ALBUQUERQUE METROPOLITAN ARROYO FLOOD CONTROL AUTHORITY

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Tijeras Arroyo

WATER SURFACE PROFILE ANALYSIS

FOR THE

I-25 BRIDGE AT THE TIJERAS ARROYO

Smith Engineering Company
A Full Service Engineering Company

JUNE 6, 1997

Smith Engineering Company
A Full Service Engineering Company

June 6, 1997

Mr. Kurt Browning, P.E.
Drainage Engineer
AMAFCA
2600 Prospect NE
Albuquerque, NM 87107

Re: Water Surface Profile Analysis for the I-25 Bridge at the Tijeras Arroyo

Dear Mr. Browning:

Smith Engineering Company is pleased to provide you with the following report for the "Water Surface Profile Analysis for the I-25 Bridge at the Tijeras Arroyo". We found that the peak discharges of 20,000 cfs and 37,000 cfs pass under the existing I-25 bridges with 6 and 9 feet of freeboard, respectively. We also found that the new floodplain based on a peak flow of 20,000 cfs as delineated by Smith Engineering east of I-25 (see Plate 1) is similar to the floodplain delineated in the 1980 "Tijeras Arroyo Drainage Management Plan" (Figure 3, Appendix A). West of I-25 the Smith Engineering floodplain is similar to the floodplain shown in the 1989 "Tijeras Arroyo Drainage Management Plan - Phase II Prudent Limits" (Plate Q-14).

We trust that the information contained in this report will allow you to better address the floodplain issues along the Tijeras Arroyo. Please let us know if we can provide further information or assistance.

Sincerely,

Stephen Paul Kemna

Stephen P. Kemna, E.I.

6400 Uptown Boulevard N.E., Suite 500E, Albuquerque, New Mexico 87110 Telephone 505/884-0700 Fax 505/884-2376
Albuquerque, NM Roswell, NM Tempe, AZ

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ARROYO FLOOD CONTROL AUTHORITY

WATER SURFACE PROFILE ANALYSIS

FOR THE

I-25 BRIDGE AT THE TIJERAS ARROYO

JUNE 6, 1997

Prepared by

SMITH ENGINEERING COMPANY
6400 UPTOWN BOULEVARD NE SUITE 500E
ALBUQUERQUE, NM 87110

SEC No. 195102C

WATER SURFACE PROFILE ANALYSIS FOR THE I-25 BRIDGES AT THE TIJERAS ARROYO

TABLE OF CONTENTS

TABLES

PLATES

APPENDIX

June 6, 1997

INTRODUCTION

The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA) has contracted with Smith Engineering (SEC) to perform a water surface profile analysis for the I-25 bridges at the Tijeras Arroyo. This hydraulic analysis is part of AMAFCA's on-call engineering services agreement with SEC updated October 30, 1996.

The Tijeras Arroyo is one of the largest ephemeral drainage systems in the Albuquerque area. At the I-25 bridges, the Tijeras Arroyo drains about 128 square miles of watershed. The upstream reaches of the Tijeras Arroyo drain portions of the Sandia Mountains.

As part of this hydraulic analysis, SEC performed the following tasks:

- Develop an HEC-RAS hydraulic model of the Tijeras Arroyo from about 2300 feet downstream to about 3500 feet upstream of the I-25 bridges.
- Utilize topography, survey information, and peak flows provided by AMAFCA.
- Prepare a revised floodplain map of the study reach based on peak flows of 20,000 cfs and 37,000 cfs, respectively.

It is anticipated that this analysis will provide important floodplain information to AMAFCA and other government agencies.

EXISTING BRIDGE AND CHANNEL DESCRIPTION

The study reach for the Tijeras Arroyo begins at the concrete lined Tijeras Inlet to the South Diversion Channel, located east of Broadway Boulevard. The study reach extends upstream to about 3,500 feet east of the I-25 bridges. Within this study reach, the main channel of the Tijeras is about 100 feet wide. West of the I-25 bridge the bed slope averages about 0.005 ft/ft. This reach of the Tijeras is relatively straight with a main channel incised about 2 feet below the overbank floodplain. Bed material consists of fine to medium sands. Overbank areas are sparsely vegetated with various grasses. Near the entrance to the Tijeras Inlet, the flow is directed by wing dikes that are protected by dumped riprap. These riprap-protected embankments provide a smooth transition for funneling flow into the Tijeras Inlet.

East of the I-25 bridges, the Tijeras Arroyo has an average slope of about 0.007 ft/ft. Here the arroyo also averages about 100 feet wide with a total floodplain width of about 1000 feet. In this reach the main channel meanders significantly, and it is deeply incised creating 10 to 15 foot high banks. These banks are sloughing and failing. While the bed material of this reach is also fine to medium sand, the channel and overbanks have more vegetation than the downstream reach.

Interstate 25 crosses the Tijeras over two parallel bridges. These bridges are separated by about 130 feet. The bridges are skewed by an angle of about 38 degrees, but the pier groups are aligned parallel to the flow allowing the arroyo to pass through on a more or less straight line. The abutment slopes at the bridges are protected by wire-enclosed riprap up to the low chord elevation. Each bridge has a concrete deck that is supported by three groups of steel piers aligned to the direction of flow. Each pier group includes 16 piers, each about 16 inches in diameter. Steel cross members support each pier group as well. These pier groups have a few small trees (about 10 feet in height) growing between some of the piers. It appears that these pier groups may readily catch debris during flood events.

HYDRAULIC MODELING APPROACH

A hydraulic model of the Tijeras Arroyo was developed for the study reach. The U.S. Army Corps of Engineer's numerical model, HEC-RAS (Version 1.2, April 1996), was used to compute the water surface profiles associated with the peak flows of 20,000 cfs and 37,000 cfs. Cross sections were scaled from 1"=200' orthophotos (1979) provided by AMAFCA. Cross sections were spaced at a maximum distance of 200 feet. The HEC-RAS cross section interpolation routine provided additional interpolated cross sections every 10 feet. The location of the cross sections is shown on Plate 1.

AMAFCA directed analysis for the peak flows of 20,000 cfs and 37,000 cfs (assumed to be the 100-year and 500-year, respectively). AMAFCA also obtained recent surveys of the I-25 bridge openings. These surveys were conducted parallel to the bridge faces. For the hydraulic model, this survey data was adjusted (by the cosine of the skew angle) to account for the reduced flow area due to the bridge skew.

Effective flow boundaries were developed to model the contraction and expansion of flow at the I-25 bridges and at the Tijeras Inlet to the South Diversion Channel. A contraction ratio of 1:1 and an expansion ratio of 2:1 were used as recommended by the publication, "Bridge Hydraulic Analysis With HEC-RAS" (April, 1996).

A field visit of the site was conducted by Steve Kemna on April 11, 1997. The existing conditions Manning's "n" values for the Tijeras Arroyo were developed based on visual estimates of the grain size distribution in the channel bed and the vegetation in the overbanks. Manning's "n" values were then computed from Tables 3.1 and 3.2 of AMAFCA's "Sediment and Erosion Design Guide". For the reach west of I-25, the Manning's "n" values ranged from 0.032 for the channel to 0.037 for the overbanks. A value of 0.045 was used for the dumped riprap bank protection. For the reach of the Tijeras Arroyo east of I-25, the Manning's "n" values ranged from 0.040 in the channel to 0.041 in the overbanks. A value of 0.036 was used for the channel at the I-25 bridges and a value of 0.040 for the wire-enclosed riprap protecting the bridge abutments.

RESULTS OF HYDRAULIC ANALYSIS

The existing I-25 bridges at the Tijeras Arroyo were modeled by SEC using all three of the available bridge modeling techniques in HEC-RAS (Energy Method, Momentum Method, and Yarnell Method). The Energy Method provided the highest water surface elevations and it was used to delineate the floodplains. Where supercritical flow occurred, the critical depth was used to map the floodplain (except at the concrete lined Tijeras Inlet to the South Diversion Channel).

Critical depth was used to provide the upstream and downstream boundary conditions for the analysis. The "mixed flow" routine provided both a supercritical and subcritical analysis of the study reach. Results for the analysis for the 20,000 cfs and 37,000 cfs events are summarized in Tables 1 and 2. The floodplains are delineated on Plate 1.

Supercritical flow occurred in the Tijeras Inlet due to its relatively steep slope of 0.021 ft/ft and its efficient concrete cross section. At the upstream end of the Tijeras Inlet the flow passed through critical depth. Upstream of the Tijeras Inlet the flow was subcritical with Froude numbers averaging about 0.5 for the peak flow of 20,000 cfs. The average channel velocity ranged from 7.3 to 10.9 fps between I-25 and the Tijeras Inlet. The maximum flow depth ranged from 13 to 18 feet for this same event.

Through the I-25 bridges, the peak flows of 20,000 cfs and 37,000 cfs passed under the low chord with about 6 and 9 feet of freeboard, respectively. For the 20,000 cfs event, the maximum flow depth was about 14 feet through the bridges, and the average channel velocity ranged from 12.2 to 14.3 fps. This same event produced a Froude number of about 0.7 through the bridges. The peak flow of 37,000 cfs passed under the bridges at critical depth. Cross sections of the east and west I-25 bridges with water surface elevations are shown on Plate 2.

East of the I-25 bridges, the peak flow of 20,000 cfs produced subcritical flow with several sub-reaches experiencing critical to near critical flow regimes. Depths ranged from 13 to 20 feet, and the channel velocity ranged from about 8.3 to 16.6 fps.

It should be noted that no sediment analysis was performed for this study. The tremendous velocities associated with these peak flows coupled with the unstable banks and an ample supply of sediment should produce significant bulking factors for the design flows. The bulked flow may produce a significant increase in the water surface elevations for the peak flows of 20,000 and 37,000 cfs. The fact that at several locations within the study reach, the flows transition from subcritical to critical flow and back again indicates that waves and hydraulic jumps may occur. These flow disturbances will likely increase the water surface elevations summarized in this report.

Based on the hydraulic analysis discussed in the previous paragraphs, the floodplains associated with the peak flows of 20,000 and 37,000 cfs were delineated for the study reach. Zones of shallow flooding were designated where overbank depths of flow were 3 feet or less. The 20,000

cfs floodplain delineated by this study is similar to the 100-year floodplain delineated by two older studies, the "Tijeras Arroyo Drainage Management Plan" of 1980, and the "Tijeras Arroyo Drainage Management Plan - Phase II Prudent Limits" of 1989.

TABLE 1. WATER SURFACE PROFILE SUMMARY - 20,000 CFS

River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
2.143371	20000.00	5022.60	5041.25	5037.09	5043.27	0.003563	11.51	1947.77	527.81	0.58
2.105402	20000.00	5021.70	5037.89	5037.66	5042.13	0.009890	16.64	1232.77	137.95	0.93
2.067614	20000.00	5020.80	5037.84		5039.90	0.003865	11.54	1747.25	164.05	0.59
2.029735	20000.00	5020.00	5034.18		5037.67	0.009253	15.47	1363.57	165.45	0.90
1.991856	20000.00	5018.40	5034.94	5029.72	5036.09	0.002333	8.63	2391.68	586.75	0.46
1.953977	20000.00	5017.00	5033.31	5029.05	5035.13	0.003411	10.94	2013.03	660.35	0.56
1.916098	20000.00	5015.60	5032.70	5027.86	5034.14	0.002779	9.64	2123.01	444.17	0.51
1.878219	20000.00	5014.20	5032.04	5026.19	5033.57	0.002826	9.92	2017.81	836.09	0.50
1.840341	20000.00	5011.70	5031.81	5024.23	5032.86	0.001684	8.26	2473.67	706.99	0.40
1.802462	20000.00	5010.50	5029.45	5027.39	5032.06	0.006154	12.98	1566.66	201.01	0.73
1.764583	20000.00	5009.30	5027.65		5029.20	0.003955	11.48	2567.03	677.96	0.59
1.726705	20000.00	5008.00	5026.12	5023.53	5028.20	0.004659	11.91	2086.88	726.61	0.64
1.688826	20000.00	5006.50	5025.48		5026.58	0.003154	9.40	2862.84	655.21	0.52
1.650947	20000.00	5005.30	5023.97	5023.97	5025.80	0.005050	12.69	2353.17	588.56	0.78
1.613068	20000.00	5004.20	5022.12	5022.24	5024.12	0.004660	12.82	2315.33	626.57	0.64
1.575189	20000.00	5002.70	5017.09	5016.09	5020.47	0.008502	14.81	1395.07	236.93	0.84
1.537311	20000.00	5001.20	5015.77	5012.13	5017.78	0.003861	11.37	1759.48	154.43	0.59
1.499432	20000.00	5000.00	5013.28	5012.28	5016.63	0.008878	14.68	1362.34	153.72	0.87
1.461553	20000.00	4998.00	5012.83	5009.91	5015.15	0.003309	12.45	1696.90	160.18	0.63
1.455682	Bridge									
1.449811	20000.00	4998.00	5011.37	5009.91	5014.44	0.005176	14.30	1465.79	155.04	0.77
1.424811	20000.00	4997.00	5011.51	5008.24	5013.74	0.003092	12.22	1728.13	157.87	0.61
1.418843	Bridge									
1.412875	20000.00	4997.00	5010.44	5008.24	5013.16	0.004208	13.44	1561.88	154.34	0.70
1.378788	20000.00	4995.00	5010.64	5008.83	5012.32	0.002381	10.87	2182.65	777.69	0.58
1.340909	20000.00	4993.30	5009.02	5009.39	5011.17	0.004302	13.35	2236.49	915.84	0.75
1.303030	20000.00	4992.00	5008.85	5008.85	5010.21	0.003326	12.00	2907.96	883.72	0.67
1.265152	20000.00	4991.40	5008.39	5006.65	5009.11	0.001402	8.46	3648.17	707.34	0.45
1.227273	20000.00	4990.70	5008.14	5006.11	5008.79	0.001433	8.57	3715.82	685.87	0.45
1.189394	20000.00	4990.10	5007.90	5004.62	5008.50	0.000986	7.26	3608.20	614.62	0.38
1.151515	20000.00	4988.90	5007.49	5003.54	5008.28	0.001049	8.00	3071.22	349.32	0.40
1.132576	20000.00	4988.30	5007.11		5008.14	0.001214	9.75	2723.33	275.57	0.43
1.113636	20000.00	4987.10	5006.74		5007.79	0.000821	8.41	2571.09	186.95	0.37
1.075757	20000.00	4983.05	5001.46	5001.46	5007.12	0.001259	19.10	1047.05	93.76	1.01
1.037878	20000.00	4978.09	4996.53	4996.53	5002.14	0.001243	19.00	1052.39	94.11	1.00
1.0	20000.00	4973.80	4989.25	4992.86	5000.95	0.003158	27.45	728.71	74.33	1.54

TABLE 2. WATER SURFACE PROFILE SUMMARY - 37,000 CFS

River Sta.	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
2.143371	37000.00	5022.60	5044.31	5044.31	5046.24	0.003274	12.79	4714.71	1187.46	0.57
2.105402	37000.00	5021.70	5043.77		5045.25	0.003300	11.74	5241.48	1335.94	0.57
2.067614	37000.00	5020.80	5043.44		5044.04	0.001107	7.87	7681.75	1308.30	0.34
2.029735	37000.00	5020.00	5037.72	5036.00	5043.12	0.011380	19.93	2685.51	988.55	1.03
1.991858	37000.00	5018.40	5037.28		5038.88	0.003004	11.02	4644.12	1063.38	0.54
1.953977	37000.00	5017.00	5036.75		5037.99	0.002403	10.58	5310.39	999.38	0.48
1.916098	37000.00	5015.60	5035.57		5037.25	0.003082	11.46	4520.77	953.13	0.55
1.878220	37000.00	5014.20	5034.90		5036.61	0.002959	11.68	4550.54	932.54	0.53
1.840341	37000.00	5011.70	5034.29		5035.68	0.002147	10.40	4906.82	885.00	0.47
1.802462	37000.00	5010.50	5032.83	5032.85	5035.07	0.004556	13.52	3962.05	859.57	0.66
1.764583	37000.00	5009.30	5029.87		5031.67	0.004307	13.43	4247.39	800.47	0.63
1.726705	37000.00	5008.00	5028.55	5028.61	5030.73	0.004664	13.63	4015.01	846.64	0.66
1.688826	37000.00	5006.50	5027.89		5029.27	0.003359	11.18	4611.53	798.38	0.56
1.650947	37000.00	5005.30	5025.75		5028.38	0.006762	16.19	3494.25	690.85	0.79
1.613068	37000.00	5004.20	5024.24		5026.63	0.005421	15.35	3872.29	843.88	0.71
1.575189	37000.00	5002.70	5021.50		5023.78	0.004520	13.83	3991.30	893.75	0.65
1.537311	37000.00	5001.20	5020.65	5018.97	5022.10	0.002233	10.94	4872.69	825.07	0.48
1.499432	37000.00	5000.00	5020.35	5017.65	5021.52	0.001938	9.98	4870.57	869.31	0.45
1.461553	37000.00	4998.00	5016.08	5014.39	5020.75	0.004931	17.81	2235.75	171.57	0.80
1.455622	Bridge									
1.449811	37000.00	4998.00	5014.38	5014.39	5020.46	0.007442	20.23	1949.35	165.61	0.96
1.424611	37000.00	4997.00	5014.52	5012.78	5019.24	0.004984	17.89	2218.85	168.15	0.80
1.418648	Bridge									
1.412675	37000.00	4997.00	5012.90	5012.78	5018.95	0.007334	20.18	1950.77	162.59	0.95
1.378768	37000.00	4995.00	5015.41	5012.26	5017.07	0.001619	11.45	4011.48	834.97	0.51
1.340889	37000.00	4993.30	5015.90	5011.26	5016.52	0.000753	7.97	6431.73	1017.21	0.34
1.303010	37000.00	4992.00	5016.00	5010.28	5016.32	0.000427	6.15	8731.95	1171.90	0.26
1.265132	37000.00	4991.40	5015.96	5008.52	5016.23	0.000294	5.47	10032.73	989.34	0.22
1.227253	37000.00	4990.70	5015.90	5008.05	5016.16	0.000291	5.46	9667.69	921.43	0.22
1.189374	37000.00	4990.10	5015.67	5006.94	5016.08	0.000344	6.08	7656.01	864.62	0.24
1.151495	37000.00	4988.90	5015.29	5006.32	5015.97	0.000501	7.63	5998.79	402.92	0.30
1.132576	37000.00	4988.30	5014.92		5015.88	0.000692	9.61	5044.95	321.98	0.35
1.113636	37000.00	4987.10	5014.17		5015.70	0.000742	10.31	4084.26	222.94	0.37
1.075757	37000.00	4983.05	5007.66	5007.66	5014.97	0.001166	21.69	1706.15	118.63	1.01
1.037878	37000.00	4978.09	5000.96	5002.31	5010.53	0.001554	24.82	1490.56	100.00	1.13
1.0	37000.00	4973.80	4995.14	4998.96	5009.66	0.002572	30.58	1210.10	84.00	1.42

CONCLUSIONS

Smith Engineering Company has completed the hydraulic analysis of the I-25 bridges at the Tijeras Arroyo. The numerical model, HEC-RAS, showed that the peak flows of 20,000 cfs and 37,000 cfs pass under the I-25 bridges with 6 and 9 feet of freeboard, respectively. The floodplains for these flows are delineated on Plate 1, and they generally resemble floodplains developed in previous studies.

The width of the floodplain associated with the 20,000 cfs event ranged from about 100 to 1200 feet wide within the study reach. Flow depths ranged from 13 to 20 feet in the main channel, while shallow flooding from 1 to 3 feet deep occurred in much of the overbanks. Channel velocities ranged from 7.3 to 16.6 fps.

No sediment analysis was performed for this study. It should be noted that the swift channel velocities combined with ample supplies of transportable sediment may significantly increase the water surface elevations predicted by this study. Also, there is evidence that hydraulic jumps may occur along certain portions of the study reach. These jumps and waves may also increase the predicted water surface elevations.

REFERENCES

Hydrologic Engineering Center, April 1996, "Bridge Hydraulic Analysis With HEC-RAS", U.S. Army Corps of Engineers, Davis, California.

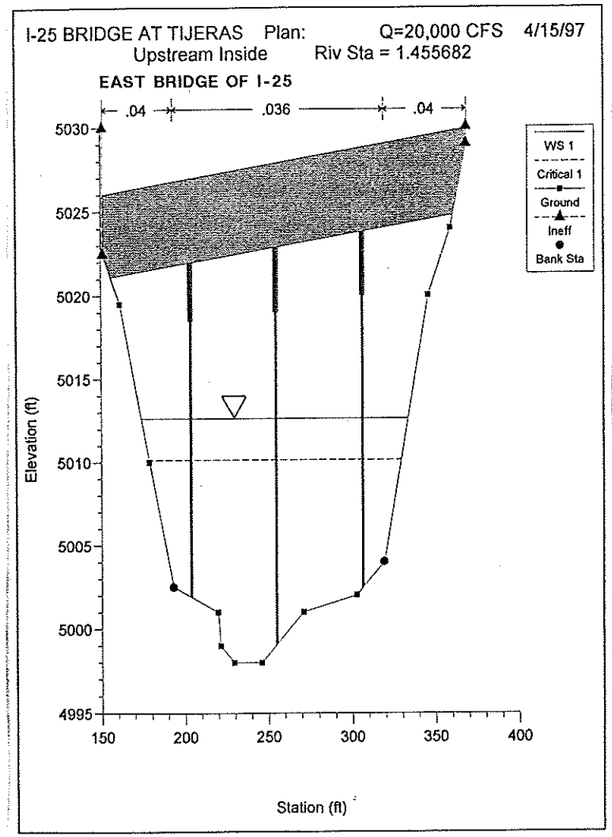
Hydrologic Engineering Center, July 1995, "HEC-RAS River Analysis System - User's Manual Version 1.0", U.S. Army Corps of Engineers, Davis, California.

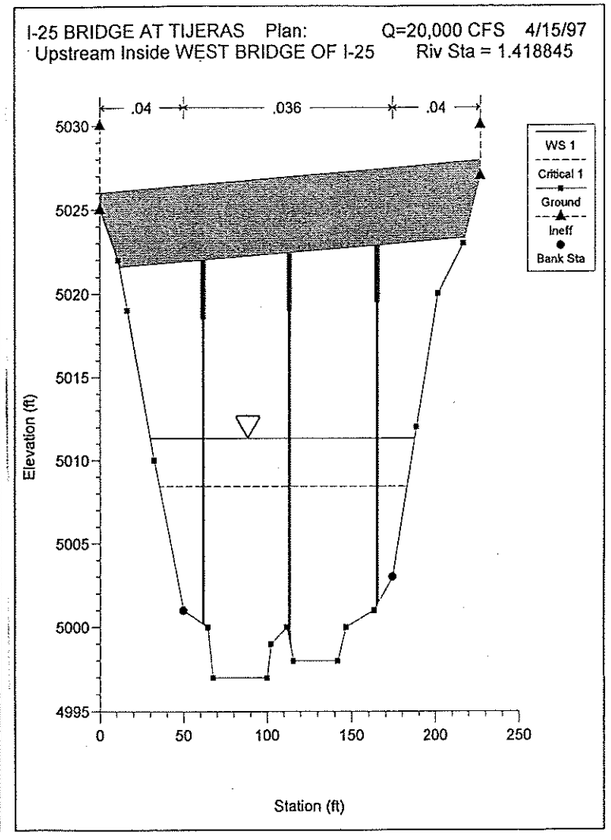
Hydrologic Engineering Center, July 1995, "HEC-RAS River Analysis System - Hydraulic Reference Manual", U.S. Army Corps of Engineers, Davis, California.

Mussetter, R.A., Lagasse, P.F., and M.D. Harvey, November 1994, "Sediment and Erosion Design Guide", Albuquerque Metropolitan Arroyo Flood Control Authority.

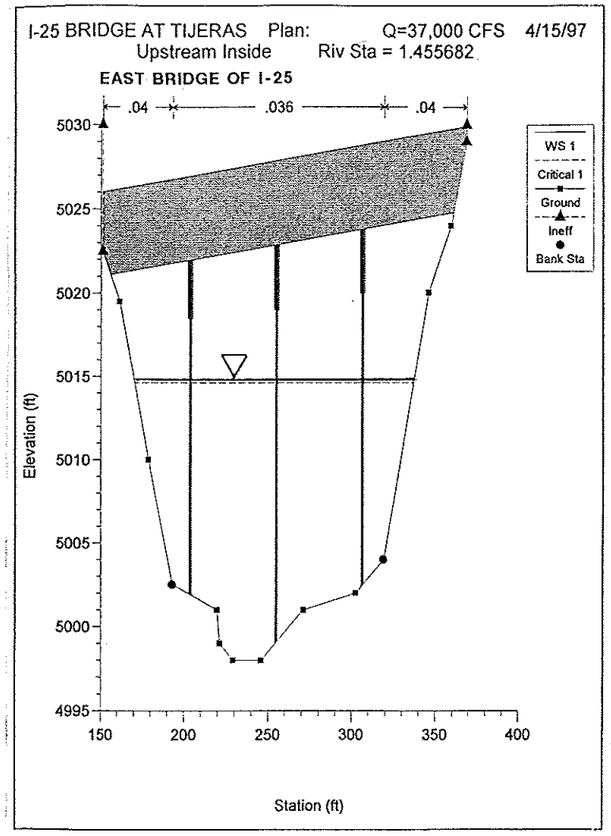
PLATES

Q = 20,000 cfs





Q = 37,000 cfs



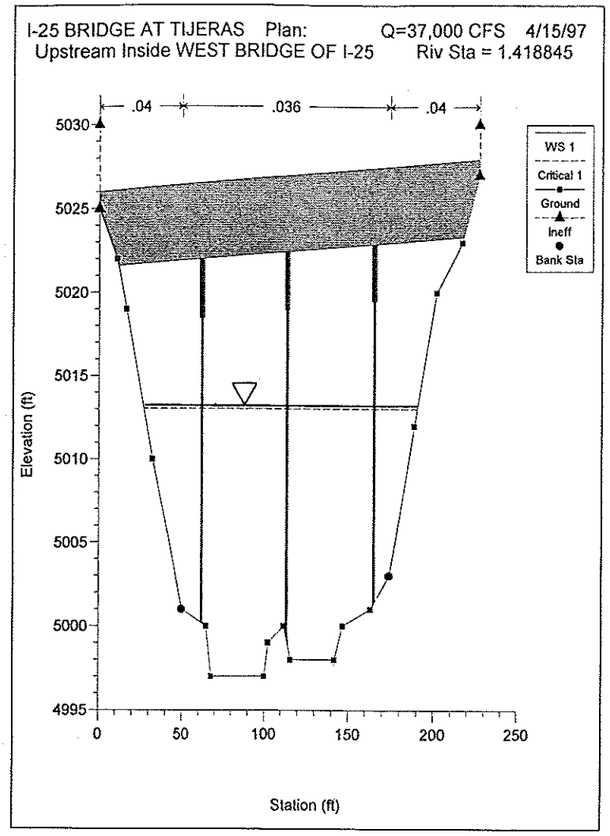


PLATE 2

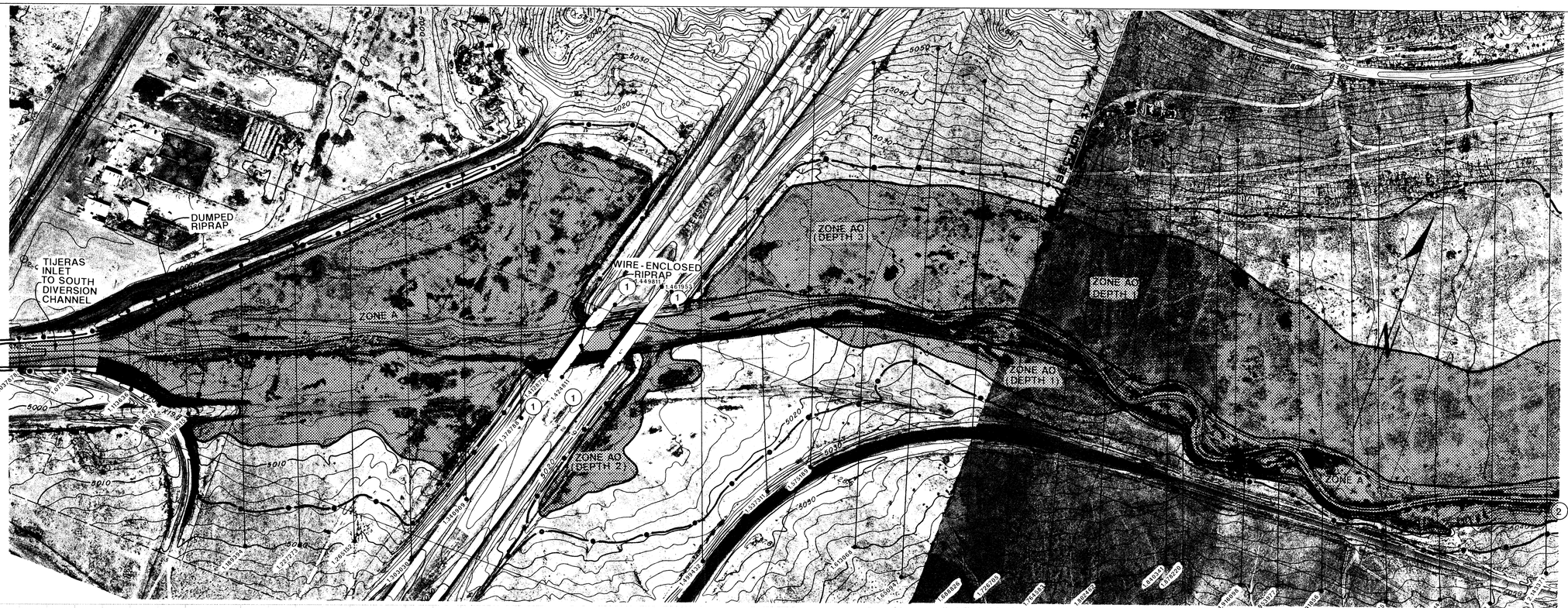
WATER SURFACE ELEVATIONS AT I-25 BRIDGE / TIJERAS ARROYO

NOTE:

- BRIDGE SURVEY BY SURV-TEK, INC., MARCH 1997
- ALL CROSS SECTIONS LOOKING DOWNSTREAM
- BRIDGE AREA ADJUSTED FOR SKEW
- ALL ELEVATIONS IN NGVD DATUM

SMITH ENGINEERING

APPENDIX A



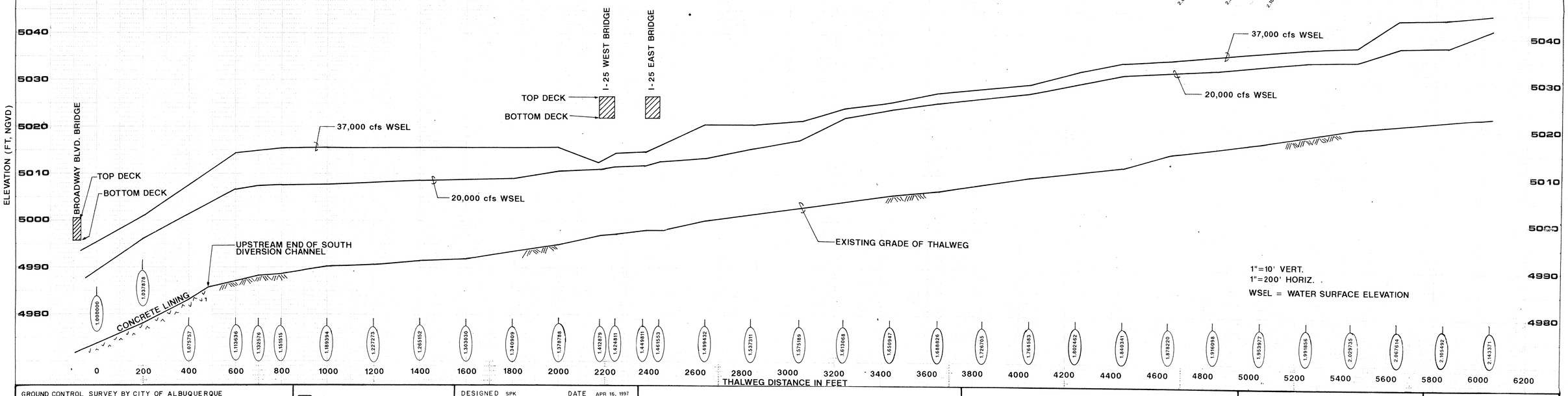
KEYED NOTES:

1. Cross sections at I-25 Bridges were surveyed by Surv-Tek, Inc. in March of 1997. These cross sections are shown parallel to the face of the bridges (as they were surveyed). For the hydraulic model, these cross sections were adjusted for bridge skew. All elevations shown are in NGVD datum.

2. Critical depth was assumed for upstream and downstream boundary conditions. The numerical model, HEC-RAS (version 1.2) was used to perform the hydraulic analysis using the "mixed flow" option (the model performed supercritical and subcritical runs). The 100-year peak flow of 20,000 cfs and the 500-year peak flow of 37,000 cfs were provided by AMAFCA.

LEGEND

- FLOOD PLAIN BASED ON 20,000 cfs
- FLOOD PLAIN BASED ON 37,000 cfs
- THALWEG OF EXISTING CHANNEL
- 2.143371 — CROSS SECTION WITH RIVER MILE
- DIRECTION OF FLOW
- 1.378788 — RIVER MILE



1"=10' VERT.
1"=200' HORIZ.
WSEL = WATER SURFACE ELEVATION

GROUND CONTROL SURVEY BY CITY OF ALBUQUERQUE
AERIAL PHOTOGRAPHY BY KOOGLE & POULS - MARCH 21, 1976
BOHANNAN, WESTMAN, HUSTON - SEPT 13, 1979
CONTOUR INTERVAL 2 FEET
BRIDGE SURVEY BY SURV-TEK, INC. - MARCH, 1997

Smith Engineering Company
A Full-Service Engineering Company
6400 Uptown Blvd., N.E. Suite 500E, Albuquerque, New Mexico 87110

DESIGNED	SPK	DATE APR 16, 1997
DRAWN	RFH	DATE APR 16, 1997
CHECKED	PJC	DATE APR 16, 1997
REVISED		DATE

ALBUQUERQUE METROPOLITAN
ARROYO FLOOD CONTROL AUTHORITY

WATER SURFACE PROFILE ANALYSIS FOR
THE I-25 BRIDGE AT THE TIJERAS ARROYO

PLATE 1