APPROXIMATE
FLOODPLAIN DELINEATION STUDY
for
portions of
TIGER WASH PIEDMONT

FCD CONTRACT NO. 98-48
Assignment No. 1

TECHNICAL DATA NOTEBOOK

June 2000

Prepared for:

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009
(602) 506-1501

Submitted by:

JE Fuller/ Hydrology & Geomorphology, Inc.

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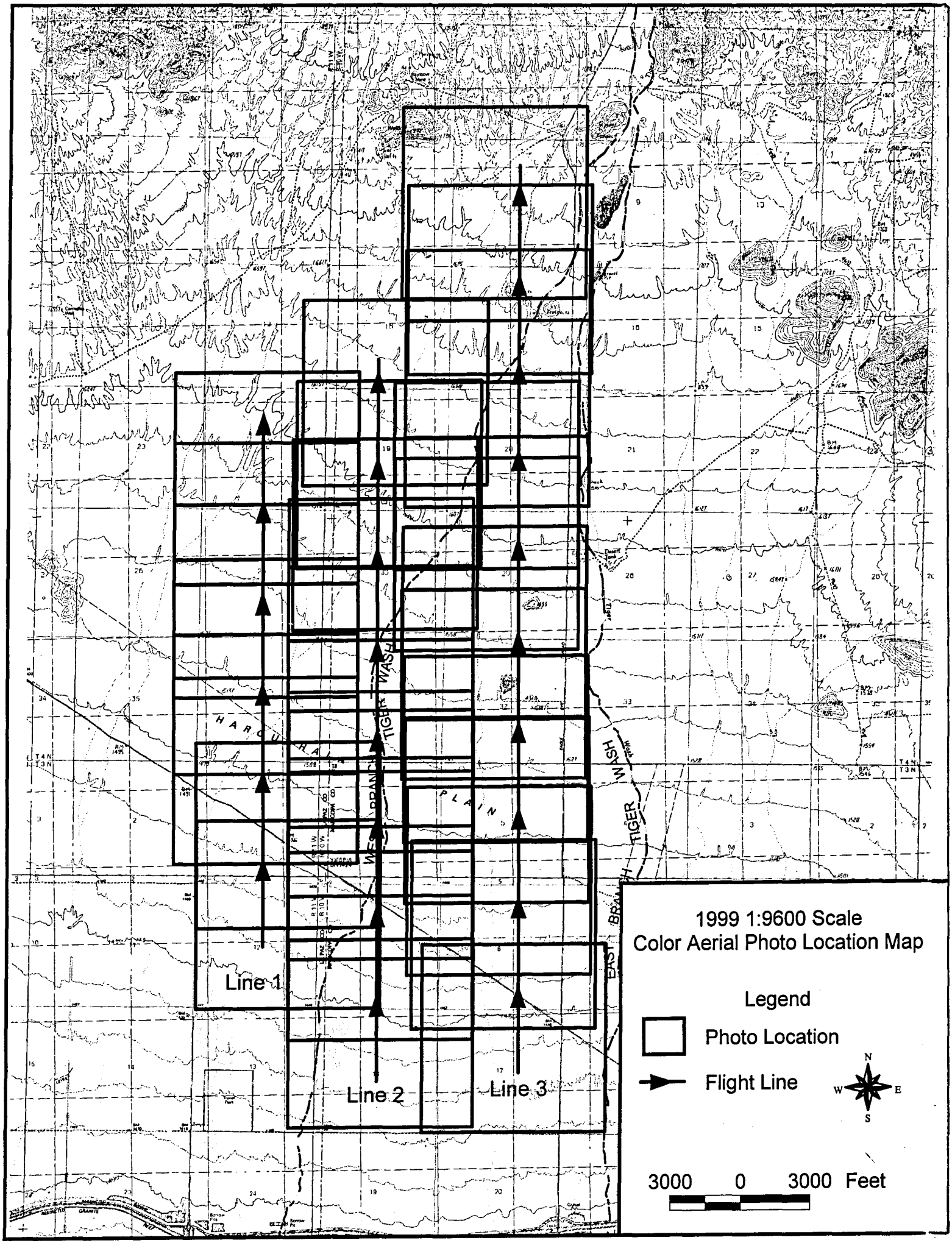
JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

Approximate FDS for Tiger Wash Piedmont
FCD Contract No. 98-48, Assignment No. 1
June 2000
Technical Data Notebook
Appendix G.4 Color Aerial Photographs


1999 1:9600 Scale
Color Aerial Photo Location Map
Legend
Photo Location
Flight Line
N
W
E
S
3000 0 3000 Feet
Line 1
Line 2
Line 3
TIGER WASH
EAST TIGER WASH
PLAIN

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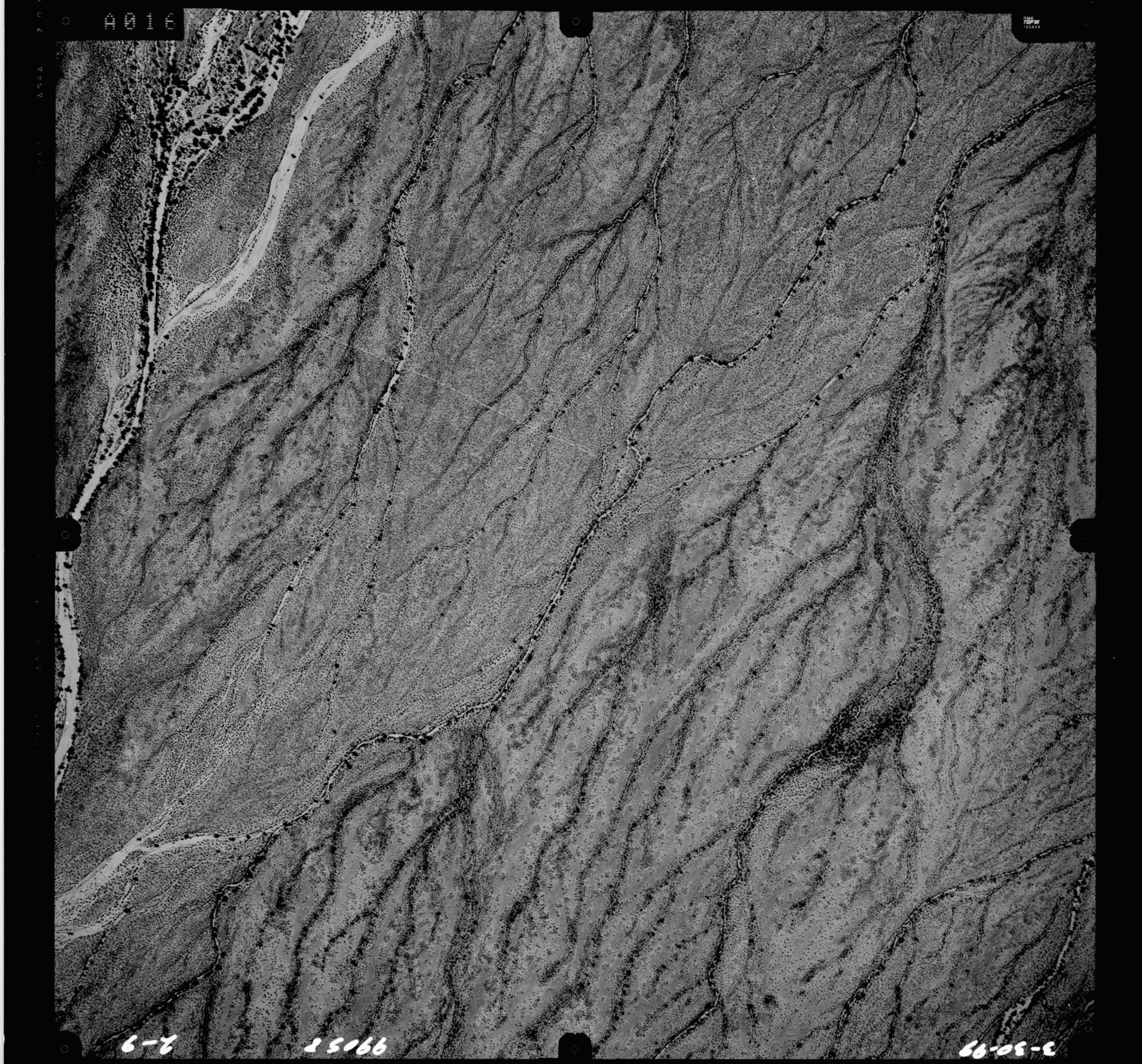

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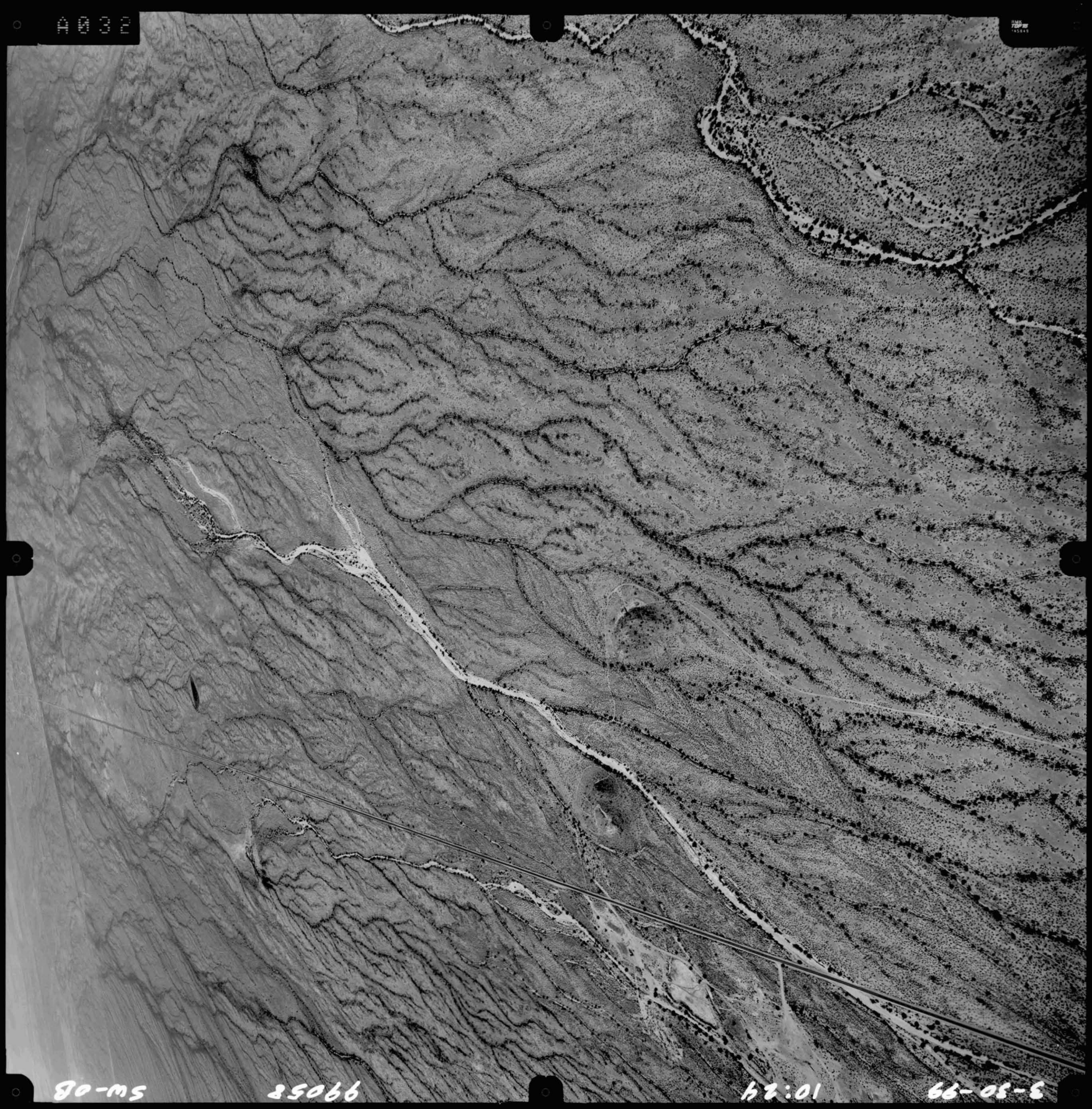

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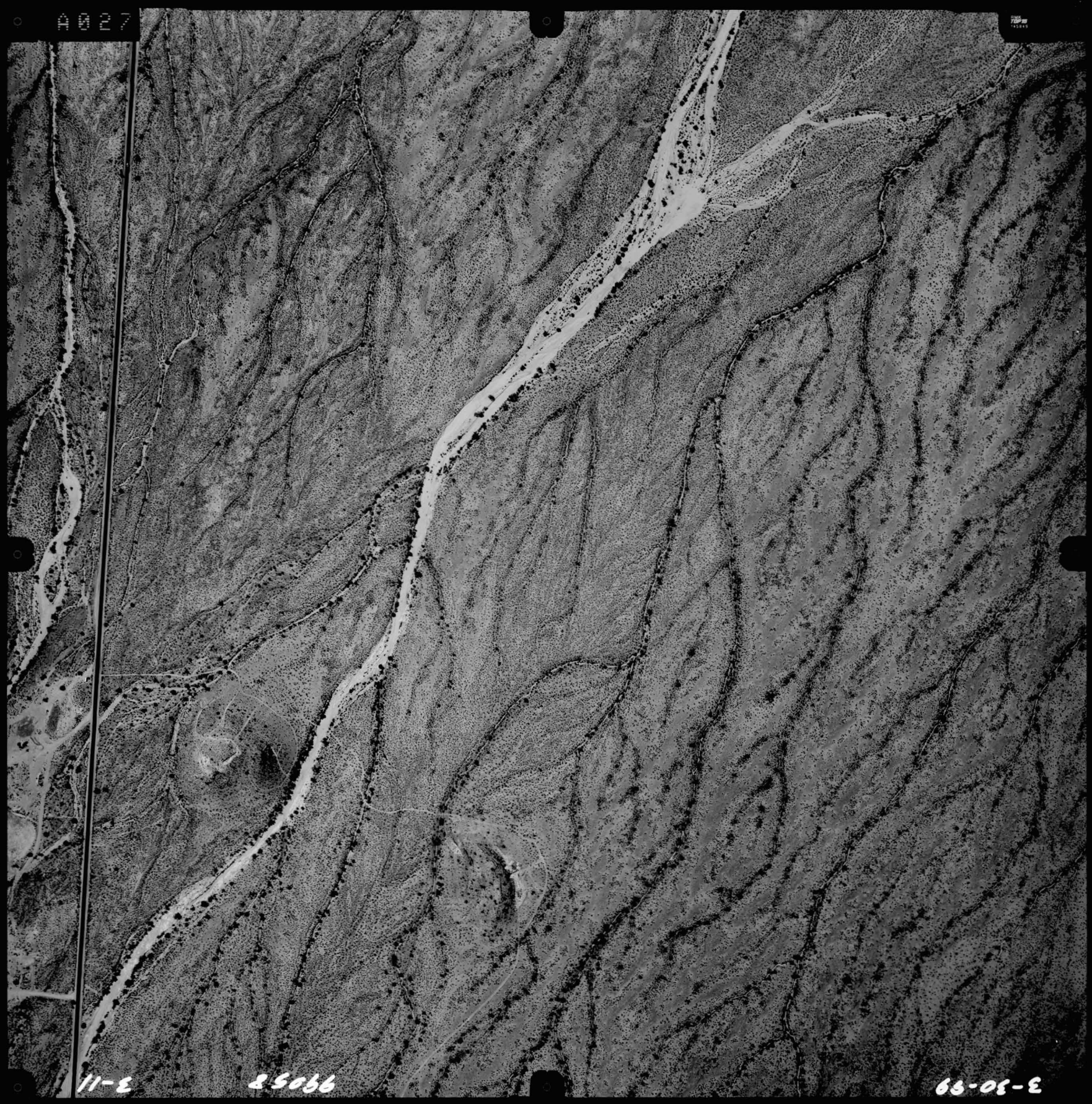

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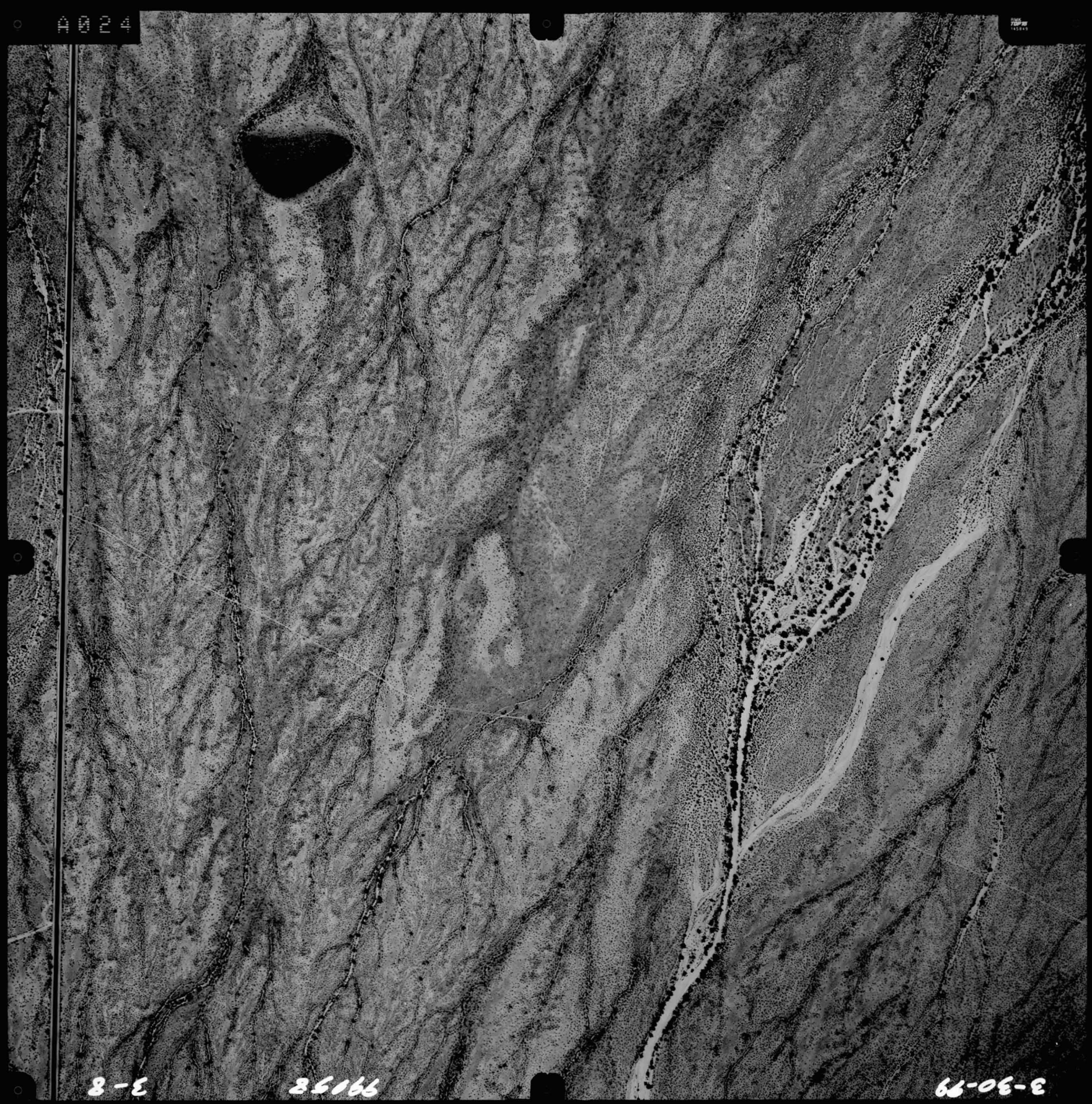

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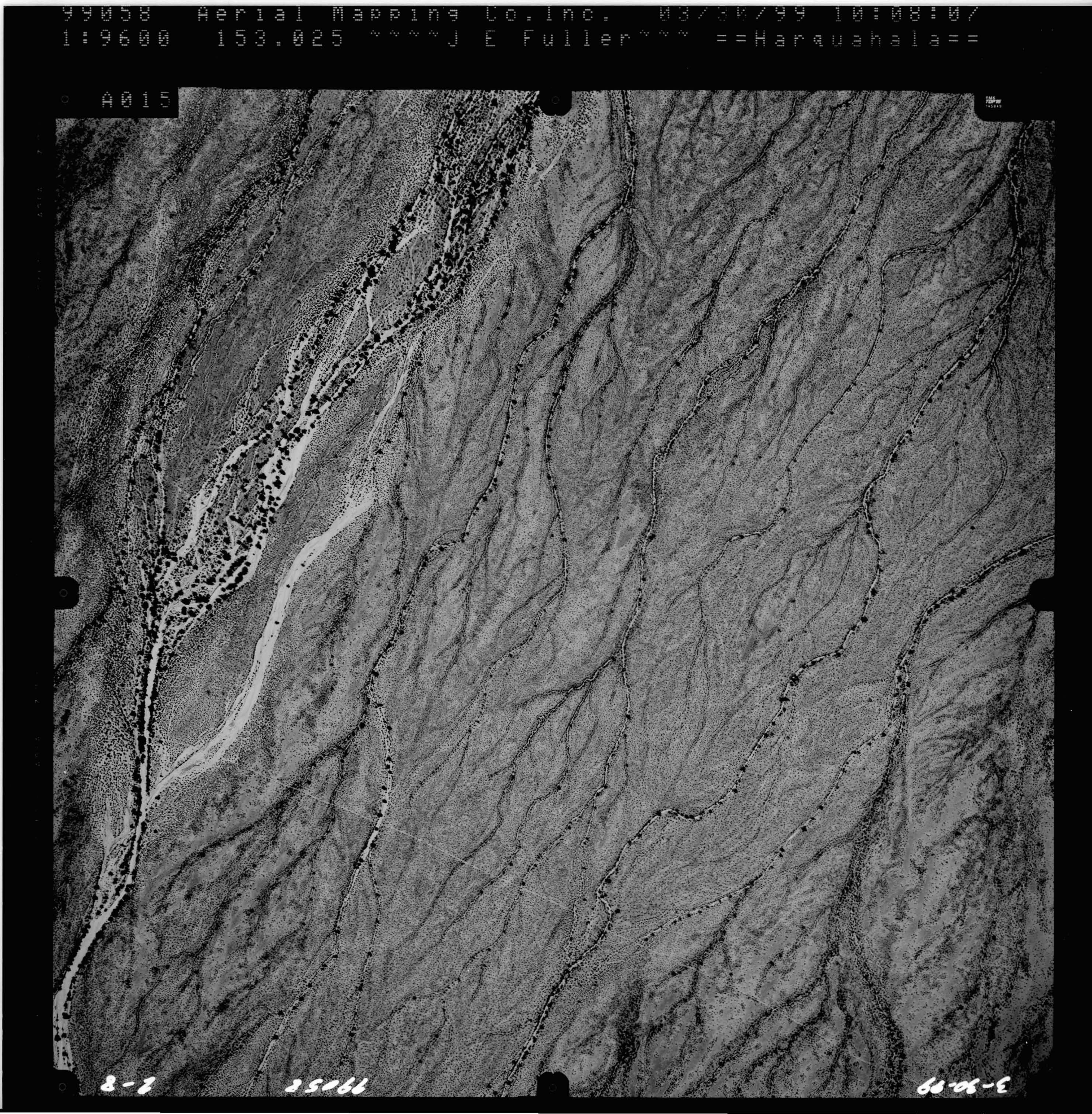

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A015
3-30-99
99058
2-8

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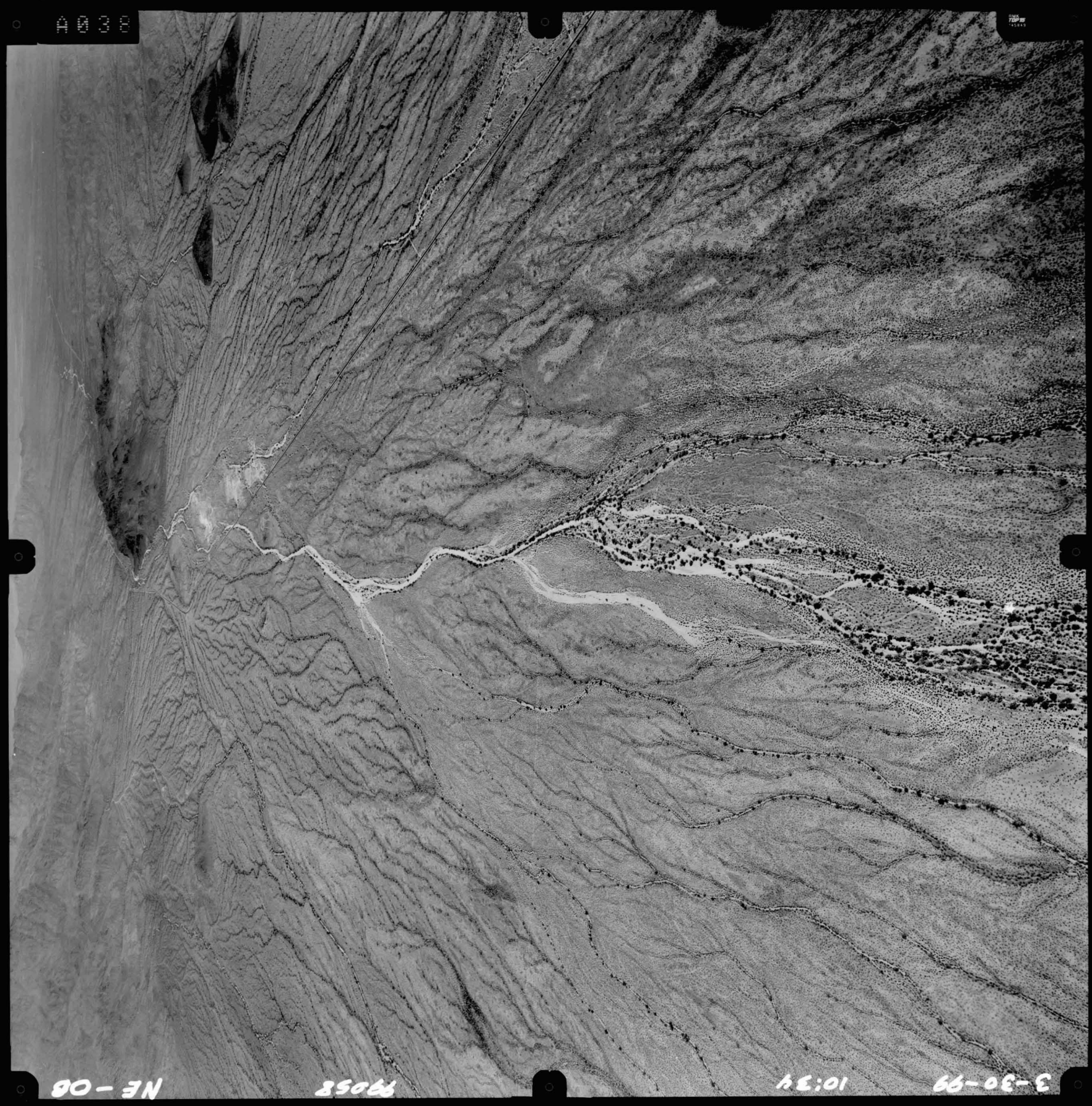

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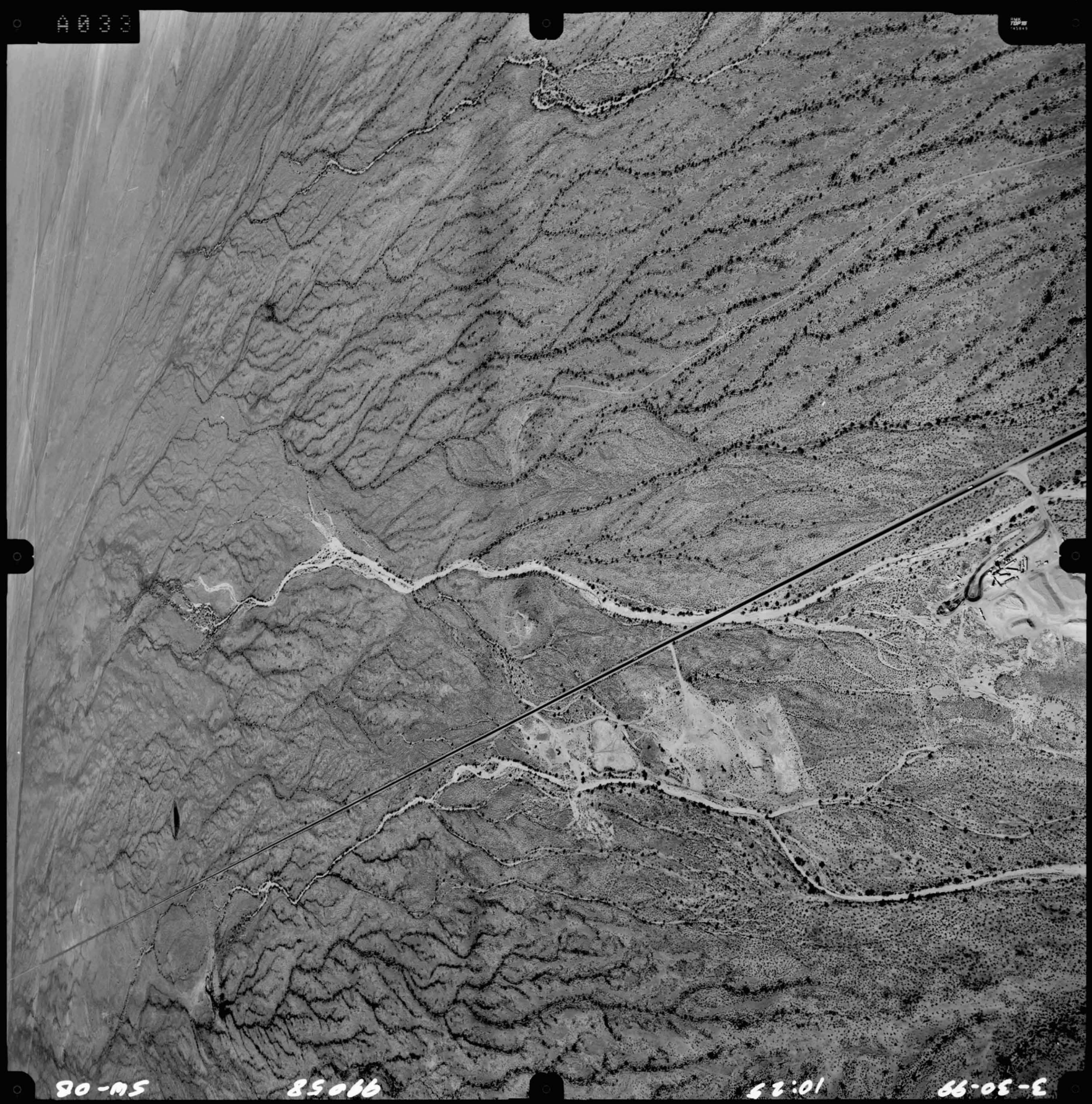

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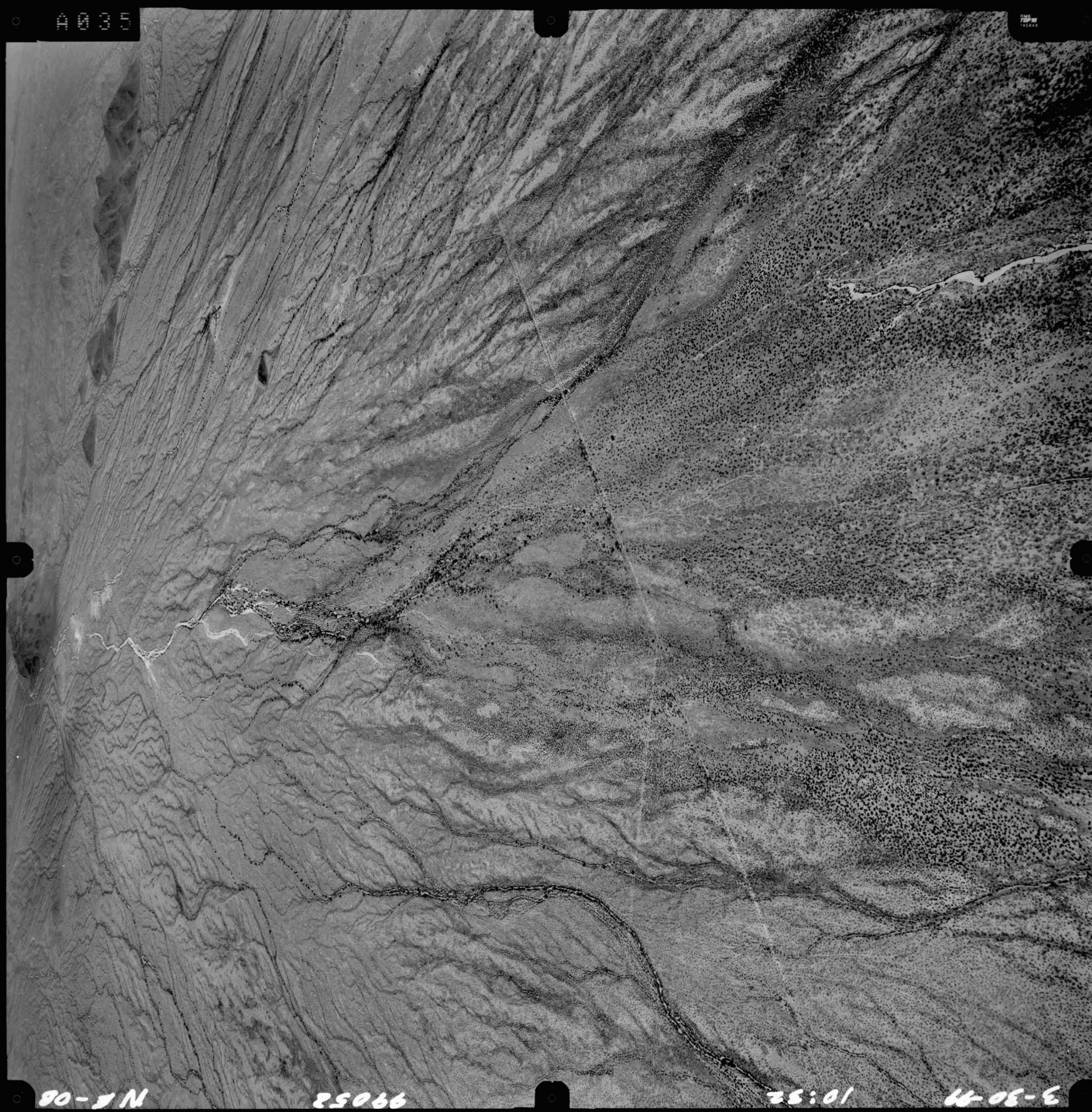

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3-30-99

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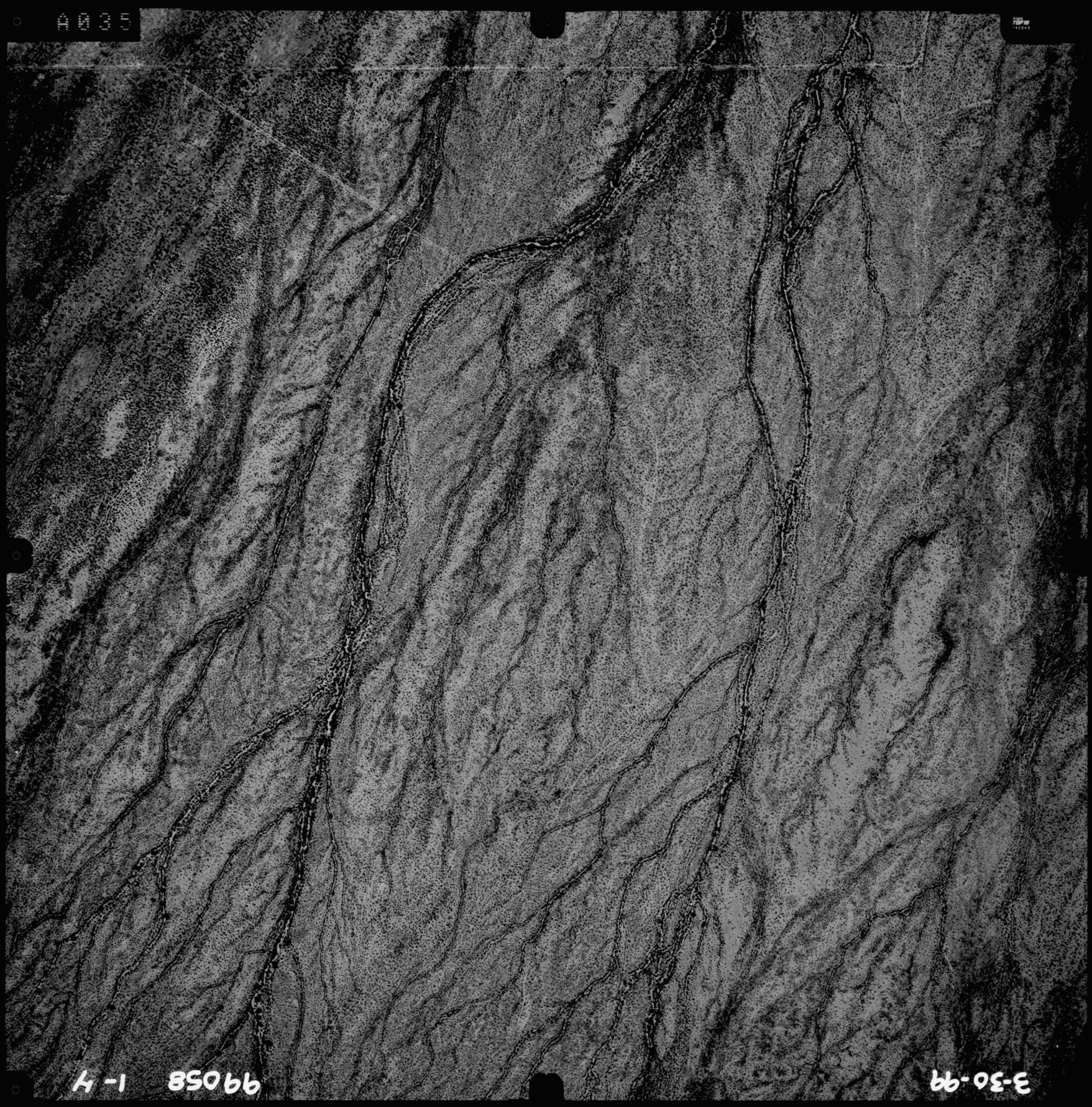

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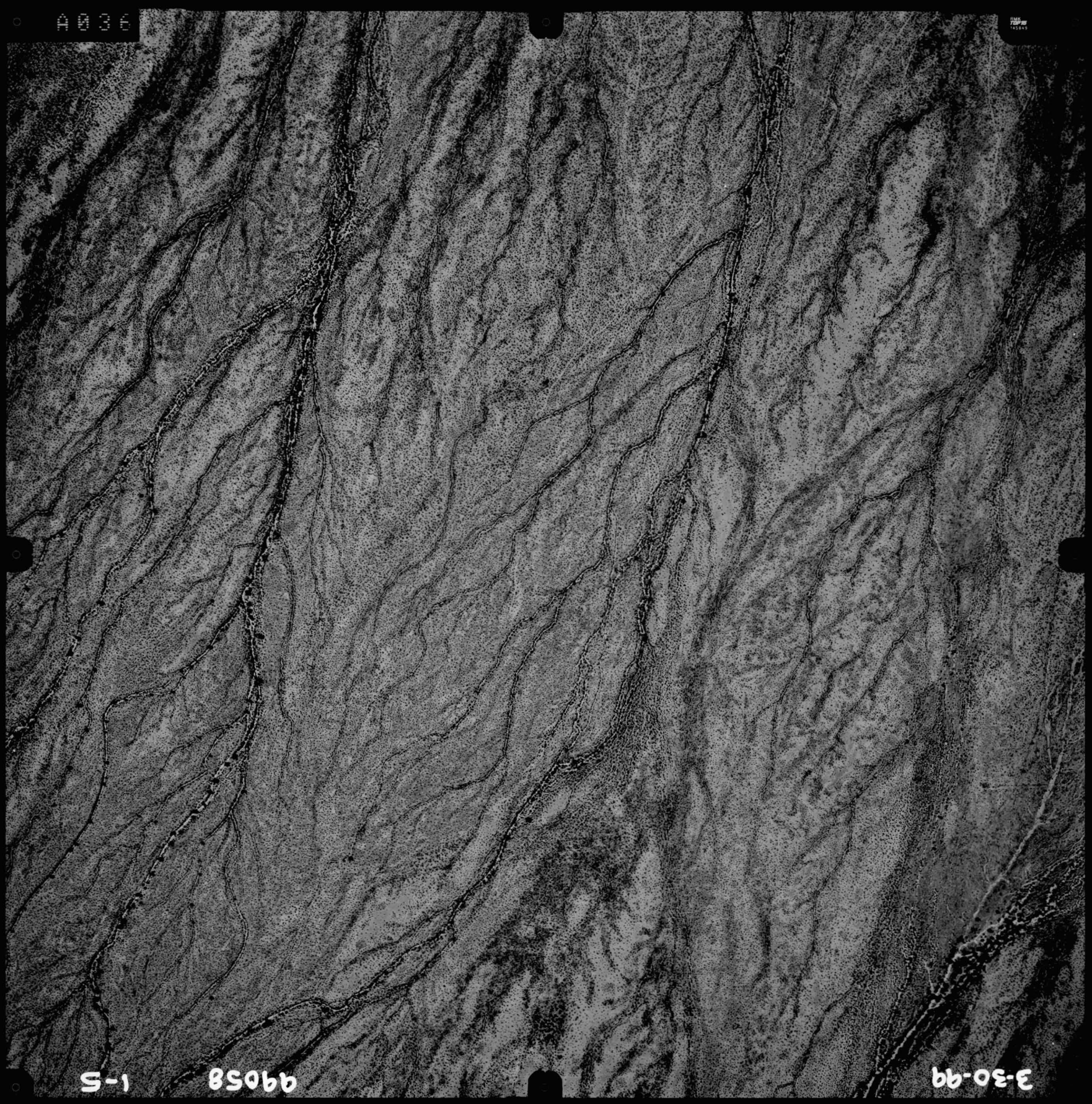

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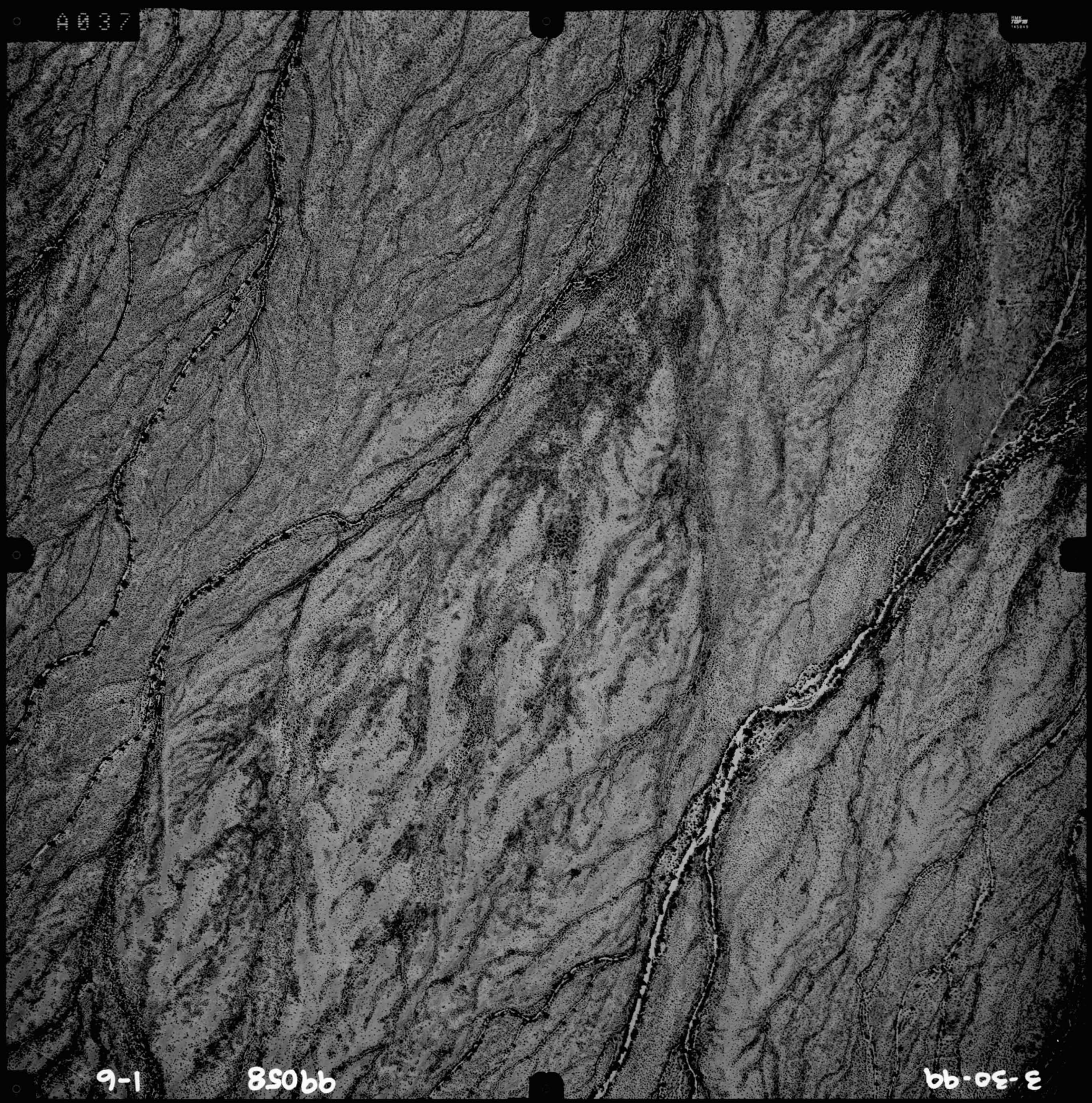

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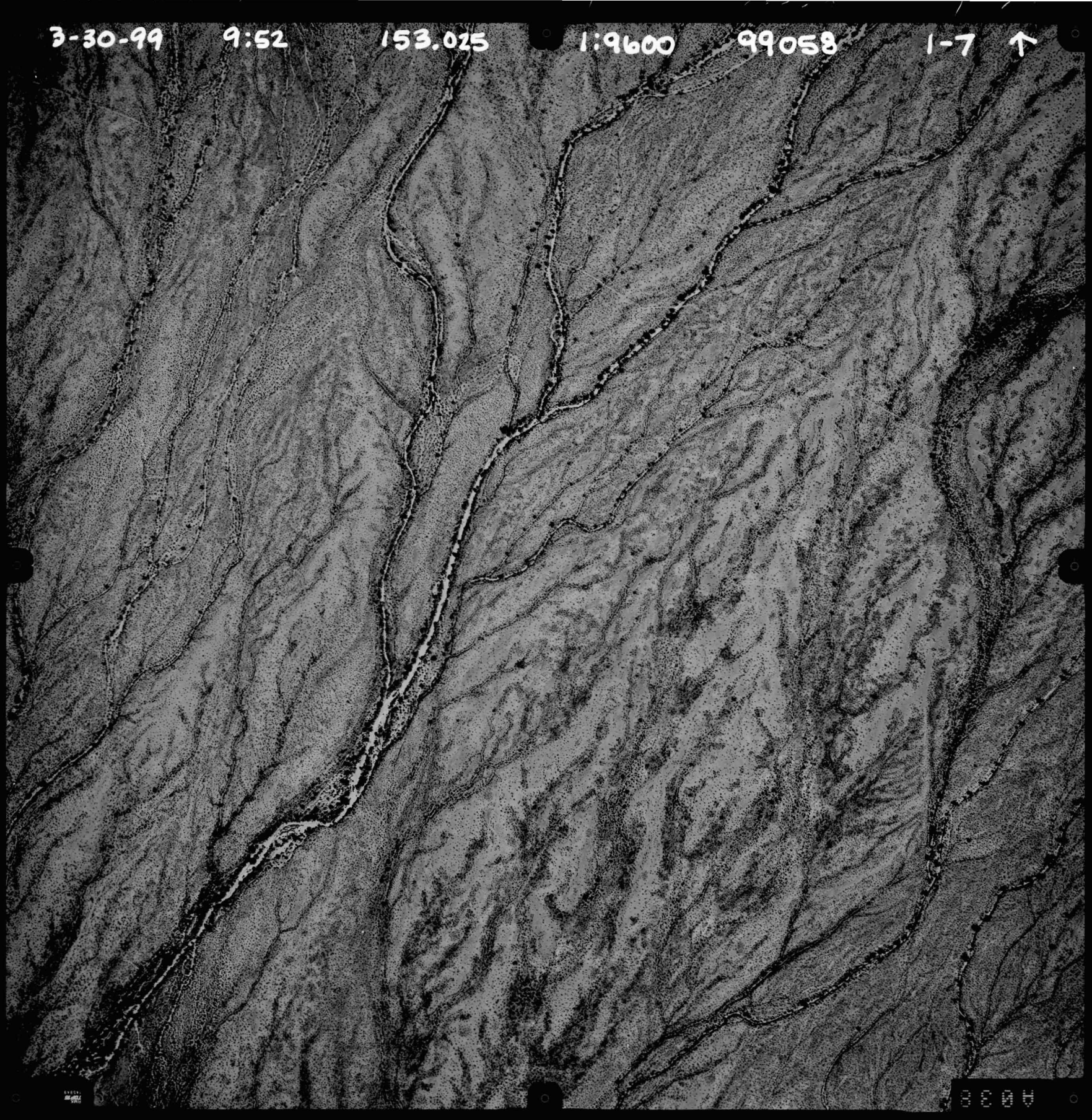
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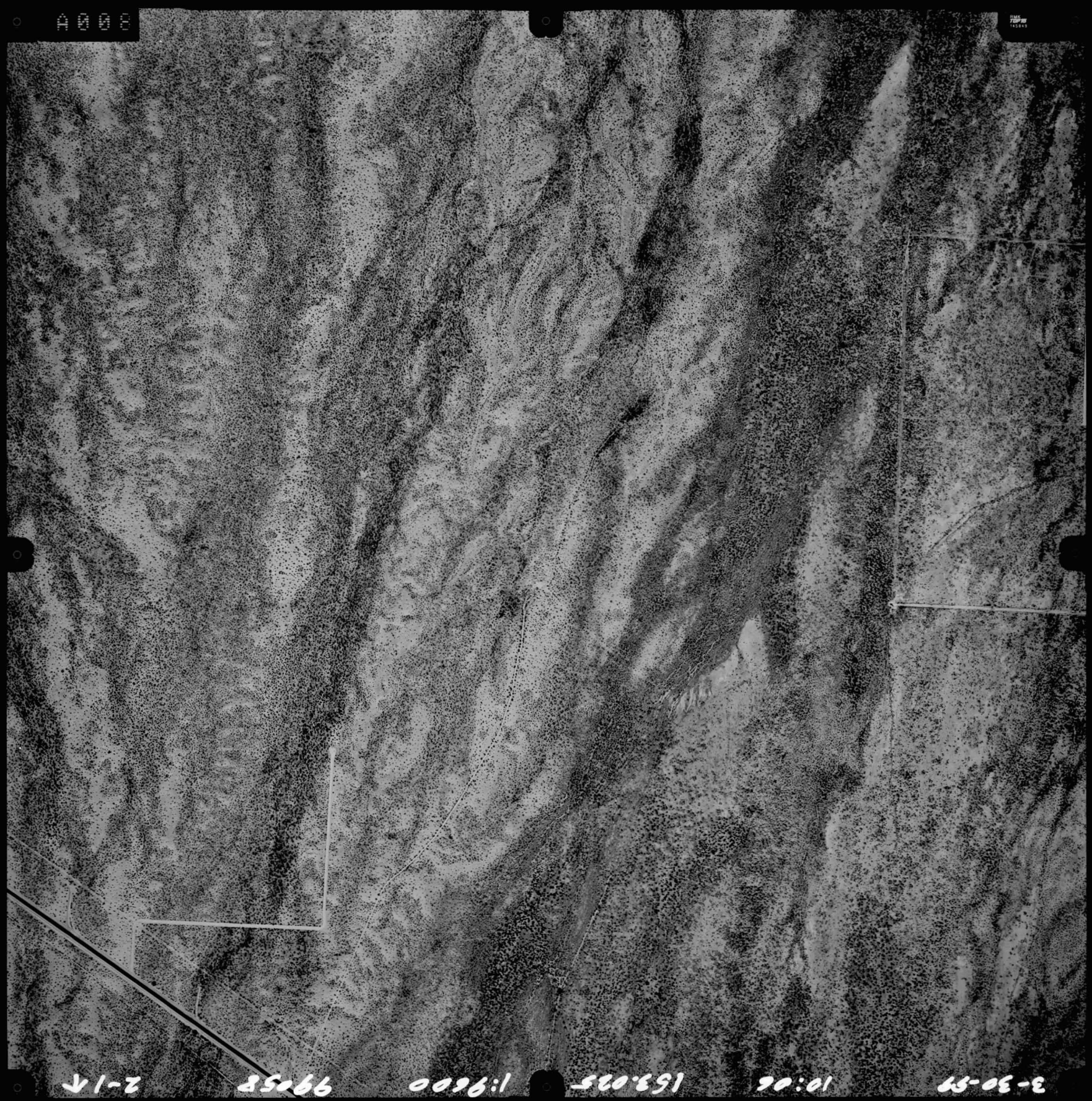

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A009

2-2 99058 3-30-99

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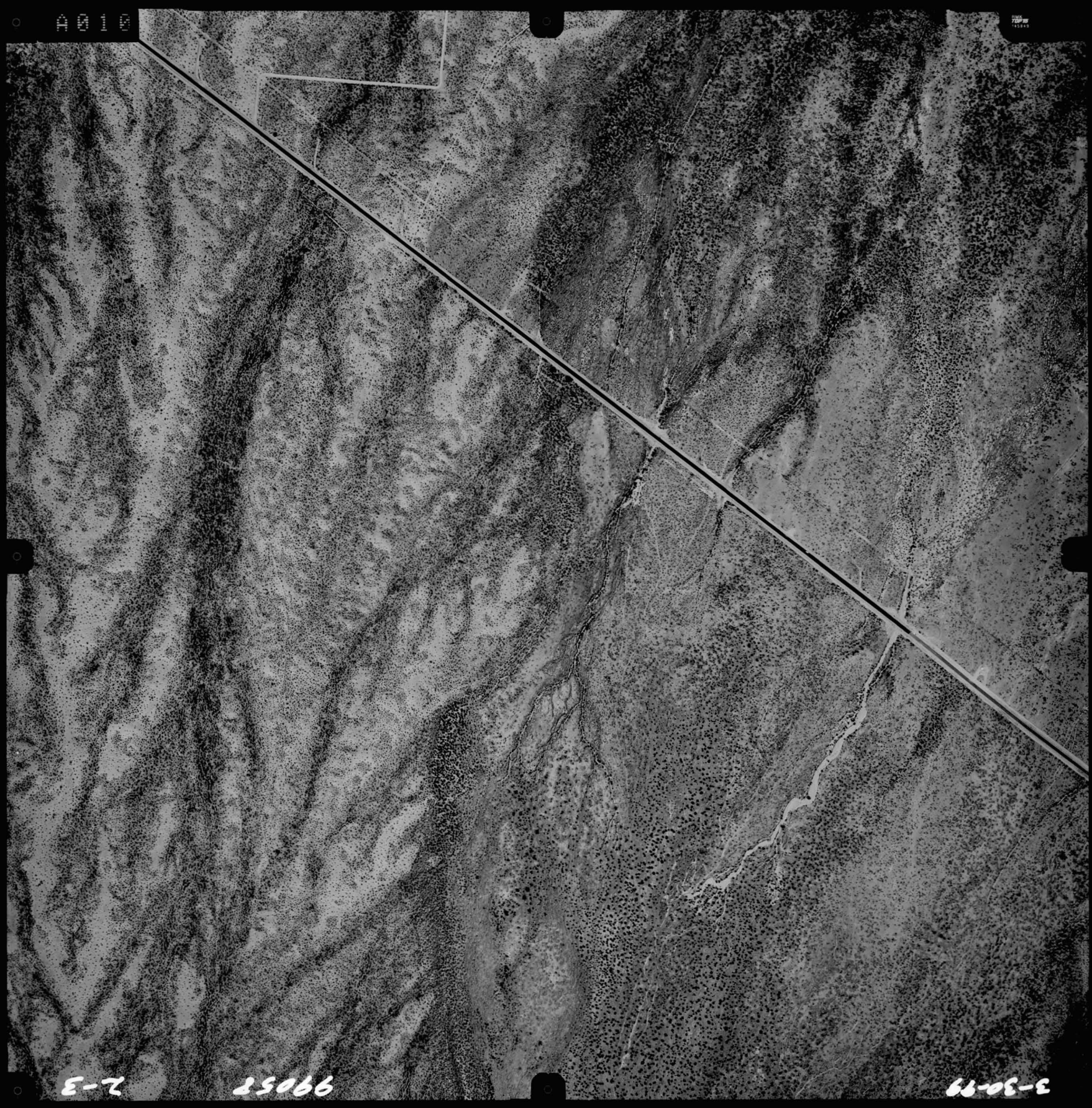

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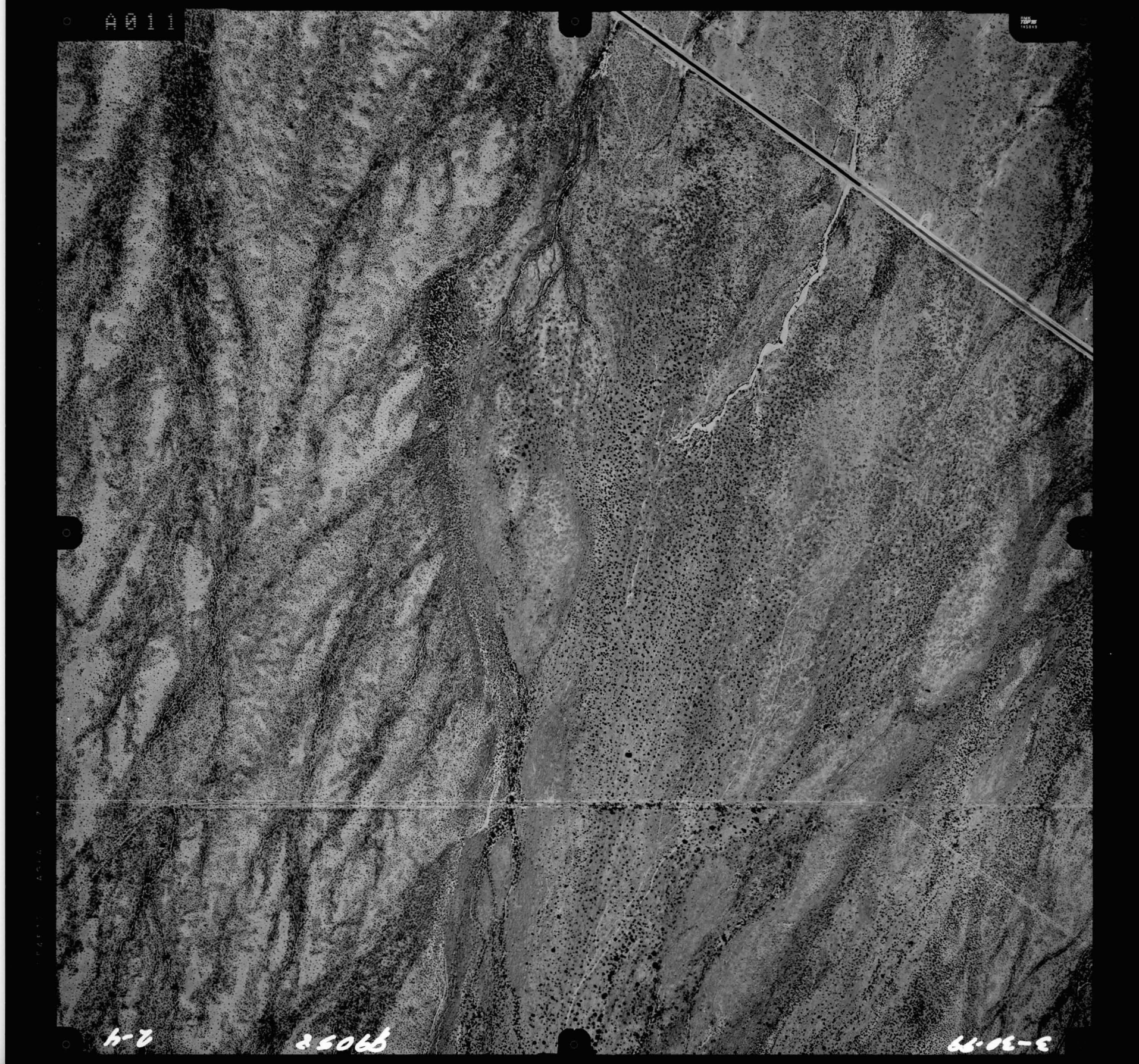

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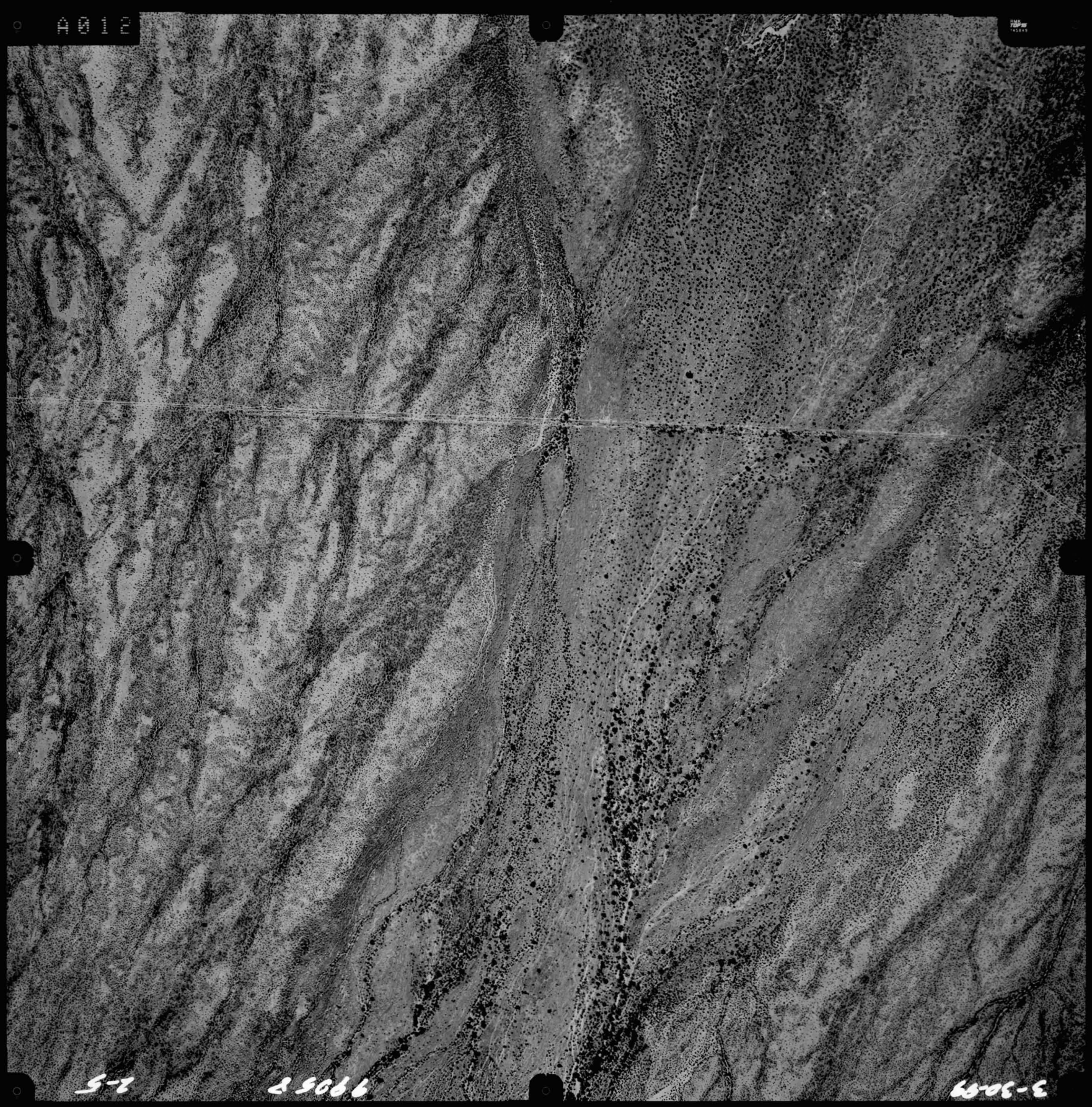

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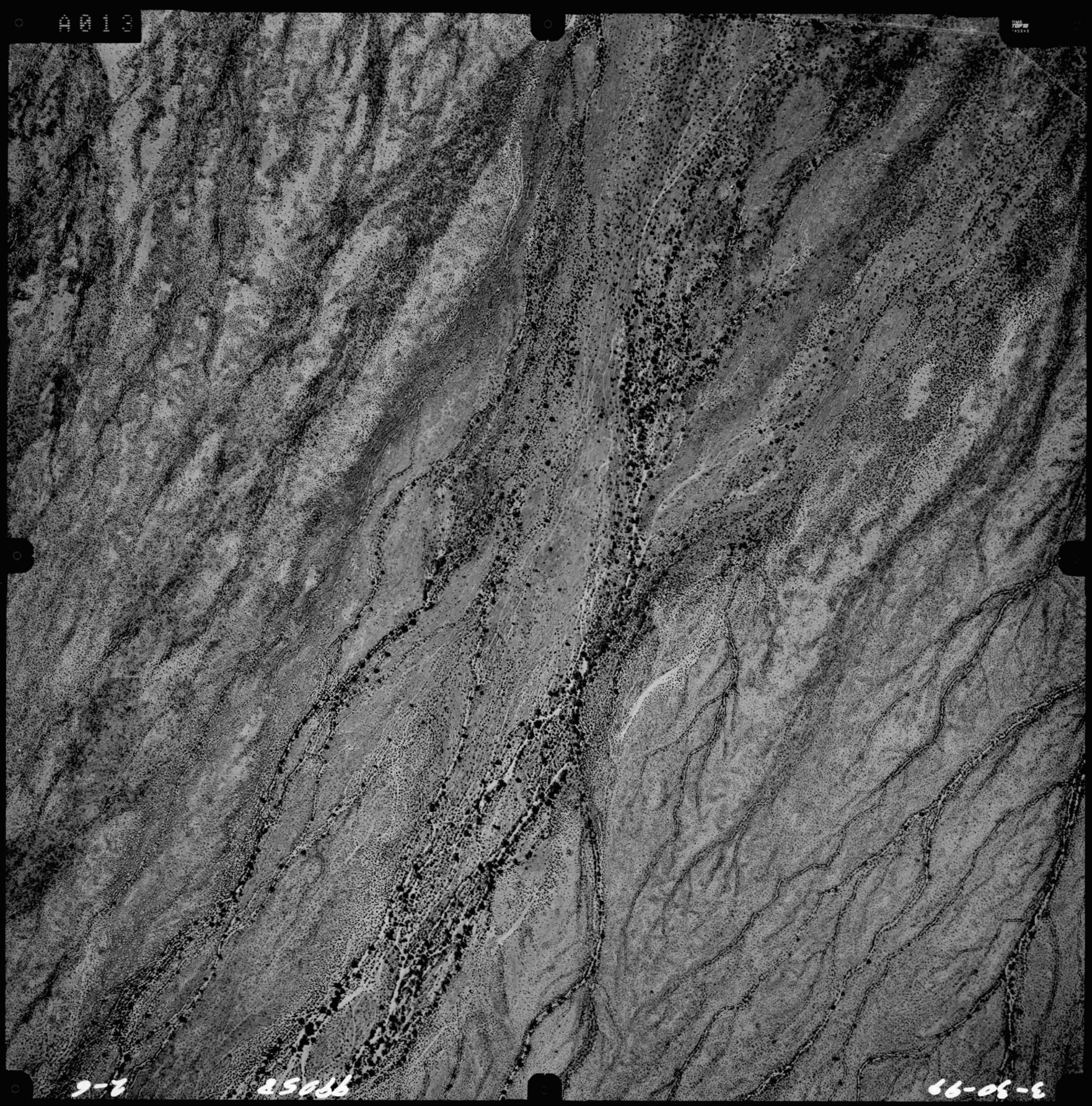

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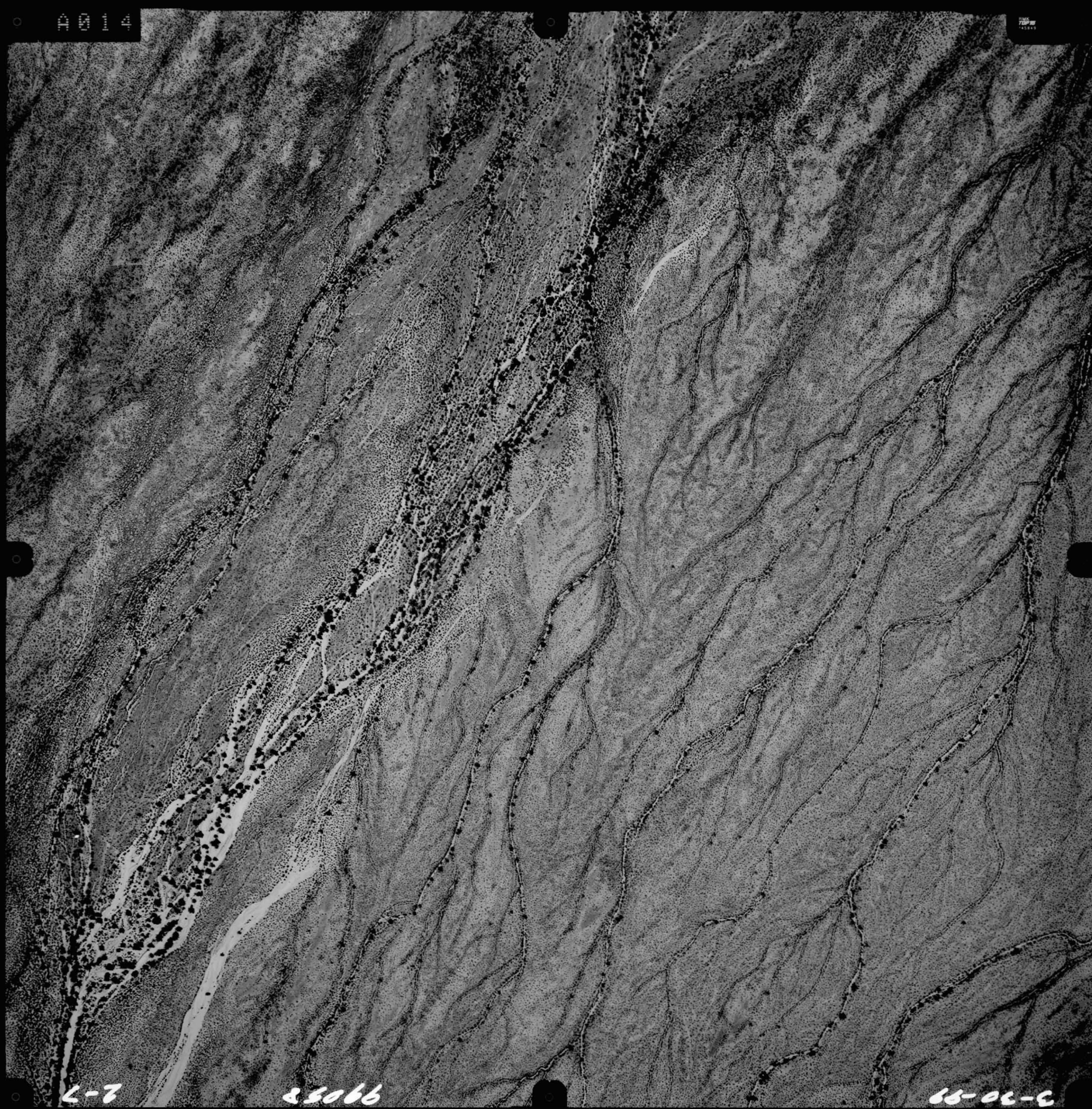

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A033

99058 Z-1

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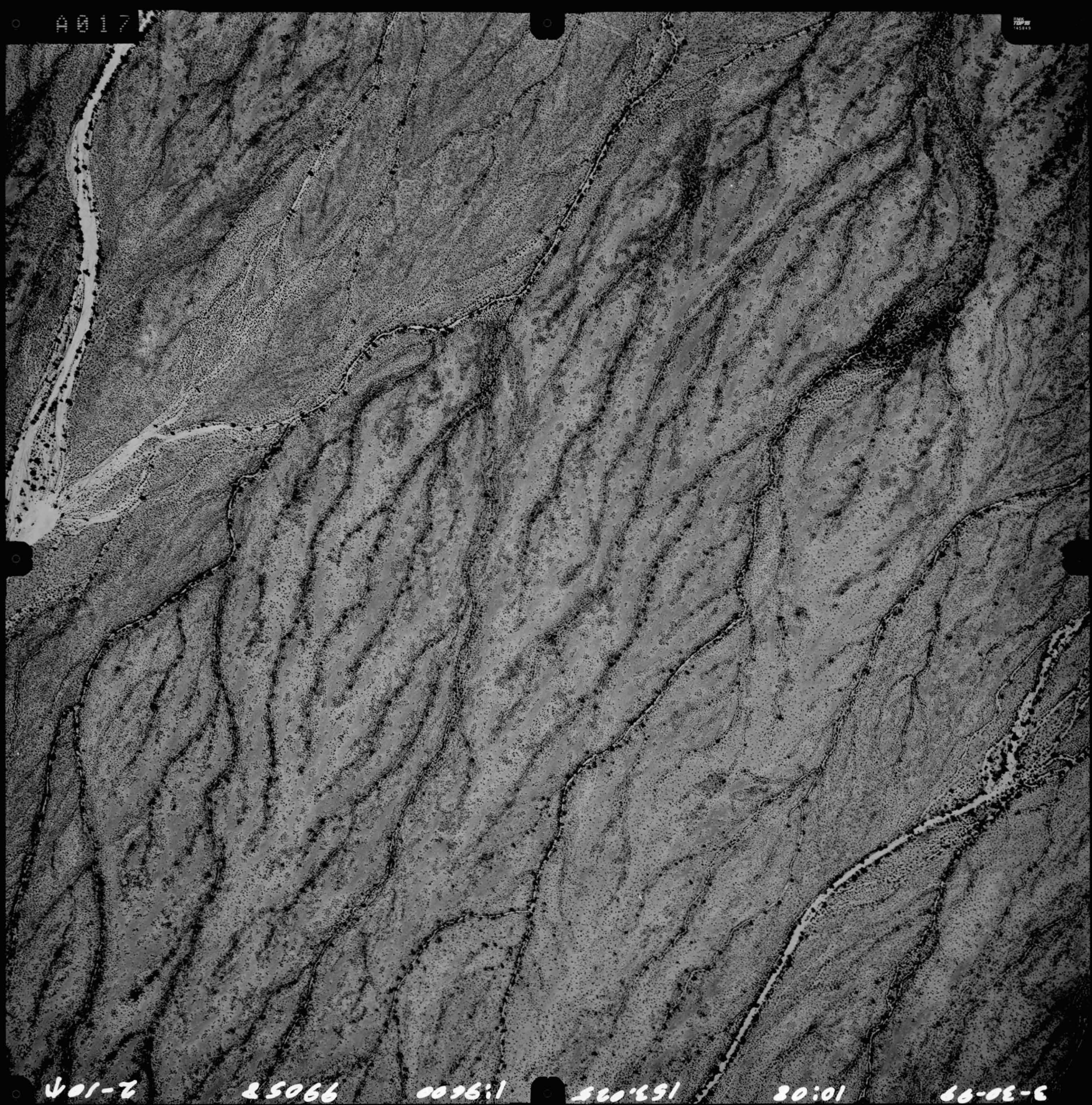

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A017

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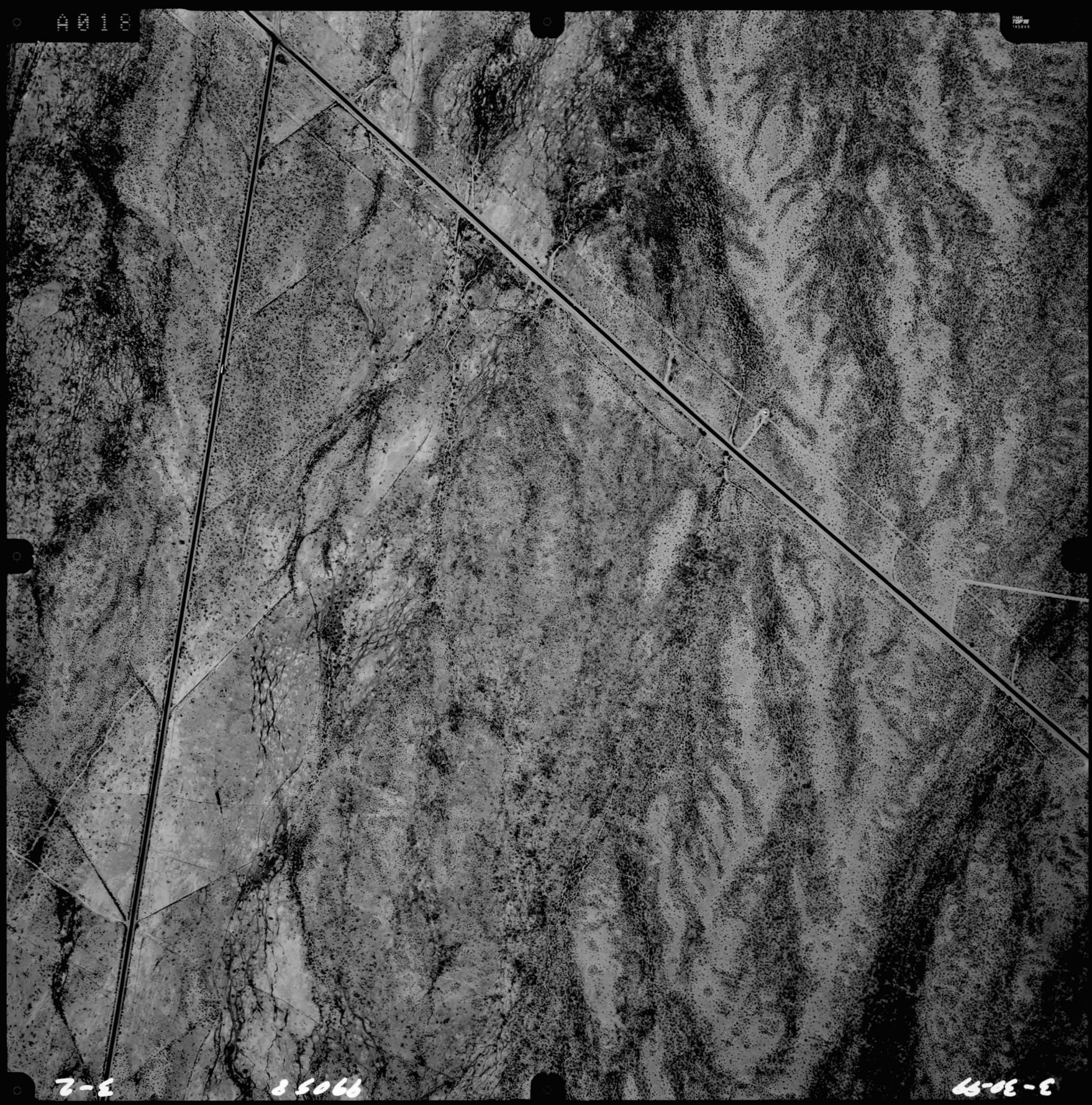

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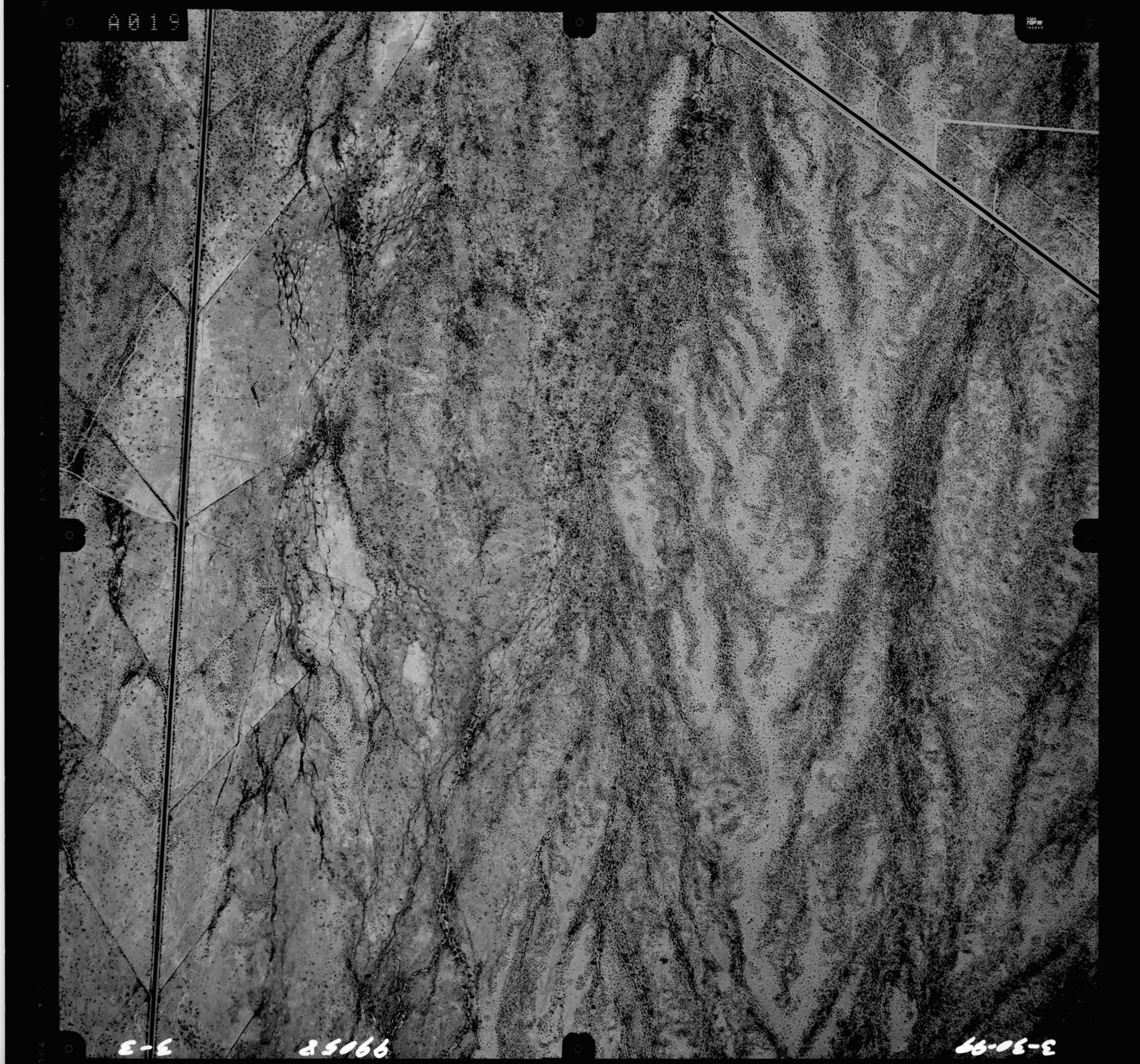

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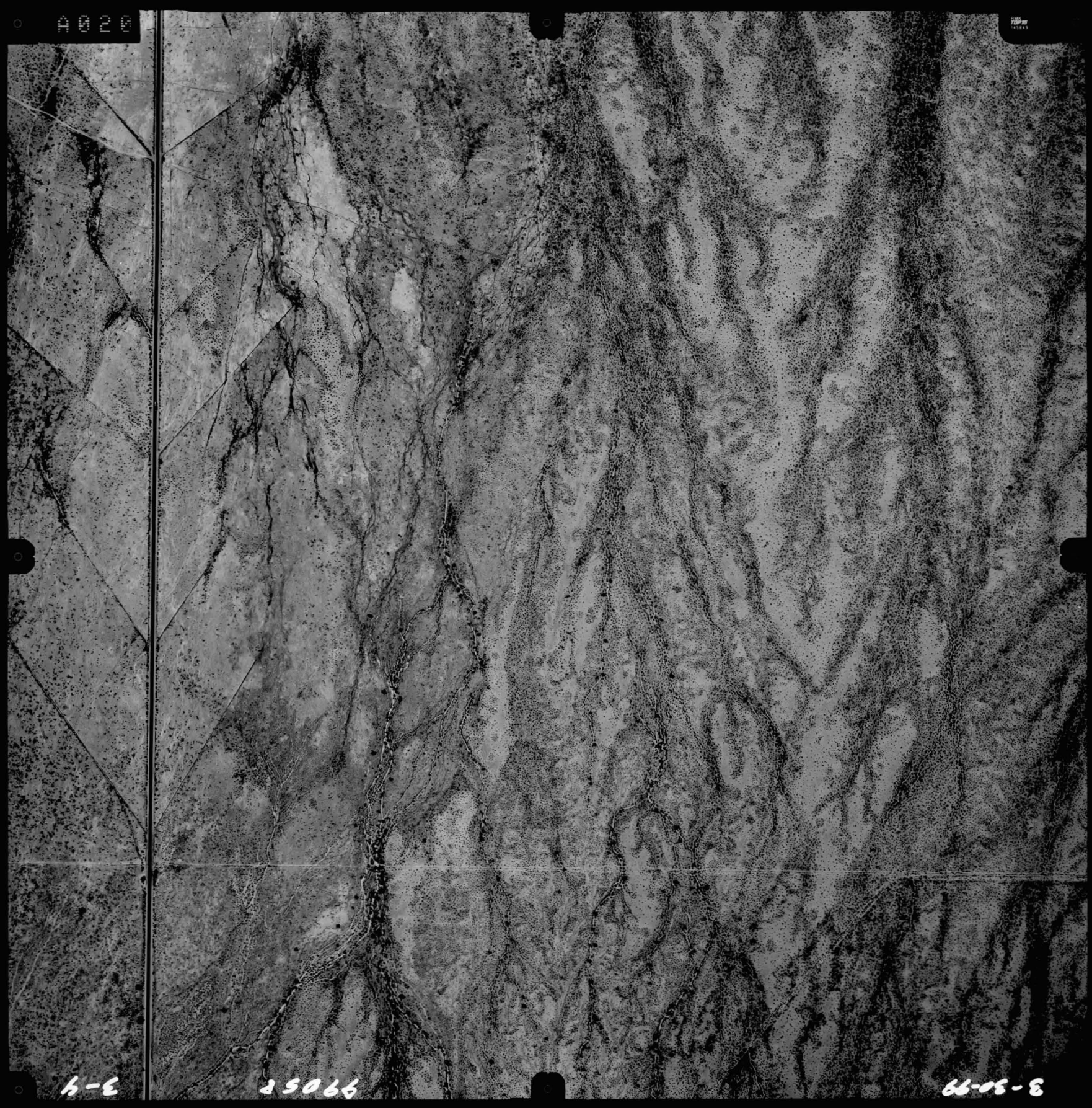

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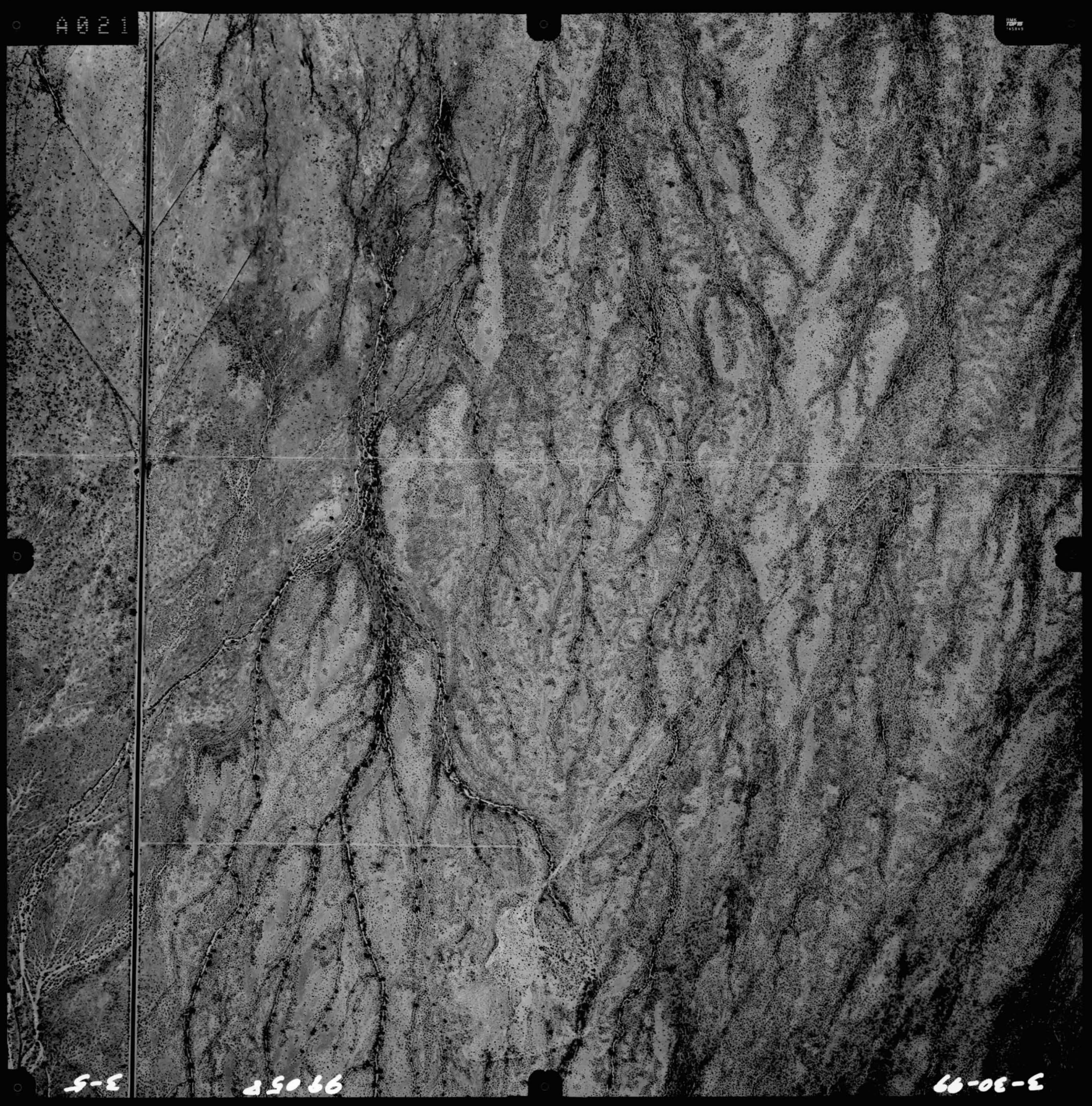

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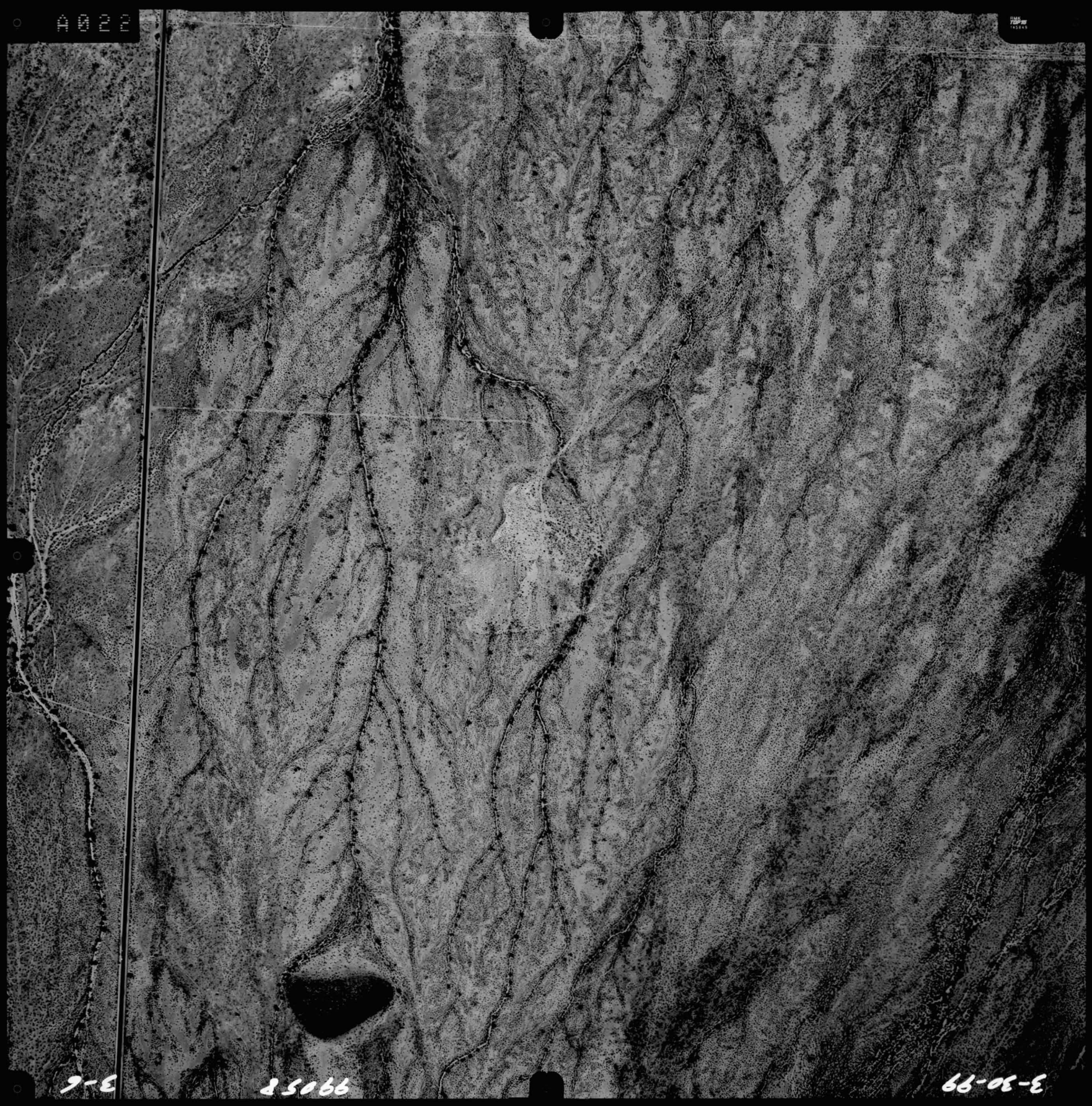

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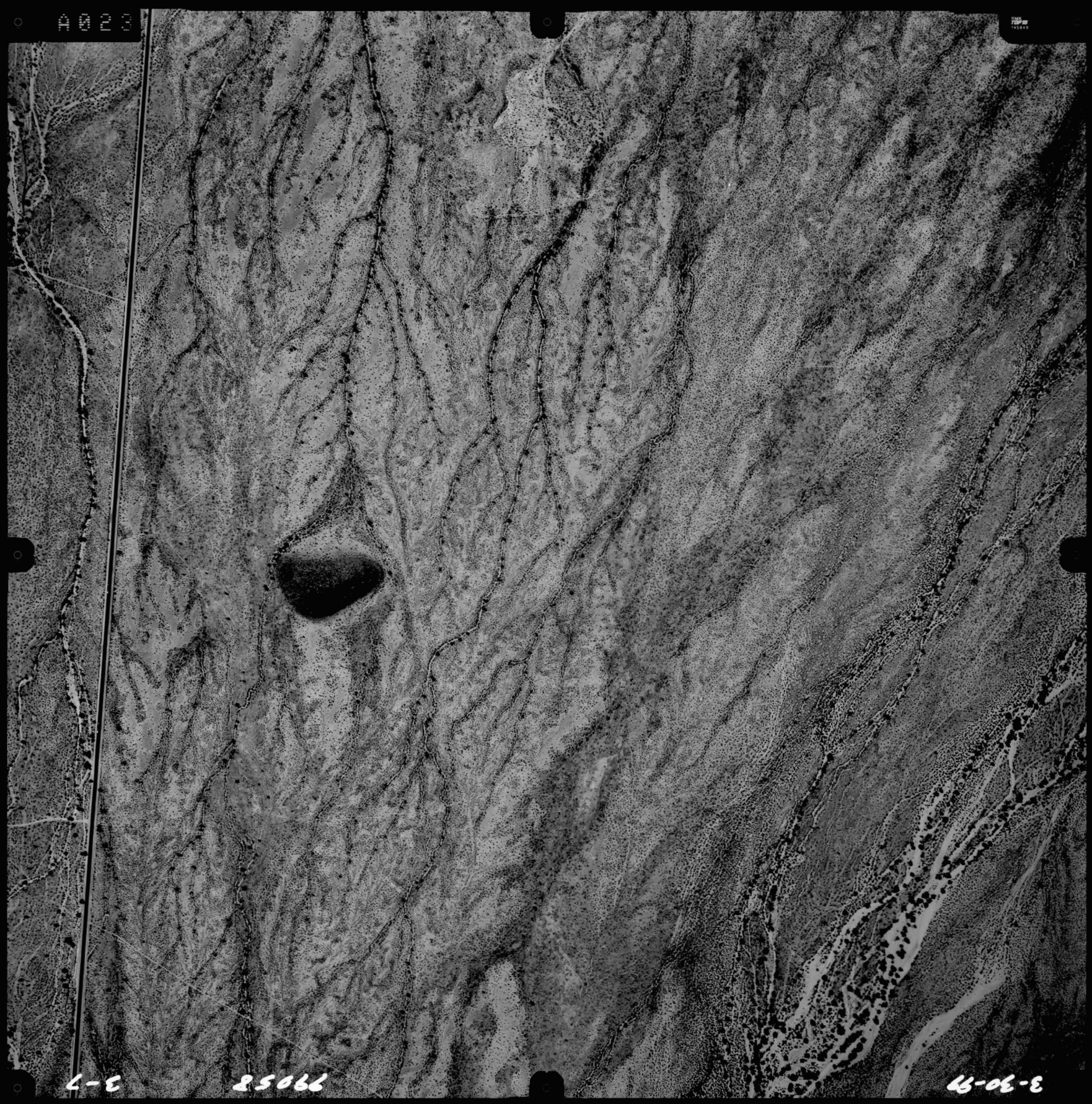

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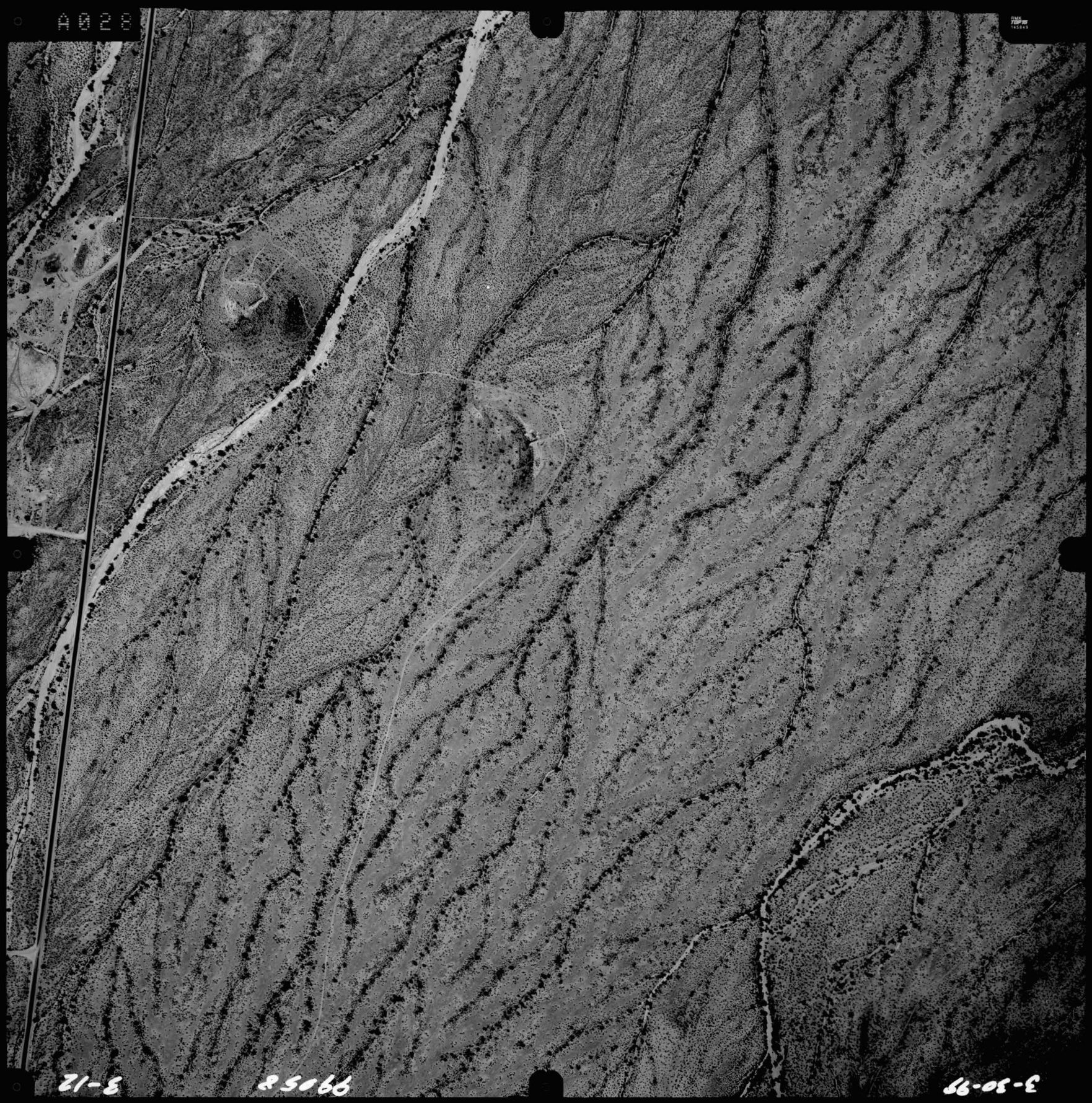

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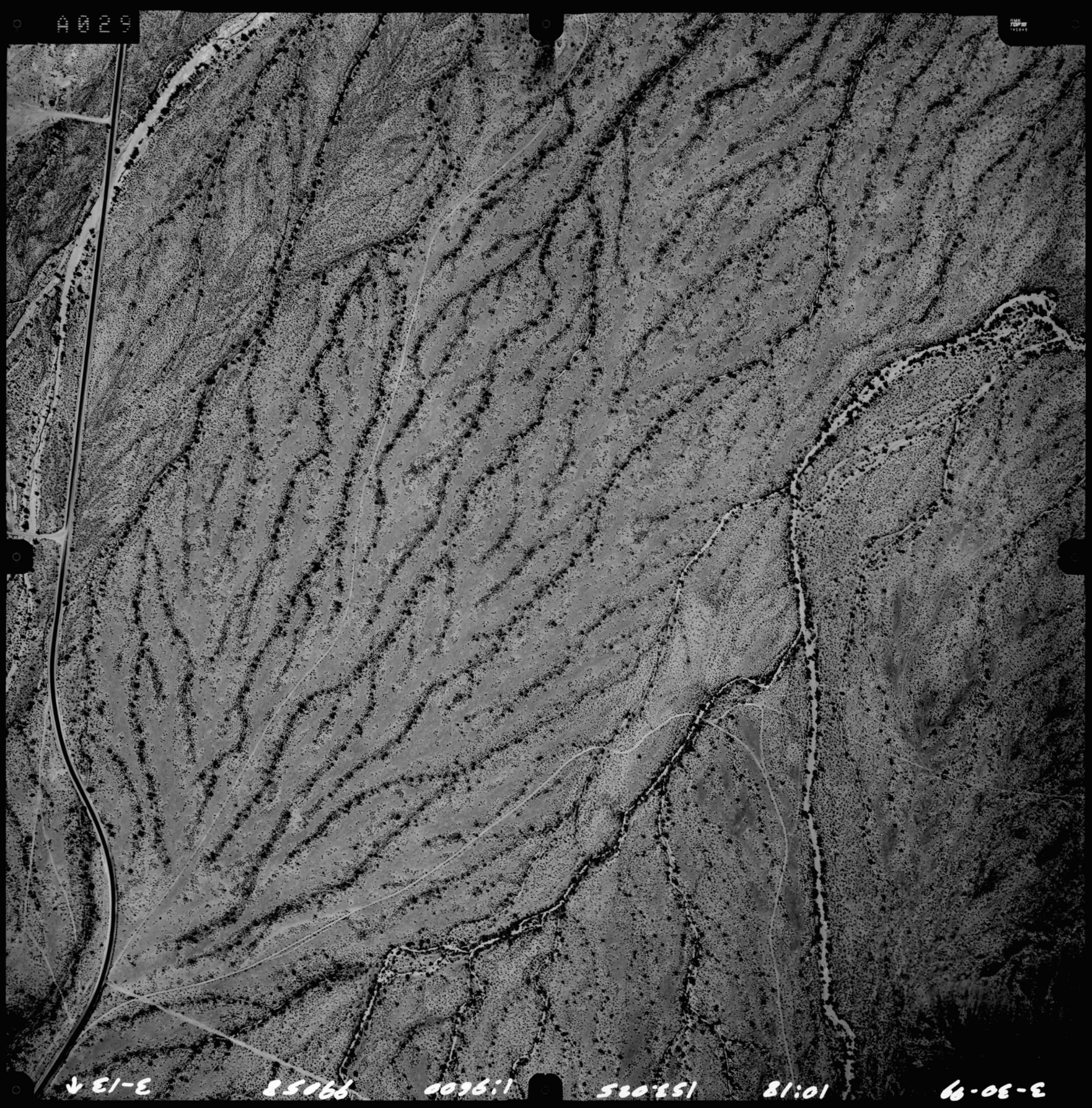

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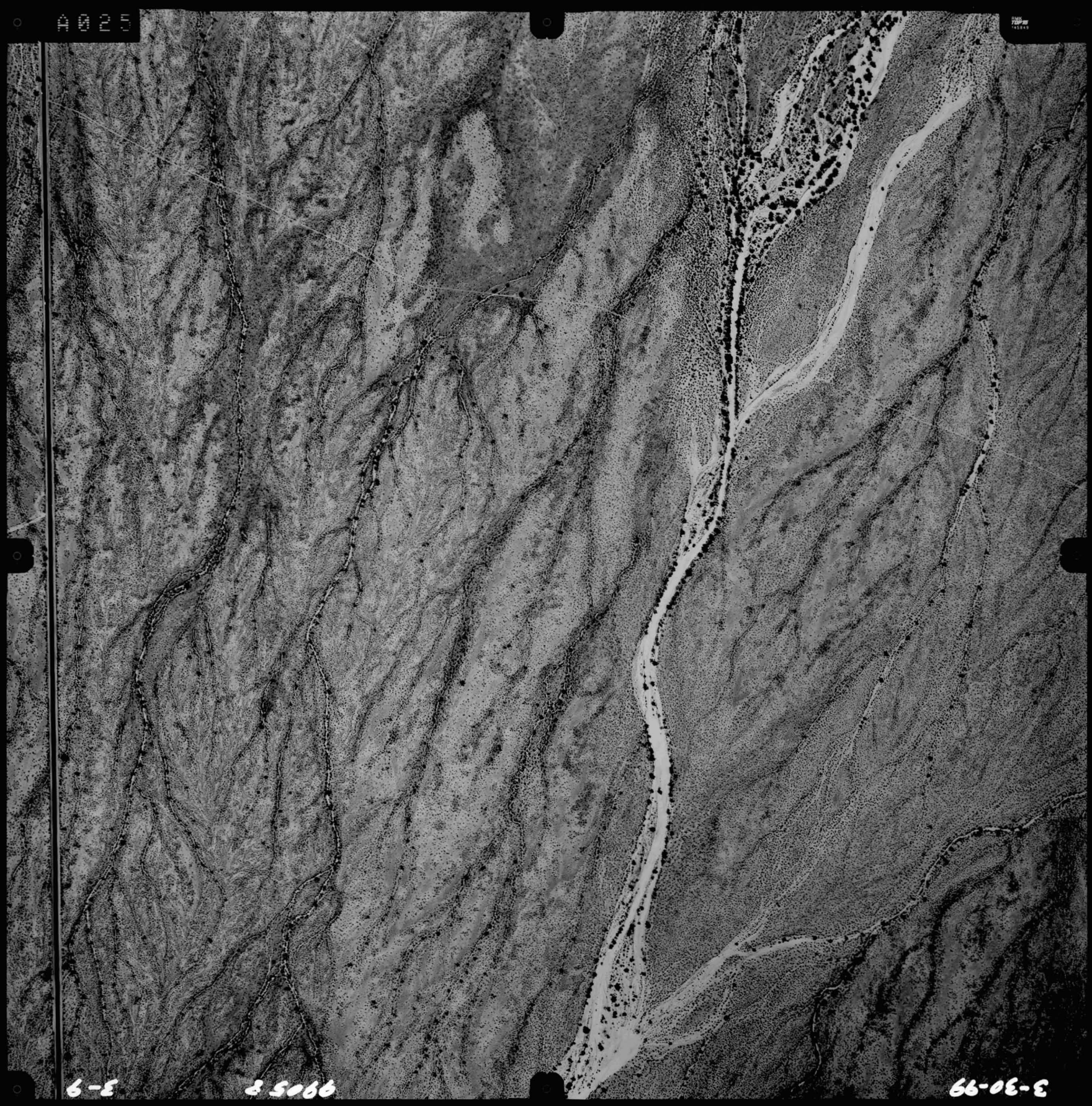

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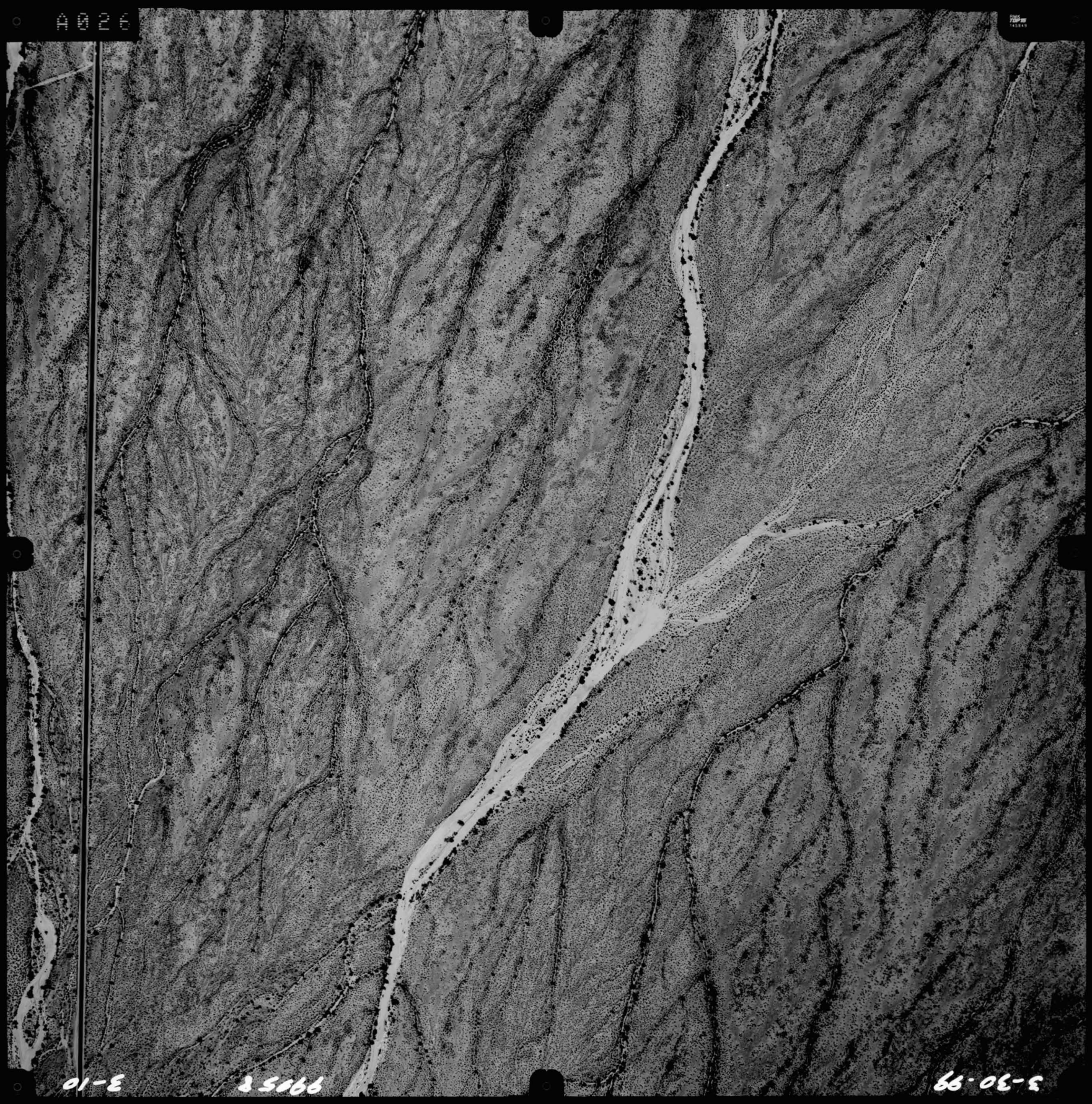


3-10 25066 3-30-99

Federal Emergency Management Agency

Washington, D.C. 20472

Property of
District of MC Library
Flood Control District
Return to
Tucson
Phoenix, AZ 85

FLOOD CONTROL DISTRICT
RECEIVED
DEC 03 '01

CH & GM	FINANCE
PIO	LANDS
ADMIN	O & M
REG	P & PM
ENG	FILE
CONTRACTS	
PLANNING	LMT

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

IN REPLY REFER TO:
Case No.: 01-09-1164X

The Honorable Janice Brewer
Chairman, Maricopa County
Board of Supervisors
301 West Jefferson, 10th Floor
Phoenix, AZ 85003

Community: Maricopa County, Arizona
Community No.: 040037
Panels Affected: 04013C0975 F and 1425 F
Effective Date of This Revision: NOV 30 2001

102-I-C

A333.
014.
004

Dear Ms. Brewer:

This responds to a request that the Federal Emergency Management Agency (FEMA) revise the effective Flood Insurance Rate Map (FIRM) for Maricopa County, Arizona and Incorporated Areas, in accordance with Part 65 of the National Flood Insurance Program (NFIP) regulations. In a letter dated July 29, 2000, Mr. Joe Tram, P.E., Floodplain Branch Manager, Flood Control District of Maricopa County (FCDMC), requested that FEMA revise the FIRM to show the effects of an approximate floodplain study of the Tiger Wash Alluvial Fan. The study encompassed the reach of Tiger Wash from just downstream of Eagle Road to just upstream of Buckeye Sacome Road. The study also included an approximate analysis of the active alluvial fan flood hazards for Tiger Wash Alluvial Fan. This study was performed in accordance with the guidelines set forth in FEMA's publication entitled *Guidelines for Determining Flood Hazards on Alluvial Fans,* dated February 23, 2000. In response to Mr. Tram's request, we issued a Letter of Map Revision (LOMR) that became effective on July 20, 2001 (Case No. 00-09-985P). In the attachments to that LOMR, the boundary delineations for Zone D, unstudied areas where flood hazards are undetermined but possible, inadvertently were not shown on annotated FIRM Panel 04013C0975 F. This LOMR is a re-issuance of the July 20 LOMR, with the Zone D boundary delineations shown on the above-mentioned FIRM panel.

All data required to complete our review of this request were submitted with letters from Mr. Jonathan Fuller, P.E., P.H., JE Fuller / Hydrology and Geomorphology, Inc., and Mr. Tram. Because this LOMR is based on a detailed hydrologic or hydraulic study conducted by a Federal, State, or local agency to replace an approximate study conducted by FEMA and shown on the flood map, fees were not assessed for the review.

We have completed our review of the submitted data and the flood data shown on the effective FIRM and in the effective Flood Insurance Study (FIS) report. We have revised the FIRM to modify the floodplain boundary delineations and zone designations of the flood having a 1-percent chance of being equaled or exceeded in any given year (base flood) along Tiger Wash from just downstream of Eagle Road to just upstream of Buckeye Sacome Road. The affected areas previously were designated Zone X (shaded), areas that would be inundated by the base flood with average depths less than 1.0 foot. As a result of the new study, Special Flood Hazard Areas (SFHAs), areas that would be inundated by the base flood, were added to the FIRM. The active and inactive areas of the alluvial fan, where an approximate study was performed, have been designated Zone A (Active Alluvial Fan Flooding) and Zone A (Inactive Alluvial Fan Flooding), respectively, SFHAs with no Base Flood Elevations

Joe Tram - FCDX

From: Ted Lehman [ted@jefuller.com]
Sent: Wednesday, September 05, 2001 9:57 AM
To: pbuch-pedersen@mbakercorp.com; Ataul Hannan
Cc: Tim Murphy - FCDX; Joe Tram - FCDX
Subject: Case No. 00-09-985P, Tiger Wash Alluvial Fan LOMR

Perneille & Atul,

Attached you will find a letter outlining the concerns with the LOMR panels I discussed this morning with Atul. I am also sending you an original in the US mail. I have also faxed a copy to Atul.

Please let me know if you have any questions.

Sincerely,

Ted Lehman, P.E.
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.
6101 S. Rural Road, Suite 110
Tempe, AZ 85283
(480) 752-2124 x 16
(480) 839-2193 FAX
ted@jefuller.com

JE Fuller/ Hydrology & Geomorphology, Inc.

Jonathan Fuller, P.E., P.H.	Pat Deschamps, P.E., L.S.	6101 S. Rural Rd., Suite 110
Brian Iserman, P.E.	Michael Henze, M.A.	Tempe, Arizona 85283
John Wallace, P.E.	Brooks Dillard, B.A.	480-752-2124 (voice)
Ted Lehman, P.E.	Zack Washburn, M.S.	480-839-2193 (fax)
W. Scott Ogden, P.E.	Mike Kellogg, M.S.	www.jefuller.com

September 5, 2001

Perneille Buch-Pedersen
Michael Baker Jr. Corp.
3601 Eisenhower Ave., Suite 600
Alexandria, VA 22304

Re: Case No. 00-09-985P, Tiger Wash Alluvial Fan LOMR

Ms. Buch-Pedersen,

This letter is to inform you of a few items of concern we noticed in the FIRM panels received for the subject LOMR (panels 04013C0975F and 04013C1425F, both revised July, 19, 2001). Upon receipt of the LOMR approval letter and FIRM panels, I forwarded these same comments to the local community (the Flood Control District of Maricopa County) on August 3, 2001. However, in a meeting yesterday, I became aware that they had not forwarded these comments to FEMA or Michael Baker Jr. (MBJ). I spoke with Mr. Atul Hannan of your office this morning regarding these issues and he suggested I forward them to you.

The items of concern are as follows:

1) On Panel 04013C1425F, the Buckeye - Salome Road is mislabeled as Buckeye "Sacome" Road.
2) On Panel 04013C0975F (previously unprinted), the areas not explicitly labeled as Zone X (unshaded), Zone X (shaded), or Zone A would be best characterized as Zone D, unstudied. There are no Zone D labels within the panel. The legend does not make extremely clear the difference between Zone X (unshaded) and Zone D. I feel the lack of clarity of the designation of the unlabeled areas could lead to future confusion about the nature of flood hazards in these portions of the panel. The potential for such confusion is especially high in the area between the colored Zones and the area identified in the panel as "Revised Area."
3) There is an error in the line work and labeling as transferred from the work study maps onto the FIRM in Section 17 on Panel 04013C0975F. (See Figure 1) I have annotated Figure 1 to show the missing line which extends north and south from the east boundary of the circular Zone X (unshaded) polygon. West of the missing line should be Zone X (shaded) and east of the line should be Zone A (inactive alluvial fan flooding).

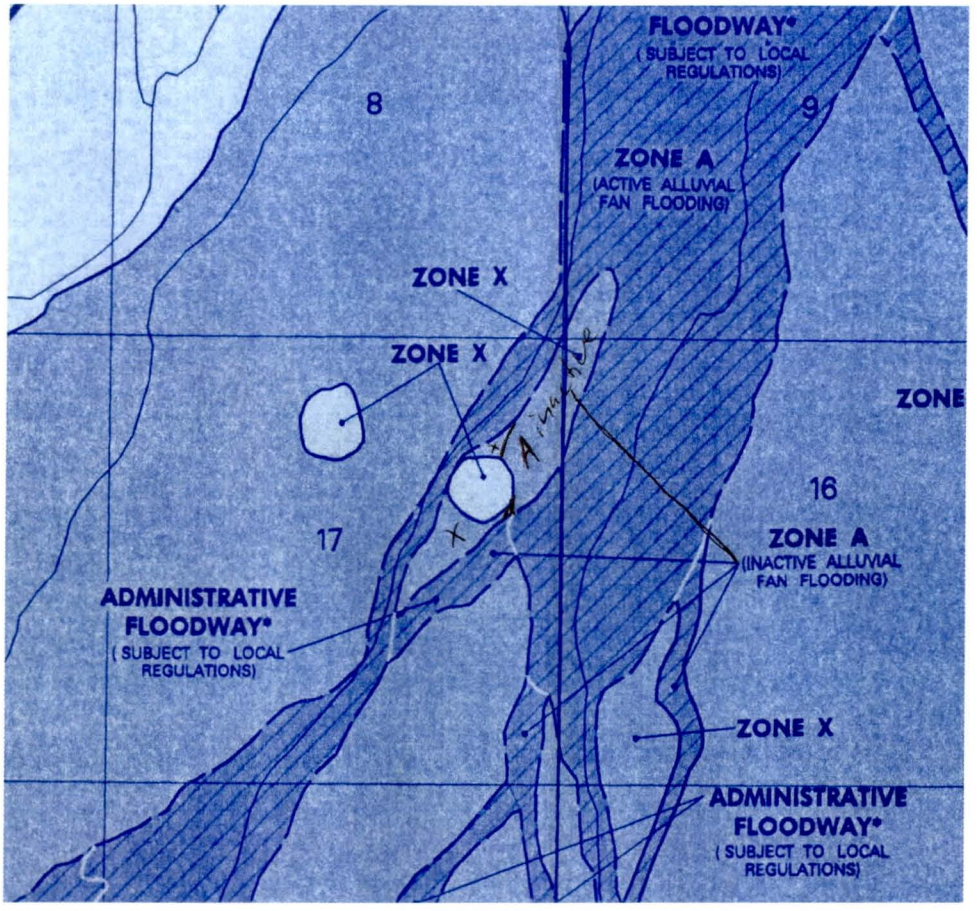


Figure 1 Portion of Panel 04013C0975F showing missing line and labels

Please let me know if you have any questions regarding these comments. Also, I would appreciate an update as to what course of action you decide to take regarding these issues.

Thank you in advance for your attention to these items. I look forward to hearing from you.

Sincerely,
JE Fuller / Hydrology & Geomorphology, Inc.

Ted Lehman, P.E.

Cc: Mr. Tim Murphy, P.E., Floodplain Branch Manager
Mr. Joe Tram, P.E., Regulatory Division Manager
Flood Control District of Maricopa County

Joe Tram - FCDX
From: Philip A. Pearthree [pearthree_phil@pop.state.az.us]
Sent: Thursday, March 22, 2001 2:05 PM
To: Amoroso, Lee; Arrowsmith, Ramon; Fuller, Jon; House, P.K.; Klawon, Jeanne; Lehman, Ted; Mayer, Larry; Pelletier, Jon; Robinson, Sarah; Joe Tram - FCDX; Vincent, Kirk; Youberg, Ann
Subject: Tiger Wash

twflood00.pdf

Dear Colleagues,

I have put together an informal report on the 2000 floods on Tiger Wash. [It only seemed like there were 2000 floods; actually, there were only 3 floods.] If this is of interest to you, I would welcome any comments, feedback, or especially, any good ideas for new projects. If this is not of interest to you, please dispose of properly.

Best regards,
Phil

Tiger Wash Floods of 2000 – Preliminary Observations and Related Ramblings

P.A. Pearthree

3/22/00

Tiger Wash experienced several moderate-magnitude floods in the early summer and fall of 2000. These are some preliminary observations regarding the genesis of these floods and their impacts on Tiger Wash alluvial fan.

Tiger Wash flood of 6/00

Background. Ted Lehman alerted me to the fact that Tiger Wash experienced a moderate flood on 6/20/00. This flood occurred as a result of a local thunderstorm associated with the extremely early onset of the Arizona monsoon season. The Flood Control District installed a telemetered pressure transducer at the USGS gage site on Tiger Wash in the spring of 1999, which provides estimates of flow depth and rate over short intervals. The measurements of the pressure transducer indicate a peak flow depth of about 3 ft at the gage site. This estimate was subsequently verified by FCDMC personnel who visited the gage site. Based on the stage-discharge relationship developed for the gage, this translates into a discharge of about 2500 cfs, or about 1/3 of the 1997 peak discharge at the gage. I was able to make some limited field observations in the late afternoon of 6/25, when the evidence of inundation was quite fresh. In addition, I assembled some information on rainfall for the drainage basin and streamflow on Tiger Wash from the FCDMC Alert Network.

Rainfall and Runoff. The 4 FCDMC Alert precipitation gages in the Tiger Wash drainage recorded moderate to reasonably large rainfall amounts for this storm, but nothing extreme (see chart 1). Since Harquahala Mtn. and Tiger Wash fan recorded so little precipitation, most of the rainfall must have occurred in the central and northern parts of the tributary area. It seems likely that the most intense precipitation avoided all of the rain gages because none of the rainfall totals are that impressive and the rain fell on very dry surfaces. Based on the timing of the rainfall data from the various gages, the storm evidently moved from NE to SW and decreased in intensity as it went. Based on streamflow data from the Tiger Wash gage, the hydrograph illustrates a pretty classic flash flood (chart 2). Flow rose modestly for about 3 hours, then increased dramatically in the next hour. The receding limb was nearly as abrupt, although there is a reasonably long tail. Total flow duration at the gage was less than 24 hrs, and there was almost certainly much less flow downstream in the distributary network.

Field Observations. During an approximately 2-hour recon on 6/25, I was able to check out Tiger Wash from the dirt track area upstream to upper western breakout (UWB) along the main western channel (see photomosaic for locations).

Based on this limited field recon, flow in the 6/20 flood followed the fluvial framework established by the 1997 flood, with reasonable amounts of flow going down the new channel (NC) and the UWB. In this upper fan area, flow was confined in channels with minimal overbank inundation. For example, at the coarse gravel deposit on the left bank near the FDCMC rain gage where a lot of water overflowed in 1997 between the campsite and the main channel, some flow came down the eastern side channel to the area of the gravel deposit. Perhaps a trickle, but no more, made it into the gravel deposit, which is at least 1 m higher than the side channel here. Rather than spilling over the gravel deposit, virtually all of the flow followed the

channel to the southwest and rejoined main channel just above the new channel breakout. There was a nice reddish brown clay veneer in the bottom of the side channel, which is a low spot where waning stage flow evidently ponded.

Flow in the main channel upstream of the NC breakout (west of the previous site) was less than 1 m deep. Very sharp, steep banks in a few places imply modest local bank erosion in 6/20 flood; channel bed was planar, w/ sand and fine gravel; fresh cobbles piled up on a bush at the NC breakout that was seriously impacted by recent flow. The bed of the pre-97 channel downstream is slightly lower than the NC and still seems to be the preferred path of flow, but lots of water in the 6/20 flood went down the NC. Flow in the NC was contained w/in banks for a couple hundred meters, at least (limit of my recon), but the channel was nearly full and water came within about 0.3 m of overtopping left bank. The veneer of reddish brown clay on channel bed is unlike the post-97 bed, which was coarser.

On the west side of the UWB where new channels formed in 97, there was very broad, shallow flow in the 6/20 flood. Flow quickly became reconfined downstream in the western breakout, and substantial flow went into each of 3-4 medium-sized channels. Flow was <0.3 m deep in largest channel. Flow spilled out of channels into overbank areas in a few limited areas, but was generally confined to channels formed or modified in 97.

On the east side of the UWB where the main channel existed prior to the 97 flood, shallow flow occurred in several channels. The westernmost eastern channel merges upstream into a broad sheetflood area between east and west splits; based on flow indicators on the channel bed, much of the sheetflood there spilled back to pre-existing eastern channel. A ~100 m wide area was almost entirely inundated by shallow flow that spilled back to eastern channel system. I estimated that certainly more than half, and maybe more like 75% of the flow went down the eastern (pre-existing) channel system at the UWB.

Preliminary observations – Tiger Wash floods of 10/00

Background. Tiger Wash experienced two more moderately large floods during the unusually wet period associated with a persistent low-pressure trough in the latter half of October 2000. Coincidentally, the area affected most by these storm systems and by dissipating Hurricane Nora was quite similar. The first flood on Tiger Wash occurred on 10/21 as a result of the same storm that caused serious flooding in the Wenden area along Centennial Wash. The preliminary peak discharge in this flood on Tiger Wash, based on the pressure transducer estimate from the gage, was about 3500 cfs. That makes this the largest flood since 1997, similar in size to a flood that occurred in 7/94, and the third or fourth largest flood of the gage record. A second flood occurred later in the same week, again as part of a storm that caused a second flood on Centennial Wash. On Tiger Wash, the estimated peak discharge of about 3100 cfs was nearly as large as the 10/21 flood peak. Although the peak discharge of each of these floods was much less than that of the 9/97 flood, each was larger than the flood of 6/00, so evidence of that flood was almost certainly obliterated or buried. This section summarizes hydrologic information obtained through the FCDMC Alert network and reconnaissance field observations made on 10/29/00 and 1/29/01.

Rainfall and runoff. The 4 FCDMC Alert System precipitation gages in the Tiger Wash drainage recorded large rainfall amounts for the 10/21 storm, but nothing close to the extreme

rainfall reported at Harquahala Mountain in 9/97. The upper basin gages received about 2.5 to 3.5 in of precipitation, with less rain falling on the fan (see chart 1). In the upper basin, the rain fell primarily in two pulses, which resulted in two flood peaks (see chart 2). Significant rainfall on Tiger Wash fan occurred only during the second pulse. In comparison, all of the rain gages in the Tiger Wash drainage area received at least 3.5 in of rain in 9/97, with 12 in. of rain reported from Harquahala Mountain.

Rainfall amounts in the same 4 rain gages for the 10/27 flood were not very impressive, much less than the 10/21 flood. The ground obviously was saturated at that point and thus runoff was facilitated. Nonetheless, the apparent difference in precipitation between these two floods that had very similar peak discharges is sobering.

Field observations. I visited Tiger Wash with Jon Pelletier's Geomorphology class on 10/29/00, and thus was able to observe the main western channel near the twin hills (overview stop for field trip guide), the upper western breakout area, the new channel breakout area, and the area of the 1992 trench just a few days after the October floods. Evidence of inundation was obvious, and included fresh, locally wet sediment with some standing water, and flotsam. I returned to Tiger Wash to assess inundation from the 2000 floods farther down the fan in 1/01, making a several-hour-long recon of the County Line arroyo and part of the area along and upstream from the BLM fence line.

Main western channel near "overview" hill: The 2000 floods were well contained in the large channel here, and there was no spillover from the east branch of Tiger Wash along the south side of overview hill (as occurred in 97). Flotsam lines from the October floods were obvious and were at least 1 m below the highest flotsam from the 97 flood. Two fresh flotsam lines were evident in several places and may record the 10/21 and 10/27 floods. It is unlikely that substantial changes occurred in the channel here, but I did not venture upstream to the area where the petrocalcic material was so well exposed in the bed after the 97 flood.

Upper western breakout area: Inundation was very extensive in the broad, low-relief expansion area that developed in the 97 flood. Flow was conveyed in both the eastern pre-97 channels and the new western breakout, but overbank flow was minimal. The breakpoint between the western and eastern flow is approximately at the large dead tree piles left by the 97 flood. The western flow became concentrated in several smaller channels in a relatively short distance downstream (quite like the 6/20/00 flood). Eventually, nearly all of the western flow ended up in the largest, westernmost channel. This channel has a fairly steep gradient and appears to be eroding headward and may have the potential to work upstream into the main expansion area. A little flow went thru the easternmost western channel, which also has a fairly steep gradient and looks to be entrenching; this flow remained separate from the rest of the western flow and continued downfan in one of the drainages incised into the broad Qy1 area.

The situation in the eastern branch also appears to be fairly dynamic. The most interesting feature is the steep gradient in the largest east-spilling channel, which was more or less the main channel prior to the 97 flood. The upper end of the steep-gradient reach is quite near the expansion reach associated with the western spillout, so it looks like there is reasonable potential for the largest eastern channel to reestablish itself as the main channel. However, the channel bed of the steep reach is armored by small to medium boulders and would probably be pretty stable in most floods. It will be interesting to monitor the continued evolution of this area, which was surveyed in detail in 4/00 in cooperation w/ Ramon Arrowsmith and others.

New channel breakout area: Lots of water went down the new channel in the 10/00 floods. My impression is that the difference in channel bed elevation between the new channel and the pre-97 channel has gotten less; there is essentially no difference now. In the area of the NCB, flow was pretty much contained in the channel. Downstream in the NC, the left bank was overtopped in several places in 10/00, primarily in low areas of the bank where older channels are cut off by the new channel. The extent of 10/00 inundation between new and main channels was limited and shallow; essentially all of this area was inundated in 97. The right bank was also overtopped locally, and there was a little overbank flow in that area.

Just upstream of the NCB, the left channel conveyed a reasonable amount of flow to the area of the large left bank gravel spew. As in the 6/20 flood, little flow overtopped the gravel spew, and the low channel area upstream of the spew contained ponded water as flow receded. This channel is filling in with mud. Quite a bit of flow in the left channel overtopped the left bank just downstream of the gravel spew and flowed into a medium-sized channel that may be starting to enlarge. This flow made it into the area between the campsite and the main channel, where there was a reasonable amount of flow in small channels in the broad deep unconfined flow (DUF) area of the 97 flood. The extent of inundation in 2000 was about 10-25% of 97 inundation in this area, and there was no inundation within ~75 m of eastern edge of 97 flow.

Trench / ironwood snag area: The area of the east end of 1992 trench where we excavated and dated an ironwood snag is the one place I have observed where inundation was more extensive in the 2000 floods than in the 97 flood. In 1992 we concluded that this relatively high area was no longer part of the active fluvial system. This area was not inundated in the 97 flood, although there was extensive inundation both east and west of the surface. Thus, we mapped the area as Qy1 (Holocene, but not part of the active system).

Surprisingly, low areas on the upper end of this "Qy1" surface had shallow inundation in 2000, and some flow spilled into pit at the ironwood snag. Evidence of inundation consisted of fine deposits draped across the landscape; they appeared to be redder and more clay-rich than those of the 97 flood. The channel just west of the "Qy1" surface had a lot of flow in 2000. East of the "Qy1" surface, the next couple of channels had moderate 2000 flows, but most of the broad 97 DUF area farther to the east had no flow in 2000.

Examination of the channel system upslope from the ironwood snag revealed that there was bank erosion and spillout onto the upper end of the "Qy1" surface; this flow made it downslope to and some distance past the ironwood snag. Upstream along this flow path, the main channel now occupies the eastern part of a major boulder spew area, on line with the main channel upstream toward the dirt track crossing. Previous to the 97 flood, the main flow path/channel had taken a rather sharp right bend here. It appears that continued boulder deposition in western part of the spew has encouraged flow to go farther east, which is straight on line with channel upstream. This has resulted in much more water getting into channel system upstream from the "Qy1" surface. I would expect to see continued changes in the distribution of water and sediment in this part of the system in the coming decades.

BLM fenceline area: I conducted a field recon along and upstream from the BLM fenceline on 1/29/01. Inundation in the 2000 floods was fairly extensive at the latitude of the BLM fence, but much less extensive and shallower than inundation in the 97 flood. Except in a few channels, 2000 flow was broad and shallow. In some parts of this area there is quite a bit of flotsam piled around bushes. The flotsam was certainly moved around by the 2000 floods, but it looks

reasonably old and I speculate that most of the flotsam got into the area in the 97 flood and was reworked by the 2000 floods. These are the areas that show up as the mysterious blue color in the satellite change image from 1997, areas that got darker in band 5 after the 97 flood. Farther upslope, the lower new channel (LNC) on the west side of the main western flow path got substantial flow in the 2000 floods. Examining the head of the LNC, it is evident that more flow spilled in from the adjacent channel system to the east and very little came down from the north. This is consistent with much less extensive sheet flooding in the 2000 floods. The situation was somewhat similar on the smaller new channel that formed in the 97 flood near very eastern edge of flow at the BLM fence. This channel got very little flow in 2000 floods, as only minor flow spilled into the new channel from existing vegetated channel to the west about 100 m above fence. Unlike 97, there was essentially no sheetflooding to the north and east of the existing vegetated channel.

County line arroyo: Headcuts associated with this relatively large arroyo continued to migrate upstream in the 2000 floods. I checked the location of headcuts on the County Line arroyo above Salome Highway against the 1999 aerial photo. As a rough estimate, headcuts migrated several hundred meters upstream in 2000 floods; they are currently ~0.4 mi. downstream of a lone large ironwood, or ~0.5 mi. downstream of BLM fence.

General Comments / Discussion

The recent moderate floods on Tiger Wash, coming so soon after the great flood of 1997, provide some potential insights into the evolution of this distributary system and perhaps others like it. Here are some of my thoughts:

Rainfall, runoff, peak discharges, and total discharges. The Alert Network is providing some fairly detailed and really interesting information about inputs (rainfall amounts and patterns) and outputs (runoff) in the Tiger Wash drainage. It is clear that a "garden variety" flood on Tiger Wash (~2000 – 4500 cfs) can be generated by a variety of storm types, including regional storms (10/21/00) and local thunderstorms that are intense but only cover a small part of the drainage (6/20/00). Looking at the flood record for the stream gage (chart 3), all of the flows in this range prior to 2000 occurred in July-Sept. Just perusing the flood record and doing no new research to verify this, it appears to me that none of the floods > 2000 cfs on Tiger Wash except 9/97 have been associated with tropical storm incursions. The October 2000 floods are certainly anomalous in the admittedly short record, being fall/winter events associated a persistent trough and not a tropical storm. No previous regional winter storms have generated sizable flows on Tiger Wash. Perhaps the really big events like 9/97 are only associated with incursions of dissipating tropical storms. Alternatively, it is possible that a mesoscale convective cell sitting squarely over Tiger Wash for several hours, or persistent regional storm systems like 10/00, could also generate big floods. As was noted earlier, the 10/27/00 flood apparently was generated by some pretty paltry rainfall. Either the most intense rainfall avoided the rain gages, or the extremely wet soil conditions greatly facilitated runoff in this event, or both.

Hydrographs for the floods of 2000 and 1997 indicate that the total volume of flow associated with different storm types may be quite different, and that is probably quite important for the amount of work that is done in the distributary part of the system. The hydrographs for the 2000 floods were generated directly from the pressure transducer – stage – discharge relations used by the FCDMC for the Tiger Wash stream gage. The 97 flood hydrograph was modeled by Ted

Lehman. Hydrographs associated with intense convective cells are likely to be sharply peaked and of short duration; thus, flow volumes are relatively low (see 6/20/00 flood for example). Note the 4-fold difference in total Q between the 6/20 and 10/21 floods with only a ~1.4 difference in peak Q. Thus, the 2000 flood hydrographs illustrate the differences in flow that result from local intense storms (6/00) and regional storms with some intense intervals of precipitation within them (10/21/00). Based on the time year that they occurred, I am going to postulate that all of the pre-97 floods of the gage record were sharply peaked and of relatively short duration.

The 1997 flood was obviously the big event during the historical record, both in terms of peak discharge and total duration. Based on the 2000 flood hydrographs, the actual 97 hydrograph likely had a substantially longer tail than is shown in the model. I speculate that both the peak Q and the total Q were larger than is represented by the model. Appending a tail from the 10/21 flood provides a basis for estimating a total Q for the 97 flood that is twice the total Q for the 10/21 flood. The 1997 flood and the 10/21/00 flood scale reasonably well in terms of peak Q and total Q, again suggesting that a broader hydrograph is characteristic of floods caused by regional storms in this drainage. Based on the model hydrograph, the 97 flood was above a pretty serious flood stage (4000 cfs) for at least 4 ½ hours, so it is not surprising in retrospect that a lot of work was done on the piedmont during that flood.

Flood	Flow duration (hours)	Time above 1000 cfs (hours)	Time above 2000 cfs (hours)	Time above 3000 cfs (hours)	Time above 4000 cfs (hours)	Time above 6000 cfs (hours)
9/26/97	36+	14:10	8:10	5:20	4:30	2:40
6/21/00	9	2:35	0:57	0:00	0:00	0:00
10/21/00	31	9:30	4:16	0:34	0:00	0:00
10/27/00	25	4:26	1:56	0:27	0:00	0:00

In the course of our field mapping of the 97 flood inundation, it was apparent that the large peak discharge / high stage of that event was also a critical factor in the great impact that that event had on the piedmont landscape. Since the distributary channel networks we have studied are characterized by alternating confined and expansion reaches, it does not take much of a flood to get extensive sheetflooding in expansion reaches. The 97 flood had such a large peak, however, that extensive inundation occurred because the distributary channels were overtopped relatively high in the system, sending water in some surprising areas. If I may speculate, I have the sense that the largest confined and expansion reach pairs of the existing channel system of the west branch were adjusted to flows of smaller magnitude than the 97 event. The new channel and the upper western breakout occurred in places that were susceptible to change (outer bends and expansion reaches), but the dramatic nature of these changes suggests to me that the 97 flood overwhelmed vulnerable elements of the existing system.

Continued change in the channel system. Two areas of the distributary system continued to change in the smaller magnitude floods of 2000. Within the complex distributary channel network downstream of the dirt track, the former sharp right bend of the largest channel was

partially cut off in the 97 flood and this tendency is continuing. The result of this is that more water is now heading down to the Qy1 surface with the dead ironwood snag. I expect this tendency to continue, because the channel sending water in that direction is straight on with the main channel upstream. This cautionary tale indicates that relatively small, low-relief "islands" of older deposits in distributary systems should not be excluded from the floodplain even if they have not received any substantial flow for hundreds or thousands of years. The arroyos upslope from Salome Highway eroded headward substantially in the 2000 floods. Given that the headcuts are formed in fine-grained, weakly consolidated Holocene sediment, I see little to constrain their continued headward erosion in any sizable flow events on Tiger Wash. New aerial photos would make it very straightforward to document headward erosion of the arroyos, and would also document the changes higher in the system.

Evolution of the new channels. Flows in the Tiger Wash distributary network during the floods of June and October 2000 may bear on some of our previous discussions of the development and evolution of new channels in this system. Basically, the new channels that formed in the 1997 flood (especially, the "new channel") are much wider and shallower than the pre-1997 channels, which had riparian vegetation established along them. Kirk and I have discussed this at length, and we feel it is reasonable to assume that the established, tree-lined channels started out with morphologies similar to the new channels that formed in 1997. If the new channels get flow frequently enough, then eventually riparian vegetation will probably become established in or along the banks of the new channels. If the flows that are important for establishing riparian vegetation are much smaller than the 1997 flow, then they will probably form some kind of channel within the larger 1997 channel along which vegetation will grow. Alternatively, vegetation might become established along existing banks and gradually encroach on the edge of the channel by trapping sediment, a process that would probably take much longer. In either case, the establishment and proliferation of riparian vegetation likely depends on 1) reasonably frequent flow in the new channel providing the extra moisture that trees need to flourish in this environment, and 2) no really large floods that would wipe out the young vegetation before it becomes established. As was noted earlier, substantial amounts of flow went down the new channels during the floods of 2000. The "new channel" especially seems to be getting about as much flow as the pre-97 channel.

The upper western breakout area has the potential to be a very dynamic area. What happens in this area is important for assessing flood hazards downslope, particularly in the broad area of moderately dissected Holocene deposits within the distributary channel network. Flood hazards in this area would appear to be quite low, because even in the 97 flood inundation was limited to fairly narrow bands along existing drainages which are incised into the Qy1 surface. The presence of extensive Holocene fan deposits, however, clearly indicates that at times in the past 10,000 years this area has received lots of water and sediment. The uncertainty is this: how will this part of the system evolve if substantially more water, and eventually bedload sediment, is introduced from the upper western breakout area in future floods? A related issue is how quickly might patterns of inundation and sedimentation evolve, because we must give some thought to the 100-yr flood concept in floodplain management.

A number of potentially opposing trends are developing in the upper western breakout that may influence the future distribution of water and sediment. The gradients of the relatively small channels that recollect flow in the western breakout are substantially steeper than the gradient of the expansion itself (no surprise, we saw that in many places on Wild Burro alluvial fan).

Whether these channels erode headward and draw more flow to the west, or are swamped by bedload sediment coming down the main channel in that direction, will be an interesting dynamic to monitor. Even more pressing, the gradients of the eastern channels are much steeper than the expansion, but their beds are to some degree armored by coarse sediment (cobbles to medium boulders). Further, the momentum of flow down the main channel upstream would tend to send flow down the western breakout, while the steeper gradients in the eastern channels tend to capture flow. A battle of kinetic vs. potential energy (thank you, Ted Lehman). I imagine that bedload sediment supply from upstream will also be a critical factor in whether the broad expansion reach is sustained or eroded in the future.

It may take decades of monitoring to begin to address these issues on Tiger Wash, but we have some baseline information now. We have ground photographs of these areas from 1999, and more were taken of the new channel in 6/00 and 10/00. If any of you have any photos you would like to contribute to the record, please let me know. These photos establish a baseline record with which to monitor changes in vegetation and channel morphology in this area. In addition, Kirk Vincent has arranged to have Air Force spy satellite images of the Tiger Wash area archived by the USGS. These high-resolution images will be obtained when the satellites have some free time. I believe that they will have about 1 m resolution, and so should pick up even sizable bushes. Those of you with security clearances will actually be able to view the images, while the rest of us can only press our noses to the glass. Nonetheless, it is reassuring to know that these data will be collected for the foreseeable future.

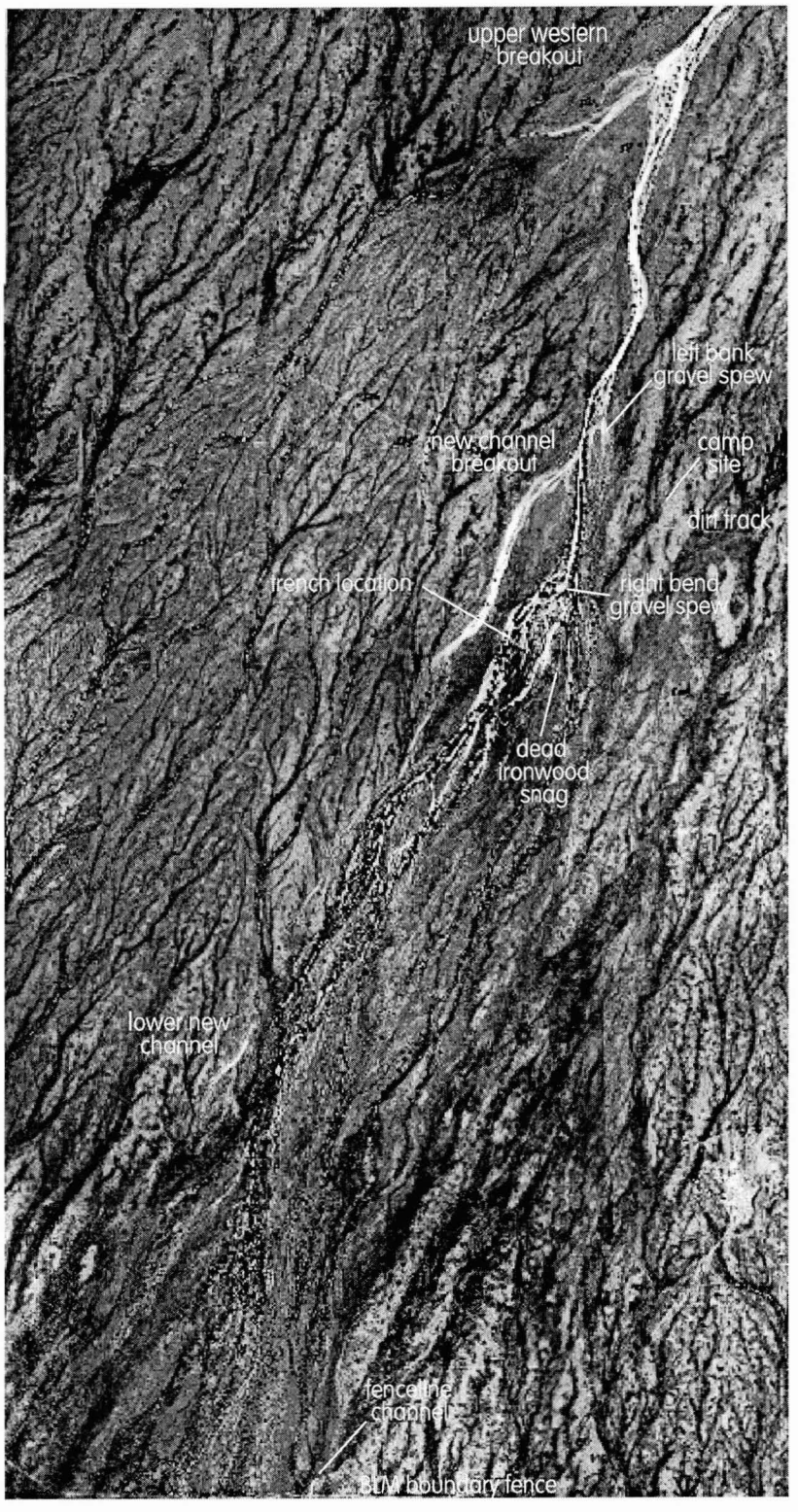
Analyses of historical aerial photos. We have aerial photos that cover Tiger Wash from 1953, 1972, 1976, 1979, 1992, 1997 (pre-flood), 1998, and 1999. I have reviewed these photos in more detail in the past few months, specifically in the area of the new channel / campsite, the upper western breakout, and the primary distributary split between the eastern and western branches of Tiger Wash. The scale and number of changes that occurred in 1997 dwarf any previous changes, which is no surprise to any of you I am sure. However, changes did occur in the smaller floods between 1953 and 1997, and some tendencies were established that were greatly exacerbated in 97. For example, it is pretty clear that some flow spilled over the right bank in the area where the new channel developed and at the upper western breakout prior to the 97 flood, so there were hints that these might be areas of potential channel changes. I would assert, however, that nothing in the photographic record would have hinted at the magnitude of the changes that occurred in these areas in the 97 flood. Vastly more water went into these areas because of the size and duration of the 97 flood, and big-time changes occurred.

Another interesting area is the primary east-west distributary split above the gravel pits. The key issue is why ~75% of the peak flow in the 97 flood went down the west branch. It is pretty clear to me now that the gravel pits had little impact on the flow split, as they are mostly downstream from it (see final figure). It appears that they in fact tended to intercept flow from the east to the west branch downstream of the main split in the 97 flood. In 1953, there were two more or less parallel channels upstream of the split, and the main east and west branch channels in the vicinity of Eagle Eye Road appear to be similar in size. Erosion along an outside bend in the left (eastern) channel is evident in the aerial photo sequence prior to 97, especially between 1953 and 1979. This tended to send more water into the western part of the split area. Then the 97 flood came along and really followed that trend, blasting the western part of the split and sending lots of water down the west branch. It would be interesting to quantify the peak discharges in the east

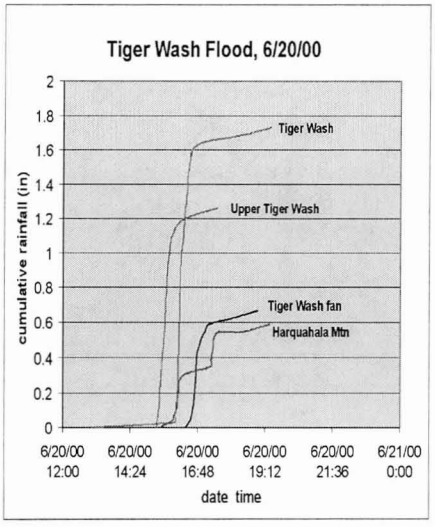
and west branches for the October 2000 floods to evaluate whether the proportion of flow was similar in the 2000 floods.

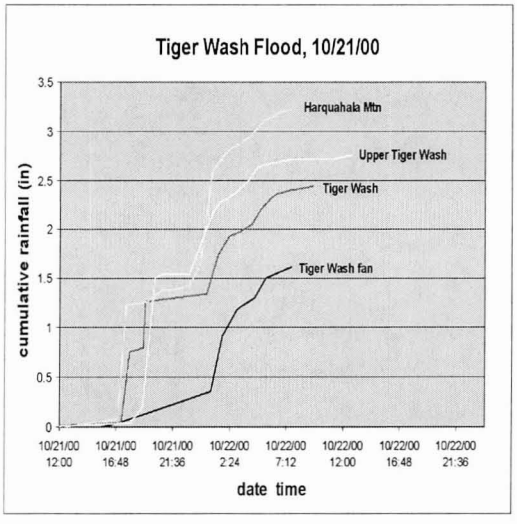
Satellite change imagery and flood inundation. Larry Mayer, Ann Youberg, and I are beginning a new project to conduct more satellite change analysis of this area in cooperation with JE Fuller. The focus of the project is Jackrabbit Wash, a sizable tributary of the Hassayampa that had a large flood in Oct 2000, but the satellite images also cover Tiger Wash. We plan to obtain images that bracket the 2000 floods (June, July, and November, 2000, most likely) and analyze them for changes. I hope eventually to use limited field observations and the satellite change images to get a pretty complete picture of the inundation in the June and October floods on Tiger Wash. I believe that acquisition of post-2000 color aerial photos would permit inundation mapping with a similar level of detail as the 97 flood inundation mapping, with far less field work than was done in 1999.

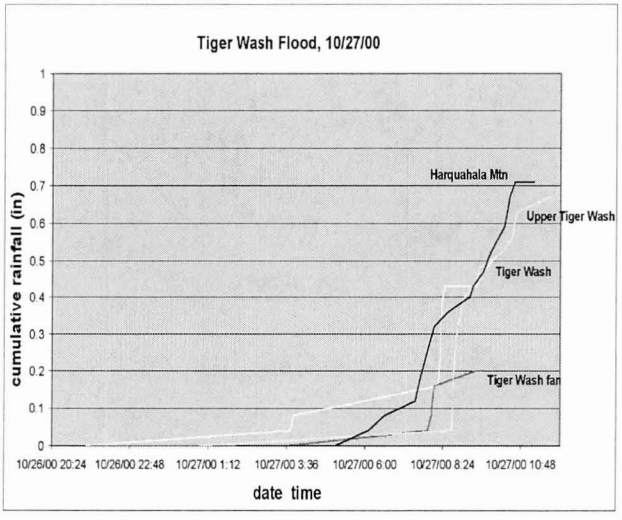
In sum, Tiger Wash is an excitingly dynamic fluvial system. We had this impression in during our first field studies in 1992, and changes that occurred in the numerous floods since that time have reinforced this impression. With luck and persistence, we may be able to continue to document changes on Tiger Wash in the coming decades and learn more about the behavior of this type of system. Please share with me any thoughts, ideas, or comments regarding any of the above topics, or anything else that comes to mind.



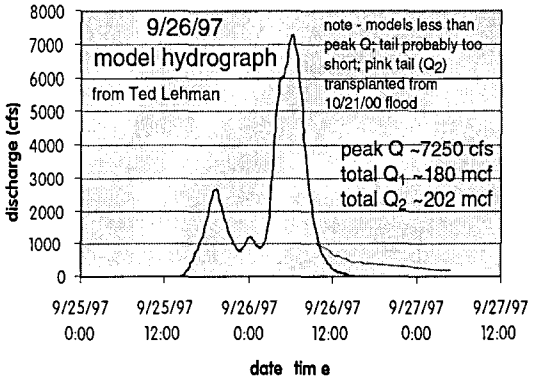
Some locations in the west branch of the Tiger Wash distributary system that are mentioned in the text. Photo base is from 1999.

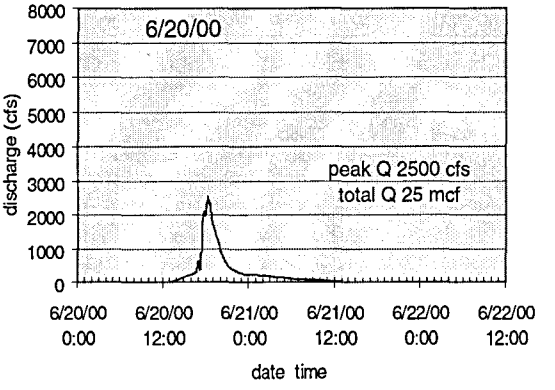

Tiger Wash Flood, 6/20/00
cumulative rainfall (in)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Tiger Wash
Upper Tiger Wash
Tiger Wash fan
Harquahala Mtn
6/20/00 12:00
6/20/00 14:24
6/20/00 16:48
6/20/00 19:12
6/20/00 21:36
6/21/00 0:00
date time

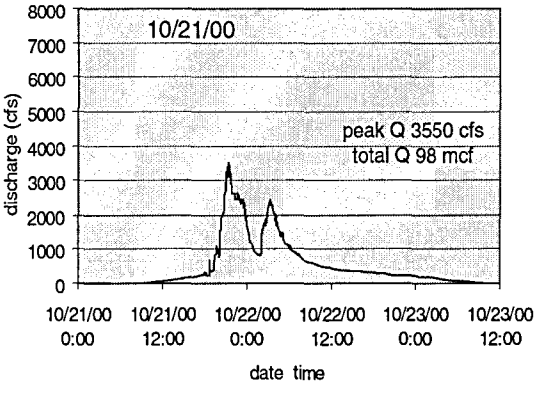

Tiger Wash Flood, 10/21/00
cumulative rainfall (in)
3.5
3
2.5
2
1.5
1
0.5
0
Harquahala Mtn
Upper Tiger Wash
Tiger Wash
Tiger Wash fan
10/21/00 12:00
10/21/00 16:48
10/21/00 21:36
10/22/00 2:24
10/22/00 7:12
10/22/00 12:00
10/22/00 16:48
10/22/00 21:36
date time

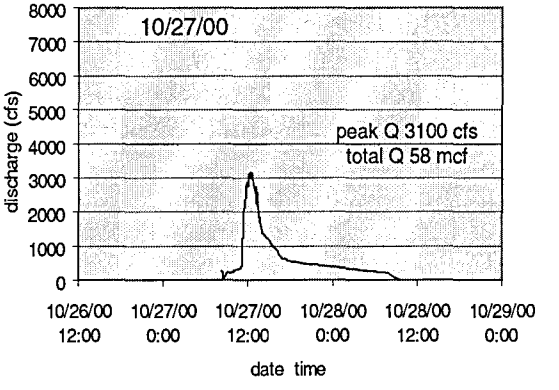

Tiger Wash Flood, 10/27/00
cumulative rainfall (in)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Harquahala Mtn
Upper Tiger Wash
Tiger Wash
Tiger Wash fan
10/26/00 20:24
10/26/00 22:48
10/27/00 1:12
10/27/00 3:36
10/27/00 6:00
10/27/00 8:24
10/27/00 10:48
date time

Recent Tiger Wash Floods (9/97 to 10/00)

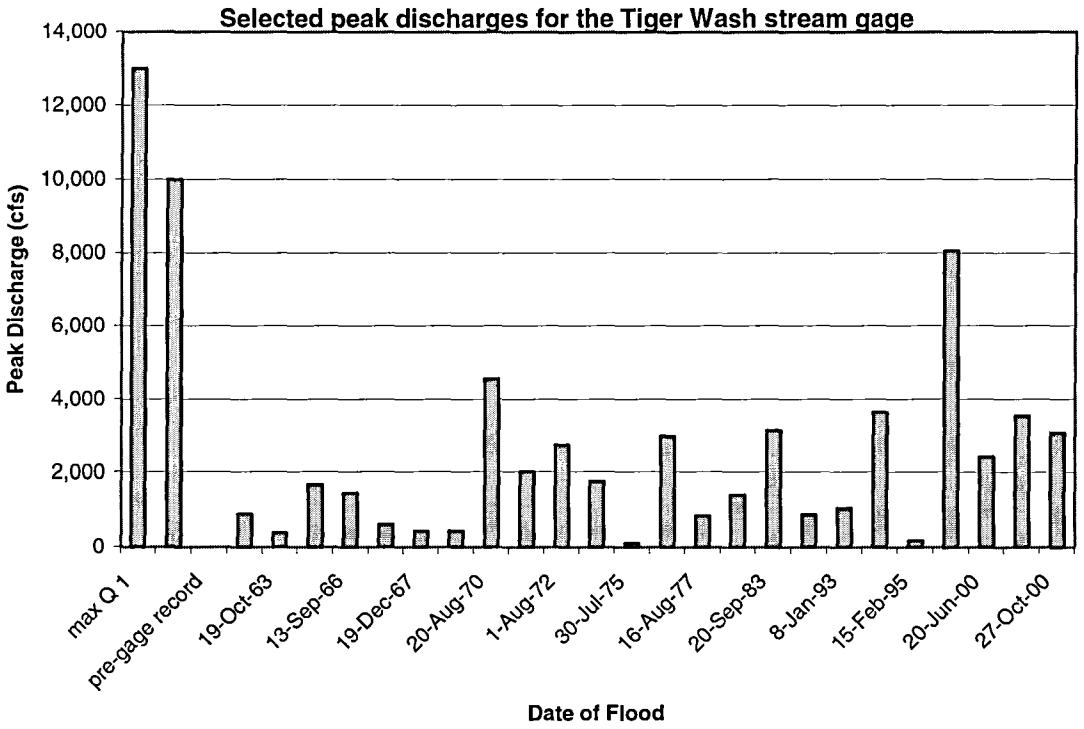


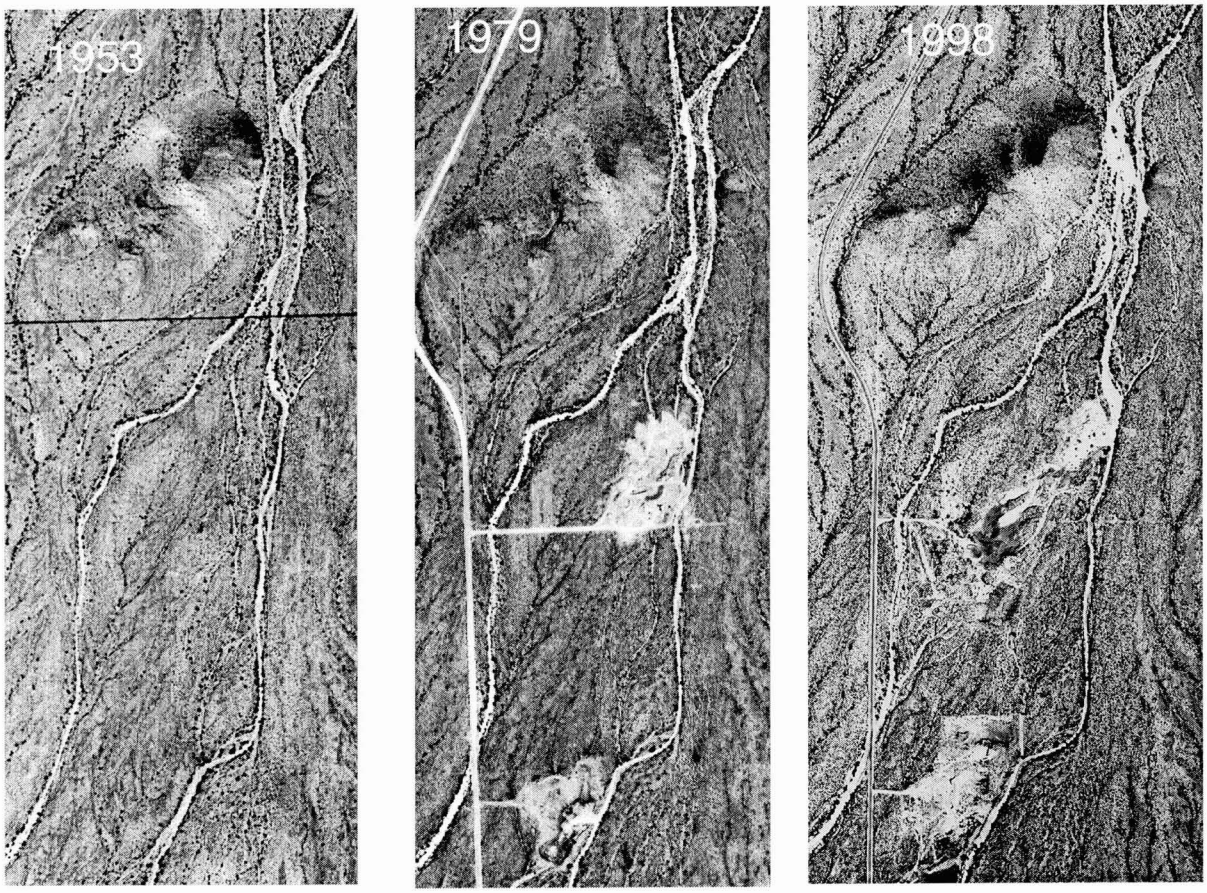






Model hydrograph from Ted Lehman, JE Fuller Hydrology / Geomorphology; real hydrographs from pressure transducer stage and discharge estimates, Flood Control District of Maricopa County Alert Flood-Warning System. MCF stands for million cubic feet.


Selected peak discharges for the Tiger Wash stream gage
Peak Discharge (cfs)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
max Q 1
pre-gage record
19-Oct-63
13-Sep-66
19-Dec-67
20-Aug-70
1-Aug-72
30-Jul-75
16-Aug-77
20-Sep-83
8-Jan-93
15-Feb-95
20-Jun-00
27-Oct-00
Date of Flood



Aerial photo sequence for area of the primary split between the east and west branches of the Tiger Wash distributary network.

Joe Tram - FCDX
From: Joe Tram - FCDX
Sent: Wednesday, April 04, 2001 4:54 PM
To: 'ahannan@mbakercorp.com'
Cc: 'ted@JeFuller.com'
Subject: FW: Tiger Wash

Mr. Atul Hannan:

Good Morning, per your request of March 30, 2000, I agree with the findings by JEFuller per the attached memo and belive that the areas should be mapped as inactive as delineated. Thanks for your cooperation on this matter....

Will be sending in another piedmont study after we take your comments from this study and integrate them into the next one....have a good day....

-----Original Message-----

From: **Ted Lehman [mailto:ted@jefuller.com]**
Sent: Tuesday, March 13, 2001 1:11 PM
To: ahannan@mbakercorp.com
Cc: Joe Tram - FCDX
Subject: Fw: Tiger Wash

mm to atul mbj re phone notes ...

Mr. Hannan,

Attached is a brief listing of the points we discussed with you today for your reference in discussion with Ms. Buch-Pederson and Mr. Yuan.

Please let Mr. Fuller or myself know if any of you have additional questions. We look forward to addressing any remaining concerns next week. Mr. Tram and Mr. Fuller will be busy Mon. and Tues. of next week, but all three of us are available later in the week for a conference call if necessary.

Sincerely,

Ted Lehman, P.E.
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.
6101 S. Rural Road, Suite 110
Tempe, AZ 85283
(480) 752-2124 x 16
(480) 839-2193 FAX
ted@jefuller.com

----- Original Message -----

From: **"Jon Fuller" <jon@jefuller.com>**
To: "Ted Lehman" <ted@jefuller.com>
Sent: Tuesday, March 13, 2001 8:31 AM
Subject: draft Tiger

--
Jon Fuller, P.E., P.H.

JE Fuller/ Hydrology & Geomorphology, Inc.
6101 S. Rural Rd., Suite 110
Tempe, AZ 85283

Phone: 480-752-2124 x17
Fax: 480-839-2193
Email: jon@jefuller.com
Web: www.jefuller.com

Joe Tram - FCDX
From: Ted Lehman [ted@jefuller.com]
Sent: Friday, March 30, 2001 10:15 AM
To: jjt@mail.maricopa.gov
Subject: Fw: Tiger Wash

Joe,

Please see the message from Ataul regarding his meeting with Mr. Max Yuan. Looks like we did it! You just need to send something via e-mail to them as described below.

Congratulations,

Ted Lehman, P.E.
JE Fuller / Hydrology & Geomorphology, Inc.
Tempe, AZ
----- Original Message -----

From: **"Ataul Hannan" <AHANNAN@mbakercorp.com>**
To: <ted@jefuller.com>
Sent: Friday, March 30, 2001 9:01 AM
Subject: Tiger Wash

Mr. Ted Lehman,

Good Morning. We talked with Mr. Max regarding the concerned area. We informed him about your support to map it as inactive area. He told us that, if Mr. Joe Tram sends us e-mail stating that he agrees with the March, 13, 2001memorandum, than we can map it as inactive area. So if you please inform Mr. Tram to send me or Pernille e-mail stating that he agrees with your findings. I think this will me sufficient to solve the mapping issue. Once again sorry for the delay. Thank you for all your cooperation.

Ataul Hannan, CFM
Michael Baker Jr., Inc.
Alexandria, VA

Joe Tram - FCDX
From: Ted Lehman [ted@jefuller.com]
Sent: Monday, March 26, 2001 10:32 AM
To: Ataul Hannan
Cc: pbuch-pedersen@mbakercorp.com; faebly@mbakercorp.com
Subject: Re: Fw: Tiger Wash

Mr. Hannan,

Having not heard back from you since Tuesday, March 13th, I am assuming that the information we sent to you explaining the delineation of the inactive areas along the western edge of the Tiger Wash piedmont satisfactorily addressed your questions. If this is not the case, I would be happy to discuss any lingering concerns you might have.

We look forward to receiving your letter of acceptance of the Tiger Wash flood hazard delineation study very soon.

Sincerely,

Ted Lehman, P.E.
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.
6101 S. Rural Road, Suite 110
Tempe, AZ 85283
(480) 752-2124 x 16
(480) 839-2193 FAX
ted@jefuller.com

----- Original Message -----

From: **"Ataul Hannan" <AHANNAN@mbakercorp.com>**
To: <ted@jefuller.com>
Sent: Tuesday, March 13, 2001 1:15 PM
Subject: Re: Fw: Tiger Wash

Thank you very much. I will get back sometimes next week.

Ataul Hannan, CFM
Michael Baker Jr., Inc.
Alexandria, VA

"Ted Lehman" <ted@jefuller.com> 03/13/01 03:10PM >>>
Mr. Hannan,

Attached is a brief listing of the points we discussed with you today for your reference in discussion with Ms. Buch-Pederson and Mr. Yuan.

Please let Mr. Fuller or myself know if any of you have additional questions. We look forward to addressing any remaining concerns next week. Mr. Tram and Mr. Fuller will be busy Mon. and Tues. of next week, but all three of us are available later in the week for a conference call if necessary.

Sincerely,

Ted Lehman, P.E.
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.
6101 S. Rural Road, Suite 110
Tempe, AZ 85283

(480) 752-2124 x 16
(480) 839-2193 FAX
ted@jefuller.com

----- Original Message -----

From: **"Jon Fuller" <jon@jefuller.com>**
To: "Ted Lehman" <ted@jefuller.com>
Sent: Tuesday, March 13, 2001 8:31 AM
Subject: draft Tiger

--
Jon Fuller, P.E., P.H.
JE Fuller/ Hydrology & Geomorphology, Inc.
6101 S. Rural Rd., Suite 110
Tempe, AZ 85283

Phone: 480-752-2124 x17
Fax: 480-839-2193
Email: jon@jefuller.com
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Joe Tram - FCDX
From: Ted Lehman [ted@jefuller.com]
Sent: Tuesday, March 13, 2001 1:11 PM
To: ahannan@mbakercorp.com
Cc: Joe Tram - FCDX
Subject: Fw: Tiger Wash

mm to atul mbj re phone notes ...

Mr. Hannan,

Attached is a brief listing of the points we discussed with you today for your reference in discussion with Ms. Buch-Pederson and Mr. Yuan.

Please let Mr. Fuller or myself know if any of you have additional questions. We look forward to addressing any remaining concerns next week. Mr. Tram and Mr. Fuller will be busy Mon. and Tues. of next week, but all three of us are available later in the week for a conference call if necessary.

Sincerely,

Ted Lehman, P.E.
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.
6101 S. Rural Road, Suite 110
Tempe, AZ 85283
(480) 752-2124 x 16
(480) 839-2193 FAX
ted@jefuller.com

----- Original Message -----

From: **"Jon Fuller" <jon@jefuller.com>**
To: "Ted Lehman" <ted@jefuller.com>
Sent: Tuesday, March 13, 2001 8:31 AM
Subject: draft Tiger

--
Jon Fuller, P.E., P.H.
JE Fuller/ Hydrology & Geomorphology, Inc.
6101 S. Rural Rd., Suite 110
Tempe, AZ 85283

Phone: 480-752-2124 x17
Fax: 480-839-2193
Email: jon@jefuller.com
Web: www.jefuller.com

Memorandum JE Fuller/ Hydrology & Geomorphology, Inc.

DATE: April 4, 2001

TO: Atul Hannan/MBJ

FROM: Jon Fuller, P.E.

RE: Tiger Wash Piedmont Flood Hazard Mapping

CC: Ted Lehman, P.E.
Joe Tram, P.E./FCDMC

Per your request, the following summarizes the bullet items we discussed on the telephone today at 11:25 a.m. on March 13, 2001:

Reference Materials:

1. Aerial photo #2-9 (photo date: 3-30-99; provided in TDN). Photo shows area in question, located near dirt road crossing diagonally to northwest. Orientation: north is toward white photo date and number print.
2. Inundation Mapping (Appendix G.3 in TDN). Shows extent of 1997 (big) flood and illustrates what an "alluvial fan" flood looked like on the ground.
3. Indirect Estimate (Appendix D.1 in TDN). Notes surveyed slopes of main channel (0.0125, i.e., steeper) and breakout channel (0.0074, i.e., flatter) of area in question.

Basic Points Supporting FCDMC/JEF, Inc. Mapping of Area in Question:

1. **Flood inundation mapping** of 1997 event shows that flow paths were not uncertain.
2. **Surficial geology** records that alluvial fan flooding (NRC definition) has not occurred.
3. **Suite of evidence** – any single characteristic is less convincing the cumulative evidence provided by the many lines of evidence used in District PFHAM.
4. **Toe of fan** – there is always a downstream limit to the active fan area at the point at which the "uncertainty can be set aside." The area in question is the toe of the small fan unit defined by young soils and the 1997 breakouts.
5. **Slope** – the main channel slope is significantly steeper than the channel or surface slope in the area of break outs. Therefore, flow will preferentially be conveyed near the main channel areas mapped as active alluvial fans. Deposition in the flat slope areas will also tend to force runoff toward the mapped active fan area.
6. **Headcuts** – headcuts advance up the main channel will steepen the main channel slope and enhance concentration of flow away from the area in question.
7. **Stream capture** – likely candidates for stream capture do not exist in the area in question, or are so far from it that it is not likely within an engineering time scale.
8. **Drainage pattern** – the area in question has a moderately incised tributary drainage pattern reflecting stability.
9. **Type of hazard** – Tiger Wash has fluvially-dominated alluvial fans, and is not subject to debris flow hazards.

10. **Time scale** – within an engineering time scale, our analysis indicates that the area in question will not be subject to uncertain flow paths.
11. **Floodplain delineation** – the area in question is mapped a flood zone, just not as an active alluvial fan flood zone.

34

52

351

FedEx USA Airbill

FedEx Tracking Number 8220 3546 3989

SLA22

Form I.D. No. 0215 Sender's Copy

1 From *Please print and press hard.*

Date 3-6-01 Sender's FedEx Account Number 2467-8585-6

Sender's Name Tim Murphy Phone (602) 506-4773

Company MARICOPA COUNTY FLOOD

Address 2801 W DURANGO ST

Dept./Floor/Suite/Room

City PHOENIX State AZ ZIP 85009

2 Your Internal Billing Reference First 24 characters will appear on invoice. OPTIONAL

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Recipient's Name FRANK AEBLY Phone ( )

Company MICHAEL BAKER, JR., INC.

Address 3601 EISENHOWER AVE.

To "HOLD" at FedEx location, print FedEx address. We cannot deliver to P.O. boxes or P.O. ZIP codes.

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4b Express Freight Service *Packages over 150 lbs.* Delivery commitment may be later in some areas.

- [ ] FedEx 1Day Freight* — Next business day
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- [x] Other Pkg. — Includes FedEx Box, FedEx Tube, and customer pkg.

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Does this shipment contain dangerous goods? One box must be checked.

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- [ ] Yes — Shipper's Declaration not required
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FedEx Acct. No. / Credit Card No. Exp. Date

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†Our liability is limited to $100 unless you declare a higher value. See back for details.

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402

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FLOOD CONTROL DISTRICT of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501
FAX (602) 506-4601
http://www.fcd.maricopa.gov/

LETTER OF TRANSMITTAL

TO: Frank Aebly
Michael Baker Jr., Inc.
3601 Eisenhower Avenue, Suite 600
Alexandra, Virginia 22304

March 6, 2001

SUBJECT: Tiger Wash Alluvial Fan

WE ARE SENDING YOU THE FOLLOWING ITEMS:
(X)Enclosed ( ) Under separate cover

	Shop Drawings		Prints		Legal Description		Samples
	Specification		Change Order		Copy of Letter		Plans
X	CD and Alluvial Fan Data Collection Report						

THESE ARE TRANSMITTED:

	For approval		Approved as submitted
X	For your use		Approved as noted
	As requested		Returned for corrections
	Resubmit( )copies for approval		For review and comments
	Submit( )copies for distribution		Return( )corrected prints
	FOR ESTIMATE DUE:		Borrowed prints being returned

Remarks: Enclosed is the CD with the 1953 and 1976 aerial photos. The shape files for the revised floodplain are also on the CD. I've also enclosed a copy of the Alluvial Fan Data Collection Report done by CH2MHILL. Let me know if there are any problems with these copies or if you need anymore information, my direct line is 605-506-4605.

SIGNED: Tim Murphy

NATIONAL FLOOD INSURANCE PROGRAM
FEMA MAP COORDINATION CONTRACTOR

February 8, 2001

Mr. Joe Tram, P.E.
Floodplain Branch Manager
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009

IN REPLY REFER TO:
Case No.: 00-09-985P
Community: Maricopa County, AZ
Community No.: 040037

316-AD/ACK

Dear Mr. Tram:

This acknowledges receipt of additional data in support of your request for a Letter of Map Revision for the above-referenced community. Our review of the submitted data indicates we have the minimum data needed to continue our evaluation. If we need additional data to complete our evaluation, or if delays are encountered, we will notify you in writing within 60 days of the date of this letter.

If you write to us about your request, please include the case number shown above in your letter. If you have general questions about your request, Federal Emergency Management Agency (FEMA) policy, or the National Flood Insurance Program, please call the FEMA Map Assistance Center, toll free, at 1-877-FEMA MAP (1-877-336-2627). If you have specific questions concerning your request, please call the Revisions Coordinator for your State, Pernille Buch-Pedersen, who may be reached at (703) 317-6224.

Sincerely,

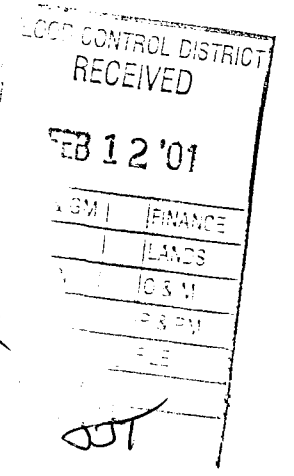
Monther S. Madanat, Director
Technical Services Division
Michael Baker Jr., Inc.

cc: Ms. Terri Miller
Program Coordinator
Arizona Division of Emergency Management

Mr. W. Dempsey Helms
Project Manager, Engineering
Arizona State Land Department

Ms. Denise Meredith
Bureau of Land Management
State of Arizona

Mr. Jon Fuller, P.E.
JE Fuller/Hydrology and Geomorphology, Inc.



3601 Eisenhower Avenue, Suite 600, Alexandria, Virginia 22304-6425 PH: 703.960.8800 FX: 703.960.9125

Michael Baker Jr. Inc., under contract with the FEDERAL EMERGENCY MANAGEMENT AGENCY, is a Map Coordination Contractor for the National Flood Insurance Program

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009-6399
Telephone (602) 506-1501
Fax (602) 506-4601
TT (602) 506-5897

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Mary Rose Garrido Wilcox

January 20, 2001

Ms. Pernille Buch-Pedersen
Michael Baker Jr., Inc.
3601 Eisenhower Avenue, Suite 600
Alexandria, VA 22304-6425

Subject: Letter from FEMA dated November 21, 2000
Case No.: 00-09-986P
Community: Maricopa County, AZ
Community No.: 040037

Dear Ms. Buch-Pedersen:

I am enclosing the responses that have been generated by the consultant for the District with respect to the subject letter and subsequent phone call with your staff on November 28, 2000.

If you have further questions, or need additional information, please give our consultant or myself a call.

Sincerely,

Joe Tram

Joe Tram, P.E.
Floodplain Branch Manager

Cc: JEFuller/Hydrology & Geomorphology, Inc.

JEFuller / Hydrology & Geomorphology, Inc.

6101 S. Rural, Suite 110
Tempe, AZ 85283
480-752-2124 (voice)
480-839-2193 (fax)
www.jefuller.com

January 5, 2001

TRANSMITTAL

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ATT: JOE TRAM
2801 W. DURANGO ST.
PHOENIX, AZ 85009-6399

JE Fuller/ Hydrology & Geomorphology, Inc. is pleased to provide you with the following materials:

1 Copy of our response to FEMA comment letter with attachments

If you have any questions, please give me a call. I will be in the field Friday.

Ted Lehman

1/5/01

Date

JE Fuller/ Hydrology & Geomorphology, Inc.

Jonathan Fuller, P.E., P.H.
Brian Iserman, P.E.
John Wallace, P.E.
Ted Lehman, M.A., E.I.T.
Michael Henze, M.A.
W. Scott Ogden, P.E.

6101 S. Rural Rd., Suite 110
Tempe, Arizona 85283
480-752-2124 (voice)
480-839-2193 (fax)
www.jefuller.com

January 5, 2001

Mr. Joe Tram, P.E.
Flood Control District of Maricopa County
2801 W. Durango Street
Phoenix, AZ 85009

Re: FEMA comment letter dated Nov. 21, 2000: Case No.: 00-09-985P, Community: Maricopa County, Arizona, Community No.: 040037

Dear Mr. Tram,

This letter is in reference to the above-referenced comment letter received from FEMA dated November 21, 2000 and our follow-up telephone conversation with FEMA reviewers on November 28, 2000. We believe the maps provided in the original TDN show a realistic depiction of the landform, stability, and floodplain for the Tiger Wash alluvial fan. The following explanations are provided to address the questions raised in the FEMA comment letter and the subsequent telephone conversation.

Item 1:

During our phone conversation with FEMA representatives on November 28, 2000 four specific areas were identified with questions regarding perceived discrepancies between the "Surficial Geology Map" and the "Floodplain Map." The basic explanation to FEMA's concerns is the false impression that the surficial geology map would completely dictate the delineation of the flood hazard map. Rather, there are areas of young geomorphic surfaces that are stable and areas of old geomorphic surfaces that are not. Therefore, there will be some differences between the surficial geology map and the Stage 2 and Stage 3 maps. The four areas in question are shown in the attached "Surficial Geology Map" and "Stage 3 – Floodplain Map" outlined and numbered in magenta.

Area 1 is a stable surface area (as shown in the Stage 2 – Stability Map) downstream of an active alluvial fan area. On the Stage 3 – Floodplain Map, the light yellow corridors are administrative floodways which the District would like to reserve and regulate as floodways for the through-flow of water and sediment from the upstream active area. The light blue areas between the light yellow floodway corridors are shown as stable areas subject to some inundation. The zones are shown as approximate floodplain areas where development would be allowed given some additional site analysis and elevation of structures placed within these areas. Some of these light blue island areas are on Pleistocene surfaces and others are on Qyl – Early to late Holocene relict alluvial fan and terrace deposits as shown on the Surficial Geology Map.

The area was identified as stable based on the predominantly tributary drainage pattern within Area 1. Also, the channels crossing this area are relatively well incised into the adjacent surfaces. Depths of channel incision range from 3 to 6 feet. Moreover, the recent extreme flood event in September 1997 showed that floodwaters were confined to the existing channel network. The District wanted to show the areas in between these channels as within an approximate floodplain area in order to ensure adequate development review and regulation of these areas even though locally some of these areas may experience only shallow or local flooding during the 1 percent chance flood.

Area 2 is a stable area within the alluvial fan landform and is shown as such on the Stage 2 – Stability Map in the Technical Data Notebook. Although Area 2 lies adjacent to the active area to the west and is subject to flooding as indicated on the Floodplain Map, the type of flooding experienced in this area is shallow sheet flooding. This was demonstrated well during the September 1997 flood. Field investigations of the reconstructed flood inundation map shown in Appendix G.3 revealed that flooding in Area 2 was limited to very shallow flow generally less than one foot in depth and frequently much less than one foot deep.

Like Area 1, the Surficial Geology Map shows this area as predominantly Qy1 surfaces with a few islands of Pleistocene surfaces. Lateral relief in this area is mild allowing for inundation by shallow flood waters from the west. There are also very few channels in this area. Examination of the historical aerial photographs show no new channels developing in this area over the period of record. Moreover, the extreme flood of September 1997 also did not form any new channels in Area 2. The lack of channel formation in this area is due to the limited depth of flooding.

Area 3 is a stable area within the alluvial fan landform, but is not part of the active alluvial fan. FEMA questioned why yellow areas (Qy2) were shown in this area on the Surficial Geology Map, but no flood hazards were shown on the Floodplain Map. The Qy2 areas shown on the Surficial Geology Map in Area 3 are tributary channels and their young overbank areas draining the Pleistocene area west of the modern Tiger Wash distributary system. These tributary channels originate on the inactive Pleistocene fan deposits and have drainage areas less than one square mile and are not connected to the active alluvial fan. Therefore, they were not mapped as alluvial fan floodplains and are shown as a Shaded X floodplain on the Floodplain Map. As implied by the Shaded X designation, there may be flood hazards in these areas either for floods in excess of the 100-year flood or for areas with drainage areas less than one square mile.

Area 4 is a stable area adjacent to active alluvial fan areas. The Surficial Geology Map shows a number of islands of Pleistocene and Qy1 surfaces in Area 4. While Area 4 is a stable area as shown by the numerous islands of older surfaces, the area has relatively mild lateral relief. Although not mapped in our reconstruction of the September 1997 flood, the area was evaluated as analogous to Area 2. Therefore, the area was mapped as an area subject to some inundation hazard on the Floodplain Map, but not subject to uncertain flow paths, debris flow, or other active alluvial fan flood hazards.

Item 2:

A revised version of the Stage 3 – Floodplain Map showing all floodplains as Zone A or Zone A - Administrative Floodways is attached. Each zone also shows the FCDMC zones per the County's revised floodplain ordinance. A revised Figure 7.1 – Redline FIRM is also included with a similar look to the new Stage 3 map, minus the USGS background.

If you have any additional questions regarding these explanations, please do not hesitate to contact us.

Sincerely,
JE Fuller / Hydrology & Geomorphology, Inc.

Jon Fuller, P.E., P.H.

Ted Lehman, M.A., E.I.T.

Attachments:

- FEMA comment letter of Nov. 21, 2000
- Surficial Geology Map showing question areas 1-4
- Original Stage 3 – Floodplain Map showing question areas 1-4
- Revised Stage 3 – Floodplain Map showing zones per FEMA preference for alluvial fans
- Revised Figure 7.1 – Redline FIRM showing zones per FEMA preference for alluvial fans
- Copy of updated Flood Control District of Maricopa County Floodplain Regulations
- Revised pages 6B-18 through 6B-20 (revised Table 6B.6.1 and the pages affected by the revised table)

Federal Emergency Management Agency

Washington, D.C. 20472

NOV 2 1 2000

Mr. Joe Tram, P.E.
Floodplain Branch Manager
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009

IN REPLY REFER TO:
Case No.: 00-09-985P
Community: Maricopa County, AZ
Community No.: 040037

316-AD

Dear Mr. Tram:

This is in reference to your July 29, 2000, request for a Letter of Map Revision for the above-referenced community. In our earlier letter to you, we indicated additional data might be required to complete our review of the request. The data required to complete our review, which must be submitted within 90 days of the date of this letter, are listed below.

1. Our review revealed discrepancies in active and inactive zone mapping between the submitted maps entitled "Surficial Geology Map" and "Floodplain Map," both contained in the submitted report entitled "Approximate Floodplain Delineation Study for portion of Tiger Wash Piedmont," prepared by JE Fuller/Hydrology and Geomorphology, Inc., dated June, 2000. Please provide an explanation for these discrepancies, or make the appropriate changes.

2. From the submitted map entitled "Floodplain Map," showing zone designations used by the County, it is not clear how these zone designations relate to the flood zones that should be shown on the annotated FIRM. Please provide a map that indicates active/inactive zones and what zone designations should be shown on the FIRM.

Please send the required data directly to our Map Coordination Contractor at the following address:

Michael Baker Jr., Inc.
3601 Eisenhower Avenue, Suite 600
Alexandria, VA 22304-6425

For identification purposes, please include the case number referenced above on all correspondence.

If you are unable to meet the 90-day deadline for submittal of required items, and would like us to continue processing your request, you must request an extension of the deadline. This request must be submitted to us in writing and must provide (1) the reason why the data cannot be submitted within the requested timeframe, and (2) a new date for the submittal of the data. We receive a very large volume of requests and cannot maintain inactive requests for an indefinite period of time. Therefore, the fees will be forfeited for any request for which neither the requested data nor a written extension request is received within 90 days.

If you have any questions concerning your request, FEMA policy, or the National Flood Insurance Program in general, please call the Revisions Coordinator for your State, Pernille Buch-Pedersen, who may be reached, toll free, at 1-877-FEMA MAP (1-877-336-2627).

Sincerely,

Max H. Yuan, P.E., Project Engineer
Hazards Study Branch
Mitigation Directorate

cc: Mr. Brian Cosson
State Coordinator
Arizona Department of Water Resources

Mr. W. Dempsey Helms
Project Manager, Engineering
Arizona State Land Department

Ms. Denise Meredith
Bureau of Land Management
State of Arizona

Mr. Jon Fuller, P.E.
JE Fuller/Hydrology and Geomorphology, Inc.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH
APPROXIMATE FLOODPLAIN
DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

SURFICIAL GEOLOGY MAP

JUNE 2000

LEGEND

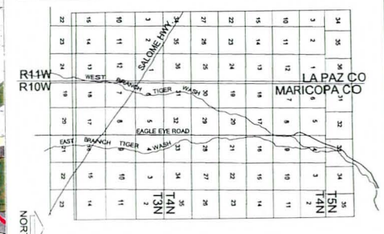
Surficial Geology

- Qyc - Late Holocene active channel deposits
- Qy2 - Late Holocene sheetflood and overbank deposits
- Qy1 - Early to late Holocene relict alluvial fan and terrace deposits
- Ql - Late Pleistocene alluvium (>10,000 years)
- Qm - Middle Pleistocene alluvial fan deposits (> 100,000 years
- R - Bedrock outcrops
- G - Gravel pits
- 1 Areas of questions by FEMA per letter of Nov. 21, 2000 and phone conversation of Nov. 28, 2000

NOTES

SURFICIAL GEOLOGY FROM: FCD 98-48, ASSIGNMENT #2
ARIZONA GEOLOGICAL SURVEY, KLAWON, J., PEARTHREE, P.

INDEX MAP



2000' 0' 4000'

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN	TWL	8-99
DESIGN CHK.	JEF	8-99
PLANS	TWL	8-99
PLANS CHK.	BRI	8-99

SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE:

APPROVED BY: DATE:

CHIEF ENGINEER AND GENERAL MANAGER

Figure 6B.4.2

LIMIT OF STUDY

WEST BRANCH TIGER WASH

EAST BRANCH TIGER WASH

HARQUAHALA

Hydrographic Apex

Topographic Apex

LA PAZ CO
MARICOPA CO

R11W
R10W

1

2

3

4

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH APPROXIMATE FLOODPLAIN DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

STAGE 3
FLOODPLAIN MAP

JUNE 2000

LEGEND

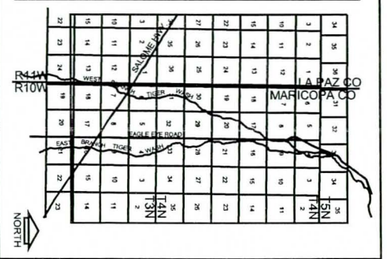
- A - Approximate Riverine Floodplains
- AFHH - Alluvial Fan High Hazard
- AAFF - Approximate Alluvial Fan Floodway
- AFZA - Alluvial Fan Zone A
- Shaded X
- AFUFD - Alluvial Fan Uncertain Flow Distribution
- X
- 1 — Areas of questions by FEMA per letter of Nov. 21, 2000 and phone conversation of Nov. 28, 2000

See Table 6B.6.1 for a complete description of flood hazard zones.

USGS DIGITAL RASTER GRAPHICS PROJECTED TO STATEPLANE NORTH AMERICAN DATUM OF 1983 AND TILED BY FCDMC.

ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP



2000' 0' 4000'

THE FLOODPLAIN ZONE DELINEATIONS WERE PERFORMED UNDER MY DIRECT SUPERVISION.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN		
DESIGN CHK.	JEF	
PLANS	TWL	
PLANS CHK.	BRI	

SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

SHEET 4 OF 4

LIMIT OF STUDY

LIMIT OF STUDY

WEST BRANCH TIGER WASH

EAST BRANCH TIGER WASH

HARQUAHALA

Hydrographic Apex

Topographic Apex

R11W R10W LA PAZ CO MARICOPA CO

T4N T3N

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH APPROXIMATE FLOODPLAIN DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

STAGE 3
FLOODPLAIN MAP

JUNE 2000

LEGEND

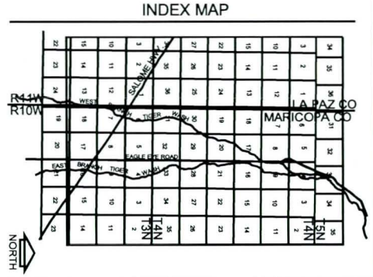
- A - Approximate Riverine Floodplains
- Zone A - Active Alluvial Fan - Administrative Floodway (AFHH - Alluvial Fan High Hazard)
- Zone A - Inactive Alluvial Fan - Administrative Floodway (AAFF - Approximate Alluvial Fan Floodway)
- Zone A - Inactive Alluvial Fan (AFZA - Alluvial Fan Zone A)
- Zone A - Active Alluvial Fan - Administrative Floodway (AFUFD - Alluvial Fan Uncertain Flow Distribution)
- Shaded X - Inactive Alluvial Fan
- X

See Table 6B.6.1 for a complete description of flood hazard zones.

USGS DIGITAL RASTER GRAPHICS PROJECTED TO STATEPLANE NORTH AMERICAN DATUM OF 1983 AND TILED BY FCDMC.

ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP



2000' 0' 4000'

Registered Professional Engineer (Civil)
No. 26846
JONATHAN E. FULLER
Date Signed 6-8-00
Arizona U.S.A.

THE FLOODPLAIN ZONE DELINEATIONS WERE PERFORMED UNDER MY DIRECT SUPERVISION.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN		
DESIGN CHK.	JEF	
PLANS	TWL	
PLANS CHK.	BRI	

SUBMITTED BY: _____ DATE: _____

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: _____ DATE: _____

APPROVED BY: _____ DATE: _____

CHIEF ENGINEER AND GENERAL MANAGER

Figure 7.1

Location of FIRM Panels, Existing Floodplains, and Revisions from this Study

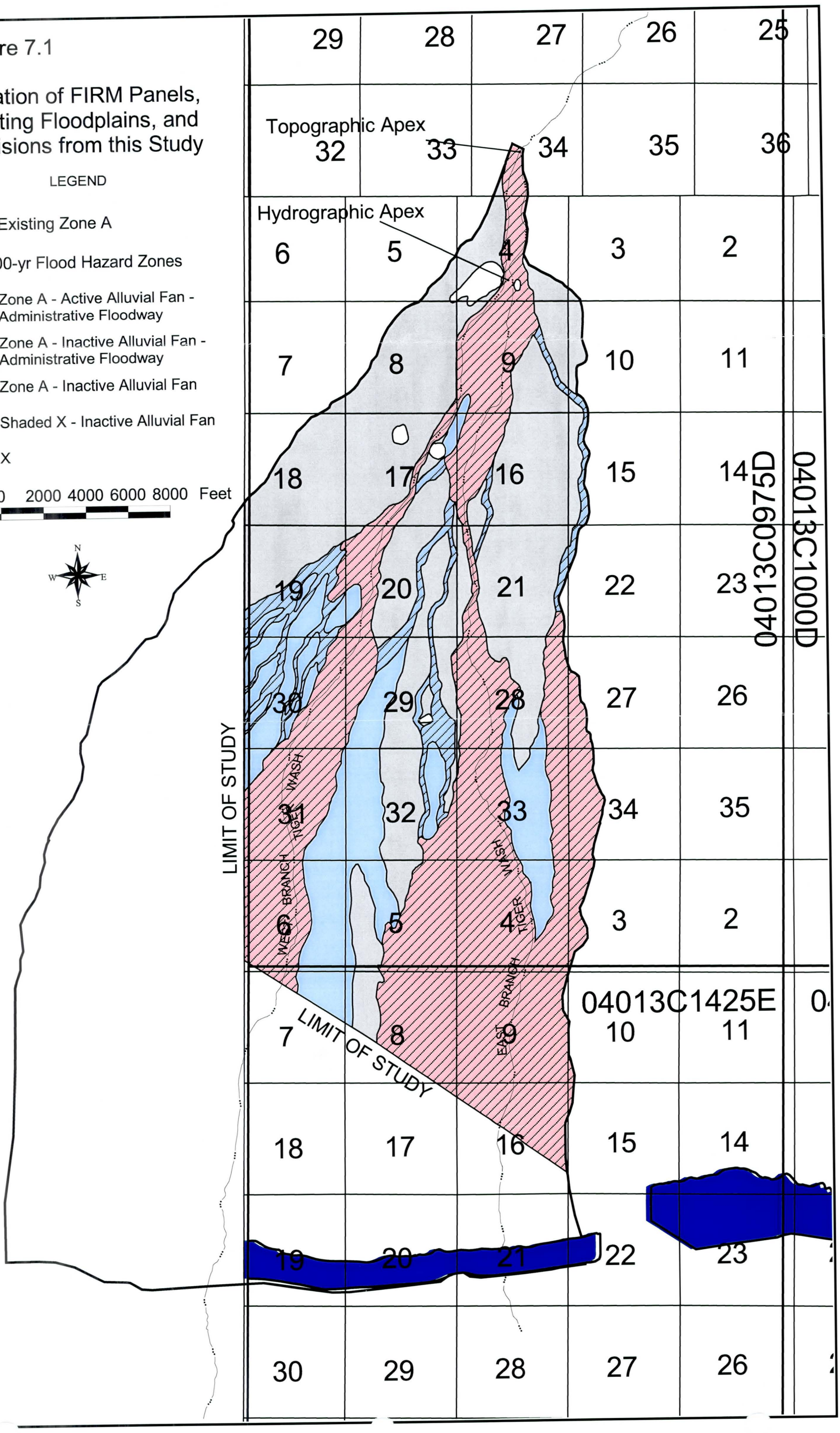
LEGEND

- Existing Zone A

New 100-yr Flood Hazard Zones

- Zone A - Active Alluvial Fan - Administrative Floodway
- Zone A - Inactive Alluvial Fan - Administrative Floodway
- Zone A - Inactive Alluvial Fan
- Shaded X - Inactive Alluvial Fan
- X

2000 0 2000 4000 6000 8000 Feet



Federal Emergency Management Agency

Washington, D.C. 20472

NOV 2 1 2000

Mr. Joe Tram, P.E.
Floodplain Branch Manager
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009

IN REPLY REFER TO:
Case No.: 00-09-985P
Community: Maricopa County, AZ
Community No.: 040037

316-AD

Dear Mr. Tram:

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2. From the submitted map entitled "Floodplain Map," showing zone designations used by the County, it is not clear how these zone designations relate to the flood zones that should be shown on the annotated FIRM. Please provide a map that indicates active/inactive zones and what zone designations should be shown on the FIRM.

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Alexandria, VA 22304-6425

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FAEBLY@mbakercorp.com + 703-960-8800

pbuch-pedersen@mbakercorp.com

1-703-
1-800-642-2537

If you have any questions concerning your request, FEMA policy, or the National Flood Insurance Program in general, please call the Revisions Coordinator for your State, Pernille Buch-Pedersen, who may be reached, toll free, at 1-877-FEMA MAP (1-877-336-2627).

Sincerely,

Max H. Yuan, P.E., Project Engineer
Hazards Study Branch
Mitigation Directorate

cc: Mr. Brian Cosson
State Coordinator
Arizona Department of Water Resources

Mr. W. Dempsey Helms
Project Manager, Engineering
Arizona State Land Department

Ms. Denise Meredith
Bureau of Land Management
State of Arizona

Mr. Jon Fuller, P.E.
JE Fuller/Hydrology and Geomorphology, Inc.

Want to talk to a Map Specialist about Flood Hazard Mapping?

If your home or business is located in the floodplain, you will need to purchase and maintain flood insurance. If you have a mortgage, your bank will require it.

FEMA MAP ASSISTANCE CENTER
FMAC
1-877-FEMA MAP

For all your flood hazard map questions, call toll-free:

1-877-FEMA MAP (1-877-336-2627)

or visit our Web Site at www.fema.gov/mit/tsd

FEMA's flood hazard maps— also called Flood Insurance Rate Maps or FIRMs— are used to determine your property's flood risk. Increasing development, severe weather events, and other activities in the floodplain will change the flood risks shown on the maps. FEMA is working hard to update and modernize all of the flood hazard maps. However, with more than 18,000 communities participating in the National Flood Insurance Program (NFIP), this will take time. Meanwhile, the FEMA Map Assistance Center (FMAC) has a staff of trained professionals ready to help

Typical flood hazard map questions we answer:

Property Owner: "My home has never flooded. Why do I need flood insurance?"

Real Estate Agent: "I think the previous owner had an exemption from flood insurance— is there a record of this exemption?"

Developers and Engineers: "What is the status of my request for a map change? How long will it take?"

Community Officials: "How do I request a physical revision to a flood map?"

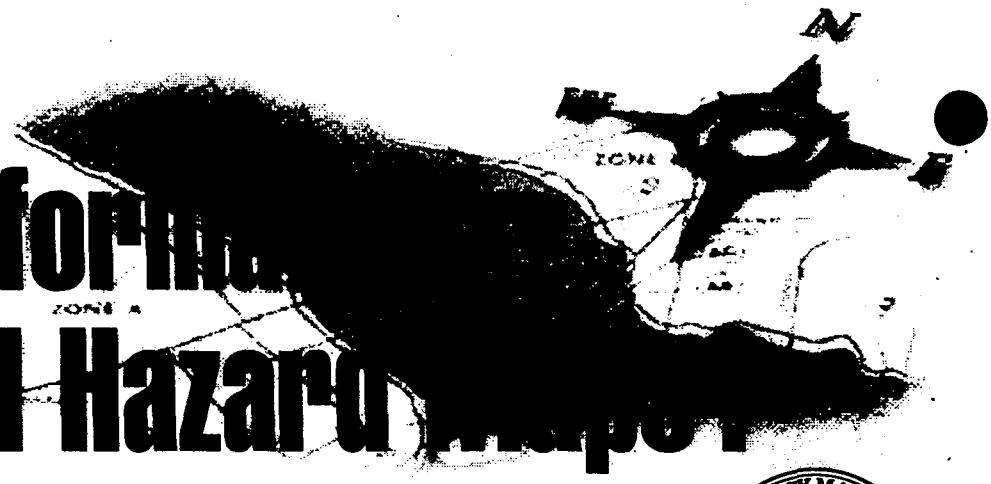
Lenders: "How can we help our customers whose homes are located in a flood zone?"

Other important National Flood Insurance Program toll-free numbers:

- To purchase flood hazard maps for a nominal fee... **1-800-358-9616**
- For general flood insurance information... **1-800-427-4661**
- To order any current FEMA publication... **1-800-480-2520**
- For lender questions on flood policy coverage and rates... **1-800-611-6125**
- For agent questions on policy coverage and rates... **1-800-720-1093**

National Flood Insurance Program
NFIP
Administered by FEMA

National Flood Insurance Program
NFIP
Administered by FEMA



Need Information on Flood Hazard Maps?

A wealth of information is only a click away at: **www.fema.gov/mit/tsd**

FEDERAL EMERGENCY MANAGEMENT AGENCY

Homeowners will find:

- A helpful tutorial: "How to Challenge a Flood Risk Determination"
- Answers to Frequently Asked Questions, including, "Why do I need flood insurance?" "What are the different flood hazard zone designations and what do they mean?" and "What is a base flood elevation?

Insurance Agents and Bankers will find:

- Information on the National Flood Insurance Reform Act of 1994, which affects lenders
- Pages containing information on how to become a "Write Your Own" insurance agent
- Pages containing flood insurance rate information and a listing of map determination companies

Engineers and Surveyors will find:

- A listing of National Flood Insurance Program (NFIP) approved and test version software with links to free downloads
- Forms and fee schedules for requesting a map change or back-up study data
- A link to a listing of training courses and conferences related to emergency management

Floodplain Managers and Community Officials will find:

- The compendium of map change actions and the Guide for Community Officials
- A listing of key contacts at FEMA with direct e-mail links
- Forms necessary to initiate requests for back-up study data

All Four Constituent groups will find:

FEMA MAP ASSISTANCE CENTER
FMAC
1-877-FEMA MAP

- NFIP policies and regulations
- Forms for making map change requests
- The answers to over 80 Frequently Asked Questions
- Access to a database containing the status of recent requests for map changes
- Numerous reports and guidance documents in both Adobe Acrobat .PDF and MS Word formats
- Information on Map Modernization initiatives with direct e-mail links to FEMA Task Leaders
- A subscription service providing free news on the latest developments in flood hazard mapping via e-mail
- E-mail links to Map Specialists at the FEMA Map Assistance Center (1-877-FEMA MAP)

Questions and suggestions? Contact John Magnotti at 202-646-3932, or john.magnotti@fema.gov

Federal Emergency Management Agency

Washington, D.C. 20472

FEE SCHEDULE FOR PROCESSING REQUESTS FOR MAP CHANGES

This notice contains the revised fee schedule for processing certain types of requests for changes to National Flood Insurance Program (NFIP) maps. The change in the fee schedule will allow FEMA to further reduce the expenses to the NFIP by more fully recovering the costs associated with processing conditional and final map change requests. The revised fee schedule for map changes is effective for all requests dated June 1, 2000, or later and supersedes the current fee schedule, which was established on March 1, 1999.

To develop the revised fee schedule for conditional and final map change requests, FEMA evaluated the actual costs of reviewing and processing requests for Conditional Letters of Map Amendment (CLOMAs), Conditional Letters of Map Revision – based on Fill (CLOMR-Fs), Conditional Letters of Map Revision (CLOMRs), Letters of Map Revision – based on Fill (LOMR-Fs), Letters of Map Revision (LOMRs), and Physical Map Revisions (PMRs).

Fee Schedule for Requests for CLOMAs, CLOMR-Fs, and LOMR-Fs

Based on our review of actual cost data for Fiscal Year 1999, we are continuing to charge the following review and processing fees, which requesters must submit with all requests:

Request for single-lot/single-structure CLOMA, CLOMR-F, and LOMR-F	$400
Request for single-lot/single-structure LOMR-F based on as-built information (CLOMR-F previously issued by us)	$300
Request for multiple-lot/multiple-structure CLOMA	$700
Request for multiple-lot/multiple-structure CLOMR-F and LOMR-F	$800
Request for multiple-lot/multiple-structure LOMR-F based on as-built information (CLOMR-F previously issued)	$700

Fee Schedule for Requests for CLOMRs

Based on our review of actual cost data for Fiscal Year 1999, we are continuing to charge the following review and processing fees, which requesters must submit with all requests unless exempted by 44 CFR 72.5:

Request based on new hydrology, bridge, culvert, channel, or combination of any of these	$3,100
Request based on levee, berm, or other structural measure	$4,000

Fee Schedule for Requests for LOMRs and PMRs

Based on our review of actual cost data for Fiscal Year 1999, **we revised the review and processing fee for requests based on levees, berms, or other structural measures, from $4,700 to $6,000.** Therefore, unless 44 CFR 72.5 exempts the request, requesters must submit the review and processing fees shown below with requests for LOMRs and PMRs dated June 1, 2000, or later that are not based on structural measures or alluvial fans.

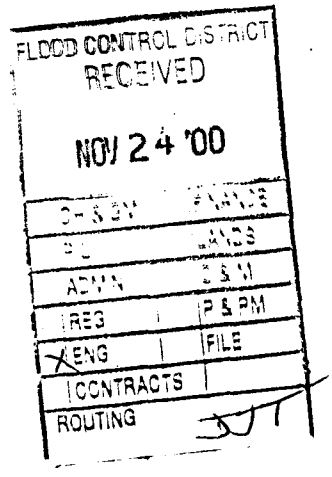
Request based on bridge, culvert, channel, or combination thereof	$4,000
Request based on levee, berm, or other structural measure	$6,000
Request based on as-built information submitted as followup to CLOMR	$3,400

Fees for CLOMRs, LOMRs, and PMRs Based on Structural Measures on Alluvial Fans

Based on our review of actual cost data for Fiscal Year 1999, we are continuing to charge $5,000 as the initial fee for requests for CLOMRs and LOMRs based on structural measures on alluvial fans. We also will continue to recover the remainder of the review and processing costs by invoicing the requester before issuing a determination letter, consistent with current practice. We will continue to use the prevailing private-sector labor rate charged to us ($50 per hour) to calculate the total reimbursable fees.

Payment Submission Requirements

Requesters must make fee payments for non-exempt requests before we render services. This payment must be in the form of a check or money order or by credit card payment. Please make all checks and money orders in U.S. funds payable to the *National Flood Insurance Program*. We will deposit all fees collected to the National Flood Insurance Fund, which is the source of funding for providing this service.



Federal Emergency Management Agency

Washington, D.C. 20472

FLOOD CONTROL DISTRICT
RECEIVED
AUG 28 '00
CH & GM | FINANCE
PIO | PLANNING
ADMIN | O & M
REG | P & PM
ENG | FLD
CONTRACTS | DAT
ROUTING

August 23, 2000

Mr. Joe Tram, P.E.
Floodplain Branch Manager
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009

IN REPLY REFER TO:
Case No.: 00-09-985P
Community: Maricopa County, AZ
Community No.: 040037

316-ACK.FRQ

Dear Mr. Tram:

This responds to your request dated July 29, 2000, that the Federal Emergency Management Agency (FEMA) issue a revision to the Flood Insurance Rate Map (FIRM) for Maricopa County, Arizona and Incorporated Areas. Pertinent information about the request is listed below.

Identifier:	Tiger Wash Floodplain Delineation Study
Flooding Source:	Tiger Wash
FIRM Panel(s) Affected:	04013C0975 D and 1435 E

As you may know, FEMA has implemented a procedure to recover costs associated with reviewing and processing requests for modifications to published flood information and maps. However, because your request is based on a detailed hydrologic or hydraulic study conducted by a Federal, State, or local agency to replace an approximate study conducted by FEMA and shown on the flood map, no fees will be assessed for our review.

We have completed an inventory of the items you submitted. We have received the required data to begin a detailed technical review of your request. If additional data are required, we will inform you within 60 days of the date of this letter.

Please direct all technical questions concerning your request to our Mapping Coordination Contractor at the following address:

Michael Baker Jr., Inc.
3601 Eisenhower Avenue, Suite 600
Alexandria, VA 22304-6425

When you write us about your request, you must include the case number referenced above in your letter.

If you have any questions concerning your request, FEMA policy, or the National Flood Insurance Program in general, please call the Revisions Coordinator for your State, Pernille Buch-Pedersen, who may be reached, toll free, at 1-877-FEMA MAP (1-877-336-2627).

Sincerely,

Max H. Yuan, P.E., Project Engineer
Hazards Study Branch
Mitigation Directorate

cc: Mr. Brian Cosson
State Coordinator
Arizona Department of Water Resources

Mr. W. Dempsey Helms
Project Manager, Engineering
Arizona State Land Department

Ms. Denise Meredith
Bureau of Land Management
State of Arizona

Mr. Jon Fuller, P.E.
JE Fuller/Hydrology and Geomorphology, Inc.

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399
(602) 506-1501
FAX: (602) 506-4601
TT: (602) 506-5859

8/17/00

Brad Herbert, P.G.
Pattalson Evenoff Engineers
1129 N. Winstel Blvd.
Tucson, AZ 85716

Subject: Draft Piedmont Assessment Manual

Dear Mr. Herbert:

Enclosed please find the Draft copy of the Piedmont Assessment Manual.

In addition to the examples in back of the manual, I am also enclosing figures *from The Tiger Wash Floodplain Delineation Study* performed by JE Fuller, Hydrology and Geomorphology that used the draft Piedmont Assessment Manual as well as the new guidelines for mappiing alluvial fans issued by FEMA.

These figures include the NRCS soil survey, figure 6B.4.1; the surfical geology map. Figure 6B.4.2; sheet 3 of 4 which was indicates the stable and unstable surfaces; and finally sheet 4 of 4 which indicates the floodplain designations that the District is using on areas where floodplains are delineated using the draft Piedmont Assessment Manual. The enclosed page 6B-18 from the Tiger Wash Floodplain study defines the legend on sheet 4 of 4.

Hope this information is a benefit to you. Please call either myself at (602)-506-4607 to discuss the manual and floodplain designations, or either myself or Mr. Jon Fuller, P.E. at (480)-752-2124 concerning the figures or sheets.

Sincerely,

Joe Tram, P.E.
Floodplain Branch Manager

Cc: Jon Fuller

A333.014.003
FCD 98-48

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107

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For Information Only SW

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009-6399
Telephone (602) 506-1501
Fax (602) 506-4601
TT (602) 506-5897

BOARD OF DIRECTORS
Jan Brewer
Fulton Brock
Andrew Kunasek
Don Stapley
Mary Rose Garrido Wilcox

July 29, 2000

Matthew B. Miller, P.E., Chief
Hazards Study Branch
Mitigation Directorate
Federal Emergency Management Agency
500 C Street SW
Washington, D.C. 20472

Attn: Michael Grimm

Re: Letter of Map Revision (LOMR) request for Tiger Wash Piedmont Floodplain Delineation Study (FCD Contract No. 98-48)

Dear Mr. Grimm:

This is a request for a Letter of Map Revision to the Flood Insurance Rate Maps for Maricopa County, Unincorporated Areas, Arizona. The reference information for this study is as follows:

Identifier:	Tiger Wash Piedmont
Flooding Source:	Tiger Wash
Map Number:	04013C
FIRM Panels Affected:	1435E, 0975D (not printed)
General location:	West Maricopa County, in several Sections of Township 3,4 & 5 North and Ranges 10 West
Jurisdictions:	Maricopa County, Arizona
Related study:	None

This study is a new Zone A (approximate) study which was performed in accordance with the guidelines set forth in FEMA's publication entitled *Guidelines for Determining Flood Hazards on Alluvial Fans,* dated July 17, 1999 and February 23, 2000 in addition to *the Draft Piedmont Flood Hazard Assessment and Floodplain Management Manual* developed for Maricopa County, 1998.

The enclosed Technical Support Data Notebook includes FEMA application forms, technical information and work maps including the demarcation of zones for floodplain management. Also enclosed is a copy of the draft Floodplain Regulations for Maricopa County that are currently being reviewed and are being processed for adoption which quantifies and qualifies floodplain management for the designated zones.

Should additional information be required, please contact Joe Tram, P.E., at 602-506-4607.

Sincerely,

Joe Tram

Joe Tram, P.E.
Floodplain Branch Manager

Enclosures

Copies to:

Brian Cosson
State Coordinator
Arizona Department of Water Resources
500 N. 3rd Street
Phoenix, AZ 85003

Jon Fuller, P.E.
JEFuller/Hydrology and Geomorphology, Inc.
5235 South Kyrene, Suite 205
Tempe, Arizona 85283

W. Dempsey Helms
Project Manager, Engineering
Arizona State Land Department
1616 W. Adams Street
Phoenix, AZ 85007

Denise Meredith
Bureau of Land Management
222 N. Central Ave.
Phoenix, AZ 85004

FLOOD CONTROL DISTRICT of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501 (Office)
(602) 506-7346 (Fax)

TIGER WASH PIEDMONT ASSESSMENT
FLOODPLAIN DELINEATION STUDY

This notice and project area map have been mailed to persons on record as owning property within the boundaries of a recently completed Tiger Wash Piedmont Assessment floodplain delineation study.

The floodplain delineation study involved the use of the Federal Emergency Management Agency *Guidelines for Determining flood Hazards on Alluvial Fans* as well as the *Piedmont Flood Hazard Assessment for Floodplain Management* Manual for Maricopa County. The study identified floodplain boundaries for the 100-year peak flood. The floodplains are shown on the attached reduced-scale project-area-map. Persons wishing to view the study report or the detailed delineation exhibits should contact the Flood Control District.

The completed study and delineation maps will be used to regulate future development, so as to reduce or prevent possible flood damage to property and structures. The study results will be submitted to the Federal Emergency Management Agency (FEMA) for use in revising Flood Insurance Rate Maps for the area. Buildings that are located within a 100-year floodplain are required by FEMA to have flood insurance coverage if they are financed by federally insured loans.

Specific information about the Tiger Wash Piedmont Assessment can be obtained by contacting:

Joe Tram, P.E.
Floodplain Branch Manager
Flood Control District of Maricopa County
2801 W. Durango St.
Phoenix, Arizona 85009

Phone: (602) 506-4607

e-mail: jjt@mail.maricopa.gov

Letter Sent to State + BLM

JEFuller / Hydrology & Geomorphology, Inc.

5235 South Kyrene, Suite 205
Tempe, AZ 85283
480-752-2124 (voice)
480-839-2193 (fax)
www.jefuller.com

June 9, 2000

TRANSMITTAL

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ATT: JOE TRAM
2801 W. DURANGO ST.
PHOENIX, AZ 85009-6399

JE Fuller/ Hydrology & Geomorphology, Inc. is pleased to provide you with the following materials:

2 Copies of the Final Technical Data Notebook for FCD 98-48, Assignment No. 1, Approximate Floodplain Delineation Study for portions of Tiger Wash Piedmont

Joe: There is a clear expanding envelope inside each TDN. The copy without aerial photos in it is for you. You can put your copies of the 9x9 color prints into this folder for storage with the TDN as Appendix G.4.

If you have any questions regarding this final submittal, please give me a call. I will be out of the office on Mon. and will be in the field Thurs. and Fri. of next week.

FOR

Jonathan E. Fuller , P.E.

6/9/00

Date

APPROXIMATE
FLOODPLAIN DELINEATION STUDY
for
portions of
TIGER WASH PIEDMONT

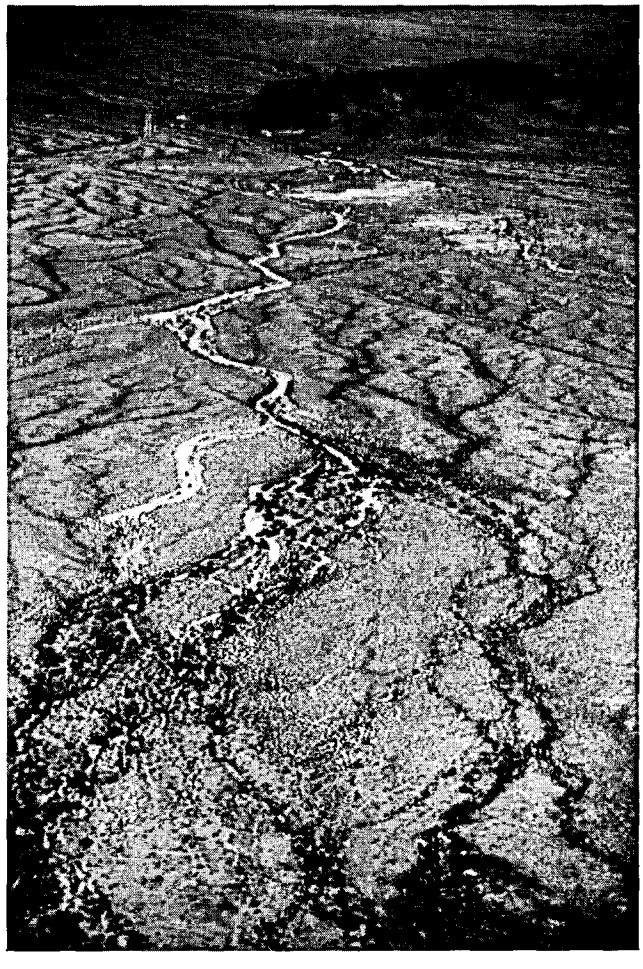
FCD CONTRACT NO. 98-48
Assignment No. 1

TECHNICAL DATA NOTEBOOK

June 2000

Prepared for:

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009
(602) 506-1501



Submitted by:

JE Fuller/ Hydrology & Geomorphology, Inc.

5235 South Kyrene, Suite 205
(480) 752-2124 voice
(480) 839-2193 fax
Tempe, Arizona 85283
www.jefuller.com

2881 North Silverspur Drive
Tucson, Arizona 85745
(520) 623-3112 voice
(520) 623-3130 fax

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

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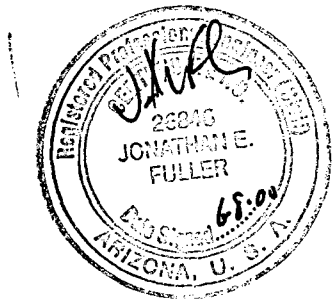

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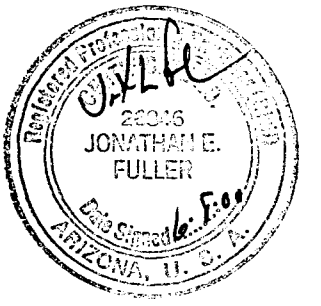

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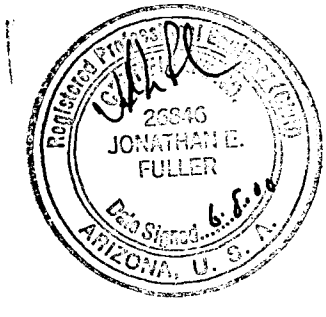
Sheet 4 of 4 Floodplain Map, reduced (½) size end of Section 6B



SECTION 1: INTRODUCTION

1.1 Purpose of study

The purpose of this floodplain delineation study is to identify and delineate the 100-year floodplain for portions of Tiger Wash in T4N, R10W and T3N, R10W in Maricopa County, Arizona using approximate methods. This study incorporates the methods for assessment of piedmont flood hazards as outlined in *Piedmont Flood Hazard Assessment Manual for Maricopa County* (Hjalmarson, 1998) and the *Guidelines for Determining Flood Hazards on Alluvial Fans* (FEMA, 1999).

1.2 Authority for study

JE Fuller / Hydrology and Geomorphology, Inc. (JEF) performed this study under contract with the Flood Control District of Maricopa County (FCDMC). JEF's Project Manager for this project was Jonathan E. Fuller, P.E., P.H. The contract number is FCD 98-48, Assignment No. 1. FCDMC is located at 2801 West Durango Street, Phoenix, AZ 85009 (602) 506-1501. The Project Manager for the FCDMC was Joe Tram, P.E.

1.3 Location of study reach

The study area is located in far western Maricopa County, Arizona (see Figure 1.1 and Figure 1.2). The total watershed is 96.4 square miles at the confluence of Blue Tank Canyon and Tiger Wash near the geologic apex of the alluvial fan. Downstream from this point Tiger Wash diverges into two branches called here the East Branch and West Branch. The East Branch flows nearly due south while the West Branch flows toward the southwest. The East Branch is labeled on the USGS quadrangle maps as Tiger Wash. The approximate floodplain delineation covers areas of the piedmont at risk of flooding from Tiger Wash and its distributaries south to Salome Highway within Maricopa County, Arizona. Flood hazards for the portions of the Tiger Wash piedmont in La Paz County were not mapped.

The climate in the study area is semi-arid desert with an average annual precipitation of generally less than 10 inches. Annual rainfall amounts generally increase with increasing elevation within watersheds near the study area. Precipitation is typically divided between two seasons of comparable rainfall amounts: summer and winter. The 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 significant precipitation are from dissipating tropical storm and/or hurricane remnants. These storms generally occur in late September and early October. These dissipating storms generate moderate to intense rainfall intensities that can last for many hours.

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This study incorporates the methods for assessment of piedmont flood hazards as outlined in *Piedmont Flood Hazard Assessement Manual for Maricopa County* (Hjalmarson, 1998) and the

Guidelines for Determining Flood Hazards on Alluvial Fans (FEMA, 1999). The methodology incorporates geomorphic methods into the flood hazard assessment of piedmont surfaces.

1.4.1 Hydrology

The hydrologic information used in this study included a flood-flow-frequency analysis of the upstream USGS gage data, evaluation of previously published paleoflood surveys, and detailed inundation mapping of the flood of September 26, 1997. These analyses indicated that the September 1997 flood reasonably approximated the 100-year flood and is the flood of record for the 26 years of gaging of Tiger Wash. Therefore, it was deemed an excellent starting point for the approximate delineation of the floodplain limits.

1.4.2 Hydraulics

Hydraulic calculations for this delineation study were limited to slope-area calculations reconstructing the September 1997 flood event at various location on the piedmont. These calculations are presented in Appendix D of the Technical Data Notebook. The remainder of the hydraulics section of this study is dedicated to a description of the geomorphic methods used to identify the type and extent of the flood hazard within the study area. The procedures applied follow the methods outlined in *Piedmont Flood Hazard Assessment Manual for Maricopa County* (Hjalmarson, 1998) and the *Guidelines for Determining Flood Hazards on Alluvial Fans* (FEMA, 1999).

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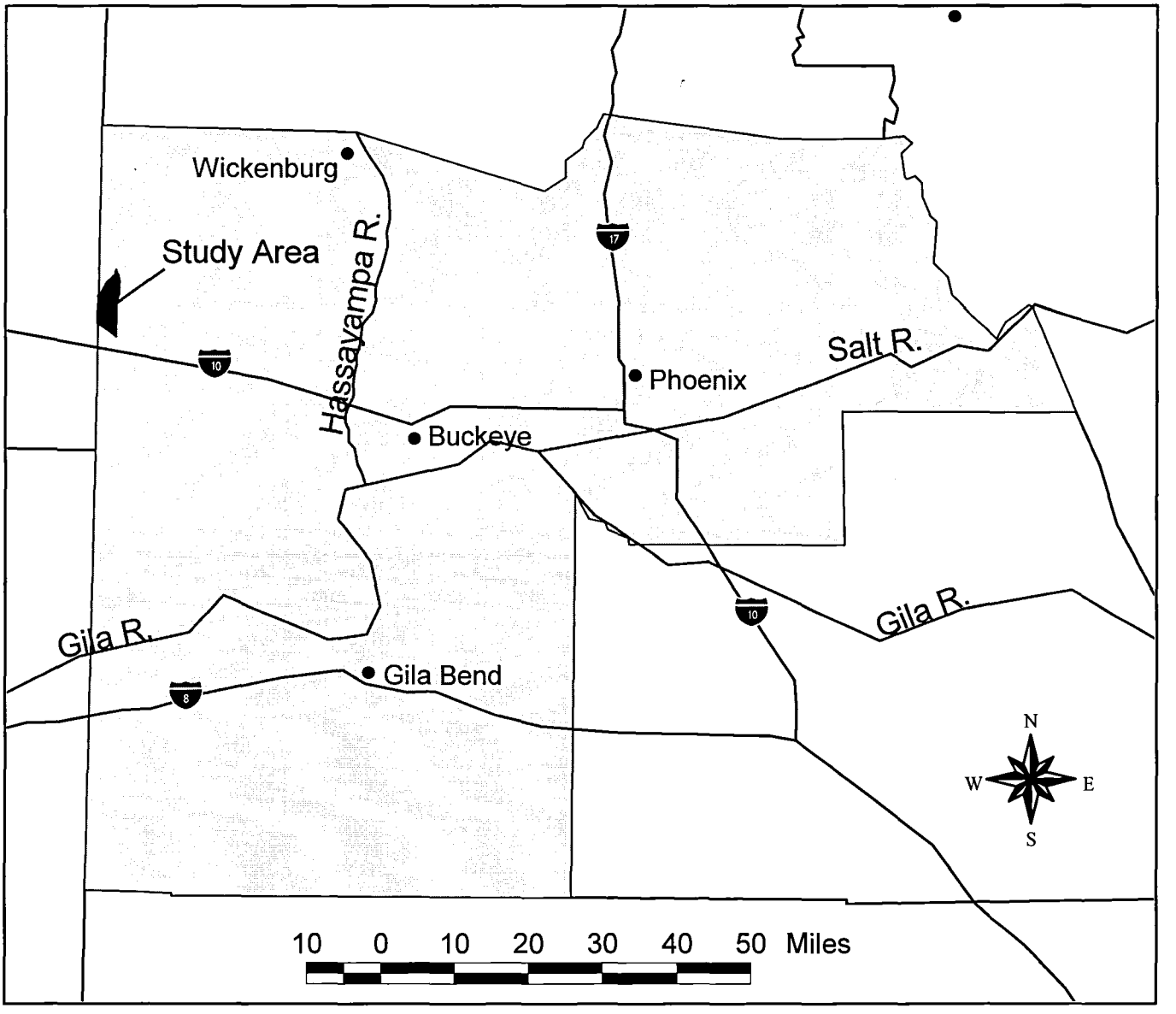
1.5 Study Results

This study resulted in the new delineation of approximately 7.2 square miles of approximate floodplain in the study area. Significant use was made of the surficial geology mapping and September 1997 flood inundation mapping performed under contract number FCD 99-48, Assignment No. 2. The inundation areas for the newly delineated floodplains are shown in the maps in Section 6B and the Exhibit Maps at the end of this notebook.



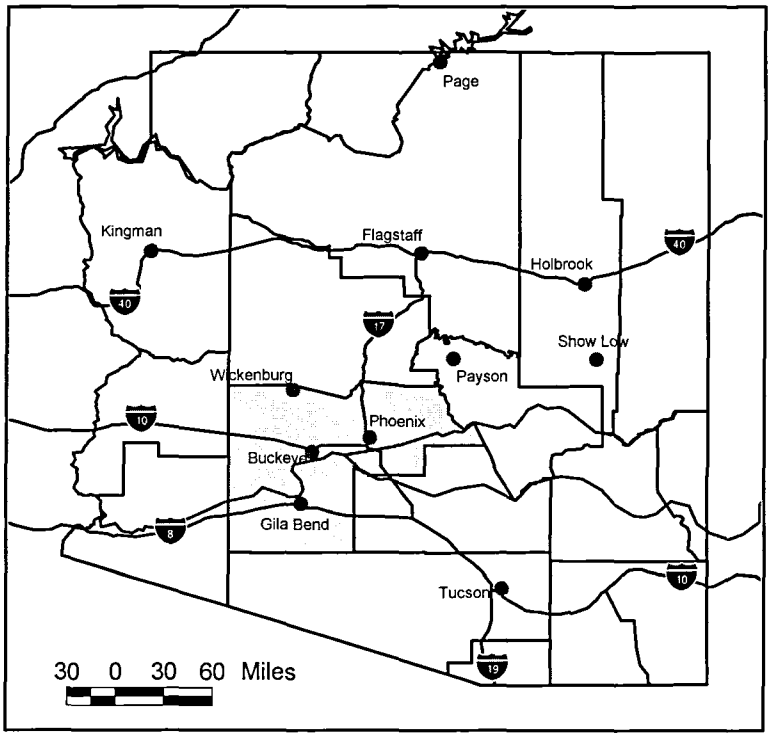


Figure 1.1
Location Map

Approximate FDS for
Portions of Tiger Wash Piedmont
JE Fuller / Hydrology & Geomorphology, Inc.
June 2000

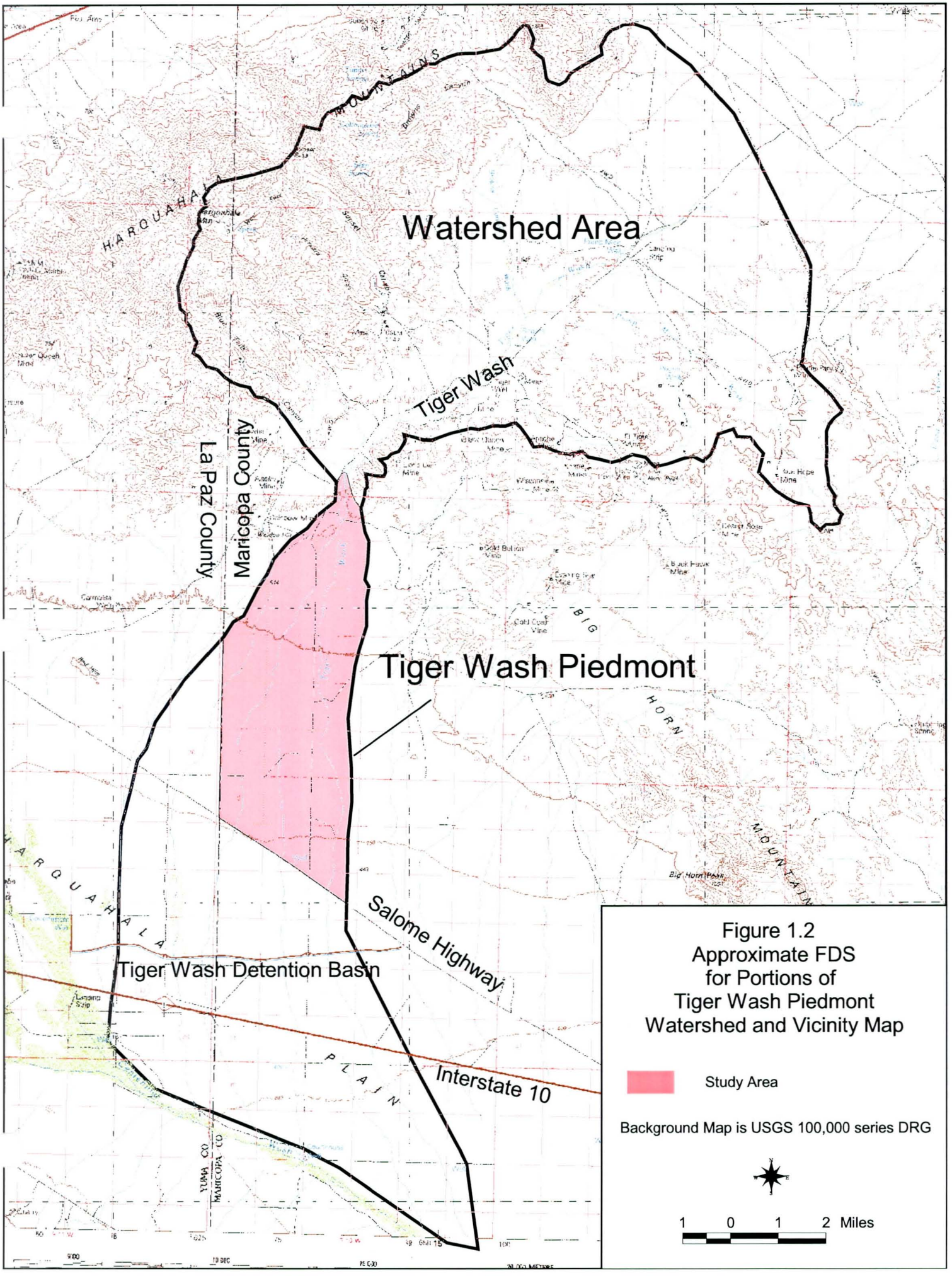


Figure 1.2
Approximate FDS
for Portions of
Tiger Wash Piedmont
Watershed and Vicinity Map

Study Area

Background Map is USGS 100,000 series DRG

1 0 1 2 Miles

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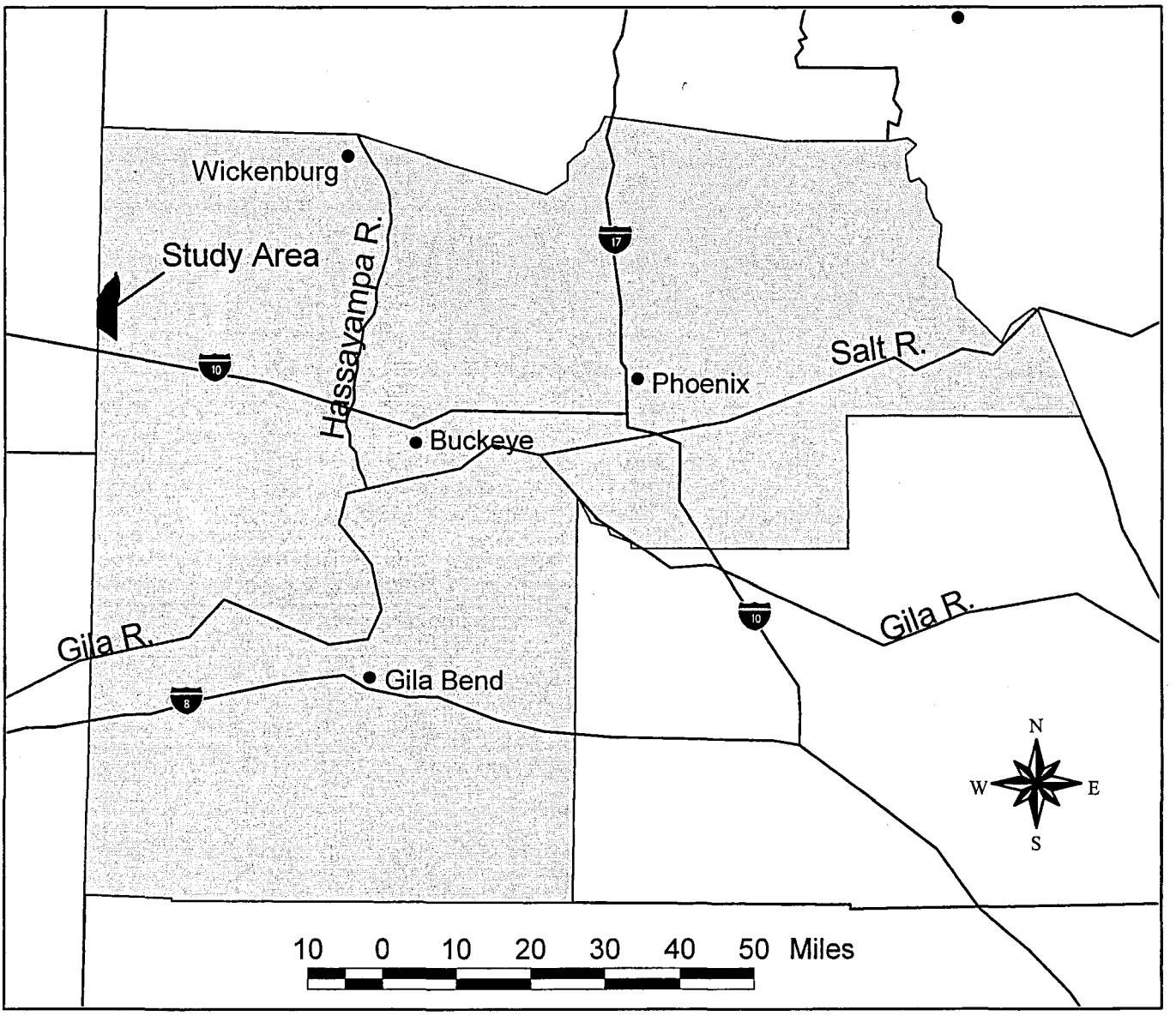

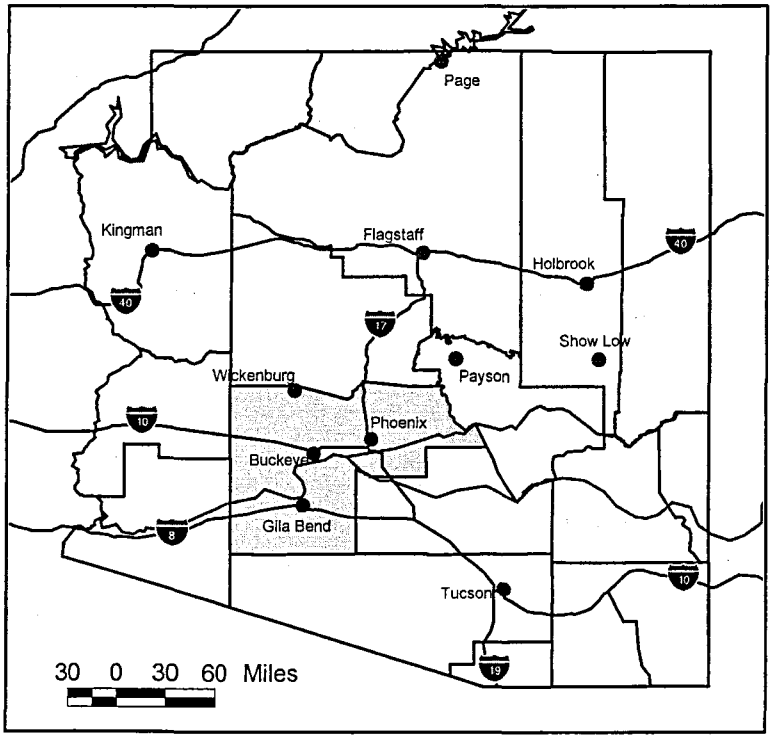

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Approximate FDS for
Portions of Tiger Wash Piedmont
JE Fuller / Hydrology & Geomorphology, Inc.
June 2000

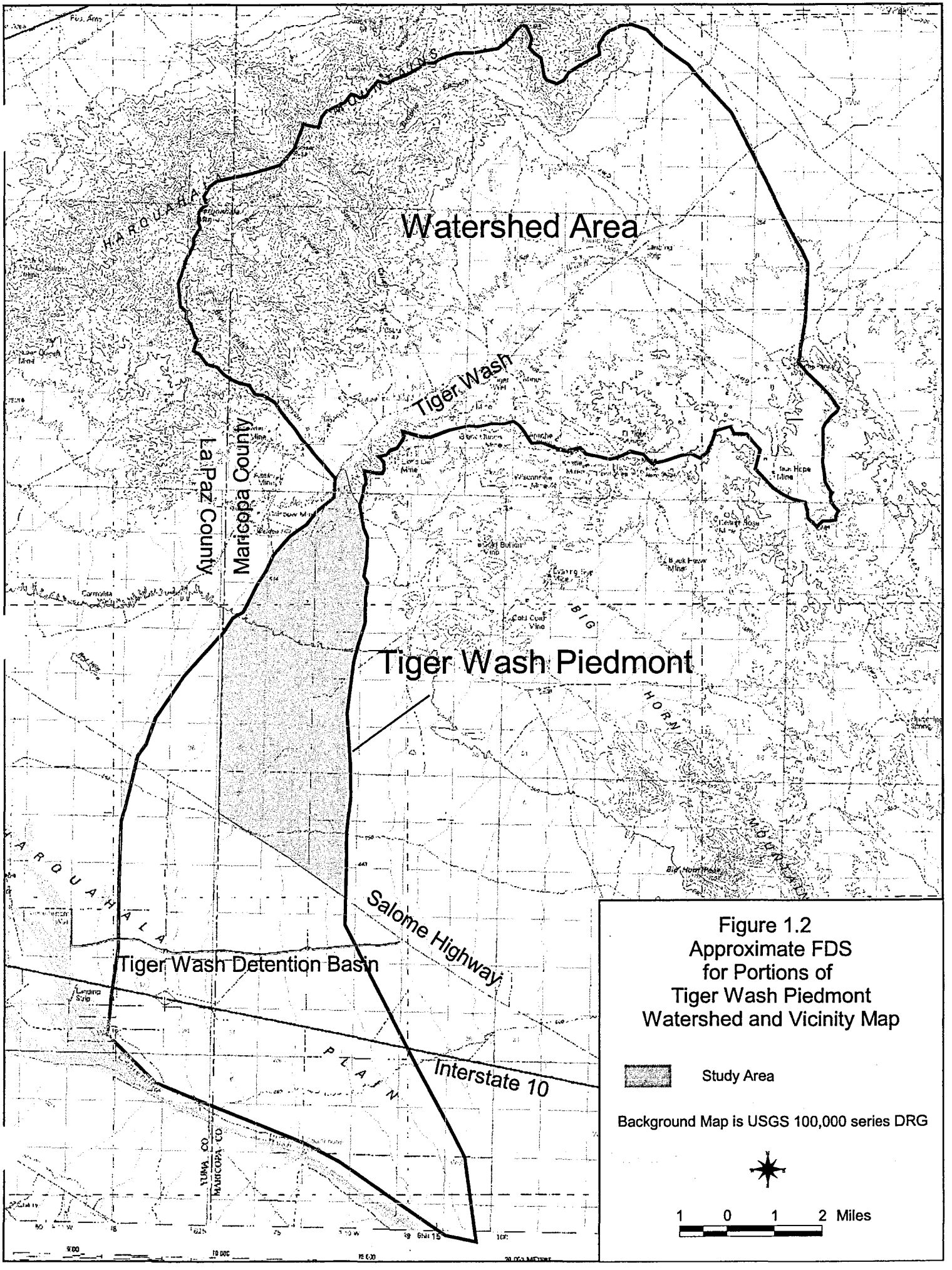

Figure 1.2
Approximate FDS
for Portions of
Tiger Wash Piedmont
Watershed and Vicinity Map

SECTION 2: ADWR/FEMA Forms and Local Government/ADWR Abstracts

2.1 Study Documentation Abstract for FEMA Submittals

Study Documentation Abstract For FEMA Submittals	Initial Study	Restudy	CLOMR	LOMR	X	Other

Section 2.1: Study Documentation Abstract for FEMA Submittals		
2.1.1	Date Study Accepted	
2.1.2	Study Contractor	JE Fuller / Hydrology and Geomorphology, Inc.
	Contact(s)	Jonathan E. Fuller, P.E.
	Address	5235 S. Kyrene Road, Suite 205 Tempe, AZ 85283
	Phone	(480) 752-2124
	Internal Reference Number	
2.1.3	FEMA Technical Review Contractor	
	Contact(s)	
	Address	
	Phone	
	Internal Reference Number	
2.1.4	FEMA Regional Reviewer	Michael Baker, Jr. Engineering
	Phone	(703) 960-8800
2.1.5	State Technical Reviewer	Arizona Department of Water Resources
	Phone	(602) 417-2445
2.1.6	Local Technical Reviewer	Flood Control District of Maricopa County
	Phone	(602) 506-1501
2.1.7	Reach Description	
2.1.8	USGS Quad Sheet(s) with original photo date & latest Photo revision date	Weldon Hill, photo dates 1951 and 1960, limited photo revision from 1984 photography Courthouse Well, photo dates 1951 and 1960, limited photo revision from 1984 photography
2.1.9	Unique Conditions and Problems	Alluvial fan
2.1.10	Coordination of Peak Discharges (Agency, Date, Comments)	USGS Annual Water Data Report AZ-97-1, 1997 USGS WRIR 98-4225, 1998

2.2 FEMA Forms

FEDERAL EMERGENCY MANAGEMENT AGENCY REVISION REQUESTER AND COMMUNITY OFFICIAL FORM	O.M.B No. 3067-0148 Expires April 30, 2001

Public reporting burden for this form is estimated to average 2.13 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

1. REQUESTED RESPONSE FROM FEMA

This request is for a:

☐ CLOMR A letter from 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 FEMA officially revising the current NFIP map to show the changes to floodplains, floodway or flood elevations. LOMRs typically decrease flood hazards. (See 44 CFR Ch. 1 Parts 60 & 65.)

☐ Other Describe:

2. OVERVIEW

1. The basis for this revision request is (are): (check all that apply)

☐ Physical Change ☐ Improved Methodology/Data ☐ Floodway Revision

☒ Other Describe: New Flood Insurance Study

Note: A photograph is not required, but is very helpful during review.

2. Flooding Source: Tiger Wash

3. Project Name/Identifier: Tiger Wash Approximate Floodplain Delineation Study FCD No. 98-48, Assignment No. 1

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

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

Community No.	Community Name	State	Map No.	Panel No.	Effective Date
Ex: 480301 480287	Katy, City Harris County	TX TX	480301 48201C	0005D 0220G	02/08/83 09/28/90
040037	Unincorporated Maricopa County	AZ	04013C	0975D	Not printed
040037	Unincorporated Maricopa County	AZ	04013C	1425E	09/04/91

6. The area of revision encompasses the following types of flooding and structures. Check all that apply.

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

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

Form 81-89, May 97 Revision Requester and Community Official Form MT-2 Form 1 Page 1 of 2

4. ENCROACHMENT INFORMATION

1. Does the State have jurisdiction over the floodway or its adoption by communities participating in the NFIP?
☐ Yes ☒ No

If Yes, attach a copy of a letter notifying the appropriate State agency of the floodway revision and documentation of the approval of the revised floodway by the appropriate State agency.

2. Does the development in the floodway cause the 1% annual chance (base) elevation to increase at any location by more than 0.000 feet? ☐ Yes ☐ No ☒ N/A

3. Does the cumulative effect of all development that has occurred since the effective SFHA was originally identified cause the base flood elevation to increase at any location by more than one foot (or other increase limit if community or state has adopted more stringent criteria - even if a floodway has not been delineated by FEMA)?
☐ Yes ☒ No

If the answer to either items is Yes, please attach documentation that all requirements of Section 65.12 of the NFIP regulations have been met, regarding evaluation of alternatives, notice to individual legal property owners, concurrence of CEO, and certification that no insurable structures are impacted.

5. MAINTENANCE RESPONSIBILITY

The community is willing to assume responsibility for ☐ performing ☐ overseeing compliance with the maintenance and operation plans of the ___ (Name)
flood control structure. If not performed promptly by an owner other than the community, the community will provide the necessary services without cost to the Federal government.
Operation and maintenance plans are attached. ☐ Yes ☐ No ☒ N/A

6. REVIEW FEE

The review fee for the appropriate request category has been included. ☒ Yes Fee amount: $

OR

This request is based on a federally sponsored flood-control project where 50 percent or more of the project's cost is federally sponsored, or the request is based on detailed hydrologic and hydraulic studies conducted by Federal, State, or local agencies to replace approximate studies conducted by FEMA and shown on the effective FIRM; thus the project is fee exempt.
☐ Yes
Please see Instructions for Fee Amounts

7. SIGNATURE

Note: I understand that my signature indicates that all information submitted in support of this request is correct Signature of Revision Requester Jonathan E. Fuller, P.E., P.H. Printed Name and Title of Revision Requester JE Fuller / Hydrology & Geomorphology, Inc. Company Name Telephone No.: (480)752-2124 Date: 6/8/00	*Note:* Signature indicates that the community understands, from the revision requester, the impacts of the revision on flooding conditions in the community. Signature of Community Official Michael S. Ellegood, Chief Engineer and General Manager Printed Name and Title of Community Official Flood Control District of Maricopa County Community Name Telephone No.: (602)506-1501 Date:
CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR This certification is in accordance with 44 CFR Ch. 1, Sect 65.2 Signature Jonathan E. Fuller, P.E., P.H. Printed Name and Title of Revision Requester Registr No. 26846 Expires (Date) 3/31/02 State AZ Type of License/Expertise: Civil	Check which forms have been included with this request ☒ Hydrologic (3) — new or revised discharges ☒ Hydraulic (4) — new or revised water-surface elevations ☒ Mapping (5) — floodplain/floodway changes ☐ Channelization (6) — channel is modified ☐ Bridge/Culvert (7) — addition/revision of bridge/culvert ☐ Levee/Floodwall (8) — addition/revision of levee/floodwall ☐ Coastal (9) — new or revised coastal elevations ☐ Coastal Structures (10) — addition/revision of coastal structure ☐ Dam (11) — addition/revision of dam ☐ Alluvial Fan (12) — structures proposed on alluvial fan

Form 81-89, May 97 Revision Requester and Community Official Form MT-2 Form 1 Page 2 of 2

FEDERAL EMERGENCY MANAGEMENT AGENCY RIVERINE HYDRAULIC ANALYSIS FORM	O.M.B No. 3067-0148 Expires April 30, 2001

Public reporting burden for this form is estimated to average 2.25 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

Note: Fill out one form for each flooding source studied

Community Name: Unincorporated Maricopa County

Flooding Source: Tiger Wash

Project Name/Identifier: Tiger Wash Approximate Floodplain Delineation Study, FCD No. 99-48, Assignment No. 1

1. REACH TO BE REVISED

Describe the limits of the revision OR submit a copy of the FIRM with the revision area clearly highlighted.
Copy of FIRM(s) attached depicting area of the revision (highlighted, or circled)? ☐ Yes
Downstream Limit: Salome Highway
Upstream Limit: Blue Tank Canyon

2. MODELS SUBMITTED

Requirements: for areas which have detailed flooding:	for areas which do not have detailed flooding:
Full input and output listings along with files on diskette for each of the models listed below (items 1-4) and a summary of the source of input parameters used in the models must be provided. The summary must include a description of any changes made from model to model (e.g., Duplicate Effective model to Corrected Effective model). At a minimum, the Duplicate Effective (item 1) and the Revised or Post-Project Conditions (item 4) models must be submitted. See instructions for directions on when other models may be required.	Only the 100-year (Base) flood profile is required. A hydraulic model is not required for areas which do not have detailed flooding; however, BFEs may not be added to the revised FIRM. If a hydraulic model is developed for the area, items 3 and 4 described below must be submitted.

If hydraulic models are not developed, hydraulic analyses (including all calculations) for existing or pre-project conditions and revised or post-project conditions must be submitted.

1. Duplicate Effective Model ☐ Natural File Name ___ ☐ Floodway File Name
Copies of the hydraulic analysis used in the effective FIS, referred to as the effective models (10-, 50-, 100-, and 500-year multi-profile runs and the floodway run) must be obtained and then reproduced on the requester's equipment to produce the Duplicate Effective model. This is required to assure that the effective models input data has been transferred correctly to the requester's equipment and to assure that the revised data will be integrated into the effective data to provide a continuous FIS model upstream and downstream of the revised reach.

2. Corrected Effective Model ☐ Natural File Name ___ ☐ Floodway File Name
The Corrected Effective model is the model that corrects any errors that occur in the Duplicate Effective model, adds any additional cross sections to the Duplicate Effective model, or incorporates more detailed topographic information than that used in the currently effective model. The Correctly Effective model must not reflect any man-made physical changes since the date of the effective model. An error could be a technical error in the modeling procedures, or any construction in the floodplain that occurred prior to the date of the effective model but was not incorporated into the effective model.

3. Existing or Pre-Project Conditions Model ☐ Natural File Name _____ ☐ Floodway File Name _____
The Duplicate Effective model or Corrective Effective model is modified to produce the Existing or Pre-Project Conditions model to reflect any modifications that have occurred within the floodplain since the date of the Effective model but prior to the construction of the project for which the revision is being requested. If no modification has occurred since the date of the effective model, then this model would be identical to the Corrected Effective model or Duplicate Effective model.

4. Revised or Post-Project Conditions Model ☐ Natural File Name ___ ☐ Floodway File Name
The Existing or Pre-Project Conditions model (or Duplicate Effective model or Corrected Effective model, as appropriate) is revised to reflect revised or post-project conditions. This model must incorporate any physical changes to the floodplain since the effective model was produced as well as the effects of the project. When the request is for the proposed project this model must reflect proposed conditions.

5. Other – Please attach a sheet describing all other models submitted along with the file names. ☐ Natural ☐ Floodway

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

Form 81-89C, May 97 Riverine Hydraulic Analysis Form MT-2 Form 4 Page 1 of 2

3. STARTING WATER-SURFACE ELEVATIONS

Explain how they were determined.
Explanation Attached? ☐ Yes ☐ No
NOTE: If the effective study is an approximate study, the slope/area method is recommended.
For detailed analysis studies, using a known water-surface elevation is recommended.

4. RESULTS (from the model used to revise the 100-year water surface elevations)

If the results indicate any of the following, attach an explanation - to this form, or to the hydraulic model printout- as to the reasonableness of the situation.

☐ Supercritial depth ☐ Critical Depth ☐ Drawdowns ☐ Negative Floodway Surcharges

☐ Floodway Surcharges Greater Than Maximum Allowed by Community/State

☐ Water surface elevations higher than the end points of cross sections.

☐ Floodway discharge is different than the Natural 100-year (base) flood discharge.

☐ Project causes 100-year floodplain or floodway elevations to increase (state if increases are located off the requester's property)

Explanation attached with Form ☐ Explanation provided on attached printout ☐
If Hydraulic model used is HEC-2, has it been checked with FEMA'S CHECK-2 computer program ☐ Yes ☐ No
(see instructions for information on how to obtain CHECK-2)

5. REVISED FIRM/FBFM AND FLOOD PROFILES

1. Profile Transition

a. 100-Year Water-Surface Elevations - indicate the difference in water surface elevations where the project 100-year elevations tie into the existing 100-year water surface elevations at each end of the project.

Downstream End: _____ within _____ (feet) Upstream End ___ within ___ (feet)

b. Floodway Elevations – indicate the difference in water surface elevations where the project floodway elevations tie into the existing floodway water surface elevations at each end of the project.

Downstream End: _____ within _____ (feet) Upstream End ___ within ___ (feet)

c. Floodway widths – indicate the difference in floodway widths where the project floodway widths tie into the existing floodway width at each end of the project.

Downstream End _____ within _____ (feet) Upstream End ___ within ___ (feet)
Cross-Section # *Cross-Section #*

2. Profile Checklist (check box if information has been provided on profile)

The following information (unless in parentheses) must be included at the same scale as the existing profiles for this project:

☐ Stream Name ☐ Community Name ☐ Corporate Limits labeled ☐ Study limits labeled

☐ Confluences labeled ☐ Channel Stationing ☐ Streambed profiled ☐ Cross Sections labeled

☐ Horizontal/Vertical Scales indicated ☐ 100-year elevs profiled*

☐ Road Crossings ☐ Labeled ☐ Low Chord Elevations ☐ Top of Road Elevations

*All recurrence intervals in the effective study must also be profiled.
Floodway Data Table
Attach a Floodway Data Table for each cross section listed in the published Floodway Data table in the FIS report.
Floodway Data Table Attached ☐ Yes ☐ Not Required

Form 81-89, May 97 Riverine Hydraulic Analysis Form MT-2 Form 4 Page 2 of 2

FEDERAL EMERGENCY MANAGEMENT AGENCY RIVERINE / COASTAL MAPPING FORM	O.M.B No. 3067-0148 Expires April 30, 2001

Public reporting burden for this form is estimated to average 1.5 hours per response. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and reviewing the form. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing this burden to: Information Collections Management, Federal Emergency Management Agency, 500 C Street, S.W., Washington DC 20472; and to the Office of Management and Budget, Paperwork Reduction Project (3067-0148), Washington, DC 20503.

You are not required to respond to this collection of information unless a valid OMB Control Number is displayed in the upper right corner of this form.

Note: Fill out one form for each flooding source studied

Community Name: Unincorporated Maricopa County

Flooding Source: Tiger Wash

Project Name/Identifier: Tiger Wash Approximate Floodplain Delineation Study, FCD No. 99-48, Assignment No. 1

This is a ☒ Manual ☐ Digital submission. *Digital map submissions may be used to update digital FIRMs (DFIRMs). For updating DFIRMs, these submissions must be coordinated with FEMA Headquarters as far in advance as possible.*

1. MAPPING CHANGES

1. A topographic workmap must be submitted showing the following information (check N/A when not applicable):

a.	Revised approximate 100-year floodplain boundaries (Zone A)	☐ Yes	☐ No	☒ N/A
b.	Revised detailed 100- and 500-year floodplain boundaries.	☐ Yes	☐ No	☒ N/A
c.	Revised floodway boundaries	☐ Yes	☐ No	☒ N/A
d.	Location and alignment of all cross sections with stationing control indicated.	☐ Yes	☐ No	☒ N/A
e.	Stream alignments, road alignments and dam alignments.	☒ Yes	☐ No	☐ N/A
f.	Current community boundaries.	☒ Yes	☐ No	☐ N/A
g.	Effective 100- year floodplain and floodway boundaries from FIRM/FBFM reduced or enlarged to the scale of the topographic workmap	☐ Yes	☐ No	☒ N/A
h.	Tie-ins between the effective and revised 100-, 500-year and floodway boundaries	☐ Yes	☐ No	☒ N/A
i.	The requester's property boundaries and community easements	☐ Yes	☐ No	☒ N/A
j.	The signed certification of a registered professional engineer	☐ Yes	☐ No	☒ N/A
k.	Location and description of reference marks	☐ Yes	☐ No	☒ N/A
l.	Vertical datum (example: NGVD, NAVD)	☐ Yes	☐ No	☒ N/A
m.	Coastal zone designations tie into adjacent areas not being revised	☐ Yes	☐ No	☒ N/A
n.	Location and alignment of all coastal transects used to revise the coastal analyze	☐ Yes	☐ No	☒ N/A
o.	V-zone has been delineated to extend landward to the heel of the primary frontal dune	☐ Yes	☐ No	☒ N/A

If any items are marked No or N/A please attach an explanation.

2. What is the source and date of the updated topographic information (example: orthophoto maps, July 1985; filed survey, May 1979, beach profile, June 1987 etc.)? No detailed mapping performed

3. What is the scale and contour interval of the following workmaps?

Effective FIS Scale _____ Contour Interval _____

Revision Request Scale 1"=2000' Contour Interval 20'

NOTE: Revised topographic information must be of equal or greater detail than effective.

4. Attach an annotated FIRM/FBFM at the scale of the effective FIRM/FBFM showing the revised 100- and 500-year floodplain and the floodway boundaries and how they tie into those shown on the effective FIRM/FBFM downstream and upstream of the revisions or adjacent to the area of revision for coastal studies. FIRM/FBFM attached? ☐ Yes ☒ No

PLEASE REFER TO THE INSTRUCTIONS FOR THE APPROPRIATE MAILING ADDRESS

Form 81-89D, May 97 Riverine / Coastal Mapping Form MT-2 Form 5 Page 1 of 2

2. EARTH FILL PLACEMENT

1. The fill is: ☐ Existing ☐ Proposed ☒ N/A

2. Has fill been/will be placed in the regulatory floodway? ☐ Yes ☐ No
If Yes, please attach completed Riverine Hydraulic Analysis Form (Form 4).

3. Has fill been/will be placed in floodway fringe (*area between the floodway and 100-year floodplain boundaries*)? ☐ Yes ☐ No

If Yes, then complete A, B, C, and D below.

a. Are fill slopes for granular materials steeper than one vertical on one-and-one-half horizontal? ☐ Yes ☐ No

If Yes, justify steeper slopes _____

b. Is adequate erosion protection provided for fill slopes exposed to moving flood waters? (*Slopes exposed to flows with velocities of up to 5 feet per second (fps) during the 100-year flood must, at a minimum, be protected by a cover of grass, vines, weeds, or similar vegetation; slopes exposed to flows with velocities greater than 5 fps during the 100-year flood must, at a minimum, be protected by stone or rock riprap.)*

☐ Yes ☐ No

If No, describe erosion protection provided _____

c. Has all fill placed in revised 100-year floodplain been compacted to 95 percent of the maximum density obtainable with the Standard Proctor Test Method or acceptable equivalent method? ☐ Yes ☐ No

d. Can structures conceivably be constructed on the fill at any time in the future? ☐ Yes ☐ No

If Yes, attach certification of fill compaction (item 3c. above) by the community's NFIP permit official, a registered professional engineer, or an accredited soils engineer in accordance with Subparagraph 65.5(a)(6) of the NFIP regulations.

Fill certification attached ☐ Yes ☐ No

4. Has fill been/will be placed in a V zone? ☐ Yes ☐ No

If Yes, is the fill protected from erosion by a flood control structure such as a revetment or seawall?

☐ Yes ☐ No

If Yes, attach the Coastal Structures Form (Form 10).

Riverine/Coastal Mapping Form MT-2 Form 5 Page 2 of 2

Explanations

1.a. No existing FIS in area approximate or otherwise.
1.b. This is an approximate study. No detailed boundaries were mapped.
1.c. No floodway mapped.
1.d. Not a detailed study.
1.g. No effective floodplains or floodways in area mapped. Panel 04013C0975D is not printed. Panel 04013C 1425E is not studied in the areas mapped for this study.
1.h. No previous studies in area mapped.
1.i. Study for Flood Control District of Maricopa County.
1.j, k., and l. No detailed mapping performed or base flood elevations calculated as this is an approximate study.
1. m.,n., and o. No coastal or V- zones.

SECTION 3: SURVEY AND MAPPING INFORMATION

3.1 Field Survey Information

The only field surveys performed for this study were for the purposes of estimating the peak discharges of the September 1997 flood event at various places on the piedmont. These survey data and results are provided in Appendix D. The Arizona Geological Survey (AZGS) also surveyed transects of portions of the piedmont at four locations to assist in the mapping of the extent of the September 1997 flood. The work by AZGS was done for FCD 98-48, Assignment No. 2. Locations, plots and survey data for these transects are shown in Appendix E.3 of the TDN.

3.2 Mapping

The AZGS mapped the lateral extent of the September 1997 flood by a combination of aerial photograph interpretation and field investigations. This mapping served as one basis for the approximate floodplain delineation. The methods and results of the AZGS effort are summarized in Appendix E.

The primary mapping used for this project was the most recent USGS 7.5 minute topographic quadrangles for the study area. Digital raster graphic versions of the quadrangles that had been projected to NAD State Plane 1983 and tiled by the Flood Control District of Maricopa County were used to compile and present the various types of data analyzed for this study.

SECTION 4: HYDROLOGY

4.1 Method Description

The hydrologic information used in this study included a flood-flow-frequency analysis of the upstream USGS gage data, evaluation of previously published paleoflood surveys, and detailed inundation mapping of the flood of September 26, 1997. These analyses indicated that the September 1997 flood reasonably approximated the 100-year flood. Therefore, it was deemed an excellent starting point for the approximate delineation of the floodplain limits for the Tiger Wash piedmont.

4.2 Gage Data

One streamflow gaging station is operated on Tiger Wash. It is located upstream of the Blue Tank Canyon confluence in the SW1/4 SW1/4 T5N, R10W, Sec. 26. The gage is a crest-stage gage and is operated by the U.S. Geological Survey (USGS) who refer to it as 'Tiger Wash near Aguila, AZ (09517280)'. It has a period of record for annual maximum discharge estimates for the period 1963-1979, 1983, and 1991 to the present. The annual maximum discharge data were collected from USGS publications including Garrett and Gellenbeck (1991), Pope and others (1998), and the annual Water Resource Data reports for Arizona.

Table 4.2.1 Annual Maximum Discharges
Tiger Wash near Aguila, 09517280

Month	Day	Year	Discharge (cfs)	Month	Day	Year	Discharge (cfs)
8	16	1963	910	9	25	1976	3,000
10	19	1963	400	8	16	1977	870
8	18	1965	1,680	3	1	1978	1,400
9	13	1966	1,450	12	18	1978	60
8	14	1967	620	9	0	1983	3,170
12	19	1967	440	3	27	1991	69
9	14	1969	441	3	3	1992	906
8	20	1970	4,550	1	8	1993	1,040
8	20	1971	2,000	7	18	1994	3,640
8	0	1972	2,770	2	15	1995	185
10	6	1972	1,750	1	1	1996	0
8	3	1974	45	9	26	1997	8,070
7	30	1975	100	3	26	1998	683

The most extreme event in the historical record from the USGS gaging station occurred on September 26, 1997. The evidence left by this flood is still visible in the field and on recent aerial photographs (AMC, 3/30/99). The Arizona Geological Survey, as part of Assignment No. 2 of FCD No. 98-48, mapped the extents of this flood within the study area.

In addition to the USGS gaging station, the Flood Control District of Maricopa County operates three real-time recording tipping bucket rain gages within the watershed. FCDMC and National

Weather Service personnel used these gages to monitor the storm as it progressed in September 1997. One of the gages is located in the highest part of the watershed near its divide on Harquahala Mountain (#5185). Another is located in the lower elevation upstream portion of the watershed about 11 miles south of Aguila, Arizona off Eagle Eye Road (#5130). The third rain gage is located on the Tiger Wash piedmont in Section 20, T4N, R10W (#5140). The installation dates, elevations, and locations of these stations are given in Table 4.2.3.2.

Table 4.2.2 FCDMC Precipitation Gages in Tiger Wash Watershed

Gage Name	FCDMC ID#	Installation Date	Elevation (feet)	TRS	Latitude	Longitude
Harquahala Mtn.	5185	02/10/1994	5,680	T5N-R10W-Sec. 6	33° 48' 43"	113° 20' 48"
Upper Tiger Wash	5130	11/01/1981	2,200	T5N-R9W-Sec. 2	33° 48' 40"	113° 10' 25"
Tiger Wash Fan	5140	09/21/1994	1,605	T4N-R10W-Sec. 20	33° 40' 06"	113° 18' 54"

As can be seen in Table 4.2.2, only gage 5130 has a period of record longer than 5 years. During the nearly 18 years of its operation, the greatest 24 hour total rainfall recorded by gage 5130 was 3.78". This occurred on September 26, 1997. For that same event, gage 5140 recorded 4.17" of rainfall and gage 5185 recorded 11.97". The 24-hour total at gage 5185 is the largest total even recorded by the FCDMC ALERT system and exceeds the highest recorded 24-hour rainfall in the State of Arizona (11.40" at Workman Creek on September 4-5, 1970).

The NOAA Atlas II 100-year 24-hour point rainfall values are shown in Figure 4.2.1.

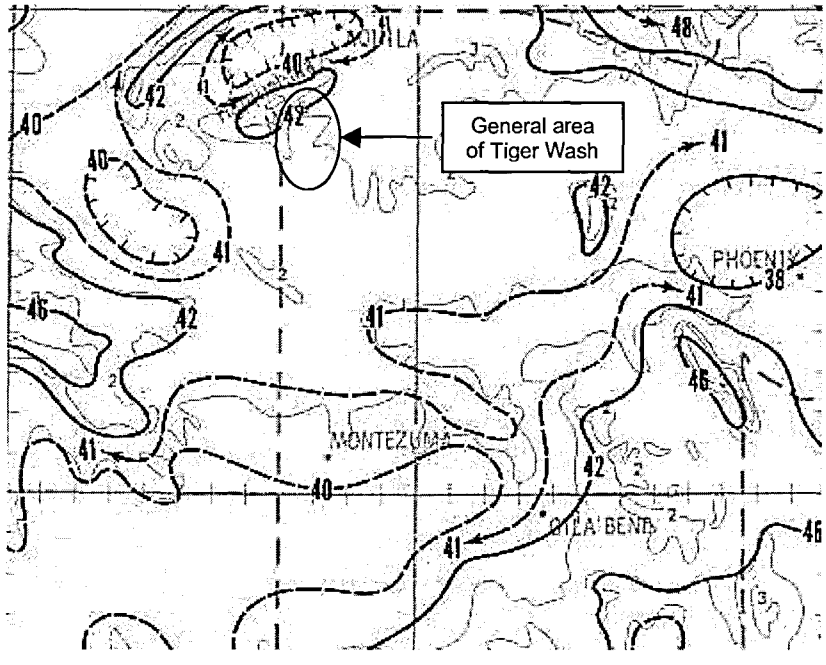

Figure 4.2.1. NOAA Atlas II 100-year 24-hour Rainfall

The NOAA Atlas II indicates a 100-year 24-hour point rainfall value for the Tiger Wash watershed of about 4.15 inches. This is almost exactly the 24-hour rainfall total recorded at gage

5140 on September 26, 1997. Further, the areally reduced rainfall for 96 square miles using the HYDRO 40 reduction curves as given in the Drainage Design Manual for Maricopa County, Volume I, Hydrology is about 3.5 inches. All three rain gages within the watershed recorded well above 3.5 inches in a 24-hour period.

4.3 Flood Flow Frequency

The USGS has two published Water Resource Investigation Reports which computed flood flow frequency for the gage on Tiger Wash. The results of these analyses are given below.

Table 4.3.1 USGS Flood Flow Frequency for Tiger Wash near Aguila, 09517280

Source	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Period of Record
WRIR 91-4041	1,010	2,120	3,060	4,450	5,630	6,910	63-79,83
WRIR 98-4225	961	2,140	3,160	4,670	5,950	7,340	63-79,83,91-96

As can be seen from Table 4.3.1, the September 1997 flood of 8,070 cfs (Tadayon, et al., 1998) exceeded the 100-year peak discharge at the gaging station according to the published USGS flood frequency statistics.

Another source to consider for flood flow frequency is the regional regression equations (Thomas, et al., 1997). The regional equations incorporate records from gages within a region which presumably should effectively extend the record for frequency analysis. Table 4.3.2 shows the estimates of peak discharges for various return periods for Region 13 (the region within which Tiger Wash watershed lies). Table 4.3.3 shows the range of values based on the statistical standard error of estimate for the regression equations for Region 13. The tables show that while the regression equation estimate of the is larger than the September 1997 flood, the September flood lies well within the standard error of the 100-year flood on Tiger Wash. Given the gage specific frequency statistics from published USGS documents and the standard error of the regression equations, the September 1997 flood may represent a reasonable approximation of the 100-year flood for Tiger Wash.

Table 4.3.2 Regional Regression Equation Estimates of Peak Discharges Region 13 (Thomas, et al., 1997)

		Peak Discharge, in cfs					
Location	Drainage Area	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
@ USGS Gage (09517280)	85.2	1,242	2,887	4,526	7,205	9,586	12,601
@ Hydrographic Apex (below Blue Tank Canyon)	96.4	1,314	3,043	4,766	7,577	10,071	13,222

Table 4.3.3 Standard Error of Peak Discharge for Region 13 at USGS Gage and Hydrographic Apex									
Recurrance	@ Gage	Standard Error				@ Apex	Standard Error		
Interval	Q, in cfs	%	cfs	low	high	Q, in cfs	cfs	low	high
2-yr	1,242	57	708	534	1,951	1,314	749	565	2,063
5-yr	2,887	40	1,155	1,732	4,042	3,043	1,217	1,826	4,260
10-yr	4,526	37	1,675	2,852	6,201	4,766	1,763	3,002	6,529
25-yr	7,205	39	2,810	4,395	10,015	7,577	2,955	4,622	10,532
50-yr	9,586	43	4,122	5,464	13,708	10,071	4,330	5,740	14,401
100-yr	12,601	48	6,049	6,553	18,650	13,222	6,347	6,875	19,568
Standard Errors from Thomas, et al. (1997).									

Additionally, the maximum stage of the September 1997 flow near the USGS gaging station was about 2 feet lower than the maximum paleoflood indicators investigated by CH2M Hill (1992). Their 1992 report indicated the maximum paleoflood magnitude at between 10,000 and 13,000 cfs. They also found evidence indicating that at least 3 floods between 6,000 and 10,000 cfs had occurred in the past 100 years (up to 1992). The September 1997 flood was, therefore, about as big as any flood in that reach in the past 100 years. Repeat cross section surveys taken by the USGS at the gaging station indicate the removal of about 1 foot of channel bottom as well as a large channel bar near the gage during the September 1997 flood. Since 1970, the bed has degraded about 2 feet (Capesius, J. and Lehman, T, in press). This suggests that the September 1997 flood may have been even larger relative to the largest paleofloods in spite of its somewhat lesser maximum absolute water surface elevation.

4.4 Conclusions

Given the extreme nature of the precipitation and flood discharge described above and their relation to the published USGS statistical analyses and the NOAA Atlas II data, it seems reasonable to conclude that the September 26, 1997 storm and resultant flood can be considered a good approximation of the 100-year flood event for Tiger Wash. As such, this flood will serve as a fundamental basis of the approximate delineation of the floodplain for Tiger Wash in this study. The manner in which the extents of the 1997 flood were incorporated into the approximate floodplain delineation are described further in Section 5 of the TDN.

4.5 References

Aerial Mapping Company, Flown March 30, 1999. Color stereo aerial photography. Covering T3N, R11W, Sec. 1 and 12, T4N, R11W, Sec.13, 24, 25, and 36, T3N, R10W, Sec. 5, 6, 7, 8, 17, and 18, and T4N, R10W, Sec. 8, 17, 19, 20, 29, 30, and 31. Scale: 1:9600.

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SECTION 5: HYDRAULIC ANALYSIS

The only hydraulic analyses performed for this study were in the reconstruction of the September 1997 peak discharges. Slope-area and slope-conveyance methods were used to estimate the peak discharges at various sites on the piedmont. The methods and results of these analyses are presented in Appendix D.

SECTION 6A: EROSION AND SEDIMENT TRANSPORT

No specific erosion or sediment transport analyses were conducted as part of this study. However, implicit to the geomorphic assessment of the active alluvial fan areas were considerations of sedimentary processes on the Tiger Wash piedmont. Therefore, areas of erosion hazards associated with the active alluvial fan flooding have been included in the areas mapped as Zone AFHH on Sheet 4 of 4.

SECTION 6B: GEOMORPHOLOGY

This section of the Technical Data Notebook is included to provide a place for a description of the geomorphic methods and results used in this study to identify the 100-year flood hazards within the Tiger Wash piedmont study area. The outline of the presentation generally follows those presented in the *Piedmont Flood Hazard Assessment Manual* and the *FEMA Guidelines for Determining Flood Hazards on Alluvial Fans*. Since parts of the geomorphic assessment require consideration of hydrologic and hydraulic characteristics of the piedmont, some of the information presented in Section 4 and 5 may be represented in Section 6B.

6B.1 Method Description

The Tiger Wash Approximate Floodplain Delineation Study area is located in western Maricopa County, Arizona (Figure 1.1, 1.2, and Cover Sheet). The watershed encompasses approximately 96 square miles and generally flows in a south-southwesterly direction.

The approximate delineation for this study begins at the confluence of Blue Tank Canyon and Tiger Wash near the geologic apex of the alluvial fan. Downstream from this point Tiger Wash diverges into two branches called here the East Branch and West Branch. The East Branch flows nearly due south while the West Branch flows toward the southwest. The East Branch is labeled on the USGS quadrangle maps as Tiger Wash. The approximate floodplain delineation covers areas of the piedmont at risk of flooding from Tiger Wash and its distributaries south to Salome Highway within Maricopa County, Arizona. Flood hazards for the portions of the Tiger Wash piedmont in La Paz County were not mapped. This study includes delineation of a total of about 12.6 square miles of floodplain on the Tiger Wash distributary system.

This section of Technical Data Notebook is dedicated to a description of the methods used to identify the type and extent of the flood hazard within the study area. The organization of the presentation of these procedures and results follows the general outline presented in the *Piedmont Flood Hazard Assessment Manual for Maricopa County* (Hjalmarson, 1998) and the *Guidelines for Determining Flood Hazards on Alluvial Fans* (FEMA, 1999). Both of these documents describe a procedure that follows a three stage process: 1) recognizing and characterizing piedmont landforms, 2) identifying the active or unstable and inactive or stable areas of the piedmont, and 3) defining and characterizing the flood hazard. The geomorphic analysis was the basis for the flood hazard delineation for the entire Tiger Wash piedmont.

6B.2 Work Study Maps

This floodplain delineation study includes geomorphic mapping and floodplain delineation of parts of the Tiger Wash piedmont. A reduced set of the work maps (Sheets 1 through 4), including a cover sheet showing the project location, is included at the end of Section 6B of the Technical Data Notebook. The full size (24" X 36", 1"=2,000' scale) study work maps are located in the map pockets at the back of the Notebook. The processes and rationale used to create these maps are described in the following sections.

6B.3 Description of Approach

The assessment of the 100-year flood hazard on the Tiger Wash piedmont generally follows the procedures outlined in the *Piedmont Flood Hazard Assessment Manual for Maricopa County(PFHAM)* (Hjalmarson, 1998). The *Guidelines for Determining Flood Hazards on Alluvial Fans* (FEMA, 2000) were also used to structure the analysis and presentation of results for this study. In particular, the geomorphic method for an approximate floodplain delineation discussed in the FEMA *Guidelines* served as the basis for identification of the 100-year flood hazard area in this study area.

The *PFHAM* method is founded on an approach to alluvial fan flood hazard assessment outlined in the National Research Council's 1996 *Alluvial Fan Flooding* report. Both documents describe a three stage method to identification of alluvial fan flood hazards.

The first stage is the recognition and characterization of piedmont landforms. Data from published sources including topographic maps, NRCS soils surveys, geologic mapping, aerial photographs, and field observations are the basis for discrimination of piedmont landforms which include mountains, inselbergs, alluvial fans, relict alluvial fans, pediments, and alluvial plains. Also identified for alluvial fan landforms are the location of the topographic and hydrographic apexes of the alluvial fan. The hydrographic apex is of particular interest because it is the location at which flow of water and sediment becomes unconfined and spreads out rapidly. The result of the sudden expansion of flow is deposition of sediment and unpredictable direction of flood flows below this point. The complex hydraulics associated with this expansion and deposition create significant uncertainties (unpredictability) that can often not be set aside in the realistic assessment of the flood hazard near the hydrographic apex and for some distance downstream.

The second stage is the identification of active and inactive areas of the piedmont. 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. The second stage also shall identify the portions of the piedmont subject to various types of flooding such as stable riverine flooding, active alluvial fan flooding, inactive alluvial fan flooding, and broad sheetflooding.

In the geomorphic approach, surface characteristics that inform on surface stability are assessed and compiled. Surface characteristics such as vegetation patterns, presence or absence of rock varnish and desert pavement, and degree of soil development provide important information. Surfaces with well developed soils, rock varnish, and desert pavement, for example, have developed these features because they have not experienced significant inundation or erosion for thousands of years. Hence, it can be inferred that they will continue to remain free from flooding in the future. Similarly, areas strongly dissected by drainage channels are less likely to unpredictably change their location than channels with little to no lateral relief relative to the neighboring land. Historical aerial photographs can also be examined to see if any movement of channel positions can be detected over the photographic record. In many instances, 50 to 60 years of record can be obtained from aerial photographs. All of these types of characteristics are considered together to produce a map of areas subject to flooding and those not subject to flooding. Further, the areas subject to flooding are evaluated and mapped as to whether the flooding is across or within stable surfaces and channels or unstable ones.

The third and final stage of the *PFHAM* method is to identify the areas subject to flooding for the 100-year flood event. Methods available for the third stage range from conventional detailed or approximate hydraulic methods using fixed-bed hydraulic models or Manning's equation to geomorphic interpretation of field observations and aerial photographs. Approaches combining conventional engineering approach and geomorphology are also strongly advocated. This study will rely solely on geomorphic interpretation of the piedmont surface characteristics.

In this study, the reconstruction of a recent, large flood will also be incorporated in the Stage 2 and Stage 3 analyses. In September 1997, a large flood occurred on the Tiger Wash piedmont. The details of this flood are presented in Section 4 and Appendices D and G. The significance of this flood to the flood hazard assessment is that it provides important data as to the nature, location, and extent of alluvial fan flooding on the Tiger Wash piedmont.

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

The first stage of the assessment of the flood hazard on the Tiger Wash piedmont was to distinguish the types of landforms which compose the piedmont based on a variety of characteristics as shown on soils maps, surficial geology maps, topographic maps, aerial photographs, and from field observations. These data also begin to reveal the identification of active and inactive areas of the piedmont which will be detailed in Stage 2.

Landforms as indicated by NRCS soil survey

Figure 6B.4.1 shows the NRCS soil map units from the *Soil Survey of Aguila-Carefree Area* (Camp, 1986). In addition to showing the map unit boundaries and designations, Figure 6B.4.1 shows the setting or type of landform which are generally associated with each of the various map units. Three main categories of landforms are distinguished by the NRCS: 1) drainageways, floodplains, and alluvial fans, 2) alluvial fan terraces, and 3) mountains and hillslopes. Table 6B.4.1 shows the important characteristics of each soil unit to the flood hazard assessment. Copies of the complete soil unit descriptions for the study area from Camp (1986) are provided in Appendix G.1

Table 6B.4.1 also shows the relationship between the NRCS soil map units and the landforms of the Tiger Wash piedmont. 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.4.1. These characteristics help identify the landform type, as well as the stability and the flood history and flood potential of the unit.

The NRCS soils maps show an area of Brios-Carrizo complex (unit 10) which begins branching into two and then three arms downstream of Blue Tank Canyon. All three branches terminate into Momoli-Carrizo complex (unit 92). The center branch rejoins the west branch downstream of an inselberg shown as unit 100 just west of Eagle Eye Road. The West Branch then continues southwest across about 1.5 miles of Momoli-Carrizo complex before returning to an area also identified as Brios-Carrizo complex. The East Branch flows south across a short reach of Momoli-Carrizo complex and then Chuckwalla-Gunsight complex before rejoining the Brios-Carrizo area east of Eagle Eye Road.

The Brios soil series is identified as found on floodplains and in larger desert drainageways. The Carrizo series is found on floodplains, drainageways, alluvial fans, fan terraces and stream terraces. The units are subject to occasional flooding and the hazard due to erosion is severe. This description by the NRCS matches well with field observations. The areas shown as unit 10 and 11 are the locations of the most channelized, highest velocity flows, where the hazard of inundation, erosion, and/or deposition is the greatest of all locations on the piedmont.

The Momoli series is associated with stream and fan terraces. While found on terraces, the soils themselves are weakly developed but also strongly effervescent at depth. As will be seen in the surficial geology data, the unit 92 area corresponds with large areas of late Pleistocene and early Holocene surfaces. That is, these are areas that have been largely removed from active inundation and sedimentation for at least several thousand years. Nevertheless, unit 92 is comprised of alluvial deposits with significant portions associated with alluvial fans.

The Gilman soil series found in units 56 and 59 is found on floodplains and alluvial fans. Unit 59 also has 25% Momoli and 20% Denure series which are associated with stream and fan terraces.

Units 19 and 20 are comprised of Chuckwalla and Gunsight soils series associated with tops and sides of fan terraces respectively. These soils are found on old surfaces generally free from flooding. On the Tiger Wash piedmont they are located along the east and downstream of the hydrographic apex. This area represents primarily the east shore terrace of the Tiger Wash alluvial fan landform with the major washes generally entrenched into and flowing through but not over these surfaces.

The Sal-Cipriano complex makes up units 106 and 107. Half of these units are Sal series which are found on fan terraces, in particular, on the tops of terraces. The Sal soils are characterized by 70-95% coverage with varnished desert pavements. The Cipriano series , on the other hand, is located on terrace side slopes and does not have desert pavement. However, the Cipriano series is characterized by a reddish yellow color and is calcareous with a significant silica-cemented hardpan at about 20 inches depth. On the Tiger Wash piedmont these units are found on the oldest surfaces on the northwest part of the alluvial fan, as well as in the area between the lower active areas of units 56 on the East and West Branches.

The above description of the soils of the Tiger Wash piedmont is consistent with the common soil types for alluvial fans shown in Table 2.1 of the *PFHAM.* The soil survey data clearly shows the piedmont to be composed of sedimentary deposits located at the base of a mountain front and having the shape of a partially extended fan. Therefore, it can be concluded that, with the exception of a few bedrock islands, the Tiger Wash piedmont in the study area is an alluvial fan. However, the NRCS soil survey was done for a very large area and the map units are composed of multiple soil types. Therefore, a more detailed surficial geologic map was produced.

N

WEST BRANCH TIGER WASH

EAST BRANCH TIGER WASH

Eagle Eye Road

Salome Highway

Blue Tank Canyon

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH
APPROXIMATE FLOODPLAIN
DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

NRCS SOIL SURVEY DATA

JUNE 2000

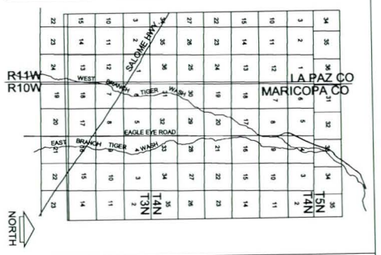
LEGEND

- Drainageways, floodplains, and alluvial fans
- Fan terraces
- Mountains and hillslopes
- 92 NRCS Soil Map Unit

NOTES

Soils data from Camp (1986).

INDEX MAP



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JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN	TWL	8-99
DESIGN CHK.	JEF	8-99
PLANS	TWL	8-99
PLANS CHK.	BRI	8-99

SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

Figure 6B.4.1

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH
APPROXIMATE FLOODPLAIN
DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

SURFICIAL GEOLOGY MAP

JUNE 2000

LEGEND

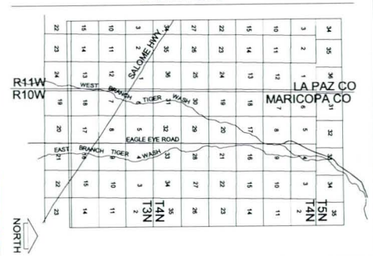
Surficial Geology

- Qyc - Late Holocene active channel deposits
- Qy2 - Late Holocene sheetflood and overbank deposits
- Qy1 - Early to late Holocene relict alluvial fan and terrace deposits
- Ql - Late Pleistocene alluvium (>10,000 years)
- Qm - Middle Pleistocene alluvial fan deposits (> 100,000 years
- R - Bedrock outcrops
- G - Gravel pits

NOTES

SURFICIAL GEOLOGY FROM: FCD 98-48, ASSIGNMENT #2
ARIZONA GEOLOGICAL SURVEY, KLAWON, J., PEARTHREE, P.

INDEX MAP



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SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

Figure 6B.4.2

Table 6B.4.1 Soil Units and Characteristics on the Tiger Wash Piedmont

SCS soils map units	Component Soil Series	Position / Landform	Important Characteristics	Subgroup, Order
From Soil Survey, Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona (Camp, 1986)				
Brios-Carrizo complex (10, 11)	Brios - 40% Carrizo - 40%	- on floodplains, and in larger drainageways - on floodplains, drainageways, alluvial fans, fan terraces, and stream terraces	- subject to occassional flooding; hazard due to water erosion is severe; channeling, deposition, and streambank erosion occur during flooding	- Typic Torrifluvents, Entisols - Typic Torriorthents, Entisols
Chuckwalla-Gunsight complex (19, 20)	Chuckwalla - 45% Gunsight - 35%	- on tops of fan terraces - on sides of fan terraces	- 85-95% of surface typically covered with varnished desert pavement - C horizon is strongly to violently effervescent and weakly cemented in some pedons ** These are old surfaces generally free from flooding.	- Typic Haplargids, Aridisols - Typic Calciorthids, Aridisols
Denure-Momoli-Carrizo complex (29, 30)	Denure - 40% Momoli - 30% Carrizo - 20%	- on stream terraces and fan terraces - on stream terraces and fan terraces - on floodplains, drainageways, alluvial fans, fan terraces, and stream terraces	- calcareous below about 8 inches; B horizon development; buried calcic or argillic horizon present in some pedons - B horizon development; strongly effervescent at depth	- Typic Camborthids, Aridisols - Typic Camborthids, Aridisols - Typic Torriorthents, Entisols
Gilman loams (56)	Gilman - 40% Gilman - 40%	- on floodplains and alluvial fans - on floodplains and alluvial fans	- non-calcareous upper 5 inches, calcareous below - calcareous throughout	- Typic Torrifluvents, Entisols - Typic Torrifluvents, Entisols
Gilman-Momoli-Denure complex (59)	Gilman - 40% Momoli - 25% Denure - 20%	- on floodplains and alluvial fans - on stream terraces and fan terraces - on stream terraces and fan terraces	- in broad, flat swales; reddish yellow and calcareous below about 2 inches - on long, narrow, slightly convex ridges - on long, narrow, slightly convex ridges	- Typic Torrifluvents, Entisols - Typic Camborthids, Aridisols - Typic Camborthids, Aridisols
Momoli-Carrizo complex (92)	Momoli - 45% Carrizo - 35%	- on stream terraces and fan terraces - on floodplains, drainageways, alluvial fans, fan terraces, and stream terraces	- weakly developed, light brown - poorly developed, pinkish gray, brown moist	- Typic Camborthids, Aridisols - Typic Torriorthents, Entisols
Pinamt-Tremant complex (98)	Pinamt - 45% Tremant - 35%	- on fan terraces - on fan terraces and stream terraces	- yellowish red B horizons which are strongly to violently effervescent - light reddish brown B horizons, caclic horizon at 5 to 24 inches, strongly to violently effervescent at depth, clay accumulation at depth	- Typic Haplargids, Aridisols - Typic Haplargids, Aridisols
Quilotosa-Vaiva-Rock outcrop complex (100)	Quilotosa - 50% Vaiva - 20% Rock outcrop - 20%	- on hillslopes and mountain slopes - on hillslopes and mountain slopes	- mapped on surfaces with 20 to 65% slopes; basically thin hillslope soils in the mountains	- Lithic Torriorthents, Entisols - Lithic Haplargids, Aridisols
Sal-Cipriano complex (106,107)	Sal - 50% Cipriano - 30%	- on fan terraces; on tops of terraces - on side slopes and in areas on tops of terraces that do not have desert pavement	- 70-95% covered with varnished desert pavement; pinkish, silica-cemented hardpan at about 20 inches - reddish yellow color; calcareous; silica-cemented hardpan at about 20 inches	- Typic Durargids, Aridisols - Typic Durothids, Aridisols
Schenco-Rock outcrop complex (108, 109)	Schenco - 50-55% Rock outcrop - 30-35%	- on mountain and hillslopes	- mapped on surfaces with 3-25% (unit 108) or 25-65% (unit 109) slopes; basically thin hillslope soils on mountains or inselbergs	- Typic Camborthids, Aridisols

Landforms as indicated by surficial geology

Figure 6B.4.2 shows the surficial geology of the Tiger Wash piedmont as mapped by the Arizona Geological Survey (Klawon and Pearthree, 1999). Table 6B.4.2 summarizes the significant distinguishing characteristics of each of the surficial geological units. Complete descriptions of the surficial geologic units from Klawon and Pearthree (1999) are included in Appendix G. The surficial geology map is coded such that the lighter the color the younger the surface. The only exception is the speckled areas which symbolize bedrock.

While the surficial geology provides greater detail than the NRCS soils maps, one can see the general agreement about the age and alluvial nature and origin of the Tiger Wash piedmont. The classes of surfaces and landforms shown in Figure 6B.4.2 and Table 6B.4.2 and their distinguishing characteristics are described in greater detail in the following sections. The advantage of the surficial geology data is that areas are distinguished by characteristics related to their age and stability.

The "y" units (Qy1, Qy2 and Qyc) shown in Table 6B.4. 2 are surfaces of Holocene age. That is, these surfaces have experienced active deposition and erosion during the last 10,000 years. The Qyc unit represents the large active channel deposits that can be mapped at this scale. The Qy2 unit is younger than the Qy1 unit. Qy2 is associated with late Holocene sheetflood and overbank deposits and is found in broad areas of the lower piedmont as well as areas adjacent to the active throughflow channels in the middle and upper piedmont. The Qy1 units are associated with late Holocene relict alluvial fan and terrace deposits. The Ql and Qm units are of Pleistocene age, that is, greater than 10,000 years old. The Ql units are identified as late Pleistocene, older than 10,000 years, while the Qm units are more than 100,000 years old alluvial fan deposits.

The "Landform" column of Table 6B.4.2 reflects the interpretation made for this study of how the NRCS data, the surficial geology, aerial photographs, topographic maps, and field observations fit together. Sheet 2 of 4, the Landform map, shows the delineation of the alluvial fan and bedrock areas on the Tiger Wash piedmont. The references to the active and inactive areas made in Table 6B.4.2 are incorporated into Stage 2 which results in the Stability map, Sheet 3 of 4 described later in section 6B.5. The areas identified as alluvial fan in Sheet 2 of 4 include both the active and inactive portions of the alluvial fan.

Table 6B.4.2 Landforms on Tiger Wash Piedmont				
Landform	Unit	Name	Significant Distinguishing Characteristics	NRCS soils units
Active alluvial fans, active channels	Qyc	Late Holocene Active Channels	composition: active channels soil development: none age: modern surficial features: sandy channels and gravel bars, no desert pavement or rock varnish	Brios-Carrizo (10,11)
Active alluvial fans, alluvial plains	Qy2	Late Holocene sheetflood and overbank deposits	composition: sheetflood areas, terraces, and limited overbank areas which are occasionally flooded soil development: minimal age: modern surficial features: fine grained, locally shallow channels (incision < 0.5 m), no desert pavement or rock varnish	Brios-Carrizo (11), Gilman (56), Gilman-Momoli-Denure (59)
Active and Inactive alluvial fans	Qy1	Early to late Holocene relict alluvial fan and terrace deposits	composition: alluvial fan and terrace deposits soil development: weak, slight structure, thin discontinuous carbonate coatings on clasts age: isolated from depostion for hundreds to a few thousand years surficial features: weak desert pavement, minimal rock varnish, distributary channels entrenched to 2 m and extensive unentrenched tributary channels heading on Qy1	Brios-Carrizo (11), Denure-Momoli-Carrizo (30), Momoli-Carrizo (92)
Inactive and relict alluvial fans	Ql	Late Pleistocene alluvium	composition: moderately old relict alluvial fan and terrace deposits soil development: weak to moderate, slight reddening, weak structure, and thin discontinuous carbonate coatings on clasts age: isolated from deposition for > 10,000 years surficial features: moderately packed desert pavement, moderately to darkly varnished with bright orange undersides, drained by local tributary channels, traversed by a few distributary channels which are incised 0.5-2 m	Chuckwalla-Gunsight (19,20), Momoli-Carrizo (92), Sal-Cipriano (106,107)
Inactive and relict alluvial fans	Qm	Middle Pleistocene alluvial fan deposits	composition: old relict alluvial fan deposits soil development: moderate, reddened zones of clay accumulation, continuous carbonate coatings, locally weak carbonate cementation age: isolated from deposition for > 100,000 years surficial features: strongly developed desert pavement with dark brown to black varnish with red coatings on undersides, well-developed tributary drainage networks, channels incised up to 3 m	Chuckwalla-Gunsight (19,20), Denure-Momoli-Carrizo (30), Momoli-Carrizo (92), Sal-Cipriano (106,107)
Adapted from Assignment No. 2, Task 3, Surficial Geology Mapping, by AZGS (Klawon and Pearthree, 1999) (see also Appendix G.2)				

6B.4.1 Relict fans

Those surfaces identified by the units labeled as Qm and Ql on the surficial geology map (Figure 6B.4.2) can be considered relict or inactive portions of the Tiger Wash alluvial fan. For the purposes of this study all of the deposits downstream of the topographic apex are considered part of the Tiger Wash alluvial fan landform. However, the oldest most dissected portions of the landform along the northeast and northwest portions of the fan could be considered relict fans. Additionally, old remnant surfaces internal to the larger alluvial fan landform may be considered relict fans in as much as they are dissected portions of much earlier alluvial fan deposits. The importance of the connection of these surfaces to the current active portions of the modern alluvial fan will be discussed in Stage 2.

The Qm and Ql units are of Pleistocene age, meaning that they have not experienced significant alluvial deposition in at least 10,000 years. The significant distinguishing characteristics of these surfaces are the dendritic drainage pattern, channel incision from 0.5 to more than 3 m, the moderate to strongly developed desert pavement and rock varnish, and the degree of soil development which includes slight to moderate reddening, thin to continuous carbonate coating on clasts and weak to moderate soil structure. Flooding on these surfaces is usually confined to incised channels with stable flow paths.

6B.4.2 Pediments

With the exception of local areas immediately adjacent to the bedrock inselbergs, there are no real pediments present on the Tiger Wash piedmont.

6B.4.3 Alluvial fans

The surficial geology, soils data, aerial photographs, and reports by others (e.g. Hjalmarson and Kemna, 1991; CH2M Hill, 1992) clearly show that the bulk of the Tiger Wash piedmont is an alluvial fan. The following subsections detail the data supporting this interpretation based on the landform's composition, morphology, and location. The limits or boundaries of the alluvial fan are also addressed. The Landform Map, Sheet 2 of 4 located at the end of this section, shows the delineation of the alluvial fan boundaries. The area shown on Sheet 2 of 4 includes both the active and inactive portions of the alluvial fan.

6B.4.3.1 Composition

With the exception of a few islands of isolated bedrock, the entire piedmont of Tiger Wash downstream of Blue Tank Canyon is a sedimentary deposit composed of alluvium. The NRCS soil survey maps for the area (Camp, 1986) demonstrate the alluvial origin of the surface materials on the piedmont. They indicate that the area is covered by fan terraces, alluvial fans, and drainageways and floodplains. Similarly, the surficial geology mapping by the Arizona Geological Survey (Klawon and Pearthree, 1999; Appendix G.2) also show the sedimentary nature and origin of the piedmont surfaces.

6B.4.3.2 Morphology

The surficial geology map, Figure 6B.4.2, clearly shows the fan shape of the landform. The fan "opens" where Tiger Wash comes out of a reach downstream of Blue Tank Canyon where the wash is confined between a bedrock hill on the west and a larger set of bedrock hills on the east. This is the location of the hydrographic apex of the Tiger Wash alluvial fan. The surficial geology map and aerial photographs also suggest that in Pleistocene time the fan may have opened nearer to the Blue Tank Canyon confluence and been extended wider than it is today. This more upstream point may be considered the topographic apex of the alluvial fan. In the channel reach between the topographic and hydrographic apexes, two large channels parallel one another confined between a high older surface on the west and a bedrock hill on the east. These two channels rejoin between two bedrock hills at the hydrographic apex. Historical aerial photographs show that the importance of these two channels upstream of the hydrographic apex has changed over time and may influence the distribution of flow downstream of the hydrographic apex.

Downstream of the hydrographic apex, the two primary channels separate again. For the purposes of this study, they are called the East Branch and West Branch of Tiger Wash. The East Branch has historically been labeled as the continuation of Tiger Wash down the piedmont on the USGS 15' and 7.5' quadrangles. However, since the beginning of the historic aerial photographic record (1953), it appears that the West Branch has been the more dominant and more active of the two branches.

Downstream of the hydrographic apex each branch crosses older relict surfaces in entrenched channels before spreading out onto large fan shaped areas of late Holocene sediments. The degree of channel incision and lateral relief decreases significantly in the areas of late Holocene sediments. Plots of topographic transects shown in Appendix G.3 demonstrate the changes in the degree of incision moving down the piedmont.

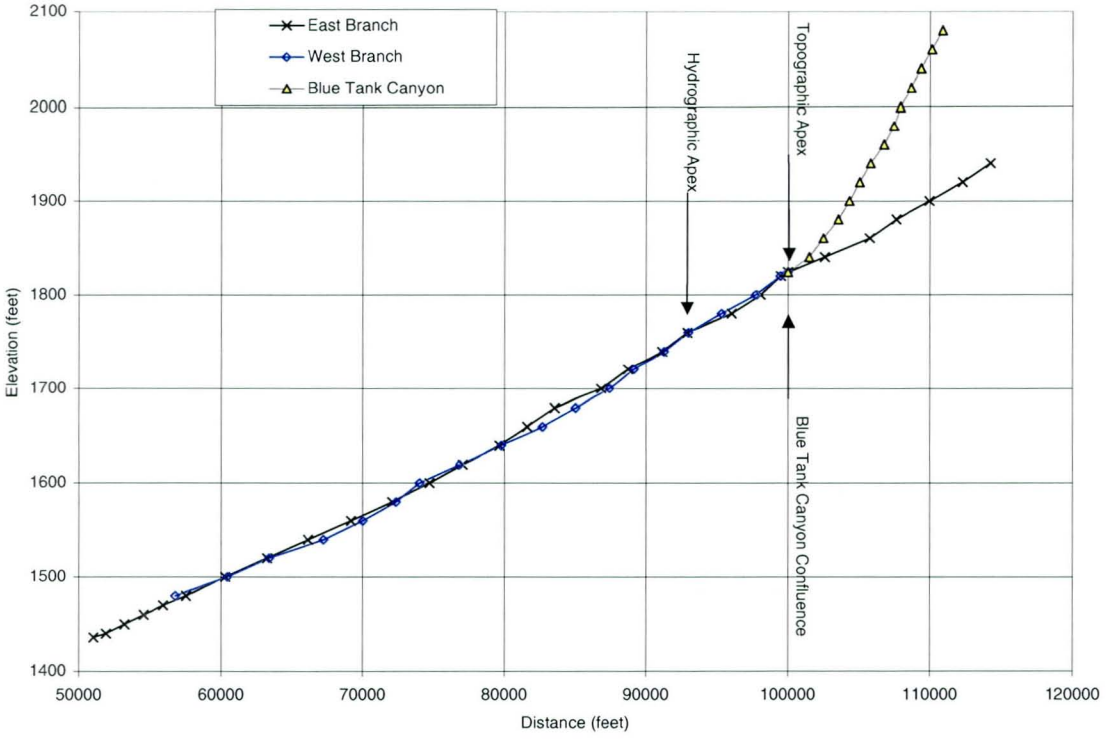
The USGS 7.5 minute contours (see Sheet 2 of 4) show a fan-shaped bowing downstream contour lines near the hydrographic apex. While indicative of an alluvial fan, the contours in this part of the piedmont are highly crenulated (wiggly) indicating a high degree of incision of drainages in this area. Continuing downslope, the contours remain highly crenulated along the west edge of the fan but become smoother and much less crenulated across the other parts of the piedmont. The 1640 ft contour also show a smaller concave downstream shape as it crosses the West Branch of Tiger Wash indicating a possible local aggradational area. Similarly another concave downstream shaped contour area is shown in the 1520 ft and 1540 ft contours near Eagle Eye Road.

6B.4.3.3 Location

The landforms within the study area begin near the mountain front of the Harquahala and Big Horn Mountains. Below Blue Tank Canyon, Tiger Wash exits a relatively confined reach and spreads out onto the piedmont. The longitudinal profile (Figure 6B.4.3.3.1) shows a typical slight hump at both the hydrographic and topographic apexes. Blue Tank Canyon is the last of several large tributary washes that drain directly off the Harquahala Mountians. If one considers the profiles of the tributaries instead of the main channel, there is also a definite break in slope

from the mountains onto the piedmont. Confinement of the main channel along the northwest edge of the Big Horn Mountains prevents the fan from developing.

Figure 6B.4.3.3.1 Tiger Wash Longitudinal Profile



6B.4.3.4 Boundaries

The downstream limit of the study area at Salome Highway does not extend to the toe of the alluvial fan. The fan toe is located approximately 6 miles downstream near the floodplain of Centennial Wash. However, since the intervention of man, the fan toe has been cut off from the rest of the alluvial fan by the Tiger Wash Detention Basin located on the upstream side of the Central Arizona Project canal and Interstate 10 about two miles downstream of the study area (Figure 1.2).

The lateral limits of the alluvial fan are defined by geomorphic characteristics and topographic information. In the upper two-thirds of the piedmont, the Tiger Wash alluvial fan is bounded by old Pleistocene surfaces which prevent movement of the Tiger Wash alluvial channels into adjacent drainages. However, in the lower third of the piedmont, both to the east and west of the fan near Salome Highway, the Tiger Wash fan begins to coalesce with alluvial fans from adjacent drainages.

While it is believed to be a reasonable delineation of the limits of the flood hazard from Tiger Wash, alluvial fan flood hazards probably exist on the lower piedmont in the immediately adjacent areas from the neighboring drainages. Specifically within Maricopa County, an adjacent alluvial fan coalesces with the alluvial fan flood hazard for the East Branch of Tiger Wash in T3N, R10W, Sections 3, 4, 9, 10, 15 and 16 and T4N, R10W, Sections 33 and 34. The eastern lateral boundary shown incorporated an inset alluvial fan area from the stream which

forms the eastern boundary along the upstream portion of the Tiger Wash alluvial fan. This inset fan receives flood waters from Tiger Wash, the Tiger Wash piedmont, and the adjacent drainages from the Big Horn Mountains and piedmont to the north and east. Additionally, in Sections 34, 3, 10, and 15, some intermingling of flood hazards exist. All areas of alluvial fan flood hazard due to the adjacent alluvial fan overlap onto alluvial fan flood hazards defined for the Tiger Wash piedmont. Between the East and West Branches alluvial fan flood hazards are separated by older relict surfaces.

6B.4.4 Alluvial plain

Within the study area portions of the Tiger Wash piedmont there is no alluvial plain. However, downstream of Interstate 10 outside the study area where the piedmont approaches the Centennial Wash floodplain, the piedmont landform does transition to an alluvial plain.

6B.4.5 Conclusions

The overall picture is of a large drainage, Tiger Wash, crossing an eroding, older, relatively stable surface in stable throughflow channels before spreading out broadly in two separate areas separated by older stable surfaces. Additionally, local runoff and adjacent tributary drainages along the eastern boundary collect sufficient flood water and sediment to create another inset fan area along the east margin of the Tiger Wash alluvial fan. Uncertainty associated with the initial split flow below the hydrographic apex creates broader areas of somewhat older, stable surfaces which are potentially subject to inundation. The extent of the active (unstable) and inactive (stable) areas and their relationship to the type of flood hazard on the Tiger Wash piedmont is discussed below in Stage 2.

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

As indicated in the Stage 1 analysis, the NRCS soil data and the surficial geology provide important clues as to the location of active and inactive areas on the Tiger Wash alluvial fan. While these data, along with the USGS topographic quadrangles, serve as a foundation for the definition of the active and inactive areas, field observations were critical to the refinement of the boundaries and understanding of features shown in the aerial photographs.

Sheet 3 of 4, located at the end of this section, shows the stable and unstable areas of the piedmont. The unstable areas are those portions of the piedmont where deposition, erosion and unstable flow paths are possible and where uncertainties about the changes in geometry and roughness cannot be set aside in the realistic assessment of the 100-year flood hazard. Stable areas are generally not subject to these uncertainties in the assessment of the flood hazard. Sheet 3 of 4 generally combines the inactive alluvial fan areas with the relict fan and inselbergs to show all of the area of the Tiger Wash piedmont that can be considered stable in the assessment of flood risk. The exception is a few small areas of older surfaces located immediately adjacent to unstable areas.

The units mapped at Qyc and Qy2 (Table 6B.4.1 and Figure 6B.4.2) are clearly areas actively being flooded where erosive and depositional processes are at work. Most of these units are within the areas of active alluvial fan flooding, although not exclusively. A large area of Qy1 deposits in T4N, R10W, Sections 19 and 30 is crossed by some linear areas mapped as Qy2.

This younger deposits are confined corridors of entrenched throughflow channels crossing through the older Qy1 surfaces. These channels can be considered stable or inactive in that their lateral position is not likely to change significantly due to alluvial fan processes. These surfaces have generally been isolated from active deposition for hundreds to a few thousand years. The most distinguishing characteristic of the older areas within the Qy1 is the extensive tributary channel networks which show up clearly on aerial photographs.

Downstream of the 1620 foot contour three unstable areas are identified spreading out onto the lower piedmont. In these areas islands of Qy1 within large areas of Qy2 deposits. Uncertainties associated with expanding flow, local deposition, and a general lack of lateral relief suggest that the Qy1 units in these locations be included within the unstable areas of the piedmont. Another large area of Qy1 lies along the east margin of the West Branch unstable area. In this vicinity, the flood hazard was evaluated as being characterized by relatively shallow sheet flooding. The September 1997 flood exhibited this type of shallow low velocity flooding in this area.

The previous study by CH2M Hill (1992) focused on the active area of the West Branch of Tiger Wash. In that study, the active area of the West Branch fan was identified as beginning in the NW ¼ of Sec. 29 or the SW ¼ of Sec. 20 of T4N, R10W. The surficial geology (Klawon and Pearthree, 1999) and the September 1997 flood both show a somewhat different picture. A relatively small but significant active area also exists beginning in the NW ¼ of Sec. 20, T4N, R10W. This area of late Holocene, Qy2, deposits experienced a large depositional episode during the September 1997 flood. Floodwaters directed over this area eventually recollected into several stable throughflow channels across the older Qy1 surface downstream of this area. Therefore, an area of active alluvial fan has been identified for this location as well (Sheet 3 of 4).

The Hjalmarson and Kemna (1991) study evaluated the degree of flood hazard for the Tiger Wash alluvial fan as a 10 out of 10 where 1 is the least hazardous and 10 is the highest. They noted that in the middle and lower portions of the alluvial fan, flood water will be unconfined and they predicted that large areas of sheetflow will occur during major flooding. This was indeed the case during the September 1997 flood.

The historical channel changes shown in Figure 6B.5.1 of this area strongly support the evaluation of a high flood hazard degree. Figure 6B.5.2a and 6B.5.2b also show some of the channel changes resulting from the September 1997 flood. The September 1997 flood also revealed areas of significant erosion and deposition flood hazard. Throughout the downstream areas of the active fan on the West Branch in Sec. 30 and 31, T4N, R10W and Sec 6, T3N, R10W large areas experienced significant scour and new channel development across areas of generally shallow flooding. The aerial photographs and surficial geology clearly show this area as actively flooded within modern times. The degree of the erosion and deposition hazard were illustrated by the September 1997 flood. Existing headcuts were extended, new headcuts were formed, broad areas of relatively small but highly active channels (re)appeared. It is clear from the post 1997 aerial photographs and field observations that even the smallest obstructions or changes in flow paths can cause significant scour and channel formation or change in this lower area of the alluvial fan.

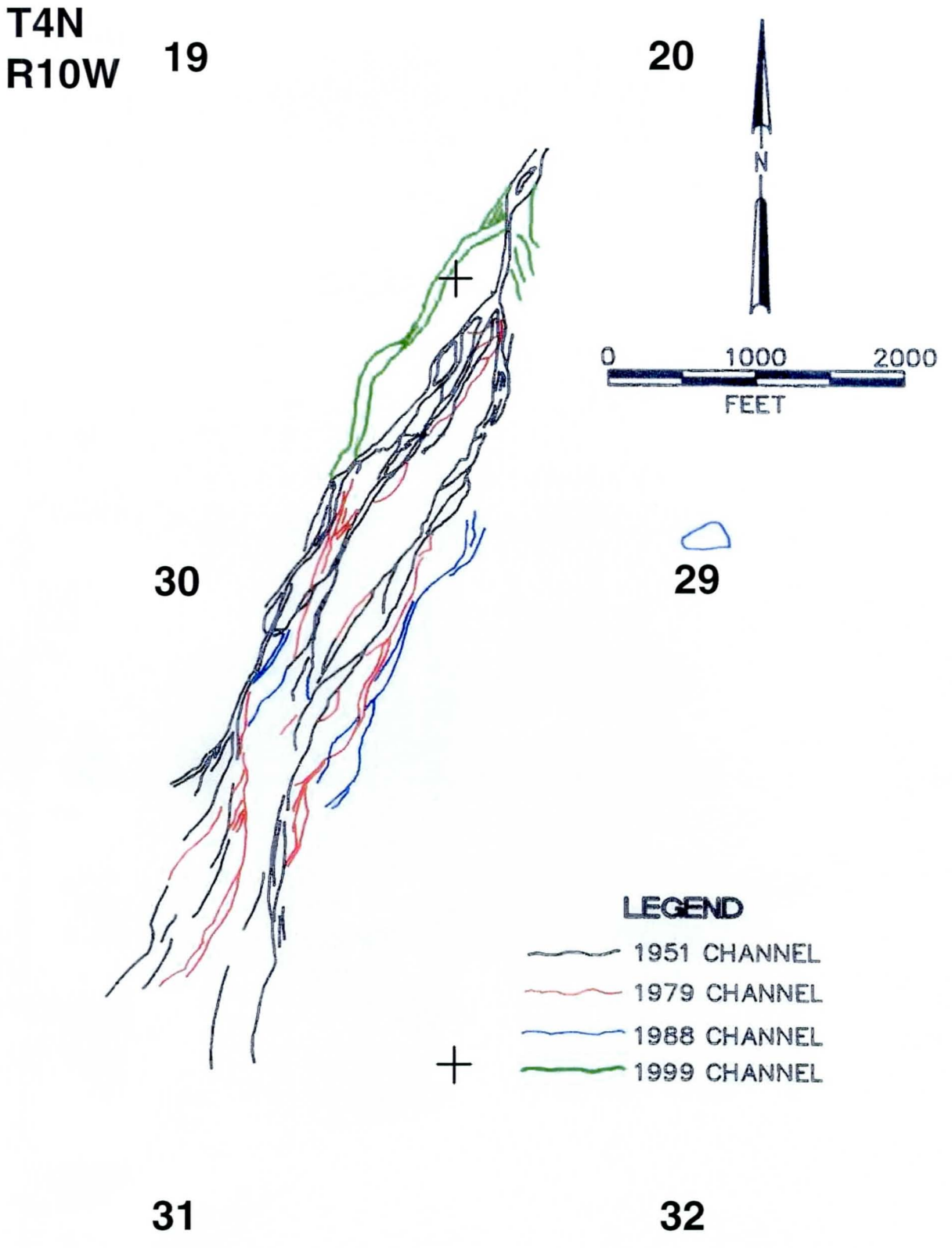


Figure 6B.5.1 Historical Channel Changes 1951-1999, Adapted from CH2M Hill, 1992.

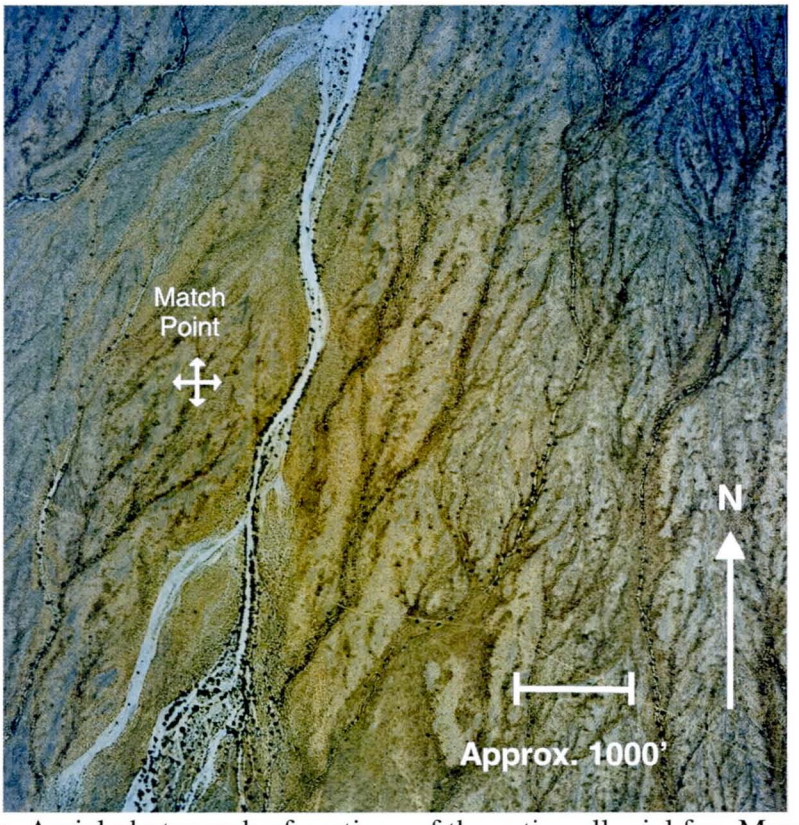


Figure 6B.5.2a Aerial photograph of portions of the active alluvial fan, March 30, 1999.

Figure 6B.5.2b Aerial photograph of portions of the active alluvial fan, 1953.

While the 1997 flood caused spectacular changes to the West Branch portion of the piedmont, the East Branch must be considered to have similar potential for erosion and deposition should a future flood direct a greater proportion of flow into the East Branch.

A few areas of old fan surfaces shown in the surficial geology map as units Qm and Ql have also been included within the unstable areas shown in Sheet 3 of 4. Although the surface characteristics indicate that these areas have been isolated from deposition for thousands of years, their location immediately adjacent to the modern active alluvial fan and low topographic position puts them at risk of erosion and deposition during future flooding. The September 1997 flood showed locations along the margins of the Qyl surface in Sec. 30 and 31, T4N, R10W and in Sec. 29 across Qm surfaces where floodwaters not only inundated but flowed across with sufficient depth and velocity to erode varnished desert pavement. These areas tend to be located in areas of low lateral relief relative to the adjacent unstable area. Therefore, these areas and areas interpreted to be similarly situated have been included in the unstable area shown in Sheet 3 of 4.

Finally, an area between the East and West Branches downstream of the hydrographic apex east of Eagle Eye Road has also been identified as unstable. Historical aerial photographs from 1953 suggest that the East Branch may have been the dominant wash at that time. Between 1953 and 1976 gravel mining began in this area as shown on the Weldon Hill quadrangle and the surficial geology map. The influence of the mining on the split during the September 1997 flood is uncertain. However, it is certain that the area between the two branches has been disturbed and consequently the channel could relocate itself unpredictably in this area. Therefore, it has been included in the unstable area shown in Sheet 3 of 4.

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

As indicated in the earlier sections, the September 1997 flood sheds important light on the nature and extent of infrequent large floods on the Tiger Wash piedmont. The peak discharge resulting from the remnants of Hurricane Nora is probably a reasonable approximation of the 100-year flood. Moreover, the duration of the flood also allowed for a greater amount of sediment to be worked down and across the piedmont. This is witnessed not only by the significant channel changes, new channel formations and so forth, but also by the fact that the floodwaters flowed down the entire length of the piedmont. This is in contrast to a large flood related in the CH2M Hill report (1992). They reported a large peak discharge that had recently occurred, as evidenced by flotsam observed in the upstream portions of Tiger Wash. They found that the same flood had completely infiltrated into the ground about halfway down the fan.

The Arizona Geological Survey performed detailed planimetric mapping of the lateral inundation limits of the September 1997 flood (Klawon and Pearthree, 1999b). Field surveys and aerial photograph interpretation were the basis of this mapping. The results of this mapping, presented in Appendix G.3, served as a basis for the 100-year floodplain for this study. From this starting point, the flood hazard areas shown in Sheet 4 of 4 were developed by eliminating small islands, adding in surfaces not inundated in 1997 which were indicated as young by the surficial geology and from interpretation of aerial photographs, and areas adjacent to flooded areas where uncertainties associated with alluvial fan flooding were incorporated.

Specifically, the unstable areas from Stage 2 have been used to identify the location of the active alluvial fan and other areas where uncertainties in channel geometry and location are too great to be set aside in the assessment of flood risk. These same areas are identified in Stage 3 and depicted in Sheet 4 of 4 as Zone AFHH, Alluvial Fan High Hazard and shall be managed by the local floodplain manager as a floodway district. The other flood hazard zones shown on Sheet 4 of 4 are given in Table 6B.6.1. The resulting flood hazard map is similar in nature to the one shown in Example 4 in Appendix 1 of the *FEMA Guidelines* (2000).

Table 6B.6.1 Flood Hazard Zones Mapped in Tiger Wash Approximate FDS

Zone Name	Description
AFHH	Alluvial fan high hazard, community to treat as a floodway district
AFUFD	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
AAFF	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
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)	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)	Areas outside the 500-year floodplain; shown only on rocky hills
D	Area not studied

Throughflow channels crossing stable areas that have been assessed as subject to inundation have been delineated as shown on Sheet 4 of 4 as approximate alluvial fan floodways (Zone AAFF). These areas are throughflow channels that have seen flooding from distributary floodwaters of Tiger Wash as evidenced by the September 1997 flood, by surficial geology data, and by interpretation of geomorphic features as shown in color aerial photographs and field observations. The remaining areas stable areas subject to broad sheet flooding have been designated as alluvial fan Zone A, (Zone AFZA). Zone AFHH is shown on areas of active alluvial fan flooding. Elsewhere, islands of very old stable Pleistocene surfaces have been delineated as shaded Zone X except for the bedrock hills. The areas are shown as shaded Zone X to reflect shallow flooding less than 1 foot deep and from local runoff off the piedmont itself. The bedrock hill have been given a Zone X designation. Areas outside the study area limits are shown as Zone D. Flood hazards in those areas have not been evaluated in this study.

6B.7 References

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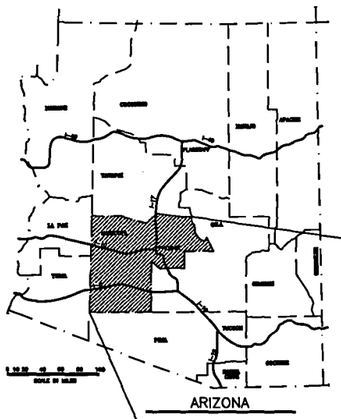
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

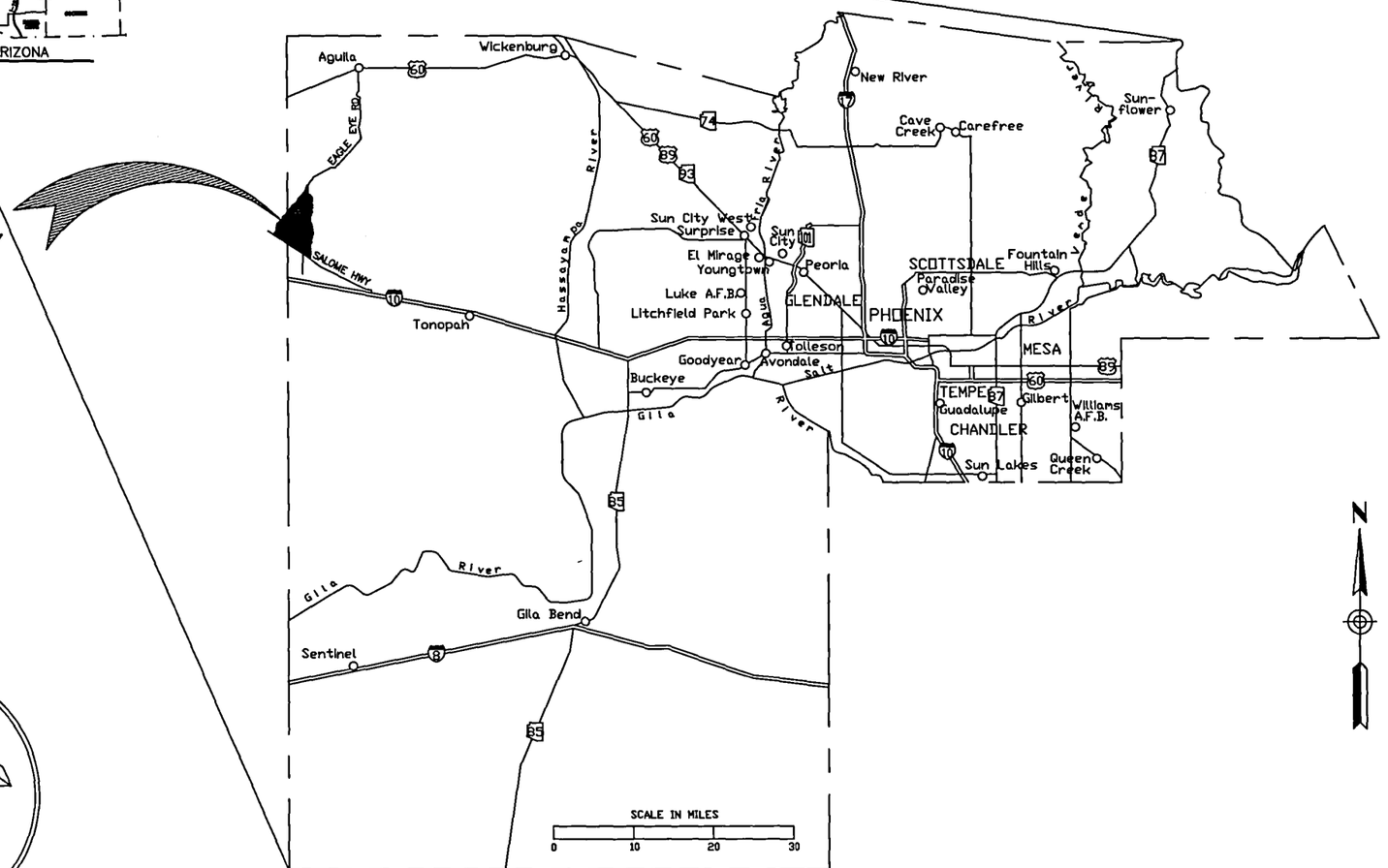
TIGER WASH
APPROXIMATE FLOODPLAIN DELINEATION STUDY

FCD 98-48

JUNE, 2000



STUDY AREA



MARICOPA COUNTY

NOTES

1. ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
2. ALL HORIZONTAL COORDINATES USE ARIZONA STATE PLANE COORDINATES BASED ON THE 1983 NORTH AMERICAN DATUM

STATEMENTS OF PROFESSIONAL REGISTRANTS

Registered 26846 JONATHAN E. FULLER Date Signed 6-5-00 ARIZONA U.S.A.

THE LANDFORM, STABILITY, AND FLOODPLAIN DELINEATIONS WERE PREPARED UNDER MY DIRECT SUPERVISION.

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

JE FULLER HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN		
DESIGN CHK.		
PLANS		
PLANS CHK.		
SUBMITTED BY: DATE:		

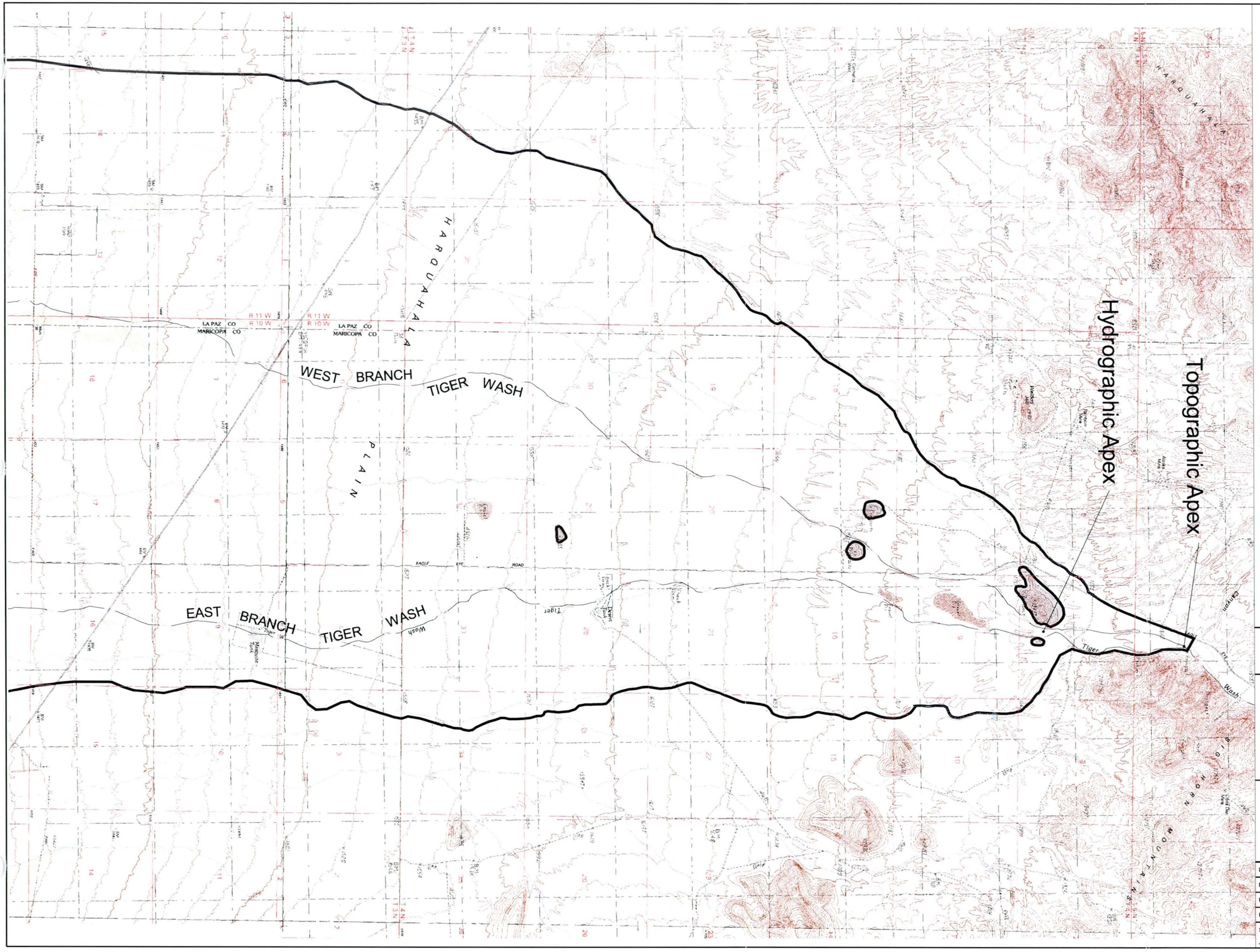
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

SHEET: COVER SHEET



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH
APPROXIMATE FLOODPLAIN
DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

STAGE 1
LANDFORM MAP

JUNE 2000

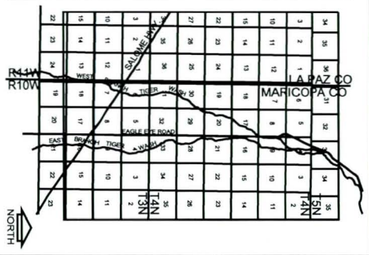
LEGEND

- ALLUVIAL FAN BOUNDARY
- BEDROCK

USGS DIGITAL RASTER GRAPHICS PROJECTED TO STATEPLANE NORTH AMERICAN DATUM OF 1983 AND TILED BY FCDMC.

ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP



2000' 0' 4000'

Registered Professional Engineer (Civil)
26846
JONATHAN E.
FULLER
Date Signed 6 Dec 00
ARIZONA, U.S.A.

THE LANDFORM DELINEATIONS WERE PERFORMED UNDER MY DIRECT SUPERVISION.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN		
DESIGN CHK.	JEF	
PLANS	TWL	
PLANS CHK.	BRI	

SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

SHEET 2 OF 4

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH
APPROXIMATE FLOODPLAIN
DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

STAGE 2
STABILITY MAP

JUNE 2000

LEGEND

UNSTABLE SURFACES

STABLE SURFACES

LIMIT OF STABILITY ANALYSIS

HARQUAHALA PLAIN

HARQUAHALA MOUNTAINS

Hydrographic Apex

Topographic Apex

WEST BRANCH TIGER WASH

EAST BRANCH TIGER WASH

EAGLE EYE ROAD

LA PAZ CO
MARICOPA CO

R11W
R10W

T5N
T4N
T3N

USGS DIGITAL RASTER GRAPHICS PROJECTED TO STATEPLANE NORTH AMERICAN DATUM OF 1983 AND TILED BY FCDMC.

ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP

NORTH

2000' 0' 4000'

Registered Professional Engineer
Certificate No. (Civil)
26846
JONATHAN E. FULLER
Date Signed 6.8.00
ARIZONA U.S.A.

THE STABLE SURFACE AND UNSTABLE SURFACE DELINEATIONS WERE PERFORMED UNDER MY DIRECT SUPERVISION.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN	JEF	
DESIGN CHK.	TWL	
PLANS	BRI	
PLANS CHK.		
SUBMITTED BY:		DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH
APPROXIMATE FLOODPLAIN
DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

STAGE 3
FLOODPLAIN MAP

JUNE 2000

LIMIT OF STUDY

LIMIT OF STUDY

WEST BRANCH TIGER WASH

EAST BRANCH TIGER WASH

HARQUAHALA PLAIN

HARQUAHALA MOUNTAINS

Hydrographic Apex

Topographic Apex

LA PAZ CO
MARICOPA CO

R11W
R10W

T4N
T3N

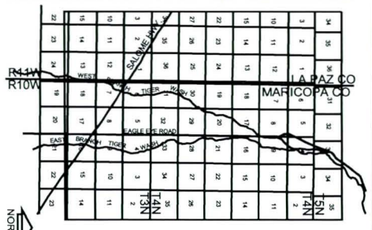
LEGEND

- A
- AFHH
- AAFF
- AFZA
- Shaded X
- AFUFD
- X
- D

USGS DIGITAL RASTER GRAPHICS PROJECTED TO STATEPLANE NORTH AMERICAN DATUM OF 1983 AND TILED BY FCDMC.

ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP



2000' 0' 4000'

Registered Professional Engineer
26846
JONATHAN E. FULLER
Date Signed 6-7-00
ARIZONA U.S.A.

THE FLOODPLAIN ZONE DELINEATIONS WERE PERFORMED UNDER MY DIRECT SUPERVISION.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN		
DESIGN CHK.	JEF	
PLANS	TWL	
PLANS CHK.	BRI	

SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

SHEET 4 OF 4

SECTION 7: DRAFT FIS REPORT DATA

7.1 Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs)			
		10-Year	50-year	100-year	500-Year
Tiger Wash at USGS gage, 09517280	85.2	--1	--1	7,340	--1
Tiger Wash below Blue Tank Canyon	96.4	--1	--1	7,700	--1

1 Not Computed

The discharges listed above are taken from Pope and others (1998) for the USGS gage 09517280. The value listed below Blue Tank Canyon was computed by multiplying the value at the gage with the ratio of the results for the 100-year discharge as computed by the USGS regional regression equations in Thomas, et al. (1997).

While the table above reports values for the 100-year peak discharge for Tiger Wash, it should be mentioned here that the absolute magnitude of the 100-year discharge is not critical to the geomorphic methods used in this study to delineate the approximate 100-year floodplain. These methods rely heavily on the distribution of surfaces of different geologic age. The surface age is inferred from interpretation of a variety of surficial characteristics including drainage pattern, degree of channel incision, degree of soil development, presence of desert pavement and desert varnish, and others. These surficial features develop following the cessation of active deposition over long periods of time which presumably included numerous 100-year or larger floods. Consequently, the surficial geologic characteristics reveal a pattern of the location of areas that have and have not been subject to flooding and therefore, are likely to be or not to be flooded in the future independent of the exact definition of the 100-year discharge.

7.2 Floodway Data

No floodway data is provided as this was not a detailed study. However, approximate alluvial fan floodway (Zone AAFF) corridors were designated for management by local floodplain administrators in order to maintain the continuity of sediment and water discharges along the piedmont. These corridors are shown in Sheet 4 of 4 at the end of Section 6B and in the Exhibit Maps appendix at the end of the Technical Data Notebook. For a definition of these floodways see Table 6B.6.1.

7.3 Annotated Flood Insurance Rate Maps

The area of flood hazard delineation includes portions of two FIRM panels in unincorporated Maricopa County, Arizona. One of the panels, 04013C1425E, is printed. A redlined copy of this map is included here showing the newly delineated areas on this panel. The remaining area is on panel 04013C0975D which to date is not printed. Therefore, a copy of Sheet 4 of 4 showing the flood hazard areas and FIRM panel boundaries is also included here. Finally, a copy of the FIRM index for Maricopa County is also included for reference to the panel locations within the County.

Location of FIRM Panels, Existing Floodplains, and Revisions from this Study

LEGEND

Existing Zone A

New 100-yr Flood Hazard Zones

- AAFF
- AFHH
- AFZA
- Shaded X
- X

2000 0 2000 4000 6000 8000 Feet

N W E S

Topographic Apex

Hydrographic Apex

LIMIT OF STUDY

LIMIT OF STUDY

WEST BRANCH TIGER WASH

EAST BRANCH TIGER WASH

04013C0975D

04013C1000D

04013C1425E

7.4 Flood Profiles

No flood profiles were computed as this was not a detailed study.

APPENDIX A: REFERENCES

A.1 Data collection summary

APPROXIMATE
FLOODPLAIN DELINEATION STUDY
for
portions of
TIGER WASH ALLUVIAL FAN

FCD CONTRACT NO. 98-48
Assignment No. 1

DATA COLLECTION REPORT
FINAL

July 1999

Prepared for:

Flood Control District of Maricopa County
2801 W. Durango Street
Phoenix, AZ 85009
(602) 506-1501

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

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(520) 623-3130 fax

Introduction

JE Fuller Hydrology and Geomorphology, Inc., (JEF) has collected and reviewed data which are pertinent to the flood hazard of the project study area. These data have come from the Flood Control District of Maricopa County and from outside sources. A large literature on alluvial fan flood hazards exists but is not cited here. Refer to the *Piedmont Assessment Manual* for a comprehensive listing of the pertinent literature on alluvial fans. This data collection effort limited its scope regarding general alluvial fan flooding issues to three documents: *Alluvial Fan Flooding* (NRC, 1996), *Piedmont Flood Hazard Assessment for Flood Plain Management, User's Manual, DRAFT* (Hjalmarson, 1998), and *Alluvial Fan Data Collection and Monitoring Study* (CH2M Hill, 1992). The remaining sources investigated were limited to those sources pertinent to Tiger Wash and the west branch piedmont in particular. However, some of the sources which address Tiger Wash discuss alluvial fan flooding more generally as well.

The following types of data were collected: historical flooding information, flood flow frequency data, as-built plans for structures, FEMA mapping, miscellaneous data, maps and aerial photographs, and field data.

Historical Flooding Information

One streamflow gaging station is operated on Tiger Wash. It is located upstream of the geologic and hydrographic apices in the SW1/4 SW1/4 T5N, R10W, Sec. 26. The gage is a crest-stage gage and is operated by the U.S. Geological Survey (USGS) who refer to it as 'Tiger Wash near Aguila, AZ (09517280)'. It has a period of record for annual maximum discharge estimates for the period 1963-1979, 1983, and 1991 to the present. The annual maximum discharge data were collected from USGS publications including Garrett and Gellenbeck (1991), Pope and others (1998), and annual Water Resource Data reports for Arizona.

Table of Annual Maximum Discharges
Tiger Wash near Aguila, 09517280

MON	DAY	YEAR	FLOW,CFS	MON	DAY	YEAR	FLOW,CFS
8	16	1963	910	9	25	1976	3000
10	19	1963	400	8	16	1977	870
8	18	1965	1680	3	1	1978	1400
9	13	1966	1450	12	18	1978	60
8	14	1967	620	9	0	1983	3170
12	19	1967	440	3	27	1991	69
9	14	1969	441	3	3	1992	906
8	20	1970	4550	1	8	1993	1040
8	20	1971	2000	7	18	1994	3640
8	0	1972	2770	2	15	1995	185
10	6	1972	1750	1	1	1996	0
8	3	1974	45	9	26	1997	8070
7	30	1975	100	3	26	1998	683

The most extreme event in the historical record from the USGS gaging station occurred on September 26, 1997. The evidence left by this flood is still visible in the field and on recent aerial photographs (AMC, 3/30/99). The Arizona Geological Survey, as part of Assignment No. 2 of FCD No. 98-48, is mapping the extents of this flood within the study area.

Flood Flow Frequency

A number of flood flow frequency analyses have been done for Tiger Wash. The results of 4 different analyses are given below.

Source	Q_2 (cfs)	Q_5 (cfs)	Q_{10} (cfs)	Q_{25} (cfs)	Q_{50} (cfs)	Q_{100} (cfs)	Period of Record
WRIR 91-4041	1,010	2,120	3,060	4,450	5,630	6,910	63-79,83
WRIR 98-4225	961	2,140	3,160	4,670	5,950	7,340	63-79,83,91-96
FFF done for this report using HECWRC	860	2,570	4,180		8,620	10,740	63-79,83,91-98
Waters, 1991 (L-P III)	798	2,320	3,870		8,770	11,400	63-79

As-Built Plans for Existing Structures:

There are no flood control type structures located in the study area which would significantly alter the natural hydrologic or hydraulic characteristics of the watersheds or washes in the study area. At-grade crossings of Tiger Wash at Eagle Eye Road and the Buckeye-Salome Highway are frequently damaged by flood erosion and deposition.

FEMA Flood Hazard Boundary Maps, LOMAs, LOMRs:

There are no existing FEMA flood hazard areas mapped within the study area.

Historical Aerial Photography

Historical aerial photographic coverage of the study area will be an important compontent of the piedmont flood hazard assessment. A number of different dates of aerial photography were identified for use in this study. The following table summarizes these data.

List of Historical Aerial Photographs of Tiger Wash Piedmont				
Source	**Photo Date**	**Scale**	**Type**	**Digital**
FCDMC archives	1953	Approx. 1:14,400	Large format black and white	Scanned by FCDMC at 400 dpi
SCS Soil Survey	1972 & 1973	1:24,000	Black and white orthophoto	No
MCDOT archives	1976	1:14,400	Black and white half townships	Scanned by FCDMC at 400 dpi
Collected by AZGS	1979		Color 9x9s	No
FCDMC image database	1998	1:7,200	Black and white	Part of FCD digital database
AMC/JEF	1999	1:9,600	Color	No
Vincent, K.	1999	N/A	Various oblique color slides	No

Field Data

Data collection field trips were performed by JEF on the following dates: January 18, February 24, April 10-11, April 27, and May 18, 1999. Photographic and miscellaneous field notes were taken relative to surface and channel characteristics on the piedmont. Of special interest were the two large breakout channels formed on the west side of the main channel. The field visits of April 10-11 and April 27, 1999 included survey for indirect estimates of peak discharge of the September 26, 1997 flood. The results of those surveys are available in a separate report (JEF, 1999). The AZGS also conducted numerous field visits to collect field information on the extent of the September 1997 flood as well as to assist in the production of a surficial geology map of the area. The AZGS work was performed as part of FCD 98-48, Assignment No. 2.

Other Pertinent Data:

Camp, 1986: This report describes the soil conditions for the area and provides soils maps and descriptions of the mapped soil units for the area. The mapping in this report indicates that most of the surface is comprised of fan terraces. Narrow portions of the through channels are shown as drainageways and floodplains. The lower portions of the piedmont are shown as intermixed fan terraces and floodplains and drainageways and alluvial fans.

CH2M Hill, 1992: This is the best single source on the Tiger Wash alluvial fan. It includes a discussion of flood flow frequency, a paleoflood analysis, and maps of the landform types and flood hazard area in general terms. This report will be used as a basis for the current study.

Hjalmarson, 1994: This document describes hydraulic geometry coefficients and exponents, as well as channel competence, for the Tiger Wash alluvial fan for various frequencies of discharge. It also discusses geomorphic and hydraulic characteristics influencing flood hazard potential for distributary flow areas (DFA) in general and provides detailed examples for a number of sites in Maricopa County including a DFA east of Tiger Wash (Hjalmarson report Site 30).

Hjalmarson and Kemna, 1992: This report addresses flood hazard type and degree for the Tiger Wash alluvial fan in addition to numerous other distributary flow sites in southwestern Arizona. It examines geometric relationships of alluvial fans in the region and relates these to degree of flood hazard. Geometric information about Tiger Wash is provided. The flood hazard of Tiger Wash alluvial fan is evaluated as a 10 on a scale of 10 where 1 is the least hazardous, and 10 is the most hazardous.

Waters, 1991: This reports describes an HEC-1 rainfall-runoff model that was constructed for the Tiger Wash watershed. Although subbasins are large, concentration points are given at the USGS gage, the split to the east and west branches, near the current FCD ALERT weather station, and at the Tiger Wash detention basin above the CAP canal. Of particular interest to this study is the evaluation of the split of discharge between the east and west branches of Tiger Wash. This study identified the split as 55% to the west branch and 45% to the east. Indirect discharge estimates of the September 1997 flood indicate about an 80% west / 20% east split (JEF, 1999). The HEC-1 model was also used to compute a flood flow frequency relation for Tiger Wash which was compared to a graphical Log-Peason III analysis. The report concludes that the HEC-1 results, while almost double the LP III results, were well within the 90% confidence limits of the LP III analysis.

References

Aerial Mapping Company, Flown March 30, 1999. Color stereo aerial photography. Covering T3N, R11W, Sec. 1 and 12, T4N, R11W, Sec.13, 24, 25, and 36, T3N, R10W, Sec. 5, 6, 7, 8, 17, and 18, and T4N, R10W, Sec. 8, 17, 19, 20, 29, 30, and 31. Scale: 1:9600.

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.

CH2M Hill, 1992, Alluvial Fan Data Collection and Monitoring Study: Tempe, Arizona, CH2M Hill and R.H. French, Ph.D., P.E. Consulting Engineer for the Flood Control District of Maricopa County, 204 p.

FCDMC, Flown January 25, 1998 and February 1, 1998. Black and white semi-rectified aerial photographs from FCDMC image database. Original photography from which digital versions were created 1:7,200 scale.

Field, John J., 1994, Processes of Channel Migration on Fluvially Dominated Alluvial Fans in Arizona. Arizona Geological Survey OFR 94-13, 40 p.

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Hjalmarson, H.W., 1998, Piedmont flood hazard assessment for flood plain management for Maricopa County, Arizona – DRAFT of August 1998: Flood Control District of Maricopa County, 158 p.

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Pope, G. L., Rigas, P. D., and Smith, C. F., 1998, Statistical Summaries of Streamflow Data and Characteristics for Selected Streamflow-Gaging Stations in Arizona Through Water Year 1996: U.S. Geological Survey, Water Resources Investigations Report 98-4225: Tucson, Arizona, 907 p.

Smith, C.F. and Garrett, J.M., 1991, Compilation of Flood Data for Maricopa County, Arizona through September 1989: Tucson, Arizona, U.S. Geological Survey Water Resources Division, 252 p.

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U.S. Army, 1953, Large format black and white aerial photography. From FCDMC archives. Scale = approximately 1:14,400.

U.S. Geological Survey, 1961, Gladden, Ariz. Quadrangle, 15 minute series, 1:62,500.

U.S. Geological Survey, 1962, Aguila, Ariz. Quadrangle, 15 minute series, 1:62,500.

U.S. Geological Survey, 1961, Big Horn Mountains, Ariz. Quadrangle, 15 minute series, 1:62,500.

U.S. Geological Survey, 1961, Lone Mountain, Ariz. Quadrangle, 15 minute series, 1:62,500.

U.S. Geological Survey, 1986, Soccoro Mine, Ariz. Quadrangle, 7.5 minute series, 1:24,000.

U.S. Geological Survey, 1986, Weldon Hill, Ariz. Quadrangle, 7.5 minute series, 1:24,000.

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U.S. Geological Survey, 1986, Courthouse Well, Ariz. Quadrangle, Provisional, 7.5 minute series, 1:24,000.

Waters, Stephen D., 1991, Tiger Wash Approximate Floodplain Study, Part 1 – Hydrology: Phoenix, Arizona, Flood Control District of Maricopa County, 10 p.

A.2 Referenced documents

APPENDIX B: GENERAL DOCUMENTATION AND CORRESPONDENCE

ANNOUNCEMENT OF INTENT TO PERFORM FLOODPLAIN DELINEATION STUDY OF PORTIONS OF TIGER WASH

The Flood Control District of Maricopa County (FCDMC) has contracted JE Fuller/Hydrology & Geomorphology, Inc. to perform an approximate floodplain delineation study for Tiger Wash west of Eagle Eye Road and north of Salome Highway.

This study will examine and evaluate the flood hazard areas in the area. The results will then be published on the flood insurance rate map used by the Federal Emergency Management Agency (FEMA).

This announcement is intended to inform all interested persons and communities of the commencement of this study so that they may have an opportunity to bring any relevant technical information to the attention of the FCDMC/FEMA, to be considered during the course of this study. Your comments should be addressed to Mr. Joe Tram, P.E., Special Projects Branch Manager at the Flood Control District of Maricopa County, 2801 West Durango Street, Phoenix, AZ 85009, (602) 506-1501.

ARIZONA BUSINESS GAZETTE

PO BOX 194
Phoenix, Arizona 85001-0194
(602) 444-7300 FAX (602) 444-7364

STATE OF ARIZONA
COUNTY OF MARICOPA } SS.

BRENDA WINDAHL, being first duly sworn, upon oath deposes and says: That she is a legal advertising representative of the Arizona Business Gazette, a newspaper of general circulation in the county of Maricopa, State of Arizona, published weekly at Phoenix, Arizona, and that the copy hereto attached is a true copy of the advertisement published in the said paper on the dates indicated.

4/29/99
5/6/99

Brenda Windahl

Sworn to before me this
6TH day of
MAY A.D. 1999

Notary Public

FLOODPLAIN DELINEATION

19

ARIZONA BUSINESS GAZETTE

PO BOX 194
Phoenix, Arizona 85001-0194
(602) 444-7300 FAX (602) 444-7364

STATE OF ARIZONA
COUNTY OF MARICOPA } SS.

BRENDA WINDAHL, being first duly sworn, upon oath deposes and says: That she is a legal advertising representative of the Arizona Business Gazette, a newspaper of general circulation in the county of Maricopa, State of Arizona, published weekly at Phoenix, Arizona, and that the copy hereto attached is a true copy of the advertisement published in the said paper on the dates indicated.

4/29/99
5/6/99

Brenda Windahl

Sworn to before me this
6TH day of
MAY A.D. 1999

Notary Public

ANNOUNCEMENT OF INTENT TO PERFORM FLOODPLAIN DELINEATION STUDY OF PORTIONS OF TIGER WASH

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ANNOUNCEMENT OF INTENT TO PERFORM FLOODPLAIN DELINEATION STUDY OF PORTIONS OF TIGER WASH

The Flood Control District of Maricopa County (FCDMC) has contracted JE Fuller/Hydrology and Geomorphology, Inc. to perform an approximate floodplain delineation study for Tiger Wash of Eagle Eye Road and north of Salome Highway.

This study will examine and evaluate the flood hazard areas in the area. The results will then be published on the flood insurance rate map used by the Federal Emergency Management Agency (FEMA).

This announcement is intended to inform all interested persons and communities of the commencement of this study so that they may have an opportunity to bring any relevant technical information to the attention of the FCDMC/FEMA, to be considered during the course of this study. Your comments should be addressed to Mr. Joe Tram, P.E., Special Projects Branch Manager at the Flood Control District of Maricopa County, 2801 West Durango Street, Phoenix, AZ 85009, (602) 506-1501.

Published in The Wickenburg Sun on April 28 and May 5, 1999.

Floodplain Delineation Study of Portions of Tiger Wash

STATE OF ARIZONA

County of Maricopa

Kevin Cloe, being duly sworn, upon oath, deposes and says: That he is the Publisher of

The Wickenburg Sun

A newspaper of general circulation in the County of Maricopa State of Arizona, Published in Wickenburg, Arizona, and that the copy hereto attached is a true copy of the advertisement as published weekly in The Wickenburg Sun on the Dates following:

April 28 and May 5, 1999

KEVIN CLOE
PUBLISHER

Sworn to before me this **5th** day of **May** A.D. **1999**

Jo Ann R. Peterson
Notary Public

OFFICIAL SEAL
JO ANN R. PETERSON
Notary Public - State of Arizona
MARICOPA COUNTY
My Comm. Expires Sept. 30, 2001

B.1 Special Problem Reports

B.2 Contact (telephone) Reports

Phone conversations of substance have been noted in memorandums contained in Appendix B.4. No other contact reports are recorded here.

B.3 Meeting Minutes or Reports

B.4 General Correspondence

Date: September 3, 1999

To: Mr. Joe Tram, PE
Special Projects Branch
FCDMC

From: Ted Lehman
JE Fuller / Hydrology & Geomorphology, Inc.

Re: Progress report for 99-48 through September 3, 1999

Assignment No. 1

A draft final of the Technical Data Notebook is being supplied to Mr. Tram for his review. It is hoped that Mr. Tram and JEF will be able to meet to address his comments and conduct a field visit to evaluate the delineation product this month.

If the office and field review can be completed within the next three weeks, JEF should be able to have a completed package for FEMA submittal by the end of September.

Assignment No. 2

The surficial geology map and Nora flood inundation map are included in the Draft TDN. Both items will be part of a field presentation given by AZGS at the International Paleoflood conference being held in Prescott at the end of September.

The piedmont flood hazard assessment using the County manual for the pre-1997 flood condition will be completed following the FEMA submittal in September to be completed by the end of the calendar year per the revised schedule presented in the June progress report. These results will be compared to the 1997 flood as a test of the manual methods on Tiger Wash fan.

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399
(602) 506-1501
FAX: (602) 506-4601
TT: (602) 506-5859

7/6/12/1999

MEMO TO: Ted Lehman, Project hydrologist

FROM: Joe Tram, P.E., Special Projects Manager

SUBJECT: Review of Draft Data Collection Report

I have the following comments concerning the subject report:

Page 1
- 1st paragraph last sentence....start as new paragraph and incorporate next paragraph

Page 2
- Clarify "in addition" it infers that USGS did not measure this flood
- Flood Frequency –
  - Is the JEF historical data collected? If so, needs a reference, if not, needs clarification. Same document is referenced on page4 under field data.
  - Waters, 1991 – was it a flood flow frequency analyses or a HEC-1 or both? Please clarify here and on page 5.

As-Builts
- What did you determine about Eagle Eye upstream by Blue Tank Canyon...did it contain a break-out per the 1959 aerials? no, I don't believe so [illegible]

Page 5
- Delete last sentence under Waters since that information is not contained within the report. Possibly include this data in the peak discharge report. Need the data to substantiate the 80/20split since it wasn't in the peak discharge report.

----------end----------

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009-6399
(602) 506-1501
FAX: (602) 506-4601
TT: (602) 506-5859

7/12/1999

MEMO TO: Ted Lehman, Project Hydrologist

FROM: Joe Tram, P.E., Special Projects Manager

SUBJECT: Review of draft summary of peak discharges for Tiger Wash

I have the following comments and recommendations:

Page 1

- Delete "also" from the 1st and 2nd to last sentence of paragraph 3
- Delete "Additionally" from 3rd to last sentence in last paragraph
- Delete last sentence in 3rd paragraph.....since additional cross section is taken into consideration for this analysis, I would assume that it was also taken into consideration for the Paleoflood analysis

Page 2

- Recompute channel Froude # for sites 2000 and USGS gage
- Put a foot note for "water slope" and "Qw/xtra A" as explained in later text
- Looks like a breakout occurred upstream of section 3000 on right bank where overbank flow was not taken into account between stations 4000 and 3000

Site 2000 = 7800 cfs	
Mile downstream	500 cfs
Site 5000 = 7300 cfs	
2/3 mile downstream	2400 cfs
Site 4000 = 4900 cfs	
1/3 mile downstream	2600 cfs
Site 3000 = 2300 cfs	

Map

- Scale is off
- Site 2000 is located 2000' versus 1000' from Eagle Eye Road ✓
- Large numbers should have "cfs" after them

Call if you have questions

----------end----------

JEFuller / Hydrology & Geomorphology, Inc.

5235 South Kyrene, Suite 205
Tempe, AZ 85283
480-752-2124 (voice)
480-839-2193 (fax)
ted@jefuller.com (email)

June 25, 1999

TRANSMITTAL

Mr. Joe Tram
FCDMC
2801 W. Durango Street
Phoenix, AZ 85009

Attached are the following materials provided by JEFuller/ Hydrology & Geomorphology, Inc.:

1) Progress report for 99-48 through June 25, 1999.

2) Proposed revised schedules for Assignments No. 1 and No. 2.

Joe:

Here is the progress report for FCD No. 98-48 for June. I have come to the conclusion that the intermediate completion dates in the original schedule will not be met. Therefore, I have included a proposed revision to the schedule. Notice that for Assignment No. 1 the FEMA submittal deadline to the District remains the end of the 3rd full week in September. As for Assignment No. 2, I have modified the schedule to show subtasks 3.2 and 3.3 (the pre-1997 flood hazard assessment and "blind test" of the manual) to following the FEMA submittal. I believe this will better allow us to complete Assignment No. 1 by the original deadline.

I would like to meet with you next week to go over these items, show you the AZGS map work to date, and discuss any other items you would like.

If you have any questions, please call me. Otherwise I will be contacting you to set up a meeting at your convenience.

Sincerely,

Ted Lehman

6/25/99

Date

Date: June 25, 1999

To: Mr. Joe Tram, PE
Special Projects Branch
FCDMC

From: Ted Lehman
JE Fuller / Hydrology & Geomorphology, Inc.

Re: Progress report for 99-48 through June 25, 1999

Assignment No. 1

Slope-Area and Slope-conveyance surveys of 6 locations have been conducted. Computations of the indirect estimates of peak discharge for the Nora flood at 5 of the 6 locations have been completed. Figures and summaries for each of the estimates and a description of how they all fit together have been completed. Mr. Tram has been provided with a copy of this work for review.

The draft Data Collection Report has been submitted to Mr. Tram for his review.

Drafts of the surficial geology map and flood inundation limits for the 1997 flood have been received from the AZGS. These maps will be used to finalize the Landform map, begin the Stability map, and serve as an important basis for the 1999 Flood Hazard map.

The surficial geology map from AZGS (Task 3, Assignment No. 2) will be used as a basis to modify, fine-tune, and finalize the Landform map during July. Mr. Tram will be provided with a copy of the results for review as soon as they are finished.

The Stability map (Step 2) will also be completed in July once comments on the Landform map have been incorporated.

Finally, it is planned to have both the Landform map and Stability maps finalized by the end of July. It is anticipated that the Flood Hazard map will be started in July and completed in August.

In order to better incorporate the AZGS work in Assignment No. 2 into the approximate floodplain study, I have delayed the schedule about one month for the intermediate tasks discussed above. However, the final completion of the delineation and submittal to FEMA is still expected on schedule in the end of September. The attached revised schedule reflects these proposed changes to the project schedule for Assignment No. 1.

Assignment No. 2

The surficial geology map (Task 3) has been transferred to the USGS 7.5 minute quad map. An overlay of the Nora flood inundation map (Task 2) has been drafted for both the

east and west branches of Tiger Wash within Maricopa County from the geologic apex to the limits of T4N. The detailed flood mapping (Task 1) is currently under construction. Field data have been collected and aerial photo interpretation is on-going.

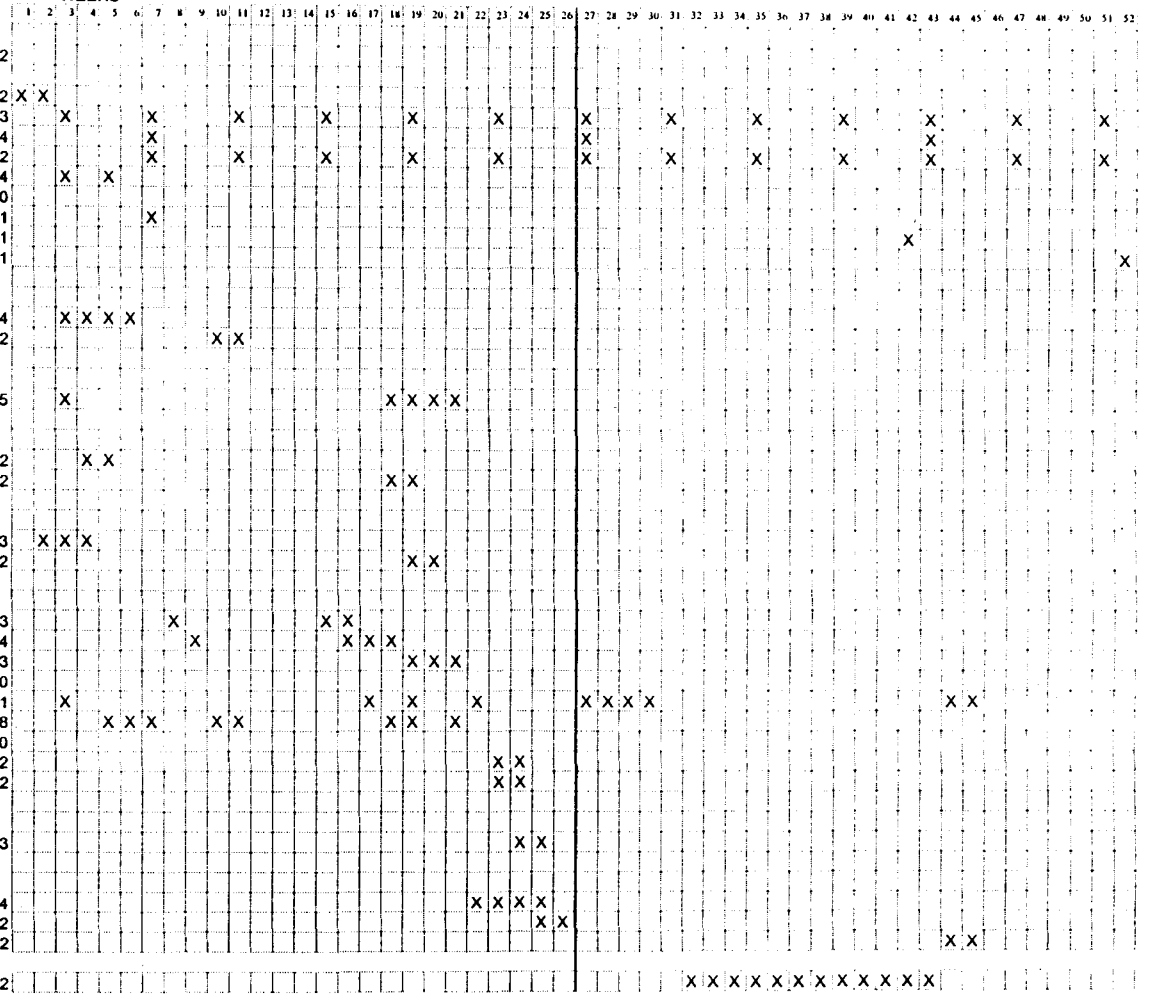
Task 1 is estimated as 50% complete, Task 2 as 90% complete, and Task 3 as 90% complete.

Remaining to be accomplished is the digitizing of the surficial geology map (Task 3) and the 1997 flood inundation map (Task 2). A partial draft of the map unit descriptions for the surficial geology map has been provided to JEF but remains to be finalized. A report on the methods and results of Tasks 1 and 2 will be done together as they are related. Finally, the detailed flood mapping continues. JEF will work with AZGS from the map data compiled by AZGS to perform a piedmont flood hazard assessment using the County manual for the pre-1997 flood condition. These results will be compared to the 1997 flood as a test of the manual methods on Tiger Wash fan. It is anticipated at this point that this "test" will be performed later in the schedule than indicated in the original schedule. If Mr. Tram agrees, JEF proposes for completion of these tasks (Tasks 3.2 and 3.3) following the FEMA submittal in September to be completed by the end of the calendar year. The revised project schedule for Assignment No. 2 is also provided.

Tiger Wash Approximate Z. . Floodplain Delineation
FCD Contract No. 98-48,
Assignment 1
Project Schedule

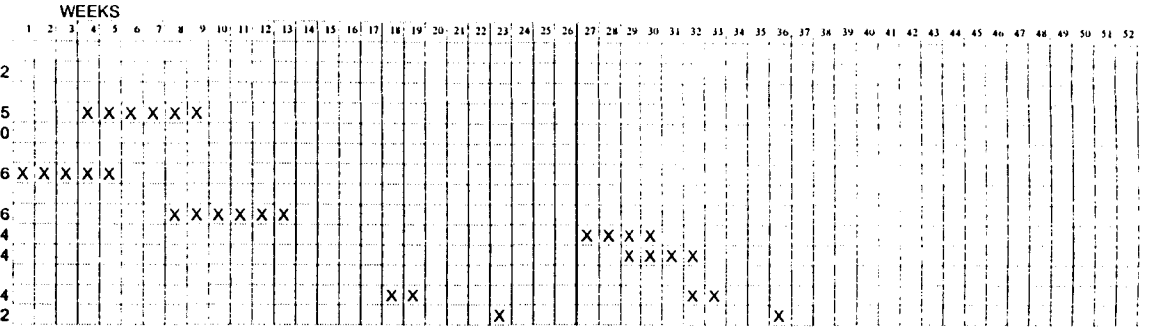
29-Mar-99 TWL

CONTRACT TASK/PHASE	Start Date	End Date	No. of Weeks
TASK A - Approximate FDS	19-Mar-99	17-Mar-00	52
Subtask 1. COORDINATION			
1.1 Project Schedule	19-Mar-99	2-Apr-99	2
1.2 Coordination Meetings	19-Mar-99	17-Mar-00	13
1.3 Quarterly Billing Summary	19-Mar-99	31-Mar-00	4
1.4 Monthly Progress Reports	19-Mar-99	31-Mar-00	12
1.5 Legal Advertising	19-Mar-99	26-Apr-99	4
1.6 Property Owner Notification	19-Mar-99	19-Mar-99	0
1.7 Community Official Meeting	19-Mar-99	10-May-99	1
1.8 Public Meetings	13-Dec-99	20-Dec-99	1
1.9 Evaluations	13-Mar-00	17-Mar-00	1
Subtask 2. DATA COLLECTION			
2.1 Collect & Review Data	5-Apr-99	3-May-99	4
2.2 Data Collection Report	24-May-99	2-Jun-99	2
Subtask 3. TOPOGRAPHIC MAPPING			
3.1 USGS Mapping	5-Apr-99	16-Aug-99	5
Subtask 4- FIELD SURVEY			
4.1 Survey Mounuments	12-Apr-99	26-Apr-99	2
4.2 TDN Documentation	19-Jul-99	30-Jul-99	2
Subtask 5. HYDROLOGY			
5.1 USGS Gage Statistics	29-Mar-99	16-Apr-99	3
5.2 TDN Documentation	26-Jul-99	9-Aug-99	2
Subtask 6- FLOODPLAIN DELINEATION			
6.1 Piedmont Landform Assessment	3-May-99	12-Jul-99	3
6.2 Piedmont Stability Assessment	31-May-99	26-Jul-99	4
6.3 100-Year Flood Hazard	28-Jun-99	16-Aug-99	3
6.4 ADWR/FEMA Standards	19-Mar-99	19-Mar-99	0
6.5 District Approvals	5-Apr-99	17-Mar-00	11
6.6 Field Reconnaissance	19-Apr-99	16-Aug-99	8
6.7 FEMA Criteria for Zone A	19-Mar-99	19-Mar-99	0
6.8 TDN Preparation	23-Aug-99	6-Sep-99	2
6.9 FEMA Form Preparation	23-Aug-99	6-Sep-99	2
Subtask 7. CAD DATA			
7.1 FCDMC HIS Layer Preparation	30-Aug-99	13-Sep-99	3
Subtask 8. DELIVERABLES			
8.1 Pre-FEMA Submittal	16-Aug-99	13-Sep-99	4
8.2 FEMASubmittal	13-Sep-99	27-Sep-99	2
8.3 Final Submittal	17-Jan-00	31-Jan-00	2
FEMA REVIEW	25-Oct-99	17-Jan-00	12



Tiger Wash Approximate [illegible], Floodplain Delineation
FCD Contract No. 98-48,
Assignment 2
Project Schedule

CONTRACT TASK/PHASE	Start Date	End Date	No. of Weeks
Assignment No. 2 - Task B			
TASK B - Mapping of 1997 Flood	19-Mar-99	17-Mar-00	52
Subtask 1. Detailed Mapping			
1.1 Mapping of West Branch Piedmont	12-Apr-99	17-May-99	5
1.2 Aerial Photographs			0
Subtask 2. Reconnaissance Mapping			
2.1 Mapping of 1997 Flood Limits	19-Mar-99	30-Apr-99	6
Subtask 3. Detailed Surficial Mapping			
3.1 Mapping of Piedmont Surfaces	10-May-99	21-Jun-99	6
3.2 Assess Pre-1997 Hazards	27-Sep-99	25-Oct-99	4
3.3 Test District Methodology	11-Oct-99	08-Nov-99	4
Subtask 4. Deliverables			
4.1 Draft Report	19-Jul-99	01-Nov-99	4
4.2 Final Report	30-Aug-99	22-Nov-99	2



JE FULLER/HYDROLOGY & GEOMORPHOLOGY, INC.
583 West Magdalena Street, Tempe, Arizona 85283 - (602)-752-2124 / Fax (602)-839-2193

FAX TRANSMITTAL

Fax #: 602 561 4601	Date: 6-16-99
To: Joe Tram	From: Ted Lehman
Company: FCDMC	Total Pages: 4
Project: FCDMC #76-48	

Message:

Joe -

As promised minutes of my meeting with Phil. I will have a complete progress report for you (including Phil's work too) at the end of next week.

Memorandum **JE Fuller/ Hydrology & Geomorphology, Inc.**

DATE: June 16, 1999

TO: File

FROM: Ted Lehman

RE: Meeting Minutes of June 16, 1999 with Phil Pearthree of AZGS

CC: Joe Tram, PE, FCDMC

Phil Pearthree met with Ted Lehman to discuss AZGS progress to date on Assignment No. 2. Also discussed were plans for the next and remaining portions of the job. A copy of Mr. Pearthree's progress summary is attached.

Mr. Peathree provided Mr. Lehman with a copy of the flood inundation map to date, as well as the surficial geology map. The surficial geology map is on loan for two weeks. AZGS will digitize this map in July for use in the production of the final reports. The flood inundation map will also be digitized by AZGS in the next few weeks.

Mr. Pearthree and Mr. Lehman discussed how the data provided by AZGS would be used in the FEMA submittal. Mr. Lehman indicated that the surficial geology map would be used to support the landform and stability map phases of the piedmont assessment manual method for the FEMA submittal. Mr. Lehman also indicated that the flood inundation map along with the flood-flow-frequency data would be used as a central source for the 100-year approximate floodplain mapping. Essentially, the argument will be made that the 1997 flood was about a 100-year flood and that hence its limits can be taken as a reasonable approximation of the 100-year floodplain. Additional designation of "high hazard" flood areas will be made based upon the surficial geology map, the detailed flood inundation map, and professional judgment.

Also discussed was the use of the surficial geology map and the pre-1997 photos as a basis for a "blind test" of the *Piedmont Flood Hazard Asssessment Manual.* Mr. Pearthree indicated that the surficial geology map was compiled without consideration of the post Nora evidence as much as possible and as such could serve as a primary foundation for a pre-Nora flood hazard assessment. AZGS and JEF agreed to work together on this test.

Problems of rectification and transfer of data from various sources to the USGS maps was also discussed. Mr. Pearthree expressed some confidence in the reasonableness of the transfer done to create the surficial geology map. Mr. Lehman suggested it could be used as a fundamental basis of "true" planimetric location of features on the fan for the other data sets including the flood inundation map, landform map, stability map, and 100-year approximate floodplain map.

Finally, Mr. Pearthree and Mr. Lehman discussed possible additional tasks that might be investigated if budget remains or should the District have an interest in funding upon completion of No. 98-48. Several ideas were brought up: 1) constructive critique and

input to the August 1998 draft of the Manual, including additions, and possible reorganization, etc. 2) detailed forensic hydrologic investigation of Nora floods elsewhere in SW AZ, 3) use of satellite data in alluvial fan assessment, 4) spatial mapping of fan channel scars across different aged surfaces, 5) further use of C_{14} dating of more ironwood trees carcasses across various portions of the fan.

Mr. Lehman provided Mr. Pearthree with a CD-ROM containing the semi-rectified aerial photos from 1953 and 1976 provided to JEF earlier by Mr. Jim Smith of the FCD.

Current Status, 6/15/99 – Tiger Wash alluvial fan analysis

Task 1 - Detailed mapping and analysis of the 1997 flood on the Tiger Wash fan, on the west branch of the larger distributary system.

50%

detailed, large-scale mapping of alluvial fan flood on Tiger Wash fan, which was trenched and studied in 1992; including mapping new channels and deposits, and probably mapping by peak flow depth category as was done for Wild Burro alluvial fan flood on the Tortolita piedmont

acquired large-scale, post-flood aerial photos of the west branch of Tiger Wash; may be feasible to do detailed flow mapping in field with new photos next fall when cooler weather returns, if budget permits

Task 2 - Reconnaissance mapping and general characterization of 1997 flood flow in the Tiger Wash distributary drainage system.

90%

document inundation areas and flow paths of the larger Tiger Wash distributary system, including both east and west distributary branches, beginning upstream of the first distributary channels and continuing downslope to the southern limit of BLM land (south sides of Sections 31, 32, and 33)

the purposes of this reconnaissance mapping of flow paths are to document the general patterns of flow in the whole distributary system, show the full extent of inundation, assess importance of channelized vs. sheetflow in this large distributary system, and to document substantial changes in channel position and areas of significant new erosion and deposition

total extent of inundation north of BLM boundary has been mapped; mapping of channel areas, areas of deep sheet flow with small channels and shallow sheet flow based on detailed transects and aerial photointerpretation is underway

Task 3 - Detailed surficial geologic mapping and geomorphologic analysis of the piedmont including the Tiger Wash distributary drainage system to define flood hazard zones as they existed prior to Sept 1997.

20%

use pre-flood color aerial photographs to make a 1:24,000-scale map of the surficial geology and geomorphology of the Tiger Wash piedmont from the bedrock ridge/confined reach of Tiger Wash downstream to Salome-Tonopah Highway; compare the implications of this analysis with the actual areas and character of flood inundation should provide a test of the methodology

have completed aerial photointerpretation and field checking and have draft version of detailed surficial geologic map of the Tiger Wash distributary system; described soils associated with most of the surficial geologic map units

remaining → digitizing + write up - draft partial

Date: May 21, 1999

To: Mr. Joe Tram, PE
Special Projects Branch
FCDMC

From: Ted Lehman
JE Fuller / Hydrology & Geomorphology, Inc.

Re: Progress report for 99-48 through May 21, 1999

Assignment No. 1

Slope-Area and Slope-conveyance surveys of 6 locations have been conducted. Computations of the indirect estimates of peak discharge for the Nora flood at 5 of the 6 locations have been completed. Figures and summaries for each of the estimates and a description of how they all fit together should be completed by the end of May. Mr. Tram will be provided with a copy of this work at that time upon request.

Research has been largely completed for the Data Collection Report. A bibliography has been compiled. As indicated in the original schedule, the draft report will be written in the following two weeks.

A draft of a preliminary Landform map (Step 1 in Piedmont Assessment procedure) is provided with this progress report along with a figure showing the soils map for the area.

The Stability map (Step 2) will begin as the Landform map is finalized and once the Draft Data Collection report has been completed in June.

Assignment No. 2

Transfer of the Nora flood inundation map (Task 2) and surficial geology map (Task 3) to USGS 7.5 minute quads in underway by the AZGS. JEF plans to receive these maps during a progress meeting with AZGS scheduled for June 3 in Tempe.

Subject: April Progress Report for FCD 98-48 (Tiger Wash)
Date: Mon, 03 May 1999 20:18:02 -0700
From: Ted Lehman <ted@jefuller.com>
Organization: JE Fuller / Hydrology & Geomorphology, Inc
To: jjt@mail.maricopa.gov
CC: jefuller@aol.com, "ted@jefuller.com" <ted@jefuller.com>

Joe,

Attached you will find my progress report for FCD 98-48 for work through the end of April. Please call me or e-reply if you have any questions.

I look forward to seeing you at AFMA in Payson Thurs. and Fri.

Sincerely,

Ted Lehman
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.

April PR.doc	**Name:** April PR.doc **Type:** Winword File (application/msword) **Encoding:** base64

Date: May 4, 1999

To: Mr. Joe Tram, PE
Special Projects Branch
FCDMC

From: Ted Lehman
JE Fuller / Hydrology & Geomorphology, Inc.

Re: Progress report for 99-48 through end of April 1999

Assignment No. 1

Slope-Area and Slope-conveyance surveys of 6 locations have been conducted. Computations of the indirect estimates of peak discharge for the Nora flood at various points along the fan are underway. The computations should be completed by mid-May.

Research has been largely completed for the Data Collection Report. A bibliography has been compiled.

The paleoflood site examined in the CH2M Hill report was also investigated. Field evidence indicates that the Nora flood maximum stage was about 2.2 feet lower than the highest paleoflood indicators.

Landform map (Step 1 in Piedmont Assessment procedure) underway.

Assignment No. 2

Task 1 - Detailed mapping and analysis of the 1997 flood on the Tiger Wash fan, on the west branch of the larger distributary system.

acquisition of large-scale, post-flood aerial photos of the west branch of Tiger Wash has been completed; will assess feasibility of detailed flow mapping in field with new photos; will probably not complete this task this spring, but may be able to do it next fall when cooler weather returns

Task 2 - Reconnaissance mapping and general characterization of 1997 flood flow in the Tiger Wash distributary drainage system.

initial inundation map of east and west branches is complete; additionally, channel areas have been mapped, depiction of extent of 3 classes of flow underway—1) areas of deep sheet flow with small channels 2) shallow sheet flow and 3) areas of channelized flow including distributary channels; verification of aforementioned analyses will be completed using new 1999 color aerial photos; digitization of results still to do

Task 3 - Detailed surficial geologic mapping and geomorphologic analysis of the piedmont including the Tiger Wash distributary drainage system to define flood hazard zones as they existed prior to Sept 1997.

aerial photointerpretation substantially complete; field descriptions of soils on various surfaces completed; remaining tasks include finalizing photo interpretation (which will be assisted by new 1999 photos due to larger scale), digitize results, final field verifications of results

final results minus digitizing should be complete by end of May

JEFuller / Hydrology & Geomorphology, Inc.

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602-839-2193 (fax)
jefuller@aol.com (email)

April 1, 1999

TRANSMITTAL

Joe Tram, P.E.
Special Projects Branch Manager
Flood Control District of Maricopa County

Attached are the following materials provided by JEFuller/ Hydrology & Geomorphology, Inc.:

Copy of the project schedules for Tiger Wash Assignments 1 and 2 (Tasks A and B).

Joe
Mr. Tram,

Per the scope of work for the Tiger Wash approximate floodplain delineation contract FCD No. 98-48, I am submitting project work schedules for Assignments No. 1 and No. 2. The schedules reflect our intention to produce a product for delivery to FEMA six (6) months from the NTP (March 19, 1999).

Sincerely,

Ted Lehman

Joe,

hed you will find Excel spreadsheets containing our proposed schedules for Task A and Task B (i.e. Assignment No. 1 and No. 2 respectively). Paper copies will follow in the regular mail.

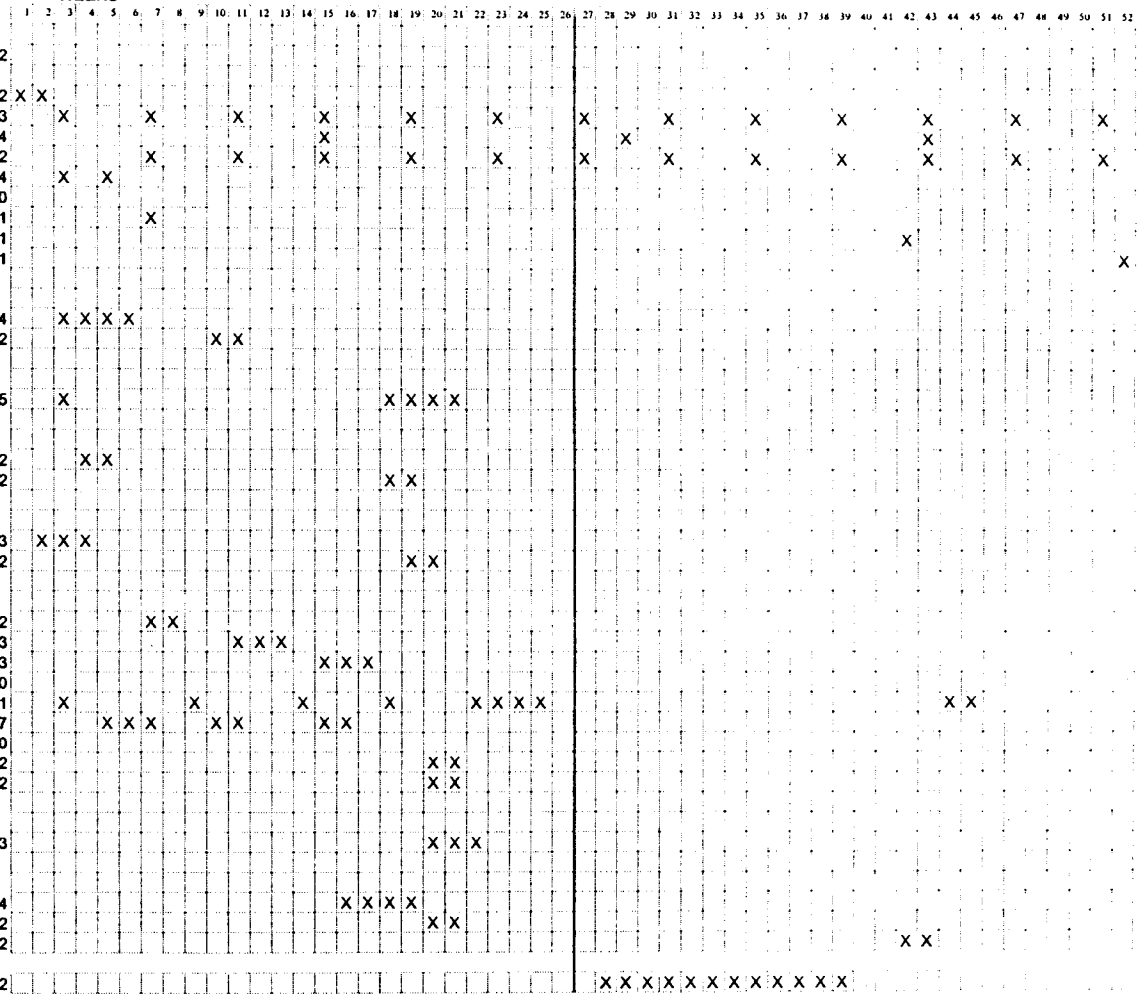
If you have any questions, please do not hesitate to call Jon or I at (480) 752-2124.

Sincerely,

Ted Lehman

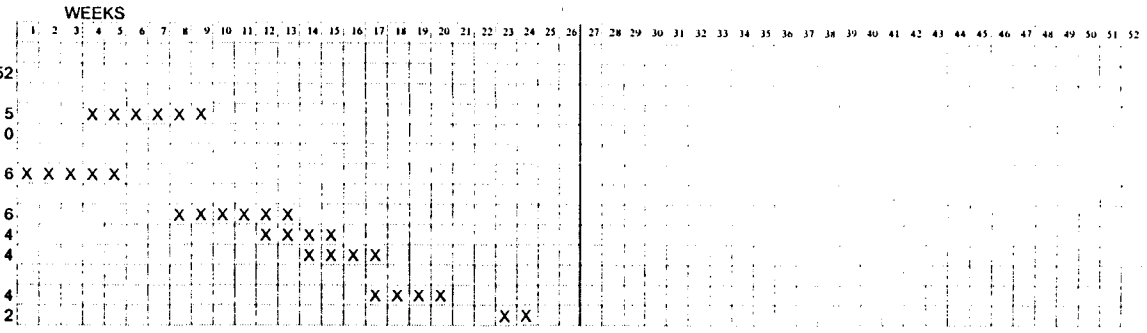
Tiger Wash Approximate Z. Floodplain Delineation
FCD Contract No. 98-48,
Assignment 1
Project Schedule

29-Mar-99 TWL CONTRACT TASK/PHASE TASK A - Approximate FDS	Start Date	End Date	No. of Weeks
	19-Mar-99	17-Mar-00	52
Subtask 1. COORDINATION			
1.1 Project Schedule	19-Mar-99	2-Apr-99	2
1.2 Coordination Meetings	19-Mar-99	17-Mar-00	13
1.3 Quarterly Billing Summary	19-Mar-99	31-Mar-00	4
1.4 Monthly Progress Reports	19-Mar-99	31-Mar-00	12
1.5 Legal Advertising	19-Mar-99	26-Apr-99	4
1.6 Property Owner Notification	19-Mar-99	19-Mar-99	0
1.7 Community Official Meeting	19-Mar-99	10-May-99	1
1.8 Public Meetings	13-Dec-99	20-Dec-99	1
1.9 Evaluations	13-Mar-00	17-Mar-00	1
Subtask 2. DATA COLLECTION			
2.1 Collect & Review Data	5-Apr-99	3-May-99	4
2.2 Data Collection Report	24-May-99	2-Jun-99	2
Subtask 3. TOPOGRAPHIC MAPPING			
3.1 USGS Mapping	5-Apr-99	16-Aug-99	5
Subtask 4- FIELD SURVEY			
4.1 Survey Mounuments	12-Apr-99	26-Apr-99	2
4.2 TDN Documentation	19-Jul-99	30-Jul-99	2
Subtask 5. HYDROLOGY			
5.1 USGS Gage Statistics	29-Mar-99	16-Apr-99	3
5.2 TDN Documentation	26-Jul-99	9-Aug-99	2
Subtask 6- FLOODPLAIN DELINEATION			
6.1 Piedmont Landform Assessment	3-May-99	17-May-99	2
6.2 Piedmont Stability Assessment	31-May-99	21-Jun-99	3
6.3 100-Year Flood Hazard	28-Jun-99	19-Jul-99	3
6.4 ADWR/FEMA Standards	19-Mar-99	19-Mar-99	0
6.5 District Approvals	5-Apr-99	17-Mar-00	11
6.6 Field Reconnaissance	19-Apr-99	9-Jul-99	7
6.7 FEMA Criteria for Zone A	19-Mar-99	19-Mar-99	0
6.8 TDN Preparation	2-Aug-99	13-Aug-99	2
6.9 FEMA Form Preparation	2-Aug-99	13-Aug-99	2
Subtask 7. CAD DATA			
7.1 FCDMC HIS Layer Preparation	2-Aug-99	23-Aug-99	3
Subtask 8. DELIVERABLES			
8.1 Pre-FEMA Submittal	5-Jul-99	30-Jul-99	4
8.2 FEMASubmittal	2-Aug-99	13-Aug-99	2
8.3 Final Submittal	10-Jan-00	24-Jan-00	2
FEMA REVIEW	27-Sep-99	24-Dec-99	12



Tiger Wash Approximate 2. / loodplain Delineation
FCD Contract No. 98-48.
Assignment 2
Project Schedule

CONTRACT TASK/PHASE	Start Date	End Date	No. of Weeks
Assignment No. 2 - Task B			
TASK B - Mapping of 1997 Flood	19-Mar-99	17-Mar-00	52
Subtask 1. Detailed Mapping			
1.1 Mapping of West Branch Piedmont	12-Apr-99	17-May-99	5
1.2 Aerial Photographs			0
Subtask 2. Reconnaissance Mapping			
2.1 Mapping of 1997 Flood Limits	19-Mar-99	30-Apr-99	6
Subtask 3. Detailed Surficial Mapping			
3.1 Mapping of Piedmont Surfaces	10-May-99	21-Jun-99	6
3.2 Assess Pre-1997 Hazards	07-Jun-99	05-Jul-99	4
3.3 Test District Methodology	21-Jun-99	19-Jul-99	4
Subtask 4. Deliverables			
4.1 Draft Report	12-Jul-99	09-Aug-99	4
4.2 Final Report	30-Aug-99	13-Sep-99	2



JEFuller / Hydrology & Geomorphology, Inc.

5235 South Kyrene, Suite 205
Tempe, AZ 85283
602-752-2124 (voice)
602-839-2193 (fax)
jefuller@aol.com (email)

March 29, 1999

TRANSMITTAL

Phil Pearthree
Arizona Geological Survey

Attached are the following materials provided by JEFuller/ Hydrology & Geomorphology, Inc.:

Copy of proposed schedule for Tiger Wash Assignments 1 and 2 (Tasks A and B).

Phil,

Please take a look at the proposed schedules I have put together for Tiger Wash. I realize they may be bit ambitious, however, we need to provide Mr. Joe Tram with something that shows we (JEF) will be using your results in our Zone A delineation. The contract duration is for 1 year, but we have a deadline of 26 weeks for the initial FEMA submittal. The schedule for Task A reflects the FEMA deadline.

Since I was aware that Jean will be leaving for CO after May and that her contributions to the project are very important, I hope my proposed schedule is not too far fetched.

Please let me know if/how the schedules need revision to best reflect the time required and the FEMA submittal deadline.

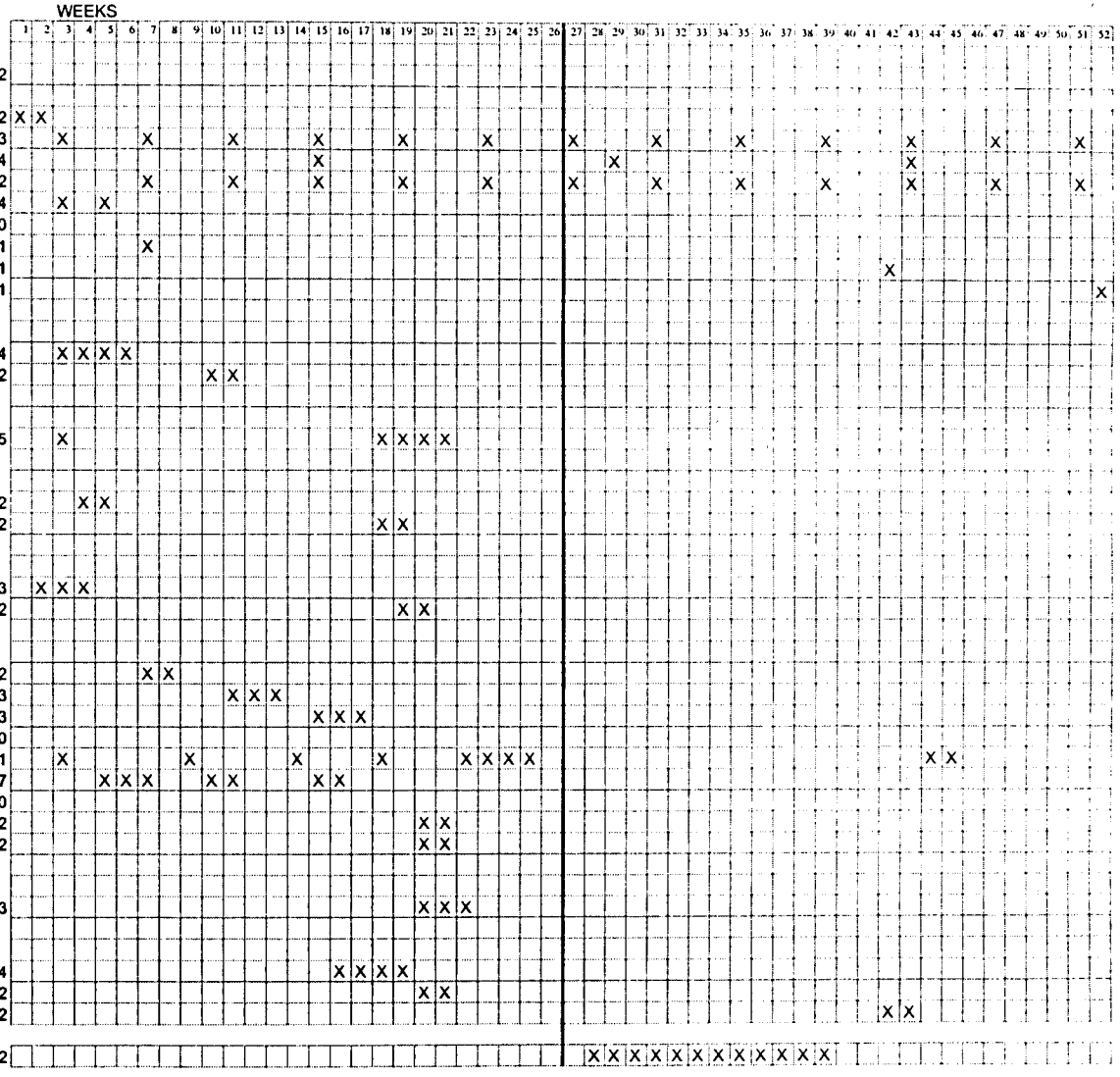
Thanks,

Ted Lehman

Tiger Wash Approximate Zone . oodplain Delineation
FCD Contract No. 98-48,
Assignment 1
Project Schedule

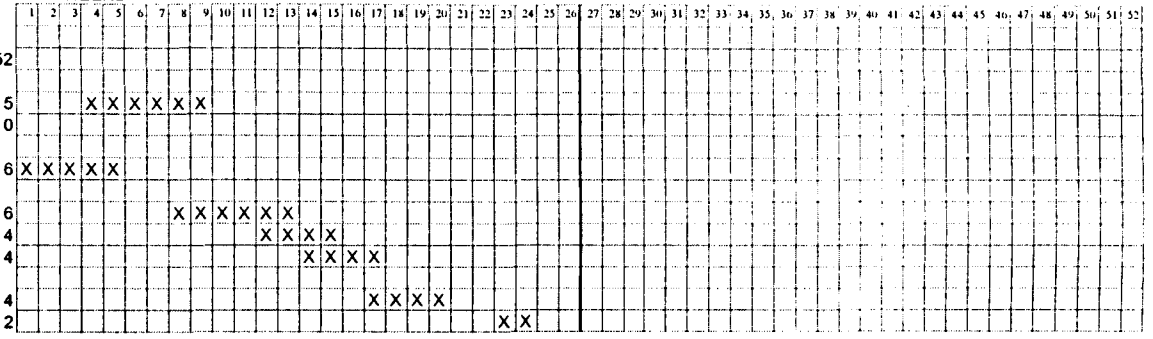
29-Mar-99 TWL

CONTRACT TASK/PHASE TASK A - Approximate FDS	Start Date	End Date	No. of Weeks
- - - -	19-Mar-99	17-Mar-00	52
Subtask 1. COORDINATION			
1.1 Project Schedule	19-Mar-99	2-Apr-99	2
1.2 Coordination Meetings	19-Mar-99	17-Mar-00	13
1.3 Quarterly Billing Summary	19-Mar-99	31-Mar-00	4
1.4 Monthly Progress Reports	19-Mar-99	31-Mar-00	12
1.5 Legal Advertising	19-Mar-99	26-Apr-99	4
1.6 Property Owner Notification	19-Mar-99	19-Mar-99	0
1.7 Community Official Meeting	19-Mar-99	10-May-99	1
1.8 Public Meetings	13-Dec-99	20-Dec-99	1
1.9 Evaluations	13-Mar-00	17-Mar-00	1
Subtask 2. DATA COLLECTION			
2.1 Collect & Review Data	5-Apr-99	3-May-99	4
2.2 Data Collection Report	24-May-99	2-Jun-99	2
Subtask 3. TOPOGRAPHIC MAPPING			
3.1 USGS Mapping	5-Apr-99	16-Aug-99	5
Subtask 4- FIELD SURVEY			
4.1 Survey Mounuments	12-Apr-99	26-Apr-99	2
4.2 TDN Documentation	19-Jul-99	30-Jul-99	2
Subtask 5. HYDROLOGY			
5.1 USGS Gage Statistics	29-Mar-99	16-Apr-99	3
5.2 TDN Documentation	26-Jul-99	9-Aug-99	2
Subtask 6- FLOODPLAIN DELINEATION			
6.1 Piedmont Landform Assessment	3-May-99	17-May-99	2
6.2 Piedmont Stability Assessment	31-May-99	21-Jun-99	3
6.3 100-Year Flood Hazard	28-Jun-99	19-Jul-99	3
6.4 ADWR/FEMA Standards	19-Mar-99	19-Mar-99	0
6.5 District Approvals	5-Apr-99	17-Mar-00	11
6.6 Field Reconnaissance	19-Apr-99	9-Jul-99	7
6.7 FEMA Criteria for Zone A	19-Mar-99	19-Mar-99	0
6.8 TDN Preparation	2-Aug-99	13-Aug-99	2
6.9 FEMA Form Preparation	2-Aug-99	13-Aug-99	2
Subtask 7. CAD DATA			
7.1 FCDMC HIS Layer Preparation	2-Aug-99	23-Aug-99	3
Subtask 8. DELIVERABLES			
8.1 Pre-FEMA Submittal	5-Jul-99	30-Jul-99	4
8.2 FEMASubmittal	2-Aug-99	13-Aug-99	2
8.3 Final Submittal	10-Jan-00	24-Jan-00	2
FEMA REVIEW	27-Sep-99	24-Dec-99	12



Tiger Wash Approximate Zone . . oodplain Delineation
FCD Contract No. 98-48,
Assignment 2
Project Schedule

CONTRACT TASK/PHASE Assignment No. 2 - Task B TASK B - Mapping of 1997 Flood	Start Date	End Date	No. of Weeks
	19-Mar-99	17-Mar-00	52
Subtask 1. Detailed Mapping			
1.1 Mapping of West Branch Piedmont	12-Apr-99	17-May-99	5
1.2 Aerial Photographs			0
Subtask 2. Reconnaissance Mapping			
2.1 Mapping of 1997 Flood Limits	19-Mar-99	30-Apr-99	6
Subtask 3. Detailed Surficial Mapping			
3.1 Mapping of Piedmont Surfaces	10-May-99	21-Jun-99	6
3.2 Assess Pre-1997 Hazards	07-Jun-99	05-Jul-99	4
3.3 Test District Methodology	21-Jun-99	19-Jul-99	4
Subtask 4. Deliverables			
4.1 Draft Report	12-Jul-99	09-Aug-99	4
4.2 Final Report	30-Aug-99	13-Sep-99	2



B.5 Contract Documents

FLOOD CONTROL DISTRICT of MARICOPA COUNTY 1959

FLOOD CONTROL DISTRICT of Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009-6399
Telephone (602) 506-1501
Fax (602) 506-4601
TT (602) 506-5897

BOARD OF DIRECTORS
Ian Brewer
Fulton Brock
Andrew Kunasek
Don Stapley
Mary Rose Garrido Wilcox

May 5, 2000

Jonathan Fuller, P.E.
JEFuller/Hydrology & Geomorphology, Inc.
5235 South Kyrene, Suite 205
Tempe, AZ 85283

Subject: Contract FCD 98-48 - Authorization of time extension and modification of work assignment

Dear Mr. Fuller:

This letter is in response to the District's verbal request for the following additional data: 1) reorganization of the TDN section 6B so that it addresses Geomorphology, 2) expansion of the study limits to include the eastern portion of the site, 3) review and coordination of definitions with FEMA and also definitions within the County's Floodplain Management Regulations, 4) re-plotting and optimizing map display of flood zones and geomorphic designations, and 5) modification of the preliminary TDN and report based upon a 3rd party review. The above request will supplant sub-task 7, CADD data deliverables, which had a contract amount of $4013.00, and will require an additional time of extension of 180 days to allow for FEMA review.

If you have any further questions, please call me at (602) 506-5537.

Sincerely,

Joe Tram

Joe Tram, P.E.
Project Manager

JE Fuller/ Hydrology & Geomorphology, Inc.

Jonathan Fuller, P.E., P.H.
Brian Iserman, P.E.
John Wallace, P.E.
Ted Lehman

5235 So. Kyrene Rd., Suite 205
Tempe, Arizona 85283
480-752-2124 (voice)
480-839-2193 (fax)
www.jefuller.com

May 21, 1999

Phil Pearthree
Arizona Geological Survey
416 W. Congress, Suite 100
Tucson, AZ 85701
(520) 770-3500 Voice
(520) 770-3505 FAX

Re: Contract Amendment – Tiger Wash, FCD No. 98-48, Assignment No. 2

Mr. Pearthree:

Per your telephone conversations with Mr. Jonathan E. Fuller of our office, we will make payment for the 3-30-99 color stereo aerial photographs by Aerial Mapping Company, Inc.. As you discussed with Mr. Fuller, the cost for the photos of $1,900 will be reduced from your total contract fee with JE Fuller, Inc. to a new total value of $20,682.00

Please have your Director Mr. Larry Fellows sign below acknowledging this change to our contract for FCD No. 98-48. Please return the signed document to the address above.

Sincerely,

Ted Lehman
Project Manager
JE Fuller / Hydrology & Geomorphology, Inc.

Agreed:

Larry Fellows
Director
Arizona Geological Survey

INDEPENDENT CONSULTANT AGREEMENT
FOR
DELINEATION OF TIGER WASH FLOODPLAIN – TASK B

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY CONTRACT FCD-98-48

This CONTRACT entered into this 1ST day of February, 1999, is an agreement between JE Fuller/ Hydrology & Geomorphology, Inc. (JEF) and the Arizona Geological Survey (AZGS), an independent consultant, hereinafter referred to as CONSULTANT.

The CONSULTANT and JEF for mutual considerations hereinafter set forth, agree as follows:

A. The CONSULTANT agrees to perform the following professional services:

> Task B, subtasks 1 and 2, and assistance with subtask 3, as described in the project scope of work, Exhibit A, and as described in the contract for, and proposal to, the Flood Control District of Maricopa County (the District) for the above-referenced study. Work shall be completed to the satisfaction of JEF and the District.

B. JEF agrees to compensate the CONSULTANT for such services as follows:

> Payment will be made on a not-to-exceed basis for a value of $22,582.00. Payment will be made in monthly installments based on the CONSULTANTS detailed invoice for work completed and subject to the provisions of Paragraph L & M of this Agreement. The final invoice for the project must be received prior to May 30, 2000.

C. CONSULTANT hereby agrees that the CONSULTANT is not an employee of JEF for any purpose including, but not limited to, Federal and State income withholding, Social Security, Federal and State unemployment insurance and worker's compensation, and agrees further that the CONSULTANT will be responsible for the payment of all Federal and State income tax and Social Security obligations with respect to payments received from JEF hereunder.

D. CONSULTANT specifically acknowledges that the payments made hereunder are the total payment for the services provided.

E. CONSULTANT shall make arrangements for and provide any required work space, transportation, material and equipment not furnished by JEF.

F. CONSULTANT is responsible for the securing of any licenses and/or permits required in connection with the performance of this contract.

G. CONSULTANT shall perform the services which are the subject matter hereof promptly, without undue delay and shall devote such time and effort to the performance of such services as may be necessary to expedite the performance thereof. CONSULTANT agrees that the services to be performed by CONSULTANT pursuant hereto, and the product of such services will of high quality in all respects.

H. CONSULTANT acknowledges that the services to be rendered by CONSULTANT pursuant to the Agreement are unique and personal. Accordingly, CONSULTANT shall not have the right to assign all or any portions of their rights, or assign or delegate all or any portion of their rights, or assign or delegate all or any portion of their duties or obligations under this Agreement without the prior written consent of JEF, which consent may be withheld in JEF's sole and absolute discretion. Any assignment or delegation in violation of the foregoing shall be void. JEF shall have the right to assign all or any portion of its right, title or interest under this Agreement at any time without the prior consent of the CONSULTANT.

I. CONSULTANT agrees not to discriminate against any employee or applicant for employment because of race, religion, color, sex, age, disability, or national origin and further agrees not to engage in unlawful employment practices.

J. CONSULTANT shall insure itself and its employees for any injuries, disability, loss of income, or other damages occurring during the performance of this contract. CONSULTANT agrees to indemnify and hold JEF harmless from any claims resulting from any negligent act or acts, jointly, severally, or individually, by the CONSULTANT or his employees, agents, or representatives during the term of this contract. CONSULTANT shall provide its own professional liability insurance during the project and for a three year period thereafter.

K. JEF agrees to pay CONSULTANT invoices as submitted pursuant to paragraph K above within fifteen (15) working days after JEF has received from their client payment for the invoiced work, unless JEF shall dispute the amounts thereof, in which event JEF shall not be required to pay the amount of any such invoice so disputed unless and until such dispute has been resolved by the agreement of the parties or a final non-appealable judgment of a court of competent jurisdiction.

L. JEF and CONSULTANT acknowledge that this Agreement constitutes the entire agreement of the parties with respect to the subject matter hereof. This Agreement may be modified or amended only by an instrument in writing signed by the parties hereto. The Agreement shall be governed by the laws of the State of Arizona. Subject to the provisions set forth herein restricting CONSULTANT'S right against assigning its rights or assigning or delegating its duties and obligations of this Agreement, this Agreement shall be binding upon and inure to the benefits of the heirs, successors, personal representatives and assigns of the respective parties hereto.

M. Either party may terminate this Agreement at any time without cause upon delivery of written notice to that effect to the other, in which event this Agreement shall terminate twenty-four (24) hours after the delivery of such written notice; provided, however, that in the event of such termination, JEF shall pay CONSULTANT for any amounts properly due under paragraphs K and L above, prorated to the date of termination, and CONSULTANT shall forthwith deliver to JEF all original sketches, drawings, tracings, computations, survey notes and any other documentation prepared or obtained by CONSULTANT in connection with this Agreement. Notwithstanding a termination of Agreement pursuant to this paragraph, the representations and certifications of CONSULTANT as set forth herein and the provisions of paragraph G above shall remain in full force and effect.

N. In the event either CONSULTANT or JEF shall be in default in connection with this Agreement, the non-defaulting party shall have the right to pursue any remedies available at law or in equity. CONSULTANT expressly acknowledges that the obligations of CONSULTANT under this Agreement, including, but not limited to paragraphs G and N hereof are unique, and accordingly, in the event CONSULTANT shall be in default under this Agreement, JEF shall have the right to enforce the provisions of this Agreement against CONSULTANT by specific performance, injunction or other equitable relief.

O. All notices, requests, demands or other communications "Notices" required or permitted to be given hereunder shall be delivered to CONSULTANT at the address set forth below CONSULTANT'S signature on this Agreement and shall be sent to JEF provided, however, that either party hereto shall have the right to change the address as to which Notices are sent to it under this Agreement by providing to the other party written notice of the change of such address in the manner set forth above. All Notices shall be in writing and shall be either personally delivered or deposited in the United States Mails, postage pre-paid to the appropriate address as set forth above. Any Notice which is personally delivered shall be deemed to be given immediately upon such delivery. Any Notice which is mailed shall be deemed to be given two (2) days after the deposit of the same into the United States Mails.

P. If any of the provisions contained in this CONTRACT are held illegal, invalid or unenforceable, the enforceability of the remaining provisions shall not be impaired thereby. Limitations of liability indemnities, and other express representations shall survive termination of this CONTRACT for any cause.

Q. This CONTRACT gives no rights or benefits to anyone other than the CLIENT and JEF and has no third party beneficiaries. JEF's responsibilities are defined solely by this CONTRACT, and not by any other contract or agreement that may be associated with the Project.

CONSULTANT: Arizona Geological Survey

By: Tony D. Williams

Title: Director Date: 01 Feb 99

Address: 416 W. Congress St. #100
Tucson, AZ 85701

JEFuller/ Hydrology & Geomorphology, Inc.

By: J. W. Fuller

Title: President Date: 2/1/99

Address: 5235 S. Kyrene Rd., Suite 205
Tempe, AZ 85283

Consultant is a corporation ____Yes ✓ No

Employer Identification # 86-6004791

Social Security # _____

FLOOD CONTROL DISTRICT of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501
Fax (602) 506-4601

LETTER OF TRANSMITTAL

TO: Jon Fuller
JE Fuller Hydrology & Geomorphology
583 W. Magdalena Dr.
Tempe, AZ 85283

March 19, 1999

SUBJECT: Contract No. 98-48
Assignment No. 1
Approximate Zone A Floodplain Delineation

WE ARE SENDING YOU THE FOLLOWING ITEMS:
( ) Enclosed ( ) Under separate cover

	Shop Drawings	Prints	Legal Description	Samples
	Specification	Change Order	Copy of Letter	Plans
X	Notice to Proceed			
X	Certificate of Performance			
X	Scope of Work			

THESE ARE TRANSMITTED:

	For Approval	Approved as submitted
X	For your use	Approved as noted
	As requested	Returned for corrections
	Resubmit ( ) copies for approval	For review and comments
	Submit ( ) copies for distribution	Return ( ) corrected prints
	FOR ESTIMATE DUE:	Borrowed prints being returned

Remarks: Please specify assignment number on all correspondence.

SIGNED: Joe Tram

Joe Tram
Project Manager

FLOOD CONTROL DISTRICT of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501
Fax (602) 506-4601

NOTICE TO PROCEED

TO: Jon Fuller
JE Fuller Hydrology & Geomorphology

March 19, 1999

SUBJECT: PCN ZAHYDGEo.00.97
FCD Contract No. 98-48
Assignment No. 1
Approximate Zone A Floodplain Delineation

Your not-to-exceed cost estimate of $47,189.86 for Assignment No. 1 has been received and accepted for this project with a completion date of 6/15/00. You are hereby authorized to proceed with the work for the referenced project as originally described in the attached Scope of Work. Please specify the assignment number on all related correspondence. Invoices should be sent to the attention of Linda Hannan of our accounting department.

If at any time during the project assignment a material change in the scope of services to be provided occurs, causing an increase in the original cost estimate shown here, you must provide the District with a written explanation of the additional work along with an estimate of additional costs. No additional work shall commence prior to written authorization by the District. No claims for additional work shall be accepted that have not received prior District approval.

I have enclosed a Certificate of Performance for this assignment. When you have completed all of the duties related to this project, please return the completed, notarized certificate to me. Feel free to call me if you have any questions.

SIGNED: _____ _____

Joe Tram
Project Manager

Michael S. Ellegood, P.E.
Chief Engineer and General Manager

Certificate of Performance of Engineering Open Order Contract and Payment of All Claims

I, _____, hereby certify to the Flood Control District of Maricopa County (FCDMC) that all lawful claims for labor, rental of equipment, material used, and any other claims by company, or its subcontractors in connection with the specific assignment described below and as authorized by the terms of the FCDMC Contract 98-48 have been paid.

Company understands that with receipt of payment for previously invoiced amounts plus any retained funds, that this is a settlement of all claims of every nature and kind against the FCDMC arising out of the performance of the FCDMC's specific assignment through FCDMC Contract 98-48 for Assignment No. 1 relating to the material, equipment, and work covered in and required by the contract.

The undersigned hereby certifies that to his/her knowledge, no contractual disputes exist in regard to this contract and that he/she has no knowledge of any pending or potential claims in regard to this contract.

Upon submission of this document and a separate invoice for any retained funds to the FCDMC, invoice processing will be completed within forty-five (45) calendar days.

Signed the _____ day of _____, 199__

_____
Signature

Title: _____

SUBSCRIBED AND SWORN TO before me this____ day of_____ , 199___ .

_____
Notary Public

My Commission Expires: _____

FLOOD CONTROL DISTRICT of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501
Fax (602) 506-4601

LETTER OF TRANSMITTAL

TO: Jon Fuller
JE Fuller Hydrology & Geomorphology
583 W. Magdalena Dr.
Tempe, AZ 85283

March 19, 1999

SUBJECT: Contract No. 98-48
Assignment No. 2
Mapping of 1997 Flood on Tiger Wash

WE ARE SENDING YOU THE FOLLOWING ITEMS:
( ) Enclosed ( ) Under separate cover

	Shop Drawings	Prints	Legal Description	Samples
	Specification	Change Order	Copy of Letter	Plans
X	Notice to Proceed			
X	Certificate of Performance			
X	Scope of Work			

THESE ARE TRANSMITTED:

	For Approval	Approved as submitted
X	For your use	Approved as noted
	As requested	Returned for corrections
	Resubmit ( ) copies for approval	For review and comments
	Submit ( ) copies for distribution	Return ( ) corrected prints
	FOR ESTIMATE DUE:	Borrowed prints being returned

Remarks: Please specify assignment number on all correspondence.

SIGNED: Joe Tram

Joe Tram, P.E.
Project Manager

FLOOD CONTROL DISTRICT of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009
(602) 506-1501
Fax (602) 506-4601

NOTICE TO PROCEED

TO: Jon Fuller
JE Fuller Hydrology & Geomorphology

March 19, 1999

SUBJECT: PCN ZAHYDGEo.00.97
FCD Contract No. 98-48
Assignment No. 2
Mapping of 1997 Flood on Tiger Wash

Your not-to-exceed cost estimate of $26,443.94 for Assignment No. 2 has been received and accepted for this project with a completion date of 6/15/00. You are hereby authorized to proceed with the work for the referenced project as originally described in the attached Scope of Work. Please specify the assignment number on all related correspondence. Invoices should be sent to the attention of Linda Hannan of our accounting department.

If at any time during the project assignment a material change in the scope of services to be provided occurs, causing an increase in the original cost estimate shown here, you must provide the District with a written explanation of the additional work along with an estimate of additional costs. No additional work shall commence prior to written authorization by the District. No claims for additional work shall be accepted that have not received prior District approval.

I have enclosed a Certificate of Performance for this assignment. When you have completed all of the duties related to this project, please return the completed, notarized certificate to me. Feel free to call me if you have any questions.

SIGNED: _____ _____

Joe Tram, P.E.
Project Manager

Michael S. Ellegood, P.E.
Chief Engineer and General Manager

Certificate of Performance of Engineering Open Order Contract and Payment of All Claims

I, _____, hereby certify to the Flood Control District of Maricopa County (FCDMC) that all lawful claims for labor, rental of equipment, material used, and any other claims by company, or its subcontractors in connection with the specific assignment described below and as authorized by the terms of the FCDMC Contract 98-48 have been paid.

Company understands that with receipt of payment for previously invoiced amounts plus any retained funds, that this is a settlement of all claims of every nature and kind against the FCDMC arising out of the performance of the FCDMC's specific assignment through FCDMC Contract 98-48 for Assignment No. 2 relating to the material, equipment, and work covered in and required by the contract.

The undersigned hereby certifies that to his/her knowledge, no contractual disputes exist in regard to this contract and that he/she has no knowledge of any pending or potential claims in regard to this contract.

Upon submission of this document and a separate invoice for any retained funds to the FCDMC, invoice processing will be completed within forty-five (45) calendar days.

Signed the _____ day of _____, 199__

_____
Signature

Title: _____

SUBSCRIBED AND SWORN TO before me this_____ day of_____ , 199___ .

_____
Notary Public

My Commission Expires: _____

SCOPE OF WORK
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
ZONE A FLOODPLAIN DELINEATION
FOR TIGER WASH
FCD 98-48

GENERAL

The project consists of Task A, the delineation of the floodplain for Tiger Wash piedmont surface downstream of its hydraulic apex, Task B, mapping of the 1997 flood limits, and Task C, application of alternative methodologies. The limits of the project are shown on attached Exhibit A. The study area is generally located in Sections 17, 19, 20, 29, 30, 31, and 32 of Township 4 North, Range 10 West. For this study the consultant will use USGS topography as the base mapping. The three-stage method identified in the draft Piedmont Assessment Manual for Maricopa County will be used to develop the floodplain delineation. This method progressively focuses on defining flood hazard zones by first recognizing and characterizing the kind and extent of piedmont landforms, and showing these landforms on a map. The second stage is the definition of the nature of the piedmont landform, identifying unstable and stable components of the piedmont, and showing these areas subject to various flood hazards on a map. The third stage identifies and applies methods for defining and characterizing areas affected by the 100-year flood, and showing these areas on a map.

All work must meet Arizona Department of Water Resources (ADWR) and Federal Emergency Management Agency (FEMA) requirements for approximate method Zone A floodplain delineations. Prior to the finalization of this contract, FEMA and the District must review and accept the results of this study, and all items called for in this Scope of Work must be delivered to the District.

The contract is valid for 2 years. Therefore all tasks assigned must be completed including FEMA review within 720 days from the notice to proceed. The FEMA submittal package must be completed within 180 days, (which includes at least 60 days for District reviews). The remaining 270 days is allotted for obtaining FEMA approval, and the completion of those tasks called for after FEMA approval is obtained.

TASK A – APPROXIMATE ZONE A FLOODPLAIN DELINEATION

Subtask 1 - COORDINATION

Coordination and project management tasks listed in Subtask 1 (1.1-1.9) apply to the administration of Tasks A, B, and C, as authorized by the District's project manager.

1.1 Within fourteen days of Notice to Proceed, the consultant will submit a project schedule to the District's Project Manager showing coordination meetings and completion dates for each task identified in the scope of work. The consultant will update this project schedule when appropriate.

1.2 The consultant will participate in regular coordination meetings (at least every 4 weeks) with the District's Project Manager, and in milestone coordination meetings in the development of the maps. The consultant is responsible for the minutes of any meetings. Whenever possible, coordination and milestone meetings will be combined. The consultant will participate in a total of no more than eight coordination and other project meetings.

1.3 The consultant will submit an estimate of the monthly billing within 14 days of Notice to Proceed. Thereafter, this estimate will be updated and submitted to the District's project manager at least 10 days before the end of each quarter.

1.4 The consultant will submit monthly progress reports at least 5 days before submittal of monthly invoices. The report shall be brief and should be no longer than two typed pages. At a minimum, the monthly report shall contain the following:

a. A description of the work accomplished by task during the reporting month.
b. Percent (%) completed for the month and percent (%) cumulative completed for each task.
c. A brief description of the work to be accomplished in the upcoming month.
d. A description of any problems encountered.

1.5 The consultant is responsible for placing the legal advertising at the beginning of the study, notifying the public of the study. The ad will be run in a widely circulated local newspaper twice, with approximately one week between runs. The ad must also be run twice in a local newspaper that serves the area being studied. After the newspapers run the ad, the consultant will supply the District with the original affidavit of publication from each newspaper for each day that the ad ran.

1.6 The District will notify all property owners and obtain any necessary Rights of Entry for the study area.

1.7 The consultant will meet with officials from the District and the Maricopa County Transportation Department. The purpose of this meeting is to identify local flooding problems.

1.8 The District may plan and conduct one public meeting in conjunction with this study. Consultant participation in Task 1.8 is limited to attending the public meeting only.

1.9 Consultant/District Performance Evaluations will be performed. An informal evaluation will be performed at the completion of the study. A formal evaluation will be performed at the completion of the project upon receipt of all deliverables.

Subtask 2 - DATA COLLECTION

2.1 The consultant will collect and review pertinent data from the District and other outside sources. The CH2M HILL report will be the baseline from which other data will be collected. The District will provide the Consultant with copies of 1998 digital aerial photography and contact prints of the study area, as well as copies of any other aerial

photographs of the study area. The District will also provide copies of the USGS topographic quadrangle maps in digital format, if readily available from the District.

2.2 A written report summarizing the data collected will be submitted to the District for information purposes. A preliminary draft of this report is due within 90 days of Notice to Proceed.

Subtask 3- TOPOGRAPHIC MAPPING

3.1 The consultant will use USGS 7.5-minute topographic maps as the base mapping for displaying the results of this study. For each exhibit developed the District's Project Manager will determine the scale, and sheet size to use.

Subtask 4 - FIELD SURVEY

4.1 Where additional monuments are needed, survey monuments identifying cross section locations , shall be placed 2" +/- above grade, and topped with a brass cap. Elevation Reference Marks will be labeled on available maps and described so that they can be readily located in the field. Surveyed cross section data required for this project may be referenced to a relative datum, and do not need to be tied to previously established elevation reference marks, except at the discretion of the Consultant.

4.2 Copies of the survey field books and office calculations, if any, must be included in the Technical Data Notebooks. If District approval is obtained, this information can be submitted separately.

Subtask 5 - HYDROLOGY

5.1 All hydrologic data for the watershed will be obtained from USGS gage data and published USGS flood frequency summaries. The USGS estimates may be updated, if necessary, with flow data through Water Year 1998, including the Hurricane Nora flood.

5.2 The findings of the hydrologic portion of the study will be presented in Section 3 of the Technical Data Notebook, and will be prepared in accordance with ADWR State Standards Attachment 1-97 (SSA 1-97). The report will be organized as specified by the District, following SSA 1-97 format.

Specific deviations from this hydrologic scope shall not be undertaken without the specific written concurrence from the District's Project Manger.

Subtask 6 - FLOODPLAIN DELINEATION

6.1 The first stage of the floodplain delineation will use the procedures in the draft Piedmont Assessment Manual for Maricopa County to determine the kind and extend of the piedmont landforms. The results of this analysis will be displayed on a map. Aerial photographs of the mapping area will provided by the District at a photo scale of ~1:10,000 (1"=800') to cover all of the Tiger Wash distributary system north of Salome Road with new

photography. The Consultant will obtain the most recent aerial photographs as 9"x 9" contact prints, and at a photo scale of ~1:5000 (1"=400') of Tiger Wash alluvial fan area only. USGS 7.5-minute topographic quadrangle maps for the study area shall be used as the base map for the floodplain delineation.

6.2 The second stage will use the procedures in the draft Piedmont Assessment Manual for Maricopa County to identify the unstable and stable components of the piedmont. A map will be generated showing the results of this analysis, and it will also show those areas subject to various types of flood hazards. In addition, the Consultant will document inundation areas and flow paths of the larger Tiger Wash distributary system, including both east and west distributary branches, beginning upstream of the first distributary channels and continuing downslope to the southern limit of BLM land upstream of the Salome Highway.

6.3 The third stage will identify and apply methods for defining and characterizing areas affected by the 100-year flood, and the results of this analysis will be shown on a map. Those areas that are subject to active alluvial fan movement will be classified as "Zone A High Hazard." Those areas classified as stable may be assessed using normal depth calculations and approximate method Zone A areas will be identified. Delineation of floodplains by detailed methods are not part of this scope of service.

6.4 The delineation work shall meet requirements for approximate floodplain delineations as prescribed by FEMA and the Arizona Department of Water Resources.

6.5 The consultant must obtain District approval at each of the following steps:
- a. Map developed under 6.1.
- b. Map developed under 6.2.
- c. Map developed under 6.3.
- d. Final report describing the analysis and procedures used to develop maps 6.1 – 6.3.

6.6 Field Reconnaissance

6.6.1 The consultant will conduct a field reconnaissance of the full study reach. This will include observation and documentation of channel and floodplain conditions, vegetation and surficial geology, soils and vegetation.

6.6.2 A draft report on the field reconnaissance will be submitted to the District for review and approval. The report will discuss floodplain conditions affecting the delineation, describe structures and obstructions, and provide color photos or photocopies of major hydraulic structures. Photo locations, structures, and important points will be displayed on reduced scale mapping developed from the USGS 7.5-minute topographic maps and included in the Final Report.

6.7 Approximate method Zone A's must be determined according to FEMA criteria and clearly labeled on the final drawings.

6.8 The findings of the approximate method floodplain delineation study will be presented in Section 4 of the Technical Data Notebook and will be prepared in accordance with ADWR

State Standards Attachment 1-97 (SSA 1-97). The report will be organized as specified by the District standards, following SSA 1-97 format.

6.9 The Consultant shall fill out all the forms required by FEMA for the submittal of an approximate method Floodplain Delineation Study.

Subtask 7 - CAD DATA

7.1 The Digital CAD data files will be prepared in conformance with the District's Hydrologic Information System Data Delivery Specifications, Revision 3.1. The following themes are the ones generally used for the data developed for Floodplain Delineation Studies. However, for this study there may not be data for every theme identified here, or the consultant might develop data for themes not listed here. Therefore, only those themes for which there is data need to be completed. If the consultant has data that do not fit one of the themes listed here, the District's Project Manager shall be contacted to determine the appropriate theme for that data. No CAD data files will be prepared for hydrologic information used in the study, or for watershed characteristics above the hydrologic apex.

a. NDXPRJ (FCD Project Map Index)
b. PRJ (Project Boundaries)
c. CARTO (Cartographic Features)
d. CORNERS (if any)
e. CTRL (Miscellaneous Control Survey Points)
g. STRCT (Structure)
h. DQ (Data Quality)
i. PRJ (Project Identification)
j. FPCTLFCD (FCD Reference Marks)
m. FPZNFCD (Floodplain FCD Zone)
n. FPBLN (Floodplain Baseline Route System)

Subtask 8 - DELIVERABLES

8.1 Prior to FEMA Submittal: The consultant will deliver the following items to the District before delivering the FEMA submittal package:
8.1.1 Original Affidavits of Publication of the legal advertisements. Additional copies are to be included in the Technical Data Notebook.
8.1.2 All topographic and related data for the District's Hydrologic Information System that isn't subject to change during FEMA's review should be submitted at this time. A digital terrain model will not be prepared for this study.
8.1.3 If bound separately from the Technical Data Notebook, two (2) copies of the field survey notes and office calculations.

8.2 FEMA Submittal: The consultant will submit the following items to the District for review by FEMA and any other appropriate governmental agency. All of the following products are considered deliverables for the FEMA submittal:
8.2.1 Two (2) complete sets of blackline topographic base maps with the approximate method floodplain delineations shown. All drawings will be signed and sealed by

persons of appropriate professional registration(s). Each registrant will provide a specific statement as to what service they performed.

8.2.2 Two (2) complete copies of the Technical Data Notebook, including any computer hydraulic/hydrologic program files on diskettes. The Technical Data Notebook will be prepared in accordance with ADWR State Standards Attachment 1-97 (SSA 1-97). The notebook will be organized as specified by the District, following SSA 1-97 format. These copies will be updated if necessary based upon FEMA's review comments. Completed FEMA forms will be included in the Technical Data Notebook.

8.3 Final Submittal: The following products are considered deliverables for the final submittal to the District after FEMA approval is issued:

8.3.1 One (1) complete composite set of non-erasable topographic/orthophoto mylars and two (2) complete sets of sealed blueline topographic/orthophoto base maps with the floodplain delineations shown of the work-study drawings. Sheets shall be 24" X 36" in size and numbered to correspond to the delineation maps. Base maps shall be prepared at a 1:24,000 scale. All drawings will be signed and sealed by persons of appropriate professional registration(s). Each registrant will provide a specific statement as to what service they performed.

8.3.2 All remaining hydrologic and floodplain delineation data in conformance with the District's Digital CAD data file specifications.

8.3.3 Two (2) complete copies of the Technical Data Notebook will be submitted. The Technical Data Notebook will be prepared in accordance with ADWR State Standards Attachment 1-97 (SSA 1-97). The notebook will be organized as specified by the District, following SSA 1-97 format. This submittal of the Technical Data Notebook shall include any correspondence and/or meeting minutes with the reviewing agencies and shall reflect any revisions required by those reviewing agencies. Revisions may include, but are not limited to, modifications to the approximate method delineation maps, and/or the Final Report. Revisions requested by FEMA that involve substantially different methodologies than those described in the Piedmont Assessment Manual for Maricopa County are not part of this scope of services.

TASK B– MAPPING OF THE 1997 FLOOD ON TIGER WASH

Initial Assessment of the 1997 Flood. Preliminary field reconnaissance of the Tiger Wash piedmont conducted in November 1998 and January 1999 revealed abundant evidence of the 1997 flood. Significant changes occurred to some existing channels and a new, large channel developed west of the primary channel network that existed in 1992. Aerial photos taken in May 1997 do not show this new channel, so the new channel must have formed in the September 1997 flood. Because the evidence of inundation is so fresh, it is possible to document many aspects of this flood, including where the flood water went, what changes occurred, and what approximate peak flow depths existed across the Tiger Wash piedmont

Subtask 1 - DETAILED MAPPING OF THE 1997 FLOOD ON TIGER WASH

1.1 The Subconsultant will prepare detailed, large-scale mapping of alluvial fan flood on the west branch of the larger distributary system on the Tiger Wash piedmont, which was trenched and studied in 1992; including mapping new channels and deposits, and mapping by peak flow depth category. The mapping will use the procedures used for previous studies by the Arizona Geological Survey for the Wild Burro Canyon flood on the Tortolita piedmont near Tucson. The area for this detailed mapping will begin upslope of the Tiger Wash piedmont hydrologic apex, where flood flow was contained in a channel and fairly limited areas of overbank flooding between Pleistocene alluvial surfaces. The mapping area covered will be estimated more precisely after mapping has begun, but will encompass portions of the Tiger Wash piedmont in Sections 20, 29, and 30 of Township 4 North, Range 10 West. This mapping will require fairly large-scale, post-flood aerial photos for maximum accuracy.

1.2 Aerial photographs will provided by the District at a photo scale of ~1:10,000 (1"=800') to cover all of the Tiger Wash distributary system as available, ideally to just north of Salome Road with new photography. The Consultant will obtain 9"x 9" contact prints, and at a photo scale of ~1:5000 (1"=400') of Tiger Wash alluvial fan area only.

Subtask 2 - RECONNAISSANCE MAPPING

2.1 The Consultant will generate a reconnaissance map and general characterization of 1997 flood flow in the Tiger Wash distributary drainage system. The Consultant will delineate and document inundation areas and flow paths of the larger Tiger Wash distributary system, including both east and west distributary branches, beginning upstream of the first distributary channels and continuing downslope to the southern limit of BLM land (south sides of Sections 31, 32, and 33). The purposes of this reconnaissance mapping of flow paths are to document the general patterns of flow in the whole distributary system, show the full extent of inundation, assess importance of channelized vs. sheetflow in this large distributary system, and to document substantial changes in channel position and areas of significant new erosion and deposition. The level of detail for the mapping in subtask 2 will be less than for subtask 1.

Subtask 3 - DETAILED SURFICIAL GEOLOGIC MAPPING

3.1 The Subconsultant will generate a detailed surficial geologic map and geomorphic analysis of the piedmont including the Tiger Wash distributary drainage system to define flood hazard zone as they existed prior to Sept 1997. The Consultant will use pre-flood color aerial photographs to make a 1:24,000-scale map of the surficial geology and geomorphology of the Tiger Wash piedmont from the bedrock ridge/confined reach of Tiger Wash downstream to Salome-Tonopah Highway.

3.2 The Consultant will employ the FCDMC piedmont flood hazard manual to assess and classify flood hazards through this part of the Tiger Wash system.

3.3 The Consultant will compare the implications of this analysis with the actual areas and character of flood inundation which would test the methodology.

Subtask 4 - DELIVERABLES

4.1 One (1) copy of a draft report will be submitted containing the work products generated from the authorized portions of Task B including maps.

4.2 Four (4) copies of the final report will be submitted.

TASK C – APPLICATION OF ALTERNATIVE METHODOLOGIES

Subtask 1 - QUANTITATIVE ANALYSIS OF AERIAL PHOTOGRAPHS

1.1 The Consultant will qualitatively analyze aerial photographs to evaluate changes in channel position and patterns of erosion and deposition on Tiger Wash fan through the historical record.

1.2 Aerial photo and digital elevation modeling should be applied to several generations of aerial photos.

1.3 Detailed field surveying of small portions of the fan to provide ground truth for remote sensing analysis should be conducted and tie into Pleistocene surfaces away from the fan that has not changed.

Subtask 2 - HYDROLOGIC/HYDRAULIC ANALYSIS

2.1 The Consultant should use information generated under Task A for hydrology.

2.2 The Consultant should revisit paleoflood sites and compare the 1997 water surface elevations with deposits and water surface levels recognized in 1992.

CONTRACT FCD 98-48

On-Call Services

for Engineering Hydrology and Geomorphology

C-69-99-070-5

CONTRACT FCD 98-48

On-Call Services

C69-99-070-S

Pursuant to the provisions of the Arizona Revised Statutes Section 48-3603, the Board of Directors of the Flood Control District has the authority to enter into contracts.

The Flood Control District of Maricopa County, Arizona, hereinafter called the "District," is desirous of having certain professional services performed when requested by the District through a specific Work Assignment for those services as more fully described in Exhibit A, Scope of Work, and Exhibit B, Fee Schedule, attached; and

J. E. Fuller/Hydrology Geomorphology, Inc., hereinafter called "Consultant," with its principal offices located at 583 West Magadelena, Tempe, Arizona 85283, is desirous of performing said services;

THEREFORE, the parties hereto mutually agree as follows:

Section I - Services of the Consultant

The Consultant, under the general supervision of the District Engineering Division Manager, shall perform services for engineering hydrology and geomorphology concerns as are necessary for the Work Assignment and according to the directions and designated standards of the District, and in accordance with Exhibit A. It is understood and agreed that the District's authorized representative shall be the Engineering Division Manager or his duly authorized representative, hereinafter called the "Agent" and that he shall be the sole contact for administering this contract.

The Consultant shall meet with the Agent or provide any reports to Agent as agreed to in the performance of work through Exhibit A.

Section II - Period of Service

The Consultant shall complete all work in accordance with the provisions of Exhibit A, Scope of Work and as negotiated for each specific Work Assignment, and the fees listed in Exhibit B, Fee Schedule.

All work initiated under this Contract must be completed on or before the expiration date of the Contract.

This contract shall be effective for a two-year period from the date of its execution or until the contract amount of $74,999.00 is expended, whichever occurs first.

Section III - Payments to the Consultant

The Consultant shall be paid for work under this Contract a fee **not to exceed seventy-four thousand, nine hundred ninety-nine dollars ($74,999.00)** plus any adjustments that have been approved in writing by the District in accordance with the Maricopa County Procurement Code. Payments will be made for the actual hours worked and/or other costs incurred or provided for in accordance with Exhibit B, Fee Schedule.

The District does not guarantee any minimum or maximum fee during the period of this contract, and Consultant, in accepting this contract, does not anticipate any minimum or maximum fee.

The District shall pay the Consultant in full for each Work Assignment authorized under this contract at the completion of each assignment provided the Consultant has (1) satisfactorily completed the requested work, and (2) completed and returned to the District an executed "Certificate of Performance" form provided by the Project Manager. Should an assignment require time in excess of thirty (30) days to complete, progress payment(s) may be made upon an invoice being submitted to and approved by the District.

Upon completion of this contract, the Consultant will furnish to the District an executed Certificate of Performance (Attachment No. 1 to this contract).

Section IV - The District's Responsibilities

The District shall furnish the Consultant, at no cost to the Consultant, the following information or services for each Work Assignment:

A. One copy of on-hand maps, records, survey ties, bench marks or other data pertinent to the Work Assignment. This does not, however, relieve the Consultant of the responsibility of searching records for additional information, for requesting specific information or for verification of that information provided. The District does not warrant the accuracy or comprehensiveness of any such information.

B. All available information and data relative to policies, standards, criteria, and studies, etc. impacting the Work Assignment as identified by the Consultant.

C. Availability of staff for consultation with the Consultant during the performance of studies and plan development in order to identify the problems, needs, and other functional aspects of the Work Assignment.

D. Examination of documents submitted by the Consultant and rendering of decisions pertaining thereto promptly, to avoid unreasonable delay in the progress of the work by the Consultant. The District will keep the Consultant advised concerning the progress of the District's review of work.

Section V - Alteration in Scope of Work

Any alteration in the Scope of Work that will result in a substantial change in the nature of a Work Assignment so as to materially increase or decrease the contract fee will require negotiation of an amendment to the Work Assignment to be executed by the District and the Consultant. No work shall commence on the change until the contract amendment has been approved by the District and the Consultant has been notified to proceed by the Agent. It is distinctly understood and agreed that no claim for extra work done or materials furnished by the Consultant will be allowed by the District except as provided herein, nor shall the Consultant do any work or furnish any materials not covered by this agreement unless such work is first authorized in writing by the District and in accordance with the Maricopa County Procurement Code. Any such work or materials furnished by the Consultant without such written authorization first being given shall be at his own risk, cost, and expense, and he hereby agrees that without such written authorization he will make no claim for compensation for such work or materials furnished.

Section VI - Records

Records of the Consultant's payroll expense pertaining to this contract and records of accounts between the District and the Consultant shall be kept on a generally recognized accounting basis and shall be available upon request to the District or its authorized representative for audit during normal business hours.

Section VII - Work Assignment Completion

If, during the course of this contract, situations arise which prevent completion within the allotted time, the Agent may grant an extension.

Section VIII - Termination

The District may terminate this contract at any time upon reimbursement to the Consultant of expenses, which include reasonable charges for time and material for the percentage of work satisfactorily completed and turned over to the District.

The District reserves the right to postpone, terminate or abandon this contract for the Consultant's failure to complete any Work Assignment on time, or failure to comply with the provisions of the contract. The District also reserves the right to terminate any or all parts of this contract for its own convenience as the District may determine at its sole discretion.

The District hereby gives notice that pursuant to ARS Section 38-511 "A" this contract may be canceled without penalty or further obligation within three years after execution if any person significantly involved in initiating, negotiating, securing, drafting, or creating a contract on behalf of the District is, at any time while the contract or any extension of the contract is in effect, an employee or agent of any other party to the contract in any capacity or a consultant to any other party of the contract with respect to the subject matter of the contract. Cancellation under this section shall be effective when written notice from the District Chief Engineer and General Manager is received by all of the parties of the contract. In addition, the District may recoup any fee or commission paid or due to any person significantly involved in initiating, negotiating, securing, drafting, or creating the contract on behalf of the District from any other party to the contract arising as a result of the contract.

The Consultant may terminate this contract in the event of nonpayment of fees as specified in Section III, Payments to the Consultant.

Section IX - Ownership of Documents

All original documents including, but not limited to, studies, reports, tracings, drawings, physical and computer models, estimates, field notes, investigations, design analyses, calculations, computer software, and specifications, prepared in the performance of this Contract are to be and remain the property of the District and are to be delivered to the Agent before final payment is made to the Consultant. The District will not alter the documents without noting such modifications or alterations and will hold the Consultant harmless from any claims arising from such modifications or alterations. The Consultant may retain reproducible copies of all such documents delivered to the District. The District reserves the right to reuse the documents as it sees fit.

Section X - Compliance With Laws

The Consultant is required to comply with all Federal, State and local laws, local ordinances and regulations. The Consultant's signature on this contract certifies compliance with the provisions of the I-9 requirements of the Immigration Reform and Control Act of 1986 for all personnel that the Consultant and any subconsultants employed to complete any Work Assignment. It is understood that the District shall conduct itself in accordance with the provisions of the Maricopa County Procurement Code.

Section XI - General Considerations

A. The failure of either party to enforce any of the provisions of this Contract or to require performance of the other party of any of the provisions hereof shall not be construed to be a waiver of such provisions, nor shall it affect the validity of this Contract or any part thereof, or the right of either party to thereafter enforce each and every provision.

B. The fact that the District has accepted or approved the Consultant's work shall in no way relieve the Consultant's responsibility.

C. It is mutually understood and agreed that this Contract shall be governed by the laws of the State of Arizona, both as to interpretation and performance. Any action at law, suit in equity, or judicial proceeding for the enforcement of this Contract, or any provision thereof, shall be instituted only in the courts of the State of Arizona.

Section XII - Successors and Assigns

This Contract shall not be assigned by either party without prior written approval of the other except that the Consultant may use in the performance of this Contract without prior approval of the District, personnel or services of its related entities and affiliated companies as if they were an integral part of the Consultant; and it shall extend to and be binding upon the heirs, executors, administrators, successors and assigns of the parties hereto.

Section XIII - No Kick-back Certification

The Consultant warrants that no person has been employed or retained to solicit or secure this Contract upon any agreement or understanding for a commission, percentage, brokerage, or contingent fee; and that no member of the Board of Directors/Supervisors or any employee of the District has any interest, financially or otherwise, in the Consultant's firm.

For breach or violation of this warranty, the District shall have the right to annul this Contract without liability, or at its discretion to deduct from the Contract price or consideration, the full amount of such commission, percentage, brokerage, or contingent fee.

Section XIV - Anti-Discrimination Provision

The Flood Control District of Maricopa County will endeavor to ensure in every way possible that minority and women-owned business enterprises shall have every opportunity to participate in providing professional services, purchased goods, and contractual services to the Flood Control District without being discriminated against on the grounds of race, religion, sex, age, disability or national origin.

The Consultant agrees not to discriminate against any employee or applicant for employment because of race, religion, color, sex, age, disability or national origin, and further agrees not to engage in any unlawful employment practices. The Consultant further agrees to insert the foregoing provisions in all subcontracts hereunder.

Section XV - Indemnification

For Professional Liability: To the fullest extent permitted by law, the Consultant shall indemnify and hold harmless the District and Maricopa County, their agents, representatives, officers, directors, officials, and employees from and against all claims, damages, losses and expenses (including but not limited to attorney fees, court costs, expert witness fees, and the cost of appellate proceedings), relating to, arising out of, or alleged to have resulted from the Consultant's negligent acts, errors, mistakes, or omissions, or the Consultant's intentional and wrongful acts, relating to professional services in the performance of this Contract. The Consultant's duty to hold harmless and indemnify the District and Maricopa County, their agents, representatives, officers, directors, officials, and employees shall arise in connection with any claim, damage, loss or expense that is attributable to bodily injury, sickness, disease, death, or injury to, impairment, or destruction of property including loss of use resulting therefrom, caused by any negligent acts, errors, mistakes or omissions related to professional services in the performance of this Contract including any person for whose acts, errors, mistakes or omissions the Consultant may be legally liable.

The amount and type of insurance coverage requirements set forth herein will in no way be construed as limiting the scope of the indemnity in this paragraph.

For all other hazards, liabilities, and exposures: Insofar as the work or services do not relate to the design, construction administration, study, evaluation or other professional services furnished in connection with any actual or proposed construction, alteration, repair, maintenance, moving, demolition or excavation of a structure, street or roadway, appurtenance or other development or improvement to land, the Consultant shall defend, indemnify and hold harmless the District and Maricopa County, their agents, representatives, officers, directors, officials and employees from and against all claims, damages, losses and expenses (including but not limited to attorney fees, court costs, expert witness fees, and the cost of appellate proceedings), relating to, arising out of or resulting from the Consultant's work or services.

Consultant's duty to defend, hold harmless, and indemnify the District and Maricopa County, their agents, representatives, officers, directors, officials and employees shall arise in connection with any claim, damage, loss or expense that is attributable to bodily injury, sickness, disease, death, injury to, impairment or destruction of property including loss of use resulting therefrom, caused in whole or in part by any act or omission of the Consultant, anyone Consultant directly or indirectly employs or anyone for whose acts Consultant may be liable, regardless of whether it is caused in part by a party indemnified hereunder including the District.

The scope of this indemnity does not extend to the sole negligence of the District.

Section XVI - Insurance

General Clauses. The Consultant, at its own expense, shall purchase and maintain the minimum insurance specified below with companies duly licensed, with a current A.M. Best, Inc. rating of B++6, or approved unlicensed by the State of Arizona Department of Insurance.

Additional Insured. The insurance coverage, except Workers' Compensation and Professional Liability, required by this Contract shall name the District, its agents, representatives, officers, directors, officials, and employees as Additional Insureds.

Coverage Term. All insurance required herein shall be maintained in full force and effect until all work or service required to be performed under the terms of the Contract is satisfactorily completed and formally accepted; failure to do so may, at the sole discretion of the District constitute a material breach of this Contract.

Primary Coverage. The Consultant's insurance shall be primary insurance as respects the District, and any insurance or self insurance maintained by the District shall not contribute to it.

Claim Reporting. Any failure to comply with the claim reporting provisions of the policies or any breach of the policy warranty shall not affect coverage afforded under the policies to protect the District.

Waiver. The policies, except Workers' Compensation, shall contain a waiver of transfer rights of recovery (subrogation) against the District, its agents, representatives, directors, officers, and employees for any claims arising out of the Consultant's work or service.

Deductible/Retention. The policies may provide coverage which contain deductibles or self-insured retentions. Such deductible and/or self insured retentions shall not be applicable with respect to the coverage provided to the District under such policies. The Consultant shall be solely responsible for the deductible and/or self-insured retention.

Copies of Policies. The District reserves the right to request and to receive, within 10 working days, certified copies of any or all of the above policies and/or endorsements. The District shall not be obligated, however, to review same or to advise Consultant of any deficiencies in such policies and endorsements, and such receipt shall not relieve Consultant from, or be deemed a waiver of the District's right to insist on strict fulfillment of the Consultant's obligations under this Contract.

Commercial General Liability. The Consultant shall maintain Commercial General Liability insurance with a limit of not less than $1,000,000 for each occurrence with a $1,000,000 General Aggregate limit. The policy shall include coverage for bodily injury, broad form property damage, personal injury, products and completed operations and blanket contractual covering, but not limited to, the liability assumed under the indemnification provisions of this Contract which coverage will be at least as broad as the Insurance Service Office, Inc. Policy Form CG 00011093 or any replacements thereof. The Commercial General liability additional insured endorsement will be at least as broad as the Insurance Service Office, Inc. Additional Insured, Form B, CG 20101093, or replacements thereof. Such policy shall contain a severability of interest provision, and shall not contain a sunset provision or commutation clause, nor any provision which would serve to limit third party action over claims.

Automobile Liability. The Consultant shall maintain Commercial/Business Automobile Liability insurance with a combined single limit for bodily injury and property damage of not less than $1,000,000 each occurrence with respect to the Consultant's any owned, hired, and non-owned vehicles assigned to or used in performance of the Consultant's work or services. Coverage will be at least as broad as coverage code 1, "any auto" (Insurance Services Office, Inc. Policy Form CA 00011293, or any replacements thereof).
Workers' Compensation. The Consultant shall carry Workers' Compensation insurance to cover obligations imposed by federal and state statutes having jurisdiction of Consultant's employees engaged in the performance of the work or services; and Employer's liability insurance of not less than $100,000 for each accident, $100,000 disease for each employee, and $500,000 disease policy limit.

In case any work is subcontracted, the Consultant will require the subcontractor to provide Workers' Compensation and Employer's Liability to at least the same extent as required of the Consultant.

Professional Liability. The Consultant retained by the District will maintain Professional Liability insurance covering errors and omissions arising out of the work or services performed by the Consultant or any person employed by the Consultant, with a limit of not less than $1,000,000 each claim.

Certificates of Insurance

Prior to commencing work or services under this Contract, the Consultant shall furnish the District with Certificates of Insurance, or formal endorsements (Attachment No. 2 to this contract), issued by the Consultant's insurer(s), as evidence that policies providing the required coverages, conditions and limits required by this Contract are in full force and effect. Such certificates shall identify this Contract number and title, as well as all other information on Attachment No. 2.

In the event any insurance policy(ies) required by this Contract is(are) written on a "claims made" basis, coverage shall extend for two years past completion and acceptance of the work or services and as evidenced by annual Certificates of Insurance. All Certificates of Insurance shall be identified with a contract number and title.

Cancellation and Expiration Notice

Insurance evidenced by this Certificate shall not expire, be canceled, or materially changed without thirty (30) days prior written notice to the District. If a policy does expire during the life of the contract, a renewal Certificate must be sent to the District at least fifteen (15) days prior to the expiration date.

IN WITNESS WHEREOF, the parties herein have executed this Contract.

J. E. FULLER/HYDROLOGY & GEOMORPHOLOGY, INC.

Principal (Signature)

Jonathon Fuller
Printed Name

President
Title

2-6-99
Date

86-0785301
Federal Tax Identification Number

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY:

2/15/99
Michael S. Ellegood, P.E. Date
Chief Engineer and General Manager

ACCEPTED AND APPROVED:

3/8/99
Chairman, Board of Directors Date

ATTEST:

3/8/99
Clerk of the Board Date

LEGAL REVIEW

Approved as to form and within the powers and authority granted under the laws of the State of Arizona to the Flood Control District of Maricopa County.

2/18/99
General Counsel, District Date

Attachment 1

CERTIFICATE OF PERFORMANCE AND PAYMENT OF ALL CLAIMS

ENGINEERING CONTRACT

_____ hereby certifies to the Flood Control District Of Maricopa County
(Name of Signer)
(District) that all lawful claims for labor, rental of equipment, material used, and any other claims by_____or its subcontractors in connection with the project described in District Contract FCD_____ for _____have been paid.

_____ understands that with receipt of payment for previously invoiced amounts plus any retained monies, that this is a settlement of all claims of every nature and kind against the District arising out of the performance of the District's Contract FCD_____, relating to the material, equipment, and work covered in and required by the contract.

The undersigned hereby certifies that to his/her knowledge, no contractual disputes exist in regard to this contract and that he/she has no knowledge of any pending or potential claims in regard to this contract.

Upon submission of this document and a separate invoice for any retained funds to the District, invoice processing will be completed within forty-five (45) calendar days.

State of Arizona)
) ss
County of Maricopa)

Signed this ____ day of _____, 199__.

_____
Signature

_____
Title

SUBSCRIBED AND SWORN TO before me this ____ day of _____, 199__.

_____
Notary Public

My Commission Expires:_____

Attachment 2

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
CERTIFICATE OF INSURANCE

CONTRACT FCD 98-48 — PROJECT TITLE : On-Call Hydrology and Geomorphology

NAME AND ADDRESS OF INSURANCE AGENCY	INSURANCE COMPANIES AFFORDING COVERAGES	
	Company Letter A	
	Company Letter B	
	Company Letter C	
NAME AND ADDRESS OF INURED	Company Letter D	
	Company Letter E	
	Company Letter F	

This is to certify that policies of insurance listed below have been issued to the insured named above and are in force at this time

CO. LTR	TYPE OF INSURANCE	POLICY NUMBER	EFFECTIVE DATE (MM/DD YY)	EXPIRATION DATE (MM/DD YY)	LIMITS	
	COMMERCIAL GENERAL ☒ LIABILITY FORM ☒ PREMISES OPERATIONS ☒ CONTRACTUAL ☒ BROAD FORM PROPERTY DAMAGE ☒ EXPLOSION & COLLAPSE ☒ PRODUCTS/COMPLETED OPERATIONS HAZARD ☒ UNDERGROUND HAZARD ☒ INDEPENDENT CONTRACTORS ☒ PERSONAL INJURY				GENERAL AGGREGATE PRODUCTS/COMPLETED OPERATIONS BODILY INJURY AND PROPERTY DAMAGE PERSONAL INJURY EACH OCCURANCE	$1.000.000 $1.000.000 $1.000.000 $1.000.000 $1.000.000
	COMPREHENSIVE AUTO ☒ LIABILITY & NON-OWNED				Each Occurrence	$1.000.000
	☐ EXCESS LIABILITY				NECESSARY IF UNDERLYING NOT ABOVE MINIMUM	
	☒ WORKERS' COMPENSATION AND EMPLOYERS' LIABILITY				STATUTORY each accident	$100.000
	☒ ENGINEERS PROFESSIONAL LIABILITY				EACH CLAIM AND ANNUAL AGGREGATE	$1.000.000
	☒ OTHER	The Flood Control District and Maricopa County are to be named as additional insured.				

Except for Professional Liability Insurance and Workers' Compensation Insurance, the Flood Control District of Maricopa County is added as an additional insured on those types of policies described herein which are required to be furnished by this contract entered into between the insured and the Flood Control District. To the extent provided in this contract, insured shall hold harmless the Flood Control District of Maricopa County from liability arising out of any services provided or duty performed by insured as required by statute, law, purchase order or otherwise required, with the exception of liability for loss or damage resulting from the sole negligence of Flood Control District, its agents, employees or indemnities. It is agreed that any insurance available to the named insured shall be primary of other sources that may be available. It is further agreed that no policy shall expire, be cancelled, or materially changed to affect the coverage available to the District without thirty (30) days written notice to the District. THIS CERTIFICATE IS NOT VALID UNLESS COUNTERSIGNED BY AN AUTHORIZED REPRESENTATIVE OF THE INSURANCE COMPANY.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
2801 West Durango Street
Phoenix, Arizona 85009

DATE ISSUED _____

_____
AUTHORIZED REPRESENTATIVE

EXHIBIT A
SCOPE OF WORK
Contract FCD 98-48
On Call Engineering, Hydrology, and Geomorphology Services

The Consultant agrees to provide to the Flood Control District of Maricopa County complete engineering, hydrology, and geomorphology services which include, but are not limited to the following:

General civil engineering and geomporpholic services on an "as-needed" basis. The amount of work requested during the life of the contract is unknown; the least amount being zero and the maximum amount being limited to the "not-to-exceed" amount of the contract. The services to be rendered under this contract shall conform to one of the following categories:

A) General Civil Engineering, including alternative analysis, design, floodplain delineation and review and evaluation of proposed or existing civil engineering project and structures. Work shall include providing general consultation services as required.

B) Geomorphic Services, including, alluvial fan assessment, stream bank erosion, aggradation, degradation and sediment supply studies.

C) Engineering and geomorphic services described above.

Civil engineering work requested under this contract shall be completed under the responsibility of a civil engineer registered in the State of Arizona. All work submitted shall bear the "wet seal" and original signature of the responsible registered civil engineer.

All work initiated under this Contract must be completed on or before the expiration data of the Contract.

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009-6399
Telephone (602) 506-1501
Fax (602) 506-4601
TT (602) 506-5897

BOARD OF DIRECTORS
Jan Brewer
Fulton Brock
Andrew Kunasek
Don Stapley
Mary Rose Garrido Wilcox

February 5, 1999

Mr. Jonathan Fuller
J. E. Fuller/Hydrology & Geomorphology, Inc.
583 W. Magdalena
Tempe, AZ 85283

SUBJECT: Contract FCD 98-48,
On-Call Engineering Hydrology and Geomorphology Services

Enclosed are four (4) copies of Contract FCD 98-48. Please execute all four copies and return them to the writer by February 19, 1999. The contract will be placed on the first available Board Agenda for approval to award.

Also, **receipt of your Insurance Certificate is required prior to commencing work or services under this contract.** To comply with the contract, your insurance carrier must submit the insurance certificate which is included as Attachment 2 in the contract documents. A substitute form may be accepted, but only if it includes the same coverage, **including the Other Insureds and identical language.**

Following contract award by the Board of Directors, a fully executed copy of the contract will be provided to you.

If you have any questions, call me at 506-4433, or Barbara Hummell at 506-4876.

Sincerely,

Dortha Klaahsen

Dortha Klaahsen
Contract Administrator

FLOOD CONTROL DISTRICT
of
MARICOPA COUNTY
1959

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009-6399
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February 5, 1999

Mr. Jonathan Fuller
J. E. Fuller/Hydrology & Geomorphology, Inc.
583 W. Magdalena
Tempe, AZ 85283

Subject: Consultant Guideline

Reference: Contract No. FCD 98-48
On-Call Engineering Hydrology and Geomorphology Services

Enclosed is Copy No. 46 of the Consultant Guideline document published by the Flood Control District of Maricopa County. This document is being furnished to all consultants doing business with the District in order to provide an understanding of the District's procedures, requirements, and deliverables, and is incorporated by reference into the District's contract documents.

As future updates are made to the Consultant Guideline, a copy of the revisions will be provided to you for insertion into your copy of this document.

Sincerely,

Dortha Klaahsen

Dortha Klaahsen
Contract Administrator

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009-6399
Telephone (602) 506-1501
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BOARD OF DIRECTORS
Jan Brewer
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December 29, 1998

Mr. Jonathan Fuller
J. E. Fuller/Hydrology & Geomorphology, Inc.
583 W. Magdalena
Tempe, AZ 85283

SUBJECT: Notice of Register Selection for Contract FCD 98-48,
On-Call Engineering Hydrology and Geomorphology Services

This letter confirms the Flood Control District's selection of J. E. Fuller from our Consultant Register for contracts under $75,000 to provide the subject on-call services. Enclosed is a copy of the proposed contract, including Exhibit A, Scope of Work. We ask that you review the contract, and if in agreement with the terms, submit three copies of your proposed fee schedule, along with a copy of your most current government audit report and payroll records, on or before January 14, 1999. Following acceptance of your fee schedule, the District will prepare contracts for your signature.

Performance will be for a period of two years after contract award or the expenditure of $74,999.00, whichever occurs first.

Attachment 2 to the contract is our Insurance Certificate form. Prior to contract award, we request that your insurance carrier complete and return the insurance certificate. A different certificate will be acceptable only if it contains the same coverage and language, and additional insured information.

If you have any questions regarding the scope of work, please call Joe Tram, the Project Manager, at 506-4607. Any contractual questions should be directed to Barbara Hummell, Contracts Manager at 506-4876, or the writer at 506-4433.

Sincerely,

Dortha Klaahsen

Dortha Klaahsen
Contract Administrator

State we have no audited rates
overhead
Payroll records - verify rates

APPENDIX C: SURVEY FIELD NOTES

C.1 Survey field notes for aerial mapping control

No aerial mapping was performed for this study.

C.2 Survey field notes for hydrologic modeling

See Appendix D for survey notes used in indirect discharge computations.
See Appendix G for survey notes used in mapping of flood inundation area for September 1997 event.

C.3 Survey Field Notes for Hydraulic Modeling

See Appendix D for survey notes used in indirect discharge computations.
See Appendix G for survey notes used in mapping of flood inundation area for September 1997 event.

APPENDIX D: HYDROLOGIC ANALYSIS SUPPORTING DOCUMENTATION

D.1 Indirect Discharge Computations for September 1997 Flood

June 7, 1999
Revised July 21, 1999
Revision 2 November 3, 1999

Summary of Hurricane Nora flood discharge estimates

Six sites were surveyed in April 1999 by JE Fuller / Hydrology & Geomorphology, Inc. (JEF) for the purpose of estimating the magnitude and distribution of peak discharges on Tiger Wash resulting from the remnants of Hurricane Nora on September 25-26, 1997. In addition, the USGS made a slope-area estimate of the peak discharge near their gaging station upstream of Blue Tank Canyon in October 1997. JEF also surveyed the Nora flood high water marks relative to the paleoflood site investigated by CH2MHill for the FCDMC in 1992.

The results of the six sites investigated by JEF are summarized in the attached map and table. They indicate that most of the flow was conveyed in the west branch channel. The results also indicate a significant decrease in discharge in the downstream direction. Part of this is due to the losses at the breakout channels, but much of it is likely due to a combination of attentuation of the peak discharge and to transmission losses into the alluvium along the channel.

Of interest was that the maximum stage of flow near the USGS gaging station was about 2 feet lower than the maximum paleoflood indicators investigated by CH2MHill. Their 1992 report indicated the maximum paleoflood magnitude at between 10,000 and 13,000 cfs. However, they also found evidence indicating that at least 3 floods between 6,000 and 10,000 cfs had occurred in the past 100 years (up to 1992). The Hurricane Nora flood was, therefore, about as big as any flood in that reach in the past 100 years. Repeat cross section surveys taken by the USGS at the gaging station indicate the removal of about 1 foot of channel bottom as well as a large channel bar near the gage during the Nora flood. Since 1970 the bed has degraded about 2 feet. This suggests that the Nora flood may have been even larger relative to the largest paleofloods in spite of its somewhat lesser maximum absolute water surface elevation.

Tiger Wash Approximate FDS
FCD No. 98-48
Slope-Area Computation Summary Table

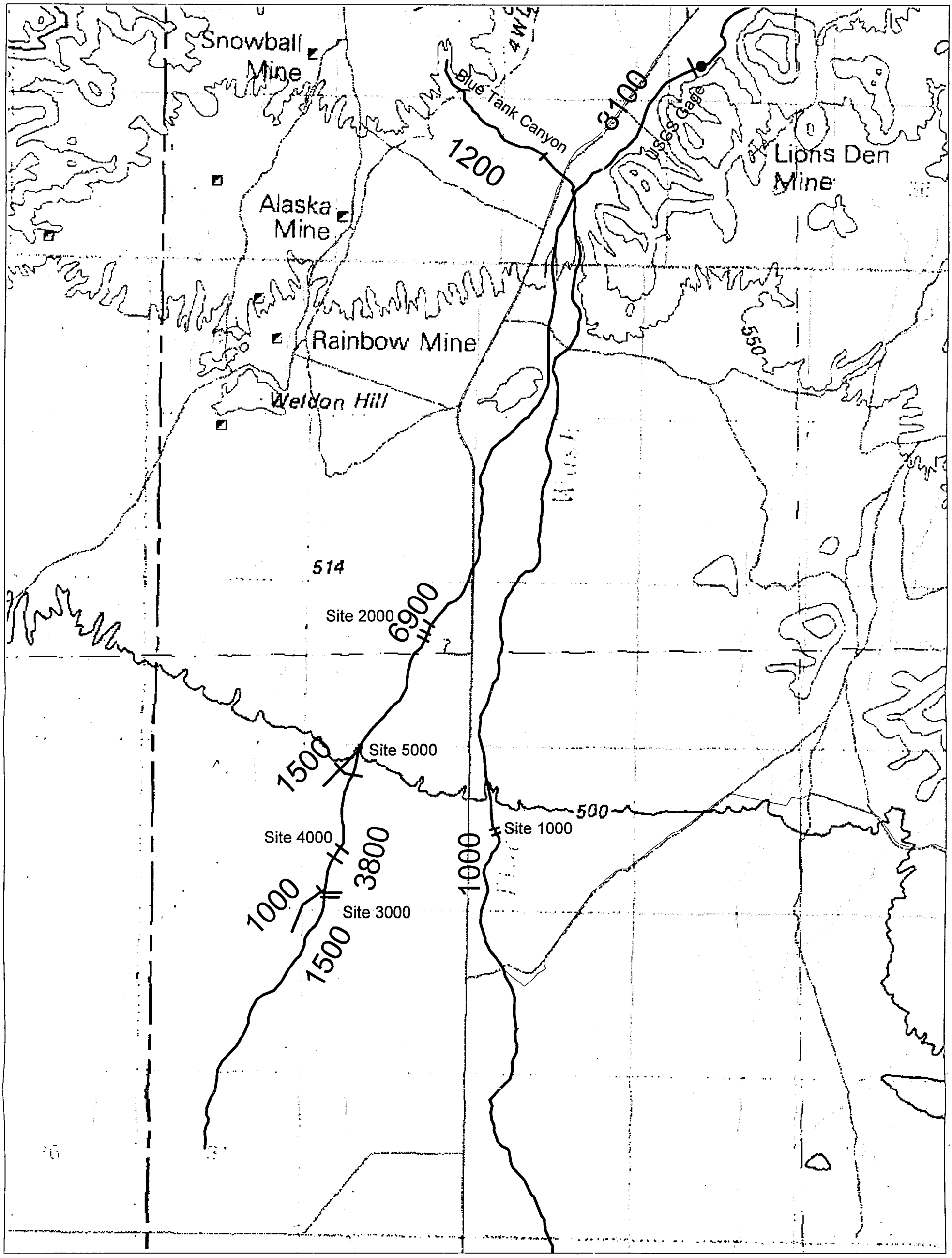
Site name[3]	Vavg (ft/s)	Froude No. average	Slope water surface[1]	Slope bed	n-value[4]	Width, channel (feet)	Q fixed bed (cfs)	Q w/xtra A[2] (cfs)	Q final (cfs)
Blue Tank Canyon	9.7	1.02	0.0156		0.035	40	1220		1200
1000	4.7	0.50	0.0048	0.0048	0.044	35	820	1000	1000
2000	11	0.90	0.0086	0.0051	0.029	70	5170	6910	6900
3000 -- AV2	4	0.41	0.01-0.0056	0.0054	0.040	105	1000		1000
3000 -- Main	3	0.53	0.01-0.0056	0.0039	0.040	65	1250-1500		1500
4000	9	0.70	0.0042	0.0049	0.030	75	2440	3820	3800
5000 -- AV1	3.0	0.37		0.0074	0.045	470	1480		1500
5000 -- Main	6.2	0.63		0.0125	0.035	520	4850		4800
USGS Gage	12	0.86	0.0085		0.027	100	8070		

[1] Water surface slope as indicated by survey of high water marks.

[2] Q w/xtra A = peak discharge estimate including additional cross sectional area as indicated by depth of scour seen in pits dug in channel beds.

[3] See summary figure for locations.

[4] Composite n-value or value for main channel at sites with subdivided cross sections.



Note: All discharges given in cubic feet per second.

Tiger Wash
Summary of Nora Discharges
September 26, 1997

N

3000 0 3000 6000 Feet

1:36000

FCD No. 98-48
Assignment No. 1
JE Fuller / Hydrology & Geomorphology, Inc.
October 1999

April 28, 1999
Revised November 3, 1999

Blue Tank Canyon

Summary of Slope-conveyance survey and estimate of peak discharge for tributary to Tiger Wash downstream of the USGS gaging station for the event of September 26, 1997

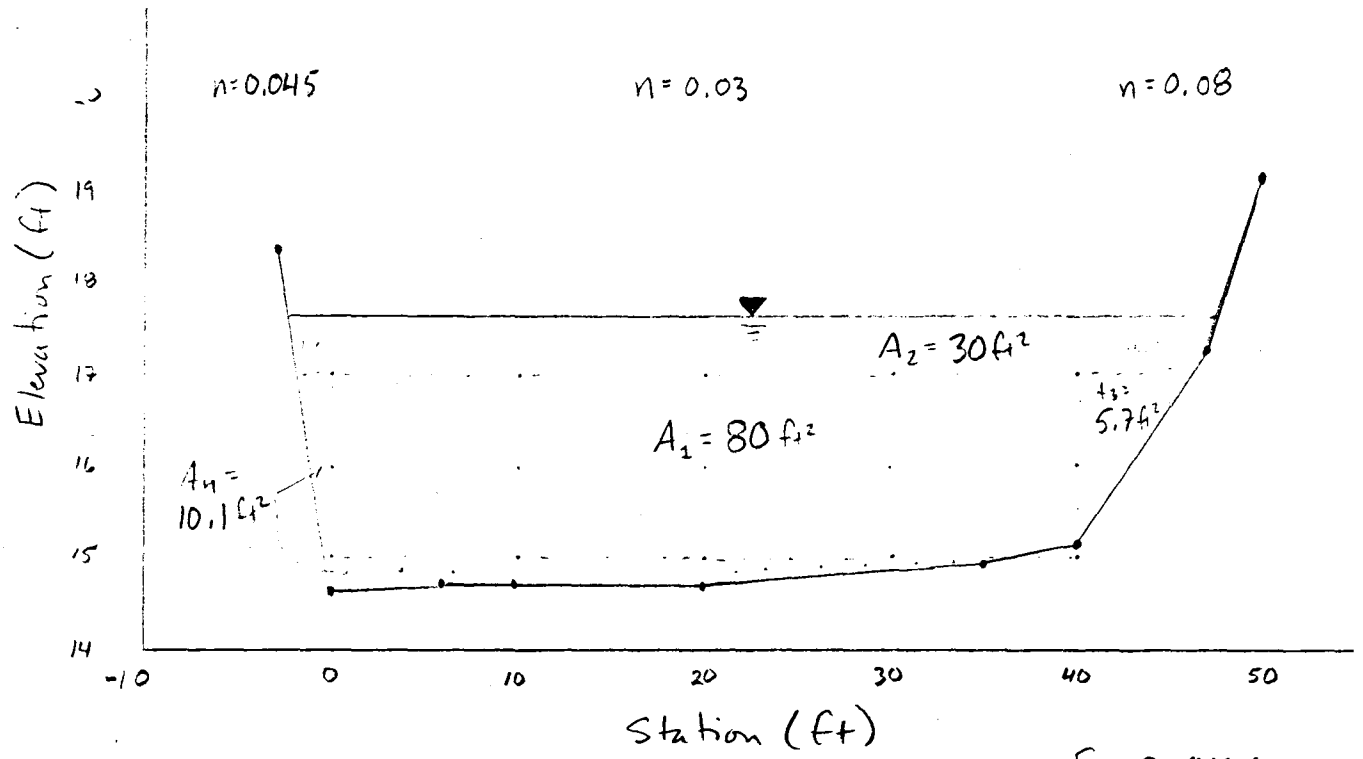
A slope-conveyance survey was performed on April 27, 1999 by T.W. Lehman and J.E. Fuller of JE Fuller / Hydrology & Geomorphology, Inc. The reach surveyed was located about 500 feet upstream of Eagle Eye Road. High water marks along the right channel bank were surveyed. No high water marks were detected along the caliche dominated left bank. The reach was about 160 feet long. The total fall through the reach was about 3 feet. The channel cross section surveyed was about 40 feet wide.

The surveyed cross section and high water marks were plotted onto graph paper. A water surface slope of 0.0156 was estimated from the plot of high water marks along the right bank. Manning's n-values of 0.045, 0.03, and 0.08 were identified for the left overbank, channel, and right overbank respectively. An area-weighted average n-value of 0.035 was computed and used in the calculation of total conveyance.

An estimate of the peak discharge of **1,220 cfs** was computed. The estimate is considered poor.

Ted Lehman
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.

Tiger Wash Trib.
Survey of 4-27-99



$S = 0.0156$

$A_{TOTAL} = 125.8\ ft^2$

$A_{n=0.045} = 4.6\ ft^2$

$A_{n=0.03} = 111.2\ ft^2$

$A_{n=0.08} = 10\ ft^2$

Using area weighting for a composite n-value,

$$\bar{n} = \frac{4.6(0.045) + 111.2(0.03) + 10(0.08)}{125.8}$$

$$= 0.035$$

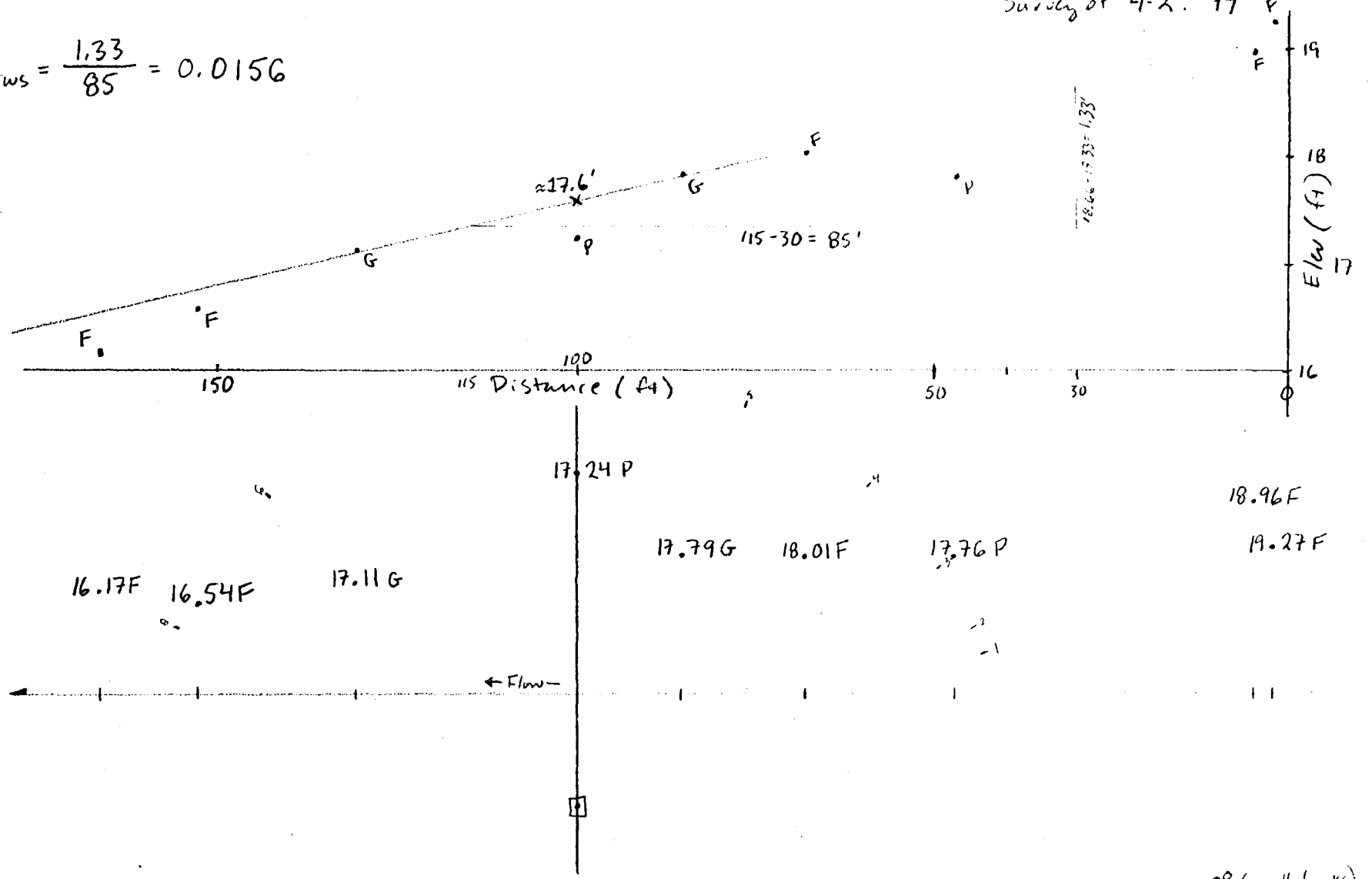
$$\therefore\ K_T = \frac{1.486}{0.035}\left(\frac{125.8}{50.9}\right)^{2/3} \cdot 125.8 = 9763$$

and $Q_T = K_T S^{1/2} = 9763 \cdot (0.0156)^{1/2} = 1{,}220\ cfs$

so, $\bar{V} = Q/A = 9.7\ ft/sec$

Tiger Wash Tributary
Survey of 4-2. 19

$$Slope_{ws} = \frac{1.33}{85} = 0.0156$$



Note: All HWM's were debris lines.
Elevations based on arbitrary datum.

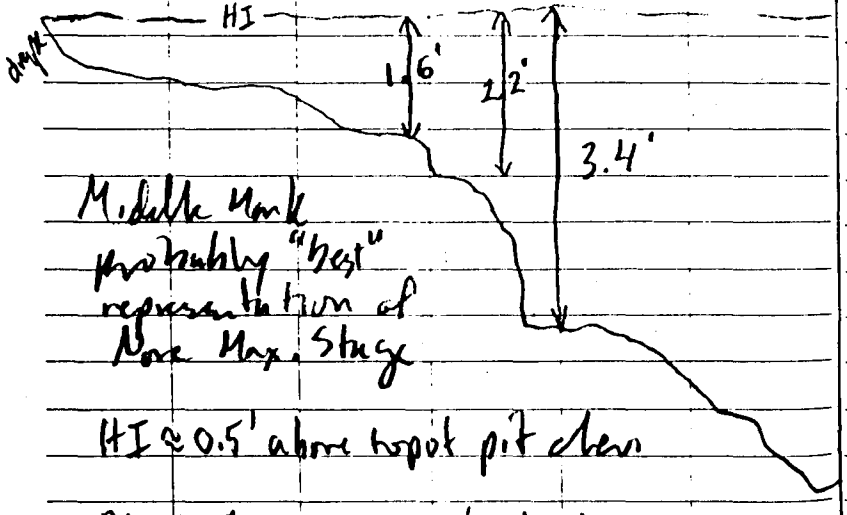
0° (parallel to XS)

1" = 20'

⊡ = Instrument location

Tiger Wash 4-27-99 1000
Hand level survey of HWMs
near Paleoflood site from
CH$_2$MHill report pg. of USGS
gage

HI ≈ Highest backwater deposit



Middle Mark
probably "best"
representation of
Nov. Max. Stage

HI ≈ 0.5' above topo pit elev

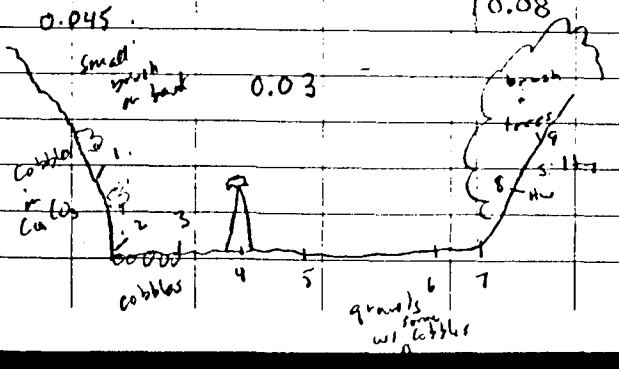
Photo # 1-1 view of HWMs
at "survey" site
Ph. 1-2 - view of old pit undisturbed
by Nov HWM x at base of talus
gray log in right of photo
Ph 1-3 → view D/S above gage
repeat of CH photo Sheet 3 Ph. 1 @
12-06

Ph. 1-4 view D/S from paleo survey
EDM site repeat of CH Photo
Sheet 4 photo 1 13-41
Ph. 1-5 view U/S from EDM site
CH repeat of Sheet 3, Ph. 3 13-40

TRIB SURVEY

HT of INSTR = ARBITRARY = 19.99

	STN	Rod	Elev.	
1	-3	+1.65	18.34	ON LB
2	0	5.37	14.62	base LB
3	6	5.32	14.67	edge cobbles
4	9.45	5.33	14.66	inset
5	20	5.36	14.63	inset LB
6.	35	5.05	14.94	
7	40	4.86	15.13	toe RB
8	46.5	2.75	17.24	debris line HWM mark (gravel)
9	50	0.93	19.06	



	Angle	Rod	Elev	Note
1.	69.5	0.72	19.27	Debris line ~~poor~~ G or F
2.	66.8	1.03	18.96	DEBRIS LINE FAIR
3.	56.8	2.33	17.76	DEBR LINE FAIR
4.	42.4	1.98	18.01	DEBR LINE FAIR
5.	23.0	2.20	17.79	DEBR LINE GOOD
6.	315.1	2.88	17.11	DEBR LINE FAIR/GOOD
7.	298.0	3.15	16.54	DEBR LINE FAIR
8.	294.0	3.82	16.17	DEBRIS LINE FAIR

PHOTO 1 - Look d/s in CHL ℄

PHOTO 2 - look u/s in CHL ℄

NAT 96.

Top	Bottom		Dist
1.24	N.V.		104'
1.55	N.V.		104'
2.55	1.92		63'
2.20	1.73		47'
2.38	2.00	u/s xn	38'
3.10	~~1.76~~ ?	d/s xn	44'
3.75	3.15		60'
4.18	3.85		73'

June 7, 1999
Revised November 3, 1999

Site 1000

Summary of Slope-area survey and estimate of peak discharge for east branch of Tiger Wash for the event of September 26, 1997.

A slope-area survey was performed on April 10, 1999 by T.W. Lehman and a field crew of JE Fuller / Hydrology & Geomorphology, Inc. The reach surveyed was located about ¾ mile north of the Big Horn Mountains Wilderness road turn off (near the large stock tank east of Eagle Eye Road) east of Eagle Eye Road. High water marks were surveyed along both channel banks for a distance of about 400 feet. Two cross sections were selected about 190 feet distant from one another. The total fall through the reach was about 2 feet with a fall of 0.9 feet between the two cross sections. The channel cross sections surveyed were about 35 feet wide.

The surveyed cross sections and high water marks were plotted using AutoCAD and Excel. A water surface slope of 0.0048 was estimated from the plot of high water marks. An area-weighted Manning's n-values of 0.044 was used in the computation of the peak discharge.

The initial estimate considered no additional cross sectional area below the observed channel bed surveyed in the field. The estimate of peak discharge was 820 cfs.

Pits dug in the channel indicated that perhaps an additional foot of depth of flow may have occurred during the flood. Although the timing of this scour (and subsequent fill) relative to the discharge that left the high water marks is unknown, the additional cross sectional area was modeled to provide an upper limit for the peak discharge for the September 1997 flood. The result of this model gave a peak discharge of 1,005 cfs.

Given the age of the high water marks and the uncertainty of additional cross sectional area due to scour, a peak discharge of **1,000 cfs** was estimated. This estimate is considered poor.

Ted Lehman
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.

```
Echo input data file
Tiger Wash East Branch Site 1000, Flood of September 26, 1997
XS   SEC1 106
GR        0,98.18,4,98.35,13,97.32,21,97.05,34,97.04,39,94.28,42,94.16
GR        46,93.58,58,93.11,74,93.64,76,95.55,80,96.25,82,97.26
GR        89,97.5,95,98.81
N         0.043
HP   SEC1 97.8
XS   SEC2 295
GR        0,99.52,8,99.28,13,97.19,25,94,34,94.03,46,94.72,56,97.17
GR        71,98.66,76,99.64
N         0.045
HP   SEC2 98.7
```

Tiger Wash East Branch Site 1000, Flood of September 26, 1997
Tiger Wash East Branch above stock tank on Big Horn road
Flood of Sept. 26, 1997 (Nora)
Survey of 4-10-99

DISCHARGE COMPUTATIONS

	dH,fall (ft)	Reach length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
SEC2 - SEC1	.90	189.	821.	4	.938	.978	.000	-.082	#

Definitions:
Spread, the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss
HF, friction head- HF = sum of Q*Q*L/(K1*K2) over subreaches; Q, discharge; L, reach length; K1, upstream section conveyance; K2, downstream section conveyance
CX, the computed discharge divided by the discharge computed with no expansion loss (k=0)
RC, velocity head change in contracting section divided by friction head
RX, velocity head change in expanding section divided by friction head
ER, warnings, *-fall < 0.5ft, @-conveyance ratio exceeded, #-reach too short

CROSS SECTION PROPERTIES

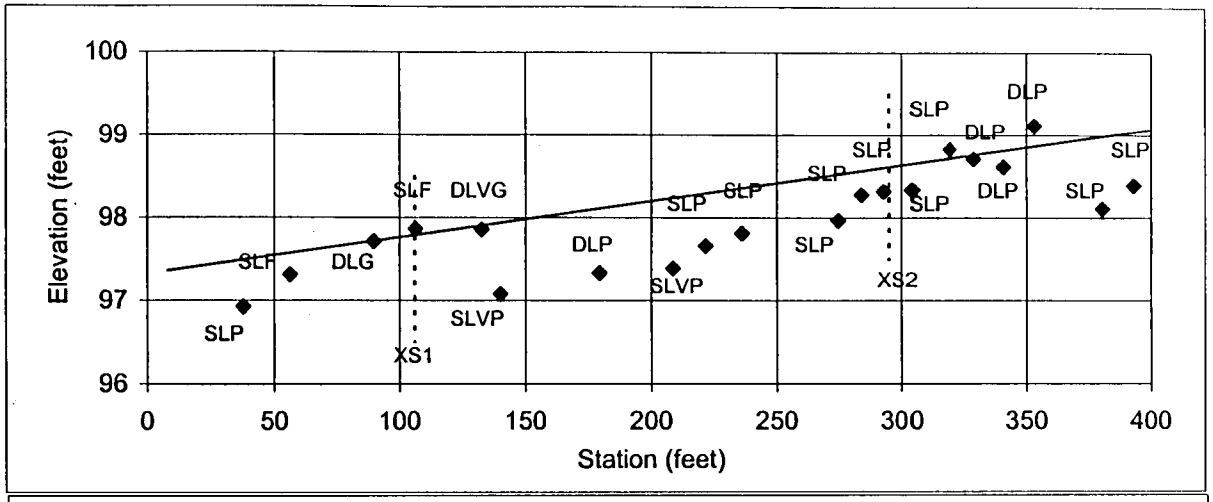
I.D. SEC1 Velocity head .27ft Discharge 821.cfs
Ref.distance 106.ft Q/K .0047 Alpha 1.000

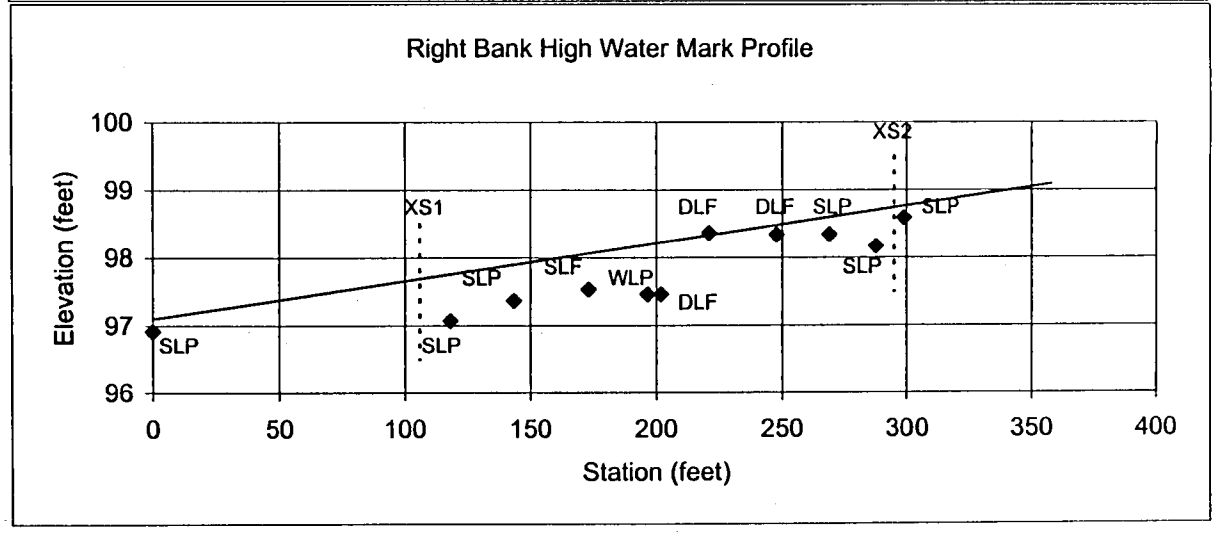
Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	97.80	.043	196.4	81.6	83.5	2.35	12.039	100.	4.2	.47
Total	97.80	---	196.	82.	83.	2.35	12.039	100.	4.2	.47

I.D. SEC2 Velocity head .35ft Discharge 821.cfs
Ref.distance 295.ft Q/K .0053 Alpha 1.000

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	98.70	.045	173.4	61.8	62.9	2.76	11.283	100.	4.7	.50
Total	98.70	---	173.	62.	63.	2.76	11.283	100.	4.7	.50

Definitions:
n, Manning's coefficient of roughness Q/K = discharge/conveyance
F, Froude number- F = Q/(A sqrt(g*(A1/TW1)); Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

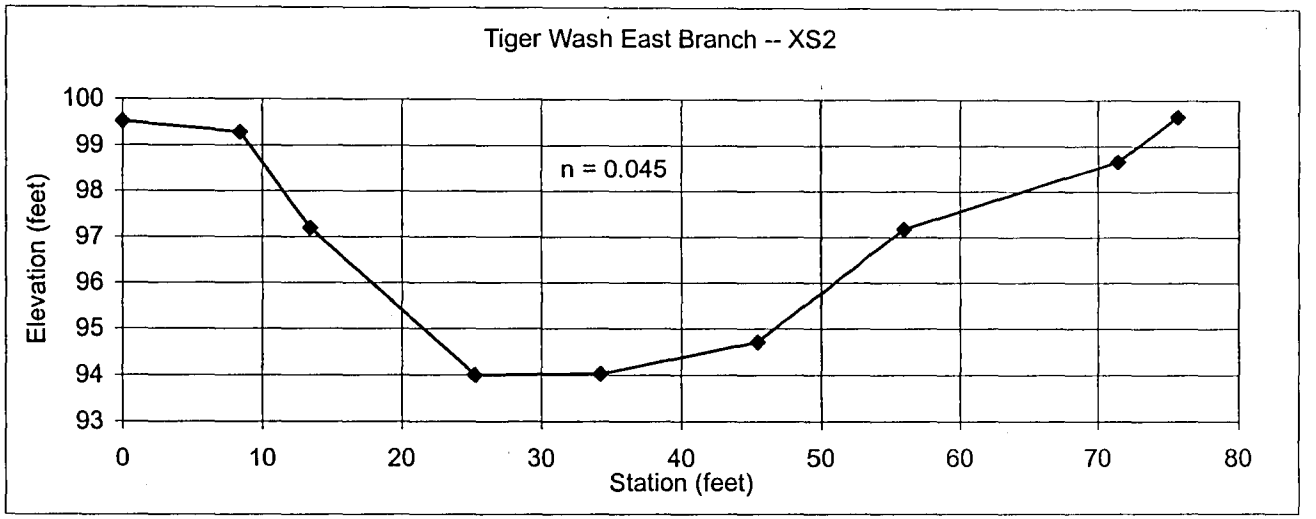

100
99
98
97
96
Elevation (feet)
0
50
100
150
200
250
300
350
400
Station (feet)
SLP
SLF
DLG
SLF
DLVG
XS1
SLVP
DLP
SLVP
SLP
SLP
SLP
SLP
SLP
SLP
XS2
SLP
DLP
DLP
DLP
SLP
SLP


Right Bank High Water Mark Profile
100
99
98
97
96
Elevation (feet)
0
50
100
150
200
250
300
350
400
Station (feet)
SLP
XS1
SLP
SLP
SLF
WLP
DLF
DLF
DLF
SLP
SLP
XS2
SLP
SLP

Tiger Wash East Branch
Slope-Area Survey of April 10, 1999

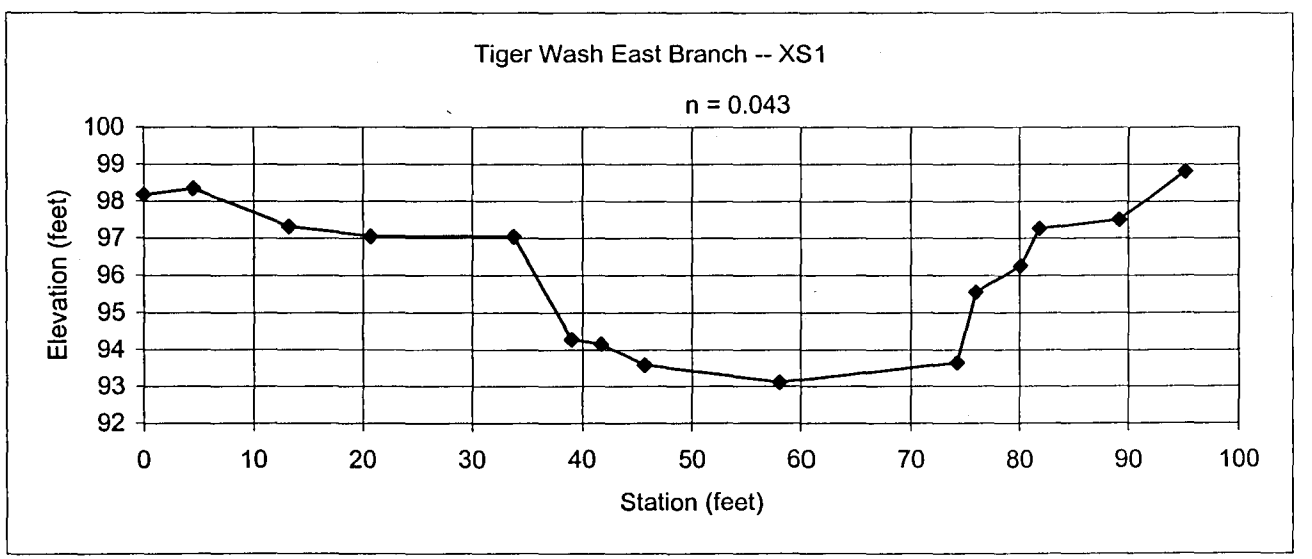
XS2
Channel Station 295

Station (feet)	Elevation (feet)
0	99.52
8	99.28
13	97.19
25	94
34	94.03
46	94.72
56	97.17
71	98.66
76	99.64



XS1
Channel Station 106

Station (feet)	Elevation (feet)
0	98.18
4	98.35
13	97.32
21	97.05
34	97.04
39	94.28
42	94.16
46	93.58
58	93.11
74	93.64
76	95.55
80	96.25
82	97.26
89	97.5
95	98.806



```
Echo input data file
Tiger Wash East Branch, Site 1000, Additional XS Area due to scour included
XS   SEC1 106
GR        0,98.18,4,98.35,13,97.32,21,97.05,34,97.04,39,94.28,42,94.16
GR        46,93.58,52,92.0,70,92.0,76,95.55,80,96.25,82,97.26
GR        89,97.5,95,98.81
N         0.043
HP   SEC1 97.8
XS   SEC2 295
GR        0,99.52,8,99.28,13,97.19,25,94,27,93.0,39,93.0,46,94.72,56,97.17
GR        71,98.66,76,99.64
N         0.045
HP   SEC2 98.7
```

Tiger Wash East Branch, Site 1000, Additional XS Area due to scour included
Tiger Wash East Branch above stock tank on Big Horn road
Flood of Sept. 26, 1997 (Nora)
Survey of 4-10-99 Extra XS Area for scour considered

DISCHARGE COMPUTATIONS

	dH,fall (ft)	Reach length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
SEC2 - SEC1	.90	189.	1005.	6	.957	.968	.000	-.119	#

Definitions:
Spread, the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss
HF, friction head- HF = sum of Q*Q*L/(K1*K2) over subreaches; Q, discharge; L, reach length; K1, upstream section conveyance; K2, downstream section conveyance
CX, the computed discharge divided by the discharge computed with no expansion loss (k=0)
RC, velocity head change in contracting section divided by friction head
RX, velocity head change in expanding section divided by friction head
ER, warnings, *-fall < 0.5ft, @-conveyance ratio exceeded, #-reach too short

CROSS SECTION PROPERTIES

I.D. SEC1 Velocity head .31ft Discharge 1005.cfs
Ref.distance 106.ft Q/K .0045 Alpha 1.000

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	97.80	.043	224.3	81.6	83.9	2.67	14.980	100.	4.5	.48
Total	97.80	---	224.	82.	84.	2.67	14.980	100.	4.5	.48

I.D. SEC2 Velocity head .43ft Discharge 1005.cfs
Ref.distance 295.ft Q/K .0057 Alpha 1.000

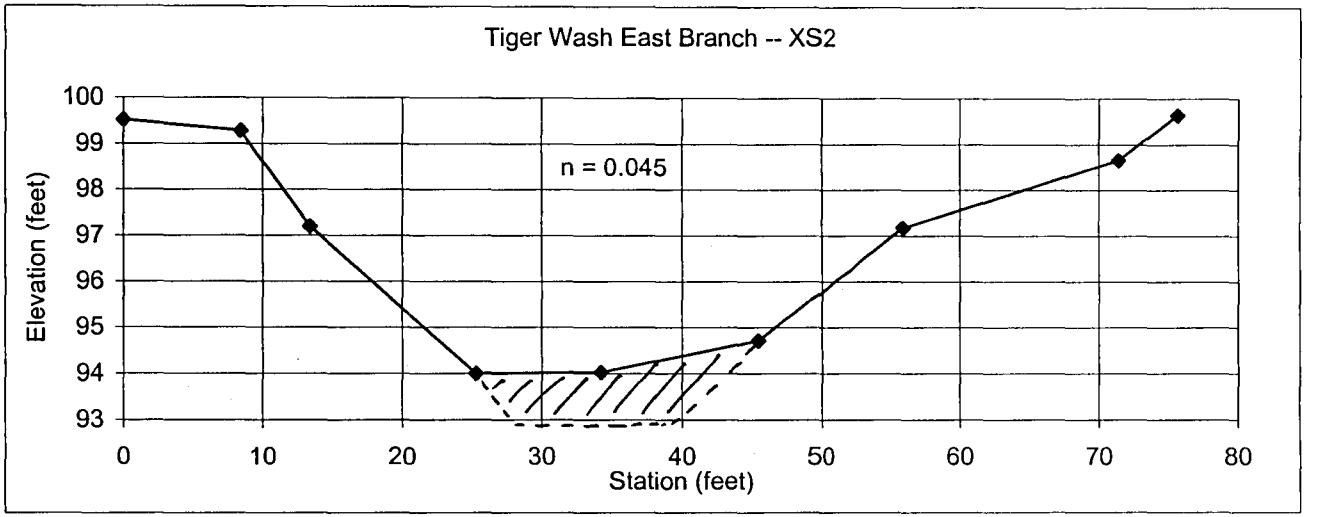
Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	98.70	.045	192.0	61.8	63.4	3.03	13.313	100.	5.2	.52
Total	98.70	---	192.	62.	63.	3.03	13.313	100.	5.2	.52

Definitions:
n, Manning's coefficient of roughness Q/K = discharge/conveyance
F, Froude number- F = Q/(A sqrt(g*(A1/TW1)); Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

Tiger Wash East Branch
Slope-Area Survey of April 10, 1999

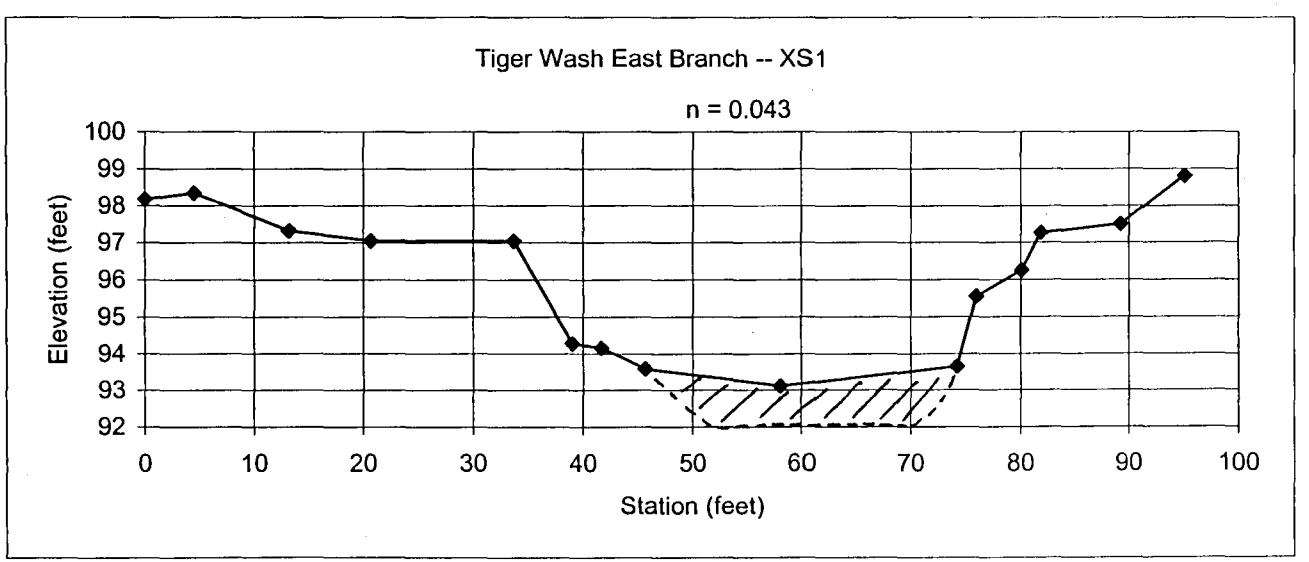
XS2
Channel Station 295

Station (feet)	Elevation (feet)
0	99.52
8	99.28
13	97.19
25	94
34	94.03
46	94.72
56	97.17
71	98.66
76	99.64



XS1
Channel Station 106

Station (feet)	Elevation (feet)
0	98.18
4	98.35
13	97.32
21	97.05
34	97.04
39	94.28
42	94.16
46	93.58
58	93.11
74	93.64
76	95.55
80	96.25
82	97.26
89	97.5
95	98.806



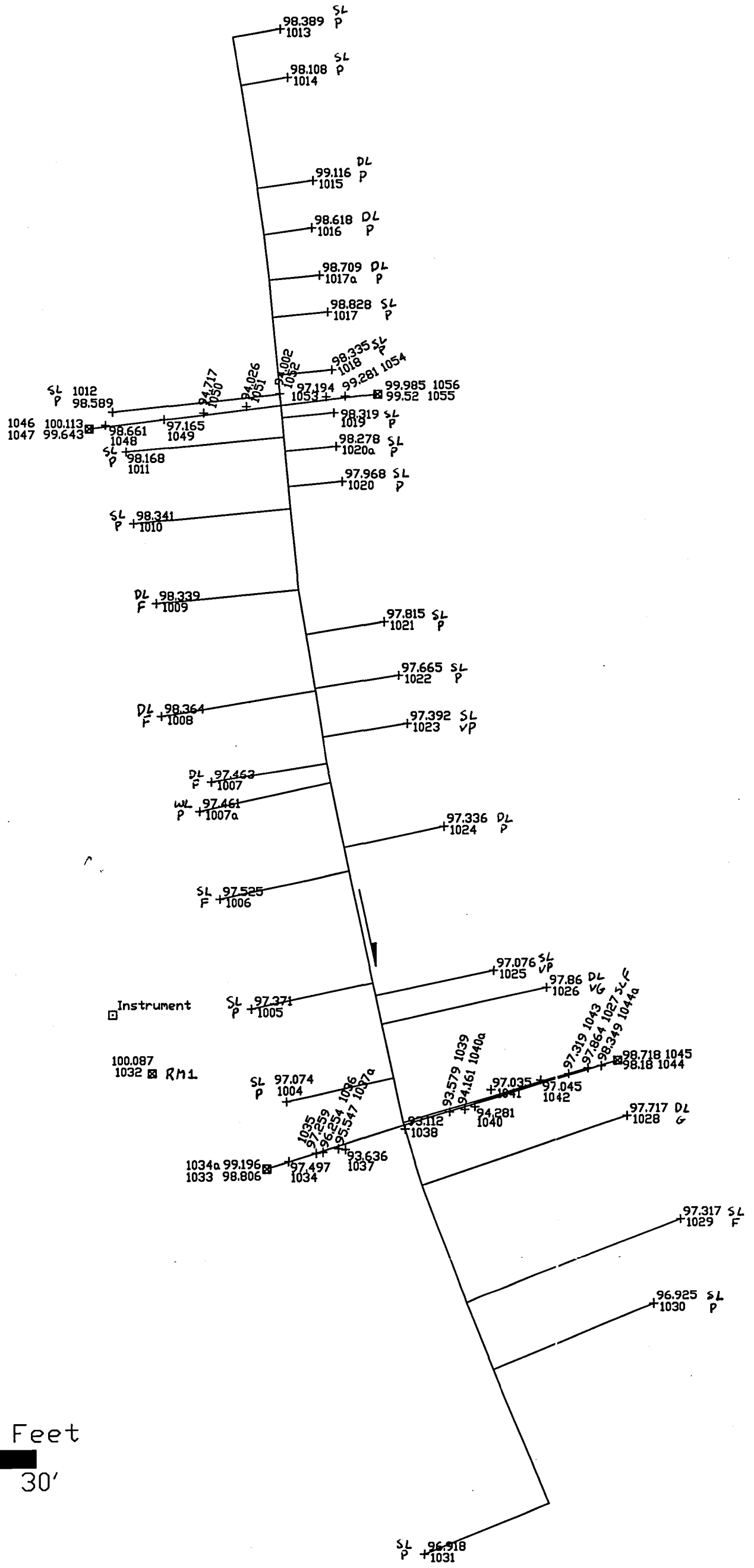
= Potential additional XS area

Tiger Wash East Branch - Slope-Area Survey Data
Survey of April 10, 1999

location#	Hor. Ang (degrees)	Vert. Ang (degrees)	slope length (feet)	easting (feet)	northing (feet)	elevation (feet)	Comment
1000	146.249	92.461	0				trial point
1001	146.105	92.461	18.635				trial point
1002	146.105	92.461	18.625	10.377	-15.446	104.19	bogus
1003	129.321	90.465	58.202	45.024	-36.88	104.518	bogus
1004	116.792	91.159	50.755	45.297	-22.873	97.074	HWMRB - SLP
1005	87.93	91.15	36.302	36.271	1.311	97.371	HWMRB - SLP
1006	27.067	91.082	41.047	28.092	29.92	97.525	HWMRB - SLF
1007a				22.933	52.646	97.461	HWMRB - WLP
1007	23.316	90.557	65.541	25.94	60.186	97.463	HWMRB - DLF
1008	9.393	89.808	78.543	12.819	77.49	98.364	HWMRB - DLF
1009	6.223	89.873	107.628	11.667	106.993	98.339	HWMRB - DLF
1010	2.546	89.892	127.848	5.678	127.721	98.341	HWMRB - SLP
1011	4.255	89.974	146.457	3.77	146.408	98.168	HWMRB - SLP
1012	0.097	89.822	156.837	0.264	156.836	98.589	HWMRB - SLP
1013	9.758	89.937	260.322	44.123	256.555	98.389	HWMLB - SLP
1014	10.663	89.998	248.327	45.948	244.039	98.108	HWMLB - SLP
1015	13.542	89.74	223.274	52.279	217.065	99.116	HWMLB - DLP
1016	14.271	89.86	211.129	52.045	204.613	98.618	HWMLB - DLP
1017a				54.127	192.317	98.709	HWMLB - DLP
1017	17.122	89.782	191.227	56.299	182.75	98.828	HWMLB - SLP
1018	18.878	89.924	177.313	57.372	167.775	98.335	HWMLB - SLP
1019	23.461	89.936	158.796	58.025	156.436	98.319	HWMLB - SLP
1020a				58.603	147.587	98.278	HWMLB - SLP
1020	34.821	90.05	150.919	60.174	138.403	97.968	HWMLB - SLP
1021	34.773	90.131	124.282	70.882	102.086	97.815	HWMLB - SLP
1022	40.28	90.216	115.322	74.557	87.978	97.665	HWMLB - SLP
1023	49.462	90.377	107.562	76.782	75.323	97.392	HWMLB - SLVP
1024	89.353	90.441	99.163	86.494	48.492	97.336	HWMLB - DLP
1025	83.736	90.588	99.747	99.147	10.883	97.076	HWMLB - SLVP (look at elev. Diff.)
1026	86.787	90.122	113.104	112.926	6.34	97.86	HWMLB - DLVG
1027	96.749	90.109	124.491	123.629	-14.631	97.864	HWMLB - SLF
1028	101.458	90.161	136.572	133.849	-27.131	97.717	HWMLB - DLG
1029	109.946	90.286	157.175	147.745	-53.617	97.317	HWMLB - SLF
1030	118.494	90.421	159.99	140.606	-76.324	96.925	HWMLB - SLP
1031	150.325	90.418	162.215	80.306	-140.936	96.918	HWMRB - SLP
1032	146.191	83.874	18.622	10.303	-15.384	100.087	EB RM1
1033	134.681	88.891	56.614	40.247	-39.802	99.196	XS1 RB -- Top of stake
1034a				40.178	-39.861	98.806	XS1 RB -- ground @ stake
1034	129.645	90.58	59.57	45.867	-38.006	97.497	
1035	124.213	90.752	64.035	52.949	-36.003	97.259	
1036	123.148	91.617	65.43	54.76	-35.763	96.254	
1037a				58.791	-34.909	95.547	
1037	120.119	93.644	70.226	60.622	-35.168	93.636	Toe RB
1038	111.643	93.489	81.965	76.045	-30.175	93.112	
1039	106.447	92.831	91.522	87.67	-25.88	93.579	
1040a				91.615	-25.197	94.161	
1040	104.585	92.247	97.411	94.2	-24.51	94.281	Toe LB
1041	101.556	90.607	100.476	98.434	-20.126	97.035	
1042	99.064	90.537	112.723	111.311	-17.757	97.045	
1043	97.699	90.374	119.705	118.623	-16.037	97.319	
1044a				127.14	-14.039	98.349	
1044	95.521	89.965	131.9	131.288	-12.691	98.18	XS1 LB -- ground @ stake
1045	95.483	89.732	132.103	131.497	-12.623	98.718	XS1 LB -- Top of stake

Tiger Wash East Branch - Slope-Area Survey Data
Survey of April 10, 1999

location#	Hor. Ang (degrees)	Vert. Ang (degrees)	slope length (feet)	easting (feet)	northing (feet)	elevation (feet)	Comment
1046	357.838	89.245	152.664	-5.758	152.542	100.113	XS2 RB -- Top of stake
1047	357.814	89.421	152.5	-5.816	152.381	99.643	XS2 RB -- ground @ stake
1048	0.608	89.79	153.392	-1.628	153.383	98.661	
1049	5.074	90.345	155.472	13.748	154.861	97.165	
1050a				11.748	154.81	95.165	bogus?
1050	8.721	91.223	158.494	24.026	156.626	94.717	
1051	12.559	91.44	162.129	35.244	158.2	94.026	center of channel
1052	15.201	91.403	167.454	43.894	161.547	94.002	Toe LB
1053	19.215	90.305	170.141	55.996	160.66	97.194	
1054	20.751	89.607	171.949	60.921	160.791	99.281	
1055	23.257	89.537	175.633	69.348	161.356	99.52	XS2 LB -- ground @ stake
1056	23.26	89.386	175.666	69.367	161.379	99.985	XS2 LB -- Top of stake



Scale in Feet

0′ 30′

TIGER WASH

JEFULLER/HYDROLOGY & GEOMORPHOLOGY, INC MAY, 1999

4-10-99 Tiger Wash
East Branch Channel
XS2 - view downstream

4-10-99 Tiger Wash
East Branch Channel
XS1 view U/S

4-10-99 Tiger Wash
East Branch Channel
XS2 view ~~D/S~~ upstream

4-10-99 Tiger Wash
East Branch Channel
XS1 view D/S

Survey Site: Tiger Wash, Site 1000
East Branch

Date:
Sept. 10, 1999

Sta/Dist	BS	HI	Top	Bottom	Forward	Elevation	Comments
EB RM1	4.87	104.96				100.09	top of 2x2 wood stake on RB
1A					4.81	100.15	top of capped 1/2" rebar stamped 1A
							Note 1A located approx. 0.3' SSW of RM 1

Party: TWL, inst, notes
MH, rod

Weather: Hot and humid

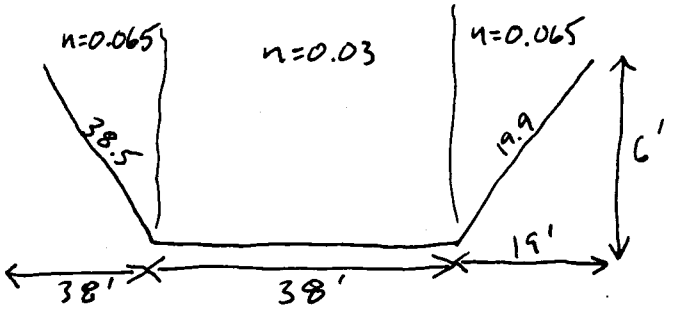
Tiger Wash n-value corrections per review comments by H.W. Hjalmarson dated 10-26-99

Site 1000

Indicated in field Notes

Composite n-value

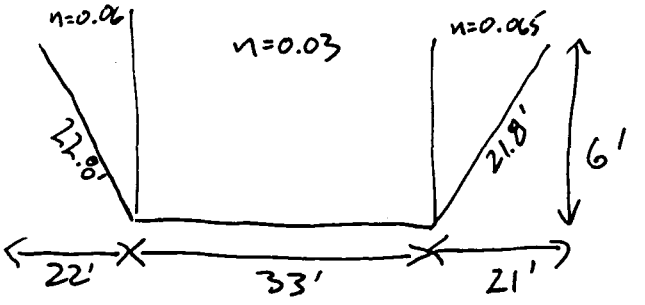
XS2



WP weight $\bar{n}$ = 0.051

A WEIGHT $\bar{n}$ = 0.045

XS1



WP WGT $\bar{n}$ = 0.049

A WGT $\bar{n}$ = 0.043

~~Site 2000~~

Alternately, using Thomsen and Hjalmarson, 1991

n_b = 0.028 , Table 1 , gravel

n_1 = 0.005 , Table 2 , minor irregularity

n_2 = 0.001 , " , negligible obstructions

n_3 = 0.010 , " , medium vegetation R > 2 ft

$\bar{n}$ = 0.044

June 7, 1999
Revised July 21, 1999
Revision 2 November 3, 1999

Site 2000

Summary of Slope-area survey and estimate of peak discharge for west branch of Tiger Wash for the event of September 26, 1997.

A slope-area survey was performed on April 10, 1999 by T.W. Lehman and a field crew of JE Fuller / Hydrology & Geomorphology, Inc. The reach surveyed was located about 2,000 feet downstream of Eagle Eye Road in the reach between two buttes. High water marks were surveyed along both channel banks for a distance of about 900 feet. Three cross sections were selected through a reach about 315 feet long. The total fall through the reach was about 7 feet with a fall of 2.7 feet between the cross sections. The channel cross sections surveyed were about 70 feet wide.

The surveyed cross sections and high water marks were plotted using AutoCAD and Excel. A water surface slope of 0.0086 was estimated from the plot of high water marks. Manning's n-values of 0.029 was used for the channel. The overbank roughness values ranged from 0.04-0.05 on the less vegetated caliche dominated right bank. On the left bank where a small inset flood plain exists, the vegetation was much heavier and Manning's n values of 0.07 to 0.075 were used.

The initial estimate considered no additional cross sectional area below the observed channel bed surveyed in the field. The estimate of peak discharge for this condition was 5,170 cfs.

Pits dug in the channel indicated that perhaps an additional two feet of depth of flow may have occurred during the flood. Although the timing of this scour (and subsequent fill) relative to the discharge that left the high water marks is unknown, the additional cross sectional area was modeled to provide an upper limit for the peak discharge for the September 1997 flood. The result of this model gave a peak discharge of 6,910 cfs.

Given the age of the high water marks and the uncertainty of additional cross sectional area due to scour, a peak discharge of **6,900 cfs** was estimated. This estimate is considered poor to fair.

Ted Lehman
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.

```
Echo input data file
Tiger Wash West Branch, Site 2000
XS   SEC1 148
GR        0,144.2,76,139.5,95,139.6,98,138.8,103,136.0,141,135.9
GR        156,135.8,162,137.3,169,137.1,171,138.5,173,139.0
GR        195,140.3,223,141.1,242,141.9
N         0.07,0.029,0.045
SA        95,173
HP   SEC1 141.2
XS   SEC2 327
GR        0,149.4,29,145.6,37,141.5,56,140.8,63,137.8,93,137.0,124,136.7
GR        126,137.6,133,138.1,136,139.2,159,141.2,166,142.0,194,142.8
GR        196,142.8,208,143.2
N         0.07,0.029,0.05
SA        56,159
HP   SEC2 142.8
XS   SEC3 461
GR        -17,146.7,0,141.9,13,141.6,24,139.2,58,137.5
GR        81,137.5,85,139.3,98,141.5,128,143.3,141,143.7,171,144.7
N         0.075,0.029,0.04
SA        13,98
HP   SEC3 143.9
```

Tiger Wash West Branch, Site 2000
Tiger Wash West Branch below Eagle Eye Road
Flood of Sept. 26, 1997 (Nora)
Survey of 4-10-99

DISCHARGE COMPUTATIONS

	dH,fall (ft)	Reach length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
SEC3 - SEC2	1.10	134.	7063.	22	1.318	.895	.000	-.331	#
SEC2 - SEC1	1.60	179.	4498.	0	.895	1.000	.788	.000	@#
SEC3 - SEC1	2.70	313.	5167.	4	1.886	.978	.493	-.124	@

Definitions:
Spread, the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss
HF, friction head- HF = sum of Q*Q*L/(K1*K2) over subreaches; Q, discharge; L, reach length; K1, upstream section conveyance; K2, downstream section conveyance
CX, the computed discharge divided by the discharge computed with no expansion loss (k=0)
RC, velocity head change in contracting section divided by friction head
RX, velocity head change in expanding section divided by friction head
ER, warnings, *-fall < 0.5ft, @-conveyance ratio exceeded, #-reach too short

CROSS SECTION PROPERTIES

I.D. SEC1 Velocity head 2.57ft Discharge 5167.cfs
Ref.distance 148.ft Q/K .0084 Alpha 1.401

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	141.20	.070	54.7	46.5	46.5	1.18	1.297	2.	2.2	1.77
2	141.20	.029	372.3	78.0	79.5	4.68	53.543	95.	13.2	.88
3	141.20	.045	48.2	52.4	52.4	.92	1.510	3.	2.9	2.00
Total	141.20	---	475.	177.	178.	2.66	56.350	100.	10.9	1.17

I.D. SEC2 Velocity head 1.64ft Discharge 5167.cfs
Ref.distance 327.ft Q/K .0052 Alpha 1.161

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	142.80	.070	33.0	21.5	21.9	1.51	.924	1.	2.0	1.36
2	142.80	.029	489.2	103.0	104.1	4.70	70.496	98.	10.4	.77
3	142.80	.050	19.6	35.0	35.1	.56	.396	1.	1.5	2.25
Total	142.80	---	542.	160.	161.	3.36	71.817	100.	9.5	.91

Definitions:
n, Manning's coefficient of roughness Q/K = discharge/conveyance
F, Froude number- F = Q/(A sqrt(g*(A1/TW1)); Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

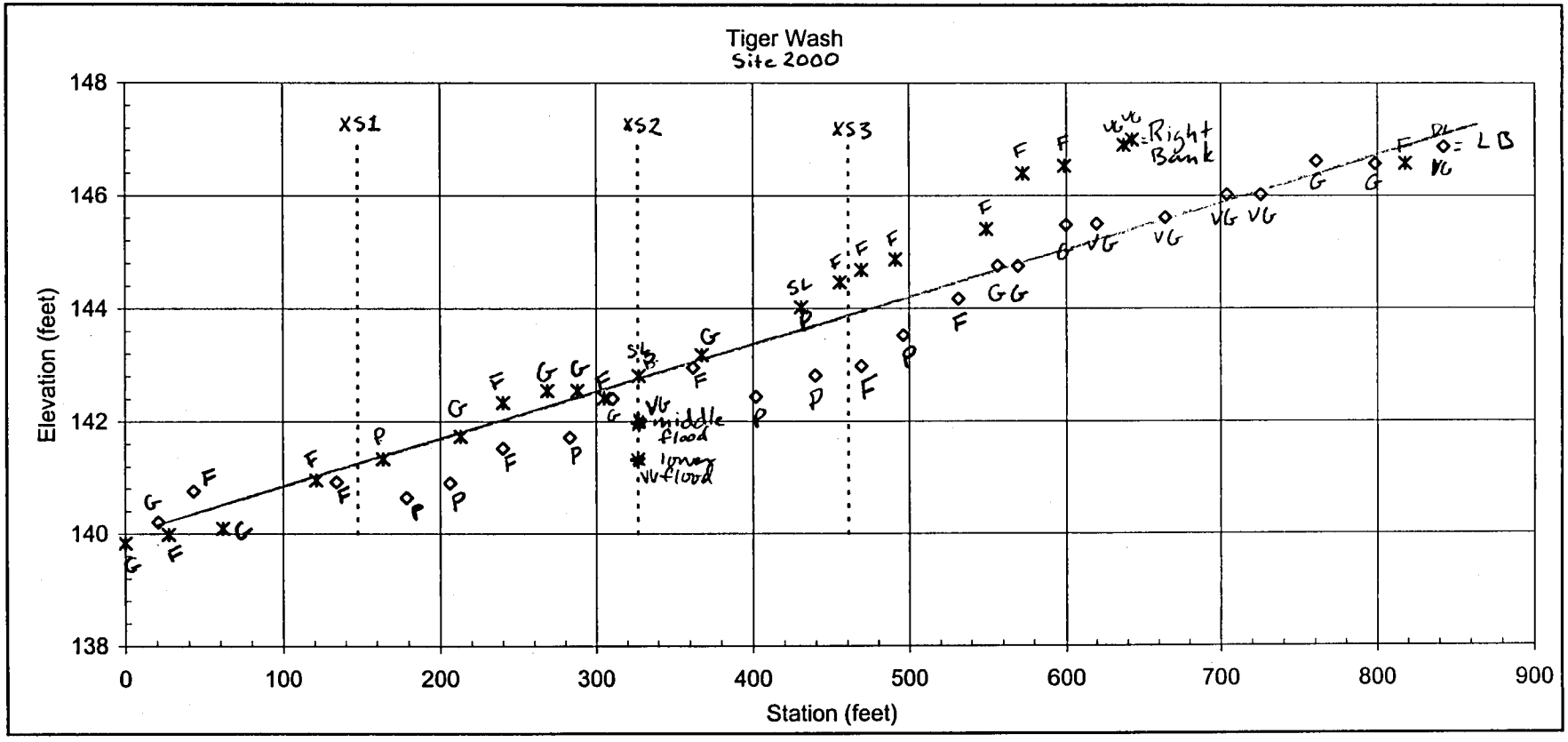
Tiger Wash West Branch, Site 2000
Tiger Wash West Branch below Eagle Eye Road
Flood of Sept. 26, 1997 (Nora)
Survey of 4-10-99

CROSS SECTION PROPERTIES

I.D. SEC3 Velocity head 1.87ft Discharge 5167.cfs
Ref.distance 461.ft Q/K .0054 Alpha 1.258

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	143.90	.075	35.0	20.1	20.4	1.72	.999	1.	2.1	1.31
2	143.90	.029	441.9	85.0	85.9	5.15	67.674	96.	11.2	.76
3	143.90	.040	50.8	49.0	49.1	1.04	1.937	3.	2.8	1.69
Total	143.90	---	528.	154.	155.	3.40	70.610	100.	9.8	.93

Definitions:
n, Manning's coefficient of roughness Q/K = discharge/conveyance
F, Froude number- F = Q/(A sqrt(g*(A1/TW1)); Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

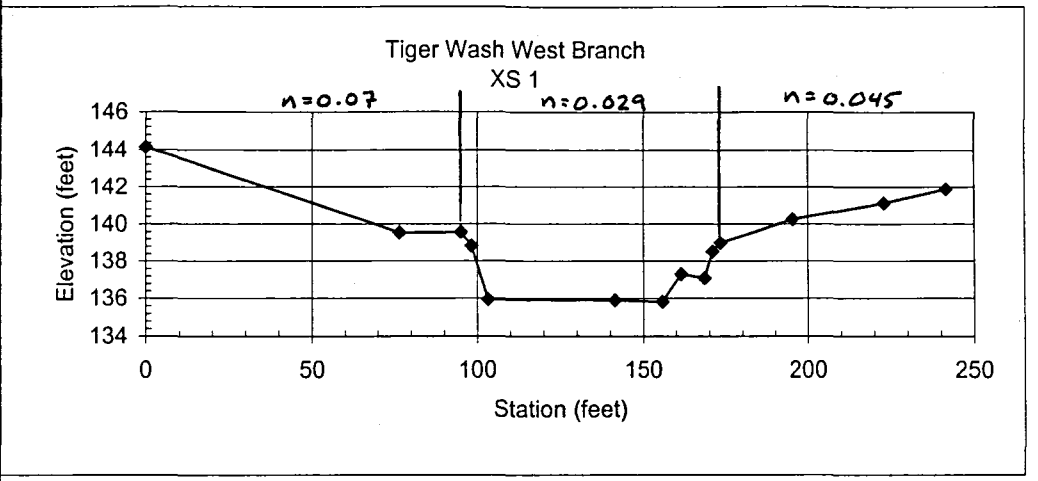


West Branch
FLD No.98-48

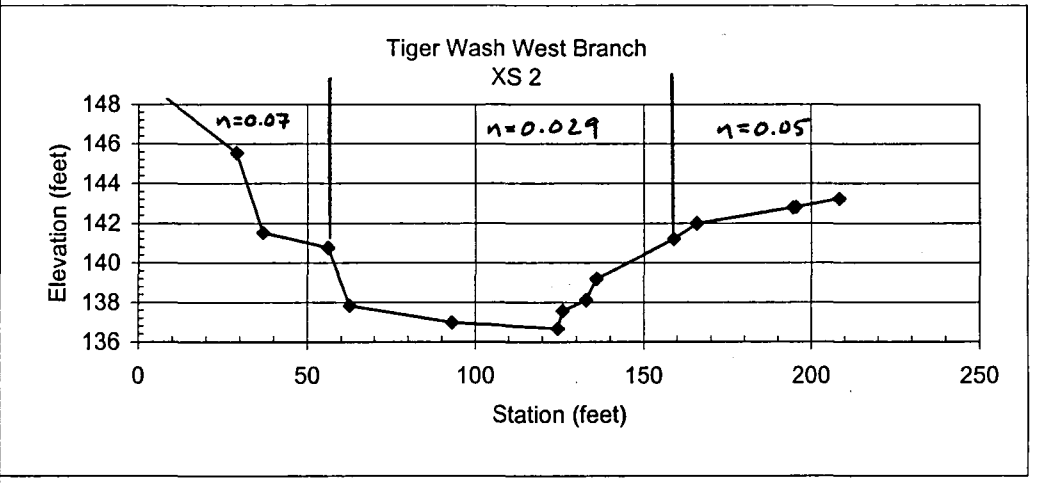
JE Fuller, Inc.
May 17, 1999

Tiger Wash West Branch
Slope-Area Survey at Site 2000
Survey of April 10, 1999

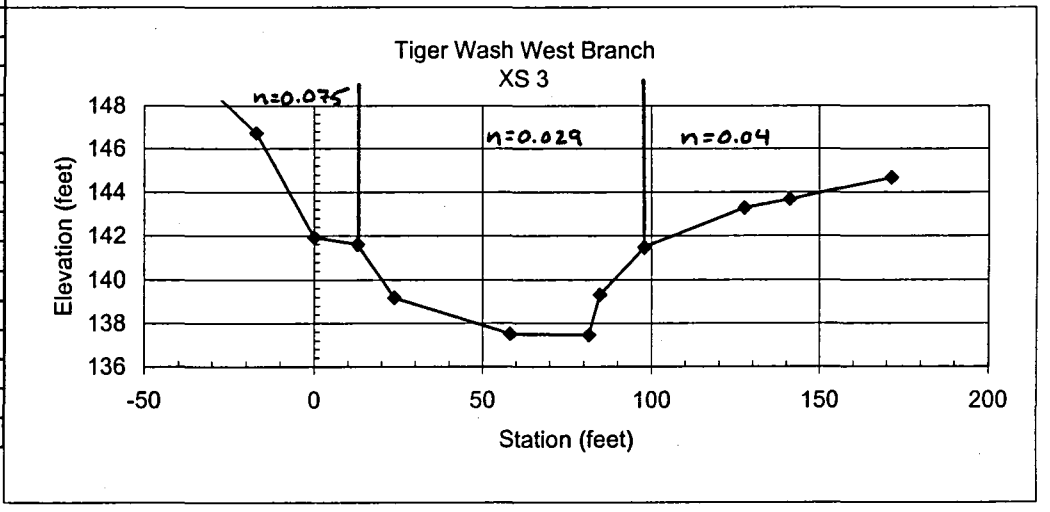
XS1 -- Channel Sta. 148	
Station	Elevation
(feet)	(feet)
0	144.2
76	139.5
95	139.6
98	138.8
103	136.0
141	135.9
156	135.8
162	137.3
169	137.1
171	138.5
173	139.0
195	140.3
223	141.1
242	141.9



XS2 -- Channel Sta. 327	
Station	Elevation
(feet)	(feet)
0	149.4
29	145.6
37	141.5
56	140.8
63	137.8
93	137.0
124	136.7
126	137.6
133	138.1
136	139.2
159	141.2
166	142.0
194	142.8
196	142.8
208	143.2



XS3 -- Channel Sta. 461	
Station	Elevation
(feet)	(feet)
-63	153.7
-48	151.4
-17	146.7
0	141.9
13	141.6
24	139.2
58	137.5
81	137.5
85	139.3
98	141.5
128	143.3
141	143.7
171	144.7



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SAC -USGS slope-area program Ver 94-5                                    page  0

Echo input data file
Tiger Wash West Branch, Site 2000
XS    SEC1 148
GR         0,144.2,76,139.5,95,139.6,98,138.8,103,136.0,110,134.0
GR         150,134.0,156,135.8,162,137.3,169,137.1,171,138.5,173,139.0
GR         195,140.3,223,141.1,242,141.9
N          0.07,0.029,0.045
SA         95,173
HP    SEC1 141.2
XS    SEC2 327
GR         0,149.4,29,145.6,37,141.5,56,140.8,63,137.8,70,136,90,135.0
GR         122,135.0,126,137.6,133,138.1,136,139.2,159,141.2,166,142.0
GR         194,142.8,196,142.8,208,143.2
N          0.07,0.029,0.05
SA         56,159
HP    SEC2 142.8
XS    SEC3 461
GR         -17,146.7,0,141.9,13,141.6,24,139.2,50,136.0,58,135.5,80,135.5
GR         81,137.5,85,139.3,98,141.5,128,143.3,141,143.7,171,144.7
N          0.075,0.029,0.04
SA         13,98
HP    SEC3 143.9
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Tiger Wash West Branch, Site 2000
Tiger Wash West Branch below Eagle Eye Road
Flood of Sept. 26, 1997 (Nora)
Survey of 4-10-99 extra XS area for scour considered

DISCHARGE COMPUTATIONS

	dH,fall (ft)	Reach length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
SEC3 - SEC2	1.10	134.	10283.	54	1.553	.767	.000	-.583	#
SEC2 - SEC1	1.60	179.	5886.	0	.797	1.000	1.007	.000	#
SEC3 - SEC1	2.70	313.	6908.	7	1.799	.961	.615	-.227	

Definitions:
Spread, the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss
HF, friction head- HF = sum of Q*Q*L/(K1*K2) over subreaches; Q, discharge; L, reach length; K1, upstream section conveyance; K2, downstream section conveyance
CX, the computed discharge divided by the discharge computed with no expansion loss (k=0)
RC, velocity head change in contracting section divided by friction head
RX, velocity head change in expanding section divided by friction head
ER, warnings, *-fall < 0.5ft, @-conveyance ratio exceeded, #-reach too short

CROSS SECTION PROPERTIES

I.D. SEC1 Velocity head 3.12ft Discharge 6908.cfs
Ref.distance 148.ft Q/K .0076 Alpha 1.343

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	141.20	.070	54.7	46.5	46.5	1.18	1.297	2.	2.1	1.99
2	141.20	.029	461.8	78.0	80.1	5.77	76.307	96.	14.4	.89
3	141.20	.045	48.2	52.4	52.4	.92	1.510	2.	2.7	2.25
Total	141.20	---	565.	177.	179.	3.15	79.114	100.	12.2	1.21

I.D. SEC2 Velocity head 2.02ft Discharge 6908.cfs
Ref.distance 327.ft Q/K .0049 Alpha 1.138

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	142.80	.070	33.0	21.5	21.9	1.51	.924	1.	2.0	1.52
2	142.80	.029	594.3	103.0	104.9	5.66	97.015	99.	11.5	.78
3	142.80	.050	19.6	35.0	35.1	.56	.396	0.	1.4	2.51
Total	142.80	---	647.	160.	162.	4.00	98.336	100.	10.7	.93

Definitions:
n, Manning's coefficient of roughness Q/K = discharge/conveyance
F, Froude number- F = Q/(A sqrt(g*(A1/TW1)); Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

Tiger Wash West Branch, Site 2000
Tiger Wash West Branch below Eagle Eye Road
Flood of Sept. 26, 1997 (Nora)
Survey of 4-10-99 extra XS area for scour considered

CROSS SECTION PROPERTIES

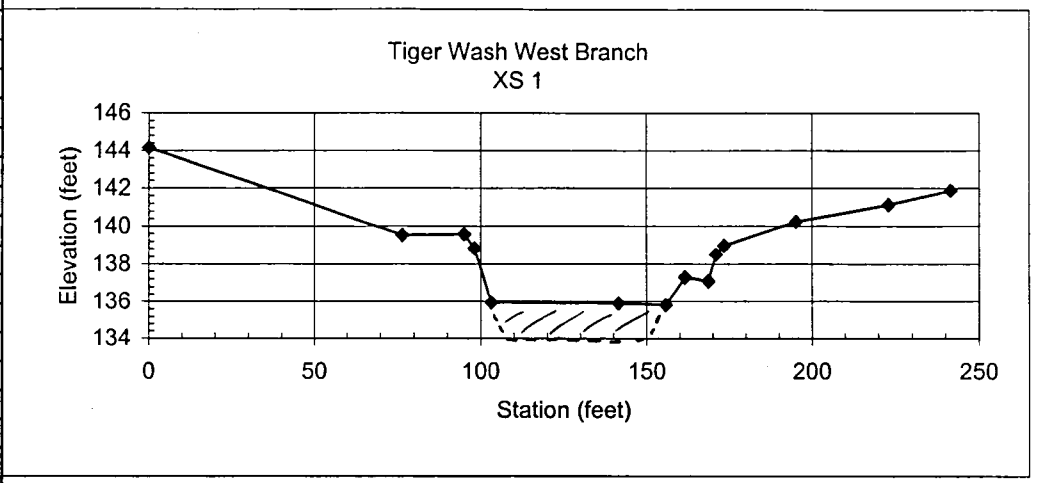
I.D. SEC3 Velocity head 2.42ft Discharge 6908.cfs
Ref.distance 461.ft Q/K .0055 Alpha 1.229

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	143.90	.075	35.0	20.1	20.4	1.72	.999	1.	2.1	1.50
2	143.90	.029	527.2	85.0	87.3	6.04	89.842	97.	12.7	.80
3	143.90	.040	50.8	49.0	49.1	1.04	1.937	2.	2.8	1.95
Total	143.90	---	613.	154.	157.	3.91	92.777	100.	11.3	1.00

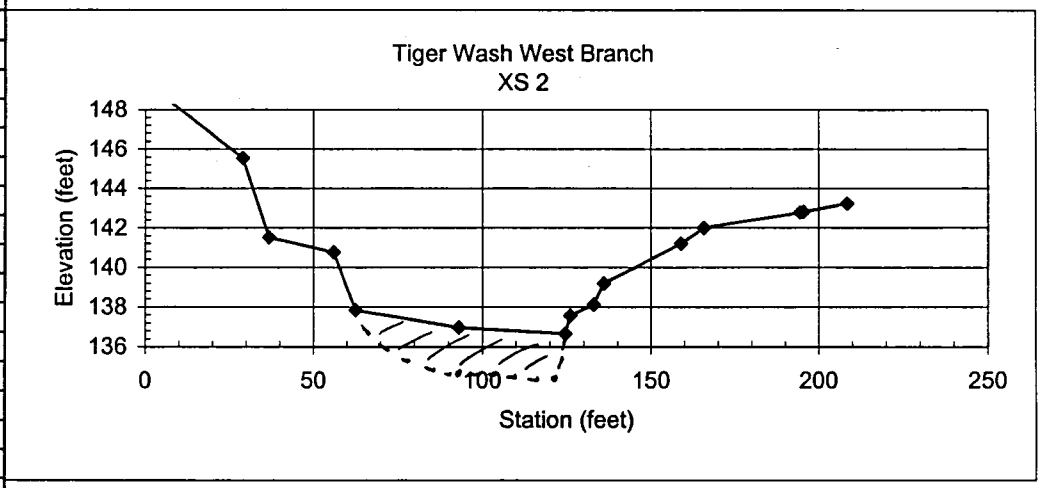
Definitions:
n, Manning's coefficient of roughness Q/K = discharge/conveyance
F, Froude number- F = Q/(A sqrt(g*(A1/TW1)); Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

Tiger Wash West Branch
Slope-Area Survey at Site 2000
Survey of April 10, 1999

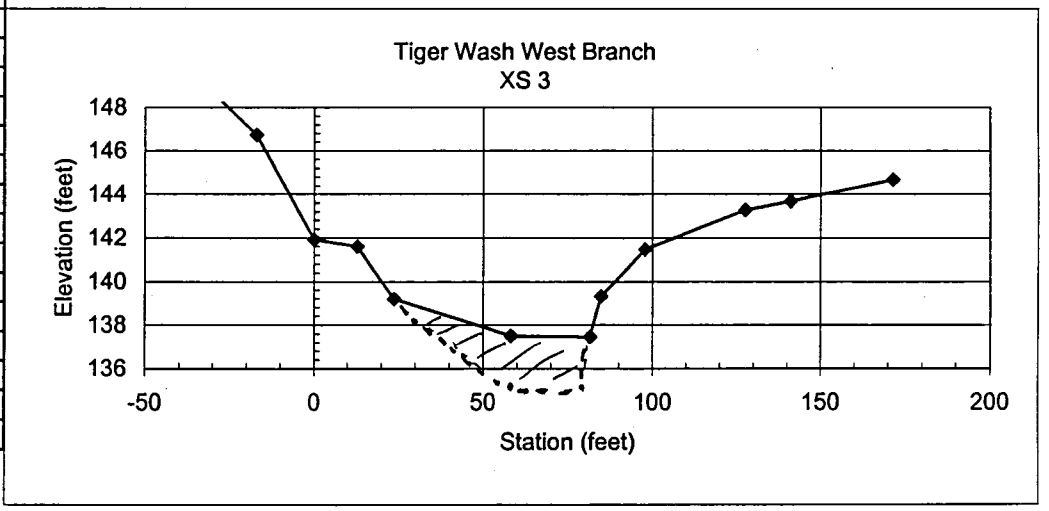
XS1 -- Channel Sta. 148	
Station	Elevation
(feet)	(feet)
0	144.2
76	139.5
95	139.6
98	138.8
103	136.0
141	135.9
156	135.8
162	137.3
169	137.1
171	138.5
173	139.0
195	140.3
223	141.1
242	141.9



XS2 -- Channel Sta. 327	
Station	Elevation
(feet)	(feet)
0	149.4
29	145.6
37	141.5
56	140.8
63	137.8
93	137.0
124	136.7
126	137.6
133	138.1
136	139.2
159	141.2
166	142.0
194	142.8
196	142.8
208	143.2



XS3 -- Channel Sta. 461	
Station	Elevation
(feet)	(feet)
-63	153.7
-48	151.4
-17	146.7
0	141.9
13	141.6
24	139.2
58	137.5
81	137.5
85	139.3
98	141.5
128	143.3
141	143.7
171	144.7



= area of possible additional XS AREA during flow

Tiger Wash Approximate FDS
FCD No. 98-48
May 17, 1999

JE Fuller / Hydrology and Geomorphology, Inc.

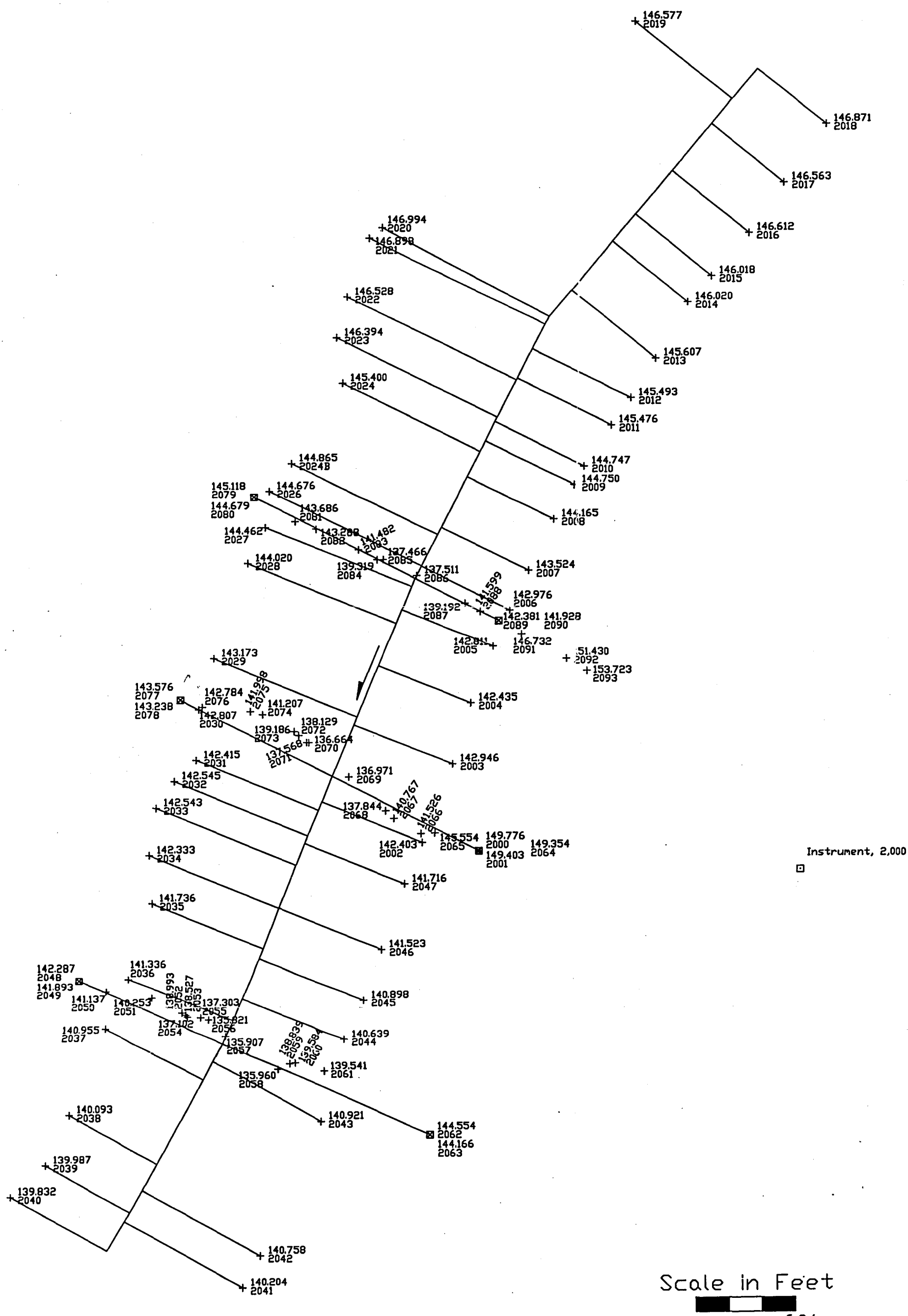
Tiger Wash West Branch - Slope-Area Survey Data
Survey of April 10, 1999

Station Setup	1001
I =	5.34
Elevation =	200
Northing =	0
Easting =	0

station name	hor. Ang (degrees)	ver. Ang (degrees)	length (feet)	Target Height (feet)	Elevation (feet)	Easting (feet)	Northing (feet)	Comment
2000	273.421	103.717	204.551	7.06	149.776	-198.363	11.858	WB LB1 -- RM1, top of 2x2 wood stake
2001	273.372	103.816	204.675	7.06	149.403	-198.409	11.690	Ground at RM1
2002	274.187	103.433	240.528	7.06	142.403	-233.323	17.081	HWMLB -- DLG
2003	286.9	103.821	231.631	7.06	142.946	-215.211	65.386	HWMLB -- DLF
2004	296.925	103.704	235.728	7.06	142.435	-204.192	103.705	HWMLB -- DLP
2005	306.105	103.226	242.444	7.06	142.811	-190.684	139.075	HWMLB -- DLP
2006	311.82	102.841	248.842	7.06	142.976	-180.810	161.776	HWMLB -- DLF
2007	317.687	102.256	257.943	7.06	143.524	-169.685	186.396	HWMLB -- DLP
2008	324.74	101.432	273.028	7.06	144.165	-154.489	218.516	HWMLB -- DLF
2009	329.405	100.857	284.19	7.06	144.750	-142.054	240.248	HWMLB -- DLG
2010	331.638	100.593	291.207	7.06	144.747	-135.978	251.885	HWMLB -- DLG
2011	336.73	99.929	306.24	7.06	145.476	-119.172	277.115	HWMLB -- DLG
2012	339.948	99.577	317.28	7.06	145.493	-107.271	293.893	HWMLB -- DLVG
2013	343.816	99.024	335.824	7.06	145.607	-92.443	318.524	HWMLB -- DLVG
2014	348.269	98.224	365.341	7.06	146.020	-73.516	354.032	HWMLB -- DLVG
2015	350.913	97.929	378.858	7.06	146.018	-59.263	370.527	HWMLB -- DLVG
2016	354.734	97.378	402.349	7.06	146.612	-36.622	397.334	HWMLB -- DLG
2017	357.896	96.87	432.352	7.06	146.563	-15.759	428.958	HWMLB -- DLG
2018	361.155	96.305	468.12	7.06	146.871	9.379	465.194	HWMLB -- DLVG
2019	348.49	95.468	542.592	7.06	146.577	-107.776	529.261	HWMRB -- DLF
2020	326.772	96.112	481.68	7.06	146.994	-262.447	400.633	HWMRB -- DLVG
2021	325.54	96.137	480.627	7.06	146.898	-270.395	394.016	HWMRB -- DLVG
2022	321.56	96.472	459.127	7.06	146.528	-283.618	357.324	HWMRB -- DLF
2023	318.843	96.722	443.274	7.06	146.394	-289.724	331.451	HWMRB -- DLF
2024	316.718	97.235	419.888	7.06	145.400	-285.579	303.240	HWMRB -- DLF
2024B				7.06	144.865	-317.504	253.838	HWMRB -- DLF
2026	305.547	97.511	410.079	7.06	144.676	-330.793	236.362	HWMRB -- DLF
2027	302.657	97.746	399.295	7.06	144.462	-333.105	213.497	HWMRB -- DLF
2028	299.072	97.857	396.926	7.06	144.020	-343.660	191.059	HWMRB -- SLP
2029	289.846	98.098	391.198	7.06	143.173	-364.295	131.485	HWMRB -- DLG
2030	284.993	98.176	390.066	7.06	142.807	-372.957	99.885	HWMRB -- SLP
2031	280.3	98.35	384.695	7.06	142.415	-374.483	68.055	HWMRB -- DLF
2032	278.053	98.099	395.61	7.06	142.545	-387.802	54.868	HWMRB -- DLG
2033	275.519	97.916	404.708	7.06	142.543	-398.993	38.552	HWMRB -- DLG
2034	271.339	97.899	407.1	7.06	142.333	-403.127	9.423	HWMRB -- DLF
2035	267.119	98.005	406.034	7.06	141.736	-401.569	-20.209	HWMRB -- DLG
2036	260.88	97.68	426.102	7.06	141.336	-416.942	-66.933	HWMRB -- DLP
2037	257.071	97.404	444.846	7.06	140.955	-429.953	-98.702	HWMRB -- DLF
2038	251.289	96.929	482.323	7.06	140.093	-453.495	-153.597	HWMRB -- DLG
2039	248.442	96.61	506.411	7.06	139.987	-467.855	-184.840	HWMRB -- DLF
2040	247.34	96.289	533.556	7.06	139.832	-489.406	-204.322	HWMRB -- DLG
2041	232.715	97.674	434.911	7.06	140.204	-342.930	-261.101	HWMLB -- DLG
2042	233.996	97.971	414.806	7.06	140.758	-332.326	-241.484	HWMLB -- DLF
2043	241.881	99.724	339.6	7.06	140.921	-295.214	-157.755	HWMLB -- DLF
2044	249.329	100.874	305.545	7.06	140.639	-280.742	-105.921	HWMLB -- SLP
2045	253.251	101.544	286.736	7.06	140.898	-269.017	-80.960	HWMLB -- DLP
2046	259.263	102.192	268.75	7.06	141.523	-258.089	-48.939	HWMLB -- DLF
2047	268.038	103.041	250.673	7.06	141.716	-244.065	-8.361	HWMLB -- DLP
2048	261.372	97.046	456.463	7.06	142.287	-447.889	-67.961	XS1 RB Top of stake
2049	261.373	97.093	456.65	7.06	141.893	-448.028	-67.974	XS1 RB ground at stake
2050	260.11	97.447	440.889	7.06	141.137	-430.674	-75.087	

Tiger Wash West Branch - Slope-Area Survey Data
Survey of April 10, 1999

station name	hor. Ang (degrees)	ver. Ang (degrees)	length (feet)	Target Height (feet)	Elevation (feet)	Easting (feet)	Northing (feet)	Comment
2051	258.849	98.061	413.806	7.06	140.253	-401.982	-79.237	
2052	256.947	98.58	397.395	7.06	138.993	-382.794	-88.748	edge of silt terrace
2053	256.662	98.691	395.436	7.06	138.527	-380.351	-90.178	
2054	256.466	98.911	394.951	7.06	137.102	-379.349	-91.312	
2055	256.118	99.065	387.021	7.06	137.303	-371.024	-91.696	
2056	255.719	99.389	382.864	7.06	135.821	-366.062	-93.179	Toe RB
2057	253.681	99.577	374.898	7.06	135.907	-354.780	-103.873	
2058	248.703	100.218	351.306	7.06	135.960	-322.124	-125.572	Toe LB
2059	248.822	99.992	342.579	7.06	138.839	-314.597	-121.885	
2060	248.709	99.966	339.16	7.06	139.584	-311.243	-121.292	
2061	246.645	100.424	324.646	7.06	139.541	-293.128	-126.574	
2062	233.795	100.802	286.67	7.06	144.554	-227.218	-166.329	XS1 LB Top of stake
2063	233.776	100.878	286.745	7.06	144.166	-227.164	-166.405	XS1 LB ground @ stake
2064	273.424	103.844	204.472	7.06	149.354	-198.178	11.857	XS2 LB (RM1) Ground @ stake
2065	275.75	103.083	232.927	7.06	145.554	-225.739	22.731	
2066	275.471	103.552	242.198	7.06	141.526	-234.382	22.449	
2067	277.239	102.803	259.534	7.06	140.767	-251.064	31.890	
2068	278.146	103.149	265.673	7.06	137.844	-256.097	36.658	Toe LB
2069	281.635	102.138	291.575	7.06	136.971	-279.199	57.489	
2070	284.555	101.088	320.387	7.06	136.664	-304.316	79.013	Toe RB
2071	284.499	100.881	321.621	7.06	137.568	-305.780	79.074	
2072	285.059	100.592	327.238	7.06	138.129	-310.616	83.572	
2073	285.351	100.305	330.338	7.06	139.186	-313.414	86.040	
2074	286.19	99.34	351.667	7.06	141.207	-333.243	96.753	HWMRB -- DLG, lower flood?
2075	286.167	99.011	359.347	7.06	141.998	-340.877	98.821	HWMRB -- DLG, middle flood?
2076	285.296	98.215	388.389	7.06	142.784	-370.787	101.408	HWMRB -- DLG, highest flood
2077	285.376	97.811	402.513	7.06	143.576	-384.505	105.737	XS2 RB Top of stake
2078	285.395	97.859	402.543	7.06	143.238	-384.454	105.860	XS2 RB ground @ stake
2079	304.379	97.347	415.722	7.06	145.118	-340.287	232.816	XS3 RB Top of stake
2080	304.363	97.405	415.889	7.06	144.679	-340.444	232.784	XS3 RB ground @ stake
2081	304.642	98.127	386.184	7.06	143.686	-314.530	217.320	
2082	305.175	98.48	372.92	7.06	143.288	-301.491	212.482	
2083	305.971	99.496	344.275	7.06	141.482	-274.809	199.448	
2084	306.26	100.234	331.857	7.06	139.319	-263.333	193.154	
2085	306.681	100.641	329.341	7.06	137.466	-259.581	193.352	Toe of RB
2086	307.531	101.414	307.074	7.06	137.511	-238.701	183.367	
2087	308.545	102.49	273.215	7.06	139.192	-208.629	166.219	Toe of LB
2088	308.972	102.484	262.208	7.06	141.599	-199.035	161.014	
2089	309.609	102.933	249.761	7.06	142.381	-187.538	155.195	XS3 LB Top of stake
2090	309.597	103.04	249.751	7.06	141.928	-187.482	155.082	XS3 LB ground @ stake
2091	310.264	102.78	233.028	7.06	146.732	-173.413	146.877	
2092	312.064	103.455	201.348	7.06	151.430	-145.377	131.193	
2093	312.922	103.798	186.821	7.06	153.723	-132.858	123.554	



TIGER WASH, REACH 2000

JEFULLER/HYDROLOGY & GEOMORPHOLOGY, INC MAY, 1999

Survey Site: Tiger Wash, Site 2000
between buttes

Date:
Sept. 10, 1999

Sta/Dist	BS	HI	Top	Bottom	Forward	Elevation	Comments
WB1 RM1	3.39	153.17				149.78	top of 2x2 wood stake on LB
1A					3.28	149.89	top of capped 1/2" rebar stamped 2A
							Note 2A located approx. 0.3' N of RM 1

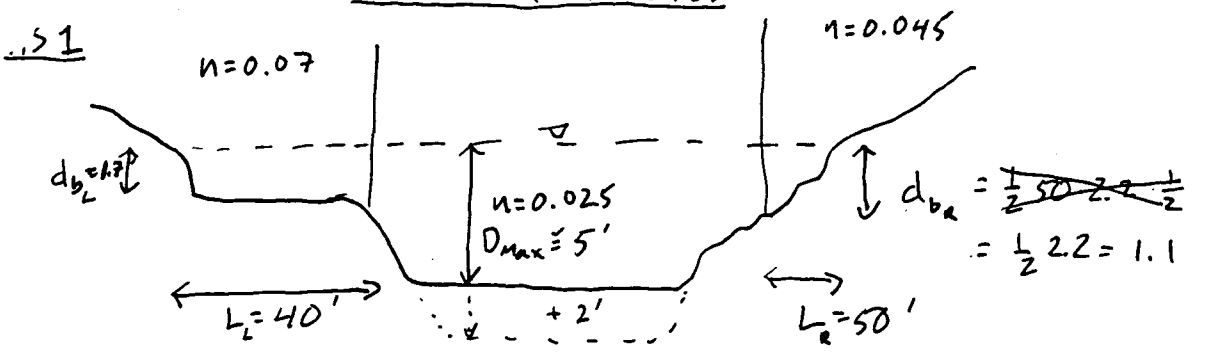
Party: TWL, inst, notes
MH, rod

Weather: Hot and humid

Site 2000

Indicated in Notes

XS1



$D_{max} > 2d_{b_L} \Rightarrow 5-7' > 3.4$

$L_L/d_{b_L} > 5 \Rightarrow 40/1.7 > 5$

∴ subdivide left bank from channel

$D_{max} > 2d_{b_R} \Rightarrow 5-7' > 2.2$

$L_R/d_{b_R} > 5 \Rightarrow 50/1.1 > 5$

∴ subdivide right overbank from channel

for channel

$n_b = 0.025$	, Table 1 ,	Chow fine gravel - Benson & Dalrymple gravel
$n_1 = 0.002$	, Table 2 ,	minor irregularity
$n_2 = 0.002$	, " ,	negligible <5% obstructions
$n_3 = 0.0$	" ,	accounted for by <5% obstr. in n_2 for veg. along RB toe scattered

$n = 0.029$

Based on XS1, XS2 & XS3 also require subdivision.

Survey Site: Tiger Wash, Site 2000
between buttes

Date:
Sept. 10, 1999

Sta/Dist	BS	HI	Top	Bottom	Forward	Elevation	Comments
WB1 RM1	3.39	153.17				149.78	top of 2x2 wood stake on LB
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							Note 2A located approx. 0.3' N of RM 1

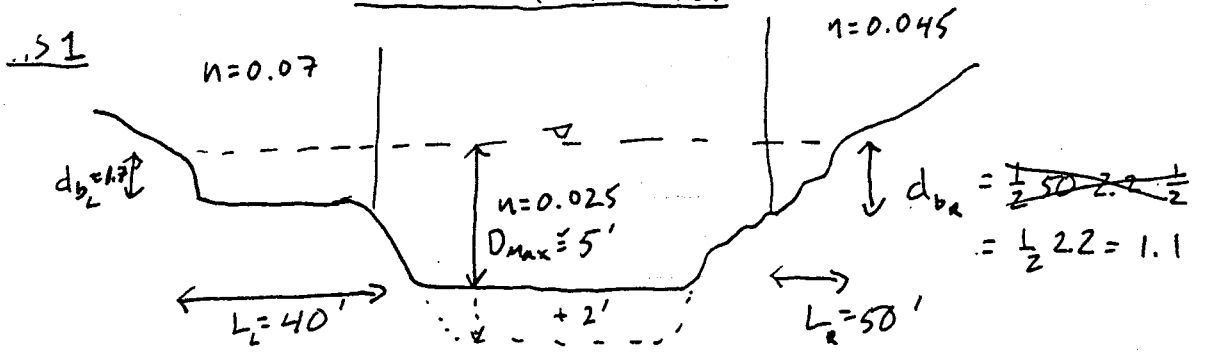
Party: TWL, inst, notes
MH, rod

Weather: Hot and humid

Site 2000

Indicated in Notes

XS1



$D_{max} > 2d_{b_L} \Rightarrow 5'-7' > 3.4$

$L_L/d_{b_L} > 5 \Rightarrow 40/1.7 > 5$

∴ subdivide left bank from channel

$D_{max} > 2d_{b_R} \Rightarrow 5-7' > 2.2$

$L_R/d_{b_R} > 5 \Rightarrow 50/1.1 > 5$

∴ subdivide right overbank from channel

for channel

$n_b = 0.025$, Table 1 , Chow fine gravel – Benson & Dalrymple gravel

$n_1 = 0.002$, Table 2 , minor irregularity

$n_2 = 0.002$, " , negligible <5% obstructions

$n_3 = 0.0$ " , accounted for by <5% obstr. in n_2 for veg. along RB toe scattered

---

$n = 0.029$

Based on XS1, XS2 & XS3 also require subdivision.

4-10-99 Tizer Wash
WB1, XS2 view upstream

4-10-99 Tizer Wash
WB1, XS1 view upstream

4-10-99 Tizer Wash
WB1, XS2 view downstream

4-10-99 Tizer Wash
WB1, XS1 view downstream

4-10-99 Tiger Wash
WB1, XS2 view upstream
along RB

4-10-99 Tiger Wash
WB1, XS3 view U/S

4-10-99 Tiger Wash
WB1, XS 3 view D/S

4-10-99 Tiger Wash
WB1
17w.M's view XS2 RB

June 7, 1999
Revised November 3, 1999

Site 3000

Summary of a survey and examination of relative split flow at the upstream avulsion on the west branch of Tiger Wash for the event of September 26, 1997. The site is located near the FCDMC ALERT weather station in the NE1/4 NW1/4 Sec. 29, T4N, R10W.

The site was surveyed on April 10-11, 1999 by T.W. Lehman and a field crew of JE Fuller / Hydrology & Geomorphology, Inc. One cross section (XS2) was taken across the avulsion approximately perpendicular to the flow in both the old/main channel as well as the new breakout or avulsion channel to the west. A second cross section (XS1) across the left or main channel and overbank was surveyed about 165 feet downstream of the first. The main channel portion of the two cross sections were located at previously surveyed markers. The previous survey was performed as part of a slope-area survey by the FCDMC in February 1995. Comparison of the bed elevations in the overlapping portions of the cross sections indicated only minor vertical differences between the 1995 and 1999.

In addition to the channel cross section, a high water marks along the sections and upstream and downstream were surveyed to give an estimate of the depth of flow and water surface slope across the section and through the reach. Finally, a point downstream in each of the two channels was surveyed to allow for an estimate of the channel bed slope in each direction. The surveyed points were plotted using AutoCAD and Excel.

The bed slope estimated for the right or breakout channel was 0.0054. The bed slope for the left or main channel was 0.0039. An approximate water surface of 102.8 ft (relative survey datum) from XS2 station 0 to 130 and 103.6 ft from station 130 to 585 was estimated from high water marks. These elevations were used at XS2 to estimate relative conveyance and discharge for the two channels. Assuming equal n-values, the discharge in the left or main channel was about 1.4 times greater than that in the right or breakout channel. Assuming n-values of 0.075 for the main channel's left overbank area, 0.04 for the main channel, and 0.04 for the breakout channel, a discharge of 1,240 cfs is estimated for the left or main channel, and a discharge of 1,000 cfs is estimated for the right or breakout channel. Therefore, the total discharge estimated using bed slopes is about 2,000 cfs.

A second analysis was conducted using the survey water surface slope for the left or main channel. The water surface slope between XS2 and XS1 was 0.0056. This yields a discharge in the main channel of about 1,500 cfs. Using this estimate the total discharge at site 3000 is about 2,500 cfs.

Therefore, it is my judgement that the best estimate of the total discharge at site 3000 is **3,000 cfs** with about **1,000 cfs** in the breakout channel and **1,500 cfs** in the main channel.

Given the gross approximations these estimates of peak discharge are considered very poor.

Ted Lehman
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.

July 21, 1999
Tiger Wash

possible additional Q in ROB @ Site 3000 unaccounted for by original 5-A/C survey

from aerial photo 3-9:
possibly an additional 300' wide of shallow over bank flow ≈ 0.5' deep beyond end of survey

∴ Assume Additional $A = 300' \times 0.5' = 150 ft^2$

$$Q_{ADD} \approx 150 \cdot V_{ROB}$$

Assum $V_{ROB} \approx V_{LOB}$:

Then $Q_{ROB\text{-}ADD} = 150 \cdot Q_{LOB}/A_{LOB}$

$= 150 \cdot 305/272$

$= 150 \cdot 1.12$

$= 168$ cfs

V = 1.1 seems too low, so
If V_{ROB} assumed ≈ 2-3 ft/s

the $Q_{ROBADD} = 300 - 450$

∴ Q_R @ Site 3000 could be

800 cfs + 300-450 = 1100 - 1250 cfs

examination of aerials suggests

$Q_{ROBADD} < Q_{LL}$

So, I would judge $Q_{ROBADD} \approx 200$ cfs

∴ $Q_R = 800 + 200 = 1000$

$Q_{T3000} = 1000 + 1500 = 2500$ cfs

Tiger Wash
May 24, 1999
Site 3000/AV2

Split Flow @ XS2 (AV2)

$Slope_{RIGHT} = (99.75 - 98.24)/277 = 0.0054$
$Slope_{LEFT} = (99.38 - 98.7)/174 = 0.0039$
} Bed Slopes

Also, Slope of WS in reach U/S of XS2 = 0.01 from plot of HWM's.

Assume WSE ≈ described by:
@ Sta 0 = 102.8 to Sta 130
Sta 130 to Sta 585 = 103.6

∴ $Area_{LEFT} \cong 472\ ft^2$

$Area_{RIGHT} \cong 192\ ft^2$

Further, assume WP ≈ Tw:

$Tw_{RIGHT} = 105$

$Tw_{LEFT} = 480$

Slopes from FCD 1995 survey

$X_1 - X_5 = 3.6/679 = 0.0053$
$X_4 - X_5 = 0.7/177 = 0.00395$

essentially the same as S_R & S_L above!

Then $R_{RIGHT} = \frac{192}{105} = 1.83$, $R_{LEFT} = \frac{472}{480} = 0.98$

∴ $K_{RIGHT} = \frac{1.49}{n} R_R^{2/3} \cdot A_R = \frac{1.49}{n}(1.83)^{2/3} \cdot 192 = \frac{429.}{n}$

$K_{LEFT} = \frac{1.49}{n}(0.98)^{2/3}(472) = \frac{695}{n}$

So, $K_R S_R^{1/2} = \frac{429}{n} \cdot (0.0054)^{1/2} = \frac{31.5}{n}$

$K_L S_L^{1/2} = \frac{695}{n} \cdot (0.0039)^{1/2} = \frac{43.4}{n}$

And, $\frac{K_L \cdot S_L^{1/2}}{K_R \cdot S_R^{1/2}} = \frac{43.4}{n_L} \cdot \frac{n_R}{31.5}$

If $n_L \propto n_R$, then $Q_L \approx 1.4\, Q_R$

If we subdivide the left flowsection for n changes

$$K_{L_L} = \frac{1.49}{0.075} \cdot \left(\frac{272}{415}\right)^{2/3} \cdot 272 = 4071$$

$$K_{L_R} = \frac{1.49}{0.04} \left(\frac{200}{65}\right)^{2/3} \cdot 200 = 15820$$

$$K_R = \frac{1.49}{0.04} \left(\frac{192}{105}\right)^{2/3} \cdot 192 = 10716$$

And $K_{L_L} \cdot S_L^{1/2} = 4071 \cdot (0.0039)^{1/2} = 254$ cfs

$K_{L_R} \cdot S_L^{1/2} = 15820 \cdot (0.0039)^{1/2} = 988$ cfs

$K_R \cdot S_R^{1/2} = 10716 \cdot (0.0054)^{1/2} = 787$ cfs

---

or $Q_L = 1240$ cfs ; $Q_R = 790$ cfs

$Q_T = 2030$ cfs

Now, the above computations used bed slope. Survey data also shot some HWM's, Those show:

WS_{SLOPE} above AV2 = 0.01
WS_{SLOPE} below AV2 (on Left) = 0.0056

If we use W_{SLOPE} on left

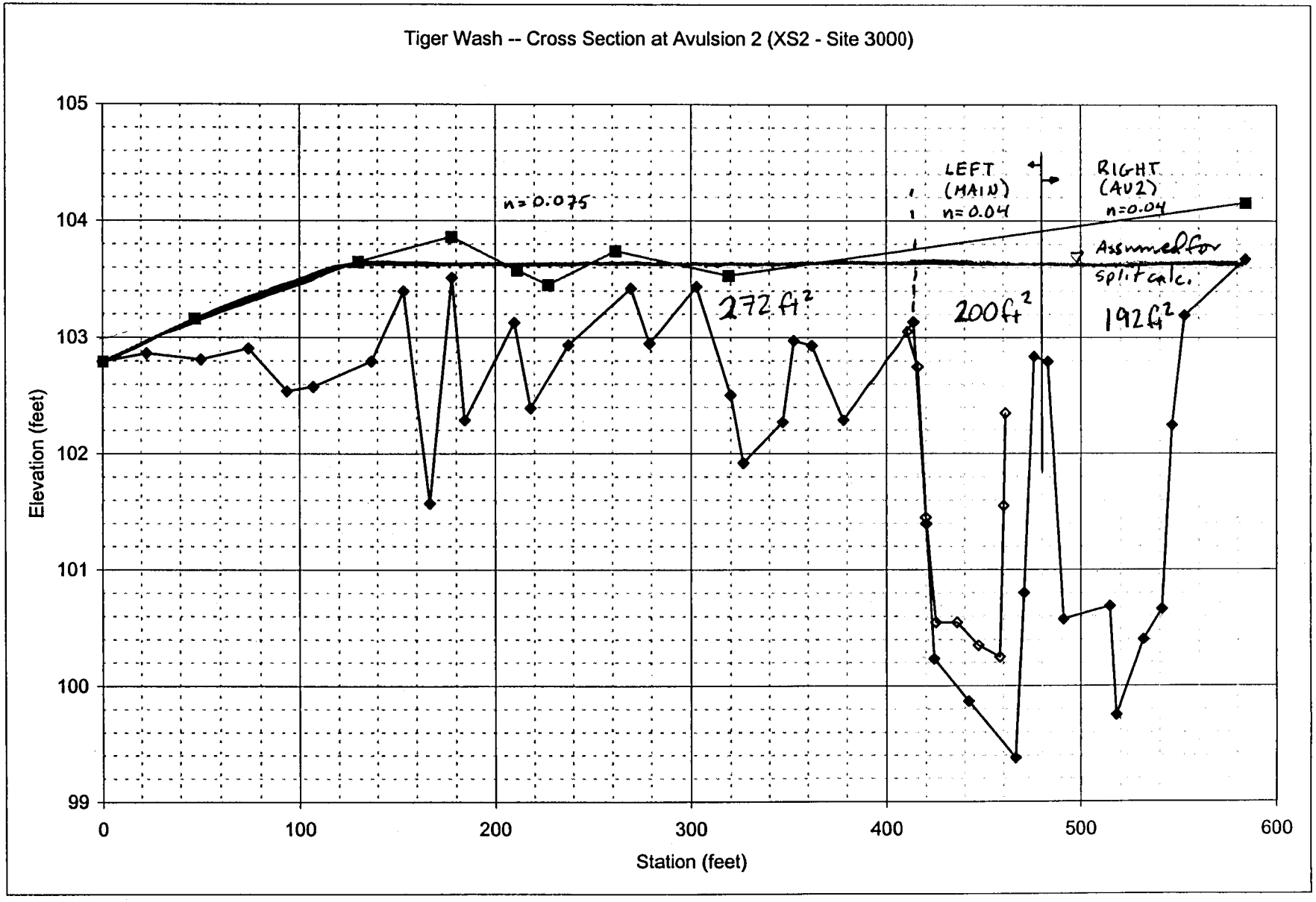
$$Q_{L_L} = 4071 \cdot (0.0056)^{1/2} = 305 \text{ cfs}$$
$$Q_{L_R} = 15820 \cdot (0.0056)^{1/2} = 1185 \text{ cfs}$$
$$\Big\} Q_L = 1{,}490 \text{ cfs}$$

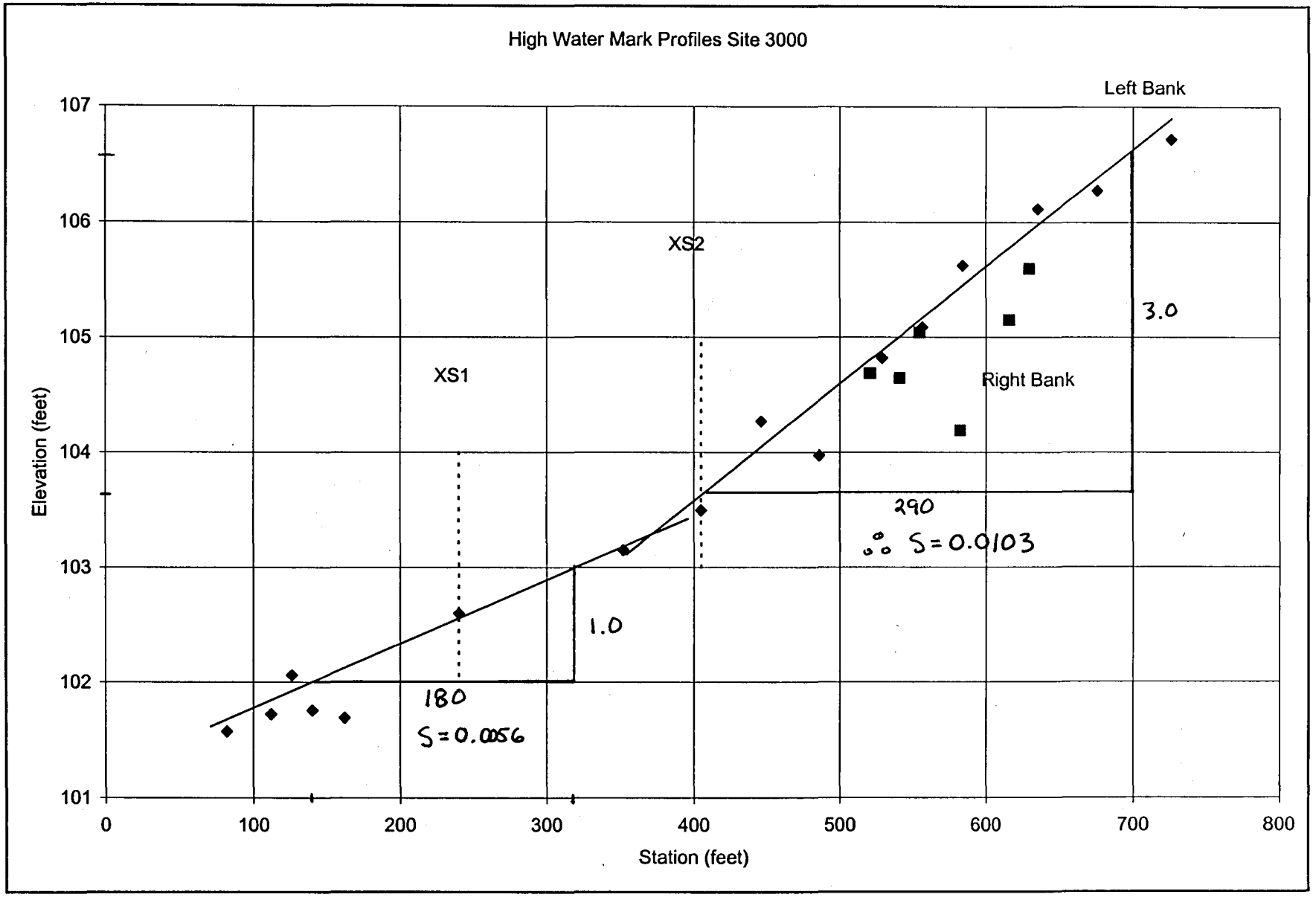
and Q_T then = 1490 + 790 = 2,275 cfs

If Q_R to AV2 more weir control, then

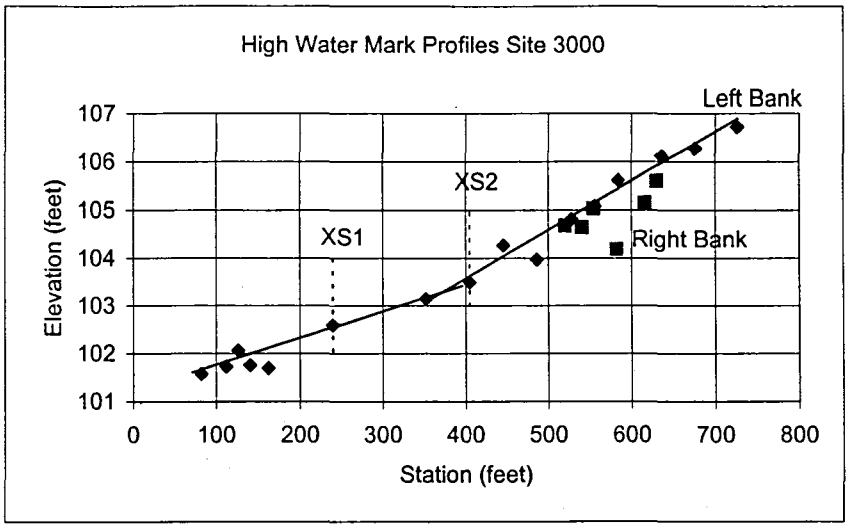
$$Q_R \cong C \cdot 120 \cdot (3.0)^{3/2} \cong C \cdot 625 \cong [1500 \text{ cfs}]$$

and $Q_T \cong 3000$ cfs


Tiger Wash -- Cross Section at Avulsion 2 (XS2 - Site 3000)
Elevation (feet)
105
104
103
102
101
100
99
0
100
200
300
400
500
600
Station (feet)
n=0.075
LEFT
(MAIN)
n=0.04
RIGHT
(AU2)
n=0.04
Assumed for
split calc.
272 ft²
200ft²
192ft²


High Water Mark Profiles Site 3000
Left Bank
Right Bank
XS1
XS2
3.0
290
S = 0.0103
1.0
180
S = 0.0056
Elevation (feet)
Station (feet)
107
106
105
104
103
102
101
0
100
200
300
400
500
600
700
800

Distance (ft)	Elevation (ft)	Point No.	Comments
726	106.722	3110	HWMLB
676	106.278	3109	HWMLB
636	106.117	3108	HWMLB
584	105.624	3107	HWMLB
556	105.086	3106	HWMLB
528	104.818	3105	HWMLB
486	103.973	3104	HWMLB
446	104.27	3104a	HWMLB
405	103.5	XS2	approx
352	103.152	3103	HWMLB
240	102.6	XS1	approx
162	101.692	3097	HWMLB
140	101.757	3098	HWMLB
126	102.059	3099	HWMLB
112	101.724	3100	HWMLB
82	101.575	3101	HWMLB
630	105.601	3029	HWMRB
616	105.153	3030	HWMRB
582	104.192	3031	HWMRB
554	105.042	3028	HWMRB
540	104.648	3032	HWMRB
520	104.688	3033	

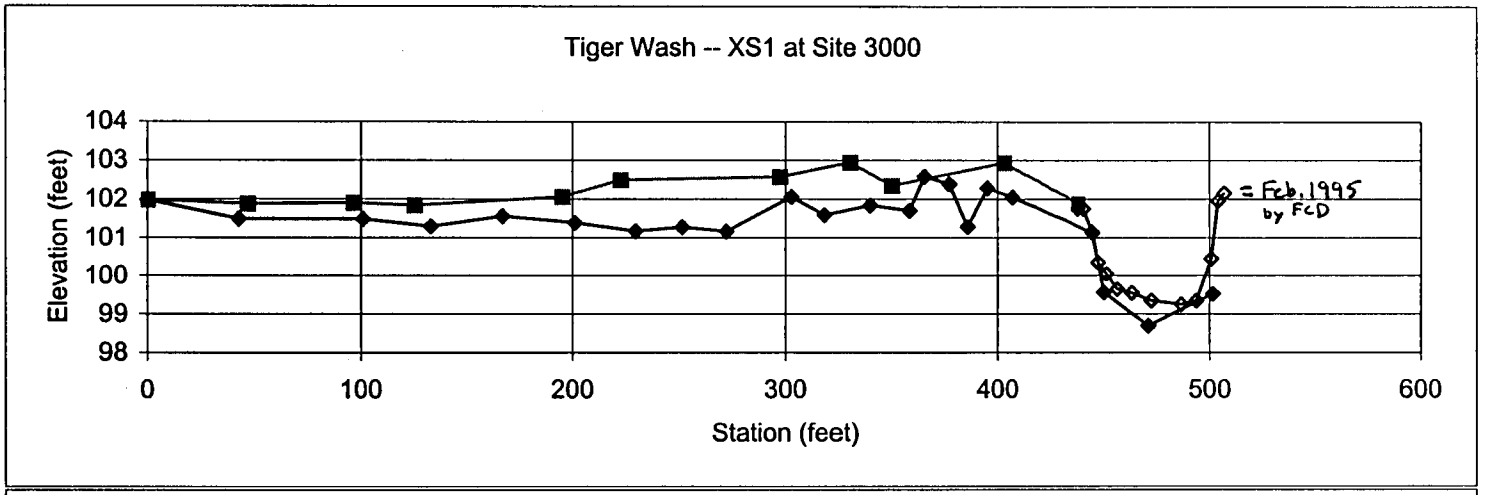


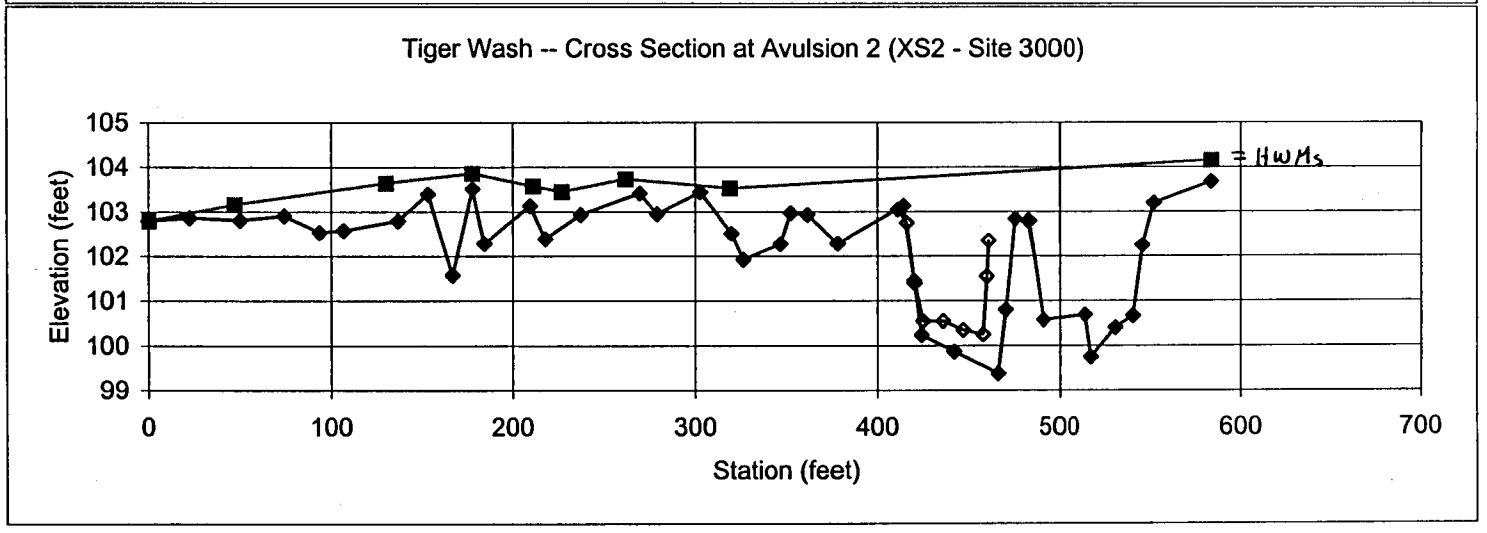
277	98.244	3020	Pt D/S on AV2 channel
Slope AV2 channel =	0.0054		
174			(XS2-XS1)
Slope 'main' channel =	0.0039		

405	103	XS2	approx
405	105		
240	104	XS1	approx
240	102		

Slope WS upper reach =	0.0103
Slope WS lower reach =	0.0056

Tiger Wash
Cross sections at Avulsion 2 (Site 3000)
Survey of April 10-11, 1999





Tiger Wash
Cross section across Avulsion 2
Survey of April 10-11, 1999

Station Setup	1002		Station Setup	1003				
I =	5.24		HI =	5.01				
Elevation =	100		Elevation =	103.518 (adjusted due to pointed target end)				
Northing =	0		Northing =	-87.637				
Easting =	0		Easting =	182.281				
station#	hor. Ang	ver. Ang	length	Target Height	elevation	easting	northing	Comments
name	(degrees)	(degrees)	(feet)	(feet)	(feet)	(feet)	(feet)	
3000	115.677	88.403	202.333	7.06	103.819	182.282	-87.636	Hub 2 --ground @ stake
3001	115.655	88.305	202.448	7.06	104.068	182.410	-87.612	Hub 2 --top of stake
3002	168.201	88.335	129.701	7.06	101.949	26.510	-126.907	XS2LB -- Top of stake (old FCD X4, elev. = 15.9')
3003	168.178	88.577	129.465	7.06	101.395	26.516	-126.680	XS2LB -- ground @ stake
3004	165.468	87.833	130.951	7.06	103.132	32.835	-126.671	
3005	169.987	89.089	129.131	7.06	100.233	22.449	-127.148	Toe LB
3006	177.917	89.24	127.234	7.06	99.868	4.624	-127.139	
3007	188.576	89.477	131.102	7.06	99.377	-19.549	-129.631	Toe RB
3008	189.963	88.895	135.974	7.06	100.802	-23.521	-133.899	
3009	191.764	88.097	140.21	7.06	102.836	-28.570	-137.189	
3010	193.998	88.197	146.644	7.06	102.794	-35.454	-142.219	begin XS for overflow channel (AV1), Top LB
3011	198.842	89.025	140.869	7.06	100.577	-45.488	-133.301	Toe LB
3012	208.249	88.915	132.467	7.06	100.688	-62.686	-116.669	
3013	209.658	89.316	131.463	7.06	99.749	-65.046	-114.232	
3014	215.542	89.017	129.557	7.06	100.403	-75.300	-105.404	
3015	219.884	88.89	128.228	7.06	100.664	-82.209	-98.377	Toe RB
3016	222.119	88.176	127.677	7.06	102.244	-85.586	-94.657	
3017	224.87	87.749	127.595	7.06	103.192	-89.949	-90.358	
3018	237.989	87.527	136.913	7.06	104.088	-115.987	-72.508	XS2RB -- Top of stake
3019	237.987	87.699	136.834	7.06	103.674	-115.932	-72.479	XS2RB -- Ground @ stake
3020	218.71	89.991	406.562	7.06	98.244	-254.255	-317.249	Point D/S in AV1 for slope estimate
3021	172.193	89.372	306.949	7.06	101.544	41.692	-304.086	XS1LB -- Top of Stake (old FCD X5, elev = 15.46)
3022	172.212	89.451	306.926	7.06	101.121	41.589	-304.081	XS1LB -- Ground @ stake
3023	170.907	88.765	307.749	10	101.873	48.625	-303.811	HWMLB -- DLF
3024	173.167	89.741	306.063	7.06	99.564	36.414	-303.886	Toe LB
3025	177.058	89.902	303.002	7.06	98.698	15.552	-302.602	
3026	182.761	89.18	299.751	10	99.530	-14.437	-299.372	Toe RB
3027	237.312	87.493	136.67	7.06	104.158	-114.915	-73.740	HWMRB -- DLVP
3028	270.449	84.983	78.461	7.06	105.042	-78.158	0.612	HWMRB -- DLF
3029	348.748	84.508	77.543	7.06	105.601	-15.061	75.703	HWMRB -- DLF
3030	36.51	84.797	76.896	7.06	105.153	45.562	61.551	HWMLB -- DLF
3031	60.289	84.23	59.797	7.06	104.192	51.673	29.487	HWMLB -- DLF
3032	107.758	82.209	47.71	7.06	104.648	45.017	-14.417	HWMLB -- DLF
3033	131.981	82.831	52.146	7.06	104.688	38.461	-34.607	HWMLB -- DLF
Begin Station 1003								
3034	295.585	90.351	202.261	7.06	100.229	-0.144	-0.292	Hub 1 -- Top of Stake
3035	250.072	89.611	120.902	7.06	102.289	68.621	-128.844	(continue XS2)
3036	245.112	89.223	107.743	7.06	102.929	84.553	-132.976	
3037a				7.06	104.155	92.731	-126.532	HWM -- TODF
3037	241.986	89.141	100.371	7.06	102.973	93.680	-134.775	
3038	239.781	89.52	95.764	7.06	102.270	99.533	-135.834	
3039	232.856	89.67	78.442	7.06	101.920	119.754	-135.001	
3040	230.372	89.18	72.536	7.06	102.506	126.419	-133.896	
3041	229.814	88.354	71.736	7.06	103.529	127.501	-133.907	HWM -- TODF
3042	221.089	88.082	58.786	7.06	103.436	143.667	-131.919	
3043	197.58	88.282	49.347	7.06	102.947	167.383	-134.658	
3044	186.441	87.762	49.977	7.06	103.420	176.679	-137.261	
3045	177.777	87.558	53.314	7.06	103.740	184.347	-140.862	HWM -- TODF
3046a				7.06	102.934	208.685	-140.825	
3046	147.395	88.326	67.92	7.06	103.452	218.864	-144.829	HWM -- TODF
3047	140.69	89.264	72.07	7.06	102.394	227.935	-143.395	
3048	136.809	88.794	78.812	7.06	103.127	236.211	-145.084	
3049	140.5	88.527	81.972	7.06	103.575	234.404	-150.868	HWM -- TODF
3050	127.713	89.529	99.721	7.06	102.288	261.166	-148.635	
3051	125.245	88.886	105.108	7.06	103.511	268.106	-148.281	
3052	124.567	88.687	104.449	7.06	103.861	268.268	-146.883	HWM -- TODF
3053	122.31	89.948	114.469	7.06	101.572	279.027	-148.821	
3054	119.469	89.128	126.601	7.06	103.395	292.490	-149.911	
3055	118.199	89.468	143.087	7.06	102.797	308.380	-155.248	

Tiger Wash
Cross section across Avulsion 2
Survey of April 10-11, 1999

station#	hor. Ang	ver. Ang	length	Target Height	elevation	easting	northing	Comments
name	(degrees)	(degrees)	(feet)	(feet)	(feet)	(feet)	(feet)	
3056	116.171	89.158	148.346	7.06	103.648	315.404	-153.058	HWM -- DLF
3057	111.982	89.623	168.668	7.06	102.578	338.684	-150.771	
3058	109.815	89.66	180.738	7.06	102.541	352.315	-148.903	
3059	108.402	89.587	199.511	7.06	102.906	371.585	-150.617	
3060	106.184	89.484	200.984	7.06	103.278	375.292	-143.654	HWM -- DLF
3061	103.393	89.407	207.884	7.06	103.620	384.501	-135.786	HWM -- DLF
3062	106.675	89.654	222.658	7.06	102.813	395.572	-151.526	
3063	106.863	89.571	226.171	7.06	103.161	398.721	-153.244	HWM -- DLF
3064	105.561	89.68	250.023	7.06	102.864	423.136	-154.708	
3065	104.48	89.714	271.654	7.06	102.824	445.303	-155.561	
3066	104.525	89.65	271.864	7.06	103.129	445.451	-155.820	HWM -- DLF
3067	99.767	89.755	310.039	7.06	102.794	487.823	-140.232	HWM -- SLF, approximate limit of flow XS2 LB
3068	205.003	89.864	242.369	7.06	102.043	79.840	-307.292	continue XS1 ground points
3069	203.767	89.657	244.262	7.06	102.930	83.841	-311.180	HWM -- TODF
3070	202.258	89.804	238.369	7.06	102.283	91.993	-308.243	
3071	200.279	90.047	234.104	7.06	101.276	101.142	-307.230	
3072	198.214	89.774	231.709	7.06	102.382	109.857	-307.735	
3073	198.575	89.616	223.281	7.06	102.964	111.157	-299.282	HWM -- TODF
3074	195.405	89.722	228.655	7.06	102.577	121.542	-308.074	
3075	193.699	89.942	227.146	7.06	101.698	128.488	-308.321	
3076	191.406	89.78	229.072	7.06	102.348	136.980	-312.183	HWM -- TODF
3077	189.019	89.906	225.417	7.06	101.838	146.944	-310.267	
3078	186.721	89.619	221.243	7.06	102.939	156.388	-307.355	HWM -- TODF
3079	186.664	89.619	221.335	7.06	102.940	156.596	-307.472	HWM -- TODF
3080	183.675	89.97	220.24	7.06	101.583	168.164	-307.424	
3081	179.477	89.846	218.586	7.06	102.056	184.276	-306.213	
3082	178.18	89.715	221.959	7.06	102.572	189.330	-309.481	HWM -- TODF
3083	172.127	90.076	231.371	7.06	101.161	213.974	-316.827	
3084	167.247	90.048	237.644	7.06	101.269	234.741	-319.418	
3085	162.692	90.069	248.284	7.06	101.169	256.147	-324.678	
3086	160.218	89.759	243.061	7.06	102.490	264.542	-316.352	HWM -- DLF
3087	157.887	90.018	266.572	7.06	101.384	282.628	-334.601	HWM -- DLF
3088	157.045	89.876	272.054	7.06	102.057	288.384	-338.147	
3089	152.677	89.983	290.577	7.06	101.554	315.658	-345.795	
3090	147.104	90.033	308.678	7.06	101.290	349.929	-346.821	HWM -- DLF
3091	146.457	89.933	315.584	7.06	101.837	356.661	-350.667	
3092	142.309	89.998	328.005	7.06	101.479	382.824	-347.194	HWM -- DLF
3093	142.252	89.926	333.33	7.06	101.899	386.342	-351.204	
3094	136.057	89.997	371.627	7.06	101.487	440.169	-355.220	
3095	137.871	89.937	374.77	7.06	101.880	433.677	-365.580	HWM -- DLF
3096	132.704	89.929	408.242	7.06	101.974	482.284	-364.511	HWM -- SLF, approximate limit of flow XS1 LB
3097	145.7	89.965	367.441	7.06	101.692	389.344	-391.179	HWM -- DLF
3098	152.718	89.955	367.986	7.06	101.757	350.955	-414.689	HWM -- DLF
3099	158.71	89.907	364.019	7.06	102.059	314.452	-426.813	HWM -- DLF
3100	170.142	89.959	357.772	7.06	101.724	243.534	-440.126	HWM -- DLF
3101	176.877	89.984	382.966	7.06	101.575	203.145	-470.034	HWM -- DLF
3102	188.934	89.935	379.154	7.06	101.898	123.400	-462.191	HWM -- DLF
3103	173.661	89.154	114.062	7.06	103.152	194.873	-200.989	HWM -- DLF
3104a					104.270	255.713	-107.281	HWM -- DLF
3104	79.654	88.688	109.4	7.06	103.973	289.874	-67.995	HWM -- DLF
3105	66.172	88.754	154.068	7.06	104.818	323.183	-25.409	HWM -- DLF
3106	59.416	88.843	179.19	7.06	105.086	336.511	3.516	HWM -- DLF
3107	47.429	88.636	174.603	7.06	105.624	310.829	30.449	HWM -- DLP
3108	39.692	88.797	221.45	7.06	106.117	323.681	82.729	HWM -- DLF
3109	38.016	88.965	266.273	7.06	106.278	346.247	122.109	HWM -- DLF
3110	32.237	89.02	307.208	7.06	106.722	346.129	172.177	HWM -- DLF
3111	53.783	89.253	437.582	7.06	107.173	535.286	170.884	RM1 -- Ground @ stake at standpipe
3112	53.804	89.344	437.441	7.06	106.476	535.273	170.677	RM1 -- Top of stake at weather station standpipe

4-10-99 Tiger Wash
AV2, XS2 view U/S
on breakout channel

4-10-99 Tiger Wash
AV2, XS2 view U/S on "main" chan
note overflow of AV2 on RB

4-10-99 Tiger Wash
AV2, XS2 view D/S
on breakout channel

4-10-99 Tiger Wash
AV2, XS2 view D/S on original channel
@ old FCO stake XS

4-10-99 Tiger Wash
AV2, XS 1 view U/S
on main channel

4-10-99 Tiger Wash
AV2, XS1 view D/S
on main channel

4-11-99 Tiger Wash
AV2, XS 1 view D/S in LOB

4-11-99 Tiger Wash
AV2, XS 1 view U/S in LOB
just left of main channel

4-11-99 Tiger Wash
AV2, XS 1 view D/S in LOB
line of taller veg - in right
of photo is LB of main
channel

4-11-99 Tiger Wash
AV2, XS 2 LOB
view D/S

Survey Site: Tiger Wash, Site 3000
at FCD ALERT Gage #5140

Date:
Sept. 10, 1999

Sta/Dist	BS	HI	Top	Bottom	Forward	Elevation	Comments
RM1	3.76	110.93				107.17	top of wood stake at base of standpipe
3A					3.65	107.28	top of capped 1/2" rebar stamped 3A
							Note 3A located at base of standpipe also

Party: TWL, inst, notes
MH, rod

Weather: Hot and humid

Site 3000

Subdivision

OK as is ⇒ Left OB $L = 400/15 > 5$

$d_b \approx 1.5'$, $D_{MAX} = 4'$ ∴ $D_{MAX} > 2 \cdot (1.5)$

Also, S_R & S_L different, so subdivision of Main & AV2 channels was required.

Site 4000

XS1 LOB, $L = 20'$, $d_b = 1.2'$; $20'/1.2' > 5$

$D_{MAX} = 3.5'$; $D_{MAX} > 2 \cdot (1.2)$

∴ subdivide

ROB $L = 37'$, $d_b = 0.5'$; $37'/0.5' > 5$

$D_{MAX} = 3.5'$; $D_{MAX} > 2 \cdot (0.5)$

∴ subdivide

XS2

LOB $L = 21'$, $d_B = 1.4'$; $21'/1.4' > 5$

$D_{MAX} = 4.6'$; $D_{MAX} > 2(1.4)$

∴ subdivide

ROB $L = 25'$, $d_b = 1.3'$; $25'/1.3' > 5$

$D_{MAX} = 4.6'$; $D_{MAX} > 2(1.3)$

∴ subdivide

For channel

$n_b = 0.025$, Table 1 coarse sand, fine gravel

$n_1 = 0.0$, Table 2, smooth

$n_2 = 0.0$ Table 2, obstructions

$n_3 = 0.005$, Table 2, some bank vegetation none in channel

$n_T = 0.030$

June 7, 1999
Revised November 3, 1999

Site 4000

Summary of Slope-area survey and estimate of peak discharge for west branch of Tiger Wash between avulsions 1 and 2 for the event of September 26, 1997. The site is located in the N1/2 SW1/4 Sec. 20, T4N, R10W.

A slope-area survey was performed on April 11, 1999 by T.W. Lehman and a field crew of JE Fuller / Hydrology & Geomorphology, Inc. The reach surveyed was located about ½ mile north of the FCDMC ALERT weather station. High water marks were surveyed along both channel banks for a distance of about 450 feet. Two cross sections were selected about 260 feet distant from one another. The total fall through the reach was about 2 feet with a fall of 1.1 feet between the two cross sections. The channel at the surveyed cross sections was about 75 feet wide.

The surveyed cross sections and high water marks were plotted using AutoCAD and Excel. A water surface slope of 0.0042 was estimated from the plot of high water marks. Manning's n-values of 0.08 and 0.030 were used for the overbanks and channel, respectively.

The initial estimate considered no additional cross sectional area below the observed channel bed surveyed in the field. The estimate of peak discharge was 2,440 cfs.

Pits dug in the channel indicated that perhaps an additional foot to two feet of depth of flow may have occurred during the flood. Although the timing of this scour (and subsequent fill) relative to the discharge that left the high water marks is unknown, the additional cross sectional area was modeled to provide an upper limit for the peak discharge for the September 1997 flood. The result of this model gave a peak discharge of 3,820 cfs.

Given the age of the high water marks and the uncertainty of additional cross sectional area due to scour, a peak discharge of **3,800 cfs** was estimated. This estimate is considered poor.

Ted Lehman
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.

```
Echo input data file
Tiger Wash West Branch, Site 4000
XS   SEC1 145
GR        0,102.6,15,102.9,17,102.1,35,101.7,42,99.2,87,99.2
GR        120,98.9,124,100.4,131,101.9,164,102.3,168,102.5
N         0.08,0.03,0.08
SA        35,131
HP   SEC1 102.9
XS   SEC2 408
GR        -13,104.1,0,102.2,8,101.4,13,99.5,47,100.6,75,101.2
GR        82,102.8,105,104.0,107,104.1
N         0.08,0.03,0.08
SA        8,82
HP   SEC2 104
```

Tiger Wash West Branch, Site 4000
Tiger Wash West Branch between two avulsions (Site 4000)
Flood of Sept. 26, 1997 (Nora)
Survey of 4-11-99

DISCHARGE COMPUTATIONS

	dH,fall (ft)	Reach length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
SEC2 - SEC1	1.10	263.	2438.	29	1.374	.866	.000	-.399	@

Definitions:
Spread, the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss
HF, friction head- HF = sum of Q*Q*L/(K1*K2) over subreaches; Q, discharge; L, reach length; K1, upstream section conveyance; K2, downstream section conveyance
CX, the computed discharge divided by the discharge computed with no expansion loss (k=0)
RC, velocity head change in contracting section divided by friction head
RX, velocity head change in expanding section divided by friction head
ER, warnings, *-fall < 0.5ft, @-conveyance ratio exceeded, #-reach too short

CROSS SECTION PROPERTIES

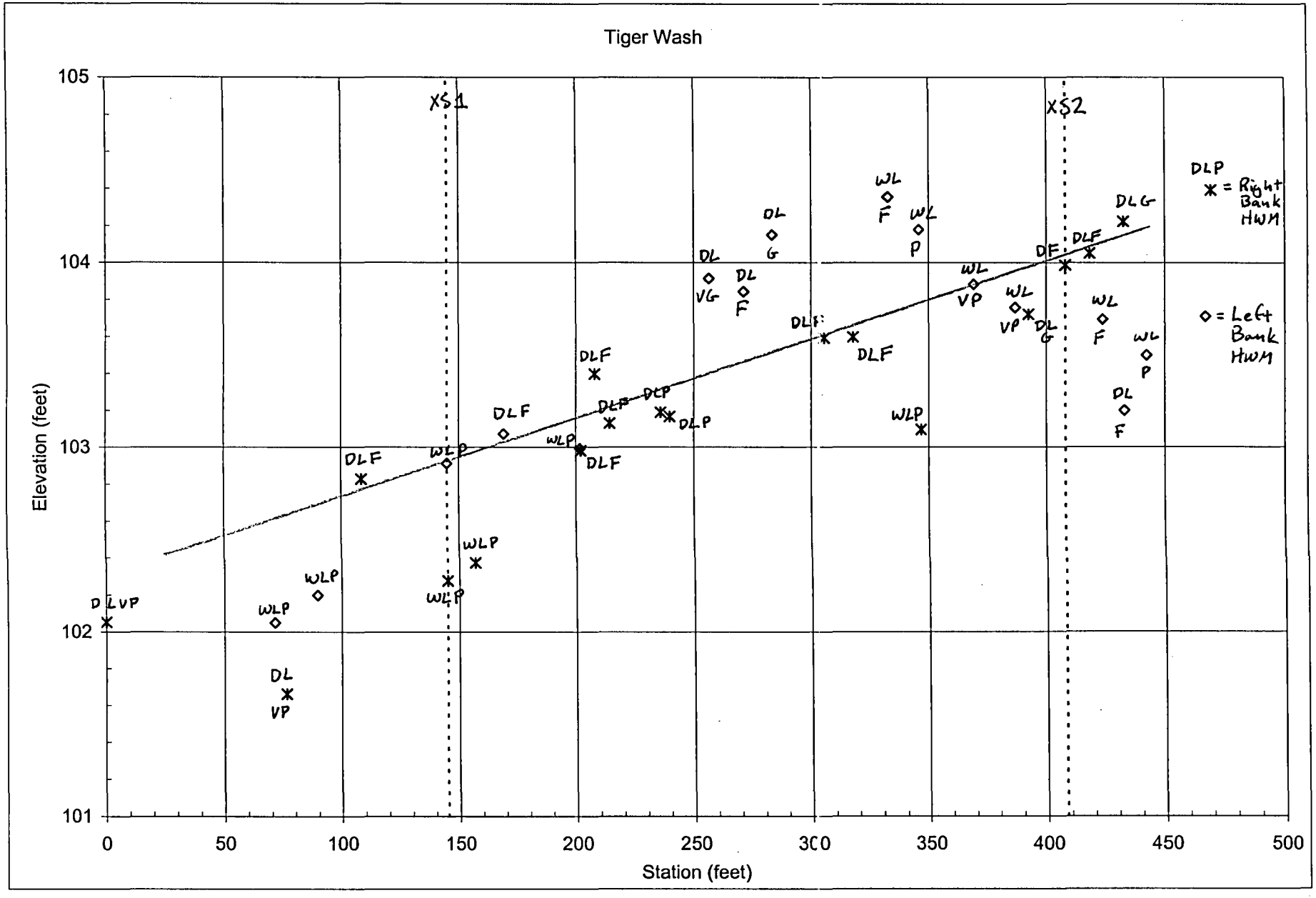
I.D. SEC1 Velocity head .77ft Discharge 2438.cfs
Ref.distance 145.ft Q/K .0039 Alpha 1.245

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	102.90	.080	21.1	35.0	35.5	.59	.277	1.	.8	1.44
2	102.90	.030	336.0	96.0	96.9	3.47	38.231	98.	7.1	.60
3	102.90	.080	28.4	37.0	37.4	.76	.440	1.	1.0	1.27
Total	102.90	---	385.	168.	170.	2.27	38.948	100.	6.3	.74

I.D. SEC2 Velocity head 1.32ft Discharge 2438.cfs
Ref.distance 408.ft Q/K .0070 Alpha 1.250

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	104.00	.080	28.7	20.3	20.5	1.40	.669	2.	1.9	1.22
2	104.00	.030	252.9	74.0	74.6	3.39	28.348	97.	9.4	.79
3	104.00	.080	13.8	23.0	23.0	.60	.183	1.	1.1	1.88
Total	104.00	---	295.	117.	118.	2.50	29.199	100.	8.3	.92

Definitions:
n, Manning's coefficient of roughness Q/K = discharge/conveyance
F, Froude number- F = Q/(A sqrt(g*(A1/TW1)); Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

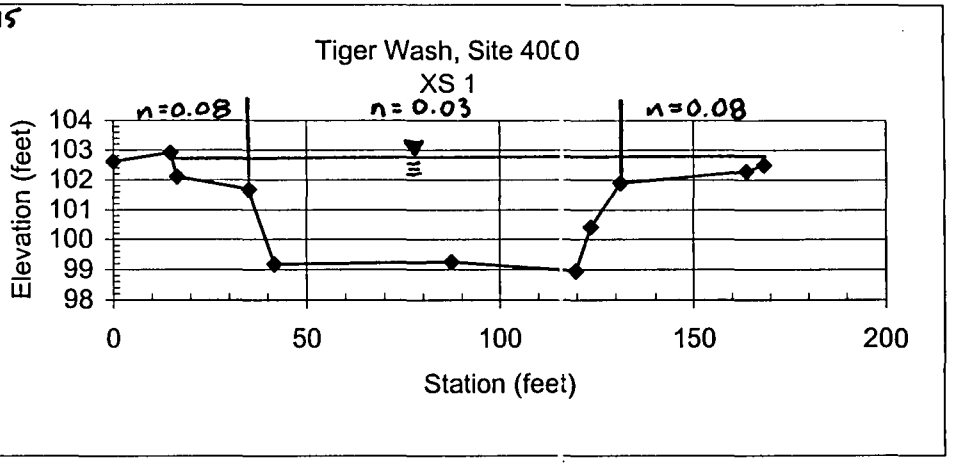


Site 4000
5/19/99

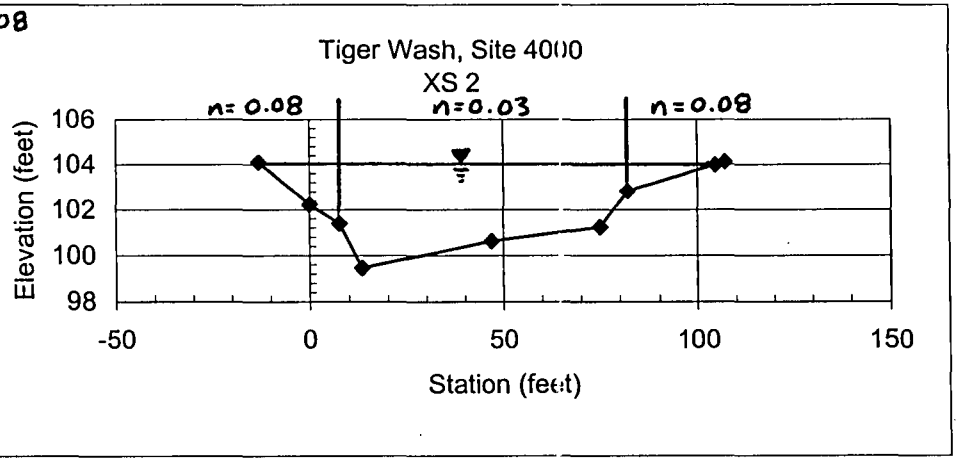
JEF, Inc.

Tiger Wash
Slope-Area Survey of Site 4000 (between AV1 and AV2)
Survey of April 11, 1999

XS1 -- Channel Sta	= 145
Station	Elevation
(feet)	(feet)
0	102.6
15	102.9
17	102.1
35	101.7
42	99.2
87	99.2
120	98.9
124	100.4
131	101.9
164	102.3
168	102.5



XS2 -- Channel Sta	= 408
Station	Elevation
(feet)	(feet)
-13	104.1
0	102.2
8	101.4
13	99.5
47	100.6
75	101.2
82	102.8
105	104.0
107	104.1



Tiger Wash West Branch, Site 4000
Tiger Wash West Branch between two avulsions (Site 4000)
Flood of Sept. 26, 1997 (Nora)
Survey of 4-11-99 Addtional XS area due to scour considered

DISCHARGE COMPUTATIONS

	dH,fall (ft)	Reach length (ft)	Discharge (cfs)	Spread (%)	HF (ft)	CX	RC	RX	ER
SEC2 - SEC1	1.10	263.	3820.	20	1.300	.905	.000	-.308	

Definitions:
Spread, the percent difference between discharge computed with no expansion loss (k=0) and discharge computed with full expansion loss (k=1.0), divided by the discharge computed with full expansion loss
HF, friction head- HF = sum of Q*Q*L/(K1*K2) over subreaches; Q, discharge; L, reach length; K1, upstream section conveyance; K2, downstream section conveyance
CX, the computed discharge divided by the discharge computed with no expansion loss (k=0)
RC, velocity head change in contracting section divided by friction head
RX, velocity head change in expanding section divided by friction head
ER, warnings, *-fall < 0.5ft, @-conveyance ratio exceeded, #-reach too short

CROSS SECTION PROPERTIES

I.D. SEC1 Velocity head 1.23ft Discharge 3820.cfs
Ref.distance 145.ft Q/K .0046 Alpha 1.202

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	102.90	.080	21.1	35.0	35.5	.59	.277	0.	.9	1.85
2	102.90	.030	420.9	96.0	97.2	4.33	55.537	99.	9.0	.68
3	102.90	.080	28.4	37.0	37.4	.76	.440	1.	1.1	1.63
Total	102.90	---	470.	168.	170.	2.77	56.254	100.	8.1	.86

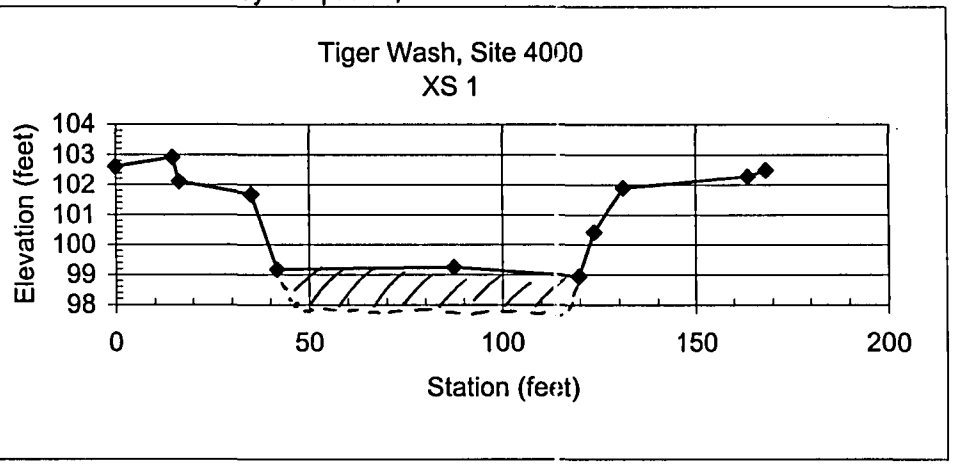
I.D. SEC2 Velocity head 1.63ft Discharge 3820.cfs
Ref.distance 408.ft Q/K .0053 Alpha 1.188

Sub area no.	Water surface el.(ft)	n	Area (sq.ft)	Top width (ft)	Wetted perimeter (ft)	Hydraulic radius (ft)	Conveyance x 0.001 (cfs)	%	Vel. (fps)	F
1	104.00	.080	28.7	20.3	20.5	1.40	.669	1.	1.7	1.39
2	104.00	.030	363.8	74.0	75.3	4.83	51.639	98.	10.3	.75
3	104.00	.080	13.8	23.0	23.0	.60	.183	0.	1.0	2.14
Total	104.00	---	406.	117.	119.	3.42	52.490	100.	9.4	.89

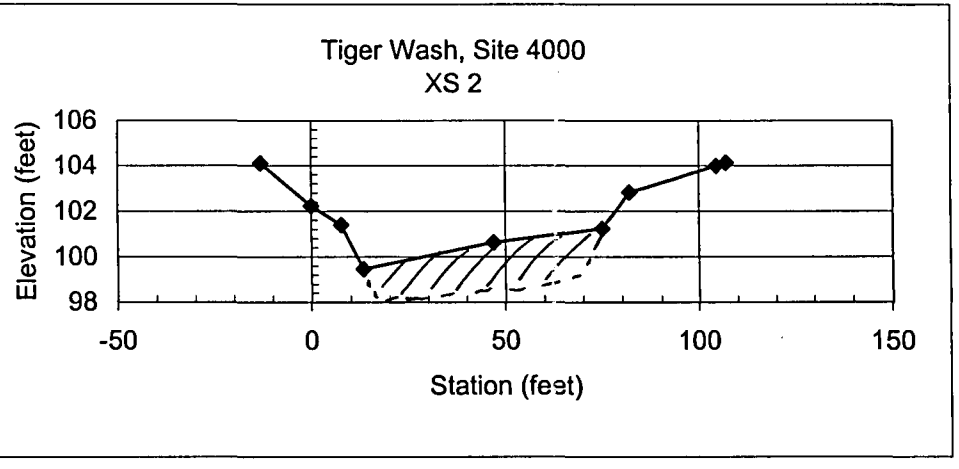
Definitions:
n, Manning's coefficient of roughness Q/K = discharge/conveyance
F, Froude number- F = Q/(A sqrt(g*(A1/TW1)); Q, discharge; A, total cross-section area; g, acceleration of gravity; A1, sub-section area; TW1, sub-section top width

Tiger Wash
Slope-Area Survey of Site 4000 (between AV1 and AV2)
Survey of April 11, 1999

XS1 -- Channel Sta	
Station	Elevation
(feet)	(feet)
0	102.6
15	102.9
17	102.1
35	101.7
42	99.2
87	99.2
120	98.9
124	100.4
131	101.9
164	102.3
168	102.5



XS2 -- Channel Sta	
Station	Elevation
(feet)	(feet)
-13	104.1
0	102.2
8	101.4
13	99.5
47	100.6
75	101.2
82	102.8
105	104.0
107	104.1



= potential additional XS Area

Tiger Wash

Slope-Area Survey of Site 4000 (between AV1 and AV2)

Survey of April 11, 1999

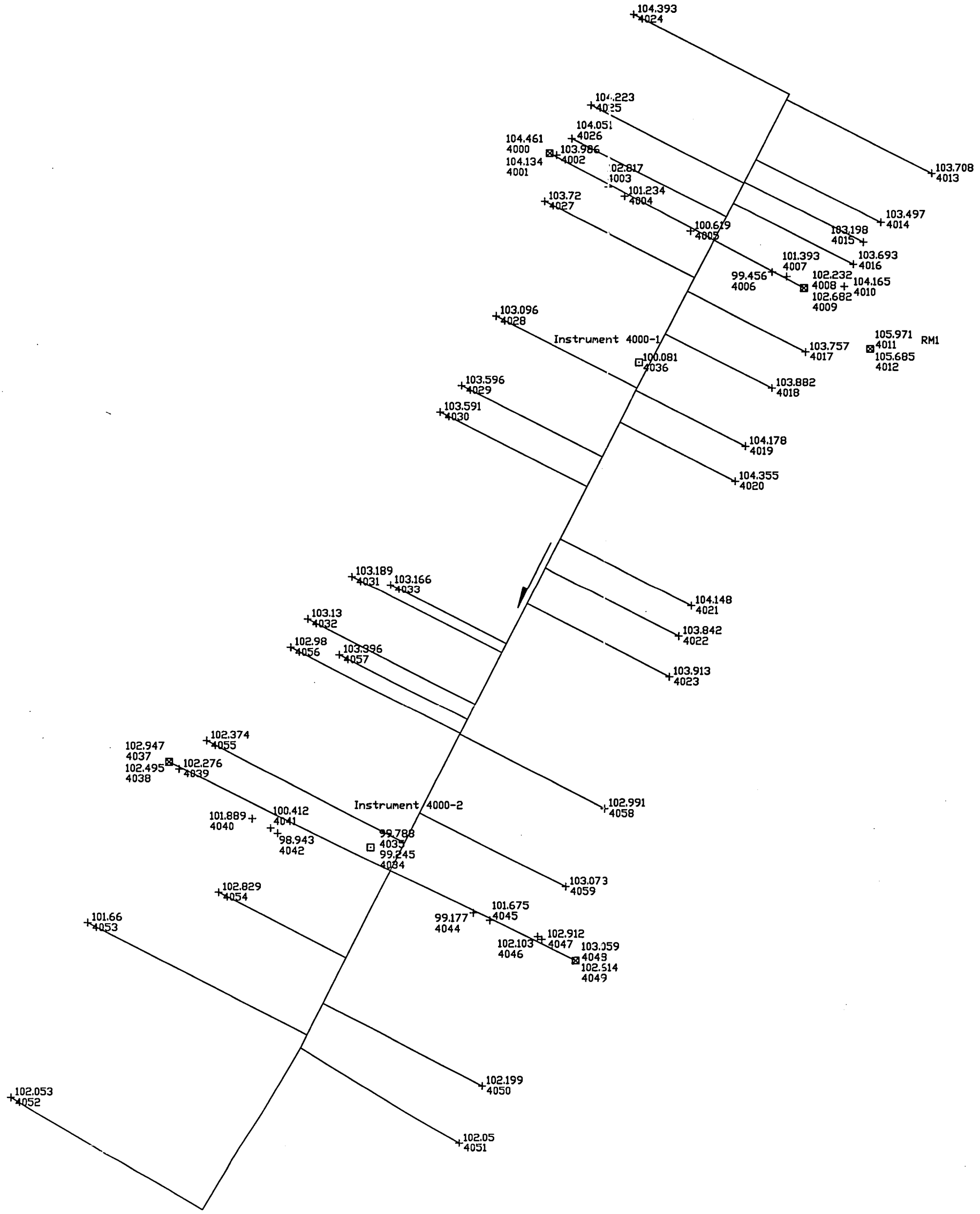
Segment Length	Channel Station	Pt No.	Bank	Elev.	Rating
71	71	4051	L	102.050	HWMLB -- WLP
13	90	4050	L	102.199	HWMLB -- WLP
0	145	4047	L	102.912	HWMLB -- WLP
12	169	4059	L	103.073	HWMLB -- DLF
33	202	4058	L	102.991	HWMLB -- WLP
17	257	4023	L	103.913	HWMLB -- DLVG
15	271	4022	L	103.842	HWMLB -- DLF
12	284	4021	L	104.148	HWMLB -- DLG
15	332	4020	L	104.355	HWMLB -- WLF
13	346	4019	L	104.178	HWMLB -- WLP
23	369	4018	L	103.882	HWMLB -- WLVP
18	387	4017	L	103.757	HWMLB -- WLVP
6	424	4016	L	103.693	HWMLB -- WLF
0	433	4015	L	103.198	HWMLB -- DLF
9	442	4014	L	103.497	HWMLB -- WLP
25	467	4013	L	103.708	HWMLB -- SLP
0	0	4052	R	102.053	HWMRB -- DLVP
5	76	4053	R	101.660	HWMRB -- DLVP
19	109	4054	R	102.829	HWMRB--DLF in tree c
0	145	4039	R	102.276	HWMRB -- WLP
12	157	4055	R	102.374	HWMRB -- WLP
0	202	4056	R	102.980	HWMRB -- DLF
6	208	4057	R	103.396	HWMRB -- DLF
6	214	4032	R	103.130	HWMRB -- DLF
22	236	4031	R	103.189	HWMRB -- DLP
4	240	4033	R	103.166	HWMRB -- DLP
22	305	4030	R	103.591	HWMRB -- DLF
12	318	4029	R	103.596	HWMRB -- DLF
1	347	4028	R	103.096	HWMRB -- WLP
6	393	4027	R	103.720	HWMRB -- DLG
0	408	4002	R	103.986	HWMRB -- DLF
10	418	4026	R	104.051	HWMRB -- DLF
9	432	4025	R	104.223	HWMRB -- DLG
2	470	4024	R	104.393	HWMRB -- DLP
36	145	XS1			
16	408	XS2			

Tiger Wash
Slope-Area Survey of Site 4000 (between AV1 and AV2)
Survey of April 11, 1999

Station Setup	1004		Station Setup	1004B				
HI =	5.17	above ground	HI =	5.18	above ground			
Elevation =	100	assumed	Elevation =	99.244				
Northing =	0		Northing =	-180.707				
Easting =	0		Easting =	-98.927				
station	hor. Ang	ver. Ang	length	Target Hgt.	elevation	easting	northing	Comments
name	(degrees)	(degrees)	(feet)	(feet)	(feet)	(feet)	(feet)	
4000	336.345	85.724	85.174	7.06	104.461	-34.079	77.800	XS2 RB top of stake
4001	336.443	85.942	85.121	7.06	104.134	-33.934	77.832	ground at stake
4002	337.798	85.966	83.527	7.06	103.986	-31.484	77.142	HWMRB -- DLF
4003	349.331	85.943	66.532	7.06	102.817	-12.287	65.218	Top of edge of bank
4004	354.222	87.12	62.182	7.06	101.234	-6.252	61.788	Toe of RB
4005	20.713	87.244	52.175	7.06	100.619	18.432	48.746	center of wash
4006	55.375	88.698	59.229	7.06	99.456	48.726	33.645	toe LB
4007	59.449	87.009	62.92	7.06	101.393	54.111	31.939	Top of LB
4008	65.371	86.46	66.765	7.06	102.232	60.575	27.771	ground at stake
4009	65.437	86.076	66.814	7.06	102.682	60.625	27.709	XS2 LB top of stake
4010	69.423	87.162	80.679	5.00	104.165	75.439	28.321	HWMLB -- WLP
4011	86.443	86.12	85.725	5.00	105.971	85.304	5.306	RM1 -- Top of Stake
4012	86.479	86.312	85.745	5.00	105.685	85.406	5.255	RM1 -- ground at stake
4013	56.606	88.425	128.714	5.00	103.708	107.423	70.817	HWMLB -- SLP
4014	59.521	88.15	103.061	5.00	103.497	88.773	52.248	HWMLB -- WLP
4015	61.403	88.151	93.832	5.00	103.198	82.342	44.889	HWMLB -- DLF
4016	65.038	87.676	86.873	5.00	103.693	78.693	36.632	HWMLB -- WLF
4017	86.199	86.675	61.837	5.00	103.757	61.597	4.092	HWMLB -- WLVP
4018	100.88	85.325	50.453	5.40	103.882	49.381	-9.491	HWMLB -- WLVP
4019	128.104	85.022	50.797	5.40	104.178	39.821	-31.228	HWMLB -- WLP
4020	140.839	83.757	57.425	7.06	104.355	36.049	-44.262	HWMLB -- WLF
4021	167.749	86.277	92.995	7.06	104.148	19.691	-90.685	HWMLB -- DLG
4022	171.549	84.884	103.533	10.56	103.842	15.155	-102.001	HWMLB -- DLF
4023	174.222	85.476	117.946	10.56	103.913	11.837	-116.981	HWMLB -- DLVG
4024	358.631	87.218	129.459	7.06	104.393	-3.089	129.270	HWMRB -- DLP
4025	348.877	86.411	97.657	7.06	104.223	-18.803	95.635	HWMRB -- DLG
4026	342.747	86.102	87.395	7.06	104.051	-25.861	83.270	HWMRB -- DLF
4027	328.982	87.166	69.783	4.90	103.720	-35.916	59.731	HWMRB -- DLG
4028	287.745	87.119	56.22	4.90	103.096	-53.478	17.113	HWMRB -- WLP
4029	262.343	87.143	66.726	4.90	103.596	-66.049	-8.880	HWMRB -- DLF
4030	255.713	87.506	76.322	4.90	103.591	-73.891	-18.817	HWMRB -- DLF
4031	233.048	89.003	133.264	4.30	103.189	-106.480	-80.099	HWMRB -- DLP
4032	231.992	89.17	155.997	4.30	103.130	-122.901	-96.048	HWMRB -- DLF
4033	227.918	88.94	124.137	4.30	103.166	-92.117	-83.182	HWMRB -- DLP
4034	208.698	90.452	206.02	4.30	99.245	-98.926	-180.707	Hub 2 ground @ stake
4035	208.675	90.301	206.056	4.30	99.788	-98.873	-180.782	Hub 2 Top of stake
Begin Station 1004B								
4036	28.712	90.012	205.791	4.30	100.081	-0.064	-0.219	Top of stake at Hub 1
4037	292.518	88.019	81.654	4.30	102.947	-174.311	-149.454	XS1RB - Top of Stake
4038	292.515	88.339	81.788	4.30	102.495	-174.449	-149.401	XS1RB - ground @ stake
4039	291.817	88.402	77.172	4.30	102.276	-170.544	-152.038	HWMRB -- WLP
4040	283.456	87.776	45.476	4.30	101.889	-143.121	-170.133	top of RB
4041	280.748	89.565	37.979	4.30	100.412	-136.239	-173.625	
4042	278.461	91.927	35.121	4.30	98.943	-133.646	-175.542	toe RB
4043a	208.754	95.98	0	4.30	100.124	-98.927	-180.707	center of wash
4043	208.762	95.98	10.509	4.30	99.029	-103.956	-189.869	also in wash
4044	122.836	91.194	45.44	4.30	99.177	-60.755	-205.341	Toe LB

Tiger Wash
Slope-Area Survey of Site 4000 (between AV1 and AV2)
Survey of April 11, 1999

station name	hor. Ang (degrees)	ver. Ang (degrees)	length (feet)	Target Hgt. (feet)	elevation (feet)	easting (feet)	northing (feet)	Comments
4045	121.661	85.267	52.244	7.06	101.675	-54.610	-208.036	Top LB
4046	118.195	87.477	70.404	5.42	102.103	-36.937	-213.939	
4047	118.36	86.9	72.257	5.42	102.912	-35.435	-214.980	HWMLB -- WLP
4048	118.896	87.332	87.103	5.42	103.059	-22.751	-222.751	XS1LB - Top of stake
4049	118.92	87.631	87.336	5.42	102.614	-22.548	-222.906	ground at stake
4050	154.652	88.13	97.913	5.42	102.199	-57.031	-269.146	HWMLB -- WLP
4051	163.171	89.041	115.059	4.30	102.050	-65.620	-290.823	HWMLB -- WLP
4052	235.294	89.323	163.238	4.30	102.053	-233.113	-273.643	HWMRB -- DLVP
4053	254.871	89.196	109.488	4.30	101.660	-204.610	-209.280	HWMRB -- DLVP
4054	253.268	87.394	59.491	4.30	102.829	-155.840	-197.816	HWMRB--DLF in tree on edge of ch
4055	302.492	88.232	72.943	4.30	102.374	-160.423	-141.542	HWMRB -- WLP
4056	337.788	87.957	80.125	4.30	102.980	-129.198	-106.575	HWMRB -- DLF
4057	350.416	87.415	72.556	4.30	103.396	-110.995	-109.236	HWMRB -- DLF
4058	80.585	88.137	88.189	4.30	102.991	-11.972	-166.288	HWMLB -- WLP
4059	101.485	87.717	74.032	4.30	103.073	-26.435	-195.436	HWMLB -- DLF



Scale in Feet

0′ 40′

4-11-99 Tiger Wash
S-A site between AV1 + AV2
XS 2 view U/S

4-11-99 Tiger Wash
S-A site betw AV1 + AV2
XS 1 view U/S

4-11-99 Tiger Wash
S-A site betw. AV1 + AV2
XS 2 view D/S

4-11-99 Tiger Wash
S-A site betw AV1 + AV2
XS 1 view D/S

Survey Site: Tiger Wash, Site 4000
between AV1 and AV2

Date:
Sept. 10, 1999

Sta/Dist	BS	HI	Top	Bottom	Forward	Elevation	Comments
RM1	5.22	111.19				105.97	top of 2x2 wood stake on LB
4A					5.27	105.92	top of capped 1/2" rebar stamped 4A
							Note 4A located approx. 0.2' SE of RM 1

Party: TWL, inst, notes
MH, rod

Weather: Hot and humid

11-3-99

Site 3000

Subdivision

OK as is ⇒ Left OB $L = 400/15 >> 5$

$d_b \approx 1.5'$, $D_{MAX} = 4'$ ∴ $D_{MAX} > 2\cdot(1.5)$

Also, S_R & S_L different, so subdivision of Main & AV2 channels was required.

Site 4000

XS1

LOB, $L = 20'$, $d_b = 1.2'$; $20'/1.2' > 5$

$D_{MAX} = 3.5'$; $D_{MAX} > 2\cdot(1.2)$

∴ subdivide

ROB $L = 37'$, $d_b = 0.5'$; $37'/0.5' > 5$

$D_{MAX} = 3.5'$; $D_{MAX} > 2\cdot(0.5)$

∴ subdivide

XS2

LOB $L = 21'$, $d_b = 1.4'$; $21'/1.4' > 5$

$D_{MAX} = 4.6'$; $D_{MAX} > 2(1.4)$

∴ subdivide

ROB $L = 25'$, $d_b = 1.3'$; $25'/1.3' > 5$

$D_{MAX} = 4.6$; $D_{MAX} > 2(1.3)$

∴ subdivide

For channel

$n_b = 0.025$, Table 1 coarse sand, fine gravel

$n_1 = 0.0$, Table 2, smooth

$n_2 = 0.0$ Table 2, obstructions

$n_3 = 0.005$, Table 2, some bank vegetation none in channel

$n_T = 0.030$

June 7, 1999
Revised November 3, 1999

Site 5000

Summary of a survey and examination of relative split flow at the upstream avulsion on the west branch of Tiger Wash for the event of September 26, 1997. The site is located in the N1/2 NW1/4 Sec. 20, T4N, R10W.

A single cross section was surveyed on April 11, 1999 by T.W. Lehman and a field crew of JE Fuller / Hydrology & Geomorphology, Inc. The section surveyed was located about 1 mile downstream of the twin buttes near Site 2000 about 1,000 feet downstream of Eagle Eye Road. The cross section was taken across the avulsion approximately perpendicular to the flow in both the old/main channel as well as the new breakout or avulsion channel to the west. In addition to the channel cross section, a few high water marks along the section were surveyed to give an estimate of the depth of flow across the section. Finally, a point downstream in each of the two branch channels was surveyed to allow for an estimate of the channel bed slope in each direction. The surveyed points were plotted using AutoCAD and Excel.

The slope estimated for the right or breakout channel was 0.0074. The slope for the left or main channel was 0.0125. Using an assumed level water surface of 100.4 ft (relative survey datum), relative conveyance was estimated for the two channels. Assuming equal n-values, the discharge in the left or main channel was about 2.5 times greater than that in the right or breakout channel. Since the depth of flow was greater in the main channel, the n-values might be expected to be relatively lower than in the breakout channel. Assuming n-values of 0.03 and 0.04 for the main and breakout channel respectively, the discharge in the main channel is 3.4 times the discharge in the breakout channel (at 100.4 feet).

The discharge estimates for the latter condition yields 5,650 cfs in the main channel and 1,670 cfs in the breakout channel. If n-values of 0.035 and 0.045 are assumed for the main and breakout channel respectively, the discharge in the main channel is 4,850 cfs and the discharge in the breakout channel is 1,480 cfs.

Given the gross approximations these estimates of peak discharge are considered very poor.

Ted Lehman
Hydrologist
JE Fuller / Hydrology & Geomorphology, Inc.

Tiger Wash
May 19, 1999
Site 5000 / AV1

Split flow

$S_{RIGHT} = (97.94 - 94.48)/467 = 0.0074$

$S_{LEFT} = (95.5 - 90.8)/375 = 0.0125$

Assume level water surface at 100.4':

$Area_{RIGHT} \cong 500\ ft^2$

$Area_{LEFT} \cong 780\ ft^2$

Further Assume $WP = T_w$:

$T_{w\ RIGHT} = 472\ ft$
$T_{w\ LEFT} = 523\ ft$

Then,

$R_{RIGHT} = \frac{500}{472} = 1.06$, $R_{LEFT} = \frac{780}{523} = 1.49$

$\therefore K_{RIGHT} = \frac{1.49}{n} R_R^{2/3} \cdot A_R = \frac{1.49}{n}(1.06)^{2/3} \cdot 500 = \frac{775}{n}$

$K_{LEFT} = \frac{1.49}{n}(1.49)^{2/3} \cdot 780 = \frac{1518}{n}$

So,

$K_R S_R^{1/2} = \frac{775}{n} \cdot (0.0074)^{1/2} = \frac{66.7}{n_R}$

$K_L S_L^{1/2} = \frac{1518}{n} \cdot (0.0125)^{1/2} = \frac{169.7}{n_L}$

And, $\frac{K_L \cdot S_L^{1/2}}{K_R \cdot S_R^{1/2}} = \frac{169.7}{n_L} \cdot \frac{n_R}{66.7}$ (1)

IF $n_L \neq n_R$, then $Q_L \cong 2.5 * Q_R$

n_L is probably lower due to greater depth [$Q_L \neq 3 Q_R$].

For example,

If $n_R = 0.04$ & $n_L = 0.03$

(1) becomes $\frac{169.7}{0.03} \cdot \frac{0.04}{66.7} = 3.4$

Also, if $n_L = 0.03$ & $n_R = 0.04$

$$Q_L = K_L \cdot S_L^{1/2} = \frac{169.7}{0.03} = 5,650 \text{ cfs}$$

and $Q_R = K_R S_R^{1/2} = \frac{66.7}{0.04} = 1,670$ cfs

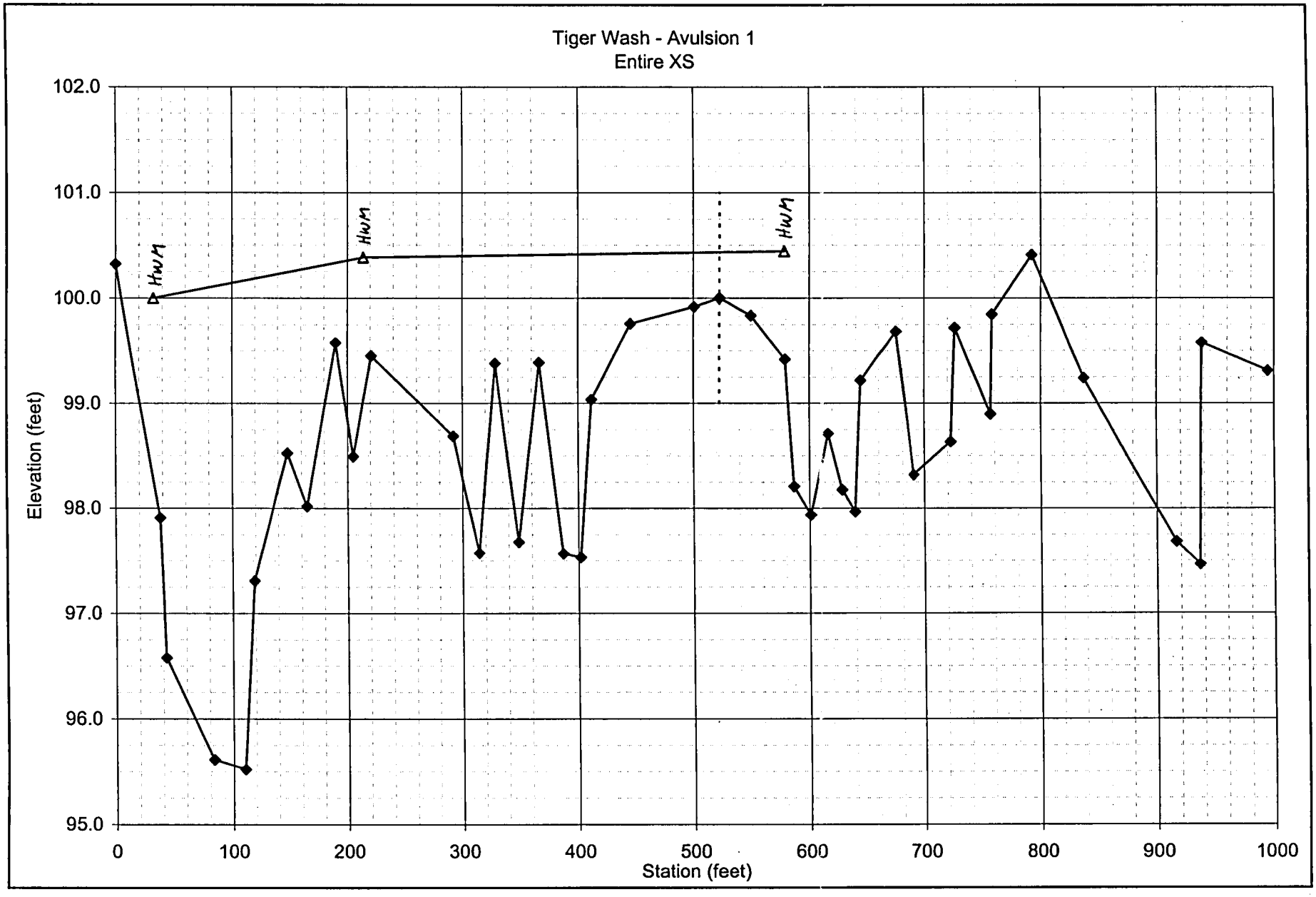
and $Q_T = 7320$ cfs

Or, if $n_L = 0.035$ & $n_R = 0.045$

$$Q_L = \frac{169.7}{0.035} = 4,850 \text{ cfs}$$

and $Q_R = \frac{66.7}{0.045} = 1,480$ cfs

and $Q_T = 6,330$ cfs

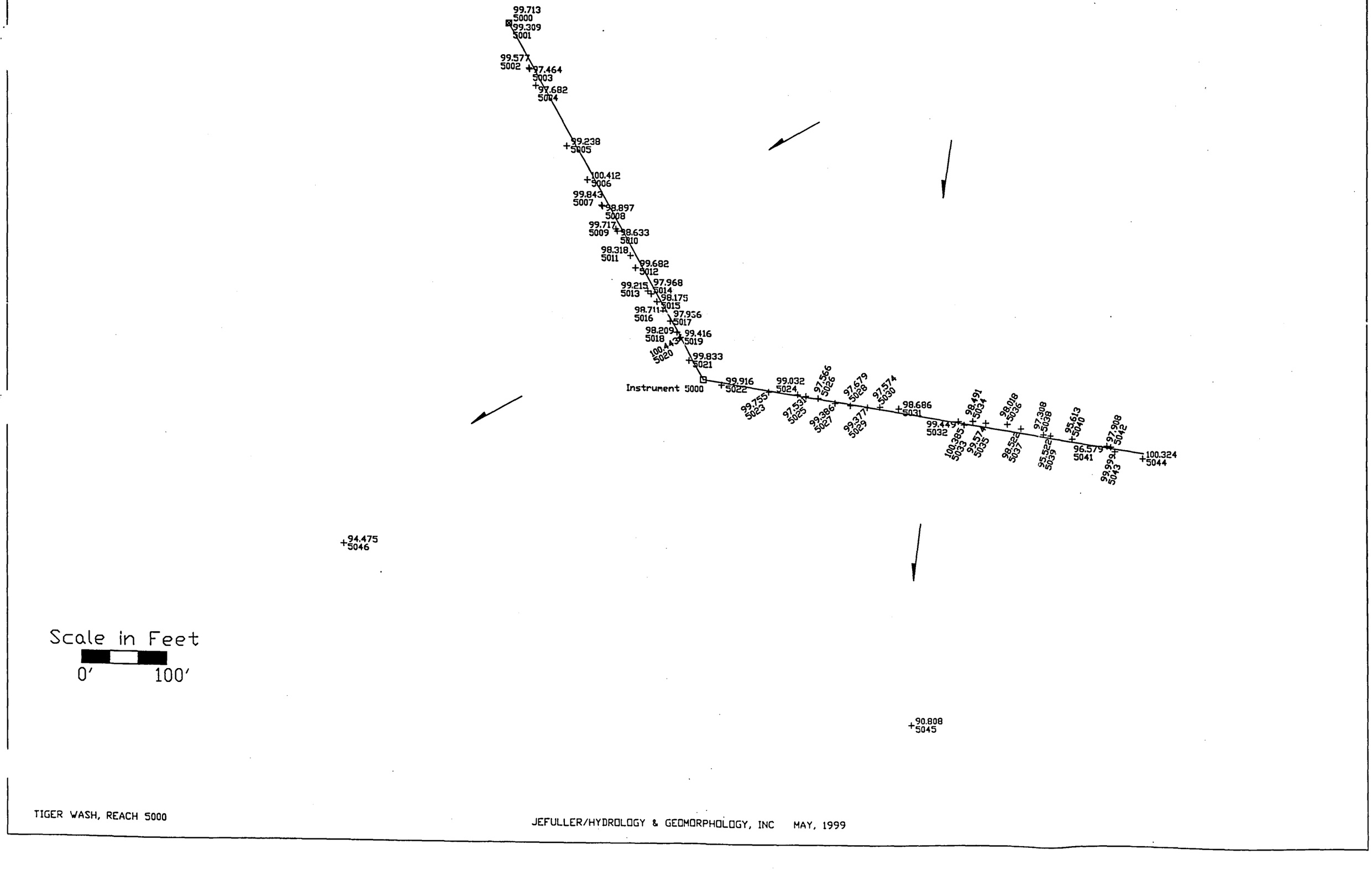


Site 5000
5/19/99

JEF, Inc.

Tiger Wash
Cross section at Avulsion 1
Survey of April 11, 1999

Station Setup	1005							
I =	5.34							
Elevation =	100	assumed						
Northing =	0							
Easting =	0							
station	hor. Ang	ver. Ang	length	Target Height	Elevation	Easting	Northing	Comments
name	(degrees)	(degrees)	(feet)	(feet)	(feet)	(feet)	(feet)	
5000	330.774	89.826	471.85	7.06	99.713	-230.382	411.782	top of stake RM1
5001	330.814	89.875	471.611	7.06	99.309	-229.979	411.735	ground @ stake
5002	330.105	89.821	415.24	7.06	99.577	-206.960	359.987	
5003	330.09	90.113	413.76	7.06	97.464	-206.316	358.650	
5004	329.662	90.087	393.537	7.06	97.682	-198.775	339.646	
5005	329.072	89.826	315.597	7.06	99.238	-162.204	270.722	
5006	329.114	89.547	269.692	7.06	100.412	-138.437	231.440	
5007	328.985	89.62	235.673	7.06	99.843	-121.431	201.975	
5008	329.028	89.849	234.259	7.06	98.897	-120.554	200.857	
5009	329.026	89.595	203.268	7.06	99.717	-104.609	174.278	
5010	329.084	89.899	200.413	7.06	98.633	-102.968	171.938	
5011	328.699	89.987	167.845	7.06	98.318	-87.201	143.415	
5012	328.026	89.474	152.667	7.06	99.682	-80.839	129.500	
5013	327.186	89.56	121.709	7.06	99.215	-65.954	102.285	
5014	327.945	90.153	116.693	7.06	97.968	-61.933	98.902	
5015	328.394	90.057	105.564	7.06	98.175	-55.323	89.906	
5016	328.614	89.734	92.766	7.06	98.711	-48.312	79.191	
5017	329.561	90.252	78.123	7.06	97.936	-39.578	67.355	
5018	329.588	90.064	63.238	7.06	98.209	-32.012	54.537	
5019	330.745	88.838	55.997	7.06	99.416	-27.360	48.845	HWM poor
5020	328.627	87.776	55.741	7.06	100.443	-28.997	47.556	
5021	322.961	86.808	27.894	7.06	99.833	-16.776	22.231	
5022	105.686	85.705	21.841	7.06	99.916	20.969	-5.888	
5023	99.82	88.897	76.647	7.06	99.755	75.510	-13.070	
5024	98.14	89.612	111.04	7.06	99.032	109.919	-15.722	
5025	98.313	90.355	120.965	7.06	97.531	119.692	-17.489	
5026	98.469	90.302	135.486	7.06	97.566	134.007	-19.953	
5027	99.456	89.593	155.751	7.06	99.386	153.631	-25.588	
5028	99.247	90.198	173.993	7.06	97.679	171.731	-27.959	
5029	99.013	89.676	193.947	7.06	99.377	191.549	-30.383	
5030	98.171	90.194	208.402	7.06	97.574	206.285	-29.620	
5031	97.776	89.899	230.581	7.06	98.686	228.460	-31.198	
5032	98.612	89.778	301.68	7.06	99.449	298.276	-45.174	
5033	99.173	89.609	308.481	7.06	100.385	304.529	-49.176	HWM
5034	98.024	89.962	317.658	7.06	98.491	314.548	-44.341	
5035	98.054	89.777	332.484	7.06	99.574	329.202	-46.583	
5036	97.681	90.042	357.713	7.06	98.018	354.503	-47.811	
5037	98.117	89.963	374.656	7.06	98.522	370.903	-52.900	
5038	98.481	90.138	403.698	7.06	97.308	399.282	-59.538	
5039	98.497	90.383	412.618	7.06	95.522	408.080	-60.966	
5040	98.446	90.348	439.147	7.06	95.613	434.376	-64.500	
5041	98.669	90.203	480.053	7.06	96.579	474.566	-72.356	
5042	98.725	90.044	484.564	7.06	97.908	478.956	-73.505	
5043	99.241	89.799	490.016	7.06	99.999	483.653	-78.690	HWM
5044	99.55	89.776	522.746	7.06	100.324	515.497	-86.727	
5045	148.945	90.552	470.368	10	90.808	242.633	-402.933	pt for slope D/S L branch
5046	245.115	90.466	467.868	7.06	94.475	-424.414	-196.872	pt for slope D/S right branch



TIGER WASH, REACH 5000

JEFULLER/HYDROLOGY & GEOMORPHOLOGY, INC MAY, 1999

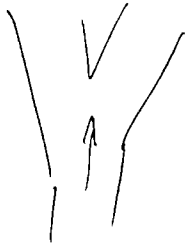
4-11-99 Tiger Wash
AV1, view D/S in leftmost channel of main just U/S of XS1

4-11-99 Tiger Wash
AV1, view U/S in "middle" channel of main just U/S of XS1

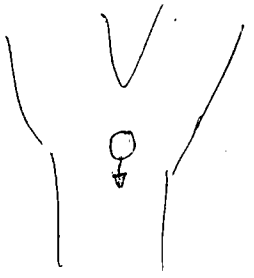
4-11-99 Tiger Wash
AV1, view D/S in "middle" channel of main channel just U/S of XS1

4-11-99 Tiger Wash
AV1 view U/S in leftmost portion of entire channel
Note: caliche in right of photo just U/S of XS1

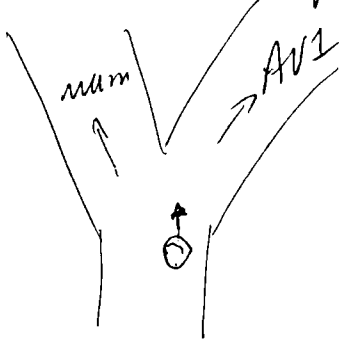
4-11-99 Tiger Wash
AV1, view D/S from u/s of split looking toward "point" of split



4-11-99 Tiger Wash
AV1, view U/S into main channel from widening area @ split



4-11-99 Tiger Wash, AV1
view D/S toward "point" betw two split channels



4-11-99 Tiger Wash
AV1, view D/S into AV1 channels to Right from U/S of split

4-11-99 Tiger Wash
AV1, view D/S in AV1
(left channel of AV1)

4-11-99 Tiger Wash
AV1, view D/S along
rightmost portion of AV1
breakout channel(s)

4-11-99 Tiger Wash
AV1, view U/S toward
split at XS1 in left portion
of AV1 channel

4-11-99 Tiger Wash
AV1, view U/S in right
portion of AV1 channel(s)

4-11-99 Tiger Wash
AV1, view U/S in right portion of left/main channel ≈ 200' D/S of XS2

4-11-99 Tiger Wash
AV1, view D/S ≈ 500' D/S of split, in left channel of the split to right of main (old) wash

4-11-99 Tiger Wash
AV1, view D/S in right portion of left/main channel ≈ 200' D/S of XS 1

4-11-99 Tiger Wash
AV1, view U/S in left channel of split, ≈ 500' D/S of split avulsion channel

4-11-99 Tiger Wash
AV1, view D/S from near center of left branch (main channel) @ XS1

4-11-99 Tiger Wash
AV1 view U/S in left/main channel @ XS1

4-11-99 Tiger Wash
AV1 view D/S in leftmost channel of left/main branch @ XS1

Survey Site: Tiger Wash, Site 5000
on RB at AV1

Date:
Sept. 10, 1999

Sta/Dist	BS	HI	Top	Bottom	Forward	Elevation	Comments
5A/195	4.69	4.69	5.66	3.71			top of capped 1/2" rebar stamped 5A, 184 deg
RM1/16			4.30	4.14	4.22	99.71	top of 2x2 wood stake on RB, 272 deg
Note: 0 deg set to Big Horn Peak							

Party: TWL, inst, notes
MH, rod

Weather: Hot and humid

Eagle Eye

7-10-99
1440
Page 1

West Branch S-Reach No. 1

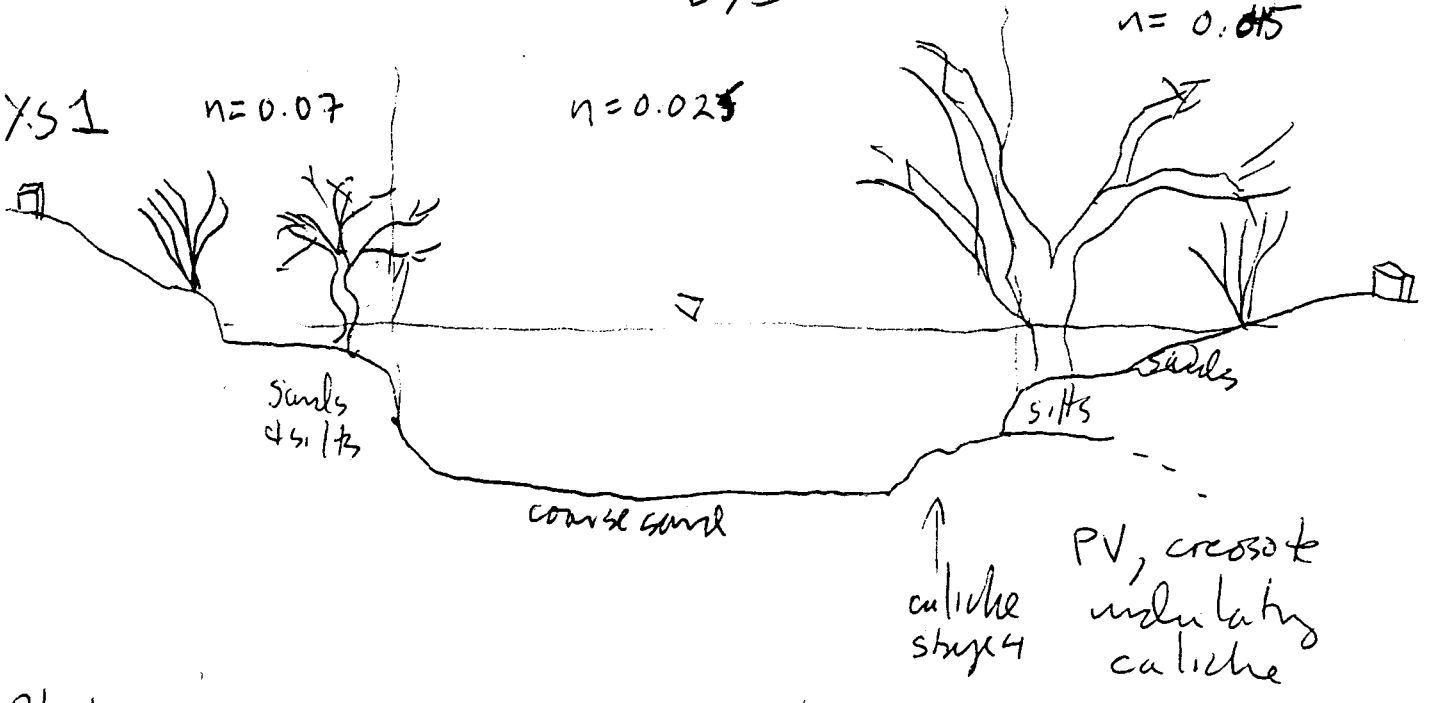
Total WB flow

Notes:

WB1 RM1 - 2x2 stake near road near XS2 ≈ 50ft from Top LB at south edge of hill

Photos: Roll #2 (1st complete TW roll)

1 - XS1 WB1 view U/S
2 - XS2 WB1 " D/S

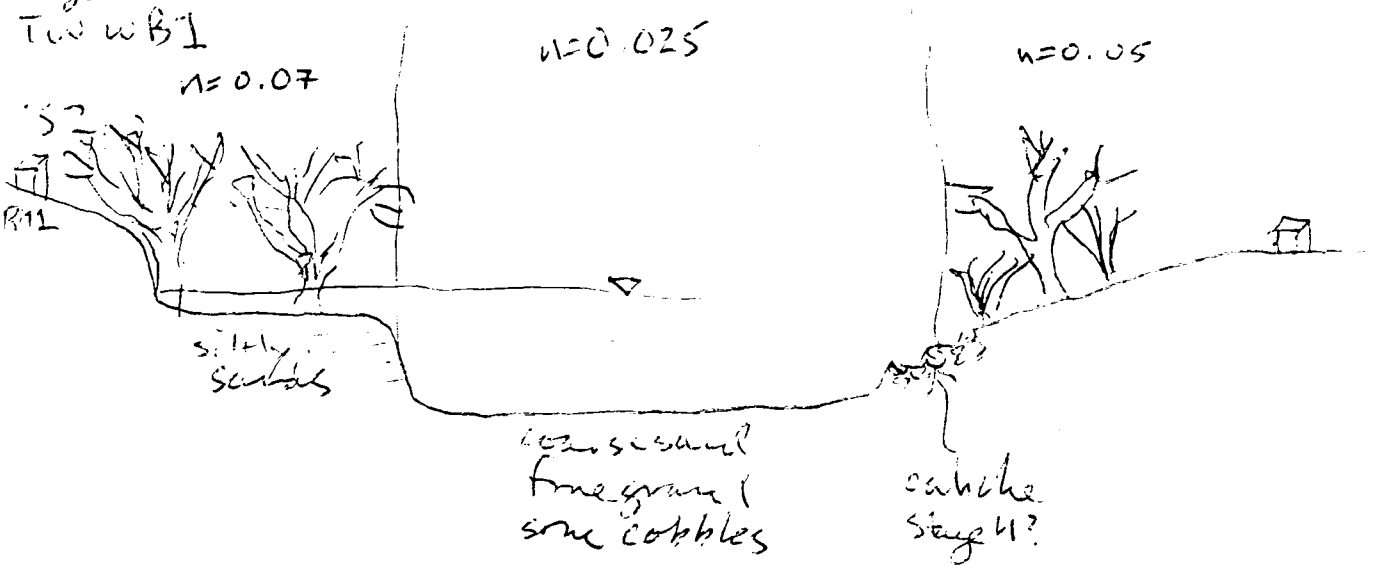


Photos: 3 - XS2 WB1 view D/S
4 - " " " U/S
5 - XS2 WB1 view U/S along RB
7 - XS3 " view D/S
8 - X33 " view U/S

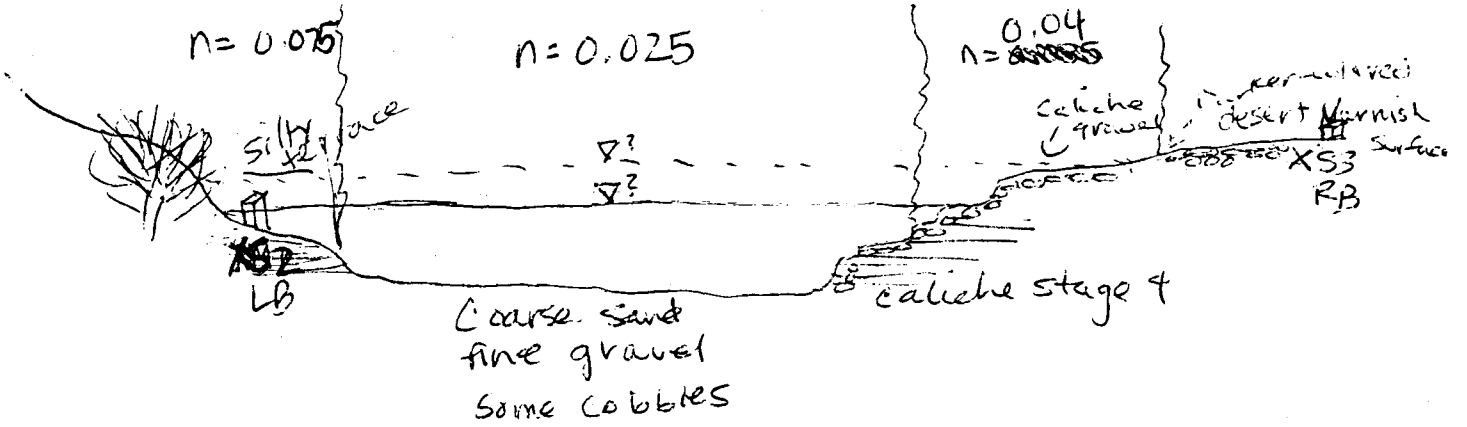
C ⇒ closeup of Multiple HUMS on RB @ XS2

Page 2

TUWBI

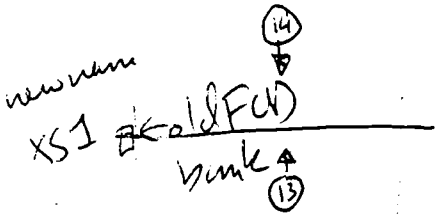


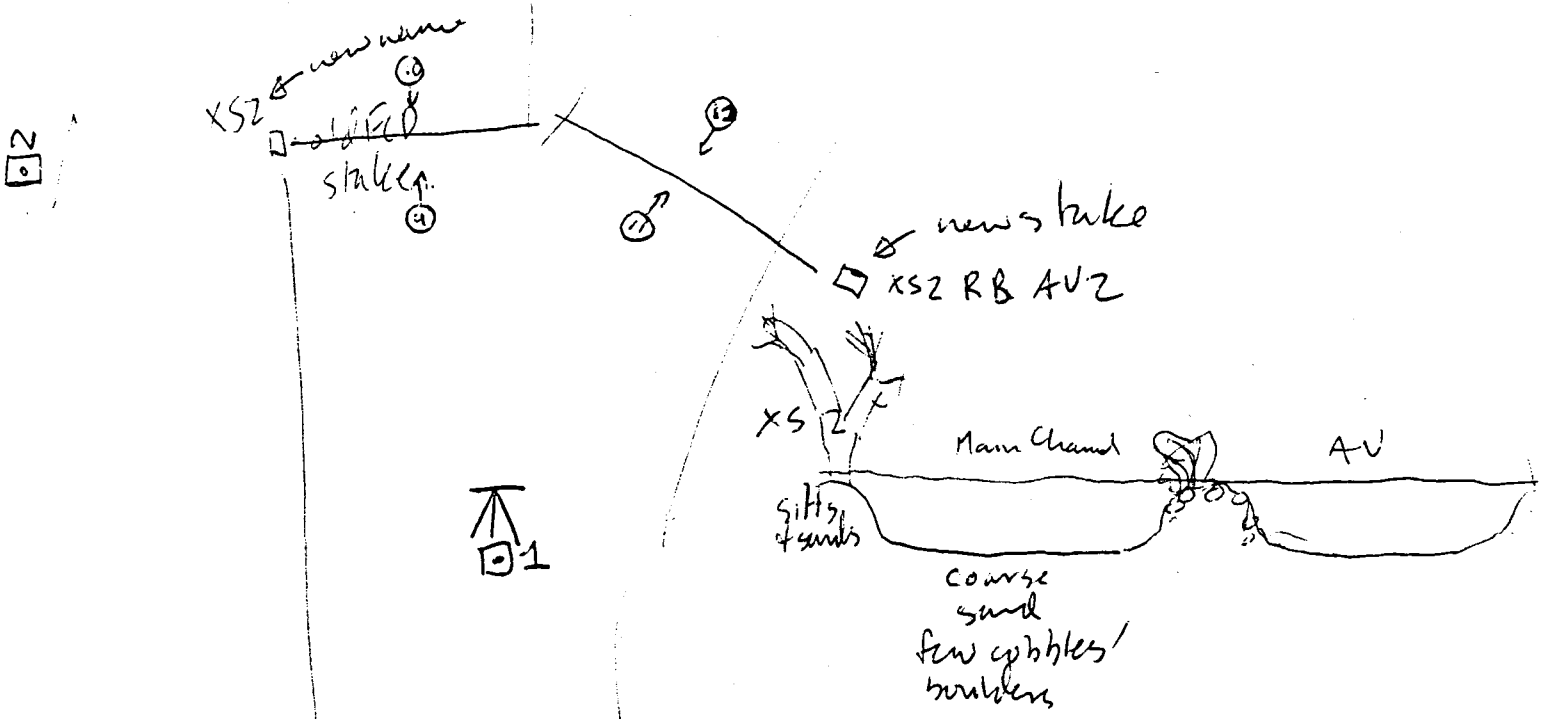
XS3



Page 3 TW WB3 (near WS @ AV2 - Avulsion 2)

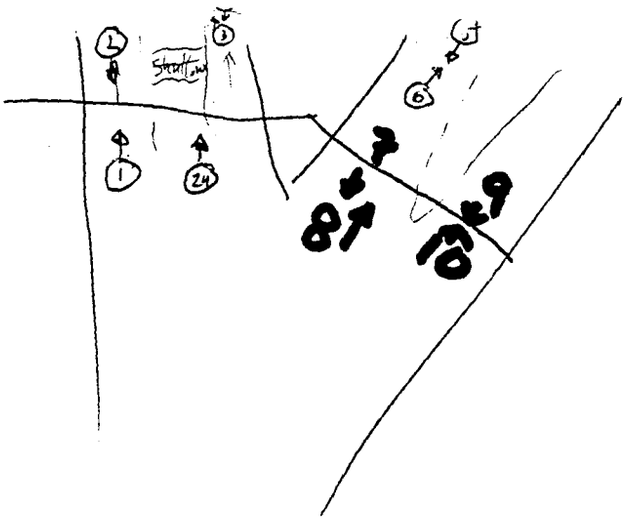
* PT for Slope #3020



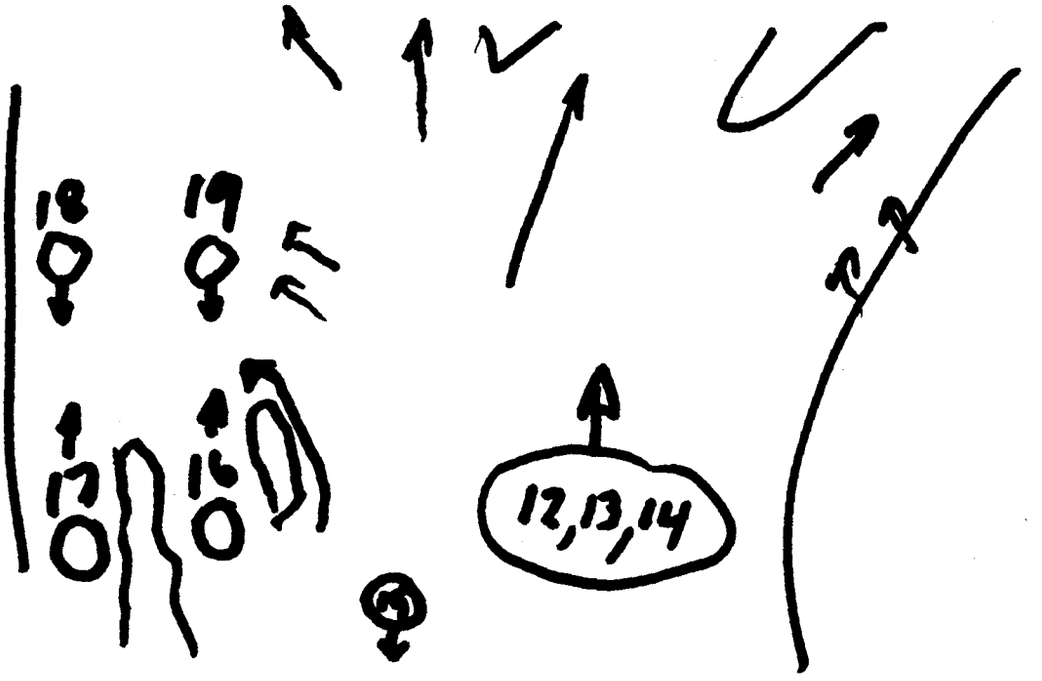


Apr 7 11
1430

Roll #2 Photo 24 View D/S



Division 1



Slope-Areas for Tyler Wash

say min 2 xs try for 3

Locations

1) East Branch ≈ 1/2 mile U/S of road to wilderness area & stock tank

2) Above 1st major breakout near knobby hill west of Eagle Eye across from gravel pit

3) Below 1st major breakout & U/S of 2nd breakout?

4) Below 2nd breakout U/S of 'real' fan

(5) Big trib D/S of USGS gage ≈ 1/3 mi U/S of road to top of Mtn turnoff

Criteria to be met

HWMs → reasonable & frequent

1) Reach $L \geq 75 \cdot \bar{D}$

2) Fall $\geq$ 1' H_v

3) Fall $\geq 0.5'$

meet at least 1 of these

- Reach slightly contracting.
- Photos

1) $75 \cdot 6 = 450'$

2) $V \approx 10$ then $H_v = \frac{V^2}{2g} = \frac{100}{64} < 2'$

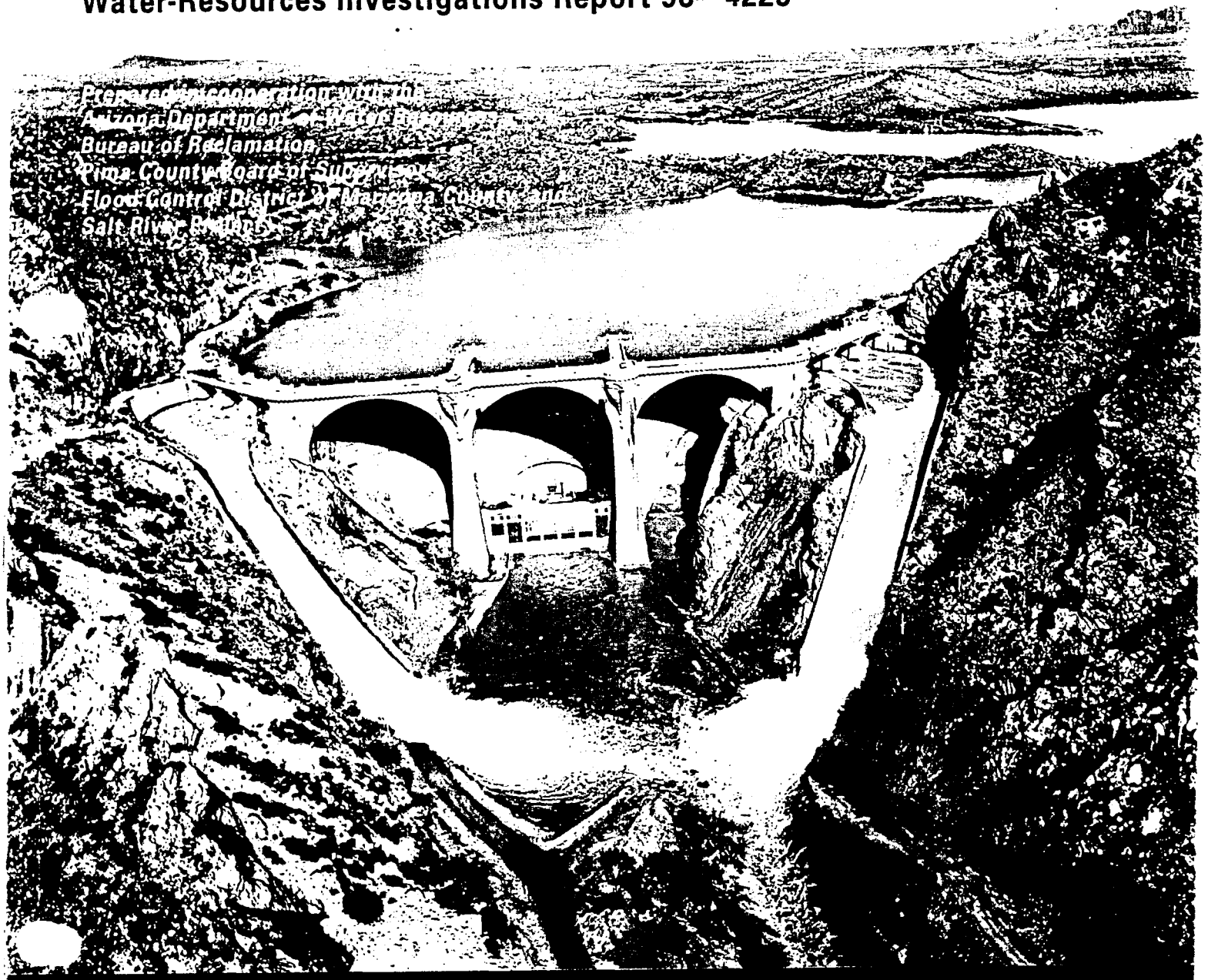
3) Fall $\geq 0.5'$

D.2 Flood Flow Frequency Data

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Statistical Summaries of Streamflow Data and Characteristics of Drainage Basins for Selected Streamflow-Gaging Stations in Arizona Through Water Year 1996

Water-Resources Investigations Report 98—4225



USGS
science for a changing world

09517280 TIGER WASH NEAR AGUILA, AZ

ATION.--Lat 33°44'30", long 113°16'43", in $SW^1/_4SW^1/_4$ sec.26, T.5 N., R.10 W., Maricopa County, Hydrologic Unit 15070104, 17 mi south of Aguila.

INAGE AREA.--85.2 mi^2.

Annual peak discharges

Water year	Date	Annual peak discharge (ft^3/s)	Discharge codes	Water year	Date	Annual peak discharge (ft^3/s)	Discharge codes
1963	08-16-63	910	ES	1975	07-30-75	100	ES
1964	10-19-63	400	ES	1976	09-25-76	3,000	
1965	08-18-65	1,680		1977	08-16-77	870	
1966	09-13-66	1,450		1978	03-01-78	1,400	
1967	08-14-67	620		1979	12-18-78	60	ES
1968	12-19-67	440		1983	09-00-83	3,170	
1969	09-14-69	441		1991	09-04-91	1	
1970	08-20-70	4,550		1992	03-03-92	906	
1971	08-20-71	2,000		1993	01-08-93	1,040	
1972	08-00-72	2,770		1994	07-18-94	3,640	
1973	10-06-72	1,750		1995	02-15-95	185	
1974	08-03-74	45	ES	1996	00-00-96	0	

scharge rating table developed October 1990

ge height (ft)	Discharge (ft^3/s)	Gage height (ft)	Discharge (ft^3/s)
6.0	133	8.5	2,070
6.5	345	9.0	2,700
7.0	650	9.5	3,410
7.5	1,040	10.0	4,210
8.0	1,520	10.2	4,550

gnitude and probability of instantaneous peak flow based on period of record 1963-79, 1983, 1991-96

	Discharge, in ft^3/s, for indicated recurrence interval in years, and exceedance probability, in percent				
2	5	10	25	50†	100†
50%	20%	10%	4%	2%	1%
961	2,140	3,160	4,670	5,950	7,340
ghted skew	(logs) =	-0.33			
Mean	(logs) =	2.96			
ndard dev.	(logs) =	0.43			

liability of values in column is uncertain, and potential errors are large.

BASIN CHARACTERISTICS AND STREAMFLOW STATISTICS IN ARIZONA AS OF 1989

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 91–4041

Prepared in cooperation with the
ARIZONA DEPARTMENT OF WATER RESOURCES and
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

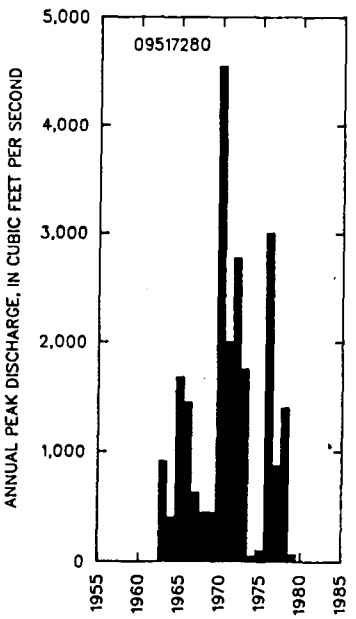
09517280 TIGER WASH NEAR AGUILA, AZ

LOCATION.--Lat 33°44'30", long 113°16'43", in SW¼SW¼ sec.26, T.5 N., R.10 W., Maricopa County, Hydrologic Unit 15070104, 17 mi south of Aguila.

DRAINAGE AREA.--85.2 mi^2.

ANNUAL PEAK DISCHARGE

WATER YEAR	DATE	ANNUAL PEAK DISCHARGE (FT^3/S)	DISCHARGE CODES
1963	08-16-63	910	ES
1964	10-19-63	400	ES
1965	08-18-65	1,680	
1966	09-13-66	1,450	
1967	08-14-67	620	
1968	12-19-67	440	
1969	09-14-69	441	
1970	08-20-70	4,550	
1971	08-20-71	2,000	
1972	08-00-72	2,770	
1973	10-06-72	1,750	
1974	08-03-74	45	ES
1975	07-30-75	100	ES
1976	09-25-76	3,000	
1977	08-16-77	870	
1978	03-01-78	1,400	
1979	12-18-78	60	ES



MAGNITUDE AND PROBABILITY OF INSTANTANEOUS PEAK FLOW
BASED ON PERIOD OF RECORD 1963-79

DISCHARGE, IN FT^3/S, FOR INDICATED RECURRENCE INTERVAL IN YEARS, AND EXCEEDANCE PROBABILITY, IN PERCENT					
2	5	10	25	50†	100†
50%	20%	10%	4%	2%	1%
1,010	2,120	3,060	4,450	5,630	6,910

WEIGHTED SKEW (LOGS)= -0.25
MEAN (LOGS)= 2.99
STANDARD DEV. (LOGS)= 0.40

† Reliability of values in column is uncertain, and potential errors are large.

BASIN CHARACTERISTICS

MAIN CHANNEL SLOPE (FT/MI)	STREAM LENGTH (MI)	MEAN BASIN ELEVATION (FT)	FORESTED AREA (PERCENT)	SOIL INDEX	MEAN ANNUAL PRECIPITATION (IN)	RAINFALL INTENSITY, 24-HOUR 2-YEAR (IN)	RAINFALL INTENSITY, 24-HOUR 50-YEAR (IN)
35.2	15.0	2,590	0.0	1.0	9.6	1.5	3.6

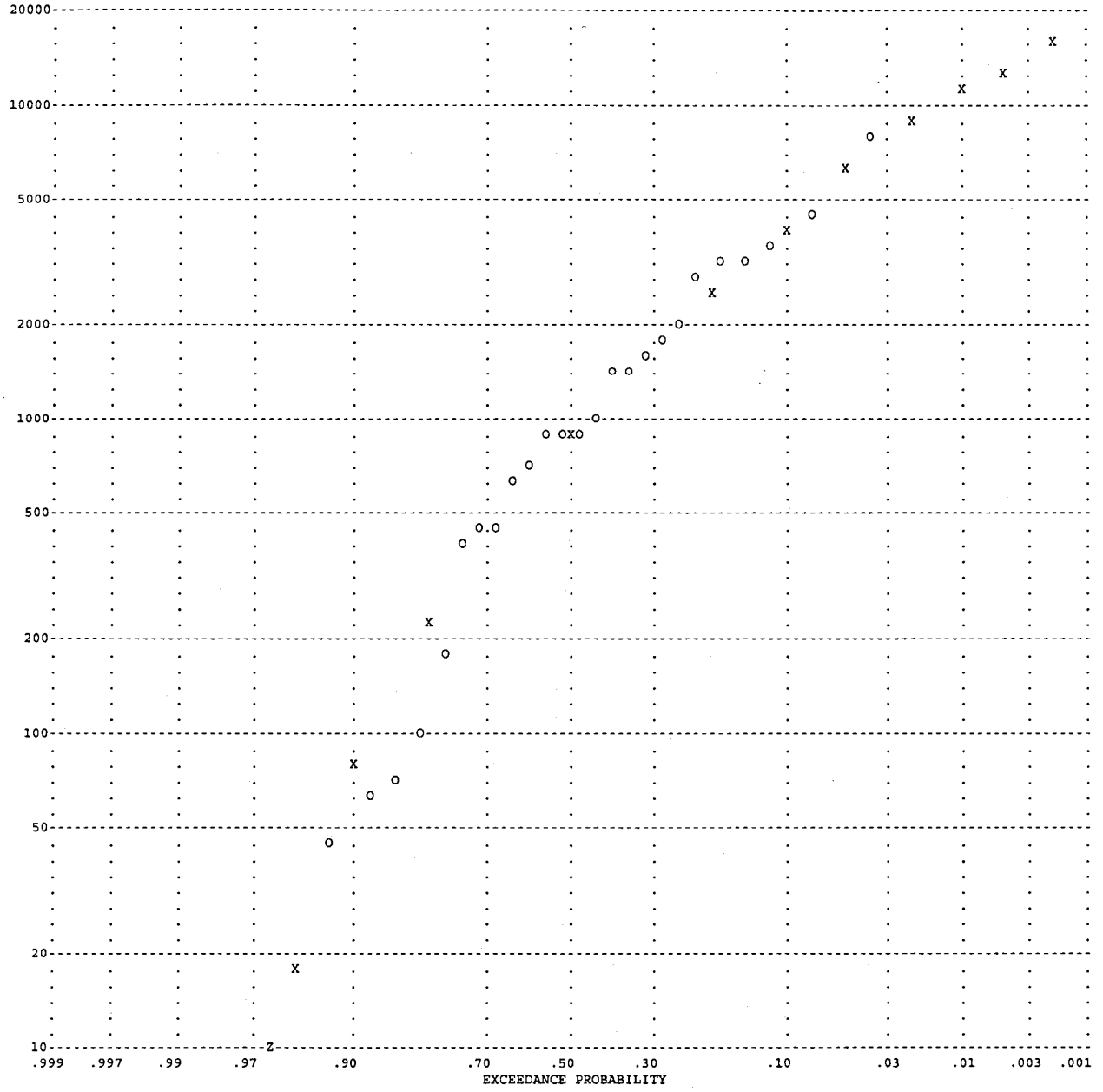
```
**********************************        ************************************
*            HECWRC              *        *                                  *
* FLOOD FLOW FREQUENCY ANALYSIS *        *   U.S. ARMY CORPS OF ENGINEERS   *
* PROGRAM DATE:    1 APRIL 1978 *        * THE HYDROLOGIC ENGINEERING CENTER *
* VERSION DATE:    1 APRIL 1987 *        *         609 SECOND STREET        *
* RUN  DATE     AND     TIME:   *        *      DAVIS, CALIFORNIA 95616     *
*     4/21/99          9:48:35  *        * (916) 551-1748 OR (FTS) 460-1748 *
**********************************        ************************************


 INPUT FILE NAME: tiger98.dat
OUTPUT FILE NAME: tiger98.out


**TITLE CARD(S)**
TT    TIGER WASH  NEAR AGUILA, AZ
TT    17 MILES SOUTH OF AGUILA
TT    DA = 85.2   PERIOD OF RECORD 1963-1998

**JOB CARD(S)**
     IPPC   ISKFX  IPROUT    IFMT    IWYR   IUNIT   ISMRY   IPNCH    IREG
J1      1       2       0       1       1       1       1       0       0

       A       B  CLIMIT
J2   .00     .00     .05

**STATION IDENTIFICATION**
ID     09517280

**GENERALIZED SKEW**
     ISTN   GGMSE    SKEW
GS   5172    .000    -.08

**SYSTEMATIC EVENTS**
     26 EVENTS TO BE ANALYZED

**END OF INPUT DATA**
ED ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++


NOTE - ADOPTED SKEW EQUALS COMPUTED SKEW AND PRELIMINARY
       FREQUENCY STATISTICS ARE FOR THE CONDITIONAL
       FREQUENCY CURVE BECAUSE OF ZERO OR MISSING EVENTS.
```

PRELIMINARY RESULTS

-FREQUENCY CURVE- 09517280

FLOW, CFS		EXCEEDANCE PROBABILITY	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY		.05 LIMIT	.95 LIMIT
15917.	19700.	.002	45100.	7900.
12940.	15500.	.005	34800.	6630.
10741.	12500.	.010	27500.	5650.
8622.	9740.	.020	20900.	4680.
5987.	6530.	.050	13300.	3400.
4177.	4430.	.100	8520.	2470.
2573.	2660.	.200	4760.	1590.
861.	861.	.500	1380.	542.
212.	199.	.800	347.	111.
79.	68.	.900	145.	33.
19.	12.	.950	42.	5.
0.	0.	.990	0.	0.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.9020	HISTORIC EVENTS	0
STANDARD DEVIATION	.6101	HIGH OUTLIERS	0
COMPUTED SKEW	-.6290	LOW OUTLIERS	0
GENERALIZED SKEW	-.0800	ZERO OR MISSING	1
ADOPTED SKEW	-.6290	SYSTEMATIC EVENTS	26


PRELIMINARY RESULTS
FREQUENCY PLOT - 09517280
BASED ON COMPUTED VALUES, FLOW IN CUBIC FEET PER SECOND
20000
10000
5000
2000
1000
500
200
100
50
20
10
.999 .997 .99 .97 .90 .70 .50 .30 .10 .03 .01 .003 .001
EXCEEDANCE PROBABILITY
LEGEND - O=OBSERVED EVENT, H=HIGH OUTLIER OR HISTORIC EVENT, L=LOW OUTLIER, Z=ZERO OR MISSING X=COMPUTED CURVE

FINAL RESULTS
-PLOTTING POSITIONS- 09517280

.....EVENTS ANALYZED.....				..... ORDERED EVENTS			
MON	DAY	YEAR	FLOW,CFS	RANK	WATER YEAR	FLOW,CFS	WEIBULL PLOT POS
8	16	1963	910.	1	1997	8070.	.0370
10	19	1963	400.	2	1970	4550.	.0741
8	18	1965	1680.	3	1994	3640.	.1111
9	13	1966	1450.	4	1983	3170.	.1481
8	14	1967	620.	5	1976	3000.	.1852
12	19	1967	440.	6	1972	2770.	.2222
9	14	1969	441.	7	1971	2000.	.2593
8	20	1970	4550.	8	1972	1750.	.2963
8	20	1971	2000.	9	1965	1680.	.3333
8	0	1972	2770.	10	1966	1450.	.3704
10	6	1972	1750.	11	1978	1400.	.4074
8	3	1974	45.	12	1993	1040.	.4444
7	30	1975	100.	13	1963	910.	.4815
9	25	1976	3000.	14	1992	906.	.5185
8	16	1977	870.	15	1977	870.	.5556
3	1	1978	1400.	16	1998	683.	.5926
12	18	1978	60.	17	1967	620.	.6296
9	0	1983	3170.	18	1969	441.	.6667
3	27	1991	69.	19	1967	440.	.7037
3	3	1992	906.	20	1963	400.	.7407
1	8	1993	1040.	21	1995	185.	.7778
7	18	1994	3640.	22	1975	100.	.8148
2	15	1995	185.	23	1991	69.	.8519
1	1	1996	0.	24	1978	60.	.8889
9	26	1997	8070.	25	1974	45.	.9259
3	26	1998	683.	26	1996	0.	.9630

-OUTLIER TESTS -

LOW OUTLIER TEST

BASED ON 25 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.486

0 LOW OUTLIER(S) IDENTIFIED BELOW TEST VALUE OF 24.3
BASED ON THE STATISTICS AFTER 1 ZERO OR MISSING EVENTS DELETED

STATISTICS AND FREQUENCY CURVE ADJUSTED FOR 0 LOW OUTLIER(S)
AND/OR 1 ZERO OR MISSING EVENT(S)

HIGH OUTLIER TEST

BASED ON 25 EVENTS, 10 PERCENT OUTLIER TEST VALUE K(N) = 2.486

0 HIGH OUTLIER(S) IDENTIFIED ABOVE TEST VALUE OF 26232.

-SKEW WEIGHTING -

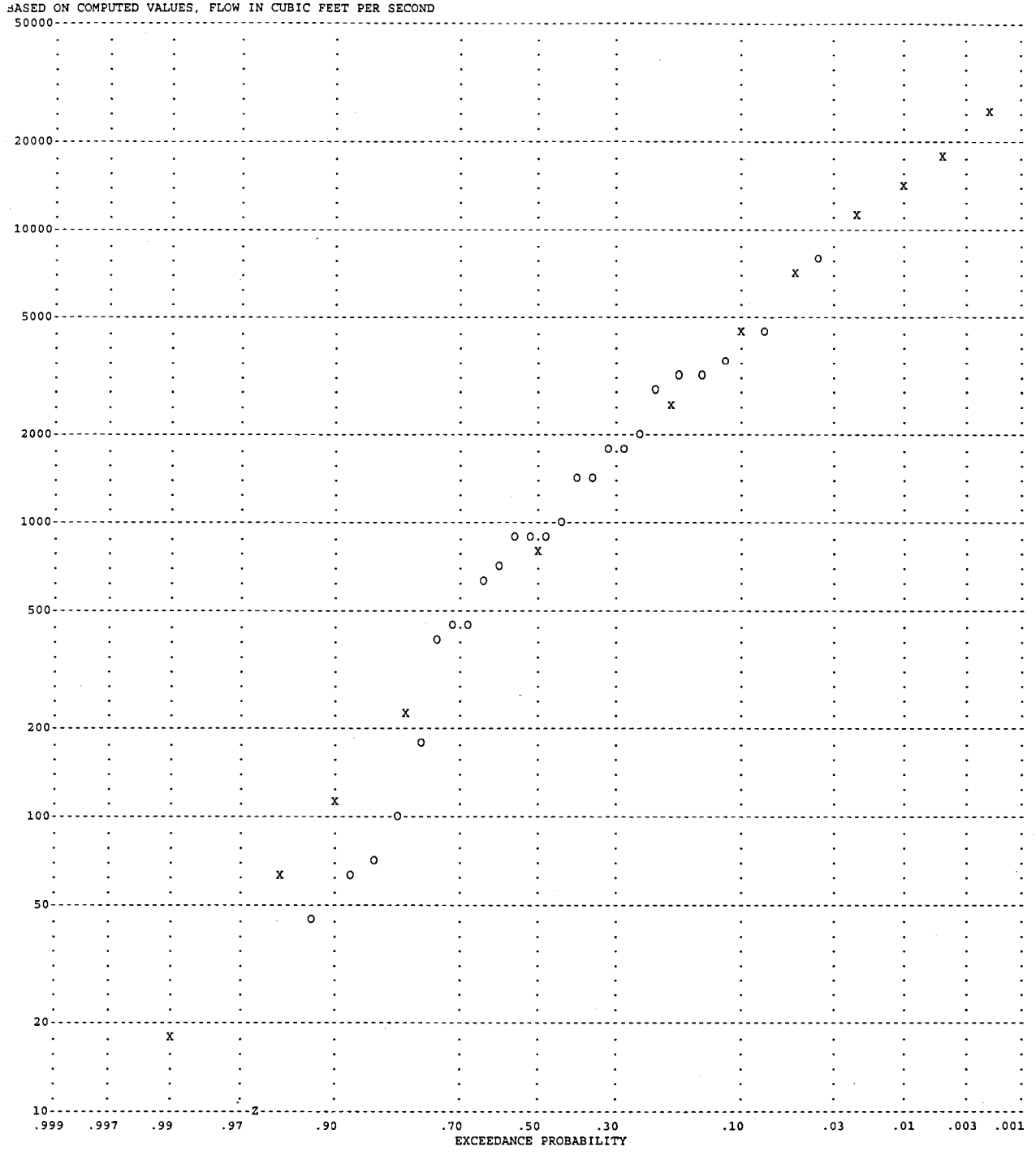
BASED ON 26 EVENTS, MEAN-SQUARE ERROR OF STATION SKEW = .251
DEFAULT OR INPUT MEAN-SQUARE ERROR OF GENERALIZED SKEW = .302

FINAL RESULTS

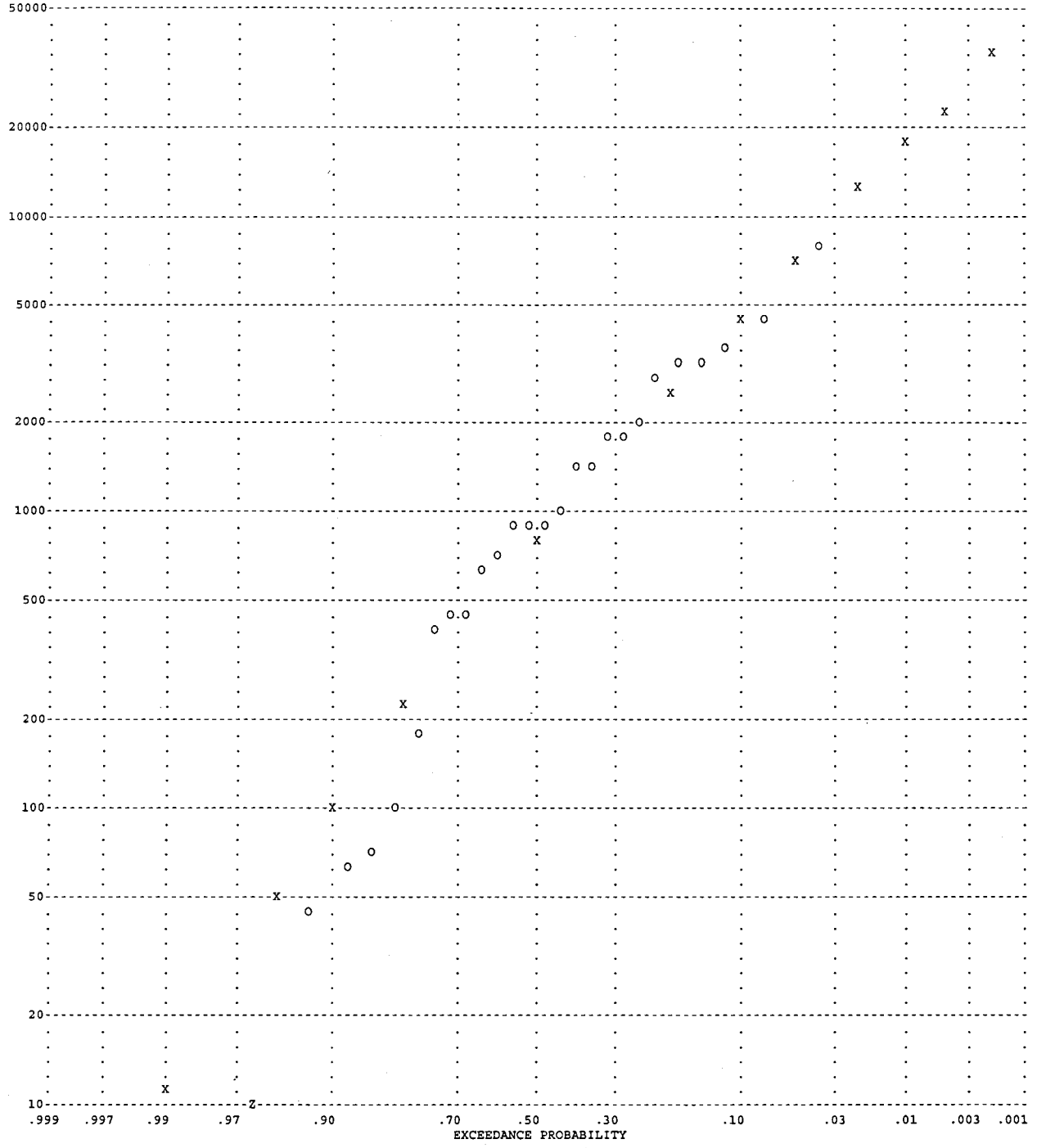
-FREQUENCY CURVE- 09517280

FLOW,CFS		EXCEEDANCE PROBABILITY	CONFIDENCE LIMITS	
COMPUTED	EXPECTED PROBABILITY		.05 LIMIT	.95 LIMIT
24200.	33500.	.002	79100.	11100.
18100.	23400.	.005	54500.	8660.
14100.	17300.	.010	39700.	6990.
10600.	12400.	.020	27600.	5470.
6710.	7480.	.050	15700.	3690.
4380.	4700.	.100	9280.	2540.
2540.	2640.	.200	4800.	1550.
811.	811.	.500	1320.	505.
228.	216.	.800	372.	122.
111.	100.	.900	194.	51.
60.	50.	.950	113.	24.
17.	12.	.990	40.	5.

FREQUENCY CURVE STATISTICS		STATISTICS BASED ON	
MEAN LOGARITHM	2.8693	HISTORIC EVENTS	0
STANDARD DEVIATION	.6263	HIGH OUTLIERS	0
COMPUTED SKEW	-.6340	LOW OUTLIERS	0
GENERALIZED SKEW	-.0800	ZERO OR MISSING	1
ADOPTED SKEW	-.3827	SYSTEMATIC EVENTS	26


FINAL RESULTS
FREQUENCY PLOT - 09517280
BASED ON COMPUTED VALUES, FLOW IN CUBIC FEET PER SECOND
50000
20000
10000
5000
2000
1000
500
200
100
50
20
10
.999 .997 .99 .97 .90 .70 .50 .30 .10 .03 .01 .003 .001
EXCEEDANCE PROBABILITY
LEGEND - O=OBSERVED EVENT, H=HIGH OUTLIER OR HISTORIC EVENT, L=LOW OUTLIER, Z=ZERO OR MISSING X=COMPUTED CURVE

FINAL RESULTS
FREQUENCY PLOT - 09517280
BASED ON EXPECTED PROBABILITY ADJUSTMENT, FLOW IN CUBIC FEET PER SECOND



LEGEND - O=OBSERVED EVENT, H=HIGH OUTLIER OR HISTORIC EVENT, L=LOW OUTLIER, Z=ZERO OR MISSING X=COMPUTED CURVE

1

TABLE 1. SUMMARY OF STATISTICS -- FINAL RESULTS

STATION NUMBER	STATION NAME AND LOCATION	AREA SQ MI	....YEARS..... RECD	SYST	HIST	MEAN LOG	STD DEV	.....SKEW..... ADOPT	COMP	GENRL	HIST EVENT	OUTLIER HI	LO	ZERO/ MSNG
09517280			26	26	0	2.869	.626	-.38	-.634	-.08	0	0	0	1

1

TABLE 2. SUMMARY OF FREQUENCY CURVE ORDINATES -- FINAL RESULTS

STATION NUMBER	STATION NAME AND LOCATION	AREA SQ MI	....YEARS..... RECD	SYST	HIST	.....PERCENT CHANCE EXCEEDANCE..... 10.	5.	2.	1.	.5	.2
09517280			26	26	0	4380	6710	10600	14100	18100	24200

++++++++++++++++++++++++++
+ END OF RUN +
+ NORMAL STOP IN HECWRC +
++++++++++++++++++++++++++

Region 13

	Peak Discharge, in cfs						
Drainage Area	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr	
1	123	295	457	724	955	1259	
10	440	1064	1680	2703	3627	4833	
100	1336	3091	4838	7690	10218	13410	
1000	3513	7504	11433	17648	22833	29082	
85.2	1242	2887	4526	7205	9586	12601	@ USGS Gage 09517280
96.4	1314	3043	4766	7577	10071	13222	@ Hydrographic Apex (below Blue Tank Canyor

	D.A.	Standard Error				D.A.	Standard Error		
	85.2	%	cfs	low	high	96.4	cfs	low	high
2-yr	1,242	57	708	534	1,951	1,314	749	565	2,063
5-yr	2,887	40	1,155	1,732	4,042	3,043	1,217	1,826	4,260
10-yr	4,526	37	1,675	2,852	6,201	4,766	1,763	3,002	6,529
25-yr	7,205	39	2,810	4,395	10,015	7,577	2,955	4,622	10,532
50-yr	9,586	43	4,122	5,464	13,708	10,071	4,330	5,740	14,401
100-yr	12,601	48	6,049	6,553	18,650	13,222	6,347	6,875	19,568

Computed using methods in Thomas, B.E, et al., 1997.

APPENDIX E: HYDRAULICS ANALYSIS SUPPORTING DOCUMENTATION

APPENDIX F: EROSION/SEDIMENT TRANSPORT SUPPORTING DOCUMENTATION

As indicated in Section 6A, no specific erosion or sediment transport analyses were conducted as part of this study. However, implicit to the geomorphic assessment of the active alluvial fan areas were considerations of sedimentary processes on the Tiger Wash piedmont. Therefore, areas of erosion hazards associated with the active alluvial fan flooding have been included in the areas mapped as Zone AFHH on Sheet 4 of 4.

APPENDIX G: PIEDMONT FLOOD HAZARD ASSESSMENT SUPPORTING DOCUMENTATION

G.1 NRCS Soil Map Unit Descriptions

Photocopies from *Soil Survey, Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona* (Camp, 1986)

...lly, the surface layer is pink cobbly sandy loam ... inch thick. The upper 7 inches of the underlying ...l is light brown very cobbly sandy loam, and the ...part to a depth of 60 inches or more is reddish ...and pink, calcareous very cobbly loamy sand. ...ded in this unit are small areas of variable, ...d sediment recently deposited by intermittent ...ns. The included areas make up about 20 percent ...total acreage. The percentage varies from one ...another.

...meability of this Arizo soil is very rapid. Available ...capacity is very low. Effective rooting depth is 60 ... or more. Runoff is slow, and the hazard of water ...on is severe. Where unprotected, this soil is subject ...casional periods of flooding. Channeling, deposition, ...streambank erosion occur during periods of flooding.

...s unit is used as rangeland and wildlife habitat. ...e soil in this unit is one of the most productive ...eland soils in the survey area. It receives extra ...ture from runoff, which increases production. The ...esponds well to rangeland management. Extra care ...nagement is needed to protect the soil from ...ng and channeling. This unit can produce forage ...round, and it is easily traversed by cattle. Because ...e availability of water, ease of access, and ...dance of feed, some areas of this unit are ...grazed.

...he riparian habitat in some areas of this unit is ...mely important to wildlife.

...few small areas of this unit in the northwestern part ...the survey area receive less precipitation than is ...ypical for the unit. These areas are somewhat less ...productive than are most other areas of the unit.

This map unit is in capability subclass VIIw, nonirrigated. It is in the Sandy Bottom, 10- to 12-inch ... range site.

9—Beeline-Cipriano complex, 3 to 45 percent slopes. This map unit is on fan terraces. The Beeline soil has slopes of 3 to 45 percent, and the Cipriano soil has slopes of 3 to 25 percent. Elevation is 1,300 to 1,700 feet. The average annual precipitation is 7 to 10 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 70 percent Beeline very gravelly sandy loam and 15 percent Cipriano very gravelly loam. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Ebon and Luke soils on flat terrace tops, Gunsight and Rillito soils intermingled with the Beeline and Cipriano soils, and Antho and Carrizo soils in drainageways. Also included are small areas where cemented, sandy conglomerate or ...dpan is exposed. The included areas make up ...ut 15 percent of the total acreage. The percentage varies from one area to another.

The Beeline soil is very shallow and shallow and is well drained. It formed in alluvium derived dominantly from acid and basic igneous rock deposited over strongly cemented, sandy conglomerate. Typically, the surface layer is light reddish brown, calcareous very gravelly sandy loam about 1 inch thick. The next layer is light reddish brown and pink, calcareous sandy loam about 8 inches thick. The underlying material to a depth of 60 inches or more is pink, strongly cemented, sandy conglomerate. Depth to conglomerate ranges from 5 to 20 inches.

Permeability of the Beeline soil is moderately rapid above the cemented, sandy conglomerate and slow through it. Available water capacity is very low. Effective rooting depth is 5 to 20 inches. Runoff is medium, and the hazard of water erosion is moderate.

The Cipriano soil is very shallow and shallow and is well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the Cipriano soil is light brown, calcareous very gravelly loam about 6 inches deep over a lime-cemented hardpan. Depth to the hardpan ranges from 4 to 20 inches.

Permeability of the Cipriano soil is moderate. Available water capacity is very low. Effective rooting depth is 4 to 20 inches. Runoff is medium, and the hazard of water erosion is moderate.

This unit is used as rangeland and wildlife habitat.

The Beeline and Cipriano soils are among the least productive rangeland soils in the survey area. They respond very slowly to rangeland management. The high content of lime and the very low available water capacity contribute to the low productivity of the soils. The included soils in drainageways are much more productive than the other soils in the unit. Management of this unit should therefore be concentrated on these included soils, because they produce nearly all the available forage.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Limy Upland, 7- to 10-inch p.z., range site.

10—Brios-Carrizo complex, 1 to 5 percent slopes. This map unit is on flood plains, in drainageways of the Agua Fria River, and in the larger desert drainageways (fig. 2). Elevation is 1,000 to 2,100 feet. The average annual precipitation is 7 to 10 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 40 percent Brios loamy sand and 40 percent Carrizo very gravelly sand. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Antho, Gilman, Maripo, and Vint soils on slightly higher benches adjacent to the main drainageways. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

Figure 2.—An area of Brios-Carrizo complex, 1 to 5 percent slopes, in a drainageway. The steeper areas are Gachado-Lomitas-Rock outcrop complex, 7 to 55 percent slopes.

The Brios soil is deep and somewhat excessively drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is pale brown loamy sand about 2 inches thick. The underlying material to a depth of 60 inches or more is pinkish gray and pale brown, stratified fine sandy loam, sand, and gravelly coarse sand. This soil is calcareous below a depth of 21 inches.

Permeability of the Brios soil is rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is severe. Where unprotected, this soil is subject to occasional periods of flooding. Channeling, deposition, and streambank erosion occur during periods of flooding.

The Carrizo soil is deep and excessively drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the soil is pinkish gray, calcareous very gravelly sand and very gravelly coarse sand to a depth of 60 inches or more.

Permeability of the Carrizo soil is very rapid. Availab water capacity is very low. Effective rooting depth is 6(inches or more. Runoff is slow, and the hazard of wat(erosion is severe. Where unprotected, this soil is subje to occasional periods of flooding. Channeling, depositi and streambank erosion occur during periods of floodi

This unit is used as rangeland and wildlife habitat.

The soils in this unit are among the most productive rangeland soils in the survey area. They receive extra moisture from runoff, which increases production. The soils respond well to rangeland management. Extra ca in management is needed to protect the soils from gullying and channeling. These soils can produce fora year round, and they are easily traversed by cattle. Because of the availability of water, ease of access, a

abundance of feed, areas of these soils are often overgrazed.

The riparian habitat in some areas of this unit is extremely important to wildlife.

This map unit is in capability subclass VIIw, nonirrigated. It is in the Sandy Bottom, 7- to 10-inch p.z., range site.

11—Brios-Carrizo complex, low precipitation, 1 to 5 percent slopes. This map unit is on flood plains, in drainageways of the Hassayampa River, and in the larger desert drainageways. Elevation is 1,000 to 2,100 feet. The average annual precipitation is 2 to 7 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 40 percent Brios loamy sand and 40 percent Carrizo very gravelly sand. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Antho, Gilman, Maripo, and Vint soils on slightly higher benches adjacent to the main drainageways. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

The Brios soil is deep and somewhat excessively drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is pale brown loamy sand about 2 inches thick. The underlying material to a depth of 60 inches or more is pinkish gray and pale brown sand and gravelly coarse sand. This soil is calcareous below a depth of 21 inches.

Permeability of the Brios soil is rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is severe. Where unprotected, this soil is subject to occasional periods of flooding. Channeling, deposition, and streambank erosion occur during periods of flooding.

The Carrizo soil is deep and excessively drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the soil is pinkish gray, calcareous very gravelly sand and very gravelly coarse sand to a depth of 60 inches or more.

Permeability of the Carrizo soil is very rapid. Available water capacity is very low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is severe. Where unprotected, this soil is subject to occasional periods of flooding. Channeling, deposition, and streambank erosion occur during periods of flooding.

This unit is used as rangeland and wildlife habitat.

The soils in this unit are among the most productive rangeland soils in the area. They receive extra moisture from runoff, which increases production. The soils respond well to rangeland management. Extra care in management is needed to protect the soils from gullying and channeling. These soils can produce forage year round, and they are easily traversed by cattle. Because of the availability of water, ease of access, and abundance of feed, areas of these soils are often overgrazed.

The riparian habitat in some areas of this unit is extremely important to wildlife.

This map unit is in capability subclass VIIw, nonirrigated. It is in the Sandy Bottom, 2- to 7-inch p.z., range site.

12—Carefree cobbly clay loam, 1 to 8 percent slopes. This deep and well drained soil is on fan terraces. It formed in alluvium derived dominantly from acid and basic igneous rock. Elevation is 1,200 to 2,200 feet. The average annual precipitation is 7 to 10 inches, and the average annual air temperature is 70 to 73 degrees F.

Typically, the surface layer is pink, calcareous cobbly clay loam about 1 inch thick. The subsoil is light reddish brown, calcareous clay about 49 inches thick over light brown, calcareous very cobbly clay that extends to a depth of 60 inches or more.

Included in this unit are small areas of Beardsley, Contine, Ebon, and Suncity soils on fan terraces and Gadsden soils on flood plains. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

Permeability of this Carefree soil is slow. Available water capacity is high. Effective rooting depth is 60 inches or more. Runoff is slow to medium, and the hazard of water erosion is slight.

Most areas of this unit are used as rangeland or wildlife habitat. A few areas are used for urban development.

This unit has moderate to high potential for producing forage. It responds well to rangeland management. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation. Tobosa, the dominant forage species, is unpalatable when cured and therefore should be used during the growing season. Fencing and developing watering facilities help to contro grazing.

If the soil in this unit is used as sites for buildings or roads, the main limitation is the shrink-swell potential. The effects of shrinking and swelling can be reduced by maintaining a constant moisture content in the soil. Runoff should be diverted away from buildings. Landscaping plants that require little water should be used near building foundations, and overwatering should be avoided. A sealer can be used under roads to preven the shrinking and swelling of the material below. The effects of shrinking and swelling on building foundations can be minimized by using an appropriate engineering design and by backfilling with material that has a low shrink-swell potential. In addition, more reinforcement can be provided.

If the soil in this unit is used for septic tank absorption fields, the main limitation is the slow permeability. This limitation can be minimized by increasing the size of the

content of large stones. The cuts needed to provide nearly level building sites or roadbeds can expose the hardpan and bedrock, which are difficult to excavate. Ripping or blasting, or both, may be necessary. Because of the steepness of slope, extensive cutting and filling are necessary to create a level building site. Fill areas should be compacted to the same density as cut areas. Cuts and fills are highly susceptible to erosion. Erosion can be controlled by using diversions or terraces to reduce the length of slopes or by revegetating to slow runoff.

If the soil in this unit is used for septic tank absorption fields, the main limitations are the depth to the cemented hardpan and to bedrock, the slope, and the content of large stones. Septic tank absorption fields may not operate properly in some areas of this unit. The depth to the hardpan and to bedrock restricts the movement of effluent. Effluent is likely to flow through cracks in the rock, resulting in little filtration. Steepness of slope makes it difficult to control the distribution of effluent. Effluent can move along the surface of the bedrock and seep to the surface downslope, creating a hazard to health. Alternatives include locating absorption fields in more suitable soils in adjacent areas and transporting the effluent to them by pipeline or installing community sewage systems.

Onsite investigation is needed to determine the most suitable alternatives and the best design of buildings, roads, and septic tank absorption fields.

This map unit is in capability subclass VIIe, nonirrigated. It is in the Basalt Hills, 7- to 10-inch p.z., range site.

19—Chuckawalla-Gunsight complex, 1 to 8 percent slopes. This map unit is on fan terraces. The Chuckawalla soil has slopes of 1 to 3 percent, and the Gunsight soil has slopes of 1 to 8 percent. Elevation is 1,200 to 1,600 feet. The average annual precipitation is 7 to 10 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 45 percent Chuckawalla extremely gravelly loam and 35 percent Gunsight very gravelly loam. The Chuckawalla soil is on the tops of fan terraces, and the Gunsight soil is on the sides of fan terraces. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Sal, Pinamt, and Tremant soils in areas of fan terraces that do not have a desert pavement; Rillito soils on side slopes; and Antho, Gilman, and Maripo soils on flood plains. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

The Chuckawalla soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, 85 to 95 percent of the surface is covered with varnished desert pavement. The surface layer is light brown extremely gravelly loam about 2 inches thick. The upper 4 inches of the subsoil is light brown, calcareous very gravelly sandy clay loam, and the lower 8 inches is yellowish red, saline extremely gravelly sandy clay loam. The substratum to a depth of 60 inches or more is white, calcareous extremely gravelly sandy loam.

Permeability of the Chuckawalla soil is moderate. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is rapid, and the hazard of water erosion is slight.

The Gunsight soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is light brown, calcareous very gravelly loam about 3 inches thick. The underlying material to a depth of 60 inches or more is light brown, calcareous very gravelly loam and pinkish gray very gravelly sandy loam.

Permeability of the Gunsight soil is moderate. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is medium, and the hazard of water erosion is slight.

This unit is used mainly as rangeland and wildlife habitat.

The soils in this unit are among the least productive rangeland soils in the survey area. They respond very slowly to rangeland management. The high content of lime and the low available water capacity contribute to the low productivity of this unit. The included Antho, Gilman, and Maripo soils on flood plains are much more productive than the other soils in the unit. Management of this unit should therefore be concentrated on these included soils because they produce nearly all the available forage.

This map unit is in capability subclass VIIs, nonirrigated. The Chuckawalla soil is in the Saline Upland (Loamy), 7- to 10-inch p.z., range site, and the Gunsight soil is in the Limy Upland, 7- to 10-inch p.z., range site.

20—Chuckawalla-Gunsight complex, low precipitation, 1 to 8 percent slopes. This map unit is on fan terraces. The Chuckawalla soil has slopes of 1 to 3 percent, and the Gunsight soil has slopes of 1 to 8 percent. Elevation is 1,200 to 1,600 feet. The average annual precipitation is 2 to 7 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 45 percent Chuckawalla extremely gravelly loam and 35 percent Gunsight very gravelly loam (fig. 4). The Chuckawalla soil is on the tops of fan terraces, and the Gunsight soil is on the sides of fan terraces. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Figure 4.—Typical area of Chuckawalla-Gunsight complex, low precipitation, 1 to 8 percent slopes. A desert pavement is on the Chuckawalla soil. Most of the vegetation is produced on the Gunsight soil.

Included in this unit are small areas of Sal, Pinamt, and Tremant soils in areas of fan terraces that do not have a desert pavement; Rillito soils on side slopes; and Antho, Gilman, and Maripo soils on flood plains. Also included are small areas of soils, adjacent to the Hassayampa River, that have slopes of as much as 45 percent. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

The Chuckawalla soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, 85 to 95 percent of the surface is covered with varnished desert pavement. The surface layer is light brown extremely gravelly loam about 2 inches thick. The upper 4 inches of the subsoil is light brown, calcareous very gravelly sandy clay loam, and the lower 8 inches is yellowish red, saline extremely gravelly sandy clay loam. The substratum to a depth of 60 inches or more is white, calcareous extremely gravelly sandy loam.

Permeability of the Chuckawalla soil is moderate. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is rapid, and the hazard of water erosion is slight.

The Gunsight soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is light brown, calcareous very gravelly loam about 3 inches thick. The underlying material to a depth of 60 inches or more is light brown, calcareous very gravelly loam and pinkish gray very gravelly sandy loam.

Permeability of the Gunsight soil is moderate. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is medium, and the hazard of water erosion is slight.

This unit is used mainly as rangeland and wildlife habitat.

The soils in this unit are among the least productive rangeland soils in the survey area. They respond very slowly to rangeland management. The high content of lime and the low available water capacity contribute to the low productivity of this unit. The included Antho, Gilman, and Maripo soils on flood plains are much more productive than the other soils in the unit. Management of this unit should therefore be concentrated on these included soils because they produce nearly all the available forage.

This map unit is in capability subclass VIIs, nonirrigated. The Chuckawalla soil is in the Saline Upland (Loamy), 2- to 7-inch p.z., range site, and the Gunsight soil is in the Limy Upland, 2- to 7-inch p.z., range site.

21—Cipriano very gravelly loam. This very shallow and shallow, well drained soil is on fan terraces. It formed in alluvium derived dominantly from acid and basic igneous rock. Slope is 0 to 3 percent. Elevation is 1,200 to 2,200 feet. The average annual precipitation is 7 to 10 inches, the average annual air temperature is 70 to 73 degrees F.

Typically, the surface layer is light brown, calcareous very gravelly loam about 1 inch thick. The underlying material is light brown, calcareous very gravelly loam about 5 inches thick over a light brown and pinkish gray, silica- and lime-cemented hardpan. In a few areas the soil is slightly less gravelly than is typical. Depth to the hardpan ranges from 4 to 20 inches.

Included in this unit are small areas of Cherioni soils on low hills, Gunsight and Suncity soils on fan terraces, and soils that have slopes of as much as 20 percent. Also included are areas of Rock outcrop and Carrizo soils in drainageways. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

Permeability of this Cipriano soil is moderate. Available water capacity is very low. Effective rooting depth is 4 to 20 inches. Runoff is medium, and the hazard of water erosion is slight.

Most areas of this unit are used as rangeland and wildlife habitat. A few areas are used for urban development.

The soil in this unit is one of the poorest forage-producing soils in the survey area. It responds very slowly to rangeland management. The high content of lime and the low available water capacity contribute to the low productivity of this unit. The included Carrizo soils in drainageways are much more productive than the rest of the unit. Management of this unit should therefc be concentrated on these included soils.

If the soil in this unit is used as sites for buildings or roads, the main limitation is the depth to the hardpan. The limited depth to the hardpan interferes with excavation, and ripping the pan may be neccesary.

If the soil in this unit is used for septic tank absorptic fields, the main limitation is the depth to the hardpan. The hardpan restricts the movement of effluent. Efflue may saturate the soil to the surface in nearly level are and it may seep to the surface downslope in steeper areas. Where the hardpan is thin and is underlain by more permeable material, the pan can be ripped and t absorption lines placed below it. Because of the restricted soil depth, the size of the absorption field m have to be increased. In some areas the size of the absorption field needed may exceed the lot size. Alternatives include locating absorption fields in more suitable adjacent areas or installing community sewag systems.

Onsite investigation is needed to determine the mos suitable alternatives and the best design of buildings, roads, and septic tank absorption fields.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Limy Upland, 7- to 10-inch p.z., range site.

22—Contine clay loam. This deep and well drained soil is on fan terraces. It formed in alluvium derived dominantly from acid and basic igneous rock. Slope is to 3 percent. Most of the areas used as cropland have slope of less than 1 percent. Elevation is 1,200 to 2,2C feet. The average annual precipitation is 7 to 10 inche the average annual air temperature is 70 to 73 degree F.

Typically, the surface layer is brown, calcareous clay loam about 2 inches thick. The subsoil is reddish brow calcareous clay loam and clay 28 inches thick. The substratum to a depth of 60 inches or more is light reddish brown, calcareous sandy loam. In some areas this soil is affected by salts and sodium.

Included in this unit are small areas of Carefree, Ebc and Mohall soils on fan terraces. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

Permeability of this Contine soil is slow. Available water capacity is high. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of wat erosion is slight. A few areas of this soil on the Gener Motors proving grounds are subject to rare periods of flooding.

This unit is used as irrigated cropland, as rangeland, as wildlife habitat, and for urban development.

If this unit is used as irrigated cropland, the main limitation is slow permeability. The design of the irrigat system should insure that water adequately permeates the soil. Sprinkler irrigation systems are not well suited

and, in the Ohaco soil, the depth to the hardpan. The effects of shrinking and swelling can be reduced by maintaining a constant moisture content in the soil. Runoff should be diverted away from buildings. Landscaping plants that require little water should be used near building foundations, and overwatering should be avoided. A sealer can be used under roads to prevent shrinking and swelling of the material below. The effects of shrinking and swelling on building foundations can be minimized by using an appropriate engineering design and by backfilling with material that has low shrink-swell potential. In addition, more reinforcement can be provided. The limited depth to the hardpan interferes with excavation. Ripping the pan may be necessary.

If the soils in this unit are used for septic tank absorption fields, the main limitations are the slow permeability and, in the Ohaco soil, the depth to the hardpan. The limitation of slow permeability can be minimized by increasing the size of the absorption field and by backfilling excavations with gravelly or sandy material.

In the Ohaco soil, the hardpan restricts the movement of effluent. Where the hardpan is thin and is underlain by more permeable material, the pan can be ripped and the absorption lines placed below it. In some areas the size of the absorption field needed may exceed the lot size. Alternatives include locating absorption fields in more suitable soils in adjacent areas or installing community sewage systems. Poor design of septic tank absorption fields can seriously compound shrink-swell problems when foundations are installed close to the absorption fields.

Onsite investigation is needed to determine the most suitable alternatives and the best design of buildings, roads, and septic tank absorption fields.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Clayey Upland, 10- to 12-inch p.z., range site.

29—Denure-Momoli-Carrizo complex. This map unit is on fan terraces. Slope is 0 to 3 percent. Elevation is 1,400 to 2,200 feet. The average annual precipitation is 7 to 10 inches, the average annual air temperature is 70 to 73 degrees F.

This unit is about 40 percent Denure fine sandy loam, 30 percent Momoli gravelly sandy loam, and 20 percent Carrizo gravelly sandy loam. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Gilman, Maripo, and Carrizo soils on flood plains. The included areas make up about 10 percent of the total acreage. The percentage varies from one area to another.

The Denure soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is light brown fine sandy loam about 2 inches thick. The underlying material to a depth of 60 inches or more is light brown sandy loam and gravelly sandy loam. This soil is calcareous below a depth of about 8 inches. In some areas the surface layer is gravelly sandy loam.

Permeability of the Denure soil is moderately rapid. Available water capacity is moderate. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

The Momoli soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is light brown gravelly sandy loam about 10 inches thick. The next layer is light brown, calcareous very gravelly and extremely gravelly sandy loam about 22 inches thick. The substratum to a depth of 60 inches or more is brown extremely gravelly sandy loam. In some areas the surface layer is sandy loam or very gravelly sandy loam.

Permeability of the Momoli soil is moderately rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

The Carrizo soil is deep and excessively drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is brown gravelly sandy loam about 10 inches thick. The upper 13 inches of the underlying material is light brown very gravelly loamy sand, and the lower part to a depth of 60 inches or more is light brown, calcareous extremely gravelly sand.

Permeability of the Carrizo soil is very rapid. Available water capacity is very low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

This unit is used as rangeland and wildlife habitat.

The soils in this unit have moderate potential for producing forage. They respond well to rangeland management. Where the range is in good or excellent condition, the soils produce forage year round. They are easily traversed by livestock. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation. Fencing and developing watering facilities help to control grazing. To control erosion, extra care must be taken to maintain a good plant cover. In a few areas these soils are calcareous in the surface layer and are therefore less productive than in most other areas of the unit.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Sandy Loam Upland, 7- to 10-inch p.z., range site.

30—Denure-Momoli-Carrizo complex, low precipitation. This map unit is on fan terraces. Slope is 0 to 3 percent. Elevation i s 1,400 to 2,200 feet. The average annual precipitation is 2 to 7 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 40 percent Denure fine sandy loam, 30 percent Momoli gravelly sandy loam, and 20 percent

Carrizo gravelly sandy loam. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Gilman, Maripo, and Carrizo soils on flood plains. The included areas make up about 10 percent of the total acreage. The percentage varies from one area to another.

The Denure soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is light brown fine sandy loam about 2 inches thick. The underlying material to a depth of 60 inches or more is light brown fine sandy loam and gravelly sandy loam. The soil is calcareous below a depth of about 8 inches. In some areas the surface layer is gravelly sandy loam.

Permeability of the Denure soil is moderately rapid. Available water capacity is moderate. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

The Momoli soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is light brown gravelly sandy loam about 10 inches thick. The next layer is light brown, calcareous very gravelly and extremely gravelly sandy loam about 22 inches thick. The substratum to a depth of 60 inches or more is brown extremely gravelly sandy loam. In some areas the surface layer is sandy loam or very gravelly sandy loam.

Permeability of the Momoli soil is moderately rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

The Carrizo soil is deep and excessively drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is brown gravelly sandy loam about 10 inches thick. The upper 13 inches of the underlying material is light brown very gravelly loamy sand, and the lower part to a depth of 60 inches or more is light brown, calcareous extremely gravelly sand.

Permeability of the Carrizo soil is very rapid. Available water capacity is very low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

This unit is used as rangeland and wildlife habitat.

The soils in this unit have low potential for producing forage. They respond well to seasonal rangeland management. Where the range is in good or excellent condition, the soils produce forage year round. They are easily traversed by livestock. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation. Fencing and developing watering facilities help to control grazing. To control erosion, extra care must be taken to maintain a good plant cover.

The soils in areas of this unit west of Tonopah commonly are calcareous throughout and are less productive than in most other areas of the unit.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Sandy Loam Upland, 2- to 7-in p.z., range site.

31—Dixaleta-Rock outcrop complex, 25 to 65 percent slopes. This map unit is on mountain slopes and hill slopes. Elevation is 1,800 to 3,000 feet. The average annual precipitation is 10 to 12 inches, and th average annual air temperature is 66 to 70 degrees F.

This unit is about 55 percent Dixaleta extremely channery sandy loam and 35 percent Rock outcrop. Tl components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Ohaco, Nickel Cave, and Eba soils on fan terraces, Gran and Lehmar soils on mountain slopes, and exposed volcanic ash deposits. The included areas make up about 10 percer of the total acreage. The percentage varies from one area to another.

The Dixaleta soil is very shallow and shallow and is well drained. It formed in alluvium and colluvium derive dominantly from schist. Typically, the surface layer is yellowish brown extremely channery sandy loam about inch thick. The subsoil is yellowish brown, calcareous extremely channery sandy loam about 7 inches thick. Below this to a depth of 27 inches is highly fractured a partially weathered schist. Unweathered schist is at a depth of 27 inches. In some areas this soil is noncalcareous throughout.

Permeability of the Dixaleta soil is moderate. Availabl water capacity is very low. Effective rooting depth is les than 20 inches. Runoff is medium to rapid, and the hazard of water erosion is moderate.

Rock outcrop consists of exposed areas of granite, andesite, and vertically oriented schist.

This unit is used mainly as rangeland and wildlife habitat. A few areas are used for urban development.

The Dixaleta soil has moderate potential for producin forage. It responds moderately well to rangeland management. It can produce forage year round. Areas this soil generally are not so steep and are easier for livestock to traverse than are other mountainous parts the survey area. Fencing and developing watering facilities help to improve distribution of livestock. Permitting a large number of livestock to graze for shor periods of time promotes an efficient distribution of livestock and use of available forage. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation.

If this unit is used as sites for buildings or roads, the main limitations are depth to rock, the areas of Rock outcrop, and slope. The cuts needed to provide nearly level building sites or roadbeds can expose soft bedroc that is relatively easy to excavate. Hard rock may be encountered in some areas. Because of the steepness of slope, extensive cutting and filling are necessary to

grasses and forbs can support grazing for about 2 to 3 months. Little forage is available during the rest of the year.

A few areas of this unit are in lower positions that receive extra moisture from runoff. These areas are far more productive than is typical for the unit. A few small areas west of the White Tank Mountains receive less precipitation than is typical for the unit. These areas are somewhat less productive than most other areas of the unit.

If this unit is used as irrigated cropland, it has few limitations. Generally, leveling cuts can be made to a depth of about 40 inches without exposing unfavorable soil material. An onsite investigation is advisable, however, before irrigation systems are planned and leveling cuts are made. Applying manure or cotton gin trash or plowing under crop residue or green manure crops improves tilth and increases the water intake rate. Keeping tillage to a minimum and varying the plowing depth help to maintain soil tilth.

If this unit is used as sites for buildings or roads, the main limitation is the hazard of flooding. The unit is subject to localized flooding from overland flow, particularly during high intensity thunderstorms of short duration. Foundations built on this unit should be placed on elevated fill material, and yards should be graded way from the foundations so that surface water will flow ay from the buildings.

If this unit is used for septic tank absorption fields, the main limitation is the hazard of flooding. In areas that are subject to flooding, sewerlines should be connected to a community sewage system to minimize the possibility of contaminating ground water and creating a hazard to health.

Onsite investigation is needed to determine the most suitable alternatives and the best design of buildings, roads, and septic tank absorption fields.

This map unit is in capability class I, irrigated, and in capability subclass VIIc, nonirrigated. The Gilman loam that is noncalcareous in the upper 5 inches is in the Loamy Upland, 7- to 10-inch p.z., range site, and the Gilman loam that is calcareous throughout is in the Limy Fan, 7- to 10-inch p.z., range site.

56—Gilman loams, low precipitation. These deep and well drained soils are on flood plains and alluvial fans. They formed in alluvium derived dominantly from acid and basic igneous rock. Slope is 0 to 3 percent. Elevation is 1,100 to 2,200 feet. The average annual precipitation is 2 to 7 inches, and the average annual air temperature is 70 to 73 degrees F.

About 40 percent of this unit is Gilman loam that is noncalcareous in the upper 5 inches and is calcareous below, and 40 percent is Gilman loam that is calcareous ughout. The components of this unit are so intricately mingled that it was not practical to map them separately at the scale used.

Typically, the upper 5 inches of these Gilman soils is reddish yellow loam. The next 38 inches is reddish yellow loam and very fine sandy loam. Below this to a depth of 60 inches or more is reddish yellow fine sandy loam.

Included in this unit are small areas of Antho and Carrizo soils in drainageways; Estrella, Glenbar, and Vint soils scattered throughout the unit; and Denure, Momoli, and Carrizo soils on fan terraces. Also included are small areas of soils that are similar to these Gilman soils but are underlain by very gravelly sand at a depth of less than 40 inches. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

Permeability of these Gilman soils is moderate. Available water capacity is high. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight. Where unprotected, these soils are subject to rare periods of flooding.

This unit is used mainly as rangeland and wildlife habitat. A few areas are used as irrigated cropland.

In areas where the soils in this unit are noncalcareous in the upper 5 inches, they have moderate potential for producing forage and respond well to rangeland management. Where the range is in good or excellent condition, it produces forage year round. The soils are easily traversed by livestock. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation. Fencing and developing watering facilities help to control grazing.

In areas where the soils are calcareous throughout, they have low potential for producing forage and respond slowly to rangeland management. Most of the vegetation is produced following rainfall in winter and spring. In favorable winters, the production of annual grasses and forbs can support grazing for about 2 to 3 months. Little forage is available during the rest of the year.

A few areas of this unit are in lower positions that receive extra moisture from runoff. These areas are far more productive than is typical for the unit.

If this unit is used as irrigated cropland, it has few limitations. Generally, leveling cuts can be made to a depth of about 40 inches without exposing unfavorable soil material. An onsite investigation is advisable, however, before irrigation systems are planned and leveling cuts are made. Applying manure or cotton gin trash or plowing under crop residue or green manure crops improves tilth and increases the water intake rate. Keeping tillage to a minimum also helps to maintain soil tilth.

This map unit is in capability class I, irrigated, and in capability subclass VIIc, nonirrigated. The Gilman loam that is noncalcareous in the upper 5 inches is in the Loamy Upland, 2- to 7-inch p.z., range site, and the Gilman loam that is calcareous throughout is in the Limy Fan, 2- to 7-inch p.z., range site.

of 60 inches or more is reddish yellow fine sandy loam, very fine sandy loam, and loam. This soil is calcareous below a depth of about 8 inches.

Permeability of the Gilman soil is moderate. Available water capacity is high. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight. Where unprotected, this soil is subject to rare periods of flooding.

The Momoli soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the upper 10 inches is light brown gravelly sandy loam. The next 12 inches is light brown, calcareous gravelly sandy loam. Below this to a depth of 60 inches or more is light brown, calcareous extremely gravelly sandy loam. In some areas this soil is noncalcareous to a depth of 18 inches or more.

Permeability of the Momoli soil is moderately rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

The Denure soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the upper 9 inches is light brown gravelly sandy loam. Below this to a depth of 60 inches or more is light brown, calcareous gravelly sandy loam. In some areas the soil is fine sandy loam or sandy loam throughout. In some areas this soil is noncalcareous to a depth of 16 inches or more.

Permeability of the Denure soil is moderately rapid. Available water capacity is moderate. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

This unit is used as rangeland and wildlife habitat.

This unit has moderate potential for producing forage. It responds moderately well to rangeland management. Where the range is in good or excellent condition, the soils in this unit produce forage year round. The unit is easily traversed by livestock. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation. Fencing and developing watering facilities help to control grazing.

This map unit is in capability subclass VIIs, nonirrigated. The Gilman soil is in the Loamy Upland, 7- to 10-inch p.z., range site, and the Momoli and Denure soils are in the Sandy Loam Upland, 7- to 10-inch p.z., range site.

59—Gilman-Momoli-Denure complex, low precipitation. This map unit is on fan terraces and the associated alluvial fans. Slope is 0 to 3 percent. Elevation is 1,400 to 1,800 feet. The average annual precipitation is 2 to 7 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 40 percent Gilman loam, 25 percent Momoli gravelly sandy loam, and 20 percent Denure gravelly sandy loam. The Gilman soil is in broad, flat swales, and the Denure and Momoli soils are on long, narrow, slightly convex ridges. The components of t unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Carrizo soi fan terraces and Antho, Carrizo, Estrella, and Maripo soils on flood plains and in drainageways. The inclu areas make up about 15 percent of the total acreag The percentage varies from one area to another.

The Gilman soil is deep and well drained. It forme alluvium derived dominantly from acid and basic ign rock. Typically, the surface layer is light brown, calcareous loam about 2 inches thick. The underlyin material to a depth of 60 inches or more is reddish yellow, calcareous fine sandy loam, very fine sandy loam, and loam.

Permeability of the Gilman soil is moderate. Availa water capacity is high. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of w erosion is slight. Where unprotected, this soil is subj to rare periods of flooding.

The Momoli soil is deep and well drained. It forme alluvium derived dominantly from acid and basic ign rock. Typically, the upper 22 inches of this soil is lig brown, calcareous gravelly sandy loam. Below this t depth of 60 inches or more is light brown, calcareou extremely gravelly sandy loam.

Permeability of the Momoli soil is moderately rapic Available water capacity is low. Effective rooting dep 60 inches or more. Runoff is slow, and the hazard o water erosion is slight.

The Denure soil is deep and well drained. It forme alluvium derived dominantly from acid and basic ign rock. Typically, this soil is light brown, calcareous gravelly sandy loam throughout. In some areas the s fine sandy loam or sandy loam throughout.

Permeability of the Denure soil is moderately rapic Available water capacity is moderate. Effective rooti depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

This unit is used as rangeland and wildlife habitat.

This unit has low potential for producing forage. It responds slowly to rangeland management. Most of vegetation is produced following rainfall in winter an spring. In favorable winters, the production of annua grasses and forbs can support grazing for about 2 t months. Little forage is available during the rest of t year.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Limy Fan, 2- to 7-inch p.z., r site.

60—Glenbar loams. These deep and well draine soils are on flood plains and alluvial fans. They form alluvium derived dominantly from acid and basic ign rock. Slope is 0 to 3 percent. Most of the areas use cropland have slopes of less than 1 percent. Elevat 1,200 to 2,200 feet. The average annual precipitatio

0—Momoli gravelly sandy loam, 1 to 5 percent opes. This deep and well drained soil is on fan races. It formed in alluvium derived dominantly from d and basic igneous rock. Elevation is 1,400 to 2,200 et. The average annual precipitation is 7 to 10 inches, d the average annual air temperature is 70 to 73 grees F.

Typically, the surface layer is strong brown gravelly ndy loam about 3 inches thick. The subsoil is strong rown very gravelly sandy loam about 23 inches thick. The substratum to a depth of 60 inches or more is rown, calcareous very gravelly sandy loam.

Included in this unit are small areas of Carrizo and Maripo soils on flood plains and Pinamt and Denure soils on fan terraces. The included areas make up about 30 ercent of the total acreage. The percentage varies from ne area to another.

Permeability of this Momoli soil is moderately rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

Most areas of this unit are used as rangeland and ildlife habitat. A few areas are used for urban evelopment.

The soil in this unit has moderate potential for ducing forage. It responds moderately well to land management. Where the range is in good or excellent condition, it produces forage year round. The soil is easily traversed by livestock. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation. Fencing and developing watering facilities help to control grazing. To control erosion, extra care must be taken to maintain a good plant cover.

If this unit is used as sites for buildings, roads, or septic tank absorption fields, it has few limitations. Onsite investigation is needed to determine the most suitable alternatives and the best design of buildings, roads, and septic tank absorption fields.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Sandy Loam Upland, 7- to 10-inch p.z., range site.

91—Momoli-Carrizo complex. This map unit is on fan terraces. Slope is 0 to 3 percent. Elevation is 1,400 to 2,200 feet. The average annual precipitation is 7 to 10 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 45 percent Momoli very gravelly sandy loam and 35 percent Carrizo very gravelly sandy loam. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Mohall, nt, Gunsight, and Chuckawalla soils on slightly terraces, Denure soils scattered throughout the unit, and Gilman, Maripo, and Carrizo soils on flood plains and in drainageways. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

The soils in some areas of this unit south of Pinnacle Peak and west of the McDowell Mountains are noncalcareous to a depth of 20 inches or more. The soils in these areas typically are extremely cobbly or extremely gravelly.

The Momoli soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is pinkish gray, calcareous very gravelly sandy loam about 1 inch thick. Below this to a depth of 60 inches or more is light brown, calcareous very gravelly sandy loam. In some areas this soil is noncalcareous to a depth of 15 inches or more.

Permeability of the Momoli soil is moderately rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

The Carrizo soil is deep and excessively drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is pinkish gray, calcareous very gravelly sandy loam about 2 inches thick. The upper 9 inches of the underlying material is light brown, calcareous very gravelly sandy loam, and the lower part to a depth of 60 inches or more is brown, calcareous extremely gravelly loamy sand. In some areas this soil is noncalcareous to a depth of 15 inches or more.

Permeability of the Carrizo soil is very rapid. Available water capacity is very low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

This unit is used as rangeland and wildlife habitat.

The soils in this unit have moderate potential for producing forage. They respond slowly to rangeland management. Most of the vegetation is produced following rainfall in winter and spring. In favorable winters, the production of annual grasses and forbs can support grazing for about 2 to 3 months. Little forage is available during the rest of the year. In some areas of this unit, west of the McDowell Mountains and south of the Vulture Mountains, the soils are noncalcareous in the surface layer and are therefore more productive than they are in most other areas of the unit.

This map unit is in capability subclass VIIs, nonirrigated. It is in Limy Fan, 7- to 10-inch p.z., range site.

92—Momoli-Carrizo complex, low precipitation. This map unit is on fan terraces. Slope is 0 to 3 percent. Elevation is 1,400 to 2,200 feet. The average annual precipitation is 2 to 7 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 45 percent Momoli very gravelly sandy loam and 35 percent Carrizo very gravelly sandy loam. The components of this unit are so intricately

intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Mohall, Tremant, Gunsight, and Chuckawalla soils on slightly higher terraces, Denure soils scattered throughout the unit, and Gilman, Maripo, and Carrizo soils on flood plains and in drainageways. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

The Momoli soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is pinkish gray, calcareous very gravelly sandy loam about 1 inch thick. Below this is light brown, calcareous very gravelly sandy loam to a depth of 60 inches or more. In some areas this soil is noncalcareous to a depth of 15 inches or more.

Permeability of the Momoli soil is moderately rapid. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

The Carrizo soil is deep and excessively drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is pinkish gray, calcareous very gravelly sandy loam about 2 inches thick. The upper 9 inches of the underlying material is light brown, calcareous very gravelly sandy loam, and lower part to a depth of 60 inches or more is brown, calcareous extremely gravelly loamy sand. In some areas this soil is noncalcareous to a depth of 15 inches or more.

Permeability of the Carrizo soil is very rapid. Available water capacity is very low. Effective rooting depth is 60 inches or more. Runoff is slow, and the hazard of water erosion is slight.

This unit is used as rangeland and wildlife habitat.

The soils in this unit have low potential for producing forage. They respond slowly to rangeland management. Most of the vegetation is produced following rainfall in winter and spring. In favorable winters, the production of annual grasses and forbs can support grazing for about 2 to 3 months. Little forage is available during the rest of the year. In some areas of this unit, the soils are noncalcareous in the surface layer and are more productive than they are in most other areas of the unit.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Limy Fan, 2- to 7-inch p.z., range site.

93—Nickel-Cave complex, 8 to 30 percent slopes. This map unit is on fan terraces. Elevation is 1,800 to 3,000 feet. The average annual precipitation is 10 to 12 inches, and the average annual air temperature is 66 to 70 degrees F.

This unit is about 50 percent Nickel gravelly sandy loam and 35 percent Cave gravelly loam. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Arizo and Anthony soils in drainageways and Pinaleno and Greyeagle soils on fan terraces. Also included are a few areas of soils that have slopes of less than 8 percent. The included areas make up about 15 percent of the total acreage. The percentage varies from one area to another.

The Nickel soil is deep and well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is pinkish gray, calcareous gravelly sandy loam about 1 inch thick. The upper 9 inches of the underlying material is pinkish gray, calcareous gravelly loam, the next 40 inches is pinkish gray, calcareous very gravelly sandy loam, and the lower part to a depth of 60 inches or more is white, calcareous very gravelly loamy sand.

Permeability of the Nickel soil is moderately slow. Available water capacity is low. Effective rooting depth is 60 inches or more. Runoff is medium, and the hazard of water erosion is slight.

The Cave soil is very shallow and shallow and is well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is light brown, calcareous gravelly loam about 1 inch thick. The next layer is pinkish gray, calcareous loam about 13 inches thick over a pinkish white, lime-cemented hardpan that is about 6 inches thick. Below this to a depth of 60 inches or more is pinkish white, calcareous very gravelly sandy loam.

Permeability of the Cave soil is moderate. Available water capacity is very low. Effective rooting depth is less than 20 inches. Runoff is medium, and the hazard of water erosion is slight.

This unit is used as rangeland, as wildlife habitat, and for urban development.

The Nickel soil has moderate potential for producing forage. It responds moderately well to rangeland management. It can produce forage year round. Fencing and developing watering facilities help to control grazing.

The Cave soil is one of the poorest forage-producing soils in the survey area. It responds very slowly to rangeland management. The high content of lime and the low available water capacity contribute to the low productivity of this soil.

If the soils in this unit are used as sites for buildings or roads, the main limitations are the cemented hardpan in the Cave soil and slope. The Nickel soil is better suited to use as sites for buildings and roads than is the Cave soil; therefore, buildings and roads should be located in areas of the Nickel soil if feasible. The cuts needed to provide nearly level building sites or roadbeds can expose a hardpan that may be difficult to excavate. Ripping the pan may be necessary. Because of the steepness of slope, extensive cutting and filling are necessary to create a level building pad. Fill areas

105—Rock outcrop-Lehmans complex, low precipitation, 15 to 65 percent slopes. This map unit is on hill slopes and mountain slopes. Elevation is 1,800 to 4,000 feet. The average annual precipitation is 8 to 10 inches, and the average annual air temperature is 66 to 70 degrees F.

This unit is about 60 percent Rock outcrop and 20 percent Lehmans very gravelly clay loam. The Rock outcrop generally is on mountaintops and the upper part of mountain slopes, and in some areas vertical exposures are common. The Lehmans soil is on the lower part of mountain slopes. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Arizo soils in drainageways and Eba and Pinaleno soils on foot slopes. Also included are small areas of exposed volcanic ash deposits and soils that have more rock fragments or lime than is typical for the Lehmans soil. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

Rock outcrop consists of exposed areas of basalt, andesite, rhyolite, tuff, and agglomerate.

The Lehmans soil is very shallow and shallow and is well drained. It formed in alluvium and colluvium derived dominantly from basalt, andesite, rhyolite, tuff, and agglomerate. The surface layer is reddish brown very gravelly clay loam about 2 inches thick. The subsoil is reddish brown clay and clay loam about 13 inches thick. The substratum is reddish brown very gravelly clay loam 5 inches thick over bedrock.

Permeability of the Lehmans soil is slow. Available water capacity is very low. Effective rooting depth is less than 20 inches. Runoff is rapid, and the hazard of water erosion is moderate.

This unit is used as rangeland and wildlife habitat.

The Lehmans soil has moderate potential for producing forage. It responds well to rangeland management. It can produce forage year round. Steepness of slope, the areas of Rock outcrop, and cobbles and stones on the surface limit use. Fencing and developing watering facilities help to improve distribution of livestock. Permitting a large number of livestock to graze for short periods of time promotes an efficient distribution of livestock and use of available forage. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation.

This map unit is in capability subclass VIIs, nonirrigated. It is in the Volcanic Hills, 8- to 10-inch p.z., range site.

106—Sal-Cipriano complex, 1 to 10 percent slopes. This map unit is on fan terraces. The Sal soil has slopes of 1 to 3 percent, and the Cipriano soil has slopes of 1 to 10 percent. Elevation is 1,200 to 1,600 feet. The average annual precipitation is 7 to 10 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 50 percent Sal extremely gravelly loam and 30 percent Cipriano very gravelly sandy loam. The Sal soil is on the tops of terraces, and the Cipriano soil is on side slopes and in areas on the tops of terraces that do not have a desert pavement. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Gunsight and Rillito soils on the steeper parts of side slopes and Brios and Carrizo soils in drainageways. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

The Sal soil is very shallow and shallow and is well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, 70 to 90 percent of the surface is covered with varnished desert pavement. The surface layer is light brown, calcareous extremely gravelly loam about 2 inches thick. The upper 5 inches of the subsoil is yellowish red, saline very gravelly clay loam, and the lower 13 inches is yellowish red, saline extremely gravelly clay loam. A pinkish white and pink, silica-cemented hardpan is at a depth of 20 inches.

Permeability of the Sal soil is moderately slow. Available water capacity is very low. Effective rooting depth is less than 20 inches. Runoff is rapid, and the hazard of water erosion is slight.

The Cipriano soil is very shallow and shallow and is well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is reddish yellow, calcareous very gravelly sandy loam about 1 inch thick. The upper 8 inches of the underlying material is reddish yellow, calcareous gravelly sandy loam, and the lower part to a depth of 20 inches is reddish yellow, calcareous very gravelly sandy loam. A silica-cemented hardpan is at a depth of 20 inches.

Permeability of the Cipriano soil is moderate. Available water capacity is very low. Effective rooting depth is less than 20 inches. Runoff is slow to medium, and the hazard of water erosion is slight.

This unit is used as rangeland and wildlife habitat.

The soils in this unit are among the least productive rangeland soils in the survey area. They respond very slowly to rangeland management. The high content of lime and the low available water capacity contribute to the low productivity of these soils. The included Brios and Carrizo soils in drainageways are much more productive than the other soils in the unit. Management of the soils in this unit should therefore be concentrated on these included soils, because they produce nearly all the available forage.

This map unit is in capability subclass VIIs, nonirrigated. The Sal soil is in the Saline Upland (Loamy), 7- to 10-inch p.z., range site, and the Cipriano soil is in the Limy Upland, 7- to 10-inch p.z., range site.

107—Sal-Cipriano complex, low precipitation, 1 to 10 percent slopes. This map unit is on fan terraces. The Sal soil has slopes of 1 to 3 percent, and the Cipriano soil has slopes of 1 to 10 percent. Elevation is 1,200 to 1,600 feet. The average annual precipitation is 2 to 7 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 50 percent Sal extremely gravelly loam and 30 percent Cipriano very gravelly sandy loam. The Sal soil is on the tops of terraces, and the Cipriano soil is on the steeper side slopes and in areas on the tops of terraces that do not have a desert pavement. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Gunsight and Rillito soils on the steeper parts of the side slopes and Brios and Carrizo soils in drainageways. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

The Sal soil is very shallow and shallow and is well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, 70 to 95 percent of the surface is covered with varnished desert pavement. The surface layer is light brown, calcareous extremely gravelly loam about 2 inches thick. The upper 5 inches of the subsoil is yellowish red, saline very gravelly clay loam, and the lower 13 inches is yellowish red, saline extremely gravelly clay loam. A silica-cemented hardpan is at a depth of 20 inches.

Permeability of the Sal soil is moderately slow. Available water capacity is very low. Effective rooting depth is less than 20 inches. Runoff is rapid, and the hazard of water erosion is slight.

The Cipriano soil is very shallow and shallow and is well drained. It formed in alluvium derived dominantly from acid and basic igneous rock. Typically, the surface layer is reddish yellow, calcareous very gravelly sandy loam about 1 inch thick. The upper 8 inches of the underlying material is reddish yellow, calcareous gravelly sandy loam, and the lower part to a depth of 20 inches is reddish yellow, calcareous very gravelly sandy loam. A silica-cemented hardpan is at a depth of 20 inches.

Permeability of the Cipriano soil is moderate. Available water capacity is very low. Effective rooting depth is less than 20 inches. Runoff is slow to medium, and the hazard of water erosion is slight.

This unit is used as rangeland and wildlife habitat.

The soils in this unit are among the least productive rangeland soils in the survey area. They respond very slowly to rangeland management. The high content of lime and the low available water capacity contribute to the low productivity of these soils. The included Brios and Carrizo soils in drainageways are much more productive than the other soils in the unit. Management of the soils in this unit should therefore be concentrated on these included soils, because they produce nearly all the available forage.

This map unit is in capability subclass VIIs, nonirrigated. The Sal soil is in the Saline Upland (Loamy), 2- to 7-inch p.z., range site, and the Cipriano soil is in the Limy Upland, 2- to 7-inch p.z., range site.

108—Schenco-Rock outcrop complex, 3 to 25 percent slopes. This map unit is on mountain slopes and hill slopes (fig. 7). Elevation is 1,500 to 2,200 feet. The average annual precipitation is 7 to 10 inches, and the average annual air temperature is 70 to 73 degrees F.

This unit is about 50 percent Schenco extremely channery loam and 30 percent Rock outcrop. The components of this unit are so intricately intermingled that it was not practical to map them separately at the scale used.

Included in this unit are small areas of Antho soils in drainageways; Beardsley, Cherioni, Cipriano, Ebon, Gunsight, and Suncity soils on fan terraces; and Gachado soils on hill slopes. Also included are small areas of Quilotosa and Vaiva soils. The included areas make up about 20 percent of the total acreage. The percentage varies from one area to another.

The Schenco soil is shallow and well drained. It formed in alluvium and colluvium derived dominantly from schist. Typically, the surface layer is reddish brown, calcareous extremely channery loam about 2 inches thick. The subsoil is light reddish brown, calcareous very channery loam about 9 inches thick. Below the subsoil to a depth of 22 inches is highly fractured and partially weathered schist. In some areas this soil is noncalcareous throughout.

Permeability of this Schenco soil is moderate. Available water capacity is very low. Effective rooting depth is less than 20 inches. Runoff is medium, and the hazard of water erosion is slight.

Rock outcrop consists of exposed areas of granite, andesite, and vertically oriented schist.

This unit is used mainly as rangeland and wildlife habitat. A few areas are used for urban development.

The Schenco soil has moderate potential for producing forage. It responds moderately well to rangeland mangement. It can produce forage year round. Areas of this unit generally are not so steep and are easier for livestock to traverse than are other mountainous areas of the survey area. Fencing and developing watering facilities help to improve distribution of livestock. Permitting a large number of livestock to graze for short periods of time promotes an efficient distribution of livestock and use of available forage. Resting pastures during alternate growing seasons helps to maintain or improve the vegetation.

If the soil in this unit is used as sites for buildings or roads, the main limitations are the depth to rock and slope. The cuts needed to provide nearly level building

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SHEET NO. 26
AGUILA-CAREFREE AREA, PARTS OF
MARICOPA AND PINAL COUNTIES, ARIZONA

This soil survey was compiled in 1978 by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies

1 ¾ ½ ¼ 0 1 2 Miles
5000 4000 3000 2000 1000 0 5000 10000 Feet
Scale 1:24000

Orthophotobase compiled from 1972 and 1973 aerial photography by the U.S. Department of The Interior, Geological Survey. Planimetric detail obtained from 7½ minute series maps. 10,000-foot grid based on state coordinate system.

AGUILA — CAREFREE AREA, PARTS OF MARICOPA AND PINAL COUNTIES, ARIZONA NO. 26

Surficial Geology of the Tiger Wash Distributary System

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Introduction

Surficial geologic mapping provides important information about the extent of flood-prone areas on the piedmonts, and it is the best way to delineate areas that may be prone to alluvial-fan flooding. Floods leave behind physical evidence of their occurrence in the form of deposits. Therefore, the extent of young deposits on piedmonts is a good indicator of areas that have been flooded in the past few thousand years, and these are the areas that are most likely to experience flooding in the future. As part of the alluvial fan flood hazard assessment for Tiger Wash in western Maricopa County, we used standard surficial geologic mapping techniques to describe and map surficial deposits of different ages that are associated with the Tiger Wash distributary system. The spatial distribution of deposits of different ages records general patterns of deposition associated with the Tiger Wash system over periods of hundreds of years to tens of thousands of years. This information may be used to evaluate the behavior of the distributary system and delineate areas that have been subject to alluvial fan flooding and other types of flooding over the past few thousand years.

The physical characteristics of alluvial surfaces (alluvial fans, stream terraces, and channels) were used to differentiate their associated deposits by age. Alluvial surfaces of similar age have a distinctive appearance and soil character because they have undergone similar post-depositional modifications, and they are different from both younger and older surfaces. Young alluvial fan surfaces that are less than a few thousand years old still retain clear evidence of the original depositional topography, such as of bars of coarse gravel deposits, swales (trough-like depressions) where low flows passed between bars, and distributary channel networks. Young fan surfaces also show minimal development of soil, desert pavement, and rock varnish, and dissection by the streams that drain them is limited. Old alluvial fan surfaces, in contrast, have been isolated from substantial fluvial deposition or reworking for tens to hundreds of thousands of years. These surfaces are characterized by strongly developed soils with clay- and calcium-carbonate-rich horizons, smooth, closely packed desert pavements between drainages, dark varnish on surface rocks, and well-developed tributary stream networks that are entrenched below the fan surface. The ages of alluvial surfaces in the southwestern United States may be roughly estimated based on these surface characteristics, especially soil development (Gile and others, 1981; Bull, 1991).

We mapped the surficial geology of the Tiger Wash distributary system primarily using color 1:24,000-scale aerial photographs from 1979, which were provided by the U.S. Bureau of Land Management. We also conducted substantial field investigations to document surface characteristics and soil development associated with the various alluvial surfaces and to check contacts between map units. The 1979 aerial photographs substantially pre-date the large flood of 1997, and we did not modify the map to reflect any changes in the extent of various map units caused by the flood. Thus, the map we have produced may be evaluated for its predictive value regarding the inundation associated with this recent flood. In some areas away from the 1997 flood inundation, 1:9,600-scale color aerial photos obtained in 1999 were used to augment our interpretation of the 1979 photos.

Surficial Geologic Map Units

Qyc Late Holocene active channel deposits

General description This unit consists of active channels of Tiger Wash that are large enough to be depicted at the 1:24,000 map scale. These channels convey the majority of bedload sediment from the upper Tiger Wash watershed into the Tiger Wash distributary system.
Distribution and drainage characteristics In the northern map area, channels are topographically confined by middle Holocene to middle Pleistocene alluvial fan deposits (see below for descriptions of these units). In this area, channel character ranges from large, single channels to smaller, multiple braided channels, and cohesive Pleistocene alluvial fan deposits are exposed in channel bed and banks in many places. Farther to the south, topographic confinement of channels is minimal and the drainage pattern is distributary, with channels branching downstream. Channels also exhibit braided patterns, where an intricate network of channels diverge and converge within the active fan. As channels increase in number downslope, they decrease in size and become discontinuous; when channels become too small to represent on the map, they are included in unit Qy2.
Sedimentology Channel sediment is very poorly sorted sand, cobbles, and boulders, with sand and silt deposited on banks and adjacent overbank locations.
Geomorphology/surface topography Relatively flat-bottomed sandy channels are most common, but sand bars, coarser gravel bars, and finer channel fringe deposits are also common.
Soils *Primary depositional layering typically is well preserved, and there is essentially no soil development.*
Vegetation Vegetation consists of moderate to large ironwood, palo verde, and acacia trees and relatively dense cover of smaller bushes along channel banks, but vegetation is small and sparse within channels.
Appearance on aerial photos Channels are light-colored on the ground and on aerial photographs due to minimal vegetation cover and weathering of surface deposits.

Qy2 Late Holocene sheetflood and overbank deposits

General description This unit includes young deposits associated with broad sheetflood areas, terraces and limited overbank areas that are part of the modern drainage system and are at least occasionally inundated. Qy2 deposits comprise most of the active alluvial fan areas within the Tiger Wash distributary drainage system.
Distribution and drainage characteristics These deposits flank channels and are found downstream from them. In the former setting, Qy2 deposits reflect overbank deposition on fairly narrow terraces and on broader sheetflood areas, where channel capacity is exceeded during large floods. In the latter setting, Qy2 deposits reflect the downstream decrease in channel capacity and the increasing importance of unconfined sheetflooding; Qy2 deposits are increasingly extensive downstream in the system. They also occupy strips of variable width along smaller piedmont drainages.
Sedimentology Qy2 sediments typically are fine-grained sand and silt, but they also contain narrow ribbons and broader sheets of coarse sand and fine gravel.
Geomorphology/surface topography Active channels typically are incised less than 0.5 m below these surfaces, but locally Qy2 surfaces are up to 1.5 m above large, confined active channels and scoured gullies. Where flow in large floods is moderately deep, drainage networks on these

surfaces typically consist of intricate, discontinuous, small to very small channels that form complex distributary or braided patterns. In these areas, streamlined vegetation mounds and sand bars are ubiquitous between channels, giving the surface a corrogated texture. Where flow is shallower, channels are very small and the surface between vegetation mounds is relatively smooth.

Soils and surface characteristics Soil development associated with Qy2 surfaces is minimal, and thin, well-preserved bedding is preserved in many places. There is no desert pavement development or rock varnish on surface clasts unless they have been reworked from older deposits.

Vegetation Creosote bushes are the predominant vegetation on Qy2 surfaces, but ironwood, palo verde, and acacia trees exist in proximity to some channels and grass and other small bushes are common locally.

Appearance on aerial photos Qy2 surfaces appear smooth with colors that are various shades of brown on color aerial photos. These characteristics reflect the general absence of dissection of these active depositional surfaces and the color of the deposits and variations in vegetative cover on the surfaces.

Qy1 Early to late Holocene relict alluvial fan and terrace deposits

General description This unit includes young alluvial fan and terrace deposits that have been isolated from active deposition from the Tiger Wash distributary drainage system for tens of years to a few thousand years. Qy1 surfaces are extensive within the modern distributary network of both the east and west branches of Tiger Wash. Their presence indicates that loci of fan deposition within the distributary system have shifted during the past few thousand years.

Distribution and drainage characteristics Qy1 surfaces are drained by a combination of fairly large, entrenched distributary channels associated with Tiger Wash and small tributary drainage networks that head on Qy1 surfaces. Distributary channels are entrenched as much as 2 m below adjacent Qy1 surfaces. The smaller local drainages have formed extensive, unentrenched tributary networks on Qy1 surfaces. These local drainages commonly follow what appear to be abandoned distributary drainage channels ("ghost" channels). On the ground, these abandoned channels are wide and shallow, presumably having been filled in somewhat since they were active.

Sedimentology Qy1 sediments consist primarily of very poorly sorted sand, pebbles, and cobbles, with lesser amounts of small boulders and silt.

Geomorphology/surface topography Surface topography typically is undulating, with local relief of about 0.5 m between coarse gravel bars and finer-grained swales. In areas where Qy1 deposits contain less coarse material, surfaces may be quite smooth. Mounds of eolian sand and silt around creosote bushes are very common on Qy1 surfaces; these mounds typically are 10 to 30 cm higher than the surrounding surface.

Soils and surface characteristics Surfaces are commonly partially covered by loose pebbles and cobbles forming weak desert pavements. These surface clasts have minimal rock varnish unless they have been reworked from older deposits, in which case they may have considerable varnish or relict carbonate coatings. Coarse bedding may be preserved, but finer sedimentary structures have been obscured by bioturbation and soil development. Soil development associated with Qy1 surfaces is weak, with slight development of soil structure and thin, discontinuous carbonate coatings on gravel clasts. Qy1 surfaces typically are slightly higher than surrounding younger and older surfaces.

Vegetation Vegetation on Qy1 surfaces is sparse; creosote is the dominant shrub, with lesser amounts of small cactus and ocotillo. Scattered trees survive along some drainages.
Appearance on aerial photos Qy1 surfaces have a mottled, light to dark gray appearance on color aerial photos.

Ql Late Pleistocene alluvium

General description This unit consists of moderately old relict alluvial fan and terrace deposits that have been isolated from active deposition from the Tiger Wash distributary system for at least 10,000 years. Ql deposits record locations of major fan deposition during the late Pleistocene that were significantly different from the modern system.
Distribution and drainage characteristics Ql deposits are found on the fringes of the Tiger Wash system in the northern part of the map area; farther south, they are found primarily between the main east and west branches of Tiger Wash within the distributary drainage network. Ql surfaces are drained primarily by local tributary channel networks, although they are traversed by a few distributary channels of the Tiger Wash system. These distributary channels are incised 0.5 to 2 m below adjacent Ql surfaces. As with Qy1 surfaces, local drainages appear to follow former distributary channels that are now partially filled with young sediment.
Sedimentology Ql sediments consist of very poorly sorted cobbles, pebbles, sand, small boulders, and silt. Ql deposits are probably the coarsest of any of the surficial units associated with Tiger Wash.
Deposit character/surface topography Ql surfaces are broadly rounded and minimally dissected, with obvious erosion limited to areas adjacent to larger channels. Ql surfaces have moderate local topographic relief because the primary bars and swales are well preserved, although excavations reveal that substantial infilling of swales by younger sediment has occurred. Ql surfaces are distinguished from older Qm surfaces by more local relief and commonly, larger clast size. Ql surfaces may actually be higher in elevation than adjacent Qm surfaces.
Soils and surface characteristics Ql surfaces typically are covered with moderately packed desert pavements composed of varnished pebbles, cobbles and boulders. Exposed surfaces of gravel clasts on relict bars typically are moderately to darkly varnished, with bright orange varnish on their undersides. Pavements are also developed in most swales, but are finer and less varnished. Coarse bedding associated with gravel deposits is preserved, but finer sedimentary structures are not evident. Soil development is weak to moderate, with slight reddening, weak soil structure, and thin, discontinuous carbonate coatings on subsurface gravel clasts.
Vegetation Vegetation on Ql surfaces is sparse; creosote is the dominant shrub, with lesser amounts of small cactus and ocotillo.
Appearance on aerial photos The Ql surface can be distinguished on aerial photos by its medium gray color and "plumose" (feathery) texture where varnished bars appear to fan out in the downslope direction.

Qm Middle Pleistocene alluvial fan deposits

General description This unit consists of old relict alluvial fan deposits that have been isolated from active deposition from the Tiger Wash distributary system for 100,000 years or more.
Distribution and drainage characteristics Extensive Qm relict alluvial fans form both the east and west margins of the Tiger Wash distributary system in the central and northern parts of the map area. Many less extensive Qm surface remnants are preserved within the distributary

system. Based on numerous exposures of Qm deposits in channel bottoms and banks, they also underlie relatively thin younger deposits in many areas. Qm surfaces are drained by well-developed tributary drainage networks that head on the piedmont. Tributary channels are entrenched from up to 3 m below adjacent Qm surfaces.

Sedimentology Qm sediments consist of very poorly sorted cobbles, pebbles, sand, small boulders, and silt. Qm deposits are quite similar in composition to Ql deposits.

Deposit character/surface topography Qm surfaces are remarkably planar between the channels and swales of the tributary drainage network. Concentrations of coarser gravel on Qm surfaces are evidence for relict gravel bars, but topographic relief between bars and swales is commonly less than 10 cm.

Soils and surface characteristics *Qm surfaces are covered by strongly developed, closely packed desert pavements. Surface clasts have dark brown to black varnish, with red coatings on their undersides. Pavement development and varnish are similar on bars and swales. Coarse sedimentary structure in gravel deposits is preserved. Soil development is moderate, with reddened zones of clay accumulation, continuous carbonate coatings and bottom pendants on gravel clasts, and locally weak carbonate cementation. Where Qm surfaces have been eroded, exposure of soil horizons results in slightly red or white surface color.*

Vegetation Vegetation on Qm surfaces is sparse. It consists primarily of clusters of creosote bushes, sparse grasses, and occasional saguaro cactus. Vegetation is concentrated along drainages.

Appearance on aerial photos Qm surfaces appear mottled medium to dark gray and orange on aerial photographs. The gray colors reflect well-preserved desert pavements; the orange color reflects more eroded portions of Qm. Tributary drainages stand out as distinctly darker than adjacent Qm surfaces because of the vegetation concentrated along them.

G gravel pits

Areas that have been profoundly disturbed by sand and gravel mining operations. They are found mainly found along the east branch Tiger Wash, exploiting the gravels of units Qy and Ql.

Discussion – Implications for the extent of alluvial fan flooding on Tiger Wash distributary system

Tiger Wash is typical of many piedmont drainage systems in southern and central Arizona in that the channel network changes from tributary to distributary (branching and diverging downstream) downslope from the mountains. Distributary systems spread water and sediment over wide portions of the piedmont, but the existence of distributary channel networks alone does not imply that the entire system is an active alluvial fan. Portions of distributary drainage systems may be considered active alluvial fans if 1) topographic relief between channels and surfaces between channels is low enough that channel banks along most reaches are overtopped during large floods; and 2) the surfaces between channels are primarily composed of Holocene deposits. The predominance of young deposits implies that most of the area within the distributary channel network has been flooded in the past few thousand years either by sheetflood inundation, changes in channel positions, or both. On active alluvial fans, channels typically are discontinuous and decrease in size downfan. The lowermost parts of these fans are

covered with young, fine-grained deposits indicative of extensive sheetflooding between small channels.

The mapped distribution of surficial deposits of different ages illustrates the general character of the Tiger Wash distributary drainage system and points to areas that are likely to be subject to alluvial fan flooding. In the northern part of the map area, young deposits are quite limited in extent and Tiger Wash is topographically confined by bedrock hills and Pleistocene alluvial fan deposits. Along this reach of Tiger Wash, the channel pattern is braided and very young terraces (unit Qy2) are fairly extensive, but the limits of the flood-prone area are well defined by topography and geology. Tiger Wash becomes a distributary system fairly quickly downstream, dividing into major east and west branches. Extensive Holocene deposits exist along both branches of Tiger Wash below the first distributary split, but very young deposits (units Qy2 and Qyc) are restricted to fairly narrow strips along the main channel systems. In this upper piedmont area, there is up to 3 m of topographic relief between channel bottoms and adjacent older alluvial surfaces (Qm, Ql, and Qyl). Because of the limited extent of very young deposits and the topographic relief in the area, we consider this part of the distributary channel system to be fairly stable, and major shifts in channel position are unlikely.

The lateral extent of Qy2 deposits increases dramatically in the middle piedmont along the east and west branches of Tiger Wash. In these same areas, channel systems are distributary, branching and becoming smaller downstream. The topographic relief across these areas is variable, but generally is less than about 1 m. We consider these areas with extensive Qy2 deposits and distributary channel networks to be active alluvial fans within the larger distributary drainage system. These areas would likely be inundated in large floods, and the potential exists for significant changes in channel patterns. Qy2 deposits are very extensive in the southern part of the map area, and channels are small and discontinuous. We infer that these areas are subject to very broad, relatively shallow sheetflooding during large flow events.

Topographic relief across the piedmont decreases gradually downslope in conjunction with the increase in extent of very young deposits, so that the topography associated with the lateral boundaries of young deposition in the middle and lower piedmont is minimal. The margins of the active alluvial fan areas are almost certainly evolving over time, and the contacts between young and older surficial deposits along the fan margins may be modified during large floods. Although the vast majority of the inundation during the 1997 flood occurred in areas covered by young deposits, we did find field evidence for local burial and erosion of Pleistocene alluvial fan surfaces during the 1997 flood.

Tiger Wash Landforms

Landform	Unit	Name	Significant Distinguishing Characteristics	SCS soils units
Active alluvial fans, active channels	Qyc	Late Holocene Active Channels	composition: active channels soil development: none age: modern surficial features: sandy channels and gravel bars, no desert pavement or rock varnish	Brios-Carrizo (10,11)
Active alluvial fans, alluvial plains	Qy2	Late Holocene sheetflood and overbank deposits	composition: sheetflood areas, terraces, and limited overbank areas which are occasionally flooded soil development: minimal age: modern surficial features: fine grained, locally shallow channels (incision < 0.5 m), no desert pavement or rock varnish	Brios-Carrizo (11), Gilman (56), Gilman-Momoli-Denure (59)
Active and Inactive alluvial fans	Qy1	Early to late Holocene relict alluvial fan and terrace deposits	composition: alluvial fan and terrace deposits soil development: weak, slight structure, thin discontinuous carbonate coatings on clasts age: isolated from depostion hundreds to a few thousand years surficial features: weak desert pavement, minimal rock varnish, distributary channels entrenched to 2 m and extensive unentrenched tributary channels heading on Qy1	Brios-Carrizo (11), Denure-Momoli-Carrizo (30), Momoli-Carrizo (92)
Relict fan	Ql	Late Pleistocene alluvium	composition: moderately old relict alluvial fan and terrace deposits soil development: weak to moderate, slight reddening, weak structure, and thin discontinuous carbonate coatings on clasts age: isolated from deposition for > 10,000 years surfical features: moderately packed desert pavement, moderately to darkly varnished with bright orange undersides, drained by local tributary channels, traversed by a few distributary channels which are incised 0.5-2 m	Chuckwalla-Gunsight (19,20), Momoli-Carrizo (92), Sal-Cipriano (106,107)
Relict fan	Qm	Middle Pleistocene alluvial fan deposits	composition: old relict alluvial fan deposits soil development: moderate, reddened zones of clay accumulation, continuous carbonate coatings, locally weak carbonate cementation age: isolated from deposition for > 100,000 years surficial features: strongly developed desert pavement with dark brown to black varnish with red coatings on undersides, well-developed tributary drainage networks, channels incised up to 3 m	Chuckwalla-Gunsight (19,20), Denure-Momoli-Carrizo (30), Momoli-Carrizo (92), Sal-Cipriano (106,107)
Adapted from Assignment No. 2, Task 3, Surficial Geology Mapping, by AZGS (Klawon and Pearthree, 1999)				

Mapping of the extent of inundation during the September 1997 flood on the Tiger Wash distributary system

The 1997 flood on Tiger Wash provides an unusual opportunity to characterize the spatial characteristics of flow during a large flood in a distributary flow system. The 1997 flood on the Tiger Wash distributary system left abundant evidence of the extent of inundation. In the spring of 1999, Arizona Geological Survey geologists J.E. Klawon and P.A. Pearthree used indicators such as fresh sediment, flotsam, and fresh scour to document the maximum extent of flood inundation. The extent of inundation was then mapped on a post-flood aerial photo base. The resultant composite map of flood inundation details the spatial characteristics of this large flood through much of the Tiger Wash distributary system.

Several kinds of evidence were used to map the extent of inundation in the field. (1) The most ubiquitous evidence of the flood is freshly transported sediment. In areas of deeper inundation, fresh sediment typically is light-colored sand and locally gravel. This sediment partially buries vegetation of various sizes, and in many places sand bars were deposited on the lee sides of vegetation. In areas of shallower flow, fresh sediment typically is fine sand, silt and clay. The color of this fine-grained sediment is typically slightly redder than deposits that pre-date the flood. In true slackwater areas, the fine sediment deposited by the flood commonly developed moderately large mud cracks as it dried. (2) Flotsam (floated organic debris) is also a very common indicator of flow. Flotsam around the margins of inundation is especially valuable, because it floats and marks the maximum extent of the water surface. Flotsam was also observed in trees and bushes in areas of deeper flow. (3) Evidence of fresh scour and gully formation was also very common. In these areas, it was evident that the surface had recently been swept clean or substantially altered. In some areas, relatively old (Pleistocene) deposits were freshly exposed in stream channels. In areas of sheet flooding, scour commonly was focused between bushes or exploited animal burrows.

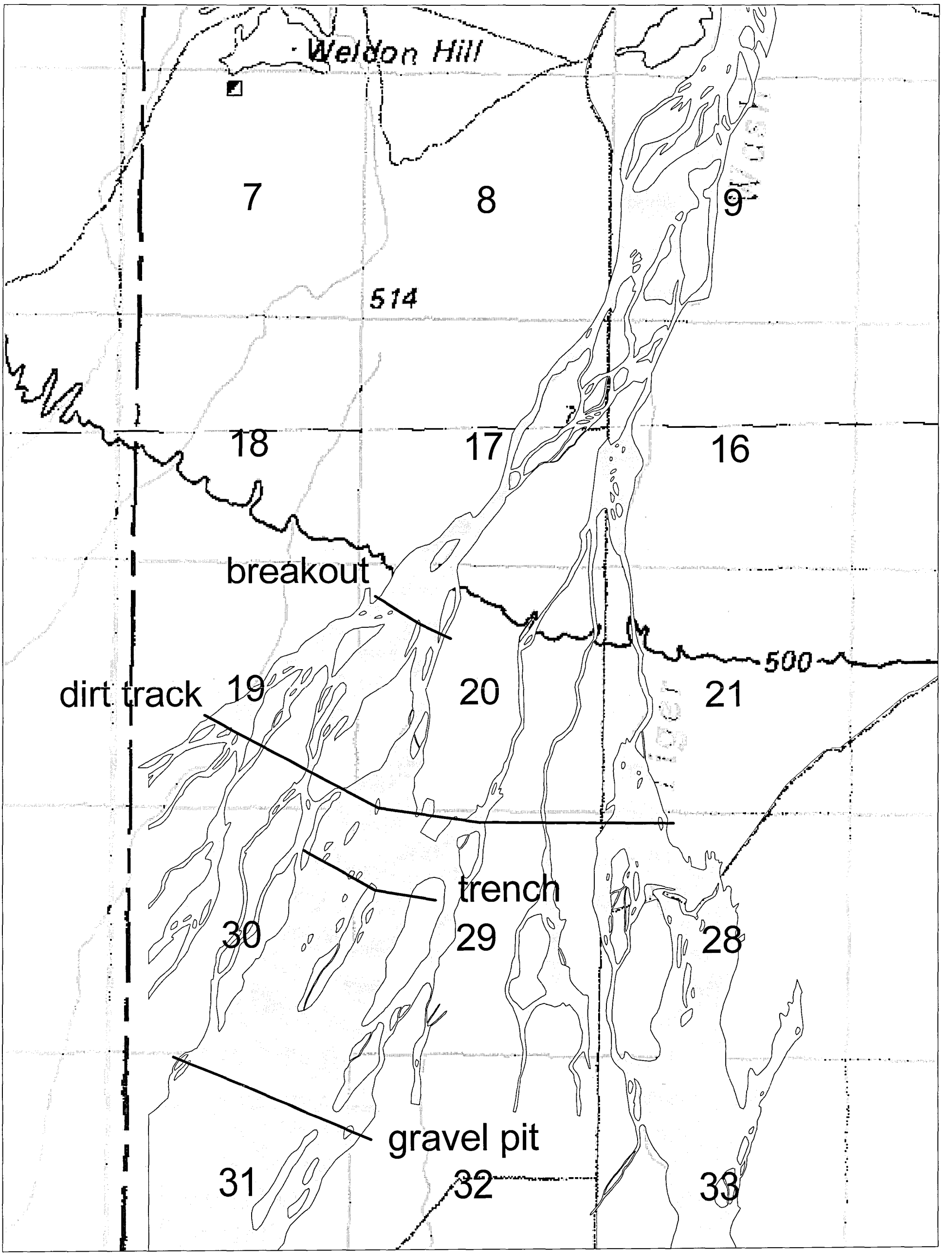
Using all of these kinds of evidence of flood inundation, the maximum extent of the flood was mapped in the field using a composite, black-and-white, ~1:15,000-scale aerial photo map made from photos taken in February, 1998. The composite map is a mosaic of digital aerial photos, with some geographic information superimposed on them from GIS data. We initially made several walking transects across the distributary system to identify areas of inundation and non-inundation. The margins of the many flow paths in the Tiger Wash system were traced in the field and mapped. Possible islands of no flow within flow paths were identified on the aerial photos and field checked. Field mapping data were then compiled over the photo mosaic base map.

Limitations

1) There is some uncertainty in the mapped flow boundaries in areas where flood lapped onto fine-grained, late Holocene deposits. As indicated above, these are generally areas of very shallow inundation less than a foot deep. The most difficult areas to delineate are located primarily along the eastern edge of the West Branch inundation area downstream of the FCDMC ALERT gage # 5140. Adjustments from the inundation mapping to the flood hazard

mapping were made with the aid of the 1999 color aerial photographs and additional field observations.

2) There is some uncertainty in the mapped flow boundaries throughout the map due to location uncertainty on composite aerial photos. The photo mosaic was registered by the FCDMC primarily using cultural features such as roads. Therefore, the photo registration for the study area is best in the vicinity of Eagle Eye Road and Salome Highway. For the remainder of the areas horizontal errors are likely in the range of a couple of hundred feet. To resolve this source of error, adjustments were made from the inundation mapping to the flood hazard mapping with the aid of the 1999 color aerial photographs and additional field observations. Also important were the USGS quadrangles which were used to correct distortions introduced by the photo mosaic. Additional features such as hills and other contour cues such as incised channel locations were used in the determination of the final flood hazard boundaries.



Note: Background map is USGS 100,000 series DRG.

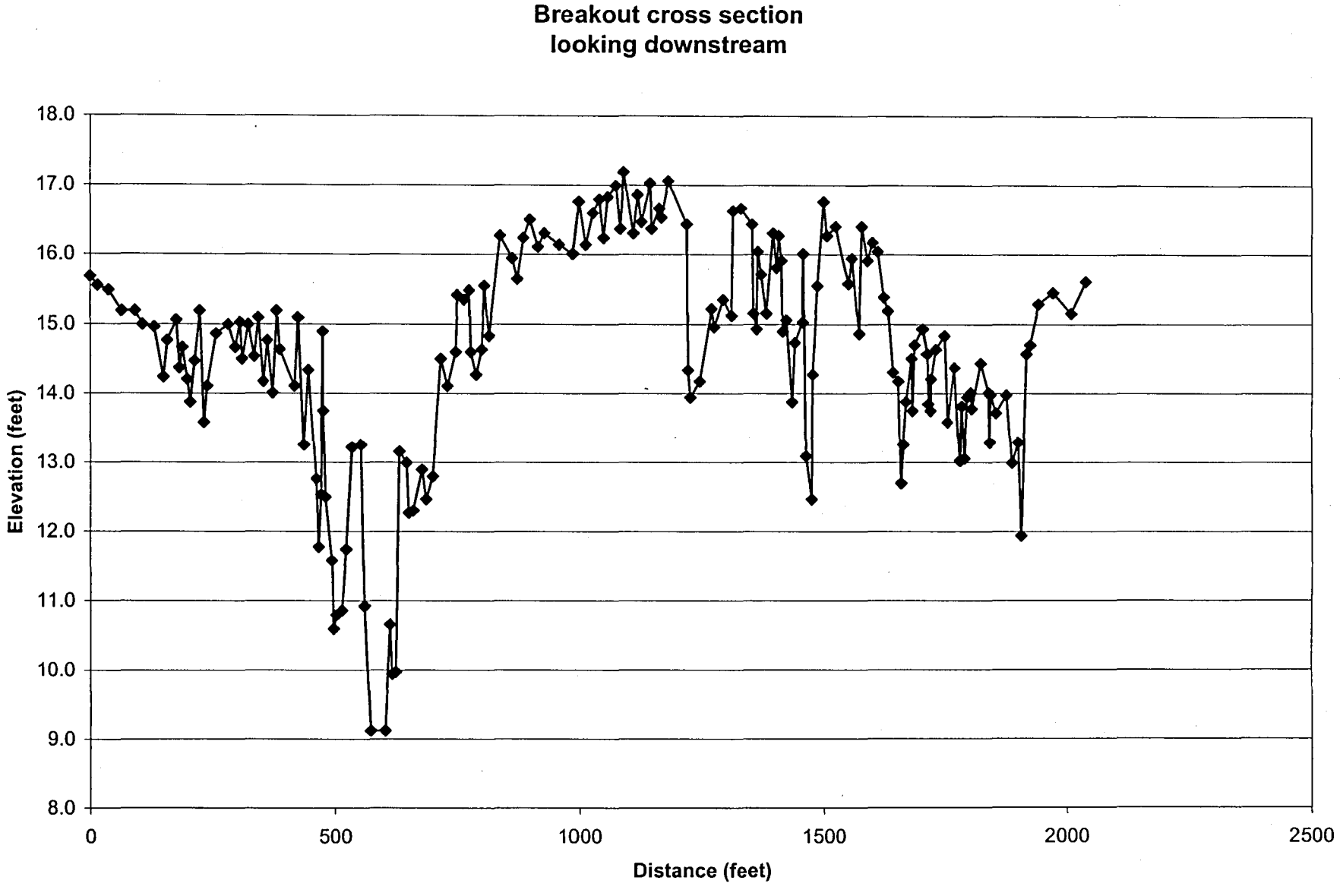
Tiger Wash
Flood Inundation Map
September 26, 1997

N

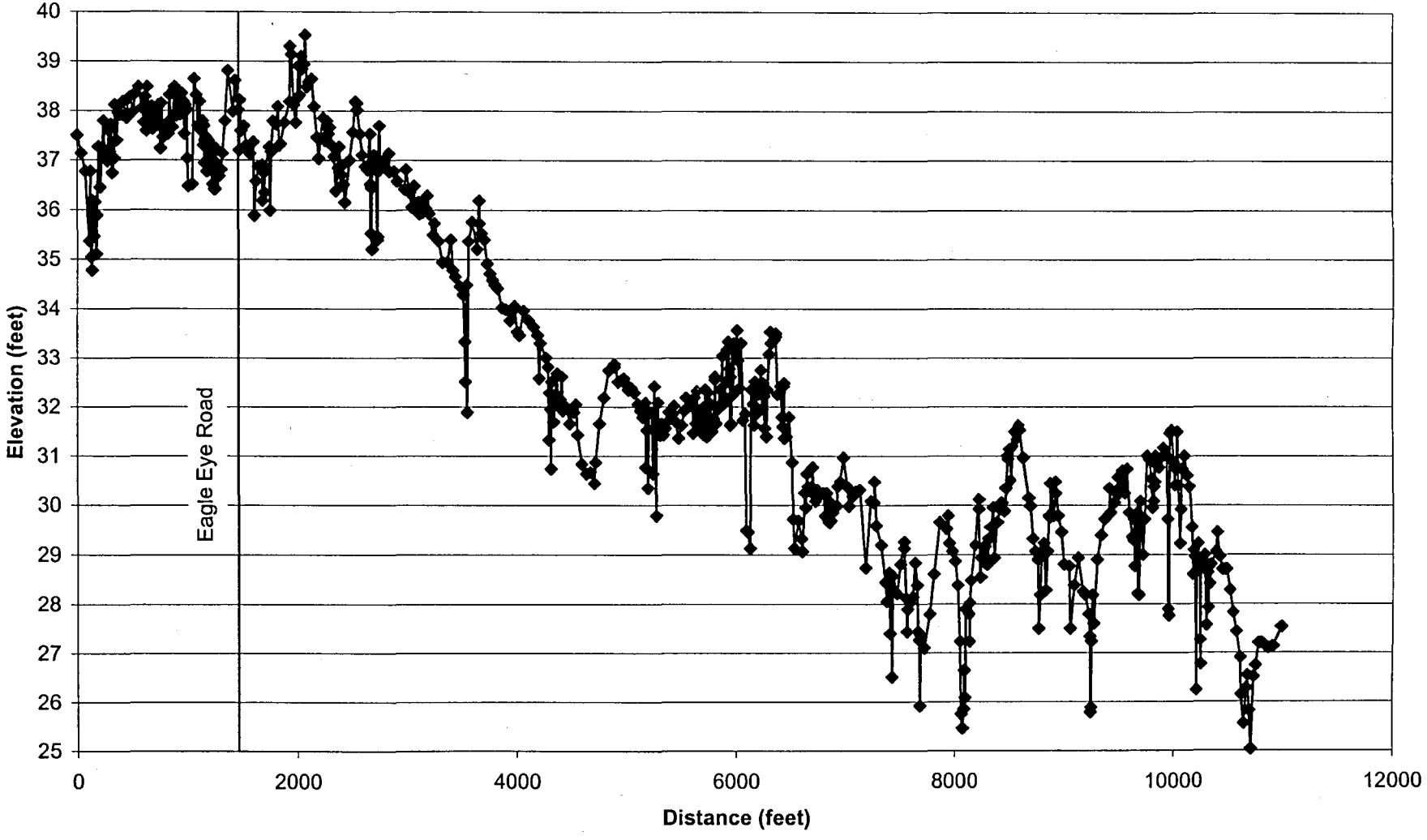
2000 0 2000 4000 Feet

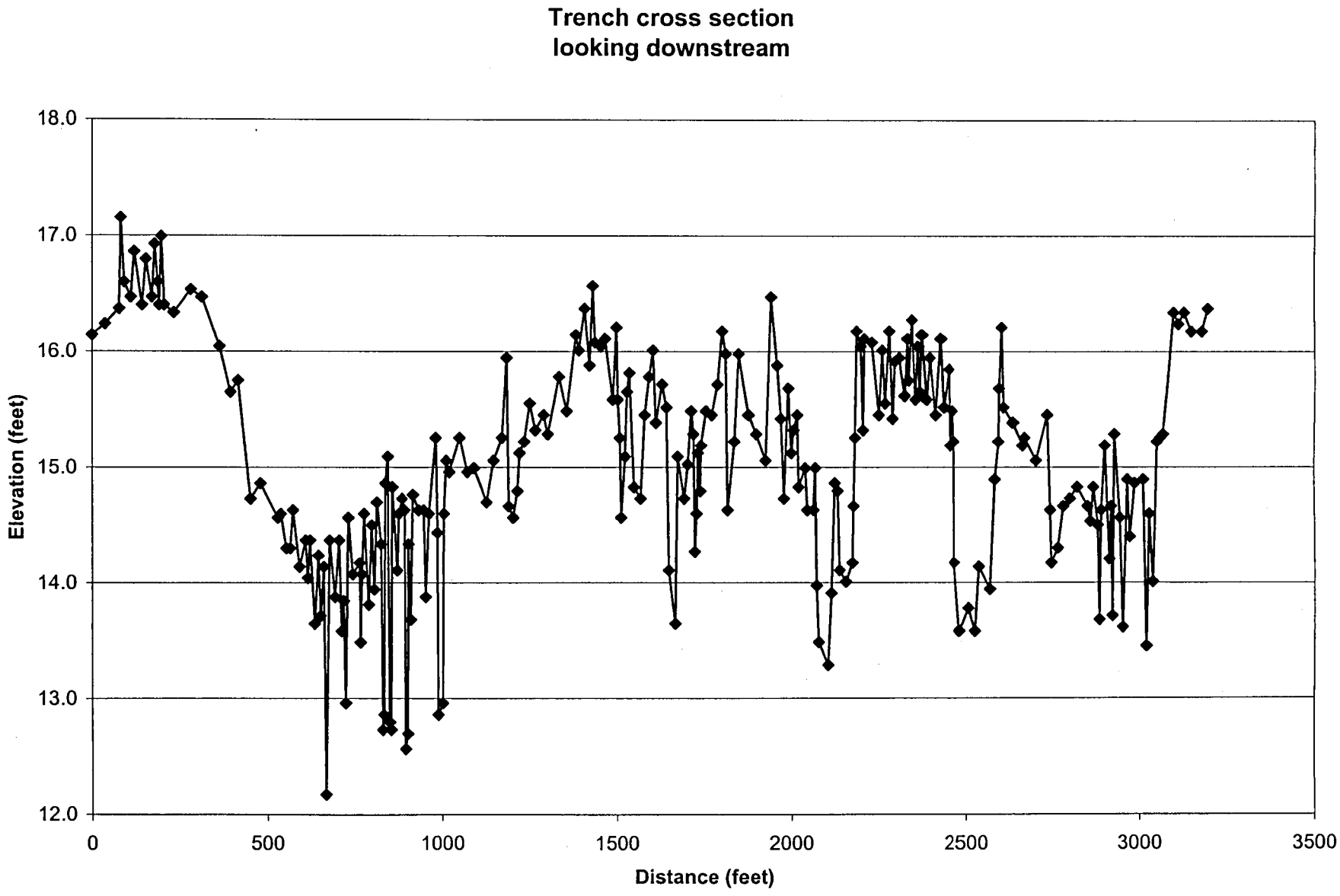
1:24000

FCD No. 98-48
Assignment No. 1
JE Fuller / Hydrology & Geomorphology, Inc.

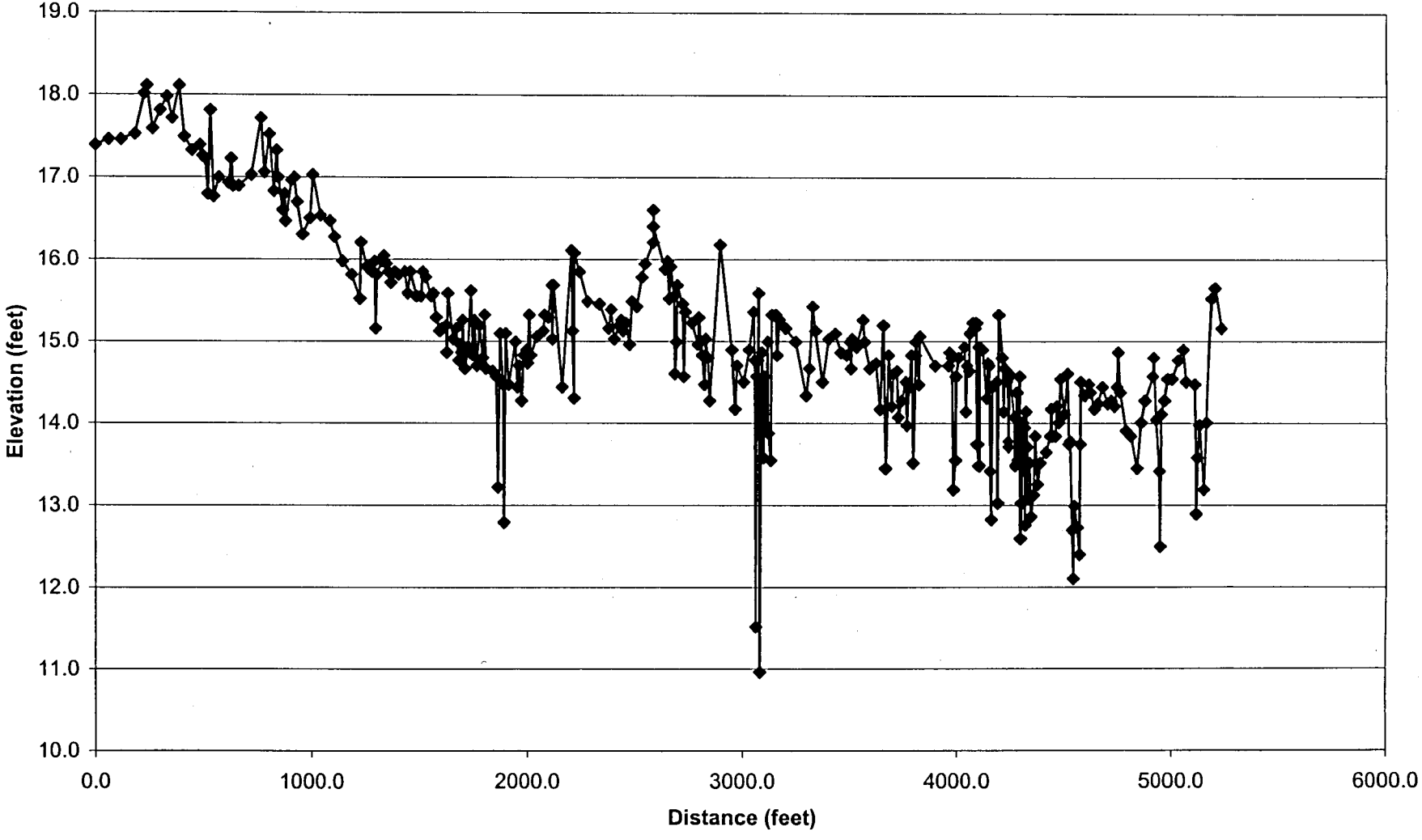

Breakout cross section
looking downstream
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
Elevation (feet)
0
500
1000
1500
2000
2500
Distance (feet)

Dirt track cross section
looking downstream

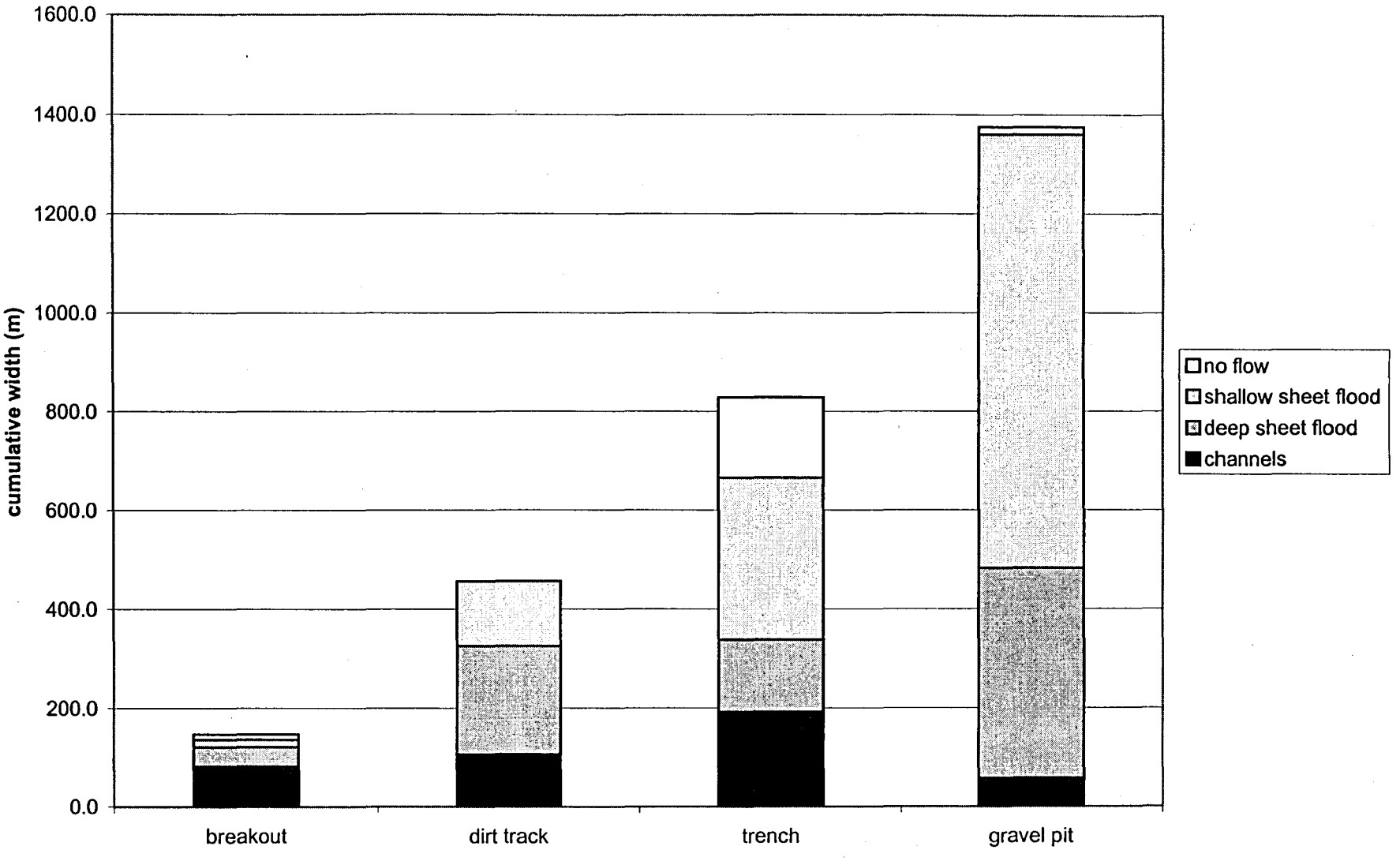


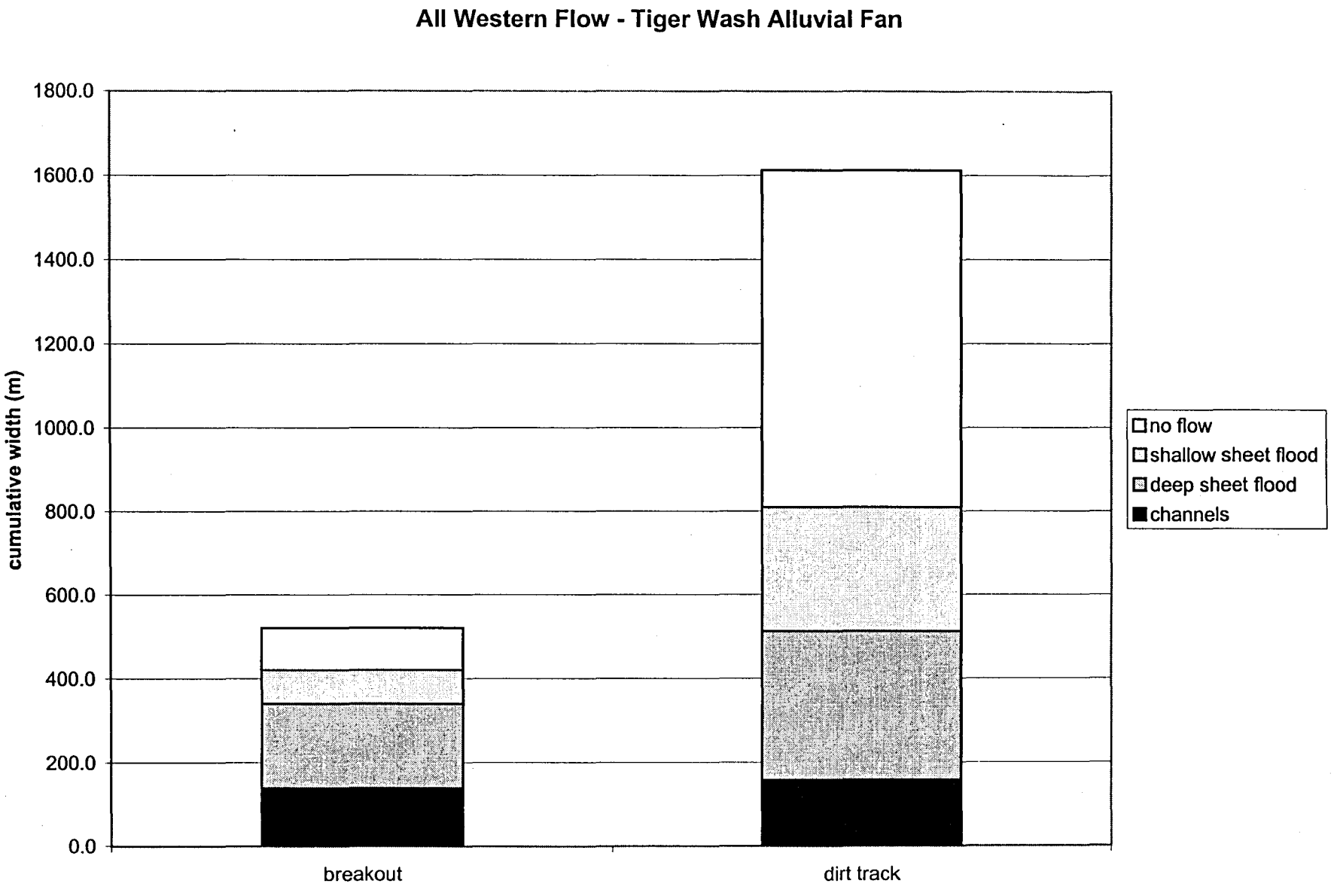

Trench cross section
looking downstream
18.0
17.0
16.0
15.0
14.0
13.0
12.0
Elevation (feet)
0
500
1000
1500
2000
2500
3000
3500
Distance (feet)

Gravel pit cross section
looking downstream



Main Western Flow Path - Tiger Wash Alluvial Fan




All Western Flow - Tiger Wash Alluvial Fan
cumulative width (m)
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
breakout
dirt track
no flow
shallow sheet flood
deep sheet flood
channels

Tiger Wash topo at 'breakout' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
1	134.16	1020.58	4.78	Qm	E end transect, grv bar
2	135.75	1016.33	4.74	Qm	swale
3	138.27	1009.99	4.72	Qm	grv bar
4	140.84	1002.15	4.63	Qm	broader swale, thin fine sed cover
5	143.13	994.35	4.63	Qm	grv bar
6	144.66	990.17	4.57	Qm/Qy2	
7	147.04	983.36	4.56	Qy2	cm
8	149.01	978.02	4.5	Qy2	swale
9	150.97	972.64	4.59	Qy2	cm
10	151.48	970.78	4.38	Qy2	sm gully
11	152.13	969.26	4.47	Qy2	cm
12	153.35	966.25	4.33	Qy2	E edge inund
13	154.11	964.66	4.23	Qy2	bottom gully
14	155.03	962.18	4.41	Qy2	W edge inund
15	156.30	959.1	4.63	Qy2	cm
16	157.34	956.72	4.14	Qy2	bottom gully
17	157.70	954.83	4.3	Qy2/Qy1	side of gully
18	159.77	949.74	4.53	Qy1	
19	162.05	942.67	4.57	Qy1	
20	163.39	938.36	4.47	Qy1	sm gully
21	164.39	935.56	4.58	Qy1	cm
22	164.76	934.35	4.42	Qy1/Qy2	E edge inund
23	166.10	930.74	4.57	Qy2	cm not inund
24	167.30	927.04	4.43	Qy2	sm gully
25	168.00	924.7	4.6	Qy2	cm, inund uncertain
26	168.84	921.45	4.32	Qy2	sm gully
27	169.73	919.15	4.5	Qy2	cm, close to WSEL
28	170.83	915.86	4.27	Qy2	sm gully
29	171.83	913.67	4.63	Qy2	cm, inund uncertain
30	172.40	911.92	4.46	Qy2	E edge sand sheet
31	176.11	902.96	4.3	Qy2	W edge sand sheet
32	176.83	900.99	4.6	Qy2	cm, barely inund
33	177.78	897.62	4.04	Qy2	sm gully
34	178.77	895.16	4.37	Qy2	cm
35	179.84	892.32	4.34	Qy2/Qyc	top left bank ch
36	180.73	890.28	3.89	Qyc/Qm	Holoc-Pleist contact in bank
37	181.39	889.01	3.59	Qm	ch bottom scoured into Qm
38	181.85	887.57	3.82	Qm/Qyc	Pleist-Holoc contact exposed in bank
39	182.00	886.67	4.19	Qyc	top rt bank ch, top left bank next channel to W
40	182.38	886.72	4.54		not topo, flotsam in creosote
41	182.20	885.48	3.81	Qyc/Qm	Holoc-Pleist contact in bank
42	183.62	881.44	3.53	Qm	scoured Qm in bank
43	183.94	880.65	3.23	Qm	scoured Qm in ch
44	184.42	879	3.29	Qm/Qyc	contact in ch bottom
45	185.38	875.72	3.31	Qyc	ch topo
46	186.11	873.07	3.58	Qyc	Qm barely concealed by ch deps
47	187.40	870	4.03	Qyc	s bar

Tiger Wash topo at 'breakout' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
48	189.61	865.16	4.04	Qyc	top left bank main ch
49	190.31	863.02	3.33	Qyc	left edge ch
50	191.52	859.41	2.78	Qyc	coarse grv lines side of ch
51	194.68	851.14	2.78	Qyc	flat sandy and grvly ch bed
52	196.04	848.35	3.25	Qyc	grv bar between main ch and W feeder ch
53	196.22	846.95	3.03	Qyc	ch topo
54	197.01	844.84	3.04	Qyc	ch topo
55	197.66	842.85	4.01	Qyc	top left bank main W ch
56	198.95	838.59	3.96	Qyc	ch topo
57	199.30	837.21	3.74	Qyc	ch topo
58	200.34	834.54	3.75	Qyc	ch topo
59	202.22	829.57	3.93	Qyc	grv bar in ch
60	203.10	827.06	3.8	Qyc	E edge sand sheet
61	204.33	823.21	3.9	Qyc	W edge sand sheet
62	206.35	818.63	4.42	Qyc/Qy2	top rt bank ch
63	204.34	814.88	4.3	Qy2	sm ch
64	208.65	811.86	4.45	Qy2/Qy1	W edge inund
65	209.01	810.92	4.7	Qy1	grv
66	210.61	806.98	4.68	Qy1	grv
67	211.66	804.02	4.72	Qy1	cm
68	211.86	802.85	4.45	Qy1/Qy2	E edge side ch inund
69	213.11	799.83	4.35	Qy2	bottom ch
70	214.57	796.7	4.46	Qy2/Qy1	W edge side ch inund
71	215.19	795.05	4.74	Qy1	cm
72	216.12	792.37	4.52	Qy1	swale
73	475.21	529.2	4.76	Qy1	W end transect on coarse Qy1 surface, grv bar
74	468.85	535.8	4.62	Qy1	swale
75	461.07	543.76	4.71	Qy1	grv bar
76	454.59	549.93	4.66	Qy1	cm
77	450.82	553.61	4.48	Qy1	grv dep, eroded slope of Qy1 surf
78	376.57	628.34	5	Qy2	s bar in deep sh fl area
79	375.25	629.32	4.53	Qy2	gully
80	372.14	632.7	4.86	Qy2	s bar
81	370.85	634.03	4.75	Qy2	sm ch
82	365.21	639.78	5	Qy2	cm
83	361.38	643.56	4.96	Qy2	cm
84	360.87	645.61	5.11		not topo, flotsam in creosote
85	357.52	647.56	4.74	Qy2/Qyc	top rt ch bank by ironwood
86	355.89	650.12	4.35	Qyc	top freshly cut low bank in ch
87	355.58	650.55	3.8	Qyc	rt edge freshly cut ch
88	352.96	653.21	3.99	Qyc	left edge ch
89	352.00	654.25	4.58	Qyc/Qy2	top left bank ch
90	351.55	654.07	4.88		not topo, flotsam in creosote
91	348.74	657.71	4.49	Qy2	s bar
92	349.10	659.26	4.23	Qy2	sm ch
93	345.61	660.62	4.59	Qy2	scoured bench
94	344.03	662.24	4.54	Qy2	sm ch
95	343.61	662.7	4.85	Qy2	top left bank sm ch

Tiger Wash topo at 'breakout' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
96	342.35	663.98	4.96	Qy2	s bar
97	341.35	665.05	4.82	Qy2	sm ch
98	340.15	666.76	4.97	Qy2/Qyc	top rt bank ch
99	337.22	669.7	4.62	Qyc	rt edge ch
100	335.03	671.96	4.79	Qyc	scoured Holoc ff deps in ch
101	333.55	673.4	4.89	Qyc	scoured Holoc ff deps in ch
102	332.87	674.07	4.55	Qyc	sandy ch bed
103	331.46	675.18	4.62	Qyc	left edge ch
104	330.74	675.86	5.01	Qyc/Qy2	top left bank ch
105	325.69	680.58	5.08	Qy2	overbank area between chs
106	321.93	683.92	5.07	Qy2/Qyc	top rt bank main breakout ch
107	321.36	684.58	4.61	Qyc	rt edge main breakout ch
108	318.07	688.52	4.68	Qyc	ch topo
109	313.84	692.86	4.56	Qyc	ch topo
110	312.96	693.85	4.64	Qyc	ch topo
111	307.75	699.13	4.32	Qyc/Qm	scoured Pleist sed in ch bottom
112	303.62	703.22	4.25	Qm	scoured Pleist sed in ch bottom
113	302.48	704.25	4.37	Qm/Qyc	left edge main breakout ch
114	301.93	704.69	5.01	Qyc/Qy2	top left bank ch
115	293.89	712.76	5.2	Qy2	cm
116	290.55	715.77	5.04	Qy2	sm ch
117	289.53	716.82	5.08	Qy2	s bar
118	285.92	719.75	4.99	Qy2	sm ch
119	285.21	719.91	5.19	Qy2	flotsam pile - not topo
120	281.51	724.08	5.02	Qy2	s bar
121	279.98	725.93	5.14	Qy2	sm ch
122	278.15	727.82	4.97	Qy2	s bar
123	274.26	732.24	5.24	Qy2	s bar
124	272.88	733.85	4.99	Qy2	s bar, near WSEL
125	271.14	735.81	5.18	Qy2	sm ch
126	267.37	739.45	5.13	Qy2	s bar
127	265.64	741.23	4.95	Qy2	cm, flotsam
128	263.99	743.43	5.12	Qy2	sm ch
129	261.38	746.25	5.06	Qy2	sm ch
130	258.26	749.6	4.92	Qy2	cm
131	254.79	752.21	5.11	Qy2	sm ch
132	252.12	754.43	4.88	Qy2/Qm	E edge inund
133	245.79	760.32	4.92	Qm	grv bar
134	239.29	766.69	4.97	Qm	grv bar
135	236.40	769.66	4.91	Qm	swale
136	232.71	773.28	5.03	Qm	swale
137	229.47	775.67	4.95	Qm	grv bar
138	226.81	778.45	4.77	Qm/Qy1	
139	224.50	780.56	4.86	Qy1	cm
140	218.86	785.91	4.96	Qy1	BS from IS2 to IS1
141	450.57	555.85	4.44	Qy1/Qy2	rt edge sm ch along contact
142	448.17	557.81	3.64	Qy2	sm ch

Tiger Wash topo at 'breakout' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
143	446.58	559.06	4.05	Qy2	left edge sm ch
144	443.94	561.95	3.96	Qyc	scoured Qy1 grv, shallow inund
145	441.61	564.49	4.26	Qy2	scoured Qy1 grv, shallow inund
146	437.31	569.32	4.18	Qy2	sm ch
147	434.96	571.92	4.26	Qy2	sm ch
148	434.56	572.31	4.05	Qy2	scour pit
149	434.03	572.85	4.27	Qy2	scoured grv
150	430.67	576.54	4.4	Qy2	grv bar, top may not have been inund
151	426.60	580.43	4.2	Qy2	sm ch
152	426.18	580.88	4.27	Qy2	s bar
153	424.42	582.3	4.25	Qy2	s bar
154	423.14	583.61	3.98	Qy2	sm ch
155	422.14	584.66	4.21	Qy2	s bar
156	421.26	585.5	3.97	Qy2	sm ch
157	418.74	587.91	4.38	Qy2	cm
158	415.80	591.48	4.14	Qy2	sm ch
159	414.27	592.92	4.52	Qy2	s bar
160	410.31	596.42	4.46	Qy2	s bar
161	408.02	598.53	4.33	Qy2/Qyc	top rt bank scoured ch
162	407.90	598.72	4.19	Qyc	rt edge ch
163	406.91	599.72	4.22	Qyc	left edge ch
164	406.32	600.21	4.44	Qyc/Qy2	top left bank ch
165	404.28	602.28	4.55	Qy2	cm
166	401.13	605.64	4.48	Qy2	s bar
167	400.11	606.3	4.19	Qy2	sm ch
168	399.51	606.73	4.42	Qy2	cm, flotsam
169	397.05	609.16	4.23	Qy2/Qyc	top rt bank scoured ch
170	395.58	610.5	4.04	Qyc	ch topo
171	394.76	611.38	3.87	Qyc	ch topo
172	393.66	612.62	4.32	Qyc/Qy2	top left bank ch
173	391.16	614.7	4.36	Qy2	grv
174	388.90	617.06	4.63	Qy2	cm
175	387.02	618.89	4.69	Qy2/Qm	partiall exposed Pleist deps
176	384.27	621.62	4.89	Qm	Pleist pavement partially exposed
177	381.81	623.88	4.93	Qm/Qy2	cm, flotsam
178	379.42	625.71	4.85	Qy2	sm ch

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
1	100.00	2000	10	Qm	IS 1; smooth pavement w/ small coppice dunes
2	96.49	2014.61	9.98	Qm	"
3	93.24	2027.89	9.81	Qm	dropping into sm swale
4	90.37	2040.15	9.65	Qy2	fine-gr inset
5	87.88	2050.38	9.41	Qy2	"
6	87.08	2053.73	9.28	Qy2	v sm ch
7	84.65	2064.44	9.35	Qy2	
8	82.05	2074.86	9.34	Qy2	
9	79.29	2087.27	9.4	Qy2	
10	76.94	2099.43	9.58	Qy2	
11	76.25	2104.04	9.77	Qm	mapped as toe Qm fan; could be younger
12	74.97	2109.92	9.72	Qm	
13	74.12	2114.32	9.74	Qm	
14	72.43	2120.19	9.65	Qm	subdued swale
15	70.08	2129.75	9.75	Qm	subdued gr bar
16	67.08	2139.53	9.73	Qy2	
17	66.30	2143.04	9.94	Ql	top gr bar
18	65.99	2146.33	9.8	Ql	
19	64.19	2153.34	9.78	Qy2	swale
20	63.74	2155.26	9.96	Ql	top gr bar
21	63.27	2159.36	9.83	Ql	W edge 97 inund.
22	62.39	2164.67	9.66	Qy2	sm gully
23	61.32	2169.75	9.91	Qy2	
24	60.83	2171.33	9.37	Qy2	sm ch
25	60.28	2172.44	9.74	Qy2	top low terrace
26	59.10	2175.15	9.84	Qy2	"
27	58.64	2176.45	9.55	Qy2	sm ch
28	57.71	2179.29	10	Qy2	top low terrace
29	56.42	2184.95	10.06	Qy2	"
30	53.36	2200.2	10.15	Qy2	"
31	53.42	2203.32	9.93	Qy2	sm gully
32	52.57	2207.5	10.2	Qy2	top low terrace
33	48.90	2218.24	10.25	Qy2	"
34	45.32	2231.49	10.29	Qy2	"
35	42.61	2246.09	10.35	Qy2	"
36	40.79	2257.08	10.2	Qy2	"
37	39.12	2263.13	10.22	Qm	sm ch eroded in 97
38	37.32	2270.92	10.38	Qm	approx E limit 97 inund.
39	34.52	2282.72	10.29	Qm	approx W edge 97 inund.
40	35.72	2275.21	10.35	Qm	
41	31.34	2294.36	10.36	Qy2	
42	28.78	2304.4	10.37	Qy2	
43	25.89	2316.78	10.49	Qy2	approx E limit 97 inund.
44	24.91	2324.25	10.51	Qm	Qm partly buried by Qy?
45	23.11	2330.41	10.54	Qm	
46	21.63	2337	10.58	Qy2	flat-bottomed swale

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
47	19.44	2344.81	10.64	Qy2	
48	17.30	2353.55	10.79	Qm	
49	15.71	2361	10.83	Qm	
50	14.43	2365.77	11.03	Qm	top relict bar - future IS?
51	103.21	1989.37	9.91	Qm	swale
52	105.41	1981.29	9.92	Qm	bar
53	107.09	1975.38	9.93	Qm	"
54	108.47	1970.41	9.9	Qm	
55	110.90	1962.44	9.86	Qm	swale
56	112.74	1955.06	9.87	Qm	bar
57	115.12	1946.36	9.84	Qm	
58	117.92	1936.64	9.77	Qm	
59	119.79	1930.04	9.73	Qy2	fine floodplain
60	121.70	1923.31	9.69	Qy2	ff
61	123.39	1917.02	9.78	Qy2	ff
62	123.64	1915.73	9.38	Qy2	gully
63	123.89	1914.64	9.71	Qy2	ff
64	124.63	1913.06	9.61	Qy2	ff
65	125.75	1909.79	9.25	Qy2	sm ch
66	126.05	1907.09	9.72	Qy2	ff
67	128.23	1900.22	9.72	Qy2	ff
68	129.21	1896.35	9.34	Qy2	gully
69	129.91	1893.28	9.88	Qy2	ff
70	131.27	1889.46	9.62	Qy2	ff
71	132.72	1888.98	9.08	Qy2	gully
72	132.95	1887.03	9.64	Qy2	ff
73	132.94	1884.33	9.78	Qy2	ff
74	133.75	1882.1	9.64	Qy2	very sm ch
75	134.39	1878.08	9.58	Qy2	
76	135.26	1875.3	9.65	Qm	gr bar
77	136.66	1869.68	9.58	Qm	swale
78	137.94	1863.99	9.62	Qm	
79	140.68	1855.96	9.72	Qm	
80	142.27	1850.52	9.68	Qm	swale
81	144.10	1843.84	9.71	Qm	
82	144.80	1840.85	9.76	Qm	gr bar
83	146.21	1835.82	9.66	Qm	E edge 97 inund
84	148.21	1828.23	9.56	Qy2	bottom of swale
85	150.69	1820.05	9.64	Qy2	
86	153.00	1813.89	9.73	Qm	inundated in 97
87	154.29	1808.18	9.81	Qm	
88	155.30	1803.8	9.75	Qy2	bottom of swale
89	157.55	1795.16	9.79	Qy2	
90	158.63	1791.87	9.77	Qm	E edge deeper sh flooding
91	159.29	1789.58	9.59	Qm	gully cut into Qm
92	160.39	1786.49	9.81	Qm	
93	161.46	1782.68	9.65	Qm	sm gully
94	162.71	1780.28	9.85	Qys	sand bar

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
95	163.26	1778.16	9.72	Qys	gully
96	165.04	1773.27	9.71	Qys	gully
97	166.26	1768.32	9.6	Qys	sand deposit around creosote
98	167.04	1762.41	9.75	Qys	s bar
99	167.30	1760.36	9.58	Qys	gully
100	168.10	1757.45	9.86	Qys	s bar
101	169.24	1753.4	9.57	Qys	gully
102	170.29	1751.22	9.84	Qys	s bar
103	170.91	1747.42	9.62	Qys	gully
104	171.93	1744.28	9.77	Qys	s bar
105	173.25	1740.35	9.6	Qys	sm ch
106	174.58	1735.23	9.68	Qys	sm ch
107	175.62	1731.84	9.94	Qys	s bar
108	176.97	1728.63	9.65	Qys	sm ch
109	178.37	1724.12	9.74	Qys	sm ch
110	180.74	1718.43	9.86	Qys	s bar
111	181.29	1716.51	9.77	Qys	sm ch
112	181.61	1712.31	10.07	Qys	s bar
113	182.38	1709.1	9.77	Qys/Qyc	E edge larger ch
114	184.28	1705.03	9.81	Qyc/Qys	W edge larger ch
115	185.57	1700.07	10.11	Qys	s bar
116	186.78	1696.98	10.16	Qys	s bar
117	188.42	1690.39	9.94	Qys	sm ch
118	189.77	1686.7	10.12	Qys	s bar, IS 2
119	175.59	1731.93	9.92		backsight?
120	185.57	1698.01	9.91	Qys	sm ch
121	187.15	1693.01	9.99	Qys	s bar
122	187.73	1691.11	9.64	Qys	sm ch
123	188.78	1688.83	9.65	Qys	sm ch
124	225.91	1572.33	10.21	Qys	gr bar, v shallow 97 inund, IS 3
125	224.39	1576.61	10.17	Qys	swale
126	222.15	1583.97	10.15	Qys	swale
127	221.66	1585.81	10.22	Qys	gr bar, barely or no 97 inund
128	220.32	1588.86	10.08	Qys	W edge deep sh flooding
129	219.03	1593.69	9.86	Qys	edge sm ch
130	218.25	1596.21	9.57	Qys	bottom sm ch
131	217.52	1598.45	9.86	Qys	pre 97 surface,shallow 97 inund
132	217.17	1600.52	9.62	Qys	bottom sm ch
133	216.94	1602.9	9.82	Qys	W edge larger, perched ch
134	216.17	1605.49	9.9	Qys	gr bar in larger ch
135	215.55	1607.81	9.74	Qys	thalweg of larger ch
136	214.55	1611.05	9.98	Qys	gr bar in larger ch
137	212.75	1616.26	9.83	Qys	sm ch
138	211.53	1620.71	9.89	Qys	
139	210.69	1623.52	9.71	Qys	sm ch
140	210.03	1626.39	9.91	Qys	
141	209.97	1628.79	9.64	Qys	bottom ch
142	209.64	1631.71	9.77	Qys	rt overbank main pre97 ch

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
143	207.38	1635.91	9.86	Qys	rt overbank main pre97 ch
144	205.87	1639.79	8.88	Qys	top rt. berm along main pre97 ch
145	204.06	1644.72	8.98	Qys	rt edge main ch
146	202.93	1649.73	8.99	Qys	left edge main ch
147	202.41	1652.35	9.71	Qys	top left berm along main pre97 ch
148	200.46	1658.07	9.67	Qys	edge left overbank and gr bar
149	198.41	1664.06	10.15	Qys	top gr bar
150	197.15	1666.92	9.87	Qys	spillover ch, left bank
151	195.57	1671.5	10.04	Qys	
152	194.77	1673.72	10.23	Qys	s bar
153	193.54	1677.32	10.09	Qys	sm ch
154	191.39	1682.5	10.15	Qys	s bar
155	190.59	1683.98	9.83	Qys	sm ch
156	225.58	1571.97	10.19		?
157	189.77	1686.67	10.14		backsight to IS2
158	357.27	1268.09	8.88	Qm	relict cobble bar, IS4
159	353.20	1277.2	8.78	Qm	
160	349.94	1285.89	8.6	Qy2	gentle swale w/ ff
161	344.22	1297.23	8.71	Qy2	gentle swale w/ ff
162	344.14	1298.86	8.08	Qy2	bottom ch
163	342.97	1301.49	8.64	Qy2	ff
164	342.14	1303.45	8.35	Qy2	bottom sm ch
165	340.85	1306.16	8.73	Qy2	ff
166	338.47	1312.13	8.55	Qy2	bottom sm ch
167	337.10	1315.61	8.67	Qy2	ff
168	333.92	1353.92	8.76	Qy2	ff
169	332.53	1327.44	8.9	Qly	fine gravelly deposit
170	326.93	1340.08	9.02	Qly	fine gravelly deposit
171	324.79	1343.74	9.29	Qm	gr bar
172	303.12	1328.8	9.06	Qm	north side of Qm soil pit
173	323.65	1345.7	9.16	Qm	swale
174	319.92	1353.87	9.17	Qm	swale
175	318.16	1358.18	9.24	Qm	gr bar
176	314.50	1367.39	9.23	Qm	
177	311.22	1377.22	9.2	Qy2	shallow swale
178	306.88	1387.11	9.14	Qy2	v sm ch
179	305.63	1390.03	9.26	Qy2	
180	301.50	1399.5	9.44	Qm	bioturbated
181	297.86	1408.06	9.29	Qm	W margin of 97 inund
182	294.73	1415.21	9.26	Qy2	v shallow 97 inund
183	293.45	1417.95	9.14	Qy2	sm swale
184	288.55	1428.63	9.1	Qy2	W edge deeper flow
185	287.01	1432.56	9.05	Qyc	sm ch
186	286.37	1434.25	9.16	Qyc	s bar
187	285.51	1436.29	9.04	Qyc	sm ch
188	284.85	1437.74	9.15	Qyc	s bar
189	284.15	1439.23	9.06	Qyc	sm ch
190	282.73	1442.77	9.22	Qyc	s bar

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
191	281.34	1446.19	9.08	Qyc	sm ch
192	279.28	1450.79	9.22	Qyc	edge sand sheet
193	275.78	1458.75	9.21	Qyc	sand sheet
194	272.95	1466.03	9.24	Qyc	sand sheet
195	270.20	1472.19	9.17	Qyc	sm breakout ch from new large ch
196	268.29	1475.57	9.21	Qyc	"
197	266.47	1477.66	9.38	Qyc	top rt. Bank new ch
198	265.71	1479.4	9.26	Qyc	rt. Edge new ch
199	261.93	1489.31	9.26	Qyc	sandy ch bed
200	260.59	1492.3	9.34	Qyc	top gr bar
201	259.10	1496.22	9.13	Qyc	sandy ch bed
202	258.25	1498.57	9.22	Qyc	gr bar, exhumed?
203	255.58	1504.83	8.86	Qyc	sandy ch bed
204	254.65	1507.13	8.94	Qyc	sandy ch bed
205	251.24	1515.22	9.05	Qyc	cobbly ch bed
206	246.85	1524.95	8.88	Qyc	cobbly ch bed
207	245.67	1527.83	9.06	Qyc	edge cobbly ch bed
208	244.36	1530.01	9.41	Qyc	base intrachannel bank
209	240.82	1538.26	9.69	Qyc	W side higher ch
210	237.76	1545.4	9.57	Qyc	sandy ch bed
211	235.70	1550.16	9.56	Qyc	E side higher ch
212	235.12	1551.26	9.9	Qyc	top left bank
213	234.30	1553.23	9.88	Qy2	ff
214	233.83	1554.1	9.63	Qys	sm ch
215	232.92	1555.84	9.69	Qys	sm ch
216	231.29	1559.32	9.88	Qys	s bar
217	229.57	1563.19	9.84	Qys	sm ch
218	227.54	1567.37	9.83	Qys	sm ch; approx E limit deep sh fl
219	452.05	1080.15	9.12	Qy1	gr bar
220	447.49	1089.16	8.9	Qy1	dropping toward terrace, W edge 97 inund
221	441.90	1100.57	8.68	Qy2	ff
222	440.58	1103.44	8.54	Qys	sm scour ch
223	440.11	1104.37	8.3	Qys	sm scour ch
224	439.74	1105.31	8.47	Qys	sm scour ch
225	435.70	1114.29	8.5	Qys	top rt bank moderate channel
226	434.63	1116.02	7.95	Qyc	side ch bottom
227	433.79	1118.19	8.12	Qyc	bar
228	433.10	1119.18	7.88	Qyc	rt edge main ch
229	428.92	1127.61	8.3	Qyc	top left bank ch
230	426.03	1133.14	8.65	Qys	mod. Deep flow
231	422.85	1139.8	8.8	Qy2	shallow overbank flow
232	420.38	1147.29	8.86	Qy2	approx. E edge 97 inund
233	415.98	1155.36	8.91	Qy1	sloping down to younger terrace
234	414.36	1159.25	9.08	Qy1	gr bar
235	412.20	1162.91	9	Qy1	swale
236	405.50	1168.35	9.03	Qy1	north edge Qy1 soil pit, Qm exposed in pit
237	439.78	1187.71	9.52	Qy1	Qy1 soil pit N of dirt track
238	406.29	1181.47	9.04	Qy1	

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
239	398.80	1195.32	8.72	Qy1	sloping down to younger terrace
240	393.07	1205.22	8.47	Qy1	"
241	384.26	1209.69	8.34	Qy2	W edge Qy2 soil pit, Pleist soil exposed in pit
242	383.27	1218.42	8.26	Qy2	
243	378.31	1227.03	8.34	Qy2	top rt bank sm ch
244	377.64	1228.65	7.9	Qy2	bottom sm ch
245	376.68	1230.15	8.31	Qy2	top left bank sm ch
246	375.30	1232.82	8.36	Qy2	
247	373.68	1235.08	8.65	Qm	
248	371.15	1240.41	8.79	Qm	gr bar
249	368.21	1245.96	8.58	Qm	
250	364.61	1252.95	8.54	Qy2	swale
251	362.16	1259.1	8.5	Qy2	
252	361.41	1260.37	8.36	Qy2	
253	359.98	1263.12	8.57	Qy2	
254	357.25	1268.12	8.92		backsight to IS4
255	430.38	1126.07	7.85	Qyc	left edge mod lg ch
256	432.25	1122.8	7.76	Qyc	middle mod lg ch
257	560.80	896.46	9.22	Qy1	gr bar, IS6
258	452.00	1080.22	9.18		backsight to IS5
259	454.70	1076.66	8.7	Qy1	sm ch
260	456.49	1073.94	8.82	Qy1	
261	460.20	1067.53	8.89	Qy1	
262	463.79	1062	8.78	Qy1	swale
263	466.17	1057.7	8.94	Qy1	
264	468.65	1053.83	9.01	Qy1	gr bar
265	471.41	1048.57	9.13	Qy1	gr bar
266	473.68	1045.21	8.82	Qy1	ch in swale
267	477.84	1038.38	9.04	Qy1	
268	481.87	1031.59	9.12	Qy1	gr bar
269	483.38	1029.03	9.16	Qy1	gr bar
270	486.93	1023.31	9.11	Qy1	swale
271	490.42	1017.64	9.25	Qy1	gr bar
272	492.23	1014.1	9.45	Qy1	gr bar
273	493.54	1011.97	9.43	Qy1	sm swale
274	494.64	1010.34	9.49	Qy1	gr bar
275	497.78	1005.44	9.3	Qy1	swale
276	501.61	999.91	9.51	Qy1	gr bar
277	502.75	998.04	9.6	Qy1	gr bar
278	505.88	992.02	9.55	Qy1	swale
279	508.81	985.42	9.64	Qy1	gr bar
280	511.87	981.51	9.61	Qy1	
281	516.87	972.89	9.44	Qy1	dropping toward drainage
282	524.33	960.6	9.19	Qy1	dropping toward drainage
283	526.49	956.61	9.14	Qy1	
284	530.01	950.95	8.94	Qy1/Qy2	
285	533.53	945.2	8.86	Qy2	ff
286	536.93	939	8.81	Qy2	top left bank sm ch

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
287	537.77	936.89	8.38	Qy2	bottom sm ch
288	539.90	932.58	8.59	Qy2/Qy1	edge ff
289	542.07	929.36	8.86	Qy1	gr
290	544.61	924.67	8.91	Qy1	gr
291	547.56	919.69	8.62	Qy1	ch in swale
292	549.79	915.8	8.86	Qy1	gr
293	551.88	912.34	9.08	Qy1	gr bar
294	552.99	910.65	9.07	Qy1	swale
295	554.38	908.55	9.28	Qy1	gr bar
296	557.66	902.47	9.08	Qy1	swale
297	563.74	891.09	9.08	Qy1	swale
298	568.19	882.83	8.98	Qy1	swale
299	571.82	876.27	8.78	Qy1/Qy2	
300	578.37	863.33	8.77	Qy2	top left bank sm ch
301	579.88	860.96	8.38	Qy2	bottom sm ch
302	584.90	851.77	8.65	Qy2/Qy1	
303	590.15	841.83	8.82	Qy1	
304	596.68	830.07	8.61	Qy1/Qy2	
305	599.61	824.24	8.59	Qy2	
306	604.14	815.44	8.47	Qy2	E edge 97 inund
307	606.09	813.38	8.33	Qy2	top left ch bank
308	606.27	812.71	7.86	Qyc	left edge ch
309	606.60	811.56	7.89	Qyc	rt edge ch
310	607.31	809.95	8.3	Qy2	top rt ch bank
311	608.80	806.94	8.59	Qy2	W edge 97 inund
312	610.21	803.43	8.41	Qy2/Qy1	
313	613.74	795.2	8.81	Qy1	
314	618.88	785.34	8.96	Qy1	
315	623.43	777.26	9.06	Qy1	
316	629.47	766.55	9.09	Qy1	
317	630.56	764.39	9.25	Qy1	mound around creosote
318	631.36	763.32	9.1	Qy1	
319	636.66	754.03	9.16	Qy1	
320	641.13	745.62	9.21	Qy1	mound around creosote
321	642.22	743.69	9.32	Qy1	
322	643.32	742.15	9.25	Qy1	mound around creosote
323	646.75	736.03	9.32	Qy1	
324	647.90	733.82	9.36	Qy1	gr bar
325	650.88	728.88	9.22	Qy1	swale
326	654.37	722.23	9.37	Qy1	gr bar
327	656.61	717.33	9.1	Qy1	
328	660.13	709.63	8.95	Qy1/Qy2	E edge 97 inund
329	662.13	706.51	8.93	Qy2	low area
330	663.13	705.64	9.06	Qys	s bar
331	663.95	704.07	8.77	Qys	sm ch
332	664.92	702.49	8.93	Qys	
333	667.54	698.35	9.1	Qy2	terrace
334	701.17	633.33	9.3	Qy2	top left bank mod ch

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
335	560.84	896.38	9.29	Qy1	IS7
336	668.44	696.76	8.6	Qyc	left edge ch
337	670.03	693.82	8.59	Qyc	rt edge ch
338	671.04	690.59	9.17	Qy2	top rt ch bank
339	673.07	687.29	9.06	Qys	mod deep sh fl
340	674.21	684.32	8.84	Qys	bottom scoured ch
341	676.66	679.7	9.06	Qys	W edge mod deep sh fl
342	680.69	672.83	9.45	Qy2	shallow sh fl between large chs
343	683.39	667.58	9.43	Qy2	"
344	686.63	662.23	9.31	Qy2	top left bank lg ch
345	687.16	661.26	9.13	Qyc	left edge ch
346	688.95	658.18	9.17	Qyc	rt edge ch
347	689.98	656.44	9.26	Qys	deep sh fl
348	690.41	655.58	9.41	Qys	s bar
349	691.14	653.99	9.29	Qys	sm ch
350	691.96	652.43	9.45	Qys	W edge deep sh fl
351	695.97	643.81	9.38	Qy2	shallow inund
352	698.87	638.86	9.44	Qy2	W edge of inund
353	875.64	358.97	8.39	Qm	W end of transect, monument
354	853.62	365.74	8.27	Qm	pebble, cobble darkly varnished surface
355	848.09	375.87	8.26	Qm/Qy2	
356	844.29	382.4	8.27	Qy2	swale
357	842.40	386.4	8.28	Qy2/Qm	
358	838.79	392.8	8.29	Qm	swale
359	837.07	395.95	8.29	Qm	gr bar
360	834.58	401.13	8.29	Qm	swale
361	830.41	408.95	8.15	Qm/Qy2	
362	827.46	414.95	8.08	Qy2	W edge 97 inund
363	823.13	421.3	7.63	Qy2	bottom sm ch
364	820.94	425.05	7.87	Qy2	
365	819.23	428.56	8.09	Qy1	gr bar; top probably not inund
366	817.93	431.68	8.01	Qy2	
367	814.04	437.66	7.79	Qy2	bottom sm ch
368	810.91	444.34	7.97	Qy2	bottom sm ch
369	809.78	445.01	8.2	Qy2	
370	804.11	454.34	8.36	Qy2/Qm	Qm partially buried by Qy2
371	799.88	462.41	8.48	Qm	
372	796.84	470.49	8.62	Qm	
373	791.77	479.57	8.75	Qm	gr bar
374	789.91	483.26	8.75	Qm/Qy2	v. shallow inund
375	786.60	490.05	8.75	Qy2	"
376	783.19	496.72	8.83	Qy2	"
377	779.89	503.31	8.98	Qy2	"
378	777.95	506.61	8.86	Qy2	"
379	771.79	517.7	8.78	Qy2/Qy	W edge deep sh fl
380	771.02	519.29	8.78	Qys	s bar
381	769.79	521.49	8.66	Qys	sm ch
382	768.62	524.34	8.77	Qys	s bar

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
383	767.87	526.06	8.51	Qys	sm ch
384	767.24	527.3	8.73	Qys	s bar
385	765.08	531.01	8.4	Qys	bottom larger ch
386	762.96	534.61	8.84	Qy2	higher terrace, shallow sh fl
387	759.19	540.63	8.81	Qy2	"
388	757.45	543.69	8.75	Qy2	top rt ch bank
389	756.70	545	8.16	Qyc	rt edge ch
390	756.01	546.38	8.31	Qyc	left edge ch
391	755.83	547.18	8.75	Qy2	top left ch bank
392	754.01	549.65	8.74	Qys	deep sh fl
393	753.27	550.5	8.91	Qys	s bar
394	751.28	553.5	8.75	Qys	rt edge ch
395	750.32	555.93	8	Qyc	bottom mod channel
396	748.67	558.63	8.83	Qy2	top left ch bank
397	747.01	561.91	8.87	Qy2	shallow sh fl
398	746.19	563.57	8.72	Qy2	bottom sm ch
399	744.49	566.37	9.01	Qy2/Qy1	E edge 97 inund
400	740.98	572.29	9.26	Qy1	gravel deposits
401	737.19	578.24	9.33	Qy1	gravel deposits
402	733.17	584.68	9.45	Qy1	gravel deposits
403	730.29	589.38	9.37	Qy1/Qy2	
404	728.57	592.62	9.12	Qy2	W edge 97 inund
405	727.51	594.57	8.91	Qy2	bottom sm ch
406	726.42	599.61	9.27	Qy2/Qy1	E edge 97 inund
407	724.63	602.23	9.6	Qy1	gr bar
408	722.10	605.46	9.37	Qy1/Qy2	W edge 97 inund
409	720.37	606.44	9.27	Qy2	bottom sm ch
410	718.47	608.95	9.41	Qy2/Qy1	E edge 97 inund
411	714.71	615.08	9.61	Qy1	
412	712.29	618.47	9.59	Qy1/Qyc	top rt ch bank; just above W edge 97 inund
413	709.37	620.02	8.46	Qyc	rt edge ch
414	708.26	621.6	8.5	Qyc	left edge ch
415	707.58	622.79	9.06	Qys	top left ch bank
416	707.09	624.88	9.45	Qy/Qy2	2nd level bank top
417	704.72	627.69	9.46	Qy2	E edge 97 inund
418	100.09	1999.89	10.02	Qm	reshoot IS1 from IS8
419	-5.94	2703.21	11.63	Qm?	IS9
420	14.38	2365.64	10.89	Qm	reshoot IS8 from IS9
421	14.57	2372.21	10.73	Qm	swale
422	14.05	2385.6	10.9	Qm	bioturbated bar
423	13.10	2396.05	10.78	Qm/Qy2	
424	11.75	2399.49	9.72	Qy2	bottom sm ch
425	11.72	2401.19	10.51	Qy2	creosote mound
426	11.13	2404.43	9.91	Qy2	bottom sm ch
427	11.16	2406.34	10.16	Qy2/Qy1	
428	11.22	2410.28	10.45	Qy1	fine gravel barely burying Ql
429	10.63	2419.4	10.5	Qy1	
430	10.20	2433.17	10.56	Qy1	

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
431	9.98	2439.42	10.6	Qy1	
432	9.38	2445.82	10.79	Qy1	burrow mound
433	8.64	2454.85	10.65	Qy1	
434	8.33	2468.45	10.65	Qy1	broad, v shallow swale
435	7.72	2478.94	10.78	Qy1	
436	8.58	2482.87	10.79	Qy1	
437	8.42	2489.81	10.89	Qy1	creosote mound
438	7.95	2495.42	10.82	Qy1	
439	7.68	2505.12	10.95	Qy1	edge gr bar
440	7.21	2510.73	11.06	Qy1	top gr bar-could be Ql bar
441	6.88	2513.83	10.98	Qy1	
442	6.02	2523.66	10.96	Qy1	
443	4.60	2531.29	10.95	Qy1	
444	3.94	2533	11.02	Qy1	top gr bar-could be Ql bar
445	3.59	2535.14	11.02	Qy1	
446	3.44	2543.76	10.98	Qy1	
447	3.66	2546.4	11.12	Qy1	creosote mound
448	3.28	2552.22	10.99	Qy1	
449	2.66	2558.52	11.08	Qy1	top gr bar-could be Ql bar
450	1.89	2568.95	11.22	Qy1	creosote mound
451	1.96	2572.42	11.1	Qy1	
452	1.06	2592.51	11.15	Qy1	
453	0.37	2602.18	11.21	Qy1	gr lag
454	-0.37	2613.94	11.21	Qy1	
455	-0.62	2616.72	11.32	Qy1	creosote mound
456	-1.09	2624.49	11.23	Qy1	
457	-1.19	2628.48	11.28	Qy1	
458	-1.42	2633.08	11.25	Qy1	
459	-2.06	2639.75	11.26	Qy1	
460	-2.41	2642.37	11.49	Qy1	creosote mound
461	-3.04	2646.43	11.21	Qy1/Qy2	W edge 97 inund?
462	-3.00	2647.66	10.81	Qy2/Qyc	rt edge ch
463	-3.12	2648.81	10.79	Qyc/Qy2	left edge ch
464	-3.37	2650.43	11.27	Qy2	top left ch bank
465	-3.41	2655.97	11.31	Qy2	v shallow 97 inund possible
466	-3.62	2660.92	11.24	Qy2	
467	-3.76	2662.12	11.11	Qy2	top rt ch bank
468	-3.69	2662.77	10.73	Qy2/Qyc	rt edge ch
469	-3.61	2664.25	10.83	Qyc/Qy2	left edge ch
470	-3.81	2666.4	11.44	Qy2	top left ch bank - creosote
471	-3.86	2665.35	11.13	Qy2	
472	-3.88	2673.54	11.22	Qy2	
473	-4.35	2680.03	11.24	Qy2/Ql	E edge 97 inund
474	-4.71	2688.68	11.31	Ql	swale
475	-5.42	2695.12	11.44	Ql	
476	-6.17	2708.11	11.64	Ql	gr bar
477	-6.54	2714.55	11.45	Ql	swale
478	-6.87	2723.95	11.28	Ql/Qy2	

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
479	-7.48	2736.67	11.02	Qy2	bottom sm ch
480	-7.45	2740.97	11.13	Qy2/Ql	
481	-7.41	2743.34	11.25	Ql	gr bar
482	-7.49	2746.12	11.19	Ql	swale
483	-7.63	2752.91	11.36	Ql	gr bar
484	-8.33	2754.41	11.23	Ql/Qy2	
485	-8.11	2760.85	11.09	Qy2	bottom sm ch
486	-8.98	2766.97	11.3	Qy2/Ql	
487	-9.79	2772.83	11.37	Ql	gr bar
488	-9.60	2778.29	11.48	Ql	gr bar
489	-9.65	2781.75	11.44	Ql	swale
490	-9.48	2785.73	11.52	Ql	gr bar
491	-9.69	2791.03	11.4	Ql	swale
492	-9.65	2796.22	11.54	Ql	gr bar
493	-10.15	2804.81	11.41	Ql/Qy2	
494	-10.18	2808.97	11.29	Qy2	deeper swale
495	-10.31	2813.79	11.42	Qy2/Ql	
496	-10.40	2821.96	11.61	Ql	
497	-10.77	2829.01	11.78	Ql	creosote mound
498	-11.38	2837.45	11.76	Ql	
499	-11.48	2842	11.73	Ql	swale
500	-11.00	2846.98	12.05	Ql	top sharp gr bar
501	-11.02	2849.8	11.87	Ql	gr bar
502	-11.18	2855.37	11.84	Ql	gr bar
503	-11.29	2857.58	11.92	Ql	top sharp gr bar
504	-11.46	2861.94	11.68	Ql	swale
505	-11.63	2865.4	11.86	Ql	gr bar / creosote mound
506	-11.98	2868.94	11.66	Ql/Qy2	
507	-12.26	2872.97	11.51	Qy2	bottom sm ch
508	-12.36	2879	11.62	Qy2/Ql	
509	-12.67	2885.51	11.93	Ql	
510	-13.08	2889.59	11.98	Ql	gr bar
511	-13.94	2889.72	11.64	Ql/Qy2	
512	-14.43	2903.72	11.51	Qy2	
513	-14.36	2914.61	11.38	Qy2	bottom sm ch
514	-14.36	2918.22	11.37	Qy2/Ql	
515	-14.11	2921.67	11.61	Ql	creosote mound
516	-14.27	2926.99	11.5	Ql	gravel lag
517	-14.98	2935.45	11.52	Ql	gravel lag
518	-15.65	2940.49	11.33	Ql/Qy2	
519	-15.45	2943.68	10.97	Qy2	bottom sm ch
520	-15.79	2945.81	11.36	Qy2	ff
521	-15.83	2957.94	11.22	Qy2	ff
522	-15.67	2959.64	11.08	Qy2	bottom sm ch
523	-15.40	2961.91	11.2	Qy2	ff
524	-15.58	2964.51	11.03	Qy2	bottom sm ch
525	-15.46	2965.48	11.25	Qy2	ff
526	-16.11	2975.85	11.24	Qy2	ff

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
527	-16.32	2982.31	11.15	Qy2	ff
528	-16.46	2987.75	10.94	Qy2	bottom sm ch
529	-16.99	2990.04	11.39	Qy2	ff
530	-17.35	2999.61	11.32	Qy2	ff
531	-18.78	3010.1	11.37	Qy2	ff
532	-19.03	3016.6	11.49	Qy2	cm
533	-19.09	3024.31	11.46	Qy2road	edge rd berm
534	-19.13	3027.69	11.65	road	
535	-18.95	3029.12	11.34	road	ditch bottom
536	-20.05	3032.24	11.59	road	W edge Eagle Eye Rd
537	-20.51	3041.01	11.77	road	E edge Eagle Eye Rd
538	-20.17	3046.32	11.58	road/Qm	ditch
539	-20.58	3060.93	11.83	Qm	
540	-30.45	3137.44	11.64	Qm	
541	-5.93	2703.02	11.59	Qm?	
542	-26.06	3066.91	11.52	Qm	
543	-26.59	3073.61	11.32	Qm/Qy2	W edge 97 inund
544	-26.98	3077.73	11.22	Qy2/Qys	sh sh fl
545	-27.27	3083.29	11.18	Qys	deep sh fl
546	-27.23	3088.03	11.21	Qys	
547	-27.42	3092.09	11.35	Qys	~ WSEL, creosote mound
548	-27.61	3094.07	11.1	Qys	bottom sm ch
549	-27.62	3095.34	11.27	Qys	s bar
550	-27.70	3096.37	11.1	Qys	sm ch
551	-28.07	3098.68	11.36	Qys	flotsam, creosote mound
552	-28.25	3100.72	11.13	Qys	sm ch
553	-28.19	3106.2	11.22	Qys	
554	-28.22	3107.18	11.32	Qys	s bar
555	-28.60	3111.02	11.26	Qys	
556	-28.44	3113.01	11.4	Qys	flotsam, creosote mound
557	-28.79	3116.71	11.21	Qys	sm ch
558	-29.17	3119.23	11.42	Qys	s bar
559	-29.08	3121.3	11.26	Qys	sm ch
560	-29.09	3122.52	11.4	Qys	s bar
561	-29.32	3123.81	11.26	Qys	
562	-29.51	3125.17	11.49	Qys	~ WSEL, creosote mound
563	-29.76	3126.61	11.37	Qys	scoured Qm was buried by Qy2
564	-29.71	3128.31	11.52	Qys	s bar
565	-30.03	3132.59	11.46	Qys	sm ch
566	18.35	3059.59	11.88	road	BM in Eagle Eye Rd, N of transect
567	-47.85	3534.77	11.81	Qm	E end of transect, gr bar
568	-47.61	3523.86	11.74	Qm	edge gr bar
569	-47.03	3513.25	11.57	Qm	swale
570	-46.47	3497.8	11.47	Qm	swale
571	-46.48	3491.33	11.48	Qm	swale
572	-45.69	3473.47	11.43	Qm	gr bar
573	-45.17	3461.96	11.32	Qm/Qy2	
574	-44.44	3450.36	11.21	Qy2/Qys	E edge 97 inund, ff very thin over Qm

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
575	-45.54	3439.68	10.78	Qys	sm ch
576	-44.19	3436.62	11.21	Qys	creosote mound, unflooded
577	-44.11	3434.84	10.68	Qys/Qyc	left edge ch
578	-44.04	3432.79	10.6	Qyc/Qys	rt edge ch
579	-43.96	3430.92	11.03	Qys	cm, ~WSEL
580	-43.93	3428.67	10.81	Qys	sm ch
581	-44.04	3424.78	11.02	Qys	cm, ~WSEL
582	-43.79	3421.24	10.7	Qys	sm ch
583	-43.74	3418.81	10.94	Qys	sm ch
584	-43.36	3414.44	11.36	Qys	cm, ~WSEL
585	-43.59	3410.08	11.11	Qys	sh fl
586	-43.28	3400.94	11.52	Qys	cm, top not inund
587	-43.23	3397.88	11.34	Qys/Qyc	left edge ch
588	-42.45	3392.94	11.31	Qyc	rt edge ch
589	-42.19	3389.28	11.27	Qyc/Qys	sm side ch
590	-42.06	3386.7	11.46	Qys	s bar
591	-41.96	3383.32	11.33	Qys	sm ch
592	-41.57	3379.94	11.5	Qys	cm
593	-41.48	3376.68	11.2	Qys	sheet flow w/ flotsam
594	-41.50	3371.53	11.29	Qys	
595	-41.40	3369.44	11.62	Qys	gr bar
596	-41.50	3365.24	11.4	Qys	sheet fl w/ little relief
597	-41.20	3359.84	11.57	Qys	
598	-41.28	3355.11	11.56	Qys	
599	-40.53	3347.52	11.64	Qys	
600	-40.20	3338.09	11.54	Qys	sm ch
601	-39.85	3334.16	11.66	Qys	gr bar
602	-39.49	3329.61	11.67	Qys	gr bar
603	-39.17	3320.45	11.58	Qys	sm ch
604	-39.03	3314.69	11.69	Qys	relict gr bar, ~WSEL
605	-37.95	3306.04	11.73	Qys	
606	-38.22	3296.01	11.6	Qys	
607	-39.03	3290.71	11.51	Qys	sm ch
608	-39.08	3286.76	11.67	Qys	
609	-38.61	3283.82	11.46	Qys	
610	-38.93	3282.17	11.73	Qys	
611	-38.84	3275.6	11.49	Qys	
612	-38.22	3269.44	11.61	Qys	
613	-38.11	3266.06	11.47	Qys	
614	-38.20	3262.68	11.56	Qys	
615	-37.84	3255.55	11.49	Qys	
616	-37.10	3250.6	11.62	Qys	cm w/ flotsam
617	-36.84	3244.57	11.35	Qys	
618	-37.03	3242.26	11.63	Qys	cm w/ flotsam
619	-36.49	3237.41	11.42	Qys	
620	-36.16	3229.91	11.5	Qys	
621	-35.78	3223.75	11.44	Qys	
622	-35.66	3219.92	11.68	Qys	

Tiger Wash topo cross section along dirt track-field data and observations					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
623	-35.15	3215.62	11.53	Qys	
624	-34.83	3212.38	11.48	Qys	
625	-34.67	3206.38	11.73	Qys	cm w/ flotsam
626	-34.38	3201.26	11.55	Qys	
627	-34.24	3197.86	11.68	Qys	
628	-33.94	3191.55	11.56	Qys	
629	-33.70	3186.41	11.69	Qys	
630	-33.53	3181.38	11.64	Qys	
631	-33.39	3179.19	11.44	Qys	
632	-33.11	3176.4	11.62	Qys	
633	-32.93	3171.99	11.59	Qys	top left bank ch
634	-32.87	3170.74	11.29	Qys/Qyc	left edge ch
635	-32.63	3167.92	11.12	Qyc	ch topo
636	-31.96	3157.37	11.13	Qyc/Qys	rt edge ch
637	-31.71	3152.68	11.78	Qys	top rt bank ch
638	-31.20	3146.46	11.68	Qys	rt overbank deep sh fl
639	-30.91	3142.34	11.49	Qys	sm ch

Tiger Wash topo at 'trench' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
IS1	100.00	1000	5	Qy1	IS 1, just W of dated ironwood snag
1	36.31	1415.37	4.92	Qy1	fine gr lag, just buries Qm bar to N, large cm co
2	37.69	1404.26	4.95	Qy1	fine flat surface
3	39.34	1392.04	4.99	Qy1	fine flat surface
4	39.98	1390.59	5.23	Qy1	cm
5	39.93	1387.71	5.06	Qy1	middle fine grv splay
6	40.76	1382.01	5.02	Qy1	fine flat surface
7	41.21	1379	5.14	Qy1	cm
8	42.18	1372.32	5	Qy1	swale
9	42.59	1368.9	5.12	Qy1	cm
10	43.50	1363.64	5.02	Qy1	fine flat surface
11	44.05	1361.47	5.16	Qy1	cm
12	44.31	1358.54	5.06	Qy2	swale w/ grv splay
13	45.40	1358.1	5	Qy2	swale
14	43.92	1356.75	5.18	Qy2	cm, E edge inund
15	44.03	1354.26	5	Qy2	swale, v sh sh fl
16	44.58	1346.08	4.98	Qy2/Qm	swale, v sh sh fl
17	46.30	1330.99	5.04	Qm	grv bar, W edge inund
18	52.46	1324.21	5.02	Qm/Qy2	E edge main inund
19	54.42	1309.06	4.89	Qy2	v sh sh fl
20	55.31	1299.45	4.77	Qy2	v sh sh fl
21	56.57	1293.04	4.8	Qy2	v sh sh fl
22	60.06	1283.08	4.49	Qy2	sm gully
23	60.91	1274.62	4.53	Qy2	v sh sh fl
24	63.13	1259.58	4.44	Qy2	v sh sh fl
25	63.34	1257.07	4.45	Qy2	v sh sh fl, partially buried Qm bar
26	64.00	1252.29	4.36	Qy2	deeper gully
27	64.06	1248.88	4.69	Qy2	not topo, flotsam in creosote
28	64.55	1248.57	4.36	Qy2	sm ch
29	64.63	1246.11	4.46	Qy2	s bar
30	65.58	1240.5	4.31	Qy2	sm ch
31	66.28	1235.25	4.38	Qy2	cm, flotsam
32	66.59	1233.24	4.28	Qy2	sm ch
33	66.72	1231.37	4.38	Qy2	s bar
34	67.39	1227.42	4.16	Qy2	somewhat larger s bars and scoured burrows
35	67.50	1224.49	4.34	Qy2	s bar
36	68.73	1224.65	4.5	Qy2	not topo, flotsam in creosote
37	67.63	1222.44	4.18	Qy2	sm ch
38	67.95	1219.72	4.31	Qy2	top left bank gully
39	68.28	1217.93	3.71	Qy2	bottom gully
40	68.96	1214.74	4.38	Qy2	top rt bank gully
41	69.48	1209.99	4.23	Qy2	swale
42	70.01	1206.57	4.38	Qy2	cm, flotsam at least 10 cm higher
43	70.34	1204.38	4.14	Qy2	sm ch
44	70.67	1202.64	4.22	Qy2	s bar
45	70.99	1201.17	3.95	Qy2	sm ch
46	71.16	1198.76	4.44	Qy2	cm, flotsam
47	71.62	1195.01	4.29	Qy2	swale

Tiger Wash topo at 'trench' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
48	72.42	1189.12	4.32	Qy2	s bar
49	72.59	1188.32	4.11	Qy2	sm ch
50	72.93	1187.1	4.29	Qy2	edge sm ch
51	72.93	1185.33	4.45	Qy2	cm, flotsam
52	74.10	1181.51	4.21	Qy2	swale
53	74.42	1178.57	4.42	Qy2	s bar
54	74.61	1176.46	4.25	Qy2	v sm ch
55	74.84	1174.14	4.48	Qy2	cm, flotsam
56	75.51	1170.76	4.37	Qy2/Qyc	top left bank ch
57	75.89	1169.25	3.88	Qyc	left edge ch
58	76.19	1168.24	3.92	Qyc	rt edge ch
59	76.02	1166.92	4.53	Qyc/Qy2	top rt bank ch
60	75.46	1164.94	4.6	Qy2/Qyc	top left bank ch
61	75.43	1163.5	3.9	Qyc	left edge ch
62	75.76	1162.15	3.88	Qyc	rt edge ch
63	76.43	1161.48	4.52	Qyc/Qy2	top rt bank ch
64	77.19	1157.14	4.3	Qy2	sand sheet
65	77.39	1155.93	4.45	Qy2	s bar
66	77.91	1153.1	4.49	Qy2	s bar
67	77.27	1150.66	4.46	Qy2/Qyc	top left bank ch
68	77.52	1149.96	3.83	Qyc	left edge ch
69	77.79	1148.11	3.87	Qyc	rt edge ch
70	78.51	1147.99	4.37	Qyc/Qy2	top rt bank ch
71	78.60	1146.21	4.17	Qy2	sm ch
72	78.88	1144.2	4.5	Qy2	cm
73	79.83	1139.41	4.46	Qy2	E edge sand sheet
74	80.57	1135.09	4.46	Qy2	sand sheet
75	80.87	1133.26	4.23	Qy2	sm ch
76	81.21	1130.36	4.45	Qy2	sand sheet
77	82.00	1124.51	4.65	Qy2	cm, flotsam, ~ WSEL
78	82.60	1123.12	4.4	Qy2/Qyc	top left bank ch
79	82.57	1122.37	3.92	Qyc	left edge ch
80	83.21	1118.49	3.95	Qyc	rt edge ch
81	83.38	1117.39	4.45	Qyc/Qy2	top rt bank ch
82	83.61	1115.39	4.59	Qy2	cm, flotsam
83	83.92	1112.75	4.56	Qyc	fine flat, some flotsam, sh sh fl
84	85.22	1104.02	4.65	Qyc	sh sh fl
85	85.93	1097.03	4.56	Qy2	sh sh fl
86	86.86	1091.6	4.57	Qy2	sh sh fl
87	88.36	1080.78	4.48	Qy2	sh sh fl
88	89.09	1074.62	4.59	Qy2	sh sh fl
89	89.84	1067.34	4.65	Qy2	sh sh fl
90	90.66	1063.26	4.86	Qy2/Qyc	cm, top left bank ch, not inund
91	90.29	1061.4	4.47	Qyc	left edge ch
92	91.00	1057.6	4.44	Qyc	ch topo
93	91.73	1054.03	4.51	Qyc	ch topo
94	91.86	1052.1	4.61	Qyc	rt edge ch
95	92.56	1048.27	4.64	Qyc/Qy1	W edge inund

Tiger Wash topo at 'trench' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
96	93.38	1043.46	4.74	Qy1	gr bar not inund
97	94.12	1038.56	4.67	Qy1/Qy2	E edge shallow prong of inund
98	95.39	1031.37	4.71	Qy2	v sh sh fl
99	97.72	1028.6	4.66	Qy2/Qy1	W edge inund
100	100.19	1019.28	4.81	Qy1	cm
101	93.44	1010.49	4.77	Qy1	topo at dated ironwood snag off profile
102	101.34	1012.6	4.72	Qy1	swale, just E of E end of trench
103	103.18	1009.82	4.92	Qy1	cm
104	104.39	1007.53	4.88	Qy1	grv bar
105	106.64	1002.9	4.99	Qy1	grv bar
106	108.90	999.28	4.84	Qy1	swale
107	110.51	997.08	5.05	Qy1	cm
108	111.26	995.46	4.9	Qy1	swale
109	113.36	990.78	4.89	Qy1	swale
110	115.20	987.7	4.91	Qy1	cm
111	118.48	981.53	4.75	Qy1	swale
112	120.14	978.99	4.94	Qy1	cm
113	120.94	978.33	4.75	Qy1/Qy2	E edge inund
114	121.92	976.67	4.65	Qy2/Qyc	top left bank ch
115	122.55	975.85	4.44	Qyc	left edge ch
116	124.13	972.73	4.6	Qyc	ch topo
117	124.43	970.96	4.77	Qyc/Qy2	cm in ch
118	126.15	969.76	4.82	Qy2/Qyc	cm in ch
119	128.16	966.28	4.52	Qyc	ch topo
120	130.74	961.17	4.49	Qyc	ch topo
121	132.30	957.95	4.71	Qyc	grv bar
122	133.87	954.36	4.81	Qyc	grv bar
123	136.61	952.65	4.88	Qyc	top grv bar in mesquite, flotsam ~ 20 cm higher
124	137.97	950.26	4.69	Qyc	ch W of mesquite
125	139.57	945.35	4.79	Qyc	grv bar
126	140.02	941.41	4.73	Qyc	ch
127	140.10	939.35	4.3	Qyc	E edge of lowest part of ch fresh bank in ch dep
128	142.06	934.3	4.16	Qyc	W edge of lowest part of ch
129	143.07	932.42	4.6	Qyc/Qy2	top rt bank ch
130	145.55	927.39	4.49	Qy2	rt overbank
131	147.17	924.72	4.58	Qy2	sm ch
132	148.49	921.99	4.72	Qy2	s bar
133	147.56	920.34	4.66	Qy2/Qyc	top left bank ch
134	147.89	919.17	4.35	Qyc	left edge ch
135	148.38	917.69	4.45	Qyc	rt edge ch
136	148.41	916.64	4.61	Qyc/Qy2	top rt bank ch
137	149.15	914.64	4.51	Qy2	sm ch
138	149.63	914.14	4.63	Qy2	sh sh fl
139	150.88	909.85	4.72	Qy2	sh sh fl
140	152.96	905.35	4.71	Qy2	sh sh fl
141	154.87	900.64	4.79	Qy2	W edge inund
142	156.30	896.96	4.93	Qy2	gr bar not inund
143	157.44	894.11	4.87	Qy2/Qyc	top left bank ch

Tiger Wash topo at 'trench' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
144	157.82	892.57	4.46	Qyc	left edge ch, v sh inund, E edge inund is E of thi
145	160.61	887.53	4.64	Qyc/Qy2	highest flotsam line in ch,W edge inund
146	161.65	883.88	4.87	Qy2	top rt bank ch
147	165.49	876.24	4.71	Qy2	swale
148	167.87	870.02	4.66	Qy2	inactive ch between lg ironwood and paloverde
150	218.99	785.7	4.9	Qy2	IS2
151	99.96	1000.05	5	Qy2	BS IS2 to IS1
152	171.57	862.54	4.59	Qy2	W edge inactive ch
153	173.68	858.33	5.02	Qy2	top relict bldr bar
154	175.39	853.52	4.84	Qy2	side relict bldr bar
155	176.87	850.39	4.7	Qy2	E edge inund
156	177.98	847.99	4.49	Qy2	bottom sm ch
157	179.94	844.68	4.78	Qy2	cm, barely inund, ~WSEL
158	180.80	842.16	4.61	Qy2	sm ch
159	181.60	840.33	4.67	Qy2	s bar
160	182.96	837.43	4.71	Qy2/Qyc	top left bank ch
161	183.47	836.45	4.52	Qyc	left edge ch
162	186.59	831.45	4.57	Qyc	s bar
163	187.52	829.86	4.46	Qyc	ch topo
164	190.47	825.35	4.46	Qyc	ch topo
165	191.25	824.25	4.57	Qyc	grv bar
166	192.06	822.95	4.26	Qyc	ch topo
167	193.10	821.43	4.11	Qyc	ch topo
168	197.80	814.68	4.05	Qyc	ch topo
169	199.68	812.29	4.24	Qyc	rt edge ch
170	201.14	809.99	4.53	Qyc	top rt bank ch, sand covered
171	202.46	807.77	4.51	Qyc	top left bank ch
172	203.31	806.21	4.3	Qyc	left edge ch
173	205.84	801.31	4.27	Qyc	ch topo
174	208.34	796.17	4.32	Qyc	rt edge ch
175	208.76	795.26	4.47	Qyc	top Qm in bank
176	209.24	794.19	4.65	Qyc	top Holoc grv in bank
177	209.50	792.71	4.93	Qyc/Qy2	top rt bank ch
178	211.25	789.4	4.89	Qy2	s bar
179	212.00	787.78	4.67	Qy2	sm ch
180	212.34	786.66	4.91	Qy2	cm
181	212.75	785.47	4.71	Qy2	sm ch
182	214.08	782.97	4.88	Qy2	cm
183	215.37	780.77	4.74	Qy2	sm ch
184	217.57	777.72	4.93	Qy2	cm
185	218.42	774.97	4.7	Qy2	swale, Qm exposed upstream
186	218.96	773.09	4.85	Qy2	s bar
187	220.43	769.29	4.86	Qy2	s bar
188	222.71	765.31	4.76	Qy2	sm ch
189	224.13	763.38	4.91	Qy2	cm
190	224.23	762.33	4.8	Qy2	sm ch
191	225.26	759.45	4.96	Qy2	cm w/ flotsam
192	226.11	756.47	4.75	Qy2	sm ch

Tiger Wash topo at 'trench' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
193	226.19	754.37	4.89	Qy2	cm w/ flotsam
194	226.56	752.75	4.77	Qy2	sm ch
195	227.21	751.43	4.92	Qy2	s bar
196	229.06	748.04	4.75	Qy2	sm ch
197	230.15	745.5	4.86	Qy2	high area, not much fresh sediment
198	232.17	740.74	4.71	Qy2	sm ch
199	233.72	736.67	4.91	Qy2	cm, flood-damaged
200	234.21	734.15	4.73	Qy2	sm ch
201	236.48	730.29	4.83	Qy2	cm, flotsam
202	237.38	729.45	4.63	Qy2	sm ch
203	238.47	727.71	4.72	Qy2	s bar
204	238.77	726.52	4.64	Qy2/Qyc	top left bank ch - new ch
205	238.86	725.98	4.32	Qyc	left edge ch
206	240.76	721.93	4.14	Qyc	ch topo
207	244.22	714.77	4.2	Qyc	ch topo
208	246.29	709.66	4.14	Qyc	ch topo
209	247.74	706.33	4.31	Qyc	grv bar, N side palo verde in ch
210	252.28	697.62	4.25	Qyc	ch topo, eroded Qm in bed
211	254.15	694.15	4.54	Qyc	low bank, eroded top Qm
212	255.47	691.03	4.64	Qyc	rt edge spill out ch
213	255.81	690.5	4.78	Qyc/Qy2	top rt bank
214	257.06	688.68	4.94	Qy2	cm, not inundated
215	257.61	687.08	4.73	Qy2	fine sed, sh sh fl
216	260.83	679.5	4.69	Qy2	fine sed, sh sh fl
217	264.32	672.35	4.63	Qy2/Qy1	W edge inund
218	264.82	670.56	4.65	Qy1	grv and sand
219	269.24	661.34	4.59	Qy1	
220	274.06	652.58	4.71	Qy1	cm
221	275.07	650.22	4.46	Qy1/Qy2	E edge inund
222	275.71	649.22	4.32	Qy2	sm ch
223	277.41	645.86	4.47	Qy2	edge partly inund Qy1 grv bar
224	280.16	640.89	4.49	Qy2	partly inund relict grv bar
225	281.31	648.43	4.36	Qy2	sm ch
226	282.59	635	4.52	Qy2	relict Qy1 bar
227	286.75	626.64	4.47	Qy2	fine grv
228	287.85	624.46	4.43	Qy2	
229	288.78	622.13	4.52	Qy2	s bar
230	290.62	618.39	4.42	Qy2	left edge gully
231	291.14	617.19	4.17	Qy2	bottom gully
232	291.79	615.65	4.46	Qy2	rt edge gully
233	292.96	612.73	4.63	Qy2	cm, not inundated
234	294.88	609.19	4.33	Qy2	bottom sm ch
235	295.46	607.78	4.47	Qy2	s bar
236	295.95	606.65	4.18	Qy2	sm ch
237	296.24	605.16	4.66	Qy2	cm, not inundated
238	298.95	601.17	4.44	Qy2	edge sm gully
239	300.45	598.85	4.15	Qy2	bottom sm gully
240	302.58	595.54	4.54	Qy2	s bar

Tiger Wash topo at 'trench' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
241	302.87	593.62	4.39	Qy2	swale
242	304.91	589.83	4.53	Qy2	s bar
243	308.07	582.94	4.54	Qy2	s bar and left bank gully
244	309.82	580.56	4.1	Qy2	bottom sm gully
245	310.26	578.48	4.45	Qy2	s bar and rt bank gully
246	311.62	575.62	4.27	Qy2	sm gully
247	313.65	572.69	4.64	Qy2	cm, top ~WSEL
248	315.02	570.36	4.67	Qy2/Qm	
249	316.45	568.1	4.66	Qm	W edge inund, modified pavement to here
250	320.51	560.03	4.98	Qm	grv bar
251	322.06	556.16	4.95	Qm	swale
252	323.95	551.38	4.98	Qm	grv bar
253	326.29	545.48	4.93	Qm	swale, some Qy2 cover

Tiger Wash topo at 'gravel pit' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
IS1	100.00	1000	5		IS 1
1	-0.61	1484.12	5.17	Qy2	v sh 97 inund
2	0.35	1480.07	5.18	Qy2	cm, not inund?
3	1.82	1476.41	5.09	Qy2	flotsam
4	3.18	1468.69	4.97	Qy2	flotsam
5	4.33	1458.53	5.03	Qy2	
6	4.95	1454.79	5.19	Qy2	cm, not inund?
7	7.08	1443.74	5.04	Qy2	v sh 97 inund
8	9.62	1430.21	5.02	Qy2	
9	10.85	1424.03	4.96	Qy2	
10	13.14	1412.68	4.87	Qy2	sh sh fl
11	16.37	1400.03	4.82	Qy2	
12	18.89	1388.99	4.73	Qy2	sm ch
13	19.47	1387.52	4.94	Qy2	
14	20.77	1379.5	4.85	Qy2	edge sand sheet
15	22.70	1372.73	4.83	Qy2	edge sand sheet
16	23.15	1368.65	4.87	Qy2	
17	23.33	1367.63	4.62	Qy2	sm gully
18	23.63	1366.23	4.82	Qy2	
19	24.95	1358.79	4.87	Qy2	
20	25.93	1356.14	4.89	Qy2	cm
21	26.33	1352.71	4.86	Qy2	s bar
22	26.63	1350.14	4.83	Qy2	
23	27.15	1346.48	4.79	Qy2	
24	28.51	1340.99	4.83	Qy2	
25	29.54	1336.09	4.82	Qy2	
26	31.44	1327.07	4.83	Qy2	
27	32.34	1322.72	4.75	Qy2	
28	32.98	1319.18	4.83	Qy2	
29	34.48	1310.83	4.74	Qy2	
30	35.79	1305.17	4.74	Qy2	
31	36.42	1302.17	4.83	Qy2	cm, flotsam ~WSEL
32	37.42	1297.88	4.81	Qy2	
33	39.24	1290.03	4.74	Qy2	
34	39.86	1287.68	4.75	Qy2	somewhat larger s bars and scoured burrows
35	40.78	1283.24	4.66	Qy2	
36	41.80	1278.51	4.61	Qy2	
37	42.48	1275.64	4.62	Qy2	
38	43.29	1270.41	4.63	Qy2	
39	43.57	1269.29	4.53	Qy2	E edge deeper sh flooding?
40	44.55	1268.18	4.75	Qy2	cm, flotsam ~WSEL
41	45.76	1260.88	4.58	Qy2	gray area between sh and deeper sh fl
42	46.50	1256.44	4.62	Qy2	
43	47.19	1253.08	4.5	Qy2	
44	47.61	1250.92	4.56	Qy2	
45	47.95	1249.53	4.53	Qy2	
46	48.38	1247.46	4.65	Qy2	cm, flotsam ~WSEL
47	48.92	1244.48	4.47	Qy2	

Tiger Wash topo at 'gravel pit' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
48	49.64	1240.02	4.55	Qy2	
49	50.62	1236.24	4.76	Qy2	
50	50.79	1233.6	4.52	Qy2	
51	51.23	1231.2	4.65	Qy2	
52	52.02	1227.81	4.48	Qy2	
53	52.89	1224.02	4.63	Qy2	
54	53.83	1219.53	4.51	Qy2	
55	54.12	1217	4.67	Qy2	cm, flotsam ~WSEL
56	54.67	1215.06	4.47	Qy2	
57	57.14	1205.86	4.46	Qy2	edge sand/gravel sheet, deeper sh fl
58	58.26	1200.96	4.44	Qy2	
59	58.74	1198.89	4.03	Qy2	bottom gully
60	58.96	1195.7	4.6	Qy2	cm, flotsam ~WSEL
61	59.99	1191.46	4.41	Qy2	
62	60.23	1190.41	3.9	Qy2	bottom gully
63	60.78	1188.04	4.6	Qy2	cm, flotsam ~WSEL
64	61.58	1183.56	4.41	Qy2	
65	63.05	1117.15	4.4	Qy2	
66	63.61	1174.42	4.57	Qy2	
67	64.11	1171.56	4.4	Qy2	
68	64.46	1169.4	4.48	Qy2	
69	65.23	1165.59	4.35	Qy2	
70	65.82	1163.03	4.52	Qy2	
71	66.85	1159	4.54	Qy2	
72	67.27	1157.37	4.49	Qy2	
73	67.85	1155.12	4.67	Qy2	cm, flotsam ~WSEL
74	67.97	1153.03	4.52	Qy2	sm ch
75	69.66	1144.2	4.59	Qy2	
76	71.78	1135.22	4.61	Qy2	
77	72.12	1133.92	4.67	Qy2	
78	73.17	1128.43	4.66	Qy2	
79	74.35	1123.5	4.78	Qy2	
80	74.54	1122.57	4.58	Qy2	bottom sm ch by palo verde
81	74.74	1121.17	4.78	Qy2	
82	76.16	1113.4	4.91	Qy2	top left bank ch
83	76.28	1112.46	4.61	Qyc	left edge ch
84	76.75	1110.26	4.36	Qyc	rt edge ch
85	76.75	1109.86	4.9	Qy2	top rt bank ch, v sh inund
86	77.33	1102.38	4.83	Qm	
87	79.69	1090.86	4.72	Qy2	
88	83.96	1075.19	4.71	Qy2	sh sh fl
89	86.56	1061.99	4.62	Qy2	
90	87.08	1058.91	4.69	Qy2	
91	88.07	1054.17	4.58	Qy2	
92	89.60	1047.64	4.63	Qy2	
93	90.20	1044.59	4.65	Qy2	
94	90.77	1041.98	4.61	Qy2	
95	91.65	1037.95	4.64	Qy2	

Tiger Wash topo at 'gravel pit' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
96	92.85	1033.03	4.56	Qy2	
97	93.65	1029.54	4.72	Qy2	
98	95.25	1023.08	4.7	Qy2	
99	96.63	1015.78	4.81	Qy2	
100	97.46	1011.34	4.86	Qy2/Qyc	edge sand sheet at margin of "channel"
101	101.68	922.6	4.93	Qyc	sand/gravel sheet
102	103.66	983.93	4.84	Qyc/Qy2	
103	104.40	980.86	4.87	Qy2	
104	105.03	978.18	4.73	Qy2	sm ch
105	105.43	976.52	4.85	Qy2	flotsam mat
106	106.52	971.89	4.74	Qy2/Qyc	top left bank ch
107	106.76	970.67	4.45	Qyc	left edge ch
108	107.50	968.3	4.57	Qyc	rt edge ch
109	107.51	967.48	4.78	Qyc/Qy2	top rt bank ch
110	109.04	960.07	4.71	Qy2	
111	109.41	958.72	4.44	Qy2	bottom sm ch
112	109.90	956.47	4.68	Qy2/Qy2	
113	112.06	947.17	4.64	Qy2	
114	113.74	938.94	4.56	Qy2	
115	114.08	937.74	4.66	Qy2	s bar
116	115.09	933.27	4.52	Qy2	
117	115.47	929.91	4.41	Qy2	bottom sm ch
118	115.55	928.47	4.58		cm completely inund
119	116.40	925.46	4.51	Qy2	
120	116.79	923.03	4.35	Qy2	sm gully
121	117.46	919.56	4.54	Qy2	s bar
122	118.64	915.25	4.32	Qy2	sm gully
123	119.32	912.53	4.48	Qy2	
124	121.27	903.71	4.42	Qy2	
125	123.08	895.84	4.54	Qy2	
126	124.15	889.48	4.68	Qy2	cm near deep gully, inund
127	124.06	888	4.5	Qy2/Qyc	top left bank deep gully
128	124.13	887.11	3.51	Qyc	bottom gully, marginal for Qyc because thin
129	123.94	885.65	4.44	Qyc/Qy2	rt bank gully
130	125.94	884.52	4.5	Qy2	cm between gullies, close to WSEL
131	125.83	882.83	4.27	Qy2/Qyc	top left bank gully
132	125.64	883.68	4.75	flot	**not topo, flotsam in creosote**
133	125.45	881.92	3.34	Qyc	bottom gully, marginal for Qyc because thin
134	126.56	880.42	4.27	Qyc/Qy2	top rt bank gully
135	127.18	878.61	4.53	Qy2	
136	127.44	876.8	4.14	Qy2	
137	128.19	875.08	4.44	Qy2	
138	128.52	873.53	4.26	Qy2	
139	129.41	870.84	4.57	Qy2/Qyc	top left bank ch
140	129.16	870.07	4.23	Qyc	left edge ch
141	129.89	866.83	4.13	Qyc	rt edge ch
142	130.45	865.08	4.67	Qyc/Qy2	top rt bank ch
143	131.87	859.41	4.67	Qy2	

Tiger Wash topo at 'gravel pit' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
144	132.54	858.04	4.52	Qy2	sm gully
145	132.83	854.89	4.65	Qy2	sh sh fl
146	134.62	845.9	4.62	Qy2	
147	137.63	832.47	4.57	Qy2	
148	175.74	665.58	4.57	Qy2	IS2, s bar in deep sh fl area
149	99.97	1000.12	4.94	Qy2	BS to IS1
150	141.03	818.03	4.37	Qy2	gully
151	140.95	817.97	4.37	Qy2	gully
152	141.82	813.74	4.47	Qy2	top large flotsam pile
153	143.38	808.98	4.7	Qy2	E edge sand sheet
154	143.97	805.1	4.61	Qy2/Qy2	W edge sand sheet
155	146.03	795.37	4.42	Qy2	low relief, sh sh fl
156	147.79	786.96	4.58	Qy2	
157	149.78	777.37	4.6	Qy2	
158	151.17	769.34	4.53	Qy2	
159	152.49	761.28	4.52	Qy2	
160	153.28	756.17	4.57	Qy2	
161	153.56	755.22	4.47	Qy2	
162	153.94	753.29	4.58	Qy2	
163	155.50	747.2	4.55	Qy2	
164	158.11	738.34	4.65	Qy2	E edge sand ch
165	158.70	736.44	4.57	Qy2	W edge sand ch
166	160.07	729.08	4.47	Qy2	
167	161.12	725.03	4.48	Qy2	deep sh fl
168	161.90	719.84	4.49	Qy2	
169	163.02	714.27	4.32	Qy2	
170	164.18	710	4.63	Qy2	top s bar
171	164.73	707.2	4.1	Qy2	bottom sm ch
172	164.98	703.14	4.52	Qy2	
173	166.16	698.83	4.33	Qy2	
174	166.73	696.54	4.45	Qy2	
175	167.91	691.52	4.46	Qy2	
176	168.50	689.78	4.29	Qy2	E edge sand sheet
177	169.91	685.39	4.35	Qy2	W edge sand sheet
178	171.78	679.24	4.42	Qy2	
179	172.12	677.99	4.26	Qy2	bottom sm ch
180	173.19	674.54	4.4	Qy2	s bar
181	173.95	671.45	4.52	Qy2	s bar
182	174.23	669.44	4.12	Qy2	sm ch
183	226.94	585.74	4.45	Qy2	s bar
184	226.02	587.62	4.2	Qy2	sm ch
185	225.29	588.72	4.42	Qy2	
186	223.25	592.6	4.47	Qy2	
187	222.32	594.02	4.31	Qy2	
188	221.46	595.35	4.51	Qy2	
189	218.43	598.64	4.67	Qy2	
190	218.32	600.7	3.97	Qy2	sm ch
191	217.55	601.6	4.42	Qy2	

Tiger Wash topo at 'gravel pit' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
192	214.50	606.39	4.4	Qy2/Qyc	top rt bank ch
193	213.40	607.8	3.91	Qyc	rt edge ch
194	212.57	609.18	4.09	Qyc	left edge ch
195	212.07	610.3	4.48	Qyc/Qy2	top left bank ch
196	210.61	611.9	4.49	Qy2	s bar
197	209.76	613.24	4.36	Qy2	sm ch
198	206.36	618.33	4.54	Qy2	
199	203.20	620.42	4.55	Qy2/Qyc	top rt bank ch
200	202.99	620.73	4.11	Qyc	rt edge ch
201	202.76	623.34	4.19	Qyc	left edge ch
202	202.12	624.34	4.64	Qyc/Qy2	top left bank ch
203	200.67	626.45	4.62	Qy2	s bar
204	200.26	656.85	4.48	Qy2	sm ch
205	199.58	627.99	4.64	Qy2	
206	196.82	631.24	4.6	Qy2	
207	196.67	632.11	4.46	Qy2	
208	195.23	634.92	4.48	Qy2	
209	194.29	636.45	4.31	Qy2	sm ch
210	193.16	638.19	4.55	Qy2	
220	179.12	681.21	4.38	Qy2	off topo line, S side prominent ironwood N of pr
221	175.64	665.72	4.52	Qy2	
222	188.33	644.92	4.51	Qy2	
223	186.74	648.1	4.44	Qy2/Qyc	top rt bank ch
224	186.08	648.89	4.13	Qyc	rt edge ch
225	184.95	651.4	4.02	Qyc	left edge ch
226	184.33	653.16	4.51	Qyc/Qy2	top left bank ch
227	182.04	655.67	4.53	Qy2	
228	181.09	656.72	4.48	Qy2	
229	179.12	660.83	4.59	Qy2	
230	177.70	662.03	4.41	Qy2	
231	225.57	587.35	4.18	Qy2	sm gully
232	226.36	585.19	4.44	Qy2	
233	229.03	579.9	4.29	Qy2	
234	229.80	578.96	4.11	Qy2	sm gully
235	230.61	576.41	4.38	Qy2	s bar
236	231.44	575.41	4.13	Qy2	sm gully
237	232.26	573.11	4.44	Qy2	top left bank ch
238	232.82	572.18	3.84	Qy1	left edge ch
239	233.01	570.82	3.97	Qy1	rt edge ch
240	233.53	569.87	4.27	Qy2	top rt bank ch
241	234.09	567.07	4.25	Qy2	
242	234.49	566.34	3.89	Qy2	
243	234.27	565.02	4.31	Qy2	cm, flotsam
244	234.69	563.03	4.18	Qy2	
245	235.15	562.36	3.99	Qy2	sm gully
246	236.77	560.73	4.12	Qm	s bar
247	238.04	559.06	3.92	Qm	left edge ch
248	239.88	555.94	4	Qm	rt edge ch

Tiger Wash topo at 'gravel pit' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
249	241.15	554.47	4.22	Qy2	s bar
250	243.21	551.14	4.04	Qy2	sm ch
251	244.83	547.86	4.12	Qy2	low relief surface, mod deep flow
252	248.61	540.23	4.16	Qy2	
253	252.33	535.41	4.22		
254	253.16	534.1	4.32	Qyc	
255	253.77	532.8	4.22	Qyc	
256	254.53	528.58	4.22	Qy1	
257	254.97	526.35	4.33		
258	256.15	524.16	4.27	Qy1	
259	257.06	521.25	4.43	Qy1	
260	259.48	516.72	4.3	Qy1	
261	261.48	512.11	4.45	Qy1	cm, E edge scour along new channel
262	262.32	510.66	4.19	Qy1	
263	263.20	509.25	4.2	Qy1	top left bank ch
264	263.53	505.18	3.69	Qy1	left edge ch
265	264.46	506.69	3.87	Qy1	top gr bar in new channel
266	265.07	505.04	3.96	Qy1	top gr bar in new channel
267	267.00	501.51	3.88	Qy1	ch topo
268	266.67	498.31	3.78	Qy1	rt edge ch
269	267.02	497.23	4.19	Qy1	
270	267.54	496.27	4.42	Qy1	top rt bank ch
271	270.07	491.59	4.37	Qy1	sand/gravel sheet overbank
272	273.54	486.58	4.41	Qy1	
273	274.57	483.99	4.38	Qy1	s bar
274	276.02	479.26	4.32	Qy1	sm gully
275	277.91	474.35	4.34	Qy1	sh sh fl
276	280.48	468.53	4.4	Qy1	
277	283.98	462.03	4.34	Qy1	
278	286.32	457.09	4.35	Qy1	relict gravel
279	288.05	453.15	4.33	Qy1	
280	289.59	449.88	4.4	Qy1	W edge inund, edge Qy1 gr bar
281	290.11	448.06	4.53	Qy1	top gr bar, not inund
282	291.41	445.41	4.38	Qy1	E edge inund
283	295.41	438.43	4.24	Qy1/Qy2	
284	299.05	432.42	4.22	Qy2	
285	302.91	424.68	4.1	Qy2	
286	305.93	419.52	4.27	Qy2	
287	308.27	414.39	4.35	Qy2/Qy1	
288	312.78	404.27	4.44	Qy1	cm, WSEL
289	313.52	403.07	4.51	Qy1	cm, not inund
290	314.14	400.11	4.28	Qy1	
291	316.05	396.08	4.09	Qy1	
292	316.43	394.38	3.81	Qy1	sm gully
293	316.61	393.04	4.3	Qy1	
294	317.50	388.84	4.35	Qy1	relict gravel
295	319.69	384.46	4.43	Qy1	relict gravel
296	322.12	379.49	4.43	Qy2/Qy1	w edge inund

Tiger Wash topo at 'gravel pit' cross section					
raw survey data					
Pt. No.	N	E	Z	Surface	Comments
297	325.19	371.48	4.5	Qy1	
298	327.84	365.36	4.54	Qy1	
299	329.65	361.74	4.42	Qy1	
300	336.57	351.34	4.41	Qy1	
301	336.67	349.28	3.93	Qy2	sm ch
302	337.12	348.01	4.14	Qy1	
303	338.88	345.6	4.26	Qy1	
304	341.83	340.34	4.02	Qy2	sm ch
305	343.47	336.54	4.27	Qy1	
306	346.56	329.84	4.73	Qy1	
307	348.08	325.58	4.77	Qy1	
308	352.07	316.92	4.62	Qy1	monument on Qy1 surface
309	99.90	1000	5.06	Qy2	
310	-1.73	1490.63	5.02	Qy2	sm gully
311	-1.96	1492.21	5.12	Qy2	
312	-2.37	1494.62	5.06	Qy2	sm gully w/ some scour
313	-3.61	1501.19	5.18	Qy2	
314	-3.84	1503.34	5.28	Qy2	possibly not inund
315	-4.54	1506.97	5.13	Qy2	sm gully
316	-5.87	1513.29	5.34	Qy2	cm not inund
317	-7.09	1520.16	5.2	Qy2	
318	-8.07	1524.74	5.4	Qy2	cm not inund
319	-10.54	1538.14	5.19	Qy2	
320	-13.57	1555.87	5.15	Qy2	
321	-14.83	1563.38	5.15	Qy2	
322	5.01	1485.69	5.15	Qy2	not on transect line, S side lone ironwood
323	-14.46	1566.07	5.25		cm not inund
324	-15.30	1569.43	5.16		
325	-17.86	1583.05	5.18		
326	-19.05	1590.1	5.11		sm gully
327	-19.71	1594.48	5.43		cm not inund
328	-20.35	1597.79	5.12		sm gully w/ some scour
329	-20.74	1601.53	5.25		
330	-21.21	1605.05	5.26	Qy2/Qy1	E edge 97 inund?
331	-22.15	1608.61	5.3	Qy1	top Ql gr bar, mostly buried
332	-24.10	1619.81	5.28	Qy1	swale
333	-26.31	1630.18	5.33	Qy1	fine gr lag
334	-27.47	1637.68	5.52	Qy1	cm
335	-30.04	1647.23	5.4	Qy1	topo consists of cms
336	-31.18	1654.26	5.48	Qy1	
337	-32.86	1663.65	5.43	Qy1	
338	-34.50	1674.35	5.36	Qy1	
339	-35.74	1682.18	5.52	Qy1	
340	-36.72	1685.96	5.49	Qy1	
341	-38.14	1698.78	5.34	Qy1	
342	-41.85	1718.29	5.32	Qy1	
343	-45.53	1735.7	5.32	Qy1	
344	-49.88	1754.25	5.3	Qy1	E end of transect, monumented at elbow in sm v

G.4 Color Aerial Photographs

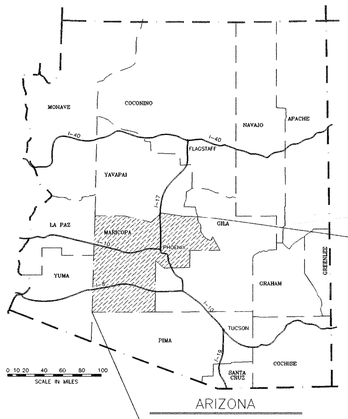
The 1:9600 scale color aerial photographs flown on March 30, 1999 for this project are provided in a separate accordion file folder along with an index sheet showing approximate locations of each photo frame.

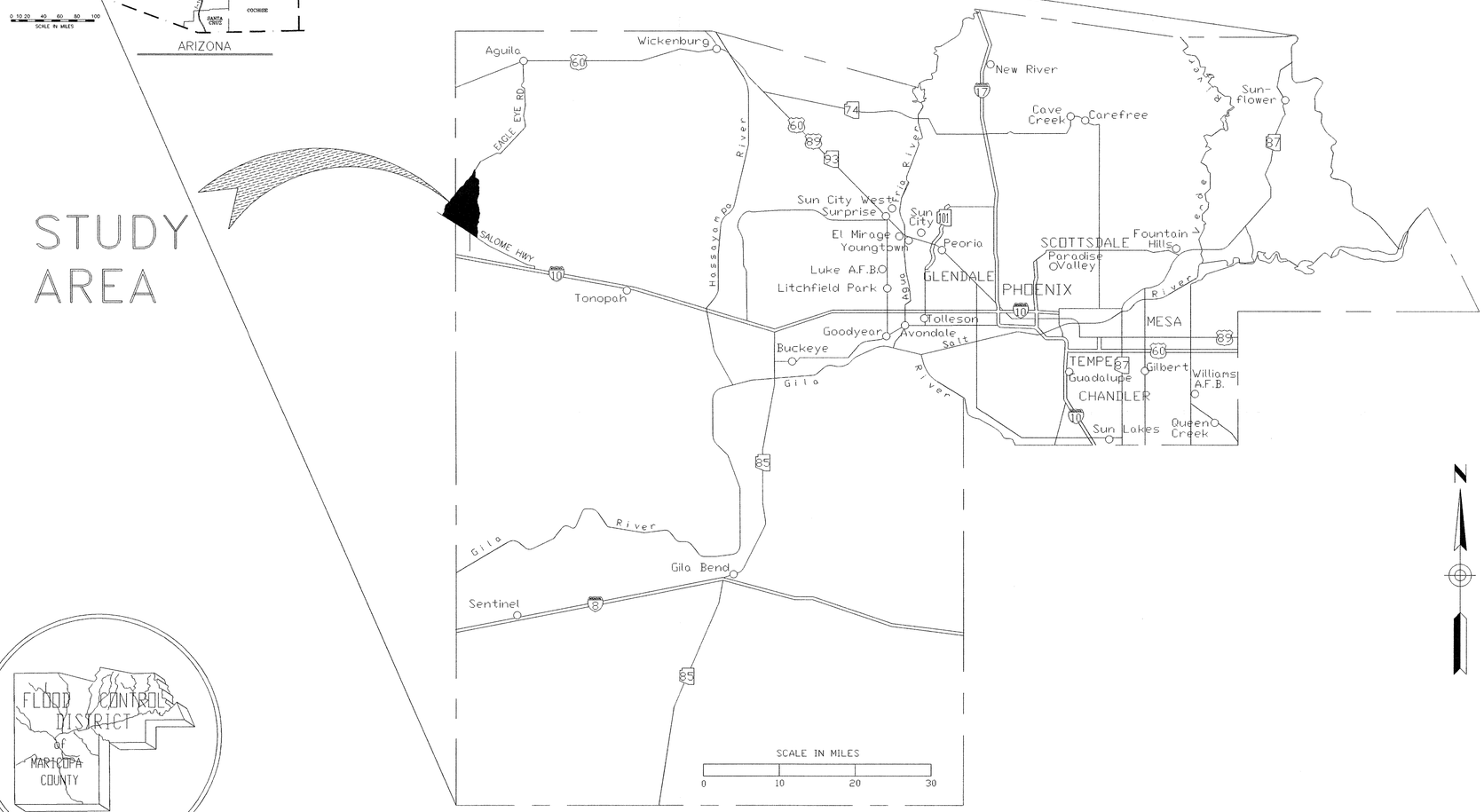
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH APPROXIMATE FLOODPLAIN DELINEATION STUDY

FCD 98-48

JUNE, 2000





NOTES

1. ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929
2. ALL HORIZONTAL COORDINATES USE ARIZONA STATE PLANE COORDINATES BASED ON THE 1983 NORTH AMERICAN DATUM

STATEMENTS OF PROFESSIONAL REGISTRANTS

REGISTERED PROFESSIONAL ENGINEER
22546
JONATHAN E. FULLER
MARICOPA COUNTY
ARIZONA, U.S.A.
6-8-00

THE LANDFORM, STABILITY AND FLOODPLAIN DELINEATIONS WERE PREPARED UNDER MY DIRECT SUPERVISION.

FLOOD CONTROL DISTRICT of MARICOPA COUNTY

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN		
DESIGN CHK.		
PLANS		
PLANS CHK.		
SUBMITTED BY: DATE:		

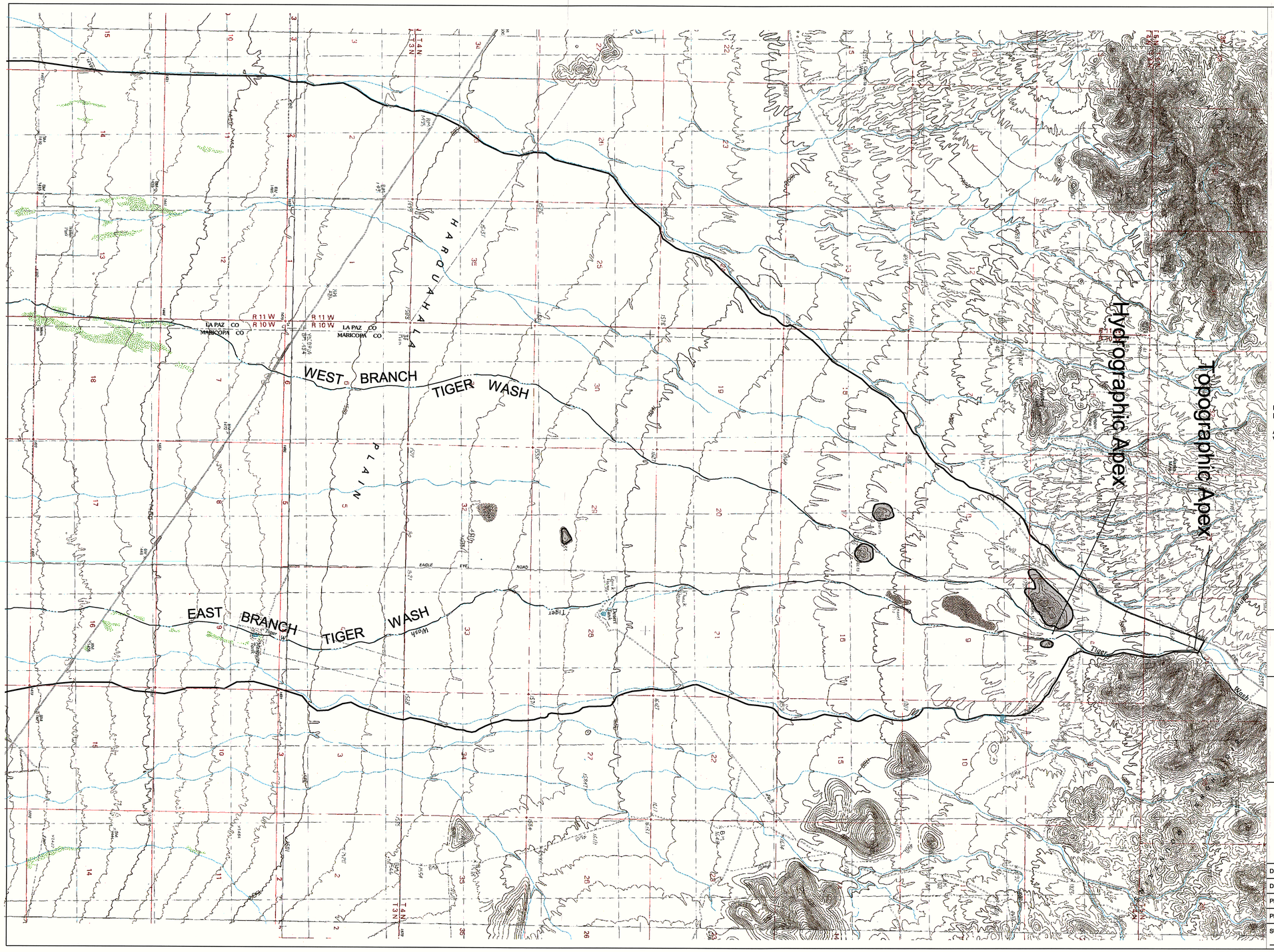
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

SHEET COVER SHEET



FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH
APPROXIMATE FLOODPLAIN
DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

STAGE 1
LANDFORM MAP

JUNE 2000

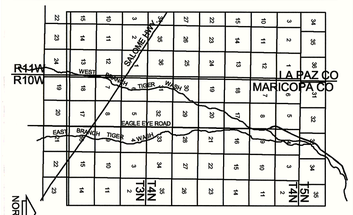
LEGEND

- ALLUVIAL FAN BOUNDARY
- BEDROCK

USGS DIGITAL RASTER GRAPHICS PROJECTED TO STATEPLANE NORTH AMERICAN DATUM OF 1983 AND TILED BY FCDMC.

ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP



2000' 0' 4000'

Registered Professional Engineer
28646
JONATHAN E. FULLER
Date Signed 6.6.00
ARIZONA, U. S. A.

THE LANDFORM DELINEATIONS WERE PERFORMED UNDER MY DIRECT SUPERVISION.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC

	BY	DATE
DESIGN	JEF	
DESIGN CHK.	TWL	
PLANS	BRI	
PLANS CHK.		

SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

SHEET 2 OF 4

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH
APPROXIMATE FLOODPLAIN
DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1

STAGE 2
STABILITY MAP

JUNE 2000

LEGEND

UNSTABLE SURFACES

STABLE SURFACES

LIMIT OF STABILITY ANALYSIS

HARQUAHALA PLAIN

WEST BRANCH TIGER WASH

EAST BRANCH TIGER WASH

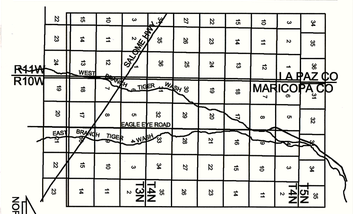
Hydrographic Apex

Topographic Apex

USGS DIGITAL RASTER GRAPHICS PROJECTED TO STATEPLANE NORTH AMERICAN DATUM OF 1983 AND TILED BY FCDMC.

ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP



2000' 0' 4000'

THE STABILITY DELINEATIONS WERE PERFORMED UNDER MY DIRECT SUPERVISION.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN	JEF	
DESIGN CHK.	TWL	
PLANS	BRI	
PLANS CHK.		

SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

SHEET 3 OF 4

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

TIGER WASH APPROXIMATE FLOODPLAIN DELINEATION STUDY

FCD 98-48
ASSIGNMENT NO. 1
STAGE 3
FLOODPLAIN MAP

JUNE 2000

LIMIT OF STUDY

WEST BRANCH TIGER WASH

EAST BRANCH TIGER WASH

HARQUAHALA

Hydrographic Apex

Topographic Apex

LA PAZ CO
MARICOPA CO

R 11 W
R 10 W

T 4 N
T 3 N

LEGEND

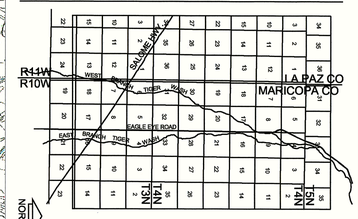
- A - Approximate Riverine Floodplains
- Zone A - Active Alluvial Fan - Administrative Floodway (AFHH - Alluvial Fan High Hazard)
- Zone A - Inactive Alluvial Fan - Administrative Floodway (AAFF - Approximate Alluvial Fan Floodway)
- Zone A - Inactive Alluvial Fan (AFZA - Alluvial Fan Zone A)
- Zone A - Active Alluvial Fan - Administrative Floodway (AFUFD - Alluvial Fan Uncertain Flow Distribution)
- Shaded X - Inactive Alluvial Fan
- X

See Table 6B.6.1 for a complete description of flood hazard zones.

USGS DIGITAL RASTER GRAPHICS PROJECTED TO STATEPLANE NORTH AMERICAN DATUM OF 1983 AND TILED BY FCDMC.

ALL ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

INDEX MAP



2000' 0' 4000'

Registered Professional Engineer
JONATHAN E. FULLER
State of Arizona, U.S.A.

THE FLOODPLAIN DELINEATIONS WERE PERFORMED UNDER MY DIRECT SUPERVISION.

JE FULLER
HYDROLOGY & GEOMORPHOLOGY, INC.

	BY	DATE
DESIGN		
DESIGN CHK.	JEF	
PLANS	TWL	
PLANS CHK.	BRI	

SUBMITTED BY: DATE:

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

RECOMMENDED BY: DATE

APPROVED BY: DATE

CHIEF ENGINEER AND GENERAL MANAGER

SHEET 4 OF 4