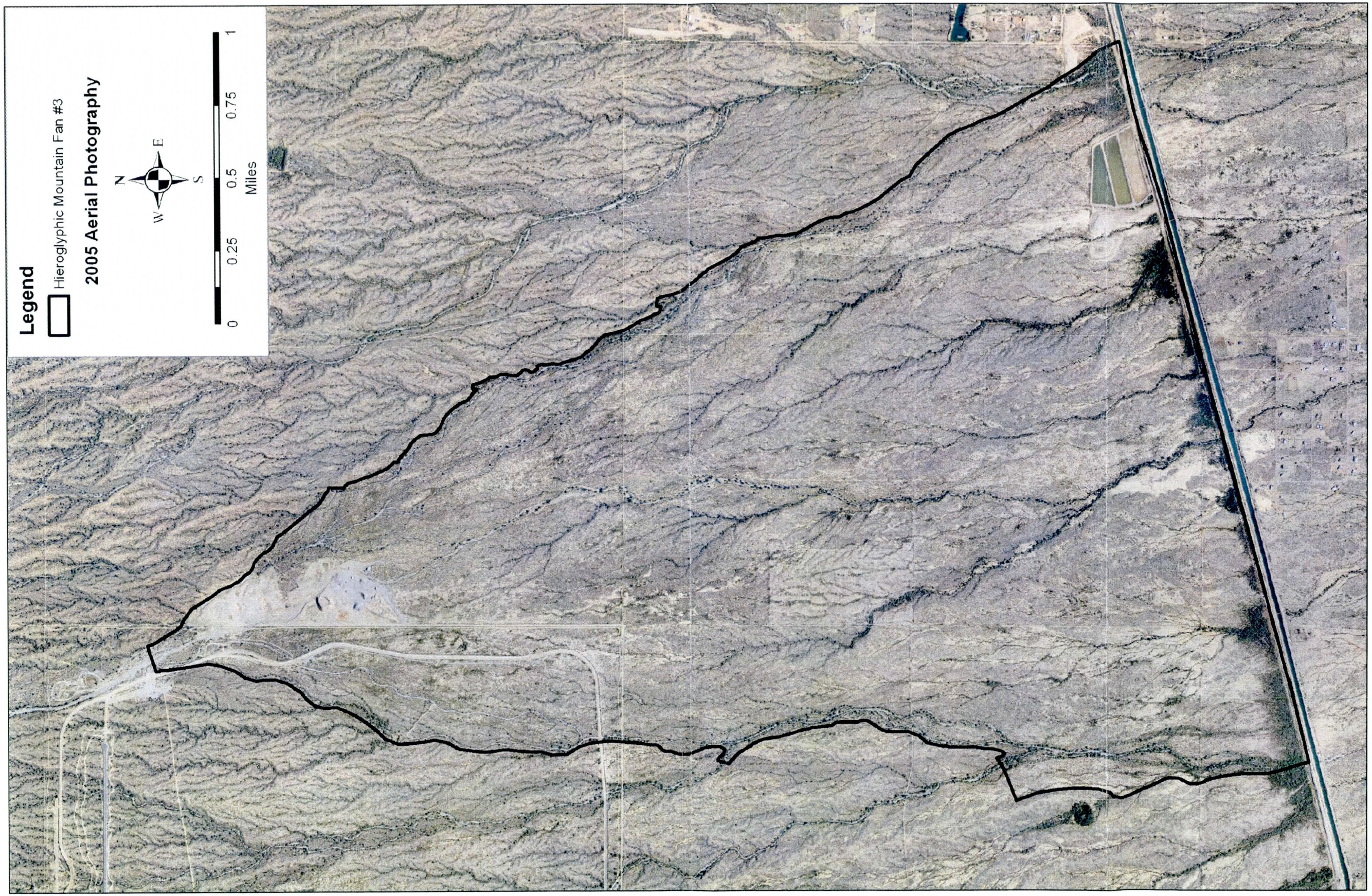


Figure 6B.3. 2005 aerial photography

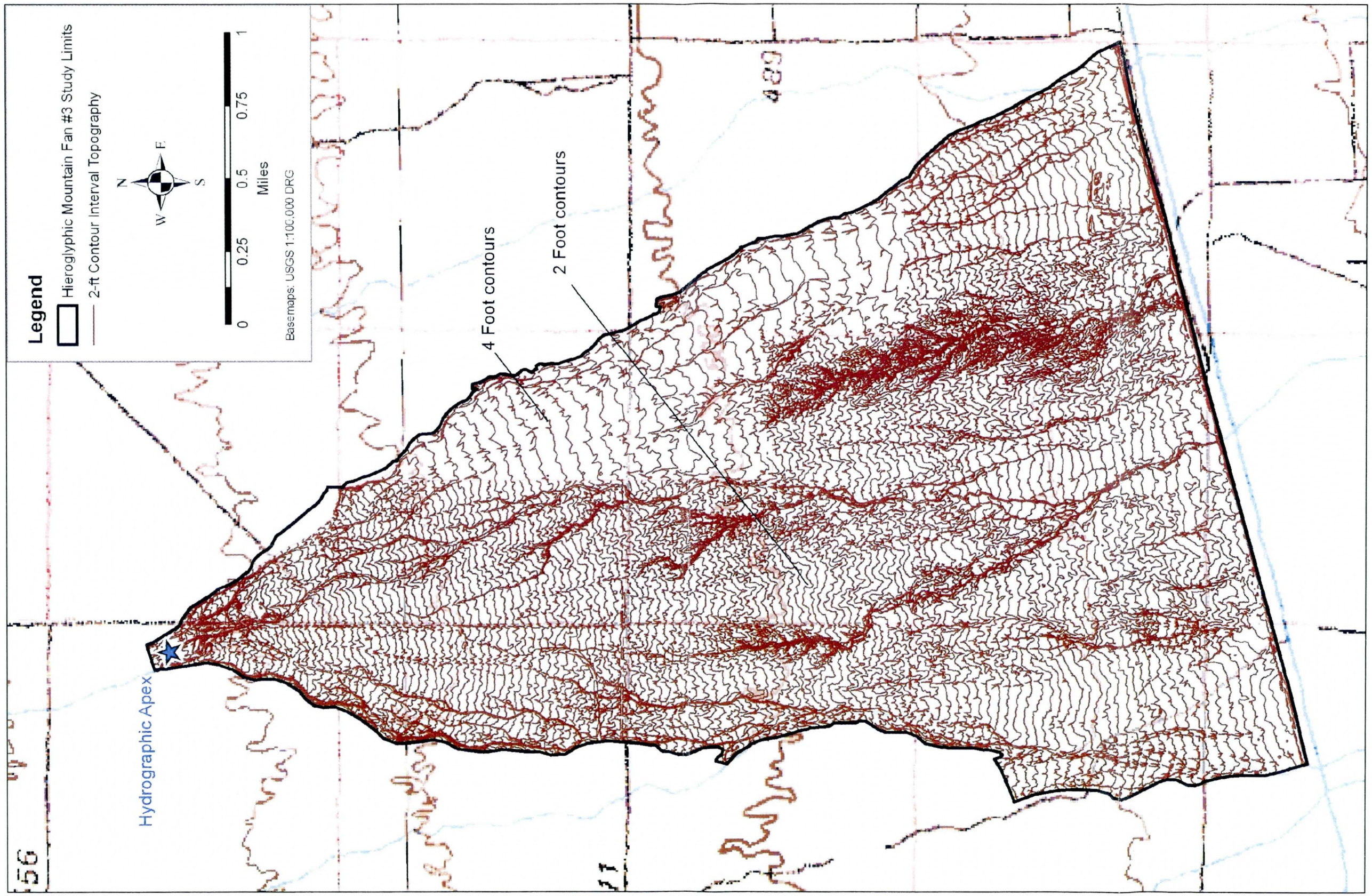
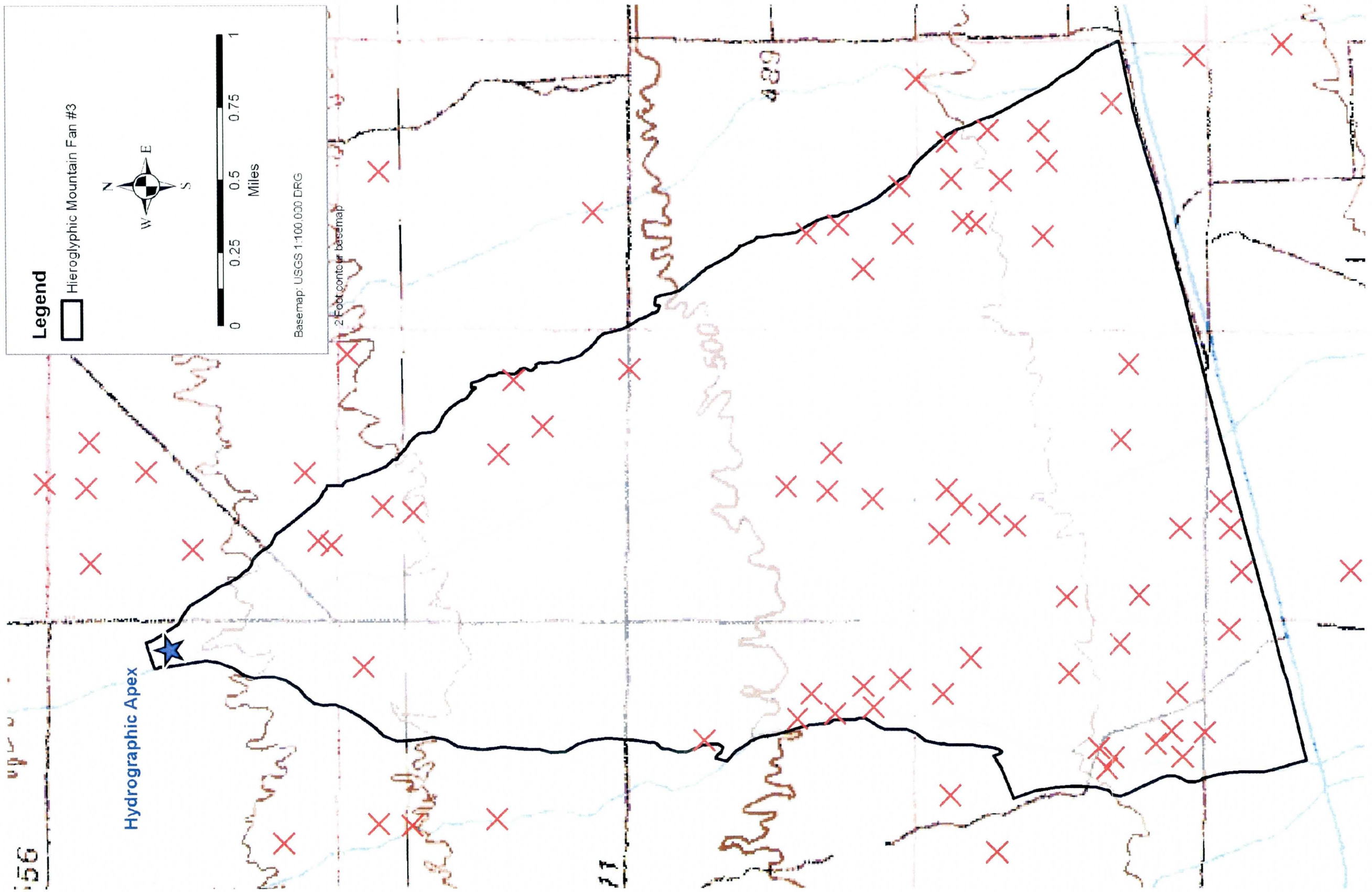


Figure 6B.4. 2-foot and 4-foot contour interval topography


Legend
Hieroglyphic Mountain Fan #3
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0.25
0.5
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1
Miles
Basemap: USGS 1:100,000 DRG
2 Foot contour basemap
Hydrographic Apex
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channels, perched flow paths, decreasing channel widths and depths in the downstream direction transitioning to sheet flow, and a rapid decrease in bed sediment sizes. Based on the analysis of the topographic and morphologic data, it is concluded that the shape of the piedmont area surrounding the Hieroglyphic Mountain Alluvial Fan #3 meets the PFHAM/FEMA Guidelines definition of an alluvial fan landform.

6B.4.3 Location

The NRC (1996) definition of an alluvial fan landform states that "alluvial fan landforms are located at a topographic break where long-term channel migration and sediment accumulation become markedly less than upstream of the break." The piedmont area for this study abuts the mountain front of the Hieroglyphic Mountains, but that boundary is located about 5.5 miles upstream of the Hieroglyphic Mountain Alluvial Fan #3 hydrographic apex, as indicated by the change in the topographic contour density shown on Figure 6B.6. The mountain front is deeply embayed, which reflects the age and long erosion history of the mountains and creates a sinuous upstream boundary at the topographic break. At the mountain front, the fluvial environment transitions from one of net erosion and bedrock outcrop to a depositional or transport environment and alluvial sediments. A second topographic break occurs at the toe of the piedmont where piedmont alluvial fan landform is truncated by the Trilby Wash historical alignment, the (riverine) axial valley stream.

6B.4.4 Hydrographic and Topographic Apex Location

The topographic apex is located at the mountain front, and represents the extreme upstream extent of the piedmont alluvial fan landform. For the study area piedmont, the topographic apex reflects the location where deposition of alluvium began in the geologic past. The topographic apex is located on a relict or inactive alluvial fan, and is well upstream of the primary hydrographic apex. The topographic apex was identified by aerial photograph interpretation, consideration of AZGS surficial and geologic mapping, field observations, and review of topographic and morphologic features in the study area. The topographic apex location is shown in Figure 6B.6.

The primary hydrographic apex is located at the highest point on the alluvial fan landform where there is physical evidence of flow bifurcation and/or significant flow outside the defined channel. The hydrographic apex was identified by plotting the location of flow bifurcations observed on aerial photographs (Figure 6B.5), in conjunction with field observations and geomorphic mapping. The point of flow bifurcation is indicated by a split stream symbol and stippled pattern (deposition) on the USGS 7.5-minute quadrangle topographic map. Experience indicates that the hydrographic apex should be located where the Holocene surfaces that bound the main channels are pinched out by older, stable surfaces, points which are often upstream of the existing flow bifurcation indicated by the channel pattern (JEF, 2000). These Holocene surfaces represent areas that are still receiving alluvial deposits and are subject to overbank flows, and thus are vulnerable to flow path movement, either by avulsion or piracy. In the case of the Hieroglyphic Mountain Alluvial Fan #3, the upstream limits of

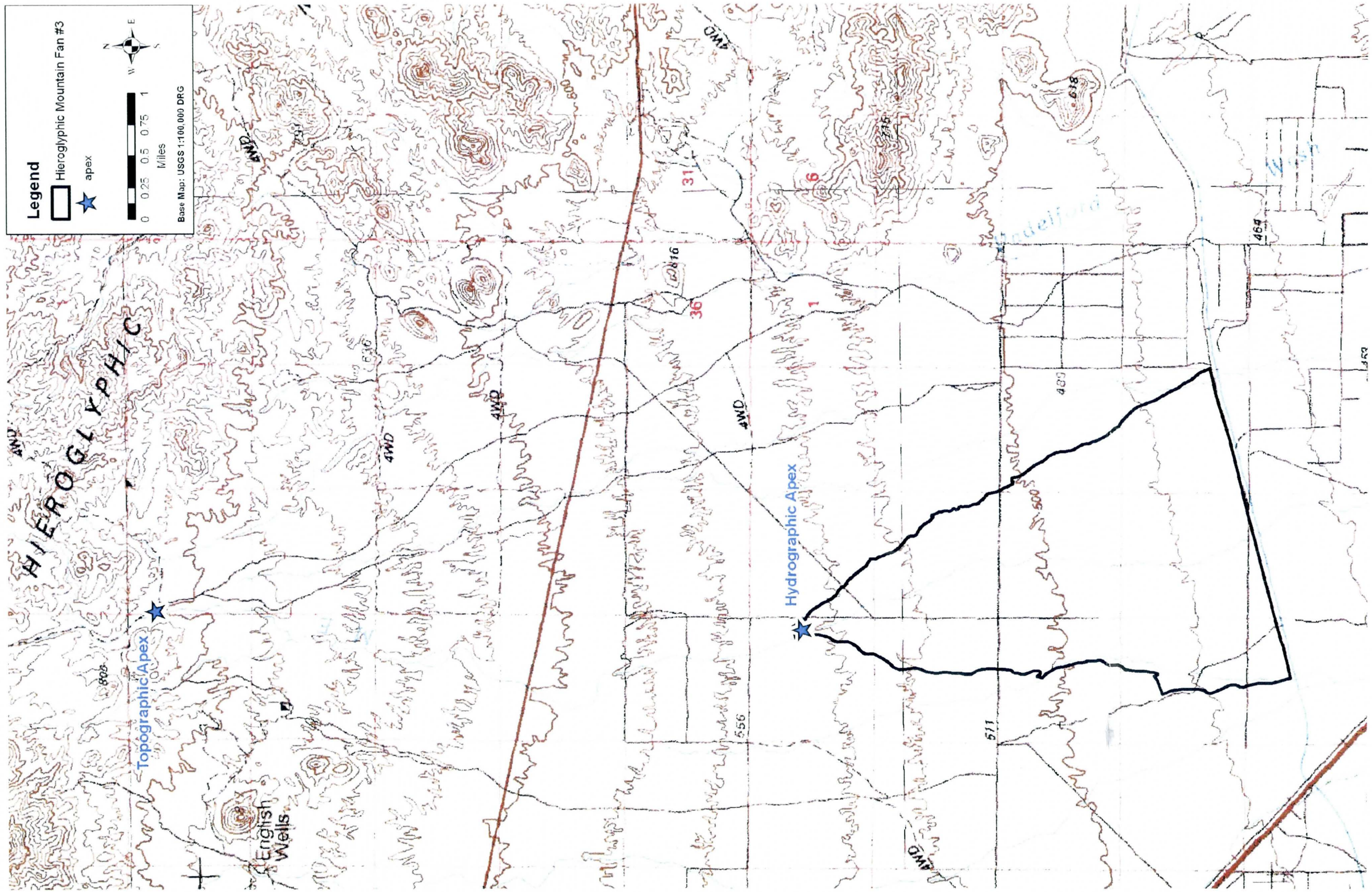

Figure 6B.6. Alluvial fan apex locations

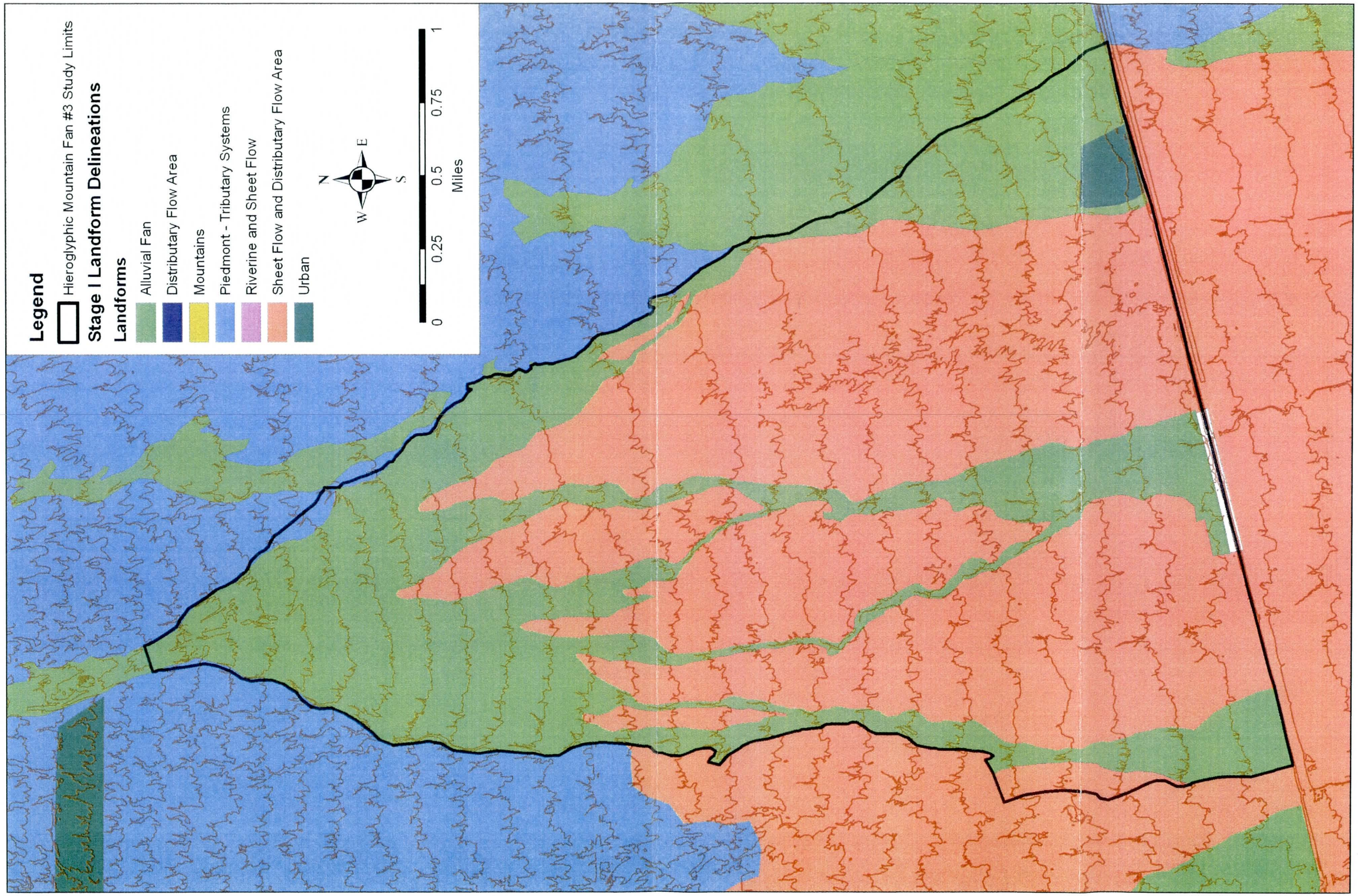

Figure 6B.7. Stage I landform delineations

the Holocene surfaces were coincident with the flow bifurcation point. The primary hydrographic apex location for the study site is shown in Figure 6B.6.

6B.4.5 Boundaries

The lateral and distal limits of the piedmont alluvial fan landform were determined from examination of the NRCS soil and AZGS surficial geologic mapping, field observations, interpretation of recent and historical aerial photographs, and experience. The upper limit of the piedmont alluvial fan landform is defined by the mountain front, as indicated by the topographic break described above. The toe or distal terminus of the piedmont alluvial fan landform is defined by the intersection of the long sloping piedmont plain with the flatter slopes of the Trilby Wash tributary floodplains. The downstream study limit is the CAP embankment.

6B.4.6 Conclusion

The NRCS soil mapping, AZGS surficial geologic mapping data, and field observations clearly show that the piedmont surrounding the Hieroglyphic Mountain Alluvial Fan #3 is composed of sedimentary deposits (alluvium). The topographic mapping shows that the landform is located at the base of a mountain front and has the shape of a partially extended fan, has steep slopes, and radiating contours. Morphologic data, such as the drainage pattern, surface distribution, relief, and channel geometry, are also characteristic of an alluvial fan landform. Therefore, it is concluded that the piedmont is an alluvial fan landform that can be evaluated using the FEMA alluvial fan mapping procedures.

6B.5 Stage 2: Defining Active and Inactive Areas

Stage 2 of the PFHAM/FEMA alluvial fan methodology consists of defining active and inactive areas within specific portions of the Hieroglyphic Mountain Alluvial Fan #3 landform, as well as characterizing the nature and types of flooding that are associated with the hydrographic apex. The primary hydrographic apex for Hieroglyphic Mountain Alluvial Fan #3 was identified in the Stage 1 analysis and is located as shown in Figure 6B.6. Active areas on an alluvial fan consist of those portions of the landform where uncertainties about channel geometry and hydraulic conditions of water and sediment discharge cannot be realistically set aside in the assessment of the flood hazard. Active areas on alluvial fans experience sediment deposition, erosion and unstable flow paths in addition to flood inundation. Inactive alluvial fan areas are the portions of the alluvial fan landform where active fan processes do not occur. Inactive portions of the alluvial fan are those areas where the surface is no longer accumulating sediment, where flow is primarily conveyed in stable entrenched channels, or where flow path uncertainty can "be set aside in realistic assessments of flood risk."

6B.5.1 Overview of Stage 2 Methodology Concepts

The physical characteristics of a landform provide clues as to its depositional history, existing level of stability, and future flood potential. If a portion of the landform becomes isolated from its original watershed

and watercourse, it ceases to receive new deposits and its surface will begin to age and develop specific physical characteristics indicative of its age. These physical characteristics include soil profile development, an integrated tributary drainage network, desert varnish, desert pavement, topographic relief, color, and distinctive vegetative suites.

In a semi-arid environment like that of the Hieroglyphic Mountain Alluvial Fan #3 study area, the degree of soil development is directly proportional to surface age. As the surface ages, a soil profile develops, and its structure, color and content changes. Clay and calcium carbonate accumulate in the soil from aeolian sources and chemical weathering of the parent material, forming distinct soil horizons (Figure 6B.8). The degree of soil profile development, particularly in the clay and carbonate horizons, can be used as a proxy for surface age. The soil surface also tends to become reddish in color with time due to oxidation of iron (rubification) as well as accumulation and weathering of clay. Young, active surfaces lack soil profile development, and on active alluvial fans consist of stream bed alluvium (Figure 6B.9).

Geomorphic surfaces may also develop an accumulation of pebbles and cobbles at the surface as they age. These gravel coverings are known as desert pavement, which form as a byproduct of windblown silt and clay accumulation in the soil column. Repeated wetting by precipitation causes the fine-grained materials to swell, lifting the larger gravels to the surface. Repeated surface drying creates cracks into which more fine windblown material may accumulate. Over thousands of years these processes form a mantle of closely packed gravels that resembles asphalt pavement (Dohrenwend, 1987; Vanden Dolder, 1992). The pebbles and cobbles that form the pavement surface, if they contain sufficient ferromagnesian minerals, will develop a dark black patina on their tops and an orange coating underneath that is known as desert varnish (Figure 6B.10).

Landform surfaces free from new deposition will also begin to erode due to direct rainfall and the ensuing runoff on the surface. As the surface erodes, new tributary channel networks develop which become more incised and integrated with time. The channels gradually deepen and widen, creating a greater degree of relief between the channel bottoms and the ridges which separate them. The degree of relief can be directly observed in the field or on aerial photographs (Figure 6B.11), but can also be detected by the examining the crenulation (curviness) of topographic map contours (Figure 6B.12).

The degree of relief of an apparently inactive landform relative to adjacent active, young surfaces is also an important characteristic. Because active alluvial fans are aggrading landforms, it follows that some older surfaces may gradually become buried by sediment deposition derived from the adjacent younger active alluvial fan (Figure 6B.13). Therefore, where there is little topographic difference between younger and older surfaces, the investigator must take care to evaluate the rate of, and potential for, long-term aggradation of the fan. Typically, the rate of fan aggradation is greatest near the hydrographic apex, with lower accumulation rates as the distance from the apex increases and/or the active fan widens.

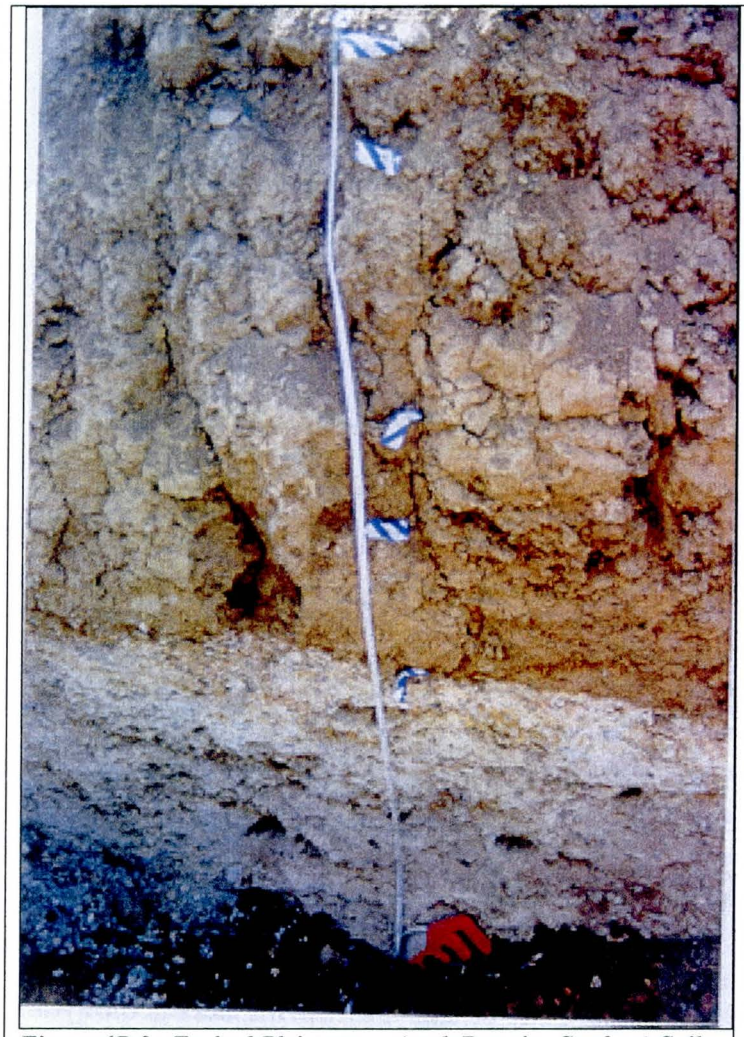

Figure 6B.8. Typical Pleistocene-Aged (Inactive Surface) Soil Profile With Well-Developed Carbonate and Clay Horizons.

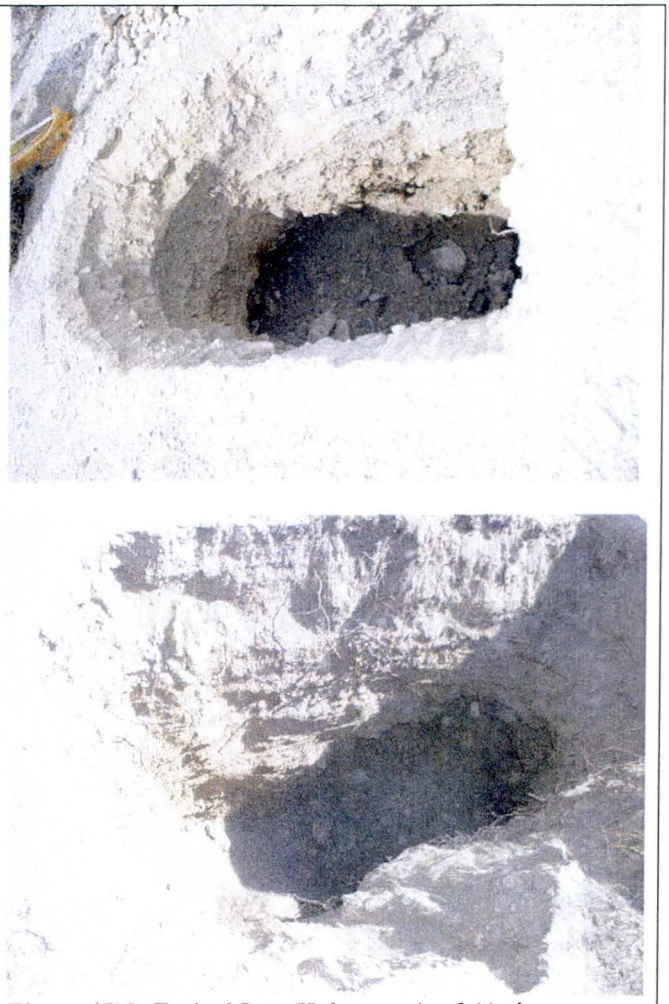

Figure 6B.9. Typical Late Holocene-Aged (Active Surface) Soil Profiles With No Soil Development.

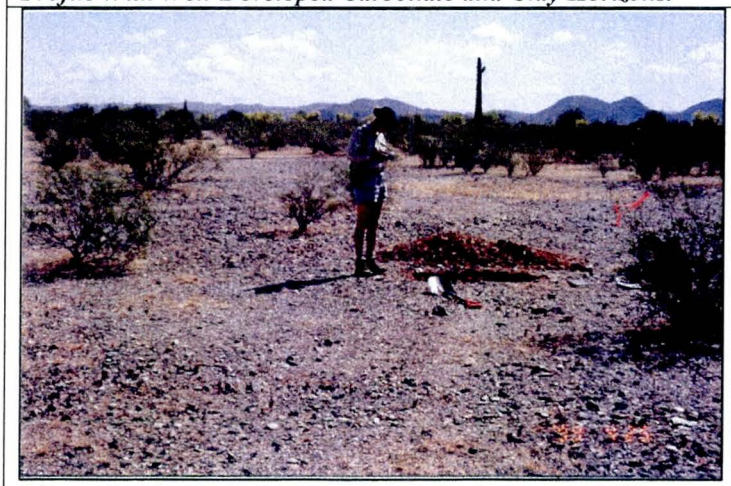

Figure 6B.10. Varnished Desert Pavement Surface on Inactive Portion of an Alluvial Fan Landform. Note the reddened clay-rich soil excavated from the soil pit.

Figure 6B.11. Aerial Photograph Showing Tributary Drainage Network on Old, Inactive Surface Adjacent to Distributary & Sheet Flow Pattern in Active Area.

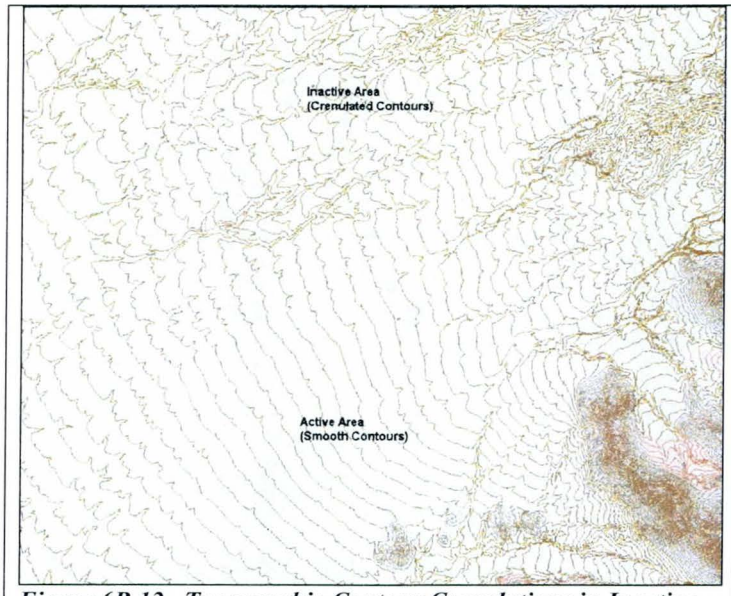

Figure 6B.12. Topographic Contour Crenulations in Inactive and Active Areas of an Alluvial Fan Landform.

Figure 6B.13. Photograph of Older Varnished Pavement Surface Partially Buried by Recent Flood Deposition (Tiger Wash, Maricopa County, Arizona).

Figure 6B.14. Photograph of Active Surface Topographically Confined by Older Surface.

In a semi-arid environment, it takes thousands of years for many of these geomorphic characteristics to develop. Therefore, surfaces that exhibit well developed soils, red color, significant carbonate development, desert pavement composed of strongly varnished gravels, and tributary drainage networks have been relatively free from flooding for thousands of years. These features provide a record of non-inundation that extends back thousands of years. The non-inundation record can be interpreted and used as a historical record of fan behavior in the same way as historical records of flood peaks are used to predict future flood peaks. As such, without external disturbance, it can be reasonably assumed that the flood hazard potential on geomorphically old (stable) surfaces will be low in the future.

The NRCS soils survey data and AZGS surficial geology mapping differentiate surfaces based on the types of geomorphic characteristics discussed above. Therefore, the map data also provide information about surface age, stability, and flood potential. Young surfaces with little soil development are likely to continue to experience flood inundation, sediment deposition, and channel movement. Older surfaces are less likely to experience such processes. Older surfaces with cemented soils and entrenched channels also tend to be more stable because their soils are more resistant due to the cohesion provided by clay, carbonate, and pavement, as well as due to containment of flow within defined, vegetation-lined channels. That is, the likelihood of the channel changing its location over time is greatly diminished. Conversely, areas with non-cohesive, coarse soil materials and little lateral relief are more susceptible to lateral changes in channel position.

Active alluvial fans are those where the uncertainty associated with flow path location is so great that it cannot be set aside in realistic assessments of the flood risk. Where risk of flow path change is minimal, that portion of the alluvial fan landform is considered inactive. The Stage 2 geomorphic analyses are intended to distinguish active, unstable, young landforms from inactive, stable, old landforms.

6B.5.2 Overview of Flooding on Hieroglyphic Mountain Alluvial Fan #3

The Hieroglyphic Mountain Alluvial Fan #3 is located within the east central portion of the southern Hieroglyphic Mountain piedmont, in portions of Township 5 North, Range 2 West. The topographic apex of the alluvial fan landform is located at the mountain front-piedmont boundary in Section 10 of Township 6 North, Range 2 West (Figure 6B.6), approximately 5.5 miles upstream of the hydrographic apex. The drainage area above the hydrographic apex, the alluvial fan area below the hydrographic apex, and other characteristics for the Hieroglyphic Mountain Alluvial Fan #3 are listed in Table 6B.3. Between the topographic apex at the mountain front and the hydrographic apex, flood flow is conveyed in a well-defined tributary drainage system, a portion of which is located immediately upstream of the hydrographic apex. Channel depths in the confined drainage channels upstream of the hydrographic apex range from more than 10 feet near the topographic apex to less than 5 feet immediately upstream of the hydrographic apex. Channel slopes in the well-defined channels above the hydrographic apex range from about 0.022 to 0.014 feet/feet, decreasing in the downstream direction. At the hydrographic apex, the drainage networks change from well-defined tributary patterns to unconfined distributary patterns on an active alluvial fan.

Table 6B.3 Alluvial Fan Characteristics

Fan	Watershed Area (mi2)	Q100 (cfs)	Location of Hydrographic Apex	Alluvial Fan Area (mi2)	Upstream Channel Slope (ft/ft)
Hieroglyphic Mountain Alluvial Fan #3	18.7	9,687	T5N-R2W-4	5.6	0.014

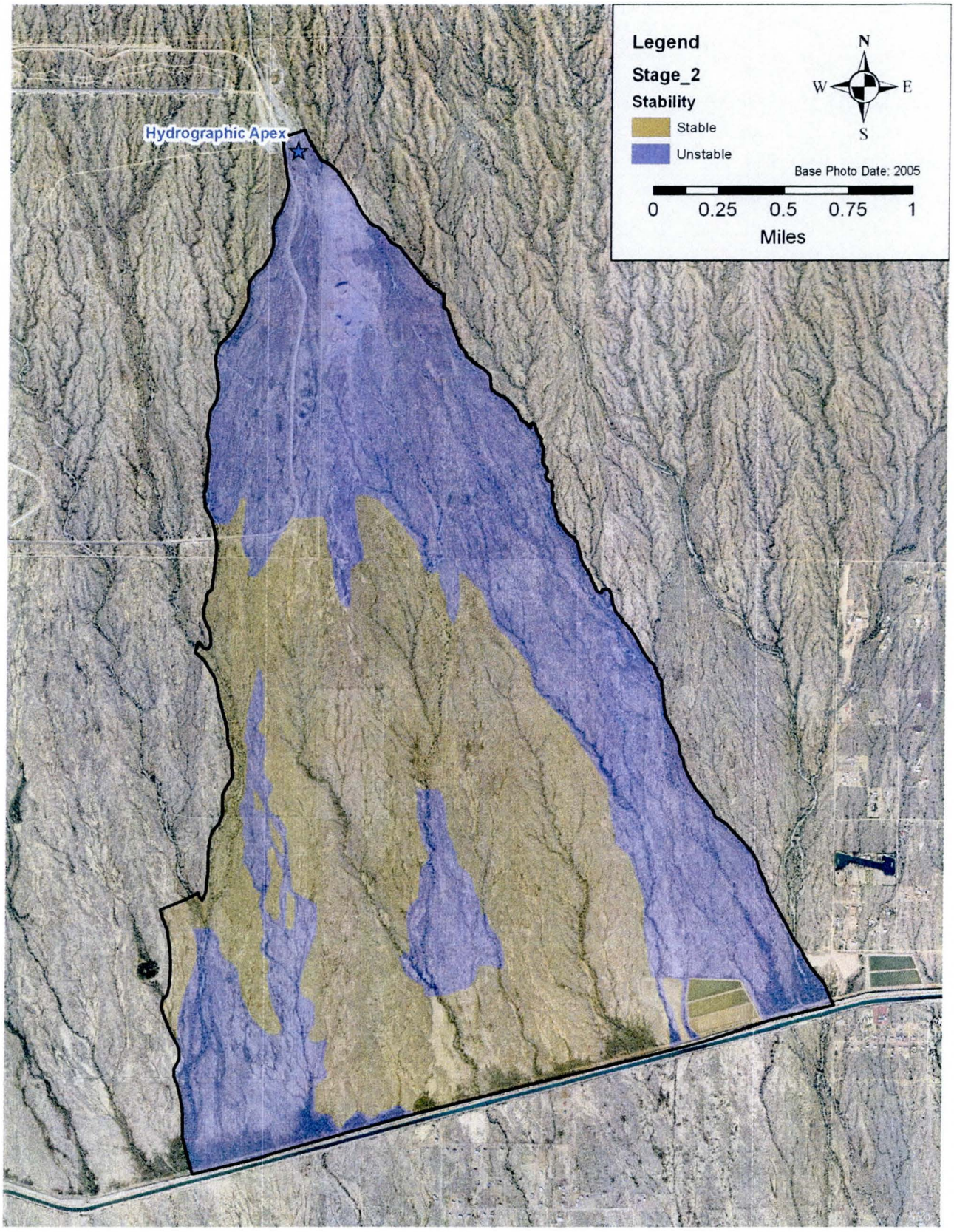

Figure 6B.15. Hieroglyphic Mountain Alluvial Fan #3 Stage II delineation: active fan areas

For this study, the primary hydrographic apex was defined at the split flow channel point located about 2,400 feet south of the Chrysler Proving Ground northern property line. Flow above the hydrographic apex is conveyed in a well-defined channel. Flow below the primary hydrographic apex is unconfined or distributary for a distance of approximately 1.1 to 1.9 miles before entering sub-parallel corridors that convey runoff further south. After approximately 2.5 miles, these corridors become less well defined with a series of three secondary hydrographic apexes that distribute unconfined flow that is then intercepted and ponded upstream of the CAP. The sub-parallel flow corridors are separated by relatively young geomorphic surfaces that have slight topographic relief, moderately well-integrated drainage patterns, and some degree of soil development. Prior to construction of the CAP, the channel pattern transitioned to a broad area of unconfined sheet flow prior to reaching McMicken Dam.

The Hieroglyphic Mountain Alluvial Fan #3 is laterally "bounded" by older fan terrace surfaces on the east and west. Geologically the toe of the fan is located at the Trilby Wash floodplain, but functionally the CAP now serves as the downstream limit of the fan, or at least for the existing delineation study.

6B.5.3 Identification of Active Areas

Elsewhere in western Maricopa County, Field and Pearthree (1991) suggested that the younger sediments (active areas) on the lower portions of broad piedmont surfaces were eroded primarily from older surfaces in the middle and upper piedmont at or below the hydrographic apex, rather than from the upper mountain watershed. Given the morphology of the Hieroglyphic Mountain Alluvial Fan #3 and its distal location from the topographic apex, it was assumed that the active fan was composed primarily from sediment eroded from upstream relict surfaces, rather than from the Hieroglyphic Mountains. As such, the Hieroglyphic Mountain Alluvial Fan #3 is subject only to water floods. Debris flows do not leave the mountains and certainly could not travel the six mile distance from the mountain front to the hydrographic apex. The water floods that reach the hydrographic apex are frequently subject to high rates of transmission losses due to storage across the wide flood-prone surfaces, division of flows into the distributary and sheet flow network, and rapid infiltration into the unconsolidated alluvium underlying the fan. Only the largest runoff events translate significant flood water and sediment across the entire piedmont downstream of the hydrographic apex to the toe of the alluvial fan. Therefore, the highest rates of aggradation and the most active alluvial fan flooding occur in the area closest to the hydrographic apex. Low rates of aggradation occur on sheet flow plains and flow dissipates and drops its sediment load. Flow rate uncertainty occurs everywhere within the alluvial fan boundaries downstream of the hydrographic apex. (Figure 6B.6).

The limits of the active areas of the Hieroglyphic Mountain Alluvial Fan #3 are shown in Figure 6B.15. These areas were identified through the use of NRCS soils surveys, AZGS surficial geology mapping, historical aerial photographs, interpretation of USGS 7.5 minute contour maps and FCDMC 10-ft contour

interval topographic mapping, field observations, surficial characteristics, and other geomorphic features. The relationship of each of these types of evidence to the limits of active and inactive areas is discussed below.

6B.5.3.1 NRCS Soils Data

The NRCS soils map for the Hieroglyphic Mountain Alluvial Fan #3 is shown in Figure 6B.16. The NRCS map describes the following soil units as (active) alluvial fans:

- Gilman loam (Unit #55)
- Estrella loam (Unit #50)

The NRCS describes these units (Table 6B.4) as young soils located in drainageways and active alluvial fans subject to frequent flooding and erosion. The boundaries of the NRCS alluvial soil units are very similar to the active fan areas delineated for this study, including the fan areas below the secondary apexes near the CAP. The primary differences between the NRCS mapping and the Stage 2 active surfaces identified for this study are in the central portion of the active area immediately downstream of the hydrographic apex, an area which is mapped by the NRCS as the Denure-Momoli-Carrizo complex (Unit #29-fan terraces). The other differences relate the boundaries of the NRCS soils units compared to the Stage 2 delineation. There are several probable explanations for the differences between the NRCS mapping the Stage 2 active fan delineation performed for this study. First, the NRCS mapping was performed at a 1:24,000 scale, with few soil test pits per Township, leading to some inaccuracies in delineation. The geomorphic mapping performed for this alluvial fan floodplain delineation study was performed at a much more detailed scale with more detailed field inspection and better (color) aerial photography and topography. Therefore, many of the smaller drainageways and active floodways ignored by the NRCS could be identified and mapped in detail. Second, the NRCS map units apply regionally over a much larger area and therefore may not account for local variations and characteristics of specific soil units. Third, the NRCS mapping was primarily concerned with soil characteristics rather than the morphologic function. Therefore, a part of the upper portion of the alluvial fan was mapped as a fan terrace by the NRCS, rather than as directly connected to the alluvial fan flooding source. The NRCS designation of some of the active alluvial fan flooding and alluvial fan sheet flow zones as inactive probably reflects a low rate of aggradation and a higher level of recent channel stability.

However, the areas of agreement between the NRCS mapping and the Stage 2 delineation are greater than their differences. The NRCS soil descriptions confirm the presence of active alluvial fan flooding areas below the hydrographic apex of the Hieroglyphic Mountain Alluvial Fan #3 and at secondary hydrographic apexes near the CAP. The NRCS alluvial fan soil units are characterized by minimal soil profile development (Torrifluvents) and minimal clay or carbonate accumulation.

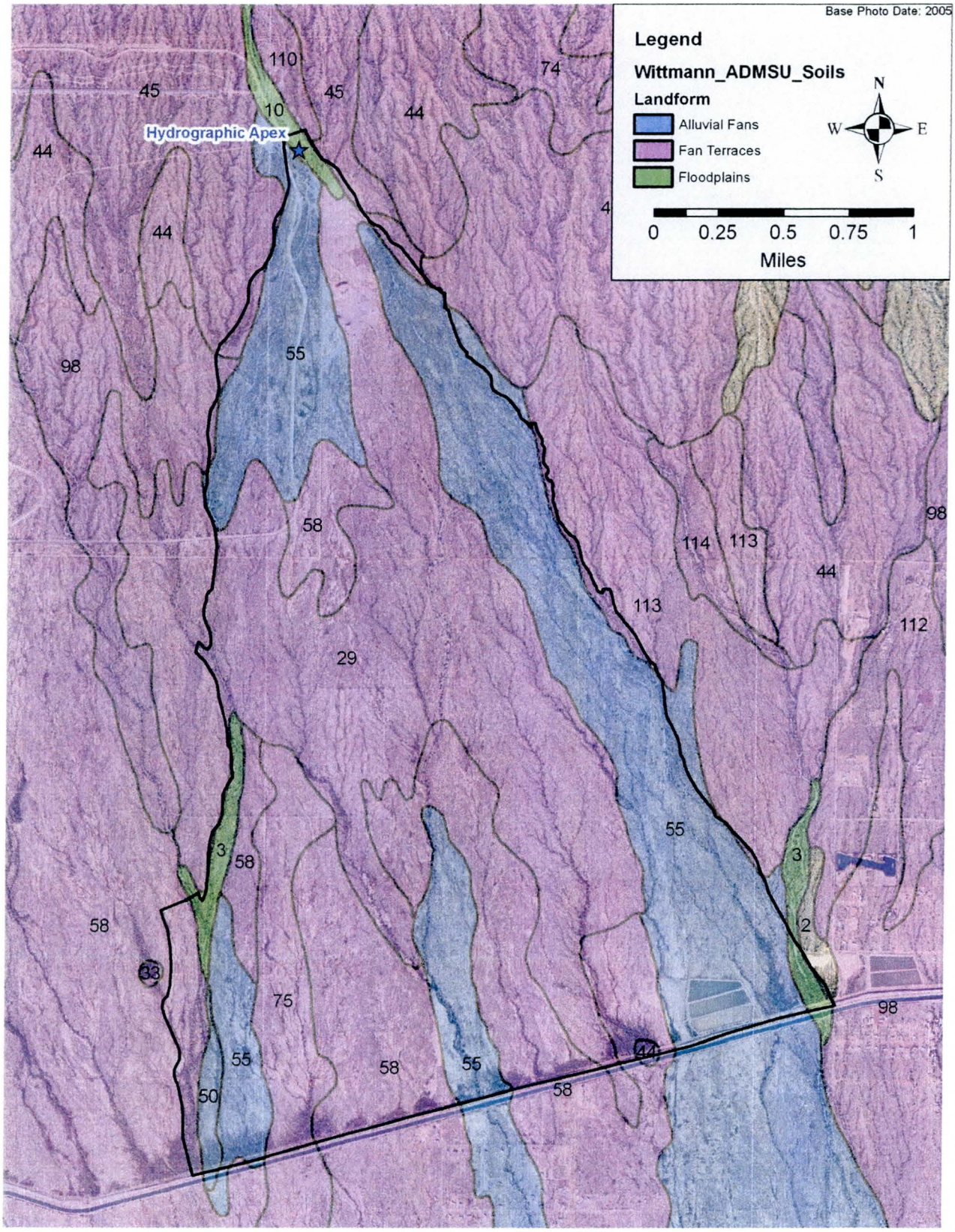

Figure 6B.16. NRCS soils mapping for the Hieroglyphic Mountain Alluvial Fan #3

Table 6B.4 NRCS Soil Unit Descriptions for Sites 1 and 2						
Map Symbol	**Soil Unit Name**	**Geomorphic Position**	**Characteristics**	**Soil Subgroup & Order**	**Geologic Age**	**PFHAM Landform**
3	Antho-Carrizo-Maripo complex	On floodplains, alluvial fans, and drainageways	Subject to occasional flooding; hazard due to water erosion is severe; channeling, deposition, and streambank erosion occur during flooding; subject to rare periods of fl	Typic Torrifluvents Entisols	-	Active Alluvial Fan
10	Brios-Carrizo complex, 1-5% slopes	On desert drainageways	Calcareous below 21 inches, slow runoff, severe erosion hazard, channeling, deposition, and streambank erosion occur during flooding.	Entisols	-	Active Alluvial Fan
29	Denure-Momoli-Carrizo complex	Stream and fan terraces	Calcareous below about 8 inches; B horizon development; buried calcic or argillic horizon present in some pedons; strongly effervescent at depth.	Typic Camborthids Aridisols	-	Inactive Alluvial Fan
44	Ebon very gravelly loam, 1-8% slopes	On fan terraces and stream terraces	Slow to medium runoff, slight erosion hazard.	Typic Haplargids Aridsols	-	Inactive Alluvial Fan
45	Ebon very gravelly loam, 8-20% slopes	On fan terraces	Slow to medium runoff, slight erosion hazard.	Typic Haplargids Aridsols	-	Inactive Alluvial Fan
50	Estrella loams	On alluvial fans	Slow runoff, slight erosion hazard. Where unprotected, soils are subject to rare periods of flooding.	Typic Torrifluvents Entisols	-	Inactive Alluvial Fan
55	Gilman loams	Floodplains and alluvial fans	Slow runoff, slight erosion hazard. Where unprotected, the soils are subject to rare periods of flooding.	Typic Torrifluvents Entisols	Few hundred to 1,000 years	Active Alluvial Fan
58	Gilman Momoli Denure Complex	On fan terraces and alluvial fans	Slow to medium runoff, slight erosion hazard.	Typic Camborthids Aridisols	-	Inactive Alluvial Fan
74	Luke-Cipriano association, 1-15% slopes	Fan terraces	Luke is dominantly on tops of terraces. Cipriano is dominantly on sides of terraces. Depth to hardpan from 20 to 40 inches.	Typic Durargids Aridsols	-	Inactive Alluvial Fan
75	Mohall loam	Fan terraces	Runoff is slow, slight erosion hazard. Depth to calcic horizon is 6 to 40 inches.	Typic Haplargids Aridsols	7,000 to 10,000 years	Inactive Alluvial Fan
98	Pinamt-Tremant complex, 1-10% slopes	Fan terraces	Yellowish red B horizons which are strongly to violently effervescent; light reddish brown B horizons, calcic horizon at 5 to 24 inches, strongly to violently	Typic Haplargids Aridisols	900,000 years	Inactive Alluvial Fan

Table 6B.4 NRCS Soil Unit Descriptions for Sites 1 and 2						
Map Symbol	**Soil Unit Name**	**Geomorphic Position**	**Characteristics**	**Soil Subgroup & Order**	**Geologic Age**	**PFHAM Landform**
			effervescent			
110	Suncity-Cipriano complex, 1-7% slopes	Fan terraces	Silica-lime cemented hardpan at depth of 9 inches. Runoff is slow to medium, erosion hazard is slight.	Typic Durargids, Typic Durorthid Aridisols	-	Inactive Alluvial Fan
112	Tremant gravelly sandy loams	Fan terraces	Runoff is slow, erosion hazard is slight. Soil is generally noncalcareous in the upper 9 inches and calcareous below, with some areas being calcareous throughout.	Typic Haplargids Aridisols	7,000 to 10,000 years	Inactive Alluvial Fan
113	Tremant gravelly loams	Fan terraces	Runoff is slow, erosion hazard is slight. Soil is generally noncalcareous in the upper 9 inches and calcareous below, with some areas being calcareous throughout.	Typic Haplargids Aridisols	7,000 to 10,000 years	Inactive Alluvial Fan
114	Tremant gravelly loams, low precipitation	Fan terraces	Runoff is slow, erosion hazard is slight. Soil is generally noncalcareous in the upper 9 inches and calcareous below, with some areas being calcareous throughout.	Typic Haplargids Aridsols	-	Inactive Alluvial Fan
115	Tremant-Antho complex, 1-5% slopes	Fan and stream terraces, and floodplains	Tremant soil is generally on fan terraces, and Antho is generally on narrow floodplains. Runoff is slow, erosion hazard is slight. Where unprotected, this soil is subject to erosion.	Typic Haplargids, Typic Torriflu Aridisols, Entisols	7,000 to 10,000 years	Inactive Alluvial Fan

6B.5.3.2 AZGS Surficial Geology

The detailed AZGS surficial geology mapping (Figure 6.17) shows complex young alluvial fan units (Ya2 and Ya1) inset within the older inactive fan surfaces (Ma1 and Ma2) that comprise most of the Hieroglyphic Piedmont upstream of the CAP. The M1b surfaces are described as composed of poorly sorted, angular to subangular sand and gravel materials with weakly developed argillic and stage II calcic horizons. The M1b surfaces themselves are moderately dissected in the upper piedmont, with decreased dissection in the downstream direction, and with abundant varnished desert pavement areas.

The Ya2 unit is the youngest unit and is found along modern stream channels. It is described as late Holocene in age, with channel incision of up to 10 meters and no soil development. These surfaces experience frequent flood inundation and active sedimentation and erosion. No evidence of 10 meter incision was observed on the Hieroglyphic Mountain Alluvial Fan #3. The Ya2 unit is

mapped with numerous bifurcations near the primary hydrographic apex, with some bifurcations and widening of the unit boundaries near the secondary hydrographic apexes. The Ya1 unit is described as found on relatively young alluvial fans. The Ya1 unit is described as Holocene in age with no or minimal soil development. These surfaces have experienced active deposition and erosion during the last 10,000 years. As mapped by the AZGS, the Ya2 and Ya1 surfaces comprise the modern alluvial fan surfaces. These modern alluvial fan surfaces are bounded by older Ma1 and Ma2 surfaces.

The Ma2 units are of Pleistocene age (10,000 to 200,000 years), and have been subject to erosion and transport in recent geologic time. The Ma1 units represent Pleistocene age (200,000 to 500,000 years) surfaces of relict and inactive alluvial fans. Both of the Pleistocene surfaces mapped by the AZGS have significant soil development, with carbonate and clay accumulation, weak to moderate desert pavements, and some topographic relief.

The AZGS also prepared a larger scale map of the regional geology for the Phoenix North 30° x 60° quadrangle (Reynolds and Grubensky, 1993), as shown in Figure 6B.2. The regional AZGS map does not distinguish between Holocene surfaces, but it does differentiate the larger Holocene surfaces from the surrounding older Pleistocene surfaces. There are significant differences in the interpreted age of the lower fan surfaces in the two AZGS maps (compare Figures 6B.2 and 6B.17). The more detailed and more recent geomorphic mapping by AZGS shows the entire landform as a modern surface subject to some degree of flood inundation and erosion hazards.

The Stage 2 delineation more closely reflects the interpretation in the large-scale AZGS maps (Figure 6B.2) than the detailed AZGS surficial geology maps (Figure 6B.17). The differences primarily reflect the differing objectives of the mapping efforts, but also are a result of better resolution of the geomorphic mapping performed for this study, and the scale of mapping. The more detailed AZGS mapping appears to have been focused more on surficial age, rather than geomorphic function and type of flood hazard.

The NRCS and AZGS mapping, and the stable/unstable area delineations performed for this study are compared in Figure 6B.18. The NRCS, AZGS, and TDN mapping are broadly similar in extent and in identifying the area as a young (active) alluvial fan. Both the AZGS and NRCS maps identified a prominent flow corridor that extends downstream from the east side of the active fan area. The differences between the AZGS and NRCS maps can be attributed to the lower resolution, large scale mapping performed by the NRCS and AZGS, as well as rectification issues associated with converting paper maps to digital coverages. The AZGS and TDN mapping identify unstable, active alluvial fan areas downstream of the hydrographic apexes, as well as less active, more stable piedmont surfaces for portions of the piedmont.

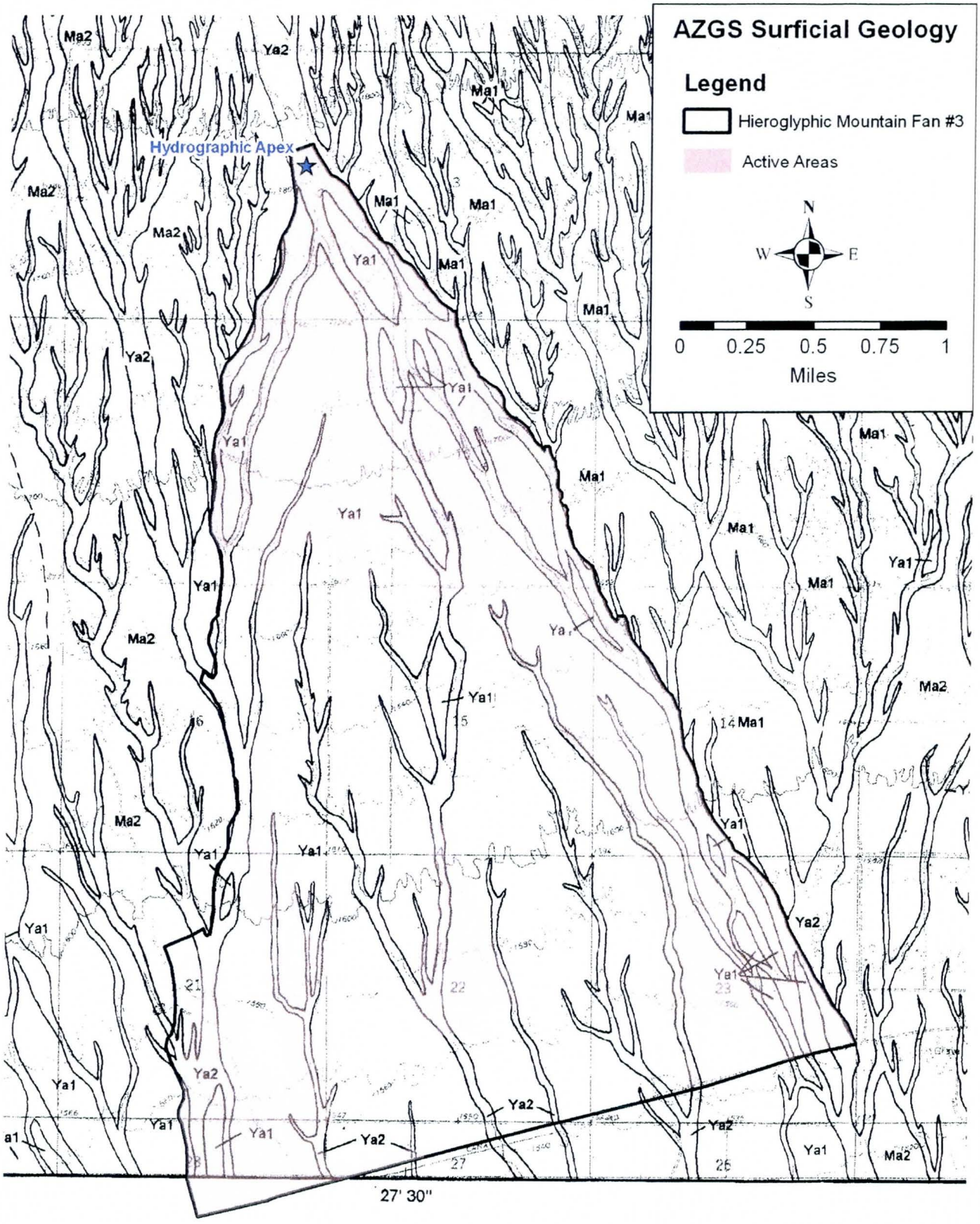

Figure 6B.17. AZGS surficial geology for Hieroglyphic Mountain Alluvial Fan #3 area

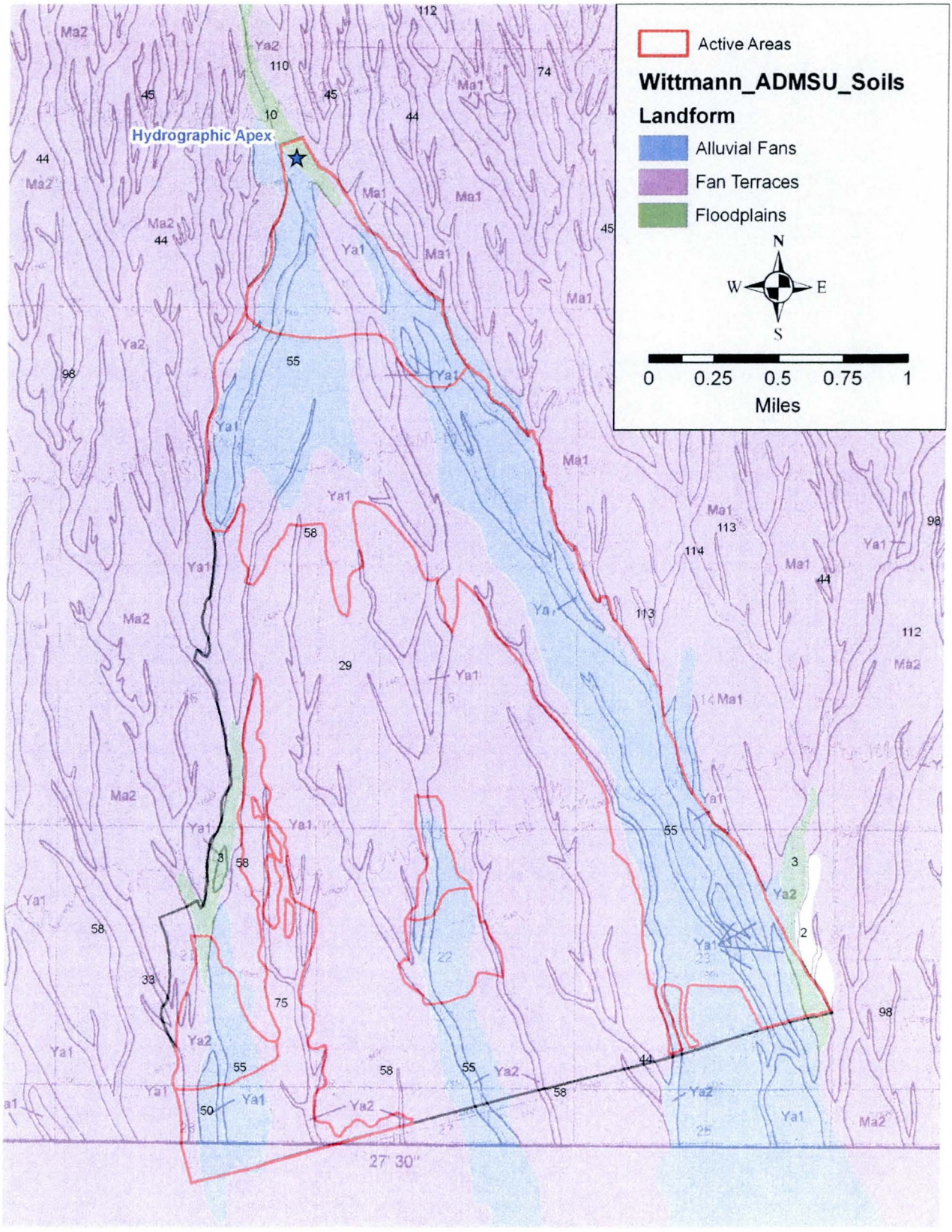

Figure 6B.18. NRCS, AZGS and unstable area mapping overlay

6B.5.3.3 Interpretation of Topography

Topographic data were available from USGS 7.5-minute quadrangle maps and from FCDMC 2- and 4-foot contour interval mapping (Figure 6B.19). Topographic data were particularly useful for delineating the alluvial fan hazards at the Hieroglyphic Mountain Alluvial Fan #3 site. Topographic data can be used in the following ways to identify stable and unstable (active/inactive) portions of alluvial fan landforms:

- Contour crenulation. Contour crenulations are "wiggles" in topographic contour lines. Since older, stable surfaces tend to have greater internal relief, better developed drainage networks, and are largely erosive landforms, the contours over such surfaces are more crenulated. Contours over younger, active, unstable surfaces tend to be smoother, reflecting the more uniform, less incised topography.
- Contour shape. Contours on active, unstable alluvial fan surfaces tend to bend downstream in a smooth radial pattern. Contours on inactive or relict fans tend to be more parallel to the mountain front.
- Contour direction. A marked change in the contour orientation occurs at the toe of the alluvial fan, where it enters the floodplain of the axial stream, which is frequently orthogonal to the fan contour orientation.
- Relief. The boundaries of active fan areas are typically confined by older, higher inactive surfaces which constrain alluvial fan flooding to topographically lower unstable surfaces. Topographic relief is addressed more directly in the Stage 3 analysis.
- Map symbols. Symbols on the USGS topographic maps useful for fan identification include stream channel bifurcation, stippling of depositional areas, and termination of stream symbols in the downstream direction.

The topographic contours downstream of the hydrograph apex exhibit the classic convex downstream characteristics indicative of an alluvial fan. While the contours in the active fan area are somewhat crenulated, they are markedly less crenulated than the contours on the surrounding older Qm surfaces. The contours become more crenulated downstream from the apex in the central part of the fan, indicating greater lateral relief and secondary channel incision in this region. The topography indicates that upstream sheet and distributary flows are captured and conveyed by more defined, incised streams for a short distance before reaching the secondary hydrographic apexes. At the secondary apexes, the contours again become less crenulated indicating the presence of secondary active fan areas upstream the CAP. There is a pronounced convex shape to the contours in the upper portion of the alluvial fan. The contour spacing increases slightly in the downstream direction, indicating a flatter piedmont slope near the toe.

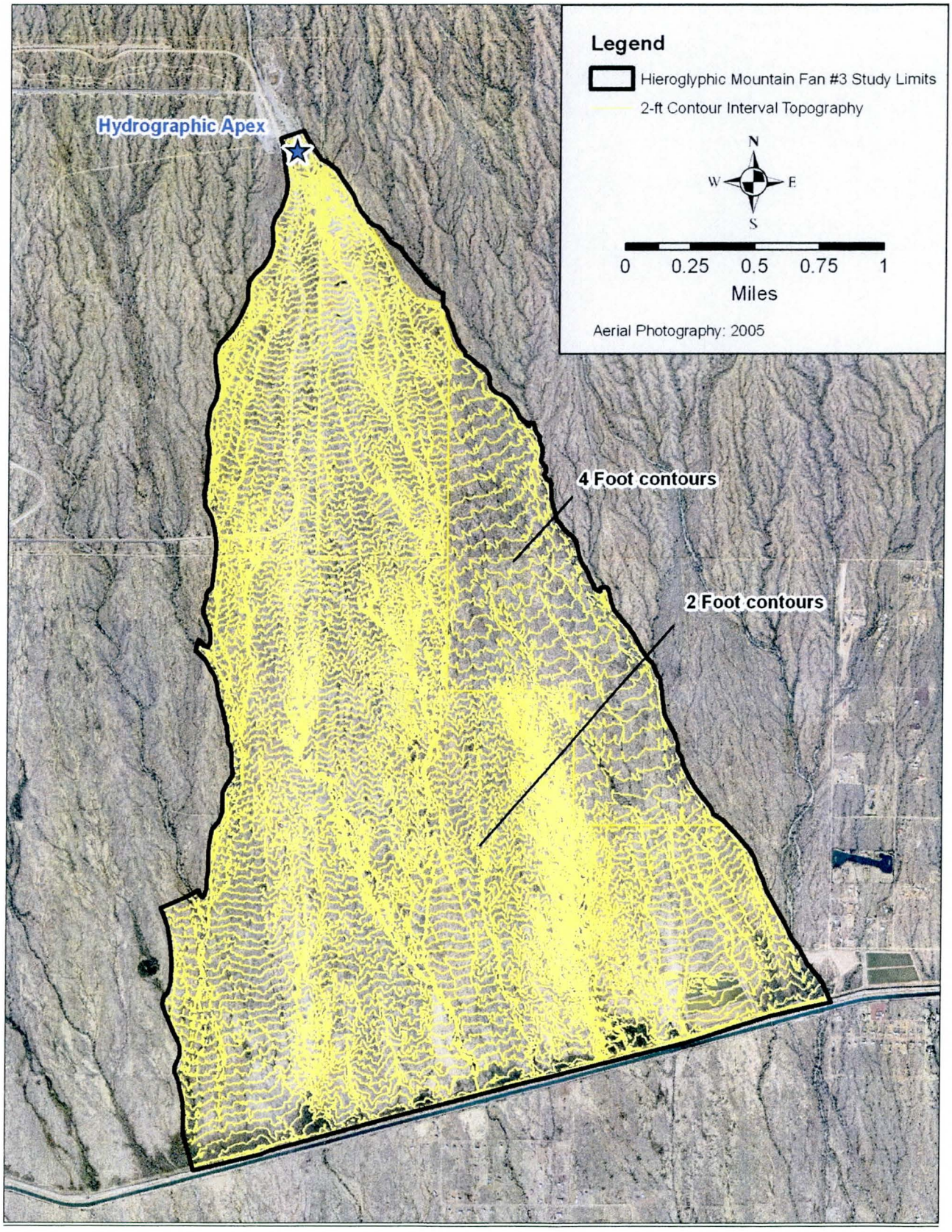

Figure 6B.19. 2- and 4-foot contour topographic mapping. Note change in contour interval along east side.

6B.5.3.4 Historical Aerial Photography

Historical aerial photographic coverage from 1949 and 2005 were available for the Hieroglyphic Mountain Alluvial Fan #3 area (Figure 6B.20 and Table 6B.5). The 1949 aerial photographs were scanned and semi-rectified using geographic features on the 2005 digital aerial photographs provided by the FCDMC. The side-by-side comparison of the historical and more recent aerial photographs of the study area shown in Figure 6B.20 indicates that there has been some channel movement within the active fan areas during 56 year period of record, with little discernable channel change in the stable areas. Several new channels have formed within the most active portions of the alluvial fans, and formerly active channels have been abandoned. There appear to have been significant changes in vegetative cover particularly in the most active portions of the landform. The primary human impact was construction of the Chrysler Proving Ground roadways and excavation of a shallow sand and gravel mine near the primary hydrographic apex.

Table 6B.5 List of Historical Aerial Photographs of White Tank Fan Study Area

Source	Photo Date	Scale	Type	Digital
FCDMC Archives (US AMS, 1949)	1949	1:20,000	Black & white prints	Scanned
FCDMC	2005	1:32,000	Color orthophotos	Yes

6B.5.3.5 Drainage Pattern

Drainage pattern is indicative of alluvial fan stability. Inactive, stable alluvial fans typically have a tributary, well-defined drainage pattern, with channels that generally increase in size with distance downstream. Active, unstable alluvial fans typically have poorly defined distributary or sheet flow drainage patterns, which have channels that often decrease (or disappear) in the downstream direction. The drainage pattern can be readily identified from aerial photographs (Figures 6B.3 and 6B.20) by the light-toned sandy channel bed materials and/or the bank vegetation which is usually denser and with different species than floodplain and terrace areas.

The drainage pattern in the unstable portions of the Hieroglyphic Mountain Alluvial Fan #3 is distributary with components of unconfined and sheet flow. Field observations suggest that large percentages of the active areas are inundated during significant floods. The stable portions of the piedmont have a tributary drainage pattern, and unstable portions have distributary and poorly defined drainage patterns. The distributary pattern persists from the primary hydrographic apex to the point where flow enters more defined, sub-parallel flow corridors, and then becomes distributary again upstream of the CAP at the secondary hydrographic apexes.

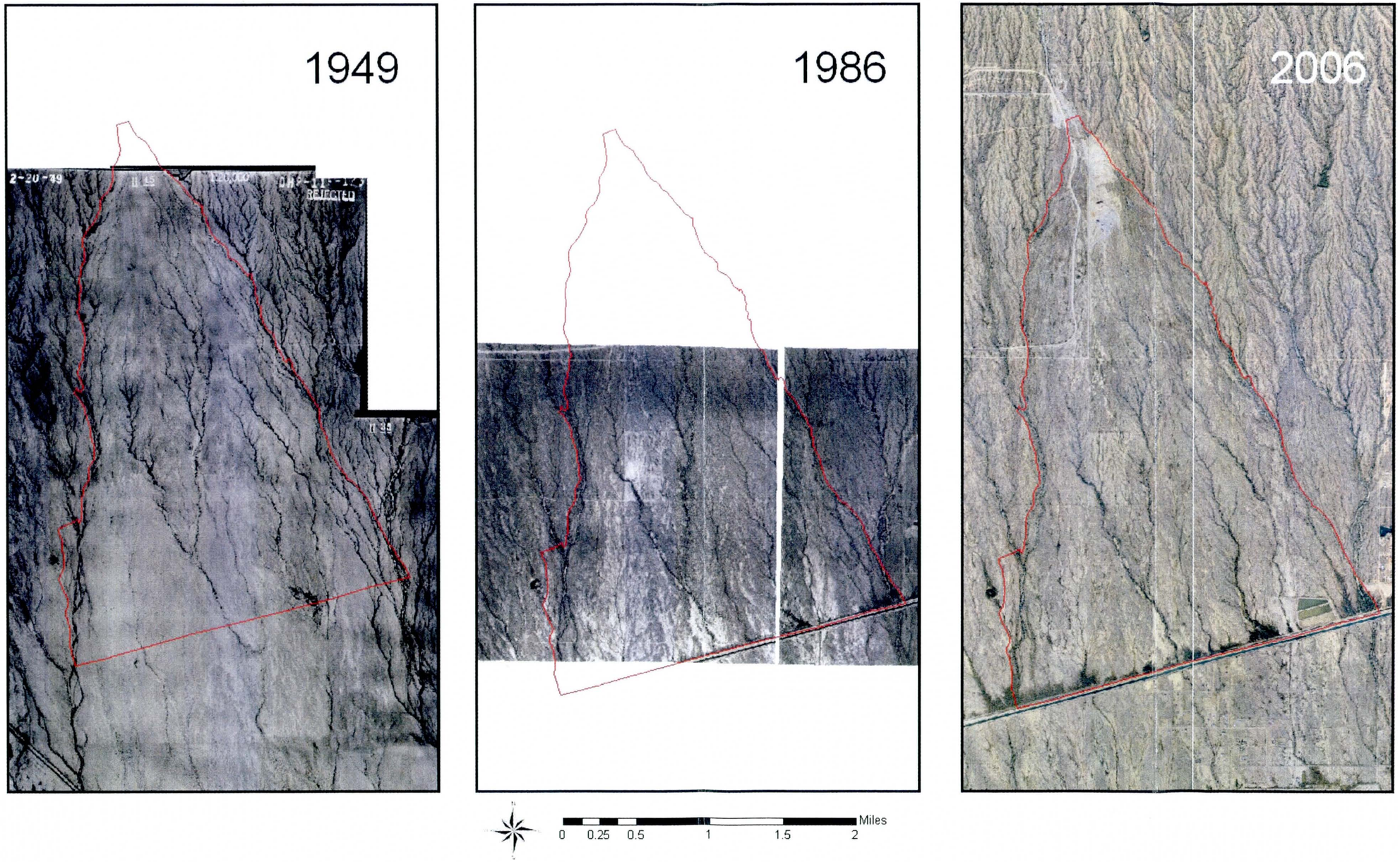

Figure 6B.20 Historical Aerial Photograph Comparison, 1949-2005

6B.5.3.6 Surficial Characteristics

Surficial landform characteristics can be used to identify stable and unstable alluvial fan surfaces, as described in Section 6B.5.1 and the PFHAM. Landform characteristics were identified during field visits, by interpretation of aerial photographs, and from NRCS soils and AZGS geologic maps. Key surficial characteristics considered for Hieroglyphic Mountain Alluvial Fan #3 delineation included the following:

- Surface Texture
- Surface Color
- Desert Varnish
- Desert Pavement

The active, unstable fan areas shown in Figure 6B.15 generally lacked surface reddening, desert varnish and desert pavement, and had relatively uniform surface texture. Inactive, stable surfaces had distinct surface texture, soil reddening, desert varnish and pavement areas. There are some surfaces with evidence of geologic age that were not mapped as inactive surfaces either because they were very small (< 1 ac), because they were dissected by active channels directly connected to the active alluvial fan drainage network, or because they were at elevations insufficient to prevent inundation from adjacent active surfaces. In some locations, the apparently older surfaces were at lower elevations than adjacent active areas. The latter factors may account for some of the discrepancies between the AZGS, NRCS, and TDN mapping. Because this floodplain mapping study used approximate methods, any surface in doubt as to its flood-prone status was considered to be within the floodplain, so that the more detailed analysis required to discern subtle differences could be deferred to future detailed-method studies.

6B.5.3.7 Vegetation

Vegetation was used in the following ways to distinguish stable and unstable alluvial fan surfaces on the Hieroglyphic Mountain Alluvial Fan #3:

- Vegetative Suites. The types of vegetation on any geomorphic surface are a function of the micro-climate (aspect, elevation, etc.), soil substrate, frequency and concentration of runoff, soil permeability, and soil chemistry. Because adjacent geomorphic surfaces on alluvial fan landforms differ in degree of clay and carbonate accumulation (substrate, chemistry, permeability), incision (runoff characteristics), and frequency of inundation, the vegetation suites on each surface are likely to vary slightly, either by species type and/or by species density or robustness.

- Marker Species. Certain species are almost always found in specific geomorphic and fluvial environments. For example: (1) ocotillo thrive in carbonate rich soils, and usually indicate that a caliche layer underlies the surface, (2) saguaro, barrel, and cholla cacti grow well in rocky, well-drained soils are usually found outside the active floodplain, (3) ironwood, palo verde, and mesquite trees typically are found on channel banks or where runoff concentrates frequently.
- Species Age. The apparent age of vegetation is used to distinguish geomorphic surface age. The age of vegetation is directly proportional to overall plant size, as well as trunk diameter (woody trees), presence or number of branches (saguaro cacti branch after about 70 to 100 years), or other factors (creosote clone ring diameter). Old vegetation is indicative of stability or at least non-erosion.
- Burial or Exposure. Burial of the plant base by sediment deposition may indicate aggradation or active alluvial fan flooding. Exposure of a plant's roots by erosion indicates scour or lateral erosion which may be associated with either stable or unstable surfaces, depending on other geomorphic characteristics.

Vegetation characteristics for the study site were identified in the field and on aerial photographs (Figure 6B.21). In general, the vegetation characteristics described above were consistent with field observations.

6B.5.3.8 Sediment Delivery Potential

Sediment yield was estimated by WEST (2005) for the Wittmann ADMSU using a variety of sediment yield methodologies. The WEST results indicated average annual sediment yield rates of about 0.4 acre-feet/square mile/year. Using the average yield value recommended by WEST, the average annual sediment yield at the hydrographic apexes is 7.5 acre-feet/year, and which would result in very low rates of net aggradation if distributed over the approximately 800 acre active, unstable portion of the fan (i.e., 0.01 ft/yr) near the primary hydrographic apex. The sediment yield data indicate that most avulsions in the active areas are probably due to local phenomena (stream capture, debris clogging, local deposition) rather than overall fan aggradation. The sediment data also suggest that minimal topographic relief is required to contain flooding within the active surfaces. The low sediment yield rate suggests that there is minimal potential for system-wide channel clogging, as well as high probability for water runoff to flow around depositional areas without leaving the active portions of the alluvial fan.

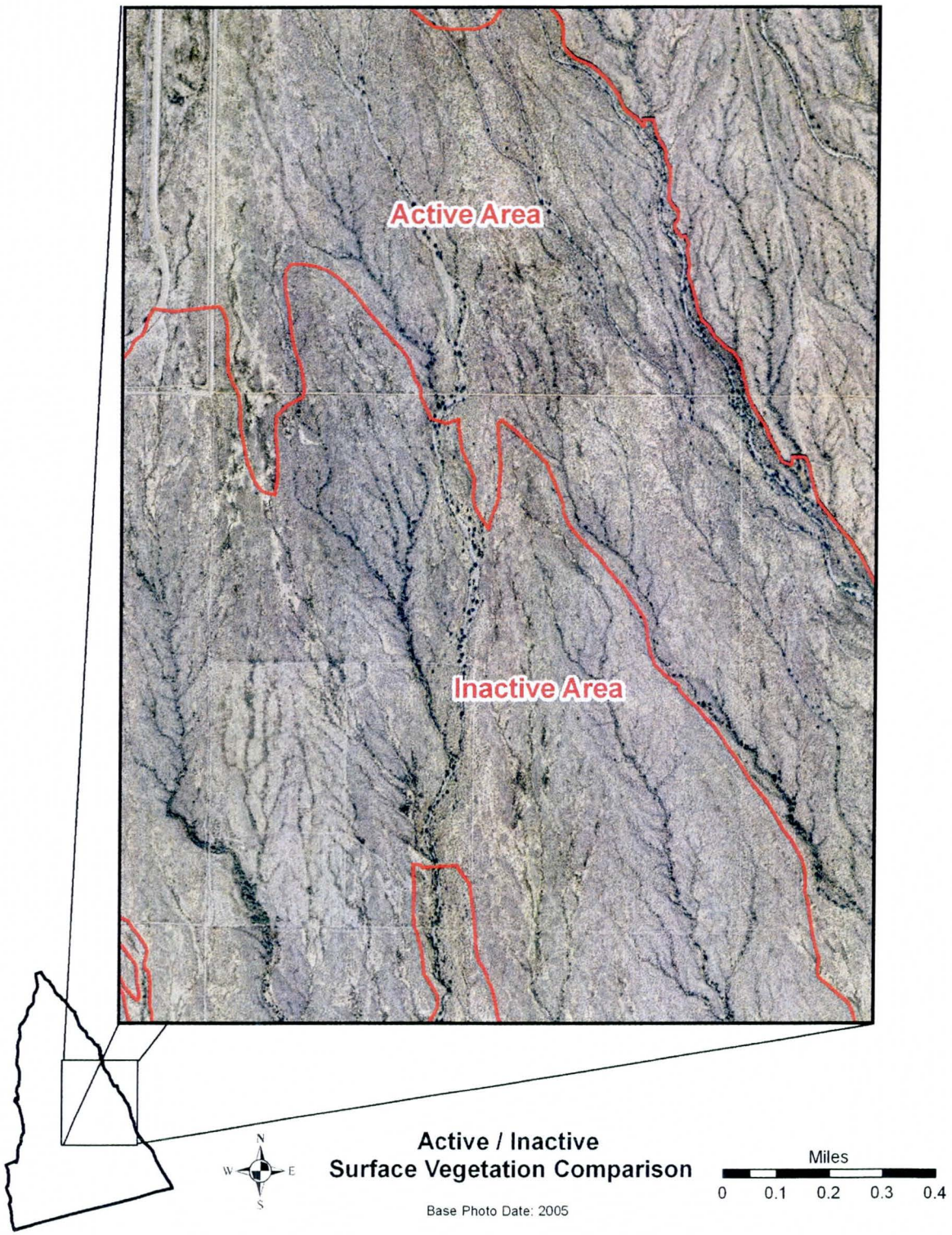

Figure 6B.21. Active/inactive surface vegetation characteristics

6B.5.3.9 Summary

Active and inactive portions of the Hieroglyphic Mountain Alluvial Fan #3 landform were identified using the geomorphic characteristics described above. The characteristics are best used in conjunction with each other, since no single characteristic is universally diagnostic of the level of stability. The stable/unstable landform delineation for the Hieroglyphic Mountain Alluvial Fan #3 is shown in Figure 6B.15.

6B.5.4 Alluvial Fan Floodplains Downstream of Unstable Areas

The unstable alluvial fan areas that experience alluvial fan flooding with flow path uncertainty, are located downstream of a hydrographic apex, either the primary hydrographic apex, or one of the secondary inset hydrographic apexes located further downstream. Runoff that passes through the entire unstable portion of the alluvial fan before reaching the toe of the alluvial fan landform is conveyed downstream through one or more of the following types of drainage networks:

- Stable Distributary Systems
- Sheet Flow Areas

Because they are interpreted as stable, both the distributary throughflow channels were mapped as inactive portions of the Hieroglyphic Mountain Alluvial Fan #3 landform. The same geomorphic characteristics described in Section 6B.5.3 were used to identify stable throughflow channels downstream of the unstable active alluvial fan areas. Note that significant flood hazards exist along the throughflow channels, as delineated in the Stage 3 analyses below, and that flow along the throughflow channels is still considered alluvial fan flooding because of uncertainty associated with the flow rate in any given corridor.

Sheet flow areas downstream of unstable fan areas were interpreted to have flow path uncertainty, but not to the degree that the uncertainty could not be "set aside in realistic assessments of flood risk." Although small channels do exist within the broad sheet flooding areas, and the distribution of flow in these very small channels (widths less than 10 feet, depths less than 2 feet) undoubtedly varies from flood to flood, and historical analysis indicates that the channel position can change with time, the overall character of flooding is not significantly impacted by such changes. That is, flood flow during the design event is likely to be shallow, consisting primarily of unconfined overbank runoff spread out over wide portions of the alluvial fan landform. Therefore, these sheet flow areas are not shown as unstable on Figure 6B.15, but instead are delineated as floodplains in the Stage 3 analysis.

6B.5.5 Identification of Inactive Areas

Along with the active alluvial fan areas at the Hieroglyphic Mountain Alluvial Fan #3, Figure 6B.15 also shows the inactive alluvial fan areas. Basically, the inactive areas are those portions of the alluvial fan

landform that are not unstable, as described in the Section 6B.5.3. As shown in Figure 6B.15, a significant portion of the Hieroglyphic Mountain Alluvial Fan #3 landform consists of inactive, stable surfaces.

6B.5.6 Types of Flooding on the Piedmont

Based on the evaluation of active and inactive areas on the Hieroglyphic Mountain Alluvial Fan #3 landform, the following locations and types of flood hazards were defined.

6B.5.6.1 Flooding Along Stable Channels: Upstream of the Hydrographic Apex

Riverine flooding upstream of the hydrographic apex was delineated using approximate method riverine delineation techniques, as described in Section 5. The riverine reach upstream of the hydrographic apex is considered stable surface flooding.

6B.5.6.2 Unstable Flow Path Flooding

Active alluvial fan flooding on the piedmont is limited to the areas downstream of the primary and secondary hydrographic apexes. These areas represent significant flood, erosion and sedimentation hazards. Three types of unstable flow path flooding were identified. First, areas immediately below the hydrographic apex are subject to higher risk of channel avulsion, aggradation and erosion. Second, active alluvial fan areas near the downstream limit of the study area are subject sheet flooding in which flow paths change during and between floods. Third, areas of likely avulsion adjacent to significant flow paths were identified. Note that flow rate uncertainty exists everywhere along the alluvial fan drainage network between the hydrographic apexes and the CAP.

6B.5.6.3 Flooding Along Stable Channels: Downstream of the Hydrographic Apex

Downstream of the unstable fan areas flood waters concentrate into a series of sub-parallel channels that cross slightly older, slightly more stable geomorphic surfaces. These channels have been stable over the past 50 years as indicated by the historical aerial photographs and possibly the past few thousand years as indicated by the surficial geology. Flood hazards along these corridors can be expected to be confined to the existing channel network and their floodplains. However, uncertainties in the discharges delivered to each channel make detailed quantitative evaluation of these hazards difficult. Until the discharge distribution uncertainty created by the active area upstream can be resolved, this study suggests that an approximate method relying on geomorphic surface interpretation can adequately and realistically evaluate the location and lateral extent of these hazards.

6B.5.6.4 Sheet Flow Areas

Sheet flow occurs in the active fan areas below the hydrographic apexes, within the transition zone from the highly active fan areas near the apex to the distributary throughflow channels, and in active fan areas near the downstream limits of the study area. Most of the lower piedmont is subject to sheet flow. Broad areas of geologically young surfaces attest to their repeated inundation over the past few thousand years. Within these areas a few defined washes do exist, which can be expected to convey portions of the flood discharge and which are likely to receive flood water much more frequently than other (non-channel) areas on the lower piedmont. Additionally, the fine-grained soils of the lower piedmont are capable of creating more frequent local runoff due to low infiltration rates.

6B.5.6.5 Debris Flow Areas

No evidence of debris flows was observed in the field, on topographic maps, or on aerial photographs. The NRCS soils mapping and AZGS geologic mapping do not mention debris flow hazards or deposits within the study area. The hydrographic apexes are located too far from the mountain front for debris flows to be of concern for the flood hazard inundation areas mapped in this study.

6B.5.7 Summary of Stage 2 Delineation

Figure 6B.15 shows the limits of the stable and unstable areas of the Hieroglyphic Mountain Alluvial Fan #3. The Stage 2 active/inactive area delineation is the foundation for the Stage 3 floodplain delineation. The most active parts of the piedmont are the areas immediately downstream of the hydrographic apexes.

6B.6 Stage 3: Defining the Approximate 100-Year Floodplain

The Stage 3 100-year flood hazard assessment is an outgrowth of the information and results identified and generated in Stages 1 and 2. In Stage 1, the study site was identified as part of an alluvial fan landform. In Stage 2, the unstable (active) and stable (inactive) portions of the alluvial fan landform were identified. According to the FEMA Guidelines, "the delineated flood-prone areas of Stage 2 should approximate the largest possible extent of the 100-year flood." In Stage 3, floodplain limits for the 100-year (1%) flood are delineated for each of the types of the following types of flooding identified in Section 6B.5:

- Flooding Along Stable Channels: Upstream of the Hydrographic Apex. The floodplain along the main channel upstream of the hydrographic apex was delineated using riverine approximate method techniques, as described in Section 5.0.
- Unstable Flow Path Flooding. The floodplain in the areas with unstable flow path flooding (active alluvial fan flooding) downstream of the hydrographic apexes were delineated using geomorphic

data. In general, the 100-year floodplain delineated in the active alluvial fan areas is coincident with the Stage 2 unstable area delineation.

- Flooding Along Stable Channels: Downstream of the Hydrographic Apex. The floodplain along stable distributary and tributary channels located downstream of the active alluvial fan areas were delineated using geomorphic data.
- Sheetflow. Areas of sheet flooding were delineated using geomorphic data.

Flood hazards for all portions of the alluvial fan downstream of the hydrographic apex were delineated using geomorphic techniques. Application of geomorphic mapping techniques to the unstable portions of the alluvial fan is the preferred delineation method in Maricopa County. Application of geomorphic techniques to the remaining portions of the alluvial fan downstream of the hydrographic apex is required by the site conditions and the available information. The stable distributary and tributary channels systems downstream of the hydrographic apex are referred to as throughflow channel corridors. Within some of the throughflow channel corridors, minor channel changes were observed in the historical aerial photo record or in the field, although the changes were confined within the corridors. The corridors are bounded by topographically higher, slightly older, somewhat more stable geomorphic surfaces. Channel changes along the throughflow corridors are analogous to minor channel changes in a braided riverine system that do not affect the flood limits or overall stream morphology. That is, there is only minimal flow path uncertainty which can be "set aside in a realistic assessment of flood risk." There is, however, significant flow *rate* uncertainty due to the uncertain flow *path* distribution in the active unstable area upstream. This flow rate uncertainty raises significant questions about traditional riverine floodplain delineation techniques for the throughflow channels because the 100-year discharge is unknown.

Flooding along the throughflow channels downstream of active unstable alluvial fan areas has the following characteristics of alluvial fan flooding, as defined by FEMA: (1) it occurs on an alluvial fan landform, (2) it originates at a hydrographic apex, (3) it is characterized by high velocity flow, (4) it is characterized by processes of erosion, sediment transport, and deposition, (5) and it is hydraulically connected to areas that experience unpredictable flow paths. According to Table G-1 in the FEMA Guidelines, floodplain delineation using geomorphic data is acceptable for alluvial fans with little or no urbanization. At the time of this study, the watershed has little or no urbanization. The through-flow channels do not have flow path uncertainty, the key characteristic of high hazard active alluvial fans. Therefore, use of geomorphic data as the basis of the floodplain delineation is acceptable for the areas downstream of the hydrographic apex.

The Stage 3 100-year floodplain delineation for the Hieroglyphic Mountain Alluvial Fan #3 is shown in Figure 6B.22.

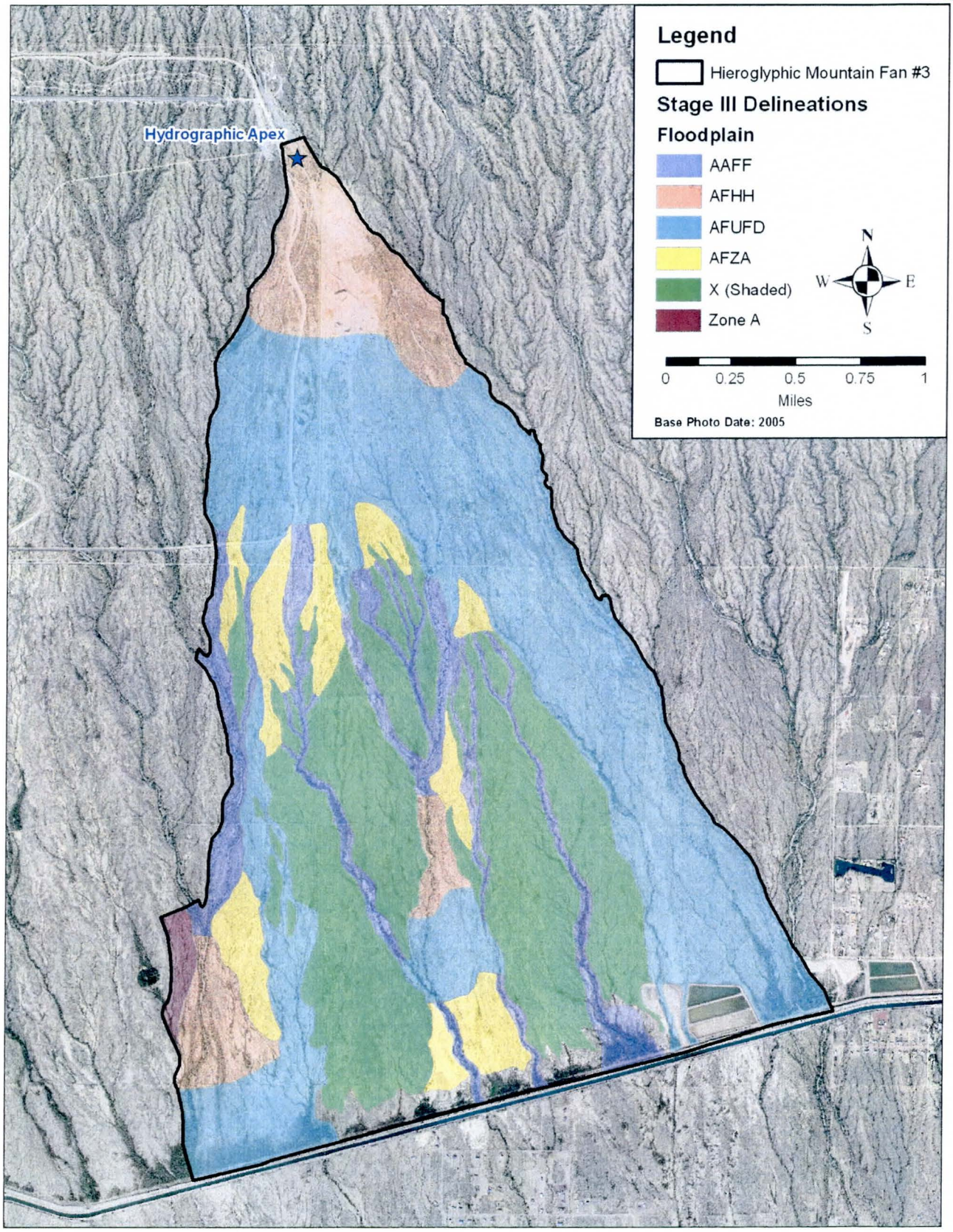

Figure 6B.22. Stage III floodplain zone delineations for the Hieroglyphic Mountain Alluvial Fan #3.

6B.6.1 Flood Hazard Zones

Table 6B.8 lists and describes the flood hazard zones identified and shown in Figure 6B.22 and the Stage 3 – 100-year Floodplain Map in the Exhibit Maps section of the TDN. These zones have been defined for use in the delineation of piedmont flood hazards in Maricopa County, Arizona by the Flood Control District of Maricopa County, and were approved the Maricopa County Board of Supervisors on November 1, 2000. The flood hazard zones shown on Figure 6B.22 are given in Table 6B.6. The resulting flood hazard map is similar in nature to the one shown in Example 4 in Appendix 1 of the FEMA Guidelines (2000). The flood hazard areas shown in Figure 6B.22 were developed by elimination of "islands" smaller than five acres, interpretation of aerial photographs, and inclusions of areas adjacent to geologically young surfaces where uncertainties associated with alluvial fan flooding were incorporated. Finally, these interpretations were supplemented and finalized based on observations of ground conditions in the field.

Specifically, the unstable areas from Stage 2 have been used to identify the location of the Zone A – Administrative Floodway Active Alluvial Fan (Local Community Zones AFHH and AFUFD). The AFHH (active alluvial fan) zone lies within the unstable area. An abandoned sand and gravel excavation lies just downstream of the primary hydrographic apex within the AFHH zone. A description of how the sand and gravel mine was considered in the flood zone delineation is described in a Special Problem Report (Appendix B.1). The AFUFD (uncertain flow distribution) zone encompasses the remainder of the unstable area as well as an additional buffer area along the downstream edge of the unstable area identified in Stage 2. This buffer area was determined by use of the soils, surficial geology data, interpretation of recent and historical aerial photographs, and engineering judgment. The AFUFD Zone also includes surfaces where the primary instability results from a high potential for channel avulsions. These areas include the AFUFD Zone that extends along the eastern margin of the fan and the AFUFD Zone that parallels the east side of the AAFF Zone located along the western margin of the fan.

Emanating from the AFUFD zone are Zone A – Administrative Floodway Inactive Alluvial Fan (Local Community Zone AAFF) corridors which traverse the more stable portions of the alluvial fan landform. These areas represent the primary throughflow channels that convey the majority of the sediment and water discharges from the watershed as evidenced by the NRCS soils data, the AZGS surficial geology data, and by interpretation of geomorphic features as shown in color aerial photographs and field observations. The throughflow channels also represent the primary low flow conveyance system on the fan. These throughflow channel corridors can be considered similar to riverine floodways in that they are areas reserved for conveyance of the 100-year flood. Although these floodway corridors do not necessarily contain the entire limits of the 100-year flood across the middle and lower piedmont under the existing condition, they are adequate in size and continuity to convey floodwaters across the piedmont if flood water were restricted to them. Reservation of these corridors will allow for engineered flood protection and mitigation within other

flood prone but stable areas of the inactive alluvial fan. The approximate alluvial fan floodways (Local Community Zone AAFF) were determined by first identifying the most prominent, continuous channels which connect the active alluvial fan upstream to the lower piedmont.

Table 6B.6 Flood Hazard Zones Used in the Stage 3 Delineation

Zone Name	Local Community Zone Designation	Description
Zone A	Zone A	Approximate 100-year floodplain; riverine reaches upstream of hydrographic apex, and previously mapped ponding area behind Buckeye FRS #1
Zone A – Administrative Floodway Riverine	Zone A	Approximate 100-year floodplain, riverine reaches upstream of hydrographic apex, managed as a floodway district.
Zone A – Administrative Floodway Active Alluvial Fan	AFHH – Administrative Floodway	Alluvial Fan High Hazard, community to treat as a floodway district
Zone A – Administrative Floodway Active Alluvial Fan	AFUFD – Administrative Floodway	Alluvial Fan Uncertain Flow Distribution Area; transitional area downstream of AFHH zone characterized by channelized and sheet flooding generally becoming more stable and less uncertain with increasing downstream distance from the AFHH zone; community to treat as a floodway district
Zone A – Administrative Floodway Inactive Alluvial Fan	AAFF - Administrative Floodway	Approximate Alluvial Fan Floodway; corridors for conveyance of water and sediment on a stable alluvial fan surface downstream of the AFHH and AFUFD; community to treat as a floodway district
Zone A – Inactive Alluvial Fan	AFZA	Alluvial Fan Zone A; areas within the 100-year floodplain on an inactive alluvial fan characterized by shallow channelized flow and sheet flooding in stable channels; zone is considered approximate because no base flood elevations are provided; flood hazards within this zone are not necessarily equal throughout, that is, the frequency and magnitude of flooding with respect to depth and velocity of flow may vary within the AFZA zone; floodplain managers should consult available aerial photographs and topographic maps for more detailed evaluation of site specific flood hazard within this zone; development will be allowed in this zone given demonstration of adequacy of site and/or design which addresses safety from inundation and sedimentation hazards
X (shaded) – Inactive Alluvial Fan	X (shaded)	Areas flooded between 100-yr and 500-yr discharge; or areas of flooding with depth of 100-year flood less than 1 foot; or drainage area less than 1 square mile
X (unshaded)	X (unshaded)	Areas outside the 500-year floodplain; shown only on rocky hills
D	D	Area not studied

Flood prone areas in inactive areas outside the alluvial fan floodways are identified in Table 6B.6 as Zone A – Inactive Alluvial Fan (Local Community Zone AFZA). The throughflow channel corridors (AAFF) convey storm water and sediment in major events. The areas designated as Local Community Zone AFZA are subject to overbank flow and local runoff. The AFZA zone is generally characterized by sheet flooding and

flooding within relatively small stable channels. These small channels may either represent small distributary drainages connected to the primary floodways, small local drainages, or various paths where broad sheet flooding recollects as it flows down the piedmont in an effort to reorganize itself. Consequently, the magnitude and frequency of flood hazards within the AFZA zone should not be considered equal at every location.

Between many of the mapped flood-prone areas are areas of slightly older, more stable geomorphic surfaces characterized by greater topographic relief and channel incision. These areas were mapped as Zone X (Shaded). The Zone X (Shaded) areas have flood hazard potential from local drainage areas smaller than one square mile as well as stable areas potentially flooded by events less frequent than the 100-year flood (e.g. the 500-year flood) or flow depths less than 0.5 foot. Also, because approximate methods were used, islands smaller than five (5) acres were not delineated. Finally, an area of Zone X (not shaded) was identified adjacent to the CAP at the western side of the fan that consisted of bermed recharge basins and very large spoil piles elevated well above the floodplain.

6B.6.2 Verification of Results

No independent studies were available for the study area from which to verify the floodplain delineation. However, the 100-year flood hazard assessment of the Hieroglyphic Mountain Alluvial Fan #3 is believed to be reasonable, sound, and defensible based on the data presented in this Technical Data Notebook. Revisions to the mapping presented here could be justified based on more detailed hydrologic and hydraulic analyses, if such analyses were able to account for flow uncertainty and sediment transport on an evolving landform.

6B.6.3 Limitations

Every modeling and mapping methodology has limitations. The limitations of the approximate geomorphic floodplain delineation method used for the study area are summarized below.

6B.6.3.1 Scale of mapping

The mapping for this study was compiled onto 1:12,000 or better scale maps. The 2005 aerial photographs used are of excellent resolution that did not limit interpretation at the map scale. Nevertheless, the size of the alluvial fan landforms considered precludes the level of detail possible when mapping at an individual lot basis.

6B.6.3.2 Accuracy of mapping

Map accuracy is also a limitation for some of the data sources used such as NRCS and AZGS soils and flood hazard mapping. These maps were scanned and semi-rectified, but some horizontal

displacement remained. Additionally, in the process of transferring field and photo interpretations to the DOQs, the accuracy is limited to one's ability to identify precisely identical locations on each photograph. Through the use of landmarks, distinctive channel features and patterns, large trees, etc. it is believed that these errors have been minimized.

6B.6.3.3 Time period of historical photo record

Period of record for historical aerial photos spans 50 years. While this is a reasonably long period, it does not ensure that a 100-year event occurred during this time period, or that the full range of expected alluvial fan processes has been observed. However, use of geomorphic data extends the period of record significantly.

6B.7 Work Study Maps

This study includes geomorphic mapping and floodplain delineation of parts of the Hieroglyphic Mountain Alluvial Fan #3 piedmont. The figures for Section 6B, including a cover sheet showing the project location and 11" x 17" versions of the Stage 1 Landform map, Stage 2 Stability map, and Stage 3 Floodplain map, are located at the end of Section 6B of the Technical Data Notebook.

6B.8 References

1. Aerial Mapping Company, 1999, Color stereographic aerial photographs of White Tank fan approximate delineation study area, flight date 9-25-99, scale 1:9,600 and flight date 10-6-99, scale 1:32,000.

2. Camp, P.D., 1986, Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona: U.S. Soil Conservation Service Report, 306 p., 53 maps, scale 1:24,000.

3. Dohrenwend, J.C., 1987, Basin and Range, *in* Graf, W.L., ed., Geomorphic systems in North America: Geological Society of America, Centennial Special Volume 2, p. 303-342.

4. FCDMC, 1996, Drainage Design Manual for Maricopa County, Arizona, Volume II, Hydraulics: Phoenix, Arizona, Flood Control District of Maricopa County.

5. FEMA, 2002, Guidelines and Specifications for Flood Hazard Mapping Partners – Appendix G: Guidance for Alluvial Fan Flooding Analyses and Mapping, February, 2002. Available on-line at http://www.fema.gov/mit/tsd/FT_alfan.htm.

6. Field, John J. and Pearthree, Philip P., 1992, Geologic Mapping of Flood Hazards in Arizona: An Example from the White Tank Mountains Area, Maricopa County. Arizona Geological Survey OFR 91-10, 16 p., 4 maps, scale 1:24,000.

7. Field, John J. and Pearthree, Philip P., 1991, Surficial Geology Around the White Tank Mountains, Central Arizona: Arizona Geological Survey OFR 91-8, 7 p., 9 maps, scale 1:24,000.

8. Hjalmarson, H.W., 2003, Piedmont flood hazard assessment for flood plain management for Maricopa County, Arizona: Flood Control District of Maricopa County, 362 p.

9. National Archive, 1949, Black and white aerial photographs, scale 1:20,000.

10. National Research Council, 1996, Alluvial Fan Flooding: Washington, D.C., National Academy Press, 172 p.

11. Sabol, G.V., Rumann, J.M., Khalili, D., Waters, S.D., Lehman, T.W., 1995, Drainage Design Manual for Maricopa County, Arizona, Volume I, Hydrology: Flood Control District of Maricopa County, Phoenix, Arizona.

12. Thomas, Blakemore E., Hjalmarson, H.W., and Waltemeyer, S.D., 1997, Methods for Estimating Magnitude and Frequency of Floods in the Southwest United States: U.S. Geological Survey, Water Supply Paper 2433, 195 p.

13. Vanden Dolder, E.M., 1992, Rock varnish and desert pavement provide geological and archaeological records: Arizona Geology, v. 22, no. 1, p. 1, 4-7.

SECTION 7: DRAFT FIS

7.1 Summary of Discharges

See Section 4 and Table 4.2 for detail regarding the origin of the discharges presented below.

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs)			
		10-Year	50-year	100-Year	500-Year
Hieroglyphic Mountain Alluvial Fan #3	18.72			9,687	

**Area estimated based on unit discharge*

7.2 Floodway Data

Floodway data tables are not presented in this TDN.

7.3 Annotated Flood Insurance Rate Maps

See C. Maps, Volume 6 of this TDN.

7.4 Flood Profiles

Flood profiles are not presented in this TDN.

Appendix A

References

1. Camp, P.D., 1986, Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona: U.S. Soil Conservation Service Report, 306 p., 53 maps, scale 1:24,000.

2. Dohrenwend, J.C., 1987, Basin and Range, in Graf, W.L., ed., Geomorphic systems in North America: Geological Society of America, Centennial Special Volume 2, p. 303-342.

3. FCDMC, 1995, Drainage Design Manual, Volume I, Hydrology, as revised January 1, 1995.

4. FCDMC, 1996, Drainage Design Manual for Maricopa County, Arizona, Volume II, Hydraulics: Phoenix, Arizona, Flood Control District of Maricopa County.

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6. Field, John J. and Pearthree, Philip P., 1992, Geologic Mapping of Flood Hazards in Arizona: An Example from the White Tank Mountains Area, Maricopa County. Arizona Geological Survey OFR 91-10, 16 p., 4 maps, scale 1:24,000.

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10. Phillips, J. V. and Ingersoll, T.L., 1998, Verification of Roughness Coefficients for Selected Natural and Constructed Stream Channels in Arizona: U.S. Geological Survey Professional Paper 1584, 77 p.

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14. U.S. Army Corps of Engineers, HEC-RAS River Analysis System, Version 3.1.3, May, 2005.

15. U.S. Geological Survey, 1982, Hieroglyphic Mountains SW, Ariz. Quadrangle, 7.5 minute series, 1:24,000 (original photo date 1971, and photo inspected with no changes made in 1982).

16. Vanden Dolder, E.M., 1992, Rock varnish and desert pavement provide geological and archaeological records: Arizona Geology, v. 22, no. 1, p. 1, 4-7.

Appendix B

Correspondence

APPENDIX B

B.1 Special Problem Reports

B.2 Contact (telephone) Reports

B.3 Meeting Minutes or Reports

B.4 General Correspondence

B.5 Contract Documents

B.6 Public Notification

B.7 FEMA Correspondence

B.1 Special Problem Reports

Special Problem Report #1 – Sand & Gravel Excavation at Primary Hydrographic Apex

A recently abandoned sand and gravel excavation exists near the primary hydrographic apex of the Hieroglyphic Mountain Alluvial Fan #3. Inspection of historical aerial photographs indicates that the shallow mine was excavated beginning after 2001 (Figure B.1-1). The FCDMC floodplain permitting staff indicates that the mine was originally operating without a valid floodplain use permit, but was later brought into compliance after submittal of an engineered mining plan. The permitted mine had a depth of 10 feet below grade and covered a footprint approximately equal to that shown in the 2005 aerial photo. After the mine was permitted, the property was sold to developers. The developers reportedly have no intention of continuing the mining operation, but are responsible for implementing the mine reclamation plan which calls for backfill to 3:1 side slopes.

The mine is located immediately downstream of the hydrographic apex and consists of two parts. The "North Pit" consists of a very shallow excavation (or possibly an area of grubbing) located furthest upstream and slightly east of the existing main channel at the apex. The North Pit is reflected on the 2-foot contour mapping provided by the District, which was used to estimate the volume of the excavation at approximately 2.1 acre-feet. The second excavation area, the "South Pit," is located west of the main channel and is only partially reflected on the 2-foot contour interval mapping provided by the District. The volume of the South Pit excavation estimated from the District topographic mapping is approximately 3.4 acre-feet. Field inspection indicates that the current pit is somewhat deeper and longer than is shown on the District topographic mapping. The South Pit is not currently directly connected to the main flow path on the fan, but could be captured during an avulsion.

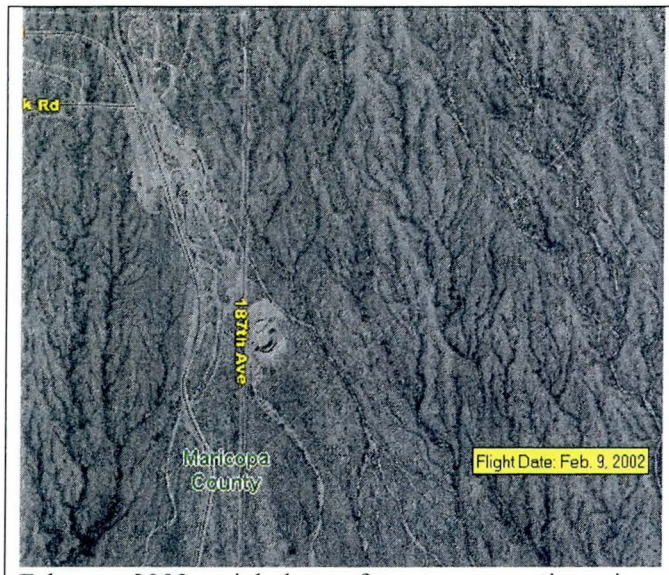
The potential impacts of the pit on alluvial fan flooding were assessed as follows:

- Conservative Mapping Approach. Consistent with the intent of approximate method mapping, a conservative approach was used to assure that all potential flood-prone areas were included in the flood hazard delineation.
- Comparison of Excavation Volume with Flood Volume. The total excavated volume estimated from the District 2-foot contour interval mapping was 5.5 acre-feet. The 100-year hydrograph (water) volume estimated from the Wittmann ADMP HEC-1 model was approximately 1,970 acre-feet at the apex (CPI681). Therefore, the excavated volume was about 0.3% of the 100-year flow volume. The entire permitted future volume of excavation (82.3 AF) is only 4% of the 100-year flood volume.

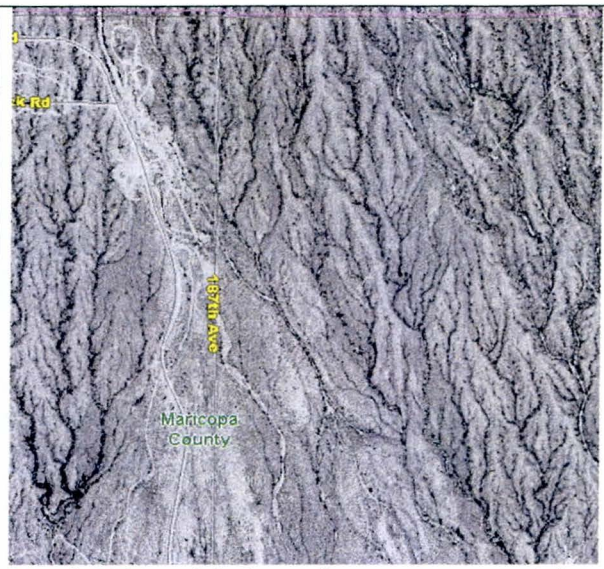
Given that sediment concentrations during large floods in semi-arid regions can reach 10 to 20 percent of the flow volume, the existing excavation could fill during the rising limb of a single large flood.

- Comparison of Excavation Volume with WEST Sediment Yield. WEST Consultants computed an average annual sediment yield for the Wittmann ADMP study area of about 0.4 AF/mi2/yr. For the 18.7 sq. mi. watershed at the apex, this translates to an average annual yield of about 7.5 AF/yr. Therefore, the existing excavation could be filled during a single average year of sediment supply.
- Location of Excavation Relative to Main Flow Paths. The largest excavation is located off the main channel and is therefore only likely to collect water and sediment from overbank flows unless an avulsion occurs. The most active part of the fan lies to the east of the South Pit as shown in Figures 6B.15 and 6B.22, and thus is less likely to be impacted during most flows.
- Potential Impact on Downstream Flows in the Event of a Breach or Capture. If the excavations capture the main flow path through an avulsion, lateral erosion or other process, flow will enter and fill the pit relatively quickly and will weir over the downstream end as sheet flow or will enter the existing channel network. Because the existing excavation spans the active portion of the fan from the channelized area near the apex to the sheet flow transition zone (AFUFD), the type of flow experienced immediately downstream of the pit will only be minimally affected compared to what it would have experienced prior to the excavation.

It is possible that future development will occur in and around the Hieroglyphic Mountain Alluvial Fan #3. At that time, it is possible that the existing excavations can be utilized in conjunction with other structural measures as part of a whole-fan solution. Until that time, it is prudent to map the floodplains as shown in this TDN.



February 2002 aerial photo of apex area – active mine.



March 2000 aerial photo of apex area – no mining.

January 2006 aerial photo of abandoned mine.

Shallow mining area in December 2006

Figure B.1-1. Aerial and ground photos of sand and gravel mining site.

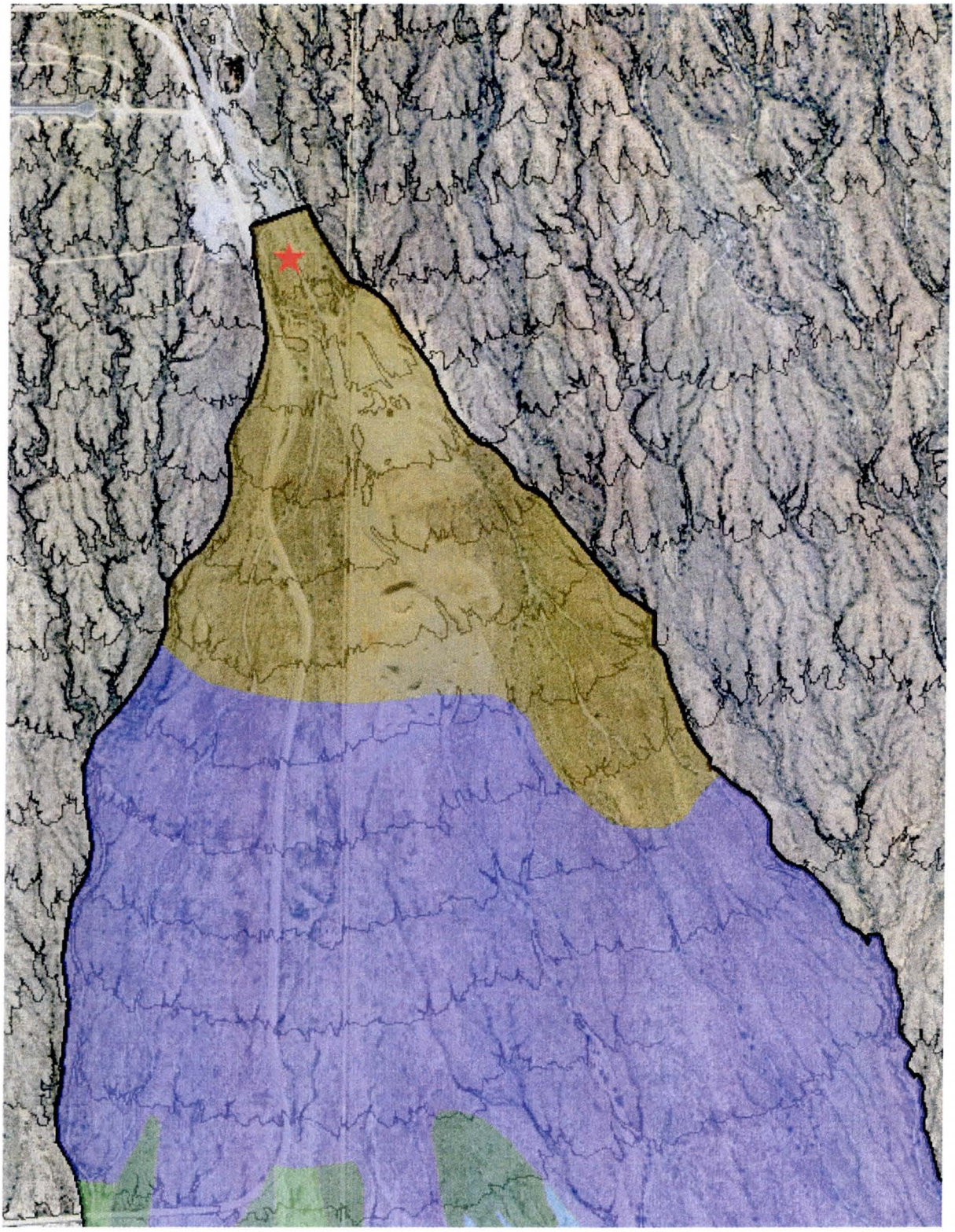


Figure B.1-2. Stage 3 delineation in area of mining activity (gold=AFHH; purple=AFUFD)

B.2 Contact (telephone) Reports

B.3 Meeting Minutes or Reports

B.4 General Correspondence

Memorandum JE Fuller/ Hydrology & Geomorphology, Inc.

DATE: April 6, 2007

TO: Kelli Sertich/FCDMC
Kathryn Gross/FCDMC

FROM: Jon Fuller, PE, RG, PH, CFM

RE: Wittmann ADMPU Task 2.8.5
Hieroglyphic Mountain Alluvial Fan #3
Response to District Review Comments Dated 4-2-07

CC: Rob Lyons, PE

This memorandum summarizes JE Fuller/Hydrology & Geomorphology, Inc. (JEF) responses to District review comments provided by Kathryn Gross/FCDMC on April 4, 2007. JEF response are indented in bold italics 10-point font after each District comment.

The TDN was submitted as Chrysler Proving Ground Fan. The District recommends its name be changed to Hieroglyphic Mountain Alluvial Fan #3. All references on maps and in the text should be updated to reflect the new name.

- ***JEF Response: We will make this change. However, we note that the scope of services references the site using the name "Chrysler Proving Ground Fan" and that making the change is not a trivial effort, particularly when it comes to the graphics, so we want you to feel sorry for us.***

Delineations and Hydraulic Analysis

1. Stage 1 Landform Delineation. The delineation appears reasonable. Depending on the scope, if the landform delineation is to be submitted for inclusion in the District's HIS database (landform.dxf or shp) some modifications may be necessary. This can be discussed with the project manager and the consultant.

    - ***JEF Response: All HIS submittals will be completed and delivered upon final approval of the TDN.***

2. Stage 2 Stability/Active Delineation. The delineation appears reasonable and is accepted. Depending on the scope, if the stability delineation is to be submitted for inclusion in the District's HIS database (landstbl.dxf or shp) the current shape file should be modified to include only the stability data in the required format.

    - ***JEF Response: All HIS submittals will be completed and delivered upon final approval of the TDN.***

3. Stage 3 Floodplain Delineation. The delineation appears reasonable. Final approval will be given when work maps are submitted with the next TDN revision. Based on the work map submitted for review of the RAS portion of the

delineation the tie-in between the RAS delineation and geomorphic delineation should be refined. The floodplain delineation will be required to meet the District's HIS specifications and be submitted for inclusion into the HIS database. Fpznfcd, fpxfcd, and fpblnfcd should be submitted.

- ***JEF Response: All HIS submittals will be completed and delivered upon final approval of the TDN.***

- Please keep in mind that approximate floodways still need to have a dashed line symbol to distinguish them from regular floodplain.

- ***JEF Response: Will do.***

4. Hydraulic analysis appears reasonable.

- ***JEF Response: No action needed.***

TDN Comments

1. Please revisit the page numbering in each section. In some sections there are shifts in the numbering.

- ***JEF Response: Done.***

2. Page 1-1 Section 1.3. The text describes the fan as draining to Trilby Wash. Can the reference to Trilby be removed? The formal Triby Wash, in the District's eyes, is located further west and may be confusing. Perhaps stating that the system ultimately drains to McMicken Dam may be an alternative?

- ***JEF Response: Done.***

3. O&C Form. Additional FIRM panels needed. The study just barely touches two other panels. Please consider adding them.
   - Update the Suffix for 715. According to our database it is now G instead of E.
   - Add 04013C0720G
   - Add 04013C1130G

- ***JEF Response: Done. 04013C0705G also contains a small portion of the riverine delineation within the panel map limits.***

4. H&H form Section A.5. "No" box is not checked. Please check the box.

- ***JEF Response: Done.***

5. Page 4-1, Section 4.1 Consider adding the FEMA Case No. under which the hydrologic information was provided. The District can provide the information to the consultant.

- ***JEF Response: If provided, it will be added.***

6. Section 5.3, Parameter Estimation. Section heading number is missing.

   - ***JEF Response: Done.***

7. Section 6B.3 second to last paragraph. Typo. Please correct "where" in the last sentence. It appears it should read, "were".

   - ***JEF Response: Done.***

8. Figure 6B.1 is somewhat hard to interpret is there a way to present the data more clearly or provide an explanation in the report?

   - ***JEF Response: The graphics guy hiccupped on that one. The figure has been fixed.***

9. Figure 6B.2 is presenting geology data from two sources should both sources be listed in the text and potentially in the legend of the figure?

   - ***JEF Response: A reference to Table 6B.1 was added to the figure.***

10. Section 6B.4.2 Morphology, third paragraph. Please re-visit the sentence: "Surficial characteristics of an alluvial fan landform observed in the study area on aerial photographs and in the field included non-linear (i.e. riverine) and radial distributions…"

    - ***JEF Response: Done.***

11. Figure 6B.5 is missing its Figure name. Consider adding the bifurcation point symbol to the legend.

    - ***JEF Response: Figure name added. Bifurcation point symbol description is listed in the Figure description.***

12. Figure 6B.7 Stage 1 Landforms. Why do the names differ from those presented in the Piedmont Manual? No action may be necessary.

    - ***JEF Response: The names used best reflect the purpose of the map, and were those developed previously for the Wittmann ADMP deliverables. I agree that no action is necessary.***

13. Section 6B.5.2 middle of first paragraph. Typo. Please correct "which located" with "which is located".

    - ***JEF Response: Done.***

14. Section 6B5.3.1. Correct the table number presented at beginning of section. Should be Table 6B.4 instead of Table 6B.5.

    - ***JEF Response: Done.***

15. Section 6B.6 end of second paragraph. Concerned about presentation of information in last two sentences. The emphasis on the validity of traditional riverine floodplain delineation on through-flow channels may be too strong. Further discussion most likely is necessary.

    - ***JEF Response: Changed "invalidates" to "raises significant questions about."***

16. Section 6B.6 third paragraph. Concerned about presentation of information in this paragraph and its relation to through-flow corridors. Characteristics presented in this section appear to represent an unstable channel condition that typically would not be the case for an AAFF through-flow corridor. Further discussion most likely is necessary.

    - ***JEF Response: Added a sentence regarding the lack of flow path uncertainty on the through-flow corridors.***

17. Section 6B.6.1. Regarding the discussion on AFZA, in this discussion structural measures are discussed as being required. This is the only hazard zone that specifically mentions structural measures. This may be somewhat confusing if it is only mentioned in this portion of the discussion, especially since this is the only zone the District will allow development in without a structural measure. This can be discussed further.

    - ***JEF Response: Deleted the offending sentence.***

Exhibits

1. Provide all necessary exhibits with next submittal.

    - ***JEF Response: Done.***

2. Hydrology exhibit. Please include an excerpt of the Wittmann ADMSU hydrology subbasin map if possible.

    - ***JEF Response: If the District provides a copy of the map prepared by others for the District in a format that can used in the TDN, we'd be happy to include it.***

3. Floodplain Work Maps. Please verify the cross-sections presented on the floodplain work maps. Based on the exhibit provided with this review submittal it appears there are potentially two cross-section locations provided for Sta. 200 (two solid darker lines crossing the floodplain).

- ***JEF Response: The extra line is a relic overlap of the geormorphic alluvial fan delineation on top of the riverine delineation (Zone A). The line will be removed. The two delineations will be matched appropriately at cross section 100.***

4. Floodplain Work Maps. It appears that all pertinent information is presented on both the map and legend.

    - ***JEF Response: No action needed.***

B.5 Contract Documents

EXHIBIT A

SCOPE OF WORK

CONTRACT FCD 2004C060

WITTMANN AREA DRAINAGE MASTER PLAN

2.7 HYDRAULIC ANALYSIS

2.7.1 The CONSULTANT shall review and become familiar with the Wittmann ADMSU information regarding hydraulic analysis.

2.7.2 In conjunction with the hydrology modeling, the CONSULTANT shall prepare hydraulic analyses as needed to determine split flows and conveyance characteristics.

2.7.3 **(OPTIONAL TASK)** The CONSULTANT shall prepare two (2) two-dimensional hydraulic models of approximately two square miles each. Input parameters and result of these analyses will be documented in the hydraulic portion of the TDN. **This optional task is not authorized with the Notice to Proceed; it may be authorized in writing by the DISTRICT based upon specific need as determined by the DISTRICT during the contract period.**

2.7.4 **(OPTIONAL TASK)** The CONSULTANT shall conduct supplemental hydraulic analysis for use in the development and assessment of McMicken Dam Project alternatives. **This optional task is not authorized with the Notice to Proceed; it may be authorized in writing by the DISTRICT based upon specific need as determined by the DISTRICT during the contract period.**

2.7.5 The CONSULTANT shall utilize the hydraulic analyses (HEC-RAS models) prepared by KHA for the dam break and floodway channel studies. The CONSULTANT shall modify these models to evaluate the alternatives proposed as part of this contract. The CONSULTANT shall use the revised HEC-RAS models for steady and unsteady flow conditions and assumptions.

2.8 GEOMORPHOLOGY AND SEDIMENTATION ANALYSIS

2.8.1 The CONSULTANT shall review and become familiar with the *Wittmann ADMSU Geomorphic and Sedimentation Analysis and Erosion Hazard Zones Reports, Volume GR.*

2.8.2 The CONSULTANT shall evaluate the McMicken Outlet Channel potential for sediment build up or erosion. The evaluation will be based on hydraulic and hydrologic data provided by the DISTRICT (or prepared separately for other authorized ADMPU tasks, i.e., no new hydraulic or hydrologic data will be prepared by the CONSULTANT under this task). The evaluation will consider the limiting stable slope by using Meyer-Per and Muller beginning transport equation documented in "computing Degradation and Local Scour" by Bureau of Reclamation, 1984. The evaluation will also consider the dynamic equilibrium slope by using the iterative method documented in "Design Manual for Engineering Analysis of Fluvial Systems" by ADWR, 1985. The evaluation will also consider field observation, comparison of readily available historical and recent topographic mapping, flow/flood history, and measurement of channel change using a historical and recent aerial photograph.

2.8.3 Watershed Geomorphic Assessment. The CONSULTANT shall perform a reconnaissance level evaluation of the geomorphology of the ADMP study area to identify flood and erosion hazards. The evaluation will build on, rather than recreate, geomorphic and sedimentation analyses completed for the ADMSU, and will focus on areas not mapped for the ADMSU.

2.8.4 The CONSULTANT will prepare a brief written technical memorandum of the geomorphic landforms in the study area, with particular emphasis on areas potentially subject to alluvial fan flooding, stable distributary flow, sheet flow, and ponding. In addition to the written summary, the CONSULTANT will prepare a Geographic Information System (GIS) showing the approximate aerial boundaries of the specific hazard types. The GIS landform hazard map will be used in conjunction with the Rules of Development.

2.8.5 The CONSULTANT will perform an approximate method alluvial fan floodplain delineation for the Chrysler Proving Ground alluvial fan using the DISTRICT's Piedmont Flood Hazard Assessment Manual (PFHAM). The upstream limit for the delineation will be the Cloud Road alignment, or the point at which containment of the floodplain can be demonstrated above the hydrographic apex, whichever is furthest upstream. The downstream limit for the floodplain delineation will be the CAP. All hydrologic and topographic data will be provided by the DISTRICT (no new hydrologic modeling will be performed by the CONSULTANT for this task). Riverine portions of the alluvial fan system will be delineated using approximate (non-detailed) methods. A flow volume accounting method, to be selected by the CONSULTANT, will be applied to estimate potential impacts from the in-stream mining area located east of the 187th Avenue alignment.

2.8.6 **(OPTIONAL TASK)** The CONSULTANT shall prepare a FEMA submittal including paper and digital copies as needed. **This optional task is not authorized with the Notice to Proceed; it may be authorized in writing by the DISTRICT based upon specific need as determined by the DISTRICT during the contract period.**

2.8.7 Erosion Hazard Zone Delineation

2.8.7.1 The CONSULTANT shall re-delineate the erosion hazard zone for approximately 1 mile reach of Iona Wash to be compatible with the new floodplain delineation. The new delineation shall tie in to the old upstream and downstream. The erosion hazard zone delineation shall consider the results of revised floodplain delineation modeling prepared for the ADMSU for Iona Wash, and will be based methodologies outlined in the DISTRICT's draft Erosion Hazard Zone Delineation and Development Guidelines Limited Detail Level 3 Methodology.

2.8.7.2 The CONSULTANT shall prepare an Erosion Hazard Zone Delineation memorandum summarizing the results of this analysis.

2.8.7.3 The CONSULTANT shall submit both paper and electronic information at each stage of the review process.

2.8.7.4 **(OPTIONAL TASK)** Erosion Hazard Zone Delineation. The CONSULTANT shall delineate five (5) miles of erosion hazard zones. The DISTRICT's limited level 3 methodology shall be used for the delineation. **This optional task is not authorized with the Notice to Proceed; it may be authorized in writing by the DISTRICT based upon specific need as determined by the DISTRICT during the contract period.**

5.6.2 The DISTRICT will provide the format for invoices and progress/status reports. Projected invoices, with progress and status reports will be delivered to the DISTRICT'S Project Manager no later than the last day of the month. The invoices will be consistent with the tasking of the SOW, project schedule, fee proposal, and projected billing.

5.6.3 The invoice will identify the contract number and include the amount of each work task and man-hour level of effort and contractor service identified in the approved fee proposal. The percent complete shall be determined by the fully loaded cost schedule and conformed by the earned value report. The total invoice submitted shall be less than or equal to the earned value report that details the task percent complete with the associated cost. The invoice will show the amounts previously billed, the amount due for the current period and the project balance. The invoice shall be split into two; one for the Study area and the other for the McMicken Dam Project.

5.6.4 The CONSULTANT shall submit one hard copy of invoices to Accounts Payable, Flood Control District of Maricopa County, 2801 West Durango Street, Phoenix, Arizona 85009. A copy of the invoice will also be provided for the DISTRICT'S Project Manager.

5.7 MCMICKEN DAM PLANNING FLOW CHART

5.7.2 The CONSULTANT shall develop a planning flow chart that identifies the roles and responsibilities for the DISTRICT, CONSULTANT, public outreach, and stakeholder involvement. The flow chart shall identify when these entities will be included in the planning process. Components of the flow chart that shall be identified include number of alternative phases, numbers of alternatives at each phase, levels of engineering and cost estimates at each phase, public and PAAC meetings, and the qualitative risk assessment. The CONSULTANT shall be responsible for periodically updating the flow chart to reflect completed and pending tasks and schedule for the duration of the project. The final flow chart shall be included in the McMicken Dam Alternatives Analysis final report.

6.0 DELIVERABLES

6.1 GENERAL ITEMS

6.1.1 The CONSULTANT shall submit all final documents 'sealed' by a registered civil engineer in the State of Arizona. Upon receipt of the final submittal, the DISTRICT shall review the report and preliminary plans for the accurate incorporation of all final comments. If incomplete and/or incorrect incorporation of those comments is found, the original documents shall be returned to the CONSULTANT for correction and re-submittal.

6.1.2 The CONSULTANT shall submit computer files of the information to the DISTRICT delivered on CD-ROM.

6.1.3 Reports, documents, figures, exhibits, and tables shall be submitted in a version of Microsoft Word later than or equal to 6.0, and/or a version of Microsoft Excel later than or equal to 97, or other acceptable software format as determined by the DISTRICT.

6.1.4 Plans should be in MicroStation (dgn) format or a version of AutoCAD later than or equal to 14 (dwg) in accordance with Section 19, CADD Drafting Standards, and Consultant Guidelines dated December 1, 2003.

6.1.5 The for the ADMP Study area, the CONSULTANT shall submit two (2) paper copies and four (4) electronic copies of each DRAFT report, estimates, schedules or drawings to the DISTRICT.

6.1.6 For the McMicken Dam Project, the CONSULTANT shall submit three (3) paper copies of each DRAFT report, estimates, schedules or drawings to the DISTRICT and six (6) paper and four (4) electronic copies of all final documents.

6.1.7 The CONSULTANT shall submit three (3) paper copies and five (5) electronic copies in PDF format of each FINAL report, estimates, schedules or drawings to the DISTRICT and one (1) electronic copy for each FINAL report, estimates, schedules or drawings to each participating agency. The total number of participating agencies to receive FINAL deliverables shall not exceed ten (10).

6.2 REPORTS

6.2.1 All reports or documents shall be submitted to the DISTRICT for review in draft form. Upon receipt of review comments, the CONSULTANT shall incorporate appropriate revisions and complete the report.

6.2.2 The following documents or reports shall be developed as a result of this project:

Study Area Reports:

Wittmann ADMP Overview

Wittmann ADMP Alternative Analysis Report
- Preliminary Analysis Chapter
- Level I Chapter
- Level II Chapter
- Level III Chapter
- Environmental Overview
- Landscape Character Analysis
- Multiple-Use Opportunity assessment
- Final Rules of Development

Wittmann Existing Conditions Addendum
- Survey Chapter
- Study Area Land Subsidence and Earth Fissures Chapter
- Update memorandums and additional data Chapter

TDN

Administrative Report

McMicken Dam Project Reports:

- McMicken Dam Project Investigation Work Plan (Task 2.3.10)
- McMicken Dam Project Subsidence and Earth Fissure Risk Zoning Report (Task 2.3.15)

- McMicken Dam Geotechnical Appraisal Report
- McMicken Dam Project Alternatives Analysis Report (Task 3.2.4.10)
- McMicken Dam Project Jurisdictional Delineation Report (Task 3.5.5.2)
- McMicken Dam Biology Review Memorandum and Letter (Task 3.5.6)

B.6 Public Notification

B.7 FEMA Correspondence

Appendix C

Survey Field Notes

Additional survey field notes were not gathered for this study.

Appendix D

Hydrologic Analysis Supporting Documentation

APPENDIX D

All hydrologic data were obtained from the previously approved Entellus Wittmann ADMSU Hydrologic Data Notebook provided on DVD with this TDN.

Appendix E

Hydraulic Analysis Supporting Documentation

E.1: Roughness Coefficient Photographs and Location Map

E.2: Cross Section Plots

E.3: Detailed HEC-RAS Output

E.1 Roughness Coefficient Estimation

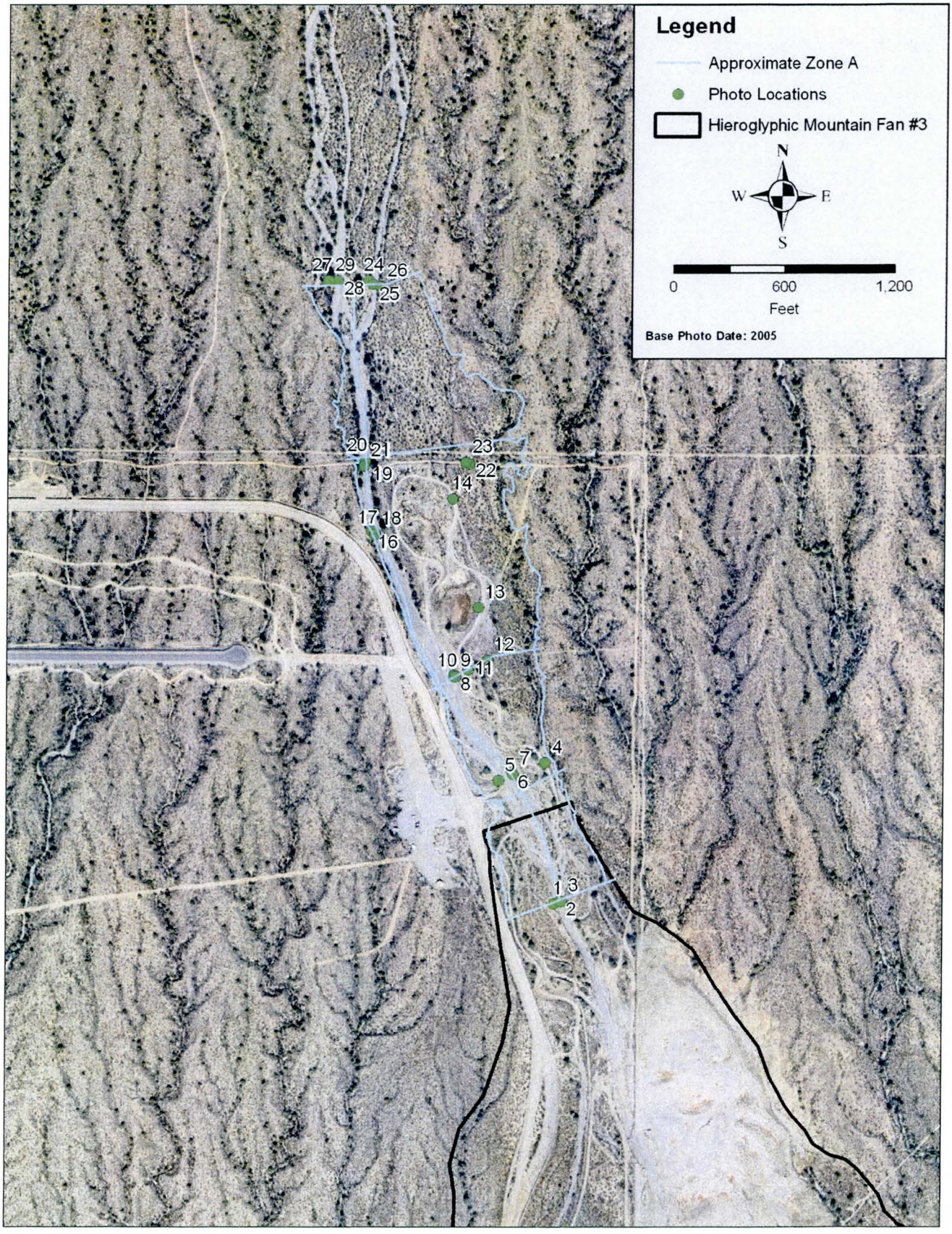

Legend
Approximate Zone A
Photo Locations
Hieroglyphic Mountain Fan #3
N
W
E
S
0
600
1,200
Feet
Base Photo Date: 2005
27
29
24
26
28
25
20
21
23
22
19
14
17
18
16
13
12
10
9
11
8
5
7
4
6
1
3
2

Photo 1: Looking Upstream

Photo 2: Looking Downstream

Photo 3: Left Overbank

Photo 4: Left Overbank Braid

Photo 5: Right Overbank

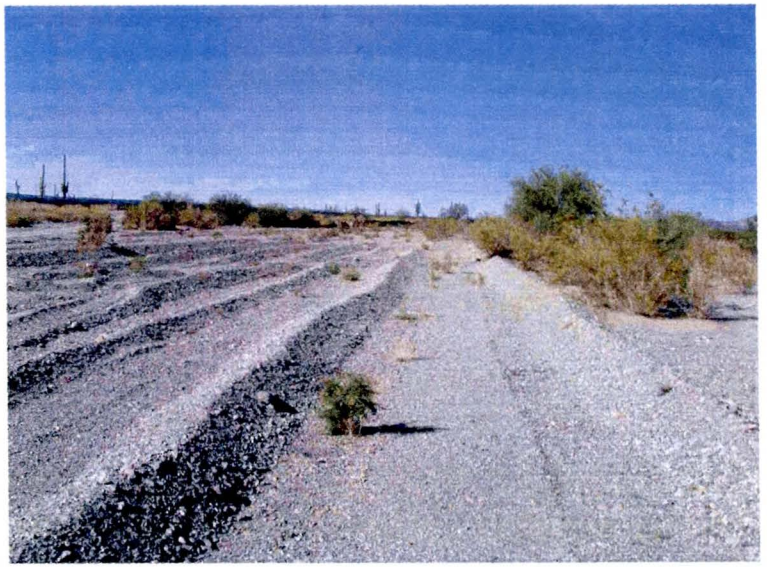


Photo 6: Looking Upstream

Photo 7: Looking Downstream

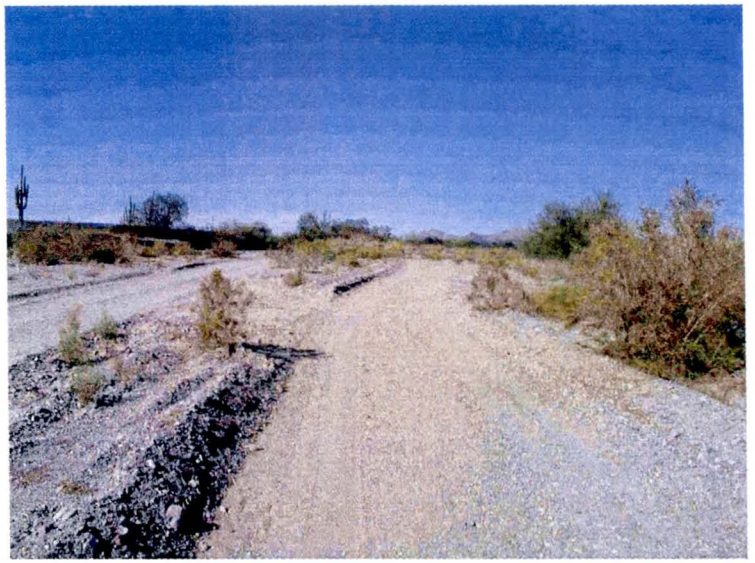


Photo 8: Looking Upstream

Photo 9: Looking Downstream

Photo 10: Right Overbank

Photo 11: Left Overbank

Photo 12: Left Overbank

Photo 13: Looking Upstream

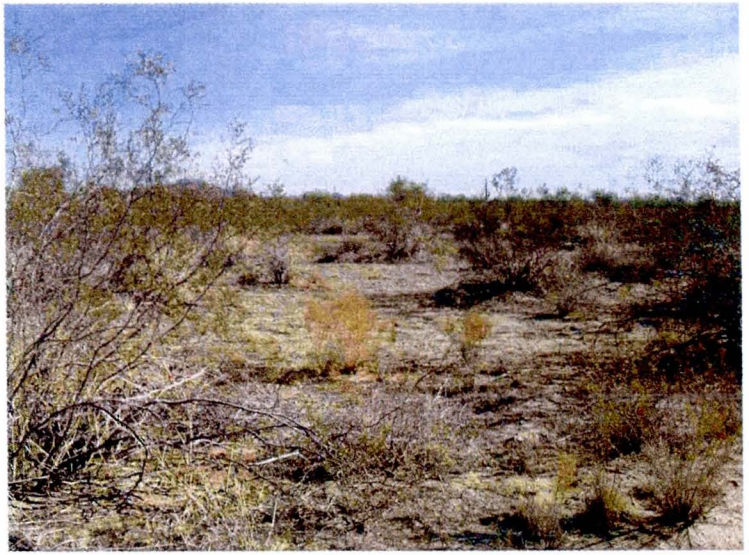


Photo 14: Left Overbank

Photo 15: Left Overbank

Photo 16: Looking Downstream

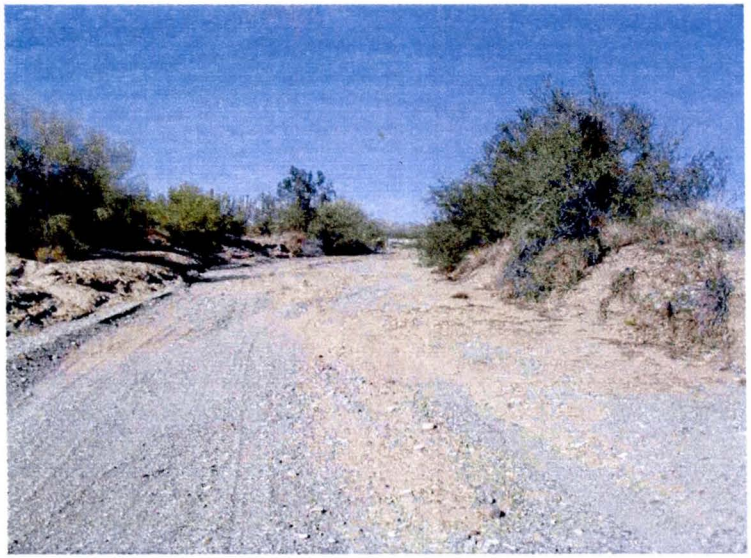


Photo 17: Looking Upstream

Photo 18: Right Overbank

Photo 19: Looking Upstream

Photo 20: Looking Downstream

Photo 21: Right Overbank

Photo 22: Left Overbank Looking Downstream

Photo 23: Left Overbank Looking Upstream

Photo 24: Left Overbank Braid Looking Upstream

Photo 25: Left Overbank Braid Looking Downstream

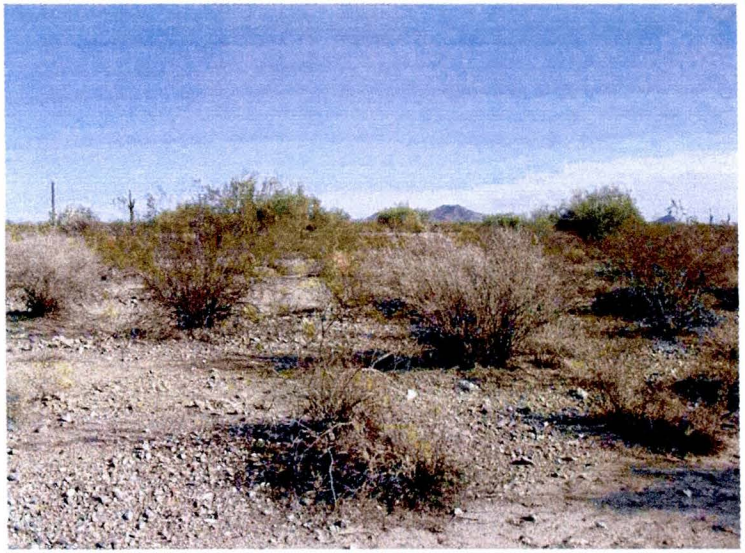


Photo 26: Left Overbank

Photo 27: Looking Downstream

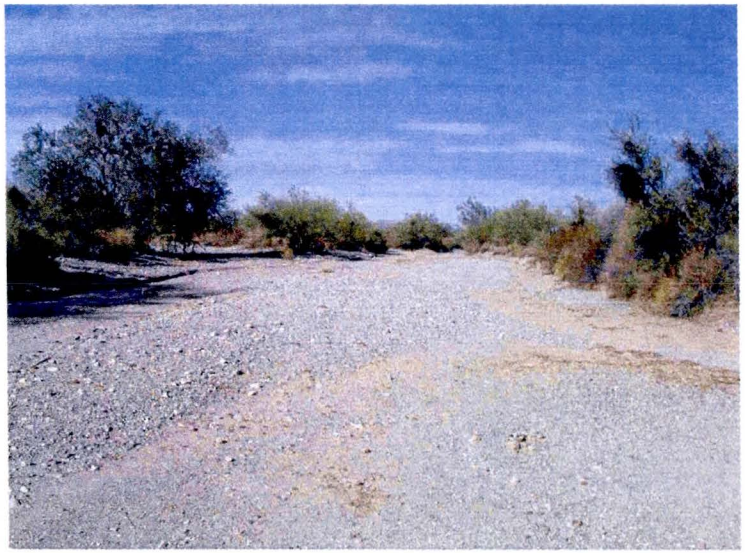
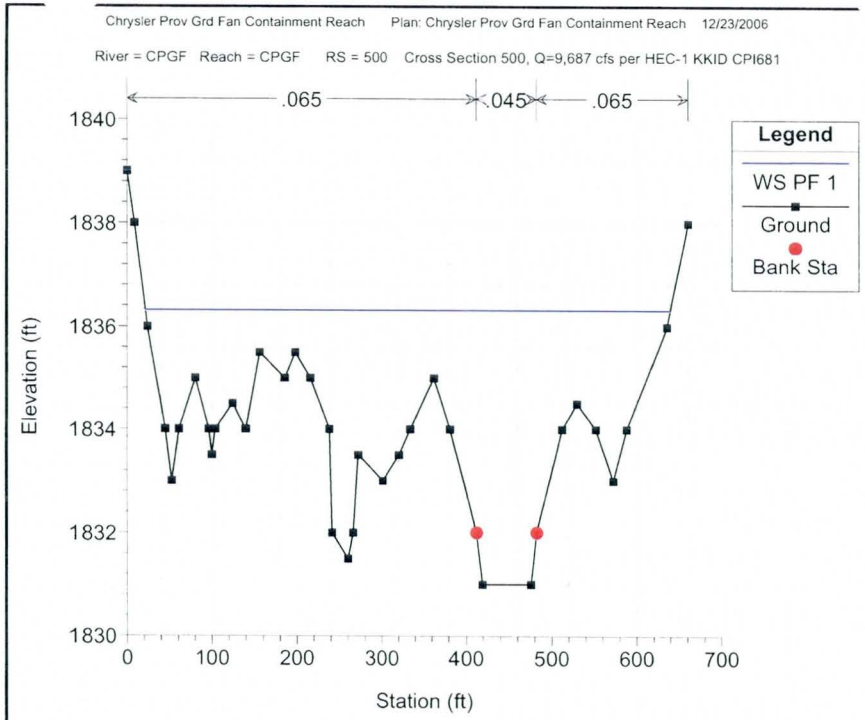
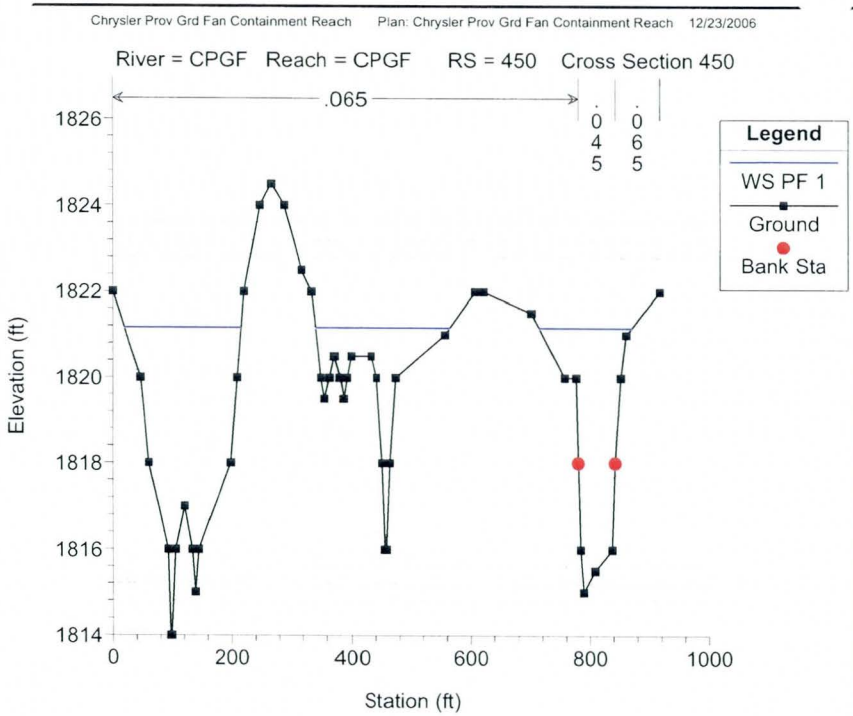


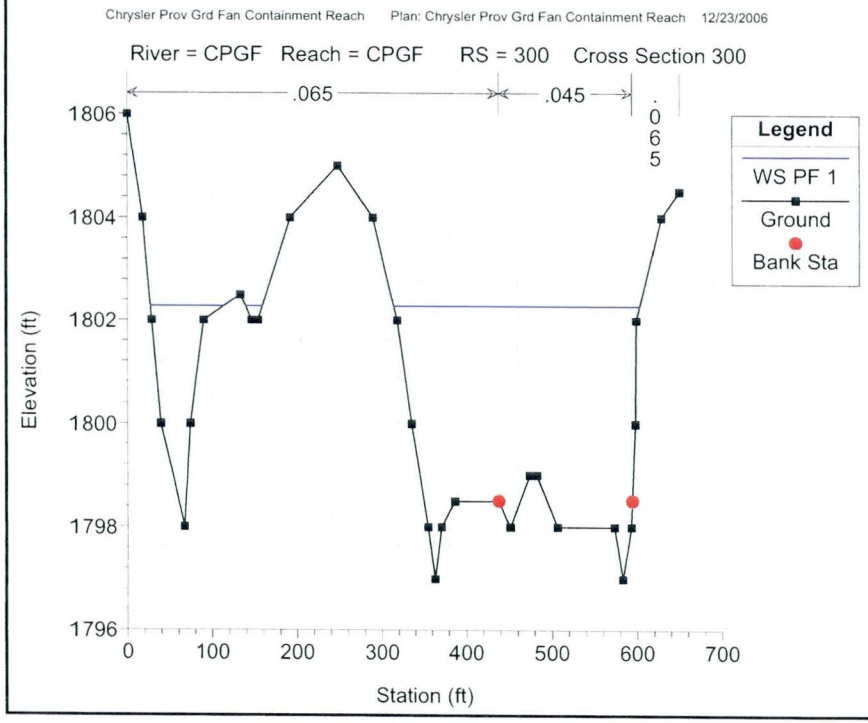
Photo 28: Looking Upstream

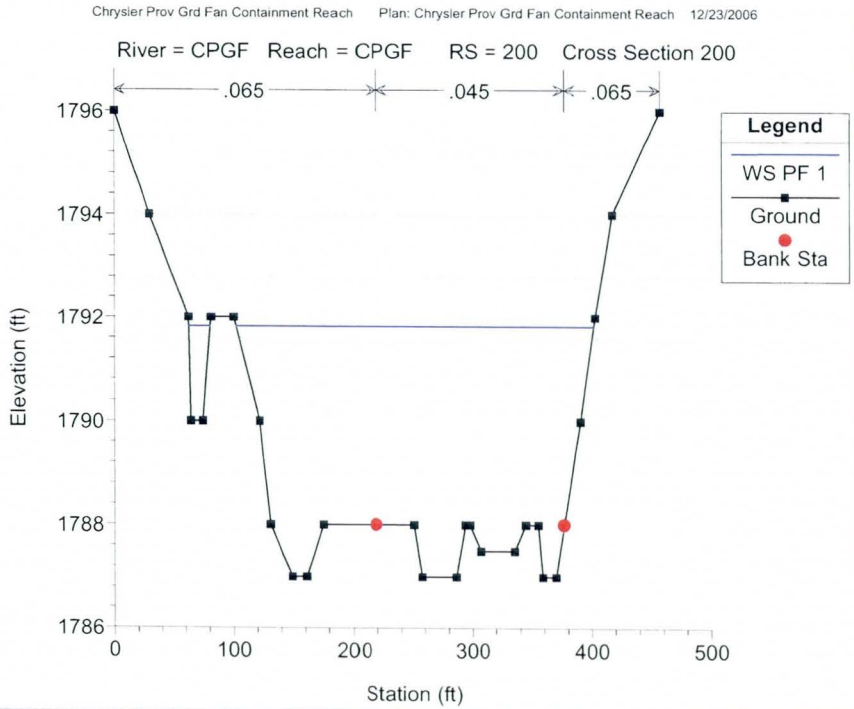
Photo 29: Right Overbank

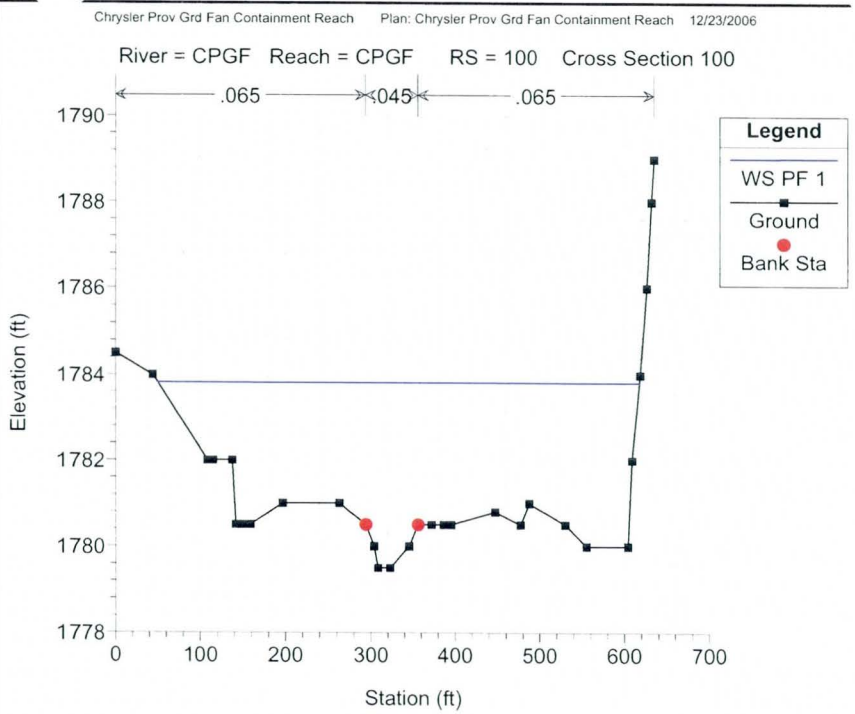
E.2 Cross Section Plots


Chrysler Prov Grd Fan Containment Reach Plan: Chrysler Prov Grd Fan Containment Reach 12/23/2006
River = CPGF Reach = CPGF RS = 500 Cross Section 500, Q=9,687 cfs per HEC-1 KKID CPI681
.065
.045
.065
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
1840
1838
1836
1834
1832
1830
0
100
200
300
400
500
600
700


Chrysler Prov Grd Fan Containment Reach Plan: Chrysler Prov Grd Fan Containment Reach 12/23/2006
River = CPGF Reach = CPGF RS = 450 Cross Section 450
.065
.045
.065
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
1826
1824
1822
1820
1818
1816
1814
0
200
400
600
800
1000


Chrysler Prov Grd Fan Containment Reach Plan: Chrysler Prov Grd Fan Containment Reach 12/23/2006
River = CPGF Reach = CPGF RS = 300 Cross Section 300
.065
.045
.065
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
1806
1804
1802
1800
1798
1796
0
100
200
300
400
500
600
700


Chrysler Prov Grd Fan Containment Reach Plan: Chrysler Prov Grd Fan Containment Reach 12/23/2006
River = CPGF Reach = CPGF RS = 200 Cross Section 200
.065
.045
.065
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
Station (ft)
1796
1794
1792
1790
1788
1786
0
100
200
300
400
500


Chrysler Prov Grd Fan Containment Reach Plan: Chrysler Prov Grd Fan Containment Reach 12/23/2006
River = CPGF Reach = CPGF RS = 100 Cross Section 100
.065
.045
.065
Legend
WS PF 1
Ground
Bank Sta
Elevation (ft)
1790
1788
1786
1784
1782
1780
1778
0
100
200
300
400
500
600
700
Station (ft)

E.3 Detailed HEC-RAS Output

HEC-RAS Version 3.1.3 May 2005
U.S. Army Corp of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X             X  X     X    X       X
X     X  X        X    X        X   X    X    X       X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: Hieroglyphic Mtn Fan 3 Containment Reach
Project File : zonea.prj
Run Date and Time: 4/20/2007 10:57:43 AM

Project in English units

Project Description:
Approximate Zone A Floodplain Delineation Study for Hieroglyphic Mountain Fan #3 upstream of the apex. This study was performed under a sub-contract with Entellus to the Flood Control District of Maricopa County (2004C060), by JE Fuller Hydrology & Geomorphology, Inc., in 2007. The Flood Control District Project Manager is Kelli Sertich. The Entellus project manager is Hernan Aristizabal, P.E. This model was developed in HEC-RAS v3.1.3 (May 2005), Based on 1"=100', 2' contour interval topographic mapping
and 1"=200', 4' contour
interval topographic mapping provided by Entellus, Flown by Stewart Geo Technologies in 2002. Flight Date for 2' mapping = April 18, 2002, Flight Date for 4' mapping = April 22, 2002, vertical datum = NAVD88, horizontal projection = NAD83. Discharges are from HEC-1 modeling produced under a separate contract by Entellus in 2005 for the Wittmann ADMP Update Technical Data Notebook ADMSU Hydrology, Volume HY-1 of 3 Addendum. Starting water surface elevation determined using normal depth proceedures. This run assumes sub-critical flow conditions.

PLAN DATA

Plan Title: Hieroglyphic Mtn Fan 3 Containment Reach
Plan File : X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.p01

Geometry Title: Hieroglyphic Mtn Fan 3 Containment Reach
Geometry File : X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.g01

Flow Title : Hieroglyphic Mtn Fan 3 Containment Reach
Flow File : X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.f01

Plan Summary Information:

Number of:	Cross Sections	= 5	Multiple Openings	=	0
	Culverts	= 0	Inline Structures	=	0
	Bridges	= 0	Lateral Structures	=	0

Computational Information

Water surface calculation tolerance	= 0.01
Critical depth calculation tolerance	= 0.01
Maximum number of iterations	= 20
Maximum difference tolerance	= 0.3
Flow tolerance factor	= 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: Hieroglyphic Mtn Fan 3 Containment Reach
Flow File : X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.f01

Flow Data (cfs)

River	Reach	RS	PF 1
CPGF	CPGF	500	9687

Boundary Conditions

River	Reach	Profile	Upstream	Downstream

GEOMETRY DATA

Geometry Title: Hieroglyphic Mtn Fan 3 Containment Reach
Geometry File : X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.g01

CROSS SECTION

RIVER: HMFan3
REACH: HMFan3 RS: 500

INPUT
Description: Cross Section 500, Q=9,687 cfs per HEC-1 KKID CPI681
Station Elevation Data num= 37

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	1839	8.71	1838	24	1836	45.08	1834	52.48	1833
61.05	1834	80.6	1835	96.47	1834	100.16	1833.5	103.83	1834
124.45	1834.5	140.05	1834	156.02	1835.5	185.57	1835	198.1	1835.5
216.04	1835	238.33	1834	241.51	1832	260.25	1831.5	266.34	1832
272.23	1833.5	301.31	1833	320.59	1833.5	334.18	1834	362.43	1835
381.7	1834	411.92	1832	419.23	1831	475.61	1831	482.54	1832
512.13	1834	530.17	1834.5	552.37	1834	572.57	1833	588.32	1834
635.74	1836	660.59	1838						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.065	411.92	.045	482.54	.065

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
411.92	482.54	943.22	932.04	962.83	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

			Left OB	Channel	Right OB
E.G. Elev (ft)	1837.37	Element			
Vel Head (ft)	1.07	Wt. n-Val.	0.065	0.045	0.065
W.S. Elev (ft)	1836.31	Reach Len. (ft)	943.22	932.04	962.83
Crit W.S. (ft)	1836.31	Flow Area (sq ft)	871.71	367.67	344.12
E.G. Slope (ft/ft)	0.013410	Area (sq ft)	871.71	367.67	344.12
Q Total (cfs)	9687.00	Flow (cfs)	3933.61	4217.59	1535.80
Top Width (ft)	617.90	Top Width (ft)	390.27	70.62	157.02
Vel Total (ft/s)	6.12	Avg. Vel. (ft/s)	4.51	11.47	4.46
Max Chl Dpth (ft)	5.31	Hydr. Depth (ft)	2.23	5.21	2.19
Conv. Total (cfs)	83652.5	Conv. (cfs)	33968.9	36421.2	13262.4
Length Wtd. (ft)	940.01	Wetted Per. (ft)	391.68	70.76	157.21
Min Ch El (ft)	1831.00	Shear (lb/sq ft)	1.86	4.35	1.83
Alpha	1.84	Stream Power (lb/ft s)	8.41	49.90	8.18
Frctn Loss (ft)	13.41	Cum Volume (acre-ft)	58.98	40.05	11.67
C & E Loss (ft)	0.02	Cum SA (acres)	25.73	8.96	4.91

Warning: The energy equation could not be balanced within the specified number of iterations. The program used critical depth for the water surface and continued on with the calculations.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Warning: During the standard step iterations, when the assumed water surface was set equal to critical depth, the calculated water surface came back below critical depth. This indicates that there is not a valid subcritical answer. The program defaulted to critical depth.

CROSS SECTION

RIVER: HMFan3
REACH: HMFan3 RS: 450

INPUT
Description: Cross Section 450
Station Elevation Data num= 49

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	1822	46.21	1820	60.41	1818	93.35	1816	97.68	1814
99.26	1814	105.3	1816	120.8	1817	133.55	1816	138.78	1815
144	1816	198.47	1818	209.22	1820	220.85	1822	247.76	1824
266.91	1824.5	288.63	1824	317.74	1822.5	334.27	1822	349.79	1820
355.78	1819.5	364.39	1820	371.71	1820.5	380.52	1820	386.03	1819.5
391.39	1820	398.99	1820.5	431.04	1820.5	441.03	1820	451.4	1818
455.97	1816	458.17	1816	463.62	1818	473.78	1820	556.48	1821
607.49	1822	621.82	1822	701.58	1821.5	757.16	1820	776.94	1820
780.67	1818	784.22	1816	789.26	1815	808.73	1815.5	837.53	1816
843.13	1818	852.08	1820	860.97	1821	916.83	1822		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.065	780.67	.045	843.13	.065

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
780.67	843.13	1256.04	1315.77	1328	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

			Left OB	Channel	Right OB
E.G. Elev (ft)	1822.43	Element			
Vel Head (ft)	1.29	Wt. n-Val.	0.065	0.045	0.065
W.S. Elev (ft)	1821.15	Reach Len. (ft)	1256.04	1315.77	1328.00

Crit W.S. (ft)	1821.05	Flow Area (sq ft)	998.38	336.68	25.58
E.G. Slope (ft/ft)	0.015202	Area (sq ft)	998.38	336.68	25.58
Q Total (cfs)	9687.00	Flow (cfs)	5445.79	4170.52	70.69
Top Width (ft)	573.88	Top Width (ft)	485.34	62.46	26.08
Vel Total (ft/s)	7.12	Avg. Vel. (ft/s)	5.45	12.39	2.76
Max Chl Dpth (ft)	7.15	Hydr. Depth (ft)	2.06	5.39	0.98
Conv. Total (cfs)	78567.2	Conv. (cfs)	44168.5	33825.4	573.4
Length Wtd. (ft)	1289.31	Wetted Per. (ft)	488.81	63.44	26.36
Min Ch El (ft)	1815.00	Shear (lb/sq ft)	1.94	5.04	0.92
Alpha	1.63	Stream Power (lb/ft s)	10.57	62.39	2.55
Frctn Loss (ft)	18.93	Cum Volume (acre-ft)	38.73	32.51	7.59
C & E Loss (ft)	0.02	Cum SA (acres)	16.25	7.54	2.89

Warning: Divided flow computed for this cross-section.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: HMFan3
REACH: HMFan3 RS: 300

INPUT
Description: Cross Section 300
Station Elevation Data num= 32

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	1806	17.98	1804	28.9	1802	39.44	1800	66.84	1798
74.14	1800	90.26	1802	133.52	1802.5	146.38	1802	153.94	1802
191.96	1804	248.14	1805	289.36	1804	318.59	1802	335.73	1800
355.15	1798	363.41	1797	370.93	1798	386.75	1798.5	438.05	1798.5
451.69	1798	473.71	1799	482.52	1799	506.18	1798	573.37	1798
583.12	1797	593.28	1798	594.51	1798.503	598.13	1800	599.48	1802
628.88	1804	650.39	1804.5						

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.065	438.05	.045	594.5	.065

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
438.05	594.5	748.87	731.89	731.24	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	1803.48	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.21	Wt. n-Val.	0.065	0.045	0.065
W.S. Elev (ft)	1802.27	Reach Len. (ft)	748.87	731.89	731.24
Crit W.S. (ft)		Flow Area (sq ft)	573.10	643.09	13.23
E.G. Slope (ft/ft)	0.014185	Area (sq ft)	573.10	643.09	13.23
Q Total (cfs)	9687.00	Flow (cfs)	3161.70	6482.88	42.42
Top Width (ft)	395.13	Top Width (ft)	229.68	156.45	8.99
Vel Total (ft/s)	7.88	Avg. Vel. (ft/s)	5.52	10.08	3.21
Max Chl Dpth (ft)	5.27	Hydr. Depth (ft)	2.50	4.11	1.47
Conv. Total (cfs)	81334.2	Conv. (cfs)	26546.4	54431.7	356.1
Length Wtd. (ft)	736.94	Wetted Per. (ft)	230.74	156.70	10.36
Min Ch El (ft)	1797.00	Shear (lb/sq ft)	2.20	3.63	1.13
Alpha	1.26	Stream Power (lb/ft s)	12.13	36.64	3.63
Frctn Loss (ft)	10.35	Cum Volume (acre-ft)	16.08	17.71	7.00
C & E Loss (ft)	0.01	Cum SA (acres)	5.94	4.23	2.35

Warning: Divided flow computed for this cross-section.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: HMFan3
REACH: HMFan3 RS: 200

INPUT
Description: Cross Section 200
Station Elevation Data num= 29

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	1796	29.4	1794	62.39	1792	64.12	1790	74.24	1790
81.19	1792	100.29	1792	121.85	1790	130.99	1788	149.1	1787
161.18	1787	175.53	1788	219	1788	250.84	1788	257.6	1787
286.29	1787	294.15	1788	297.94	1788	307.03	1787.5	335.37	1787.5
344.58	1788	355.05	1788	358.76	1787	369.75	1787	376.69	1788
390.32	1790	402.9	1792	417.61	1794	457.242	1796		

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.065	219	.045	376.69	.065

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
219	376.69	646.65	631.25	629.04	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	1793.12	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.31	Wt. n-Val.	0.065	0.045	0.065
W.S. Elev (ft)	1791.81	Reach Len. (ft)	646.65	631.25	629.04

Crit W.S. (ft)	1791.33	Flow Area (sq ft)	432.98	672.54	48.71
E.G. Slope (ft/ft)	0.013909	Area (sq ft)	432.98	672.54	48.71
Q Total (cfs)	9687.00	Flow (cfs)	2606.55	6877.36	203.09
Top Width (ft)	317.43	Top Width (ft)	134.70	157.69	25.04
Vel Total (ft/s)	8.39	Avg. Vel. (ft/s)	6.02	10.23	4.17
Max Chl Dpth (ft)	4.81	Hydr. Depth (ft)	3.21	4.26	1.95
Conv. Total (cfs)	82136.7	Conv. (cfs)	22101.1	58313.6	1722.0
Length Wtd. (ft)	634.80	Wetted Per. (ft)	136.15	158.06	25.33
Min Ch El (ft)	1787.00	Shear (lb/sq ft)	2.76	3.69	1.67
Alpha	1.20	Stream Power (lb/ft s)	16.62	37.78	6.96
Frctn Loss (ft)	8.47	Cum Volume (acre-ft)	7.43	6.66	6.48
C & E Loss (ft)	0.20	Cum SA (acres)	2.81	1.59	2.07

Warning: Divided flow computed for this cross-section.
Warning: The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning: The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

CROSS SECTION

RIVER: HMFan3
REACH: HMFan3 RS: 100

INPUT
Description: Cross Section 100
Station Elevation Data num= 30

Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev	Sta	Elev
0	1784.5	44.23	1784	108.97	1782	114.95	1782	137.73	1782
141.9	1780.5	151.14	1780.5	158.97	1780.5	196.91	1781	263.43	1781
293.84	1780.5	303.75	1780	308.32	1779.5	322.77	1779.5	345.53	1780
356.26	1780.5	372.29	1780.5	386.91	1780.5	395.31	1780.5	447.29	1780.8
477.37	1780.5	487.67	1781	530.2	1780.5	555.24	1780	604.69	1780
609.55	1782	618.46	1784	626.11	1786	631.42	1788	634.55	1789

Manning's n Values num= 3

Sta	n Val	Sta	n Val	Sta	n Val
0	.065	293.84	.045	356.26	.065

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
293.84	356.26	0	0	.1	.3

CROSS SECTION OUTPUT Profile #PF 1

E.G. Elev (ft)	1784.46	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.65	Wt. n-Val.	0.065	0.045	0.065
W.S. Elev (ft)	1783.81	Reach Len. (ft)			
Crit W.S. (ft)	1783.12	Flow Area (sq ft)	567.99	246.63	848.36
E.G. Slope (ft/ft)	0.012802	Area (sq ft)	567.99	246.63	848.36
Q Total (cfs)	9687.00	Flow (cfs)	2582.43	2301.51	4803.05
Top Width (ft)	567.18	Top Width (ft)	243.41	62.42	261.35
Vel Total (ft/s)	5.83	Avg. Vel. (ft/s)	4.55	9.33	5.66
Max Chl Dpth (ft)	4.31	Hydr. Depth (ft)	2.33	3.95	3.25
Conv. Total (cfs)	85616.0	Conv. (cfs)	22824.1	20341.3	42450.5
Length Wtd. (ft)		Wetted Per. (ft)	243.71	62.48	261.97
Min Ch El (ft)	1779.50	Shear (lb/sq ft)	1.86	3.15	2.59
Alpha	1.24	Stream Power (lb/ft s)	8.47	29.44	14.65
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

SUMMARY OF MANNING'S N VALUES

River:HMFan3

Reach	River Sta.	n1	n2	n3
HMFan3	500	.065	.045	.065
HMFan3	450	.065	.045	.065
HMFan3	300	.065	.045	.065
HMFan3	200	.065	.045	.065
HMFan3	100	.065	.045	.065

SUMMARY OF REACH LENGTHS

River: HMFan3

Reach	River Sta.	Left	Channel	Right
HMFan3	500	943.22	932.04	962.83
HMFan3	450	1256.04	1315.77	1328
HMFan3	300	748.87	731.89	731.24
HMFan3	200	646.65	631.25	629.04
HMFan3	100	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: HMFan3

Reach	River Sta.	Contr.	Expan.
HMFan3	500	.1	.3
HMFan3	450	.1	.3
HMFan3	300	.1	.3
HMFan3	200	.1	.3
HMFan3	100	.1	.3

CHECK-RAS Program: NT Check
Manning's n Value and Transition Loss Coefficient Review

Project File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.prj
Plan File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.p01
Geometry File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.g01
Flow File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.f01
Report File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.nt
Selected profiles: PF 1
Date: 4/20/2007
Time: 11:12:13 AM

SECNO	STRUCTURE	NLOB	NCHL	NROB	CNTR	EXP
HMFan3,HMFan3						
500		0.065	0.045	0.065	0.1	0.3
450		0.065	0.045	0.065	0.1	0.3
300		0.065	0.045	0.065	0.1	0.3
200		0.065	0.045	0.065	0.1	0.3
100		0.065	0.045	0.065	0.1	0.3

---Summary of Statistics---

	Minimum	Maximum
Left Overbank n Value:	0.065	0.065
Right Overbank n Value:	0.065	0.065
Channel n Value:	0.045	0.045
Contraction Coefficient:	0.1	0.1
Expansion Coefficient:	0.3	0.3

ROUGHNESS COEFFICIENT CHECK

TRANSITION LOSS COEFFICIENT CHECK

ROUGHNESS COEFFICIENT AT STRUCTURES

---END---

CHECK-RAS Program, XS Check
Cross Section Location and Alignment Review

Project File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.prj
Plan File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.p01
Geometry File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.g01
Flow File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.f01
Report File: X:\projects\Consult\Entellus\Wittmann\hec-ras\zonea.xs
Selected profiles: PF 1
Date: 4/20/2007
Time: 11:12:49 AM

SECNO	Len Lob	Len Chl	Len Rob	TopWdthAct	Q Total	Flow Code
HMFan3,HMFan3						
500	943.22	932.04	962.83	617.9	9687	C
450	1256.04	1315.77	1328	573.88	9687	D
300	748.87	731.89	731.24	395.13	9687	D
200	646.65	631.25	629.04	317.43	9687	D
100	0	0	0	567.18	9687	

```
B=blocked obstruction      XS SC 05
C=critial depth            XS SC 03
D=divided flow             XS SC 01
E=cross section extended   XS SC 02
K=known water-surface      XS SC 04


DISTANCE CHECK
----------------


SPACING CHECK
--------------


INEFFECTIVE FLOW CHECK
-----------------------


DISCHARGE CHECK
----------------

XS DC 02 Constant dicharge used for the HMFan3,HMFan3


LOCATION CHECK
---------------


BOUNDARY CONDITION CHECK
-------------------------

XS BC 03 Maximum number of iterations is 0
         It should not be less than 20.


LATERAL WEIRS CHECK
------------------------

---END---
```

WARNING EXPLANATIONS:
XS DC 02: The reach is relatively short with only 5 cross sections. The peak discharge used in all cross sections of the reach was computed at the most downstream cross section and applied to all cross sections. The discharge used is therefore considered conservative.

XS BC 03: The warning seems to be in error, the number of iterations reported by HEC-RAS is 20. With multiple cross sections running at supercritical, the energy equation could not be balanced and required the maximum number of iterations (20) before the WSEL defaulted to critical depth in the specified sub-critical flow regime model run.

Appendix F

Erosion/Sediment Transport

No erosion or sediment transport analyses were conducted for this study.

Appendix G

Geomorphology Analyses Supporting Documentation

EXHIBIT A

HYDROLOGY EXHIBIT MAPS

No hydrology was conducted for this study.

EXHIBIT B

GEOMORPHOLOGY EXHIBIT MAPS

Legend

Hieroglyphic Mountain Fan #3 Study Limits

Stage I Landform Delineations

Landforms

- Alluvial Fan
- Distributary Flow Area
- Mountains
- Piedmont - Tributary Systems
- Riverine and Sheet Flow
- Sheet Flow and Distributary Flow Area
- Urban

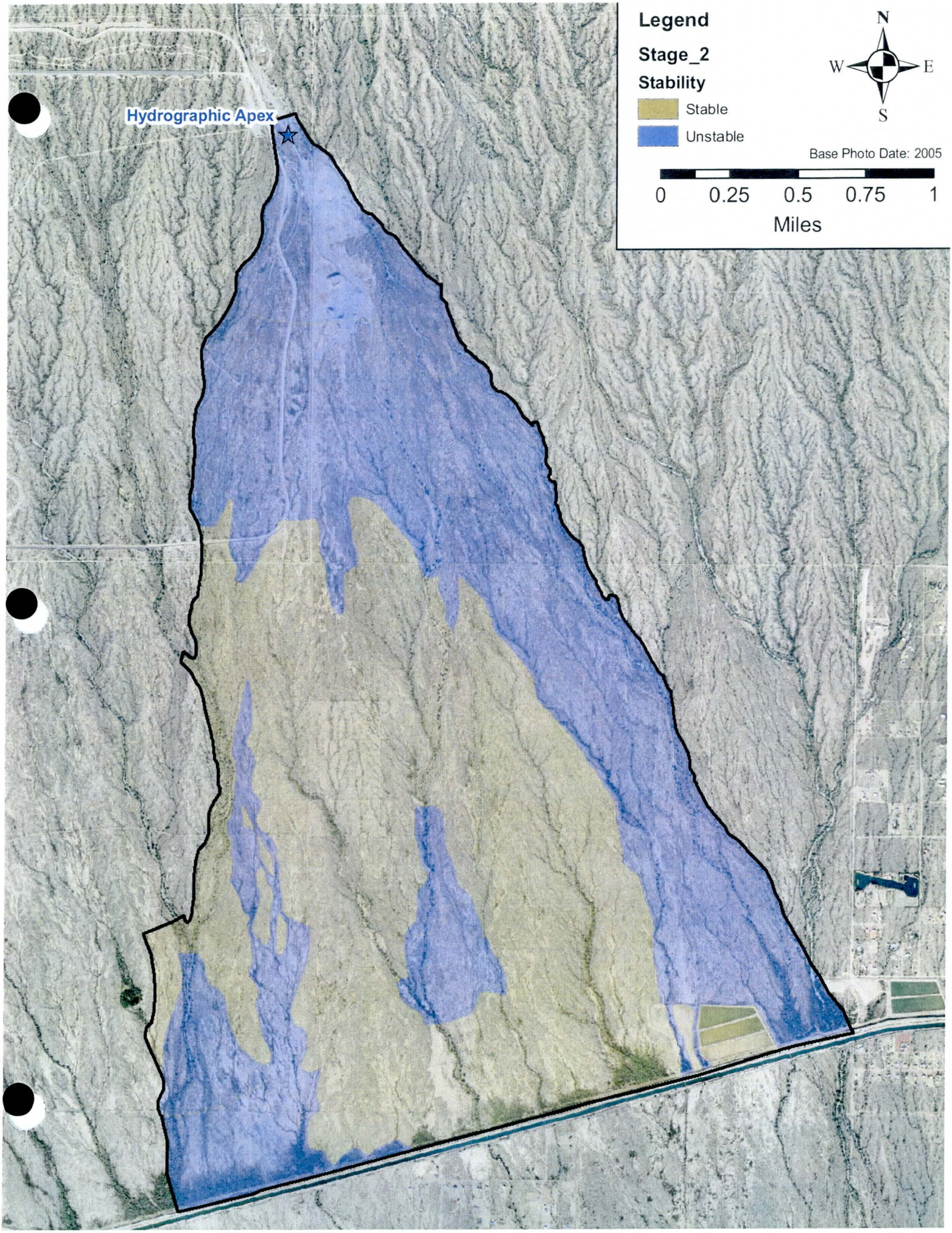
N

W E

S

0 0.25 0.5 0.75 1

Miles


Legend
Stage_2
Stability
Stable
Unstable
N
W
E
S
Base Photo Date: 2005
0
0.25
0.5
0.75
1
Miles
Hydrographic Apex

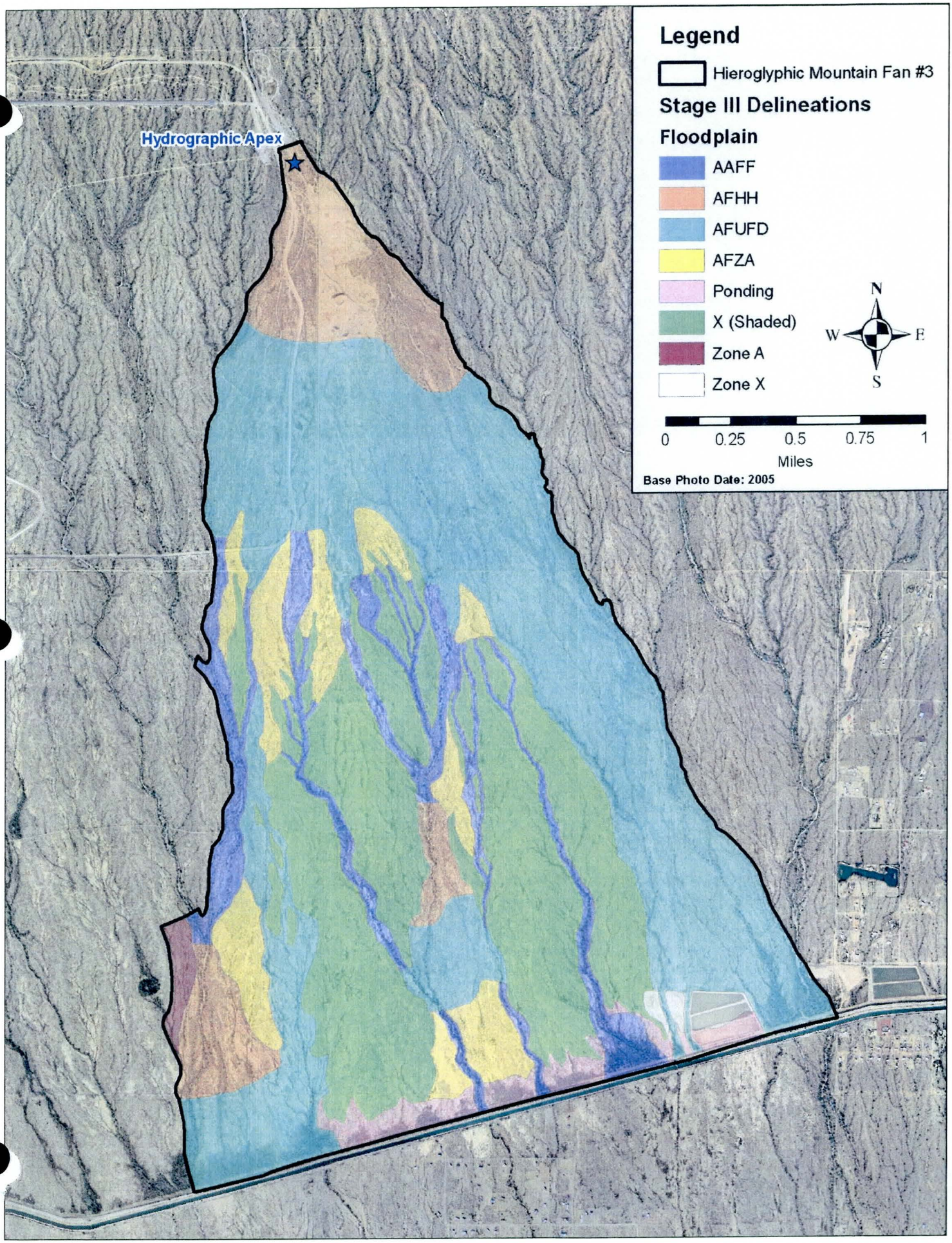
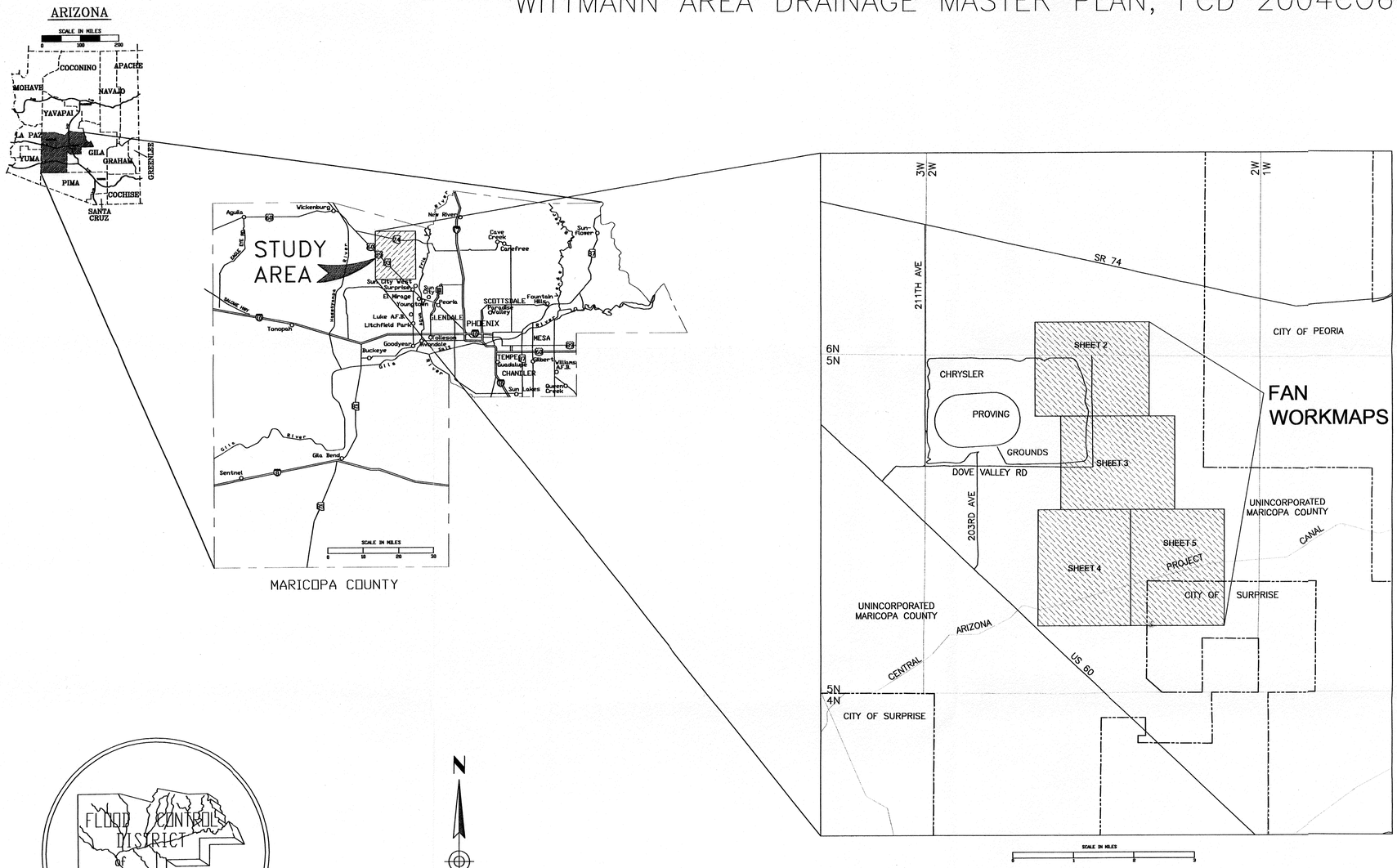

Hydrographic Apex
Legend
Hieroglyphic Mountain Fan #3
Stage III Delineations
Floodplain
AAFF
AFHH
AFUFD
AFZA
Ponding
X (Shaded)
Zone A
Zone X
N
W
E
S
0
0.25
0.5
0.75
1
Miles
Base Photo Date: 2005

EXHIBIT C

HYDRAULICS STUDY WORK MAPS

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

APPROXIMATE ZONE A FLOODPLAIN DELINEATION STUDY OF HIEROGLYPHIC MOUNTAIN ALLUVIAL FAN #3 WITTMANN AREA DRAINAGE MASTER PLAN, FCD 2004C060



NOTES

1. HORIZONTAL PROJECTION IS ARIZONA STATE PLANE, CENTRAL ZONE, NORTH AMERICAN DATUM OF 1983.
2. ALL ELEVATIONS ARE BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.

STATEMENTS OF PROFESSIONAL REGISTRANT

THE FLOODPLAIN DELINEATIONS PRESENTED ON THE FOLLOWING SHEETS WERE PREPARED UNDER MY DIRECT SUPERVISION.

Registered Professional Engineer (Civil) CERTIFICATE NO. 26846 JONATHAN E. FULLER Date Signed ARIZONA, U.S.A.

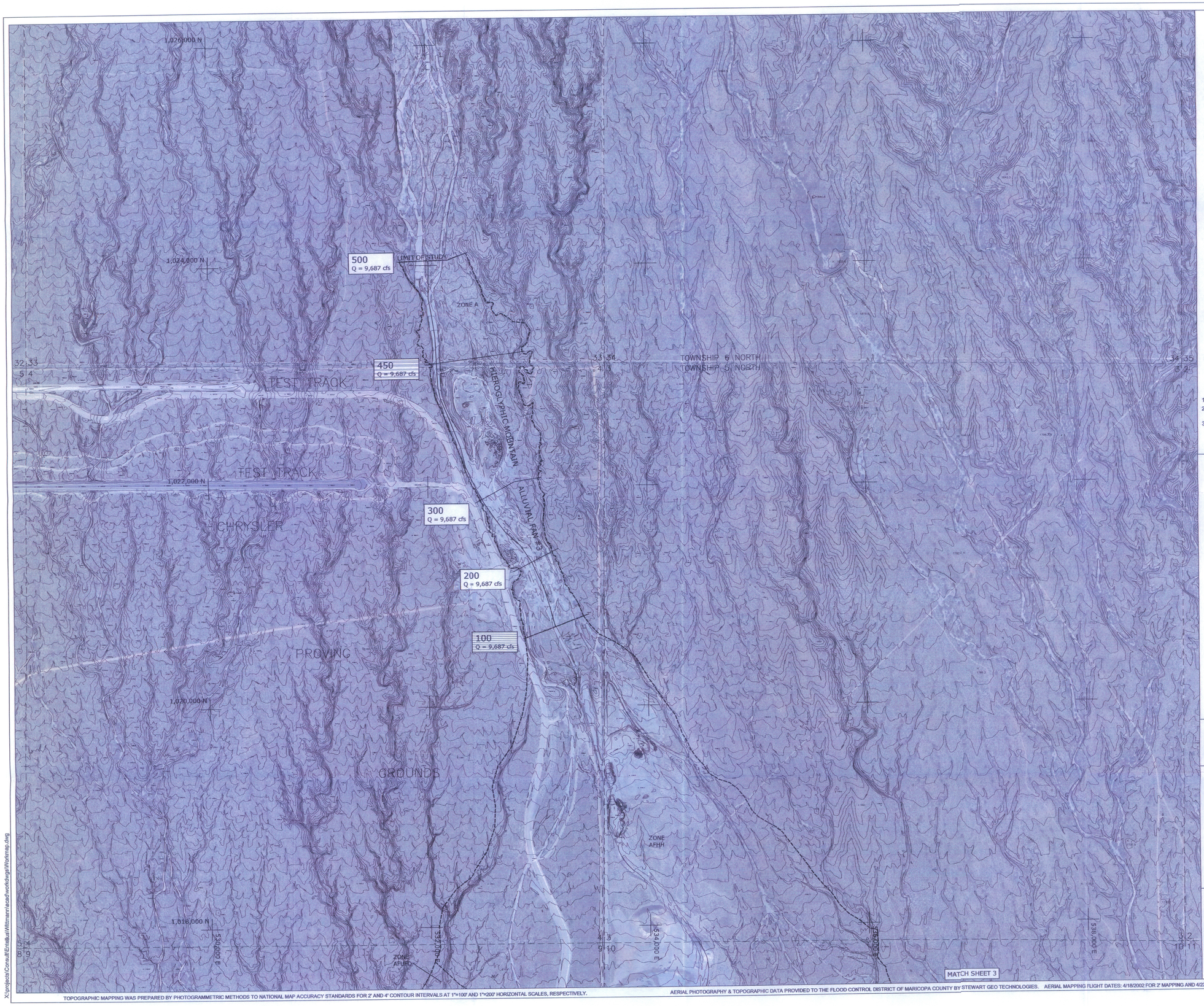
FLOOD CONTROL DISTRICT of MARICOPA COUNTY

N

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.
8400 S. KYRENE ROAD, SUITE 201
TEMPE, ARIZONA 85284
PHONE: 480-752-2124
FAX: 480-838-2183

INDEX SHEET

APRIL, 2007



LEGEND

- 100-YR FLOODPLAIN
- 100-YR ADMINISTRATIVE FLOODWAY
- EFFECTIVE 100-YR FLOODPLAIN BOUNDARY
- EFFECTIVE 100-YR FLOODWAY
- SECTION BOUNDARY
- CROSS SECTION — 200 Q = 9,687 cfs
- CORPORATE LIMITS — Corporate Limits
- COUNTY BOUNDARY — County Boundary
- STATE PLANE COORDINATES — 1,046,800 N / 648,800 E

ZONE DESIGNATIONS

ZONE A	Approximate 100-year administrative floodway; riverine reaches upstream of hydrologic apex.
ZONE A	Approximate 100-year floodplain.
ZONE AFHH	Alluvial Fan High Hazard administrative floodway
ZONE AFUFD	Alluvial Fan Uncertain Flow Distribution Area administrative floodway
ZONE AAFF	Approximate Alluvial Fan Floodway administrative floodway
ZONE AFZA	Alluvial Fan Zone A floodplain
ZONE X (SHADED)	Areas flooded between 100- and 500-yr discharge, areas of 100-yr flooding depth less than 1 foot, or drainage area less than 1 square mile
ZONE X	Areas outside the 500-yr floodplain
ZONE D	Area not studied

NOTES

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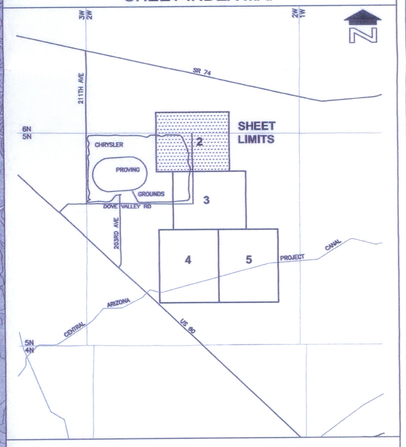
2. HORIZONTAL PROJECTION IS ARIZONA STATE PLANE, CENTRAL ZONE, NORTH AMERICAN DATUM OF 1983.
3. ALL ELEVATIONS ARE BASED ON NORTH AMERICAN VERTICAL DATUM OF 1988.

SHEET INDEX MAP



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

APPROXIMATE ZONE A FLOODPLAIN DELINEATION STUDY OF HIEROGLYPHIC MOUNTAIN ALLUVIAL

FAN #3

FCD 2004CO60
WITTMANN
AREA DRAINAGE MASTER PLAN
APRIL, 2007

Registered Professional Engineer (Civil) — CERTIFICATE NO. 26846 — JONATHAN E. FULLER — Date Signed 4-27-07 — ARIZONA, U.S.A.

SCALE IN FEET
400' 0' 400' 800'
CONTOUR INTERVAL = 2 AND 4 FEET

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.
3883 S. KYRENE ROAD, SUITE 201, TEMPE, ARIZONA 85284
PHONE: 480-752-2120
FAX: 480-839-2102

SHEET 2 OF 5

TOPOGRAPHIC MAPPING WAS PREPARED BY PHOTOGRAMMETRIC METHODS TO NATIONAL MAP ACCURACY STANDARDS FOR 2' AND 4' CONTOUR INTERVALS AT 1"=100' AND 1"=200' HORIZONTAL SCALES, RESPECTIVELY.

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AERIAL UPDATE: NOVEMBER 2004.

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MATCH SHEET 2

CHRYSLER PROVING GROUNDS

TEST TRACK

DOVE VALLEY RD

533,000 E

534,000 E

535,000 E

536,000 E

1,016,000 N

1,014,000 N

1,012,000 N

1,010,000 N

ZONE AFHH

ZONE AFUFD

ZONE AFZA

ZONE AAFF

ZONE X (SHADED)

ZONE D

MATCH SHEET 4

MATCH SHEET 5

LEGEND

- 100-YR FLOODPLAIN
- 100-YR ADMINISTRATIVE FLOODWAY
- EFFECTIVE 100-YR FLOODPLAIN BOUNDARY
- EFFECTIVE 100-YR FLOODWAY
- SECTION BOUNDARY
- CROSS SECTION — 200, Q = 9,687 cfs
- CORPORATE LIMITS — Corporate Limits
- COUNTY BOUNDARY — County Boundary
- STATE PLANE COORDINATES — 1,046,800 N | 646,800 E

ZONE DESIGNATIONS

ZONE A	Approximate 100-year administrative floodway; riverine reaches upstream of hydrologic apex.
ZONE A	Approximate 100-year floodplain.
ZONE AFHH	Alluvial Fan High Hazard administrative floodway
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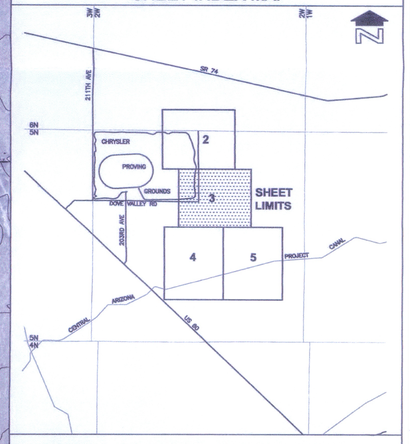

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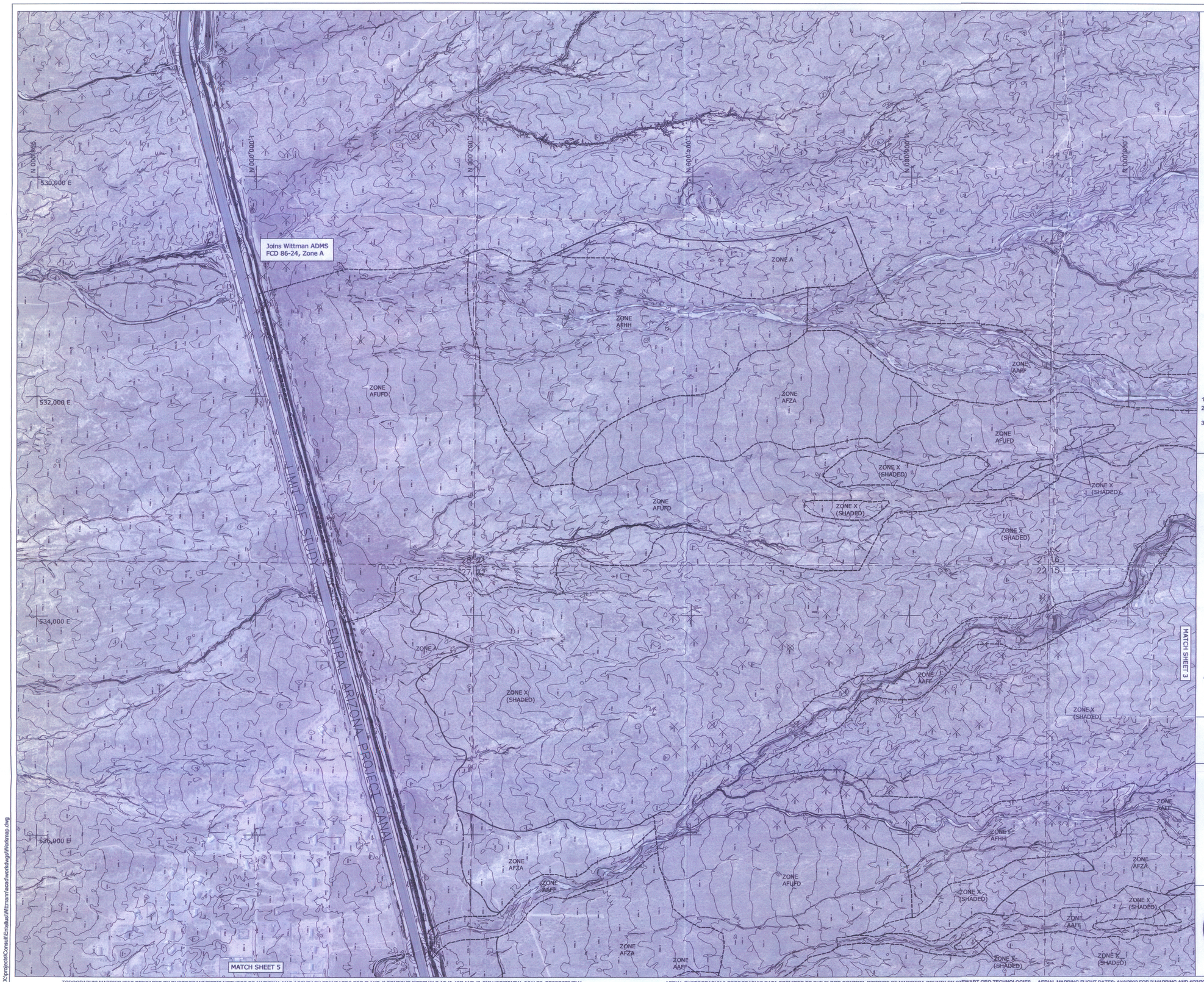

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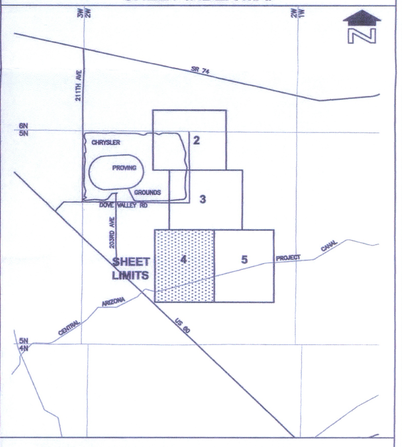

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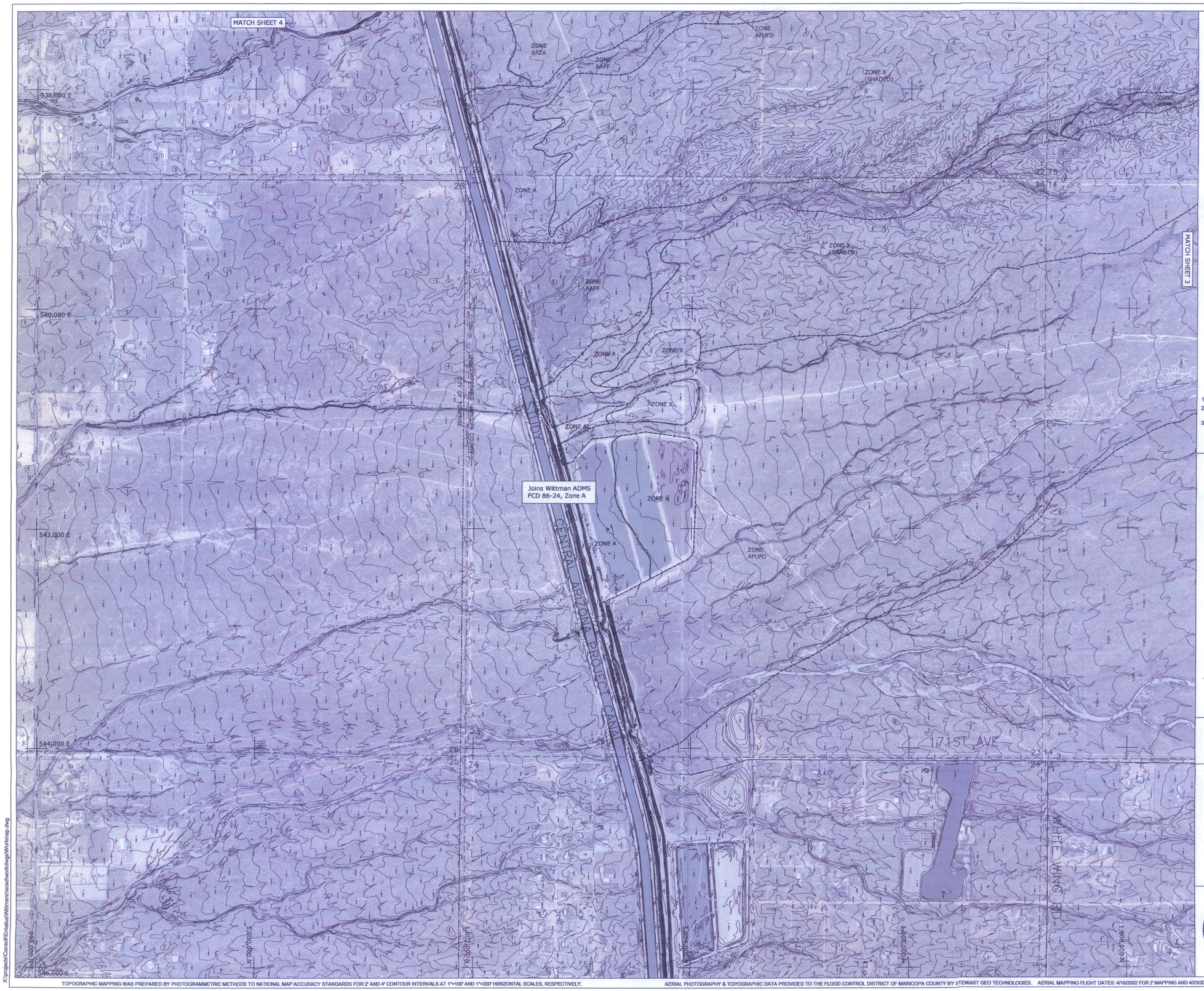

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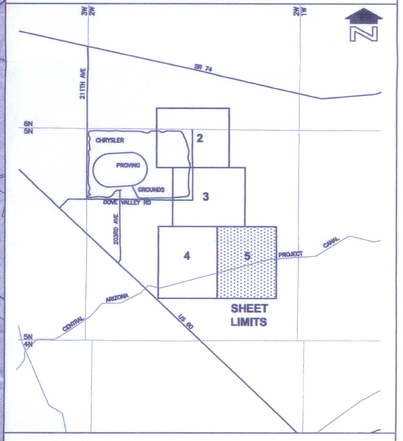

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

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SHEET 5 OF 5

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National Geodetic Survey, NOAA
Silver Spring Metro Center
1315 East-West Highway
Silver Spring, Maryland 20910
(310) 713-3191

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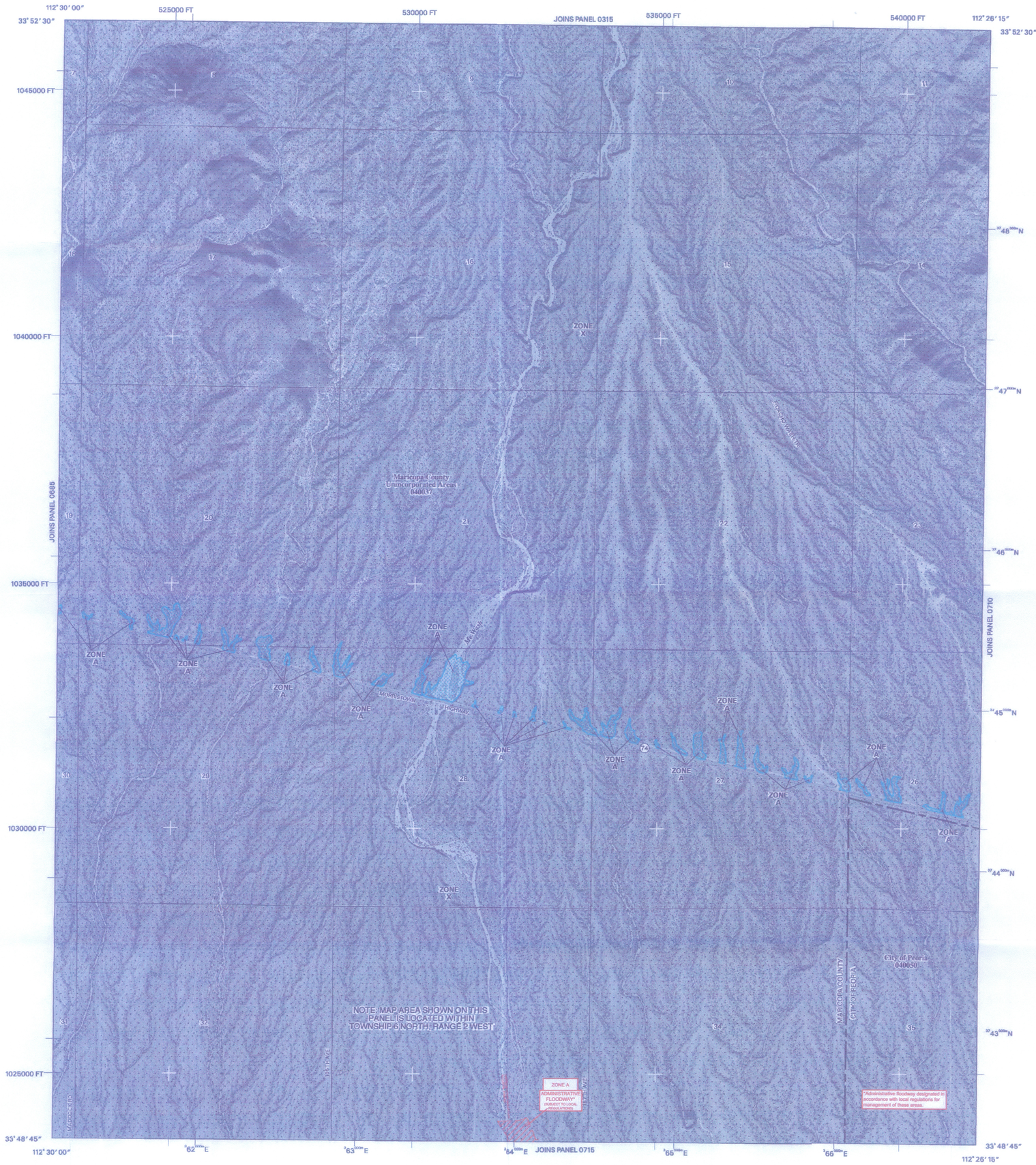
LEGEND FOR ANNOTATION

100-YEAR ADMINISTRATIVE FLOODWAY

100-YEAR FLOODPLAIN

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC. 2007



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Area Zones, and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
513	Base Flood Elevation line and value; elevation in feet *
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet *

* Referenced to the National Geodetic Vertical Datum of 1929

A — A	Cross section line
2 — 2	Transect line
112° 07' 08", 33° 25' 41"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere.
7 500m E	1000-meter Universal Transverse Mercator grid tick values zone 12.
875000 FT	5000-foot grid tick values: Arizona State Plane coordinate system, central zone (FIPSZONE 3176) NAD83 (Transverse Mercator)
X DV2313	Bench mark (see explanation in Notes to Users section of this FIRM panel)
M1.5	River Mile

MAP REPOSITORY
Refer to Repositories Listing on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
April 15, 1988

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
September 4, 1991, July 19, 2001

September 30, 2005 - to update corporate limits, to change Base Flood Elevations, to add Base Flood Elevations, to add Special Flood Hazard Areas, to change Special Flood Hazard Areas, to change zone designations, to add roads and road names, to incorporate previously issued Letters of Map Revision, and to incorporate previously issued Letters of Map Amendment.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

(ANNOTATED 2007)

MAP SCALE 1" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0705G

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 705 OF 4350

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY	040037	0705	G

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C0705G
MAP REVISED
SEPTEMBER 30, 2005

Federal Emergency Management Agency

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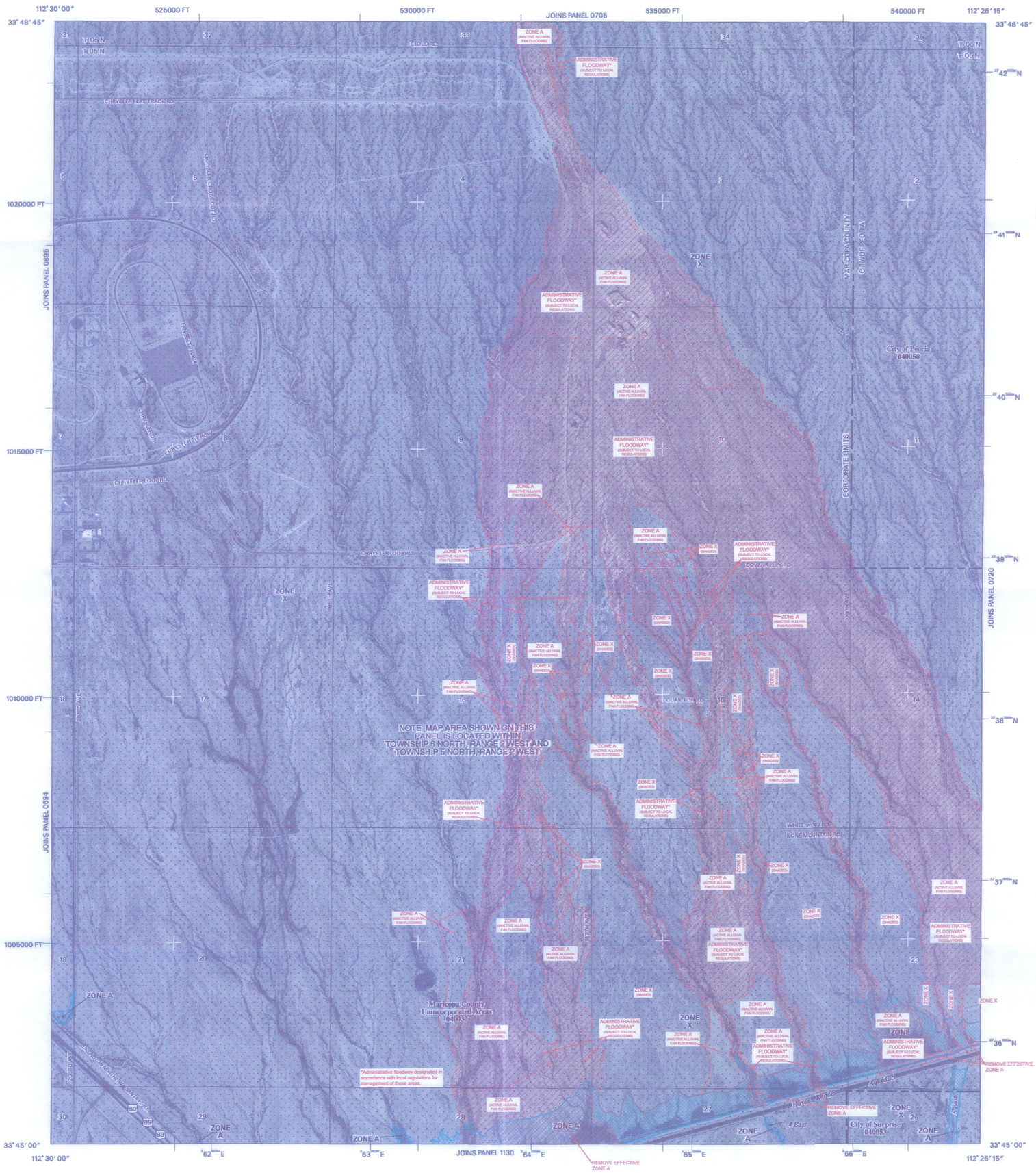


LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

- **ZONE A** No Base Flood Elevations determined.
- **ZONE AE** Base Flood Elevations determined.
- **ZONE AH** Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
- **ZONE AO** Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
- **ZONE AR** Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
- **ZONE A99** Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
- **ZONE V** Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
- **ZONE VE** Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

- **ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

- **ZONE X** Areas determined to be outside the 0.2% annual chance floodplain.
- **ZONE D** Areas in which flood hazards are undetermined, but possible

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% annual chance floodplain boundary
- 0.2% annual chance floodplain boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones, and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
- 513 — Base Flood Elevation line and value; elevation in feet*
- (EL 987) — Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the National Geodetic Vertical Datum of 1929

- (A)—(A) Cross section line
- (2)—(2) Transect line
- 112° 07' 08", 33° 25' 41" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere.
- 76 mE Universal Transverse Mercator grid tick values zone 12
- 875000 FT State Plane coordinate system, central zone (FIPSZONE 3176) NAD83 (Transverse Mercator)
- DV2313 Bench mark (see explanation in Notes to Users section of this FIRM panel)
- M1.5 River Mile

MAP REPOSITORY
Refer to Repositories Listing on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
April 15, 1988

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
September 4, 1981, July 19, 2001

September 30, 2005 - to update corporate limits, to change Base Flood Elevations, to add Base Flood Elevations, to add Special Flood Hazard Areas, to change Special Flood Hazard Areas, to change zone designations, to add roads and road names, to incorporate previously issued Letters of Map Revision, and to incorporate previously issued Letters of Map Amendment.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0715G

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 715 OF 4350

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY	040037	0715	G
SURPRISE, CITY OF	040053	0715	G

(ANNOTATED 2007)

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C0715G
MAP REVISED
SEPTEMBER 30, 2005

Federal Emergency Management Agency

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles, Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' National Geodetic Vertical Datum of 1929 (NGVD 29). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was *Arizona State Plane Zone 3176 (central Arizona)*. The **horizontal datum** was *NAD83, GRS80 spheroid*. Differences in datum, spheroid, projection or State Plane zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the *National Geodetic Vertical Datum of 1929*. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

Spatial Reference System Division
National Geodetic Survey, NOAA
Silver Spring Metro Center
1315 East-West Highway
Silver Spring, Maryland 20910
(310) 713-3191

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713-3242**, or visit its website at http://www.ngs.noaa.gov.

Base map information shown on this FIRM was derived from multiple sources. Base map files were provided in digital format by Maricopa County. Orthophoto images were produced at a scale of 1:6000 using HARN for control. Aerial photography is dated December 2000 to December 2002

This map reflects more detailed and up-to-date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables in the Flood Insurance Study report (which contains authoritative hydraulic data) may reflect stream channel distances that differ from what is shown on this map.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://www.msc.fema.gov/.

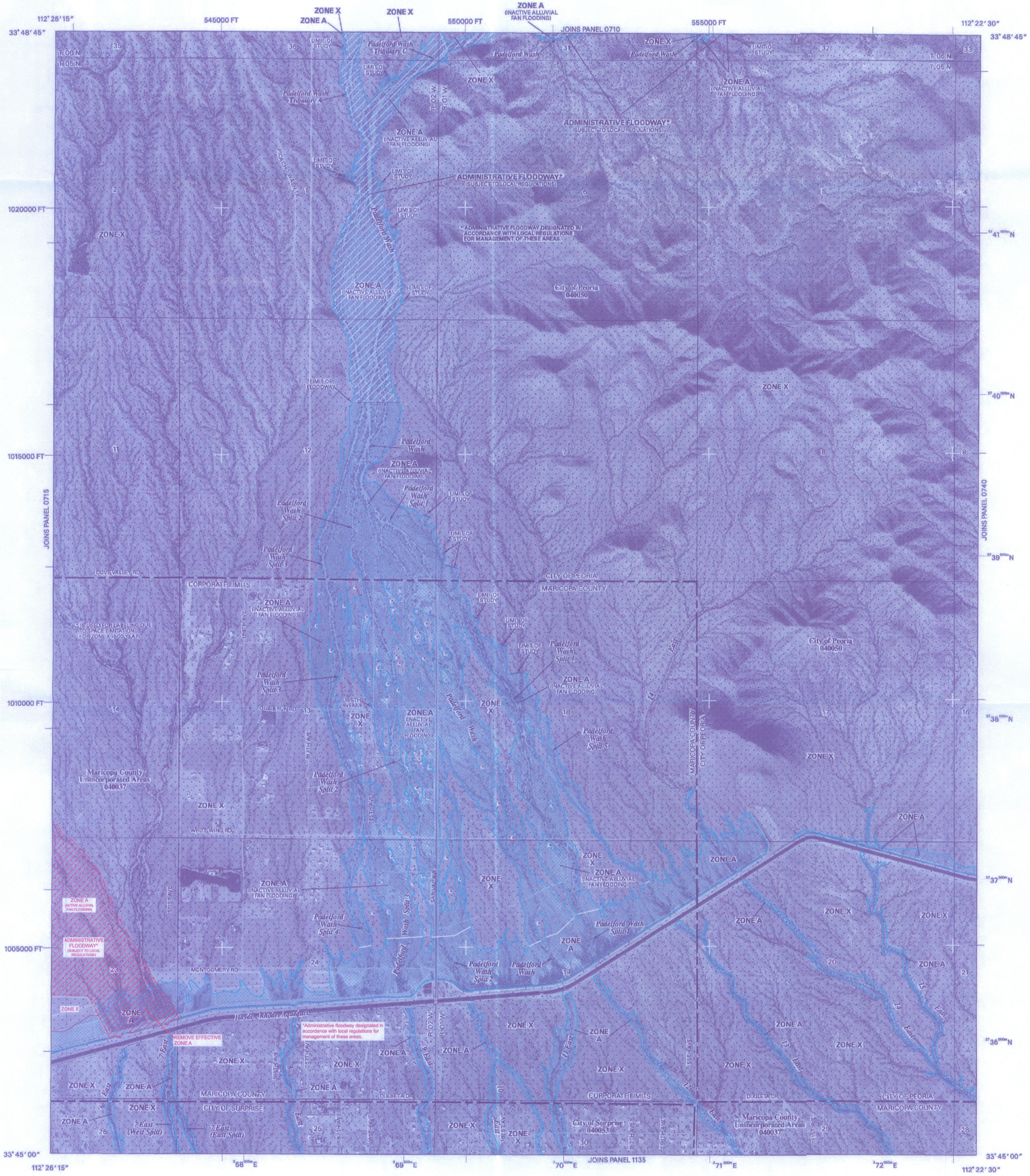
If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1-877-FEMAMAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/.

LEGEND FOR ANNOTATION

100-YEAR ADMINISTRATIVE FLOODWAY

100-YEAR FLOODPLAIN

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC. 2007



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Area Zones, and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities.
513	Base Flood Elevation line and value; elevation in feet *
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet *

* Referenced to the National Geodetic Vertical Datum of 1929

A — A	Cross section line
2 — 2	Transect line
112°07'08",33°26'41"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere.
3776000mE	1000-meter Universal Transverse Mercator grid tick values zone 12.
875000 FT	5000-foot grid tick values: Arizona State Plane coordinate system, central zone (FIPSZONE 3176) NAD83 (Transverse Mercator)
X DV2313	Bench mark (see explanation in Notes to Users section of this FIRM panel)
* M1.5	River Mile

MAP REPOSITORY
Refer to Repositories Listing on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
April 16, 1988

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
September 4, 1991, July 19, 2001

September 30, 2005 - to update corporate limits, to change Base Flood Elevations, to add Base Flood Elevations, to add Special Flood Hazard Areas, to change Special Flood Hazard Areas, to change zone designations, to add roads and road names, to incorporate previously issued Letters of Map Revision, and to incorporate previously issued Letters of Map Amendment.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

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MAP SCALE 1" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0720G

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 720 OF 4350

ISSE MAP INDEX FOR FIRM PANEL LAYOUT

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY	040037	0720	G
PEORIA, CITY OF	040050	0720	G
SURPRISE, CITY OF	040053	0720	G

(ANNOTATED 2007)

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C0720G
MAP REVISED
SEPTEMBER 30, 2005

Federal Emergency Management Agency

NOTES TO USERS

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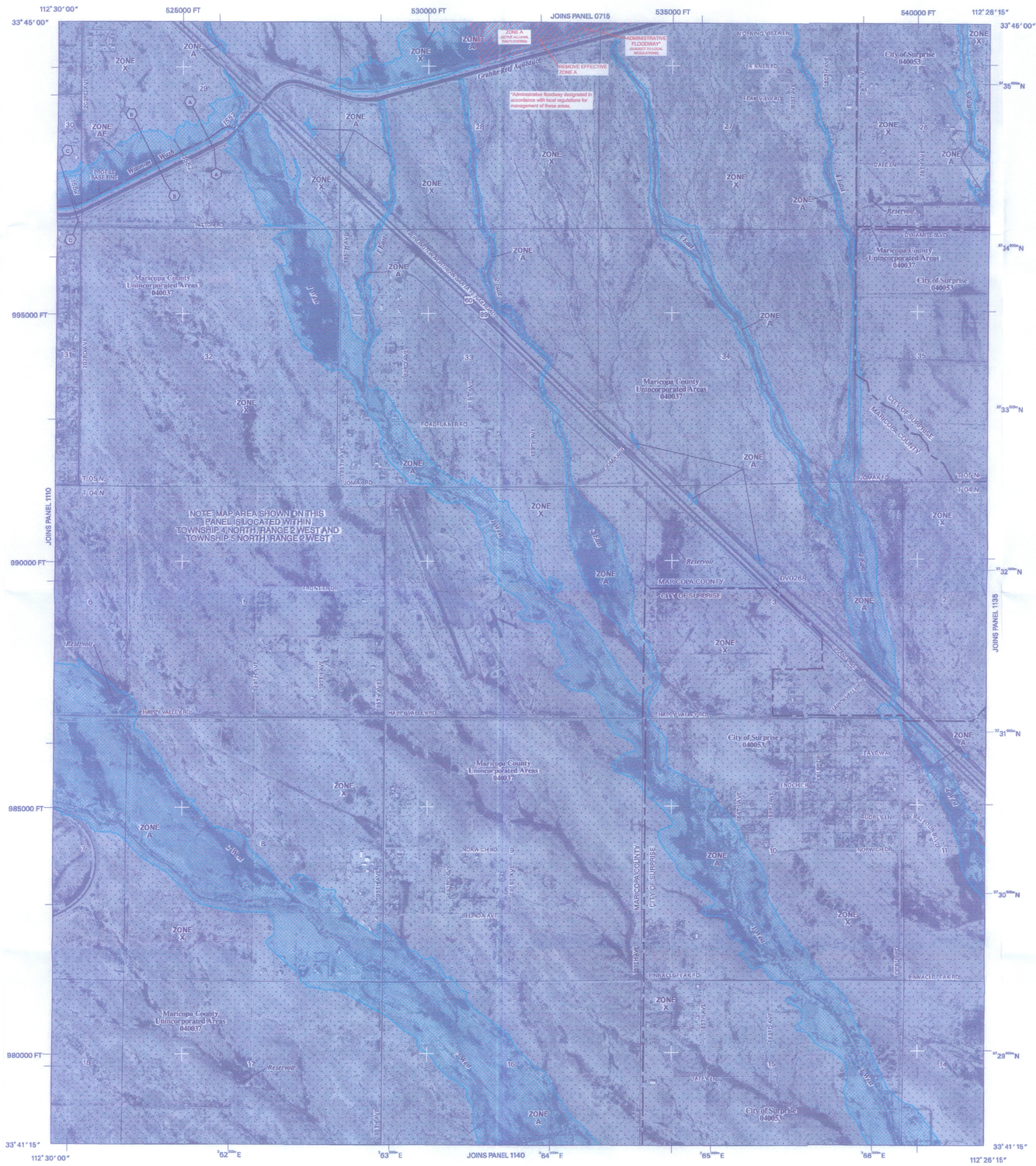
LEGEND FOR ANNOTATION

100-YEAR ADMINISTRATIVE FLOODWAY	- - - - -
100-YEAR FLOODPLAIN	———
JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.	2007



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

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ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
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COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
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(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the National Geodetic Vertical Datum of 1929

A — A	Cross section line
2 — 2	Transect line
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4276000mE	1000-meter Universal Transverse Mercator grid tick values zone 12
875000 FT	5000-foot grid tick values: Arizona State Plane coordinate system, central zone (FIPSZONE 3176) NAD83 (Transverse Mercator)
DV2313	Bench mark (see explanation in Notes to Users section of this FIRM panel)
M1.5	River Mile

MAP REPOSITORY
Refer to Repositories Listing on Map Index

EFFECTIVE DATE OF COUNTYWIDE FLOOD INSURANCE RATE MAP
April 15, 1988

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL
September 4, 1991, July 18, 2001

September 30, 2005 - to update corporate limits, to change Base Flood Elevations, to add Base Flood Elevations, to add Special Flood Hazard Areas, to change Special Flood Hazard Areas, to change zone designations, to add roads and road names, to incorporate previously issued Letters of Map Revision, and to incorporate previously issued Letters of Map Amendment.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 1000'
500 0 1000 2000 FEET
300 0 300 600 METERS

NFIP
NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1130G

FIRM
FLOOD INSURANCE RATE MAP
MARICOPA COUNTY, ARIZONA
AND INCORPORATED AREAS

PANEL 1130 OF 4350

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
MARICOPA COUNTY	040037	1130	G
SURPRISE, CITY OF	040053	1130	G

(ANNOTATED 2007)

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
04013C1130G
MAP REVISED
SEPTEMBER 30, 2005

Federal Emergency Management Agency