ALLUVIAL FAN STABILITY ASSESSMENT (FDC 93-53)

Task 4 of Contract FCD 93-53

Compare and differentiate between Figure 5 in WRI 91-4171 and Figure A5-1 in 1985 FEMA Guidelines.

by

Hjalmar W. Hjalmarson, P.E.

Registered Professional Engineer (Civil)
CERTIFICATE NO.
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ARIZONA, U.S.A.

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The data used for the graph in the FEMA Guidelines was first reviewed. Because there are data errors (*See Review of current FEMA methodology and appeal data for fans 5 and 6 of the Scottsdale Flood Insurance Study by the author*) the data on which Figure A5-1 was based are examined. Figure A5-1 (1985 FEMA Guidelines) is from Figure 18 of the DMA report (1985) (See Exhibit A of this report). The second part of this report is the comparison of the graph in figure A5-1 with data for sites in Maricopa County. The site data are shown graphically in figure 5 of WRI91-4171 (Exhibit B of this report).

DATA REVIEW

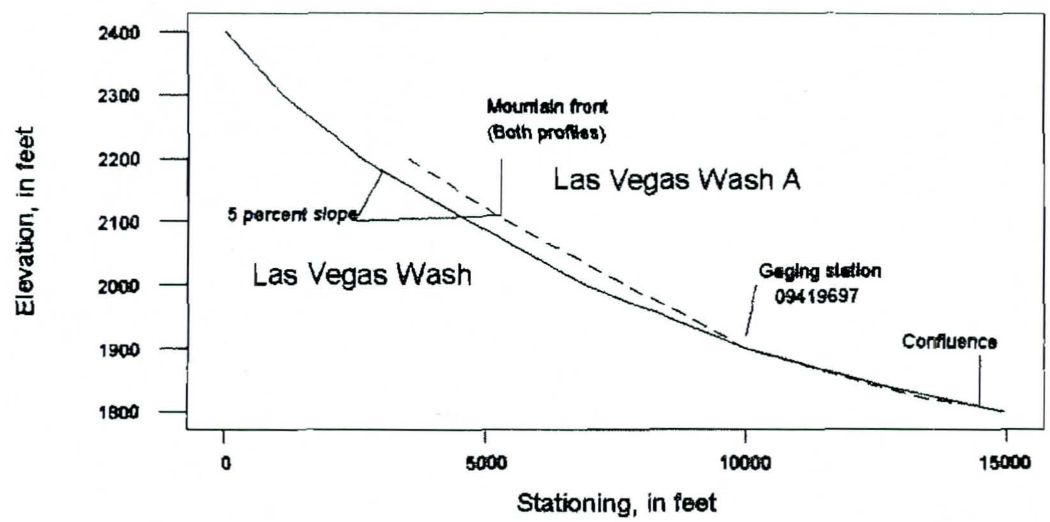
The topographic maps and description of sites published in the DMA report and data in USGS streamflow and basin characteristics files were used for this review. Findings and opinions for selected sites follow.

Las Vegas Wash Tributary and Las Vegas A

The data for "Las Vegas Wash Tributary near Henderson, Nevada" and the adjacent site "Las Vegas A" are critical to the definition of the relation between the length of the main channel and the ratio between canyon slope and fan slope shown in Figure A5-1. All data for these sites are considered suspect because of the major error in the drainage area in the DMA report. A drainage area of 0.06 mi^2 was incorrectly used for Las Vegas Wash Tributary where the correct drainage area reported by the USGS is 1.17 mi^2. The length of the single channel for both washes could not be identied on the copy of the aerial photograph used for this review.

For Las Vegas Wash Tributary, the dividing point between the drainage basin and the fan could not be clearly identified because the "fan slope extends into the canyon upstream of the mountain front" (DMA, 1985, p. 23) apparently upstream of the gaging station. In order to determine the drainage area and peak discharge (DMA, 1985, p. 58), the point on the stream channel separating the drainage basin and the fan is the gaging station but to determine the factors used to develope the grapgh in figure A5-1 (see Exhibit A), a second point on the stream channel upstream of the gaging station and above the mountain front is used. This second point appears to be located where the profile slope is about 0.050 (DMA, 1985,p.23) almost 5,000 ft. upstream of the gaging station (figure 1). There is no

Figure 1.--Profiles for Las Vegas Wash Tributaries
(From DMA report)



clear indication in the DMA report that the apex of the "fan" and the location of the gaging are at different locations but the listing of data in tables 2 and 3 (Exhibits C and D of this report) indicates the apex and gage are at the same location.

The profile slope for Las Vegas Wash Tributary does not equal 0.050 until well within the canyon upstream of the confluence with a large tributary. These is little valley fill at this location and floodwater appears to be confined to a single channel for at least 1,000 ft. downstream where the channel slope is less than 0.050. In fact, an active alluvial fan upstream of the gaging station is not apparent on the aerial photograph and topographic map in the DMA report.

It is writer's opinion there are data errors for Las Vegas Wash Tributary in the DMA report that cannot be easily resolved.

The canyon mouth or point of separation of the canyon and the fan appears to closely coincide with the mountain front for Las Vegas Wash A. The slope of the stream profile is the reported fan slope of 0.056 (DMA, 1985, p. 24) a short distance above the mountain front (figure 1). About 3,400 ft. below the "canyon mouth" the channel is bounded on the right by a levee (DMA, 1985, figure 5). This point closely corresponds to the location where the channel reportedly splits and changes into braided sheet flow. The presence of levee, whose remnants reportedly are depicted on the four sets of photographs (DMA, 1985, p. 24), at the time of the floods is unknown to this writer. It would appear the levee could have a significant effect on factors such as the length of the channel and the fan radius (see Exhibit 2).

How and where the canyon mouth is located is unclear based on the confusing differences between the two sites. The use of factors determined at different locations along Las Vegas Wash Tributary (See table 3, DMA, 1985) is equally confusing. It would be difficult to select the canyon mouths of other sites based on information presented for these two sites. Perhaps this is the source of the confusion exhibited by consultants working with distributary-flow areas in Arizona a few years ago.

Lytle Wash

The network of channels below the gaging station on Lytle Wash near Fontana, California appears to be part of a braided channel and not an alluvial fan. The braided channel may be of the Holocene Epoch while the fan may be much older. The channel of Lytle Creek shown on the topographic map is slightly above the land to the right at the interstate highway about 1 mile below the gaging station. This evidence, as depicted on the topographic map, that the channel may be actively aggrading is limited to this location. There appears to be some channel incision along much of the braided channel. Based on the absense of relief transverse to the flow and the large concavity of the contours, the area within the expansion angle of 95 degrees may be part of an active alluvial fan. Information potentially gleaned from soils maps and a field inspection are needed to identify the system.

The location selected for the canyon mouth by DMA(1985, p.32) is unclear and the canyon and channel slopes of 0.031 and 0.026, respectively, are confusing. Using the topographic map in the DMA report with a contour interval of only 40 ft., the profile of the canyon and fan along the centerline of the braided channel indicates a the "fan" becomes steeper rather than flatter downslope (figure 2). A rather constant slope of 0.028 is indicated for the canyon and near the mountain front above the interstate highway the slope changes to a rather uniform 0.029. The slope of 0.026 reported by DMA(1985, p. 32) appears to be for a short reach of fan because it cannot be obtained from the topographic map for any significant distance along the present flow system.

Piute Wash

Topographic detail needed to decern features of Piute Wash Tributary at Searchlight, Nevada is not shown on the topographic map (DMA, 1985, figure 6). Again, the drainage area and peak discharges are for a gaging station located downstream of the canyon mouth. The precise location of the canyon mouth, as selected by DMA, is unknown but based on the canyon and fan slope estimated from the 40 ft. countour intervals the canyon mouth is at least one mile upstream of the gaging station. The channel slope in the vicinity gaging station number 09423300 is about 0.015 or less than the 0.016 determined by DMA (1985, p. 26). The channel appears to be incised into old fan remnants but additional information is needed to evaluate the soils, geology and topography. The magnitudes of the floods mentioned in the DMA report are small and insignificant for the evaluation of flow path stability.

Day Creek

The topographic features for Day Creek (DAM, 1985, figure 10) closely correspond to those in the DMA report (1985, p. 34) except for the slope of the channel above the canyon mouth. The slope of the canyon appears to be less than 0.149 reported by DMA. For example, at 1500 ft. upstream of the gaging station the slope is 0.12 (figure 3). This lesser slope would give a canyon slope-fan slope ratio of about 1.2 which would plot very near the relation in figure A5-1 of the 1985 FEMA Guidelines.

Deer Creek

Characteristics of Deer Creek are in agreement with the topography and the slopes are in agreement with the profile for the creek (figure 4). However, because the slope of the creek is gradually decreasing it is difficult to duplicate the slopes published by DMA. The precise location of the canyon mouth as well as the locations of the slope determinations are not defined. Based on the profile (figure 4) the reported fan slope of 0.109 (DMA, 1985, p. 37) appears to be at a location about one mile downstream of the point where the canyon slope was determined. This distance seems to be large for a stream draining only 3.4 mi^2 but this intuition cannot be checked using the information in the DMA report..

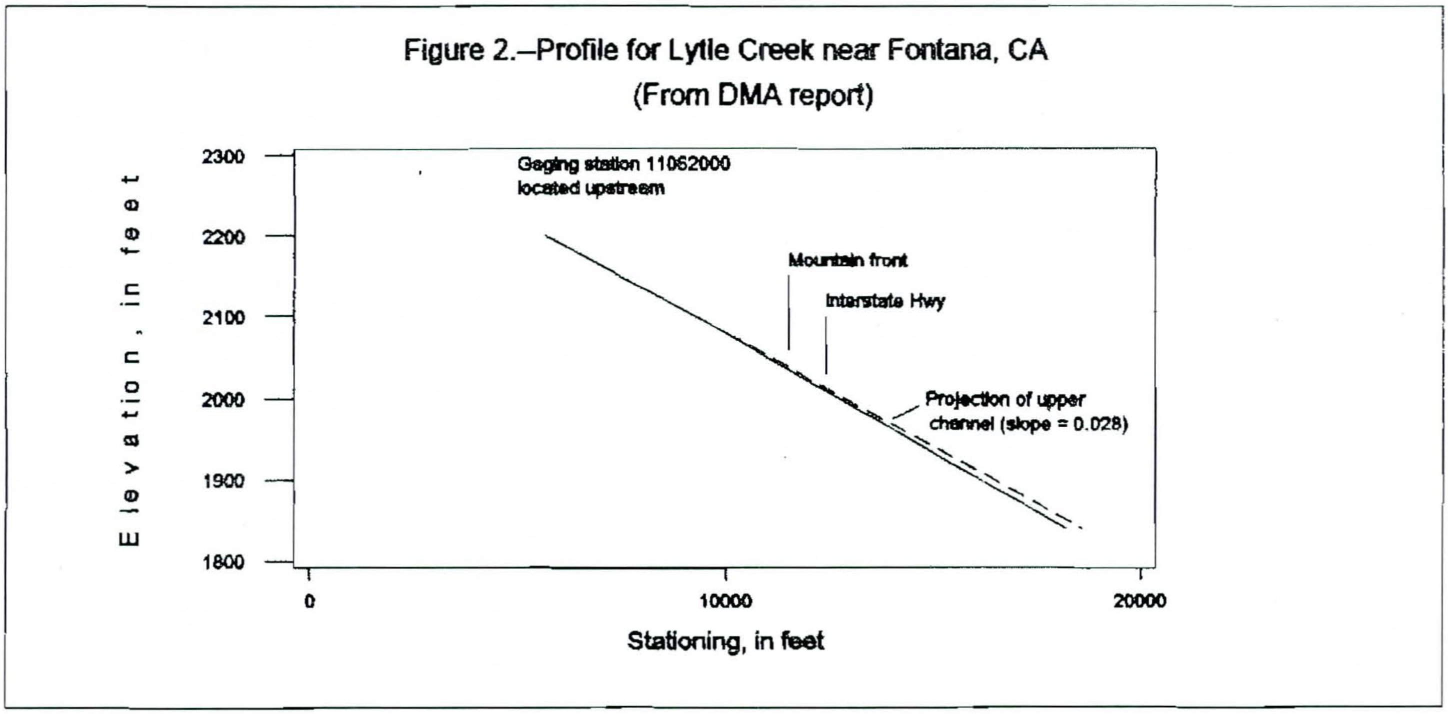


Figure 2.--Profile for Lytle Creek near Fontana, CA
(From DMA report)
Gaging station 11062000
located upstream
Mountain front
Interstate Hwy
Projection of upper
channel (slope = 0.028)
2300
2200
2100
2000
1900
1800
Elevation, in feet
0
10000
20000
Stationing, in feet

Figure 3.–Profile for Day Creek nead Etiwanda, CA
(From DMA report)

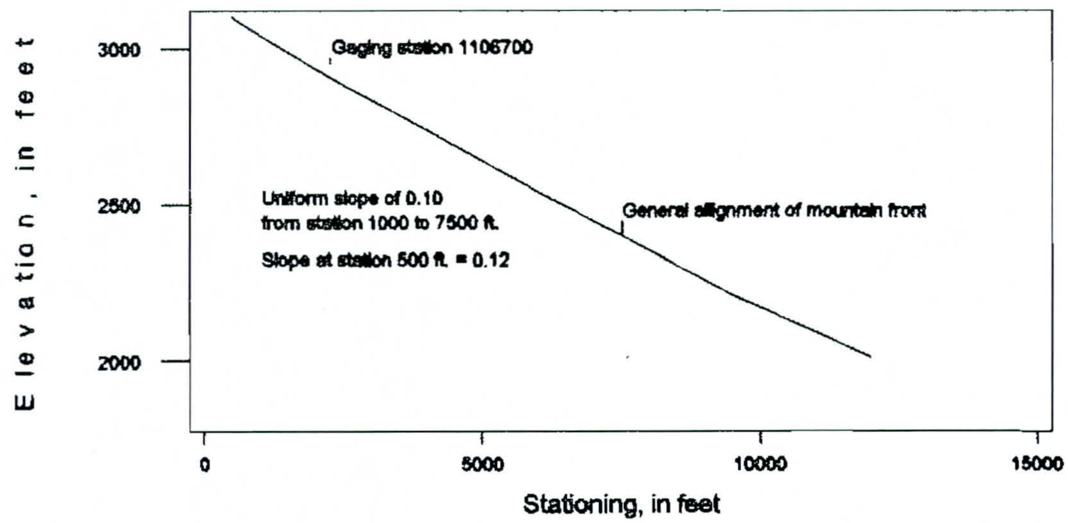
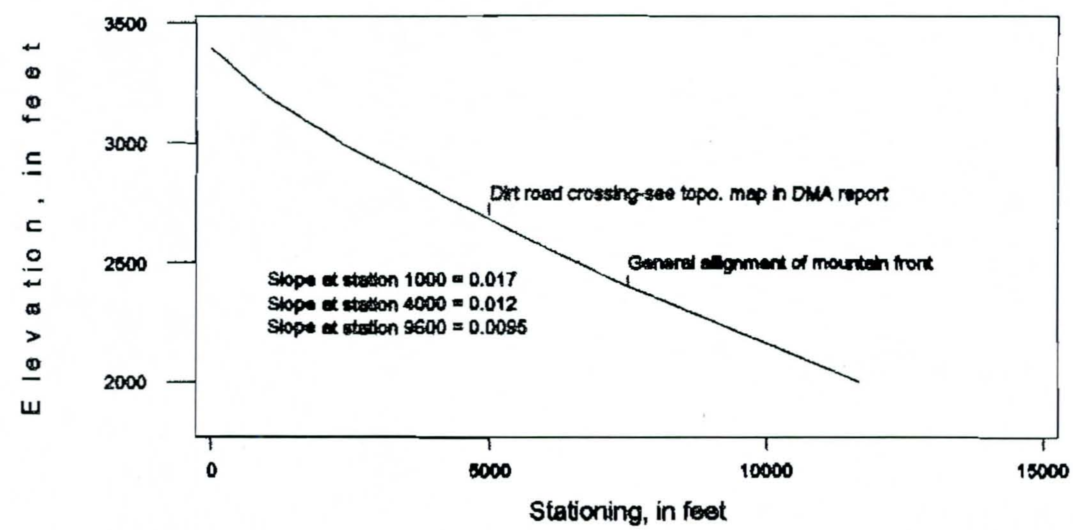


Figure 4.–Profile for Deer Creek nead Etiwanda, CA
(From DMA report)



Conclusions

The factors such as canyon slope, fan slope and observed length of the single channel used for the relation in figure 18 (DMA, 1985) cannot be duplicated because specific criteria for the definition of the location of the (1) canyon mouth, (2) determination point for the canyon slope, and (3) determination point for fan slope are missing in the DMA report and in the 1985 FEMA Guidelines. The review of the DMA methods for the above sites indicates inconsistant criteria were used by DMA and that some of the results are in error.

DMA has not related the location of the canyon mouth to features of the Piedmont slopes. For example, is the 100-year flood contained in a single channel at the canyon mouth?. Is the canyon mouth located on a pediment and are the channel bed and banks stable? Does a uniform of slightly convex profile like that for Lytle Creek and a concave profile like that for Deer Creek indicate that dissimilar processes are at work and perhaps Lytle Creek presently is a braided channel and not an active alluvial fan?

The DMA report is lacking required technical specificity needed to understand the methods and duplicate the results. There are several technical and data errors in the DMA report. A discussion of some of these errors recently was sent to the ASCE Journal of Irrigation and Drainage Engineering (Exhibit E).

COMPARISON OF GRAPHS

This section is a comparison and differentiation between the channel slope and length characteristics of sites in Maricopa County as shown in Figure 5 of WRI 91-4171 and Figure A5-1 in the 1985 FEMA Guidelines. The channel slope, DFA slope and channel lengths for 15 sites in Maricopa County were determined from profiles defined by Hjalmarson and Kemna (1992) and compared to the graph in figure A5-1. The data for sites in Maricopa County do not plot on the relation between the observed single channel length and the ration of canyon slope to fan slope.

The channel slope, DFA slope and channel lengths for the 15 sites shown in figure 5 are listed in table 1. These values generally correspond to the values for sites in the DMA report (Exhibit C). As previously discussed, the specifications for determining the location of the "Canyon" are unclear in the DMA report. Thus, two channel lengths were used for the sites in Maricopa County. The first channel length is the distance from the PD to the seperation of the thalweg of the main channel into two or more separate distributary channels. The second length includes the distance, if any, above the PD to the canyon mouth. The relations of the length of single channel versus the ratio of the channel and "fan" slopes for the first and second lengths are shown in figures 6 and 7, respectively. Three sites with more that a single channel (table 1) were not used. The relations for the remaining 12 Maricopa County sites are well below the relation for the DMA sites. The data for the sites in Maricopa County do not indicate the relations bend sharply upward for small ratios of canyon and "fan" slope.

The poorly defined relation for the first length (below the PD) is:

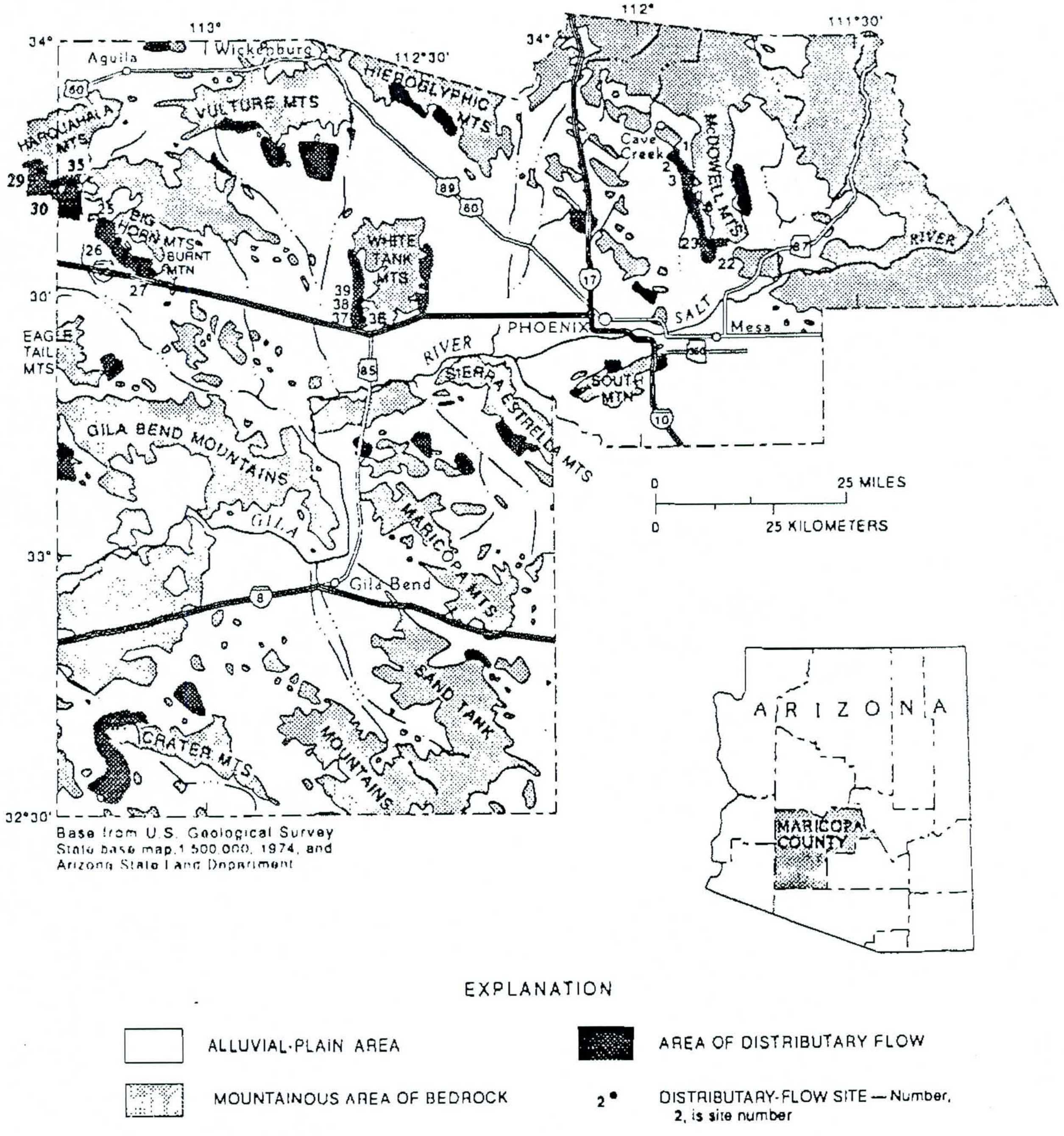
Length = 5,509 - 3,743 (ratio)

The relation for the second length (below the canyon mouth) also is poorly defined and is:

Length = 5,567 - 3,206 (ratio)

These relations are not statistically significant at the 68 percent level of significance and are considered rough estimates because of the wide scatter of the data about the relations.

Except for the Northumberland and Plute sites of the DMA study, the data for the 12 Maricopa County sites using the length below the canyon mouth are fairly similar (figure 7). The single channel lengths of the remaining DMA sites are generally larger but there is some overlapping of the plot of data for the two groups. With the inclusion of the Northumberland and Plute sites, however, the data for the Maricopa County sites do not define the relation in Exhibit A. The relation between the length of single channel and the ratio of canyon slope to fan slope defined by DMA (Exhibit A) and shown in figure A5-1



NOTE
SITE 6A IS THE SOUTHERN PART OF SITE 2

Figure 5.--Distributary-flow sites, areas of distributary flow, bedrock mountainous areas, and alluvial-plain areas.

Table 1.--Channel characteristics of distributary-flow areas in Maricopa County.

Site	Channel slope	DFA slope	Ratio[a]	Length of channel[b] below PD[c]	Length of channel[b] below canyon	Number[d] of channels
1	0.026	0.0190	1.37	300	300	<1
2	.023	.0190	1.21	20300	12000	<1
3	.021	.0200	1.05	3100	3100	1
6	.031	.0270	1.15	5000	2900	1
22	.013	.0110	1.18	3000	2400	1
23	.030	.0250	1.20	3300	2300	1
25	.013	.0140	.93	1400	900	<1
26	.027	.0220	1.23	4600	3500	1
29	.024	.0210	1.14	3800	2100	1
30	.028	.0200	1.40	1200	600	1
35	.010	.0090	1.11	1300	800	1
36	.019	.0160	1.19	2600	1900	1
37	.021	.0170	1.24	800	800	1
38	.015	.0135	1.11	500	500	1
39	.014	.0120	1.17	500	500	1

[a]Canyon slope/slope of distributary-flow area.

[b]The length of the channel below the canyon may be greater than the length of channel below the primary diffluence(pd) because the pd commonly is is below the canyon mouth.

[c]Primary diffluence.

[d]Some sites have multiple channels at the primary diffluence and below the confluence of the major tributaries in the drainage basin upstream.

Figure 6.--Relation between length of a single channel below the primary diffluence and ratio of canyon slope to fan slope.

(Figure A5-1 of FEMA, 1985)

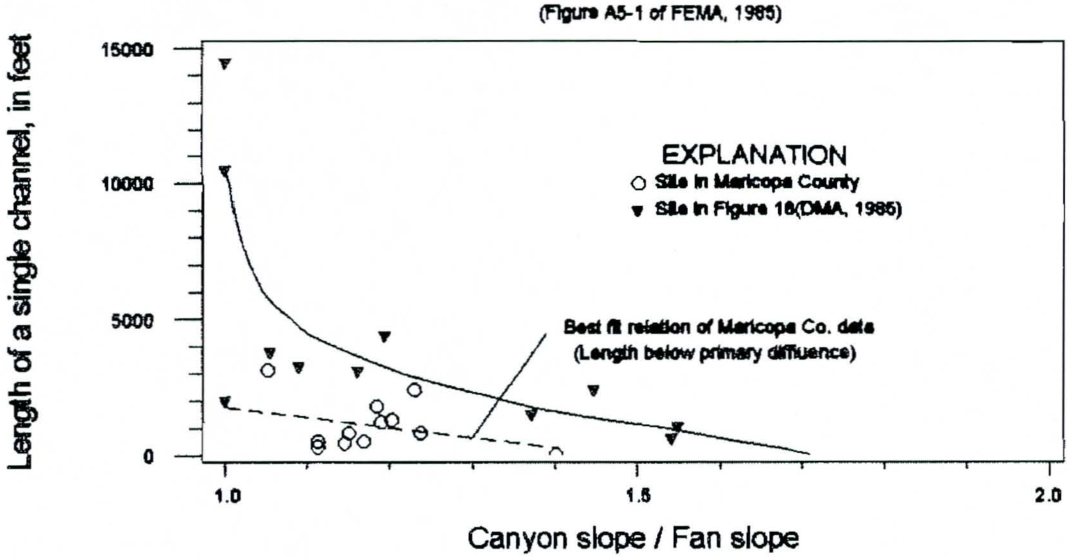
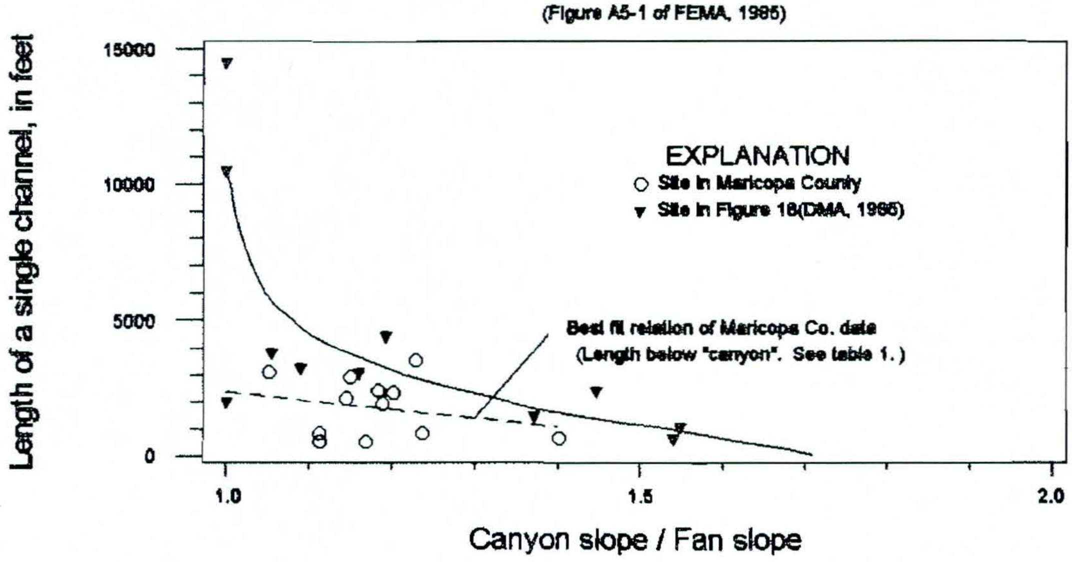


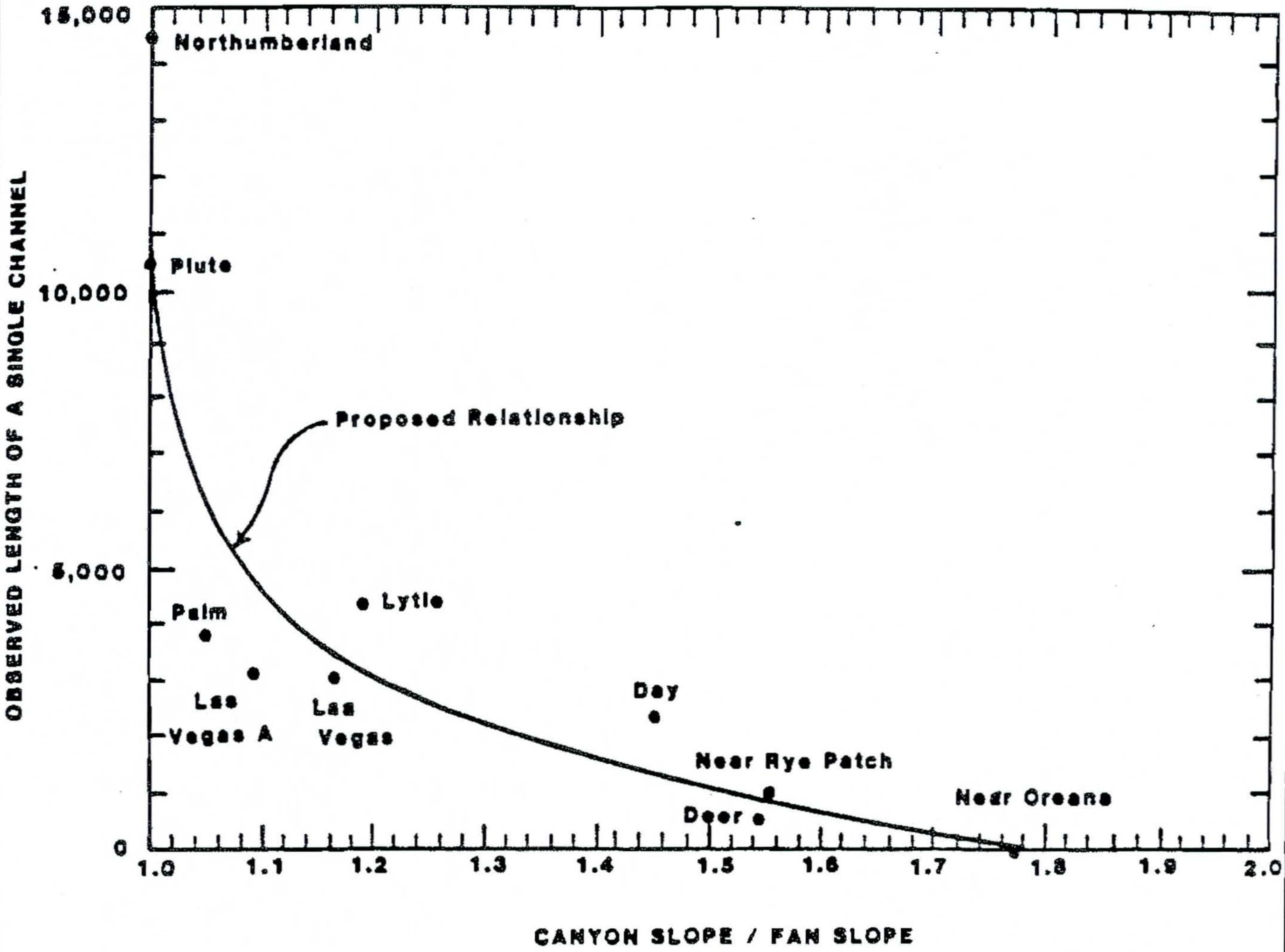
Figure 7.--Relation between length of a single channel below the "canyon" and ratio of canyon slope to fan slope.

(Figure A5-1 of FEMA, 1985)



of the 1985 FEMA Guidelines is not confirmed by data collected at 12 sites in Maricopa County. The relation is not supported by DMA using physical processes and thus, there is no way to explain the differences between the Maricopa Co. data and the relation. The relation in figure A5-1 apparently does not apply to sites in Maricopa County.

EXHIBIT A
(HJALMARSON - FCD 93-53)



CONSULTING ENGINEERS

FIGURE 18
Relationship Between Observed Length of a Single Channel and the Ratio of Canyon Slope to Fan Slope

EXHIBIT B
(HJALMARSON - FCD 93-53)

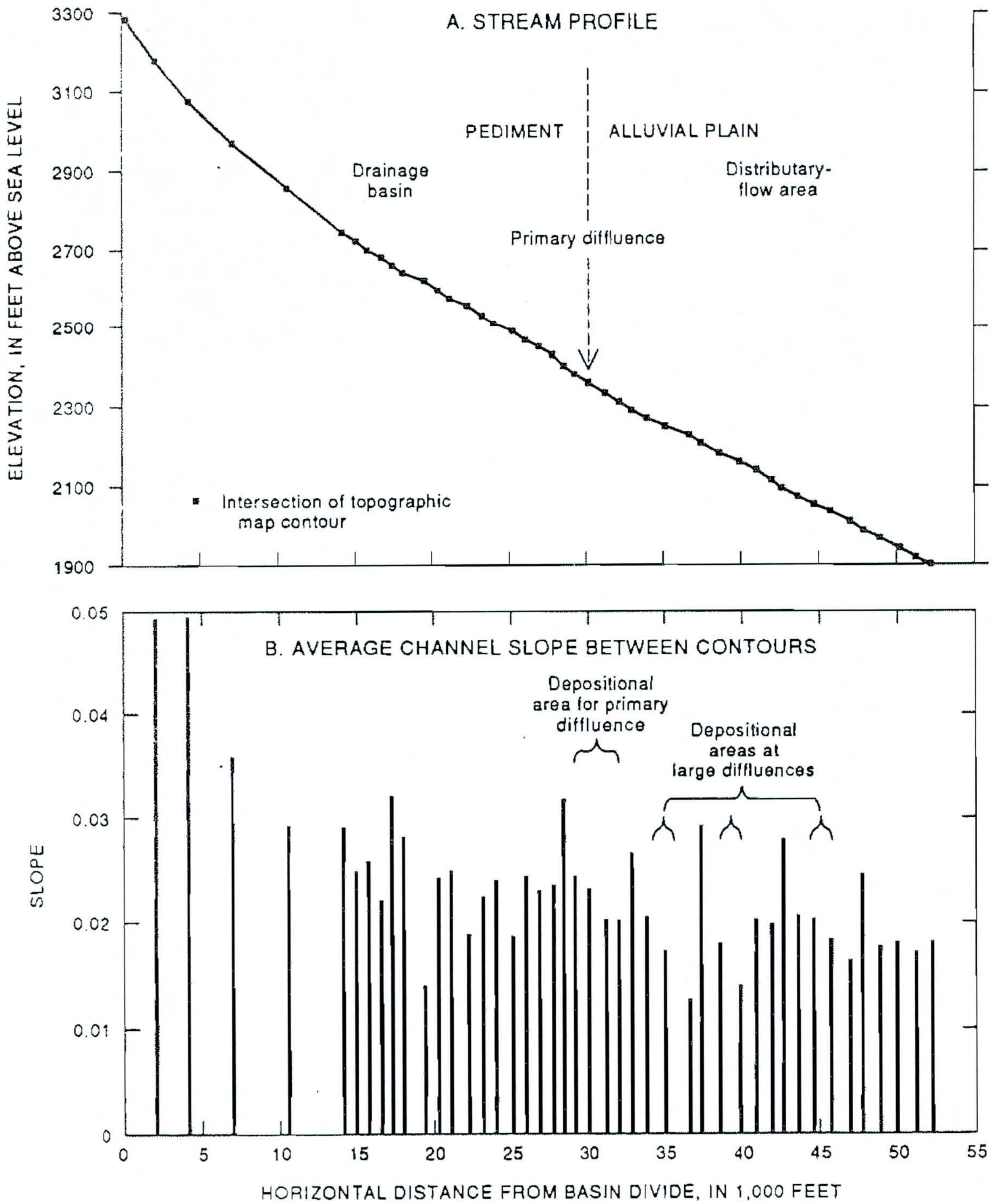


Figure 5.—Stream profile and average slope of channel between topographic-map contours showing location of primary diffluence for site 1.

EXHIBIT C

(HJALMARSON - FCD 93-53)

TABLE 2

SUMMARY OF ALLUVIAL FAN AND FLOOD CHANNEL CHARACTERISTICS

ALLUVIAL FAN	DRAINAGE AREA SQ. MI.	CANYON SLOPE S_{cyn}	FAN SLOPE S_{fan}	EXPAN. ANGLE DEG	FAN RADIUS FT	OBSERVED SINGLE CHANNEL LENGTH FT	OBSERVED SINGLE CHANNEL WIDTH[a] FT	DIRECTION[b] OF CHANNEL DEG	S_{cyn} / S_{fan}	DATE OF PHOTO
Northumberland Cyn near Austin, NV	18.1	.033[e]	.033	80	20000	14800	380	40	1.00	8-19-81
Mason Valley Trib. near Mason, NV	2.8	.088	.028	75	2800	--[d]	--[e]	--[e]	1.68	10-7-88
Humboldt River Trib. near Rye Patch, NV	.88	.110	.071	80	7300	1080	58	48	1.56	6-23-73
Rocky Canyon near Oreana, NV	4.08	.108	.058	110	12800	--[f]	--[f]	90	1.88	6-23-73
Humboldt River Trib. near Oreana, NV	.78	.134	.070	90	13000	--[f]	--[f]	38	1.77	8-23-73
Las Vegas Wash near Henderson, NV	.08	.088[e]	.060	80	3200	3075	88	30	1.18	7-4-80
Las Vegas Wash Fan A nr Henderson, NV	--	.081[e]	.088	40	8800	3250	182	20	1.08	7-4-80
Piute Wash Trib. at Searchlight, NV	3.40	.018[d]	.018	--[e]	--[e]	10800	90	--[e]	1.00	10-7-88
San Antonio Wash near Tonopah, NV	3.43	.070	.053	60	17700	--[f]	--[f]	10	1.32	8-29-73
Eldorado Valley Trib. nr Nelson, NV	1.40	.038[c]	.035	30	5800	2000	--[h]	--[h]	1.00	7-24-73
Lytle Creek near Fontana, CA	48.3	.021	.028	95	49000	4400	781	20	1.18	1-30-88
Day Creek near Etiwanda, CA	11.8	.148	.103	80	41200	2400	388	85	1.48	3-10-38
Deer Creek near Guasti, CA	3.4	.188	.108	80	37500	800	278	30	1.54	3-10-38
Cucamonga Creek near Upland, CA	10.1	.075	.048	58	42200	7900[d]	288[d]	45	1.58	3-10-38
San Antonio Creek near Claremont, CA	28.2	.088	.048	80	87800	8150[d]	370[d]	88	1.20	3-10-38
Tahquitz Creek nr Palm Springs, CA	43.5	.111	.048	90	7200	--[f]	--[f]	80	2.41	4-20-38
Palm Canyon nr Palm Springs	93.3	.088[g]	.058	25	18000	3825	350	20	1.05	11-5-40
Devil Canyon nr San Bernardino, CA	5.81	.085	.082	32	8400	1300[d]	216[d]	30	1.37	2-10-38
Whitewater River nr Whitewater, CA	57.40	.034[e]	.030	70	8980	880[d]	840[d]	18	1.13	8-8-38

a. Channel width was measured within a well-defined reach.

b. Direction of the single channel was measured as the angle between the single channel and the left fan boundary, when looking downstream. For an alluvial fan without a single channel region, it was approximated with the direction of a major channel.

c. Fan slope extends into canyon upstream of mountain front.

d. The channels on the alluvial fans were affected by levees, percolation basins, dikes, etc.

e. Not a well-defined alluvial fan, which is generally characterized by a rather uniform radial slope from the apex.

f. Without a single channel region on the alluvial fan.

g. No flood channels could be identified.

h. Width of a single channel not well-defined.

EXHIBIT D
(HJALMARSON - FCD 93-53)

TABLE 3

SUMMARY OF THE SINGLE CHANNEL WIDTHS CALCULATED USING THE FEMA AND EDWARDS & THIELMANN'S METHODS

ALLUVIAL FAN	DRAINAGE AREA, A	CANYON SLOPE	FAN SLOPE	OBS. CHANNEL WIDTH, Wo	S_{cyn}/S_{fan}	DISCH. Qp	DATE FLOOD	Q/A	CAL. WIDTH (FEMA), Wf	W/Wo	CAL. WIDTH (EDWARDS & THIELMANN), FT		
	SQ. MI.	S_{cyn}	S_{fan}	FT		CFS			FT		n=.25	n=.30	n=.35
Northumberland Cyn near Austin, NV	16.1	.033	.033	390	1.00	7680	8-7-78	68	340	.87	233	256	268
Humboldt River Trib. near Rye Patch, NV	.85	.110	.071	58	1.55	8940	8-31-73	10517	261	7.48	314	338	343
Las Vegas Wash near Henderson, NV	.06	.060	.060	88	1.10	655	7-30-68	10817	137	1.56	88	93	97
Pinto Wash Trib. at Moonlight, NV	2.40	.014	.018	90	1.00	376	9-11-78	108	101	1.12	84	82	87
Lytle Creek near Fontana, CA	46.2	.031	.036	781	1.18	38900	1-25-69	775	838	.83	438	488	494
Day Creek near Etiwanda, CA	11.5	.148	.103	383	1.45	8600	1-25-69	798	378	1.41	204	218	232
Day Creek near Etiwanda, CA	11.5	.148	.103	284	1.48	4300	3-2-38	383	387	1.86	160	181	171
Cucamonga Creek near Upland, CA	10.1	.075	.048	366	1.56	10388	3-2-38	1018	382	1.06	243	280	278
San Antonio Creek near Claremont, CA	26.2	.055	.046	378	1.38	21400	3-2-38	817	813	1.38	323	348	384
Palm Canyon near Palm Springs, CA	93.2	.058	.055	380	1.05	3650	3-8-37	41	288	1.08	194	178	186
Devil Canyon near San Bernardino, CA	6.81	.085	.063	318	1.37	3330	3-2-38	593	343	1.12	161	182	173

EXHIBIT E
(HJALMARSON - FCD 93-53)

Hjalmar W. Hjalmarson, P.E.
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(602) 567-6755

May 16, 1994

Journal of Irrigation and Drainage Engineering,
ASCE
345 East 47th Street
New York, NY 10017-2398

Dear ASCE:

Enclosed is an original and one copy of a discussion by Hjalmar W. Hjalmarson of the recent paper *Comparison of Results from Alluvial Fan Design Methodology with Historical Data* by Syndi J. Flippin and Richard H. French that appeared in the **Journal of Irrigation and Drainage Engineering**, Vol. 120, No.1, January/February, 1994. If you have any questions or concerns, please call me at the above number.

Sincerely,

Hjalmar W. Hjalmarson
Member, ASCE

COMPARISON OF RESULTS FROM ALLUVIAL FAN DESIGN METHODOLOGY WITH HISTORICAL DATA[a]

Discussion by Hjalmar W. Hjalmarson, Member, ASCE[1]

The authors report their study of flood flow frequency and magnitude of alluvial fans as exhibited by records of flood damage at railroad structures along railroad allignments in Clark County, Nevada. Three sites were studied where the Union Pacific Railroad crosses the lower part of alluvial fans. Records of flood damage were compared to design methodology that primarily consisted of a rainfall-funoff analysis and a method of distributing floodflow for segments of an allignment across an alluvial fan. The authors concluded that the design methodology yields conservative results because of the absence of structural damage experienced at the railroad structures. The writer would like to express concern about (1) the magnitude and frequency of floods and (2) a reference used by the authors.

For the approximately 64 to 67 years of structure age at the three alluvial fans, the probability is about 0.5 that a 100-year flood was exceeded at the apex of each of the sites. For independent peaks at the group of three sites the probability is about 0.87 that a 100-year flood was exceeded at at least one of the sites. These probabilities are estimated using fundamental statistical principles applied to the apexes where the floodflow reportedly is last confined in a single channel. The lack of structure overtopping indicates the capacity of the structures is greater than the 100-year peak discharge.

Interestingly, the combined capacity of the structures is about equal to the authors' 100-year peak discharge at the apex of site UPRR1 and considerably less than the authors peak discharge at sites UPRR2 and 3 (Table 1). For sites UPRR2 and 3 the combined capacity is approximately equal to the peak discharge of the 25-year flood assuming the authors' peak discharges for the 2-, 10-, and 100-year floods are described by a logarithmic normal flood distribution. Assuming a distribution of peak discharge that corresponds to the capacity of the structures and assuming no floodflow losses between the apex to the structures, the probability is at least 0.9 that the structures at sites 2 and 3 would be overtopped. Other distributions of peak discharge across the toe of the fans would result in a greater frequency of structure overtopping. Because no overtopping was noted, it follows that the peak discharges determined by the authors probably are greatly biased and excessively great.

Recently determined regional flood frequency relations by the U.S. Geological Survey (Thomas and others, 1994) using methods by Hjalmarson and Thomas (1992) appear to be in better agreement with the record of structure overtopping. The 100-year peak discharge from the regional relations, defined using streamflow gaging station records, is about 40 percent of the combined capacity at site 1 (Table 1). At site 2 the 100-year

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[a]January/February, 1994, Vol. 120, No. 1, By Syndi J. Flippin and Richard H. French(Paper 4600).

[1]Consultant, HC75 Box 3558, Camp Verde, Arizona 86322.

peak discharge is about the same as the combined capacity of the structures and at site 3 the combined capacity is about 70 percent of the 100-year peak discharge at the apex. Using fundamental probability, overtopping of structures might be expected at site 3 but not at site 1. The probability is about 0.5 that overtopping would occur at site 2. Thus, the regional relations appear reasonable and bias, if any, appears less than that of the authors'.

The authors' estimates of peak discharge appear biased and much to great. The modification of the National Flood Insurance Program method of floodplain delineation (French, 1992) appears to yield excessive peak discharge at the toe of alluvial fans where the railroad structures are located. As noted by the authors, losses of floodwater to infiltration along the sand channels of the alluvial fans and attenuation of flood peak discharge as floodwater divides into multiple channels or flows overland on the fan surface certainly are omitted factors of concern. The authors, however, only briefly mention and neglect to estimate the effect of these and other factors. The writer doubts the use of the term "conservative results" is justified and feels the report is incomplete. How conservative are the results and how much unnecessary expense might be incured by constructing needlessly large-capacity structures?

The writer's second concern is the authors' use of the graph developed by DMA ("Alluvial" 1985) or FEMA ("Flood" 1985) because there are errors in the data used by DMA. The are several certain and probable data errors in the DMA report. The writer suggests the graph developed by DMA is incorrect for the following reasons:

(1) A drainage area of 0.16 km^2 (0.06 sq mi) was used by DMA for Las Vegas Wash Tributary but the correct drainage area reported by the U. S. Geological Survey (USGS) is 3.03 km^2 (1.17 sq mi) (Thomas and others, 1994). Also, the peak discharge used by DMA is for the USGS gaging station but the site characteristics given in the graph referenced by the authors' can be approximated only at a location about 1,500 km (5,000 ft) upstream of the gaging station. The canyon and fan slopes reported by DMA can only be found in the confines of canyon upstream where there is little valley fill. The writer considers the data suspect at this site and suggests the topographic map used by DMA was in error.

(2) The network of channels below the gaging station on Lytle Wash near Fontana, California appears part of a braided channel and not an active alluvial fan. The braided channel may be of the Holocene Epoch while the fan may be much older. The profile of the canyon and "fan" along the centerline of the braided channel becomes steeper rather than flatter downslope as reported by DMA. A constant slope of 0.028 is indicated for the canyon and near the mountain front above the interstate highway the slope changes to a uniform 0.029. The slope of 0.026 reported by DMA (1985, p. 32) cannot be found by the writer.

(3) The drainage area and peak discharges for Piute Wash Tributary at Searchlight, Nevada are for a gaging station located downstream of the canyon mouth. The channel slope of 0.016 reported by DMA is not found near the gage. A channel slope of 0.016 is found at least 1.6 km (1 mi) upstream of the gaging station in the confines of a canyon.

(4) The drainage area used by DMA for Humbolt River Tributary near Oreana, Nevada was determined as 2.0 km^2 (0.76 sq mi) by the USGS. Based on recent topographic maps the drainage area is considerably larger and has been revised by the USGS.

Appendix. References

French, R.H., 1992, *Design of flood protection for transportation alignments on alluvial fans*: Journal of Irrigation and Drainage Division, ASCE, vol. 118, no 2, p. 320-330.

Hjalmarson, H.W.and Thomas,B.E., 1992, *A new look at regional flood-frequency relations for arid lands*: American Society of Civil Engineers, Journal of Hydraulic Engineering, vol. 118, no.6, p. 868-886.

Thomas, B.E., Hjalmarson, H.W., and Waltemeyer, S.D., 1994, *Methods for estimating the magnitude and frequency of floods in the Southwestern United States*: U.S. Geological Survey Open File Report 93-419, 211 p.

Table 1. Peak discharge and combined capacity of railroad structures at sites.

Study site	Authors' Peak discharge m^3/s (cu ft/sec)			USGS peak discharge m^3/s (cu ft/sec)			Combined capacity of railroad structures m^3/s (cu ft/sec)
	2-year	10-year	100-year	2-year	10-year	100-year	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
UPRR1	2.6 (91)	41.9 (1,480)	393 (13,875)	1.8 (63)	33.4 (1,180)	173 (6,120)	437 (15,430)
UPRR2	2.7 (96)	29.3 (1,035)	196 (6,948)	0.76 (27)	13.3 (470)	62.6 (2,210)	65.1 (2,300)
UPRR3	2.0 (69)	22.6 (799)	161 (5,685)	0.85 (30)	15.0 (530)	71.1 (2,510)	50.7 (1,790)