DICK PERREAULT

ADDENDUM NO. 4 TO:
PRELIMINARY HYDRAULIC ANALYSIS OF THE SALT RIVER FOR THE EAST PAPAGO FREEWAY AND RED MOUNTAIN INTERCHANGE

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PRELIMINARY HYDRAULIC ANALYSIS OF THE SALT RIVER FOR THE EAST PAPAGO FREEWAY AND RED MOUNTAIN INTERCHANGE

Submitted to:

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MARCH 12, 1990

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PREFACE

The results presented in this report are based on state-of-the-art techniques for river mechanics and scour analysis. However, the state-of-the-art of river mechanics is such that flow depths on the order of those which exist within the Salt River cannot realistically be predicted more accurately than plus or minus 10%. In addition, the state-of-the-art for scour analysis is such that predictions may vary by as much as 50% to 100%. The results obtained depend on the data base used, assumptions made, engineering computer models utilized, engineering judgement exercised, etc. Some of the assumptions made in conjunction with this study effort include: 1) hydrology (flood peaks) for the Salt River is correct; 2) the 1986 topographic mapping is sufficient to accurately depict topographic conditions; 3) sediment sampling adequately represents the existing sediment distributions in the stream bed; and 4) one-dimensional hydraulic modeling is appropriate to apply to the study reach. Consequently, the results obtained by different investigators could vary widely. Because the results presented within this report are considered to be conservative, based on the assumptions made, they can be used to give a relative measure of the maximum impacts associated with the proposed project. However, the results are only preliminary and not to be used for final design.

I. INTRODUCTION

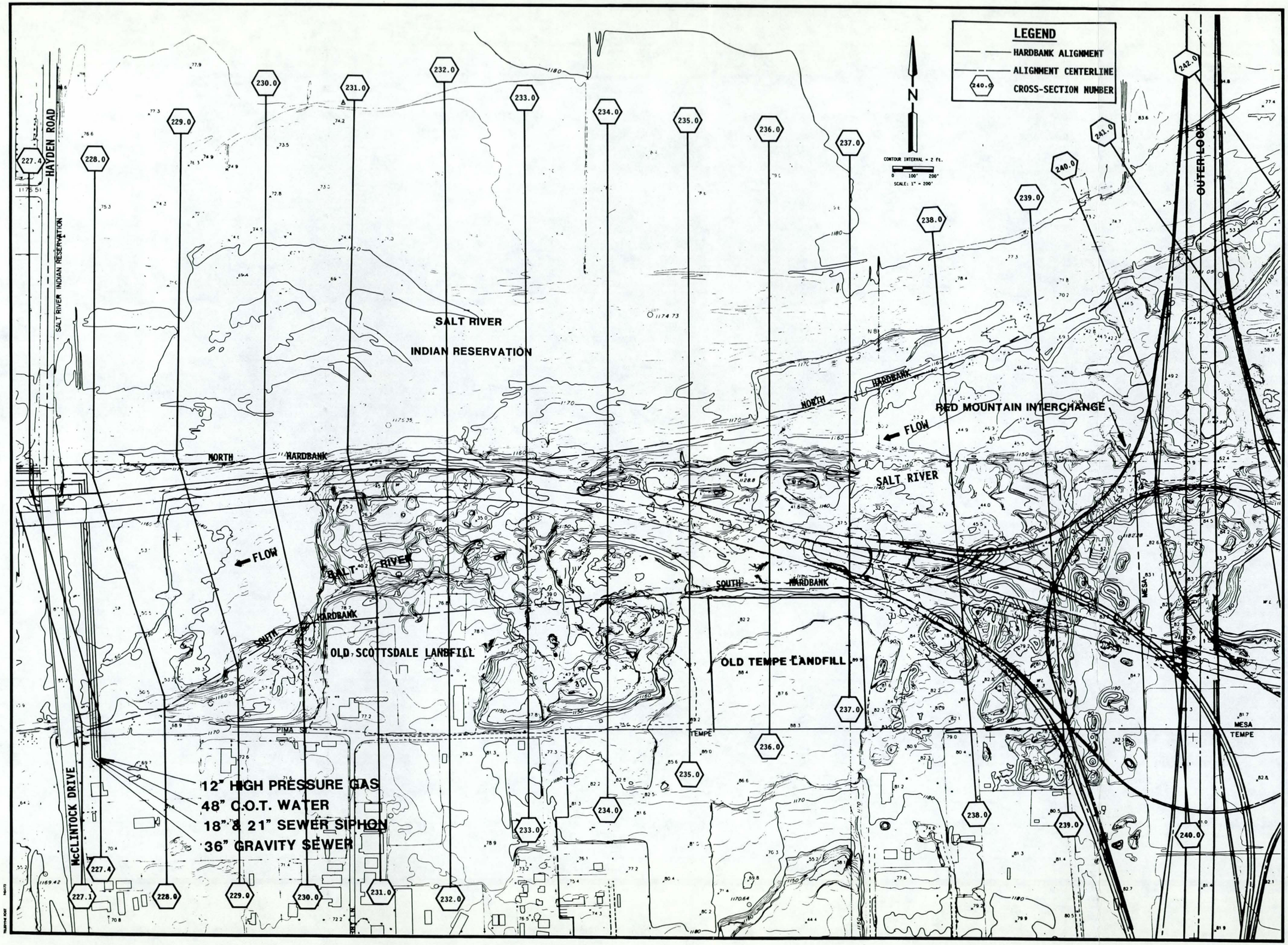
Preliminary hydraulic and scour analyses have been conducted for proposed alternate alignments of Section 6 of the East Papago Freeway. The initial analysis was for a proposed alignment which would cross the existing Hayden Road Bridge on a southeasterly skew, and then generally follow the southern bank of the Salt River on fill. This initial alignment for Section 6 of the East Papago, has been referred to as the southern alignment. A report titled "Preliminary Hydraulic Analysis of the Salt River for the East Papago and Red Mountain Interchange" (1), dated September 1989, presented the results of a preliminary hydraulic and scour analyses for this southern alignment.

An alternate northern alignment for Section 6 of the East Papago Freeway was subsequently proposed which would minimize some of the impacts identified with the southern alignment. This alternate northern alignment would be entirely on structure east of Hayden Road. This alignment would cross the existing Hayden Road Bridge at an approximate right angle, then follow the north bank of the river to a point north of the Old Tempe Landfill, where the alignment would turn southeasterly and cross the Salt River in order to tie into the Red Mountain Interchange. Alternative channel configurations associated with this proposed northern alignment have been analyzed, and reported in addendums to the initial report.

"Addendum No. 1 to: Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange" (2), dated November 22, 1989, presented the results of the preliminary hydraulic analysis for Alternative 1. Concept conditions for Alternative 1 utilized a south hardbank for protection of the Old Scottsdale Landfill and the Old Tempe Landfill. No bank protection was provided along the north bank of the Salt River. "Addendum No. 2 to: Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange" (3), dated December 7, 1989, presented the results of the preliminary hydraulic analysis for Alternative 2. Concept conditions for Alternative 2 utilized bank protection on both the north and south banks of the Salt River. The reach of river from the existing Hayden Road Bridge through the Outer Loop Highway crossing was assumed to be leveed to contain the design flow between the north and south banks. "Addendum No. 3 to: Preliminary Hydraulic

Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange" (4), dated December 1989, presented the results of the preliminary hydraulic analysis for Alternative 3. Concept conditions for Alternative 3 also utilized bank protection on both the north and south banks between the existing Hayden Road Bridge and the Outer Loop Highway crossing. However, the north hardbank was not leveed. It was assumed bank protection would be provided to an elevation of 1170.0 feet, the approximate existing top of bank elevation for this reach of the Salt River.

This addendum evaluates an alternative having the same northern structural alignment for Section 6 of the East Papago Freeway as that presented in previous addendums. Concept conditions for this alternative, Alternative 4, utilize a north hardbank protected to the height of the existing top of bank (approximately elevation 1170 feet). The south bank is leveed to a height which will contain the 100-year flood, and is located near the northern edge of the Old Scottsdale Landfill. Concept conditions for Alternative 4 differ from concept conditions for Alternative 3 in that, for Alternative 4, the channel invert elevations for concept conditions have been modified through the project reach, and the pier diameters for the East Papago crossing of the Salt River have been increased to reflect current design conditions. Figure 1 shows the general location of the northern alignment for Section 6 of the East Papago Freeway, and the general location of the bank protection for Alternative 4.



SIMONS, LI & ASSOCIATES, INC.
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EAST PAPAGO FREEWAY - SECTION 6
ALTERNATIVE 4

Project No.	AZ-DMJM-03
Date:	02-15-90
Design:	
Drawn:	JRM
Check:	
Revisions:	

FIGURE 1

II. HYDRAULIC ANALYSIS FOR ALTERNATIVE 4

2.1 General

The procedures and data base used for the hydraulic analysis of Alternative 4 were the same as those described in the initial report (1). For concept conditions of Alternative 4 (proposed northern alignment with leveed south bank and north bank protection to elevation 1170.0 ft.), bridge routines were not used to analyze the East Papago crossing of the Salt River. Instead, the same procedure was used as that described in the first addendum (2). Piers from the East Papago structure were modeled as obstructions in the flow field, thus removing the pier area from the effective flow area of the channel. This modeling procedure was used due to the alignment of the structure with respect to the flow.

A baseline condition, with the effects of gravel pits removed, was used to analyze project impacts. This is the same approach as was used in the initial report and previous addendums, and was done to provide an estimate of water-surface elevations that would result if the gravel pits were filled in with water and/or sediment during flood events. Baseline conditions presented in this addendum are identical to baseline conditions in the previous addendums (2,3,4). A consistent baseline condition permits relative comparison among the various alternatives.

2.2 Concept Analysis - Alternative 4

Concept conditions for Alternative 4 are a consequence of the best estimate of conditions resulting from: (1) the northern alignment of the East Papago Freeway, which is entirely on structure; (2) a leveed embankment on the south side of the Salt River, which does not permit flow in the south overbank; (3) a protected north bank to an elevation of 1170.0 ft.; and (4) the best estimate of the Outer Loop bridge configuration. Concept conditions assume the channel invert has a uniform slope through the project reach.

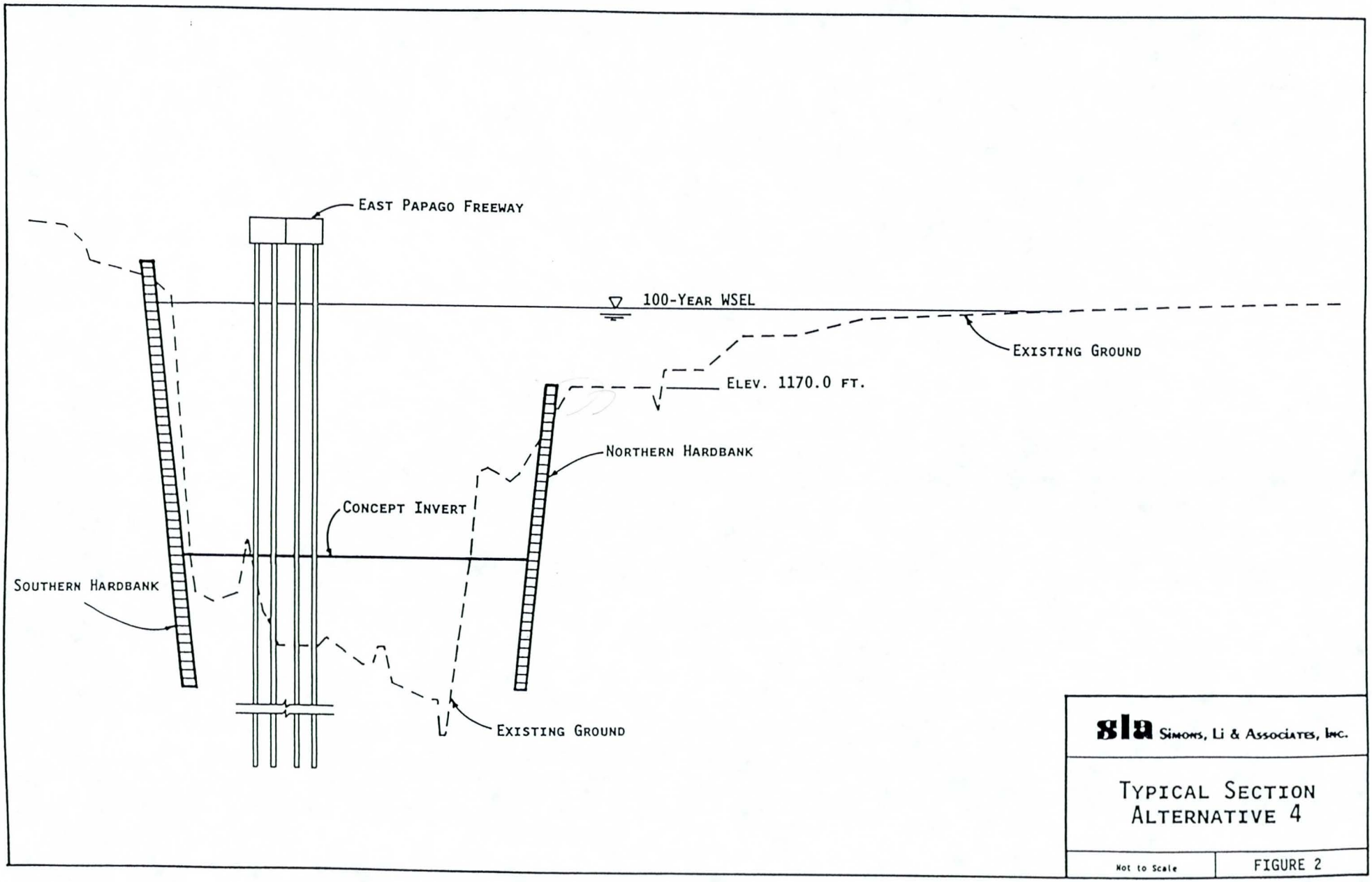
Concept conditions for Alternative 4 include bank protection along the south bank of the river identical to that described in the previous addendums. The south bank protection was located adjacent to the Old Scottsdale Landfill and the Old Tempe Landfill in an effort to minimize disturbance to the sites,

and yet maximize conveyance in the Salt River channel. Alignment of the bank protection on the north bank is identical to that described in the second and third addendums, and generally follows the southern edge of the Salt River Project's power transmission easement on the north bank of the Salt River. Concept conditions for Alternative 4 utilize bank protection along the north bank line to an elevation of 1170.0 feet, the approximate existing top of bank of the main channel for this reach of the Salt River. This protection of the north bank will extend between the Hayden Road Bridge and the Outer Loop Highway crossing, and will permit flow in the north overbank similar to baseline conditions for large magnitude flood events. Figure 2 presents a typical channel section which illustrates concept conditions for Alternative 4.

Concept conditions for the proposed northern alignment of the East Papago Freeway assumed a structure consisting of 135-foot spans with 9-foot diameter columns, 2 columns per structure. Each column of the East Papago structure will be exposed to the flow. The effective length of the mainline of the Outer Loop crossing under concept conditions is approximately 1200 feet. Concept conditions for the Outer Loop crossing of the Salt River were analyzed using 130-foot spans with 6-foot diameter columns, 3 columns per structure. As a result of the small angle to which the structures are skewed to the flow, it was assumed that the piers for the Outer Loop crossing would essentially be aligned with the flow.

Water-surface profiles for Alternative 4 were computed for the 100-year peak discharge (215,000 cfs) for two concept conditions. The first case did not consider debris buildup on the piers, whereas the second case did consider debris buildup on the piers. To account for debris buildup, an effective pier width equal to the pier diameter plus two feet of debris overhang on each side of the pier was used for both the East Papago crossing and the Outer Loop Highway crossing. The hydraulic results are presented in Table 1 for the case without debris buildup, and in Table 2 for the case with debris buildup. The case with debris buildup provides a more conservative estimate of water-surface elevations.

Figure 3 presents plots of computed water-surface profiles of baseline and concept conditions for Alternative 4 for the 100-year event with debris buildup. Table 3 presents computed differences in water-surface elevations, average velocities, and topwidths between concept conditions for Alternative 4 and baseline conditions.



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TYPICAL SECTION
ALTERNATIVE 4

Not to Scale | FIGURE 2

TABLE 1. Hydraulic Information -- Baseline and Concept Conditions for Alternative 4, 100-Year Event Without Debris Buildup

		----- BASELINE CONDITION -----				----- CONCEPT CONDITION -----				
PROJECT STATION (ft)	CROSS-SECTION NUMBER	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	PHYSICAL FEATURE
36263	225.00	1170.5	17.6	10.6	2180	1171.2	22.8	8.2	1344	
36660	226.00	1171.3	17.6	10.7	2252	1171.5	22.9	7.8	1223	
37027	227.10	1171.8	17.1	11.0	1571	1171.7	22.4	8.4	1537	Hayden Road Bridge
37116	227.40	1171.8	14.2	13.2	1496	1172.6	23.2	8.1	1737	
37436	228.00	1173.8	18.7	10.5	2426	1173.1	23.1	7.2	2199	
37836	229.00	1174.9	22.7	7.7	2430	1173.2	22.4	8.9	2116	
38236	230.00	1175.0	22.6	8.7	2655	1173.3	21.8	11.3	2066	
38635	231.00	1175.0	21.3	12.8	2059	1173.8	22.1	12.0	1830	Old Scottsdale
39042	232.00	1175.4	22.8	13.0	2093	1174.5	22.3	12.2	1766	Landfill
39444	233.00	1177.3	15.4	9.1	2311	1175.2	22.2	12.5	1488	
39840	234.00	1177.7	24.6	8.4	1987	1176.0	23.0	12.2	1527	
40246	235.00	1177.7	22.3	10.8	1603	1177.1	24.2	11.0	1549	
40647	236.00	1178.6	24.6	9.1	1875	1178.0	24.6	9.9	1527	Old Tempe Landfill
41043	237.00	1179.1	24.6	8.6	1472	1178.8	25.4	8.6	1397	
41553	238.00	1179.6	25.2	7.8	1456	1179.5	25.9	7.4	1558	
42018	239.00	1179.8	16.5	8.9	1438	1179.7	26.0	7.6	1532	
42568	240.00	1180.4	25.0	8.0	1461	1179.9	26.1	8.9	945	Outer Loop Highway
43073	241.00	1181.0	22.9	6.8	1826	1180.7	26.7	6.9	1186	
43588	242.00	1181.5	25.0	5.1	2324	1181.3	23.5	5.6	2063	
44058	243.00	1181.7	25.7	4.0	2482	1181.6	24.5	4.4	2182	
44528	244.00	1181.8	19.2	4.5	2532	1181.6	18.8	4.8	2438	
45078	245.00	1181.9	16.1	4.8	2868	1181.8	16.0	5.1	2730	
45693	246.00	1182.2	16.9	4.2	3146	1182.2	16.6	4.2	3145	Evergreen Road
46197	247.00	1182.2	13.6	6.9	2354	1182.2	13.4	6.9	2376	
46736	248.00	1183.0	17.0	4.1	3177	1182.9	17.1	4.1	3173	
47237	249.00	1183.1	19.5	4.4	2579	1183.0	19.2	4.5	2579	
47757	250.00	1183.2	17.7	5.1	2450	1183.2	18.0	5.0	2449	
48364	251.00	1183.2	13.0	9.1	1861	1183.2	13.1	9.0	1861	
48862	252.00	1183.9	15.1	9.4	1558	1183.9	15.0	9.4	1558	Dobson Road
49506	253.00	1185.3	11.8	8.8	2121	1185.3	11.8	8.8	2120	
49980	254.00	1185.5	9.5	15.0	1545	1185.5	9.5	15.1	1545	
50487	255.00	1189.7	12.8	11.1	1541	1189.7	12.8	11.1	1542	
50957	256.00	1191.5	18.4	7.5	1586	1191.5	18.4	7.5	1586	
51491	257.00	1191.5	13.2	11.2	1496	1191.5	13.2	11.1	1496	
51910	258.00	1192.6	17.3	11.0	1162	1192.6	17.3	11.0	1162	
52496	259.00	1194.3	15.5	9.1	1565	1194.3	15.5	9.1	1565	
53001	260.00	1195.3	17.8	8.0	1662	1195.3	17.8	8.0	1662	
53445	261.00	1195.9	20.9	6.9	2069	1195.9	20.9	6.9	2069	
53954	262.00	1195.9	17.2	11.7	1820	1195.9	17.2	11.7	1820	
54478	263.00	1196.9	13.1	11.7	2145	1196.9	13.1	11.7	2145	
55034	264.00	1198.2	12.2	12.2	1871	1198.2	12.2	12.2	1871	
55471	265.00	1199.6	13.4	11.0	2008	1199.6	13.4	11.0	2008	Alma School Road

TABLE 2. Hydraulic Information -- Baseline and Concept Conditions for Alternative 4, 100-Year With Debris Buildup

		----- BASELINE CONDITION -----				----- CONCEPT CONDITION -----				
PROJECT STATION (ft)	CROSS-SECTION NUMBER	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	PHYSICAL FEATURE
36263	225.00	1170.5	17.6	10.6	2180	1171.2	22.8	8.2	1344	
36660	226.00	1171.3	17.6	10.7	2252	1171.5	22.9	7.8	1223	
37027	227.10	1171.8	17.1	11.0	1571	1171.7	22.4	8.4	1537	Hayden Road Bridge
37116	227.40	1171.8	14.2	13.2	1496	1172.6	23.2	8.1	1737	
37436	228.00	1173.8	18.7	10.5	2426	1173.0	22.7	7.3	2181	
37836	229.00	1174.9	22.7	7.7	2430	1173.1	22.0	9.0	2098	
38236	230.00	1175.0	22.6	8.7	2655	1173.2	21.3	11.6	2038	
38635	231.00	1175.0	21.3	12.8	2059	1173.8	21.6	12.2	1814	Old Scottsdale
39042	232.00	1175.4	22.8	13.0	2093	1174.5	21.8	12.5	1767	Landfill
39444	233.00	1177.3	15.4	9.1	2311	1175.2	21.7	12.7	1474	
39840	234.00	1177.7	24.6	8.4	1987	1176.1	22.5	12.4	1532	
40246	235.00	1177.7	22.3	10.8	1603	1177.3	23.8	11.1	1534	
40647	236.00	1178.6	24.6	9.1	1875	1178.2	24.2	10.0	1607	Old Tempe Landfill
41043	237.00	1179.1	24.6	8.6	1472	1179.0	25.1	8.7	1384	
41553	238.00	1179.6	25.2	7.8	1456	1179.7	26.0	7.4	1559	
42018	239.00	1179.8	16.5	8.9	1438	1180.0	26.2	7.5	1531	
42568	240.00	1180.4	25.0	8.0	1461	1180.1	26.3	8.9	945	Outer Loop Highway
43073	241.00	1181.0	22.9	6.8	1826	1181.0	27.0	6.9	1187	
43588	242.00	1181.5	25.0	5.1	2324	1181.6	23.8	5.5	2064	
44058	243.00	1181.7	25.7	4.0	2482	1181.9	24.8	4.3	2182	
44528	244.00	1181.8	19.2	4.5	2532	1181.9	19.1	4.7	2438	
45078	245.00	1181.9	16.1	4.8	2868	1182.1	16.2	5.0	2730	
45693	246.00	1182.2	16.9	4.2	3146	1182.5	16.8	4.2	3148	Evergreen Road
46197	247.00	1182.2	13.6	6.9	2354	1182.5	13.6	6.8	2388	
46736	248.00	1183.0	17.0	4.1	3177	1183.2	17.3	4.0	3178	
47237	249.00	1183.1	19.5	4.4	2579	1183.3	19.4	4.4	2581	
47757	250.00	1183.2	17.7	5.1	2450	1183.4	18.2	4.9	2454	
48364	251.00	1183.2	13.0	9.1	1861	1183.4	13.4	8.8	1862	
48862	252.00	1183.9	15.1	9.4	1558	1184.0	15.2	9.3	1559	Dobson Road
49506	253.00	1185.3	11.8	8.8	2121	1185.4	11.9	8.7	2121	
49980	254.00	1185.5	9.5	15.0	1545	1185.6	9.5	14.9	1547	
50487	255.00	1189.7	12.8	11.1	1541	1189.7	12.8	11.1	1541	
50957	256.00	1191.5	18.4	7.5	1586	1191.5	18.4	7.5	1586	
51491	257.00	1191.5	13.2	11.2	1496	1191.5	13.2	11.2	1496	
51910	258.00	1192.6	17.3	11.0	1162	1192.6	17.2	11.0	1162	
52496	259.00	1194.3	15.5	9.1	1565	1194.3	15.5	9.1	1565	
53001	260.00	1195.3	17.8	8.0	1662	1195.3	17.8	8.0	1662	
53445	261.00	1195.9	20.9	6.9	2069	1195.9	20.9	6.9	2069	
53954	262.00	1195.9	17.2	11.7	1820	1195.9	17.2	11.7	1820	
54478	263.00	1196.9	13.1	11.7	2145	1196.9	13.1	11.8	2144	
55034	264.00	1198.2	12.2	12.2	1871	1198.2	12.2	12.2	1871	
55471	265.00	1199.6	13.4	11.0	2008	1199.6	13.3	11.0	2008	Alma School Road

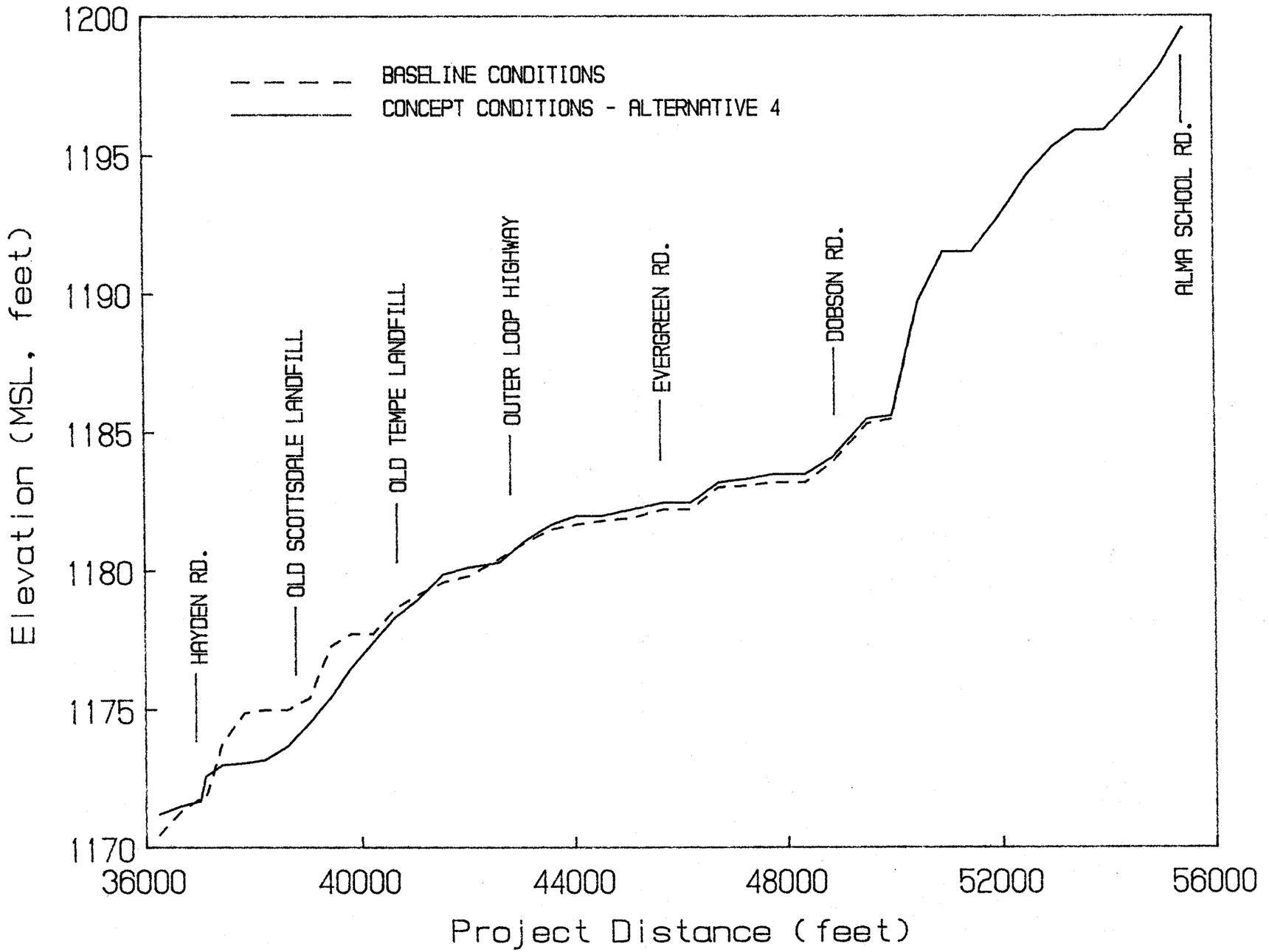

Figure 3. Water-Surface Profiles of Baseline and Concept Conditions for Alternative 4, 100-Year Event with Debris Buildup

TABLE 3. Water-Surface Elevations, Average Velocity, and Topwidth Comparisons -- Concept Conditions for Alternative 4 Minus Baseline Conditions, 100-Year Event with Debris Buildup

PROJECT STATION (feet)	CROSS-SECTION NUMBER	WATER SURFACE ELEVATION (feet)	CHANNEL VELOCITY (ft/sec)	TOPWIDTH (ft)	PHYSICAL FEATURE
36263	225.0	0.7	-2.3	-835	
36660	226.0	0.3	-2.9	-1029	
37027	227.1	-0.1	-2.6	-34	Hayden Road Bridge
37116	227.4	0.8	-5.1	241	
37436	228.0	-0.7	-3.3	-245	
37836	229.0	-1.8	1.4	-332	
38236	230.0	-1.8	2.9	-617	
38635	231.0	-1.3	-0.6	-245	Old Scottsdale Landfill
39042	232.0	-0.9	-0.5	-325	
39444	233.0	-2.0	3.6	-837	
39840	234.0	-1.6	4.0	-455	
40246	235.0	-0.4	0.4	-69	
40647	236.0	-0.4	0.8	-268	Old Tempe Landfill
41043	237.0	-0.1	0.1	-88	
41553	238.0	0.1	-0.4	103	
42018	239.0	0.2	-1.4	93	
42568	240.0	-0.2	0.9	-515	Outer Loop Highway
43073	241.0	0.0	0.1	-639	
43588	242.0	0.1	0.5	-260	
44058	243.0	0.1	0.4	-300	
44528	244.0	0.2	0.2	-94	
45078	245.0	0.2	0.2	-138	
45693	246.0	0.2	0.0	2	Evergreen Road
46197	247.0	0.2	-0.1	34	
46736	248.0	0.2	-0.1	1	
47237	249.0	0.2	0.0	2	
47757	250.0	0.2	-0.1	4	
48364	251.0	0.2	-0.2	1	
48862	252.0	0.1	-0.1	1	Dobson Road
49506	253.0	0.1	-0.1	1	
49980	254.0	0.1	-0.1	2	
50487	255.0	0.0	0.0	0	
50957	256.0	0.0	0.0	0	
51491	257.0	0.0	0.0	0	
51910	258.0	0.0	0.0	0	
52496	259.0	0.0	0.0	0	
53001	260.0	0.0	0.0	0	
53445	261.0	0.0	0.0	0	
53954	262.0	0.0	0.0	0	
54478	263.0	0.0	0.0	0	
55034	264.0	0.0	0.0	0	
55471	265.0	0.0	0.0	0	Alma School Road

Results from the hydraulic analysis for concept conditions of Alternative 4 show a maximum increase in water-surface elevation of 0.8 feet, which occurs at the upstream face of the Hayden Road bridge. This increase is due to the East Papago freeway encroachment on the Salt River downstream of Hayden Road, and the assumed configuration of the East Papago freeway crossing. A hydraulic constriction through the Old Scottsdale Landfill and the Old Tempe Landfill results in a 0.2 foot increase in water-surface elevation downstream of the Outer Loop Highway crossing (cross-section 239.0). Upstream of the Outer Loop crossing, the increase in water-surface elevation above baseline gradually decreases from 0.2 feet to baseline conditions around Dobson Road. The maximum increase in average velocity over baseline conditions is 4.0 feet per second upstream of the Old Scottsdale Landfill at cross-section 234.00.

III. LOCAL SCOUR

Local scour, due to the presence of structures and debris in the flow field, was computed for the 100-year design flood under concept conditions for Alternative 4. Concept conditions assume that sand and gravel mining operations would not be permitted to extensively impact channel invert stability west of the Outer Loop Highway crossing. Local-scour computations at all locations were based primarily on the CSU Equation (5), which takes into account both the flow depth and the velocity of flow (the latter via the Froude number). Laursen's Equation (5), which accounts only for flow depth, was used as a means of comparison. Debris buildup and overlap of scour holes were considered in the local-scour analysis.

To account for debris buildup, an effective pier width equal to the pier diameter plus two feet of debris overhang on each side of the pier was used for both the East Papago crossing and the Outer Loop Highway crossing. By including an effective pier width to account for debris buildup in local-scour computations, it is assumed that the width of the debris extends from the water surface to the bed of the channel, and thus increases the local-scour potential.

Due to the close proximity of pier columns relative to the direction of the flow, pier scour and its resulting zone of influence was considered in the analyses for the East Papago crossing of the Salt River. The zone of influence for local scour is the distance that the local scour extends from the face of the pier. This zone of influence was approximated by assuming that the bottom of the scour hole extends horizontally to the edge of the debris (i.e., two feet away from the face along the sides of the pier), and then slopes upward to the bed of the channel on a 1.75 to 1 (horizontal to vertical) side-slope, which is approximately equal to the natural angle of repose of the streambed sediments. For example, the zone of influence for a 9-foot diameter pier with 25.6 feet of local scour would be 46.8 feet (2 feet plus 1.75 times 25.6 feet).

Local scour can be deeper if scour holes overlap. The mechanisms of this phenomenon are not well understood, but a conservative estimate of local scour can be obtained by considering the local-scour components to be additive at a given location. Consequently, if the predicted local scour for an individual 9-foot diameter pier column is 25.6 feet, the total (additive) local scour for

9-foot columns spaced on 40-foot centers would be 35.7 feet due to the overlapping of the scour holes. During the passage of the design flood, this 35.7-foot-deep scour hole could migrate against the face of either pier. In addition, the zone of influence of this increased local scour, due to the overlapping of the scour holes, would expand to approximately 64.5 feet (2 feet plus 1.75 times 35.7 feet). This example demonstrates the need to carefully evaluate the size and location of piers in relation to each other when considering local scour.

A conservative approach for computing local scour under concept conditions was taken, since nothing in the literature addresses the determination of local scour at piers subject to such unique flow conditions. It is possible that a more precise estimate of local scour for these conditions could be developed with the aid of a physical model, should a more definitive estimate of local scour be desired.

IV. TOTAL SCOUR

As was stated in the initial report, the total-scour depth at any given point along the reach of the Salt River under investigation is the sum of the general scour; bedform-trough depths; local scour; and long-term degradation. A summary of total-scour depths that can be expected under concept conditions are presented in Table 4. The scour depths included in Table 4 were based on the assumption that mining operations would not be allowed in a channel reach having bank protection on both banks.

Pier scour included in Table 4 is for an East Papago structure with 135-foot spans and 9-foot diameter columns, with 4 feet of additional pier width included for debris buildup. Pier-scour calculations at the Outer Loop crossing were performed assuming 130-foot spans and 6-foot diameter columns, with 4 feet of additional pier width included for debris buildup. Local-scour depths included in the table account for the overlap of scour holes, and assume that no bedrock is encountered within the scour zone.

As stated previously, it was assumed that, under concept conditions, sand and gravel mining operations within a channel having bank protection along both banks would not be permitted. As addressed in the initial report (1), particles with a minimum diameter of 110 mm are necessary to provide armoring for hydraulic conditions during a 100-year event. Assuming the fill material used to construct the concept channel invert contained material at least ten percent coarser than the particle diameter necessary to form an armor layer, the long-term channel response would be governed by the armoring process. Using twice the diameter of the particle size necessary for armoring to constitute the thickness of the armor layer (6), a sufficient quantity of material is available within the top 6.5 feet of the concept channel invert to form an armor layer which will prevent further degradation beyond a depth of 6.5 feet during the 100-year design flood. Because this 6.5 feet of degradation occurs during the 100-year flood, and all floods of lesser magnitude would produce armoring depths less than 6.5 feet; it is felt that 6.5 feet of degradation is justified, under the preceding assumptions, as representative of the long-term channel response for concept conditions along the subject reach of the Salt River.

TABLE 4. Summary of Total-Scour Depths at Piers for Alternative 4, 100-Year Event

Project Station (ft)	Cross-Section Number	General Scour (ft)	Bed-Form Scour (ft)	Pier[1] Scour (ft)	Long-term[2] Degradation (ft)	Safety Factor (ft)	Total Scour at Piers (ft)	Minimum[3] Predicted Invert Elevation (ft)	Physical Feature
36263	225.0	1.7	2.0	28.0	6.5	3.1	41.3	1106.3	
36660	226.0	1.9	2.0	28.0	6.5	3.1	41.5	1106.4	
37027	227.1	1.6	2.0	28.0	6.5	3.0	41.1	1107.1	Hayden Road Bridge
37116	227.4	0.0	2.0	28.0	6.5	2.6	39.1	1109.3	
37436	228.0	0.0	2.0	28.0	6.5	2.6	39.1	1109.5	
37836	229.0	3.0	2.0	28.0	6.5	3.4	43.0	1106.0	
38236	230.0	3.0	2.0	36.0	6.5	3.4	51.0	1098.3	
38635	231.0	3.0	2.0	36.0	6.5	3.4	51.0	1098.6	Old Scottsdale
39042	232.0	3.0	2.0	36.0	6.5	3.4	51.0	1098.9	Landfill
39444	233.0	3.0	2.0	36.0	6.5	3.4	51.0	1099.1	
39840	234.0	3.0	2.0	36.0	6.5	3.4	51.0	1099.6	
40246	235.0	3.0	2.0	36.0	6.5	3.4	51.0	1099.9	
40647	236.0	3.0	2.0	31.0	6.5	3.4	46.0	1105.1	Old Tempe Landfill
41043	237.0	3.0	2.0	31.0	6.5	3.4	46.0	1105.5	
41553	238.0	0.6	2.0	31.0	6.5	2.7	42.8	1109.0	
42018	239.0	0.5	2.0	19.0	6.5	8.4	36.4	1115.8	
42568	240.0	0.2	2.0	19.0	6.5	8.3	36.0	1116.6	Outer Loop Highway
43073	241.0	0.2	2.0	19.0	6.5	8.3	36.0	1117.0	
43588	242.0	0.5	2.0	19.0	6.5	8.4	36.4	1117.1	

NOTES:

1 Includes consideration for debris buildup and scour hole overlap.
2 Assumes armoring is the controlling process.
3 Based upon ADOT 1986 topographic mapping.

Except for when scour holes overlap, a safety factor equal to 30 percent of the sum of the above scour components is included to account for the non-uniform flow distribution that is typical of alluvial channels. It is felt that the conservative approach of simply adding depths for overlapping scour holes already incorporates an adequate safety factor for local scour at those locations where scour overlap occurs.

It should be noted that the minimum predicted invert elevations presented in Table 4 are intended for use in the design of bridge foundations. Toe-down depths for bank-protection systems should be designed considering the zone of influence of local scour at bridge piers. Since the location of the channel banks has not yet been determined, use of the long-term predicted invert elevation given in Table 4 for bank protection toe-down depths may produce an overly conservative design with regard to this component of bank protection design.

V. COMPARISON OF ALTERNATIVES

Addendum No. 1 to the initial report presented a preliminary hydraulic analysis of Alternative 1, comprised of a south bank levee and the northern structural alignment east of Hayden Road. No bank protection was provided along the north bank of the Salt River. Upstream of Hayden Road, the maximum increase in water-surface elevation above baseline conditions was 1.0 foot, which occurred in the vicinity of the Old Scottsdale Landfill (cross-section 232.00). In the reach between Hayden Road and the Outer Loop Highway crossing of the Salt River, the highest average velocity was 10.8 feet per second at cross-section 231.00. The maximum increase in average velocity above baseline conditions was 1.4 feet per second, which occurred at cross-section 230.00 as well as at cross-section 234.00.

Alternative 2 consisted of a channel having both a south bank and a north bank levee, which provided channel capacity to convey the design discharge within the channel banks. The maximum increase in water-surface elevation above baseline conditions upstream of the Hayden Road bridge was 1.7 feet. This increase occurred downstream of the Outer Loop crossing (cross-sections 238.00 through 240.00). The highest average velocity was 12.8 feet per second at cross-section 231.00. The maximum increase in average velocity above baseline conditions was 2.7 feet per second, which occurred immediately upstream of the Old Scottsdale Landfill (cross-sections 233.00 and 234.00).

Alternative 3 consisted of bank protection along both the north and south banks of the Salt River. However, bank protection along the north bank was limited to the top of the existing bank (approximate elevation of 1170.0 feet). For Alternative 3, the maximum increase in water-surface elevation above baseline conditions upstream of the Hayden Road bridge was 1.2 feet, and occurred in the vicinity of the Old Scottsdale Landfill (cross-section 232.00). The highest average velocity was 10.7 feet per second, which also occurs at cross-section 232.00. The maximum increase in average velocity was 1.7 feet per second, which occurred at cross-section 230.00.

This addendum presents the results of an alternative that has the same bank protection alignment and configuration as Alternative 3; although the channel invert elevations have been modified through the project reach to account for

concept design conditions. In addition, 9-foot-diameter piers have been utilized for the East Papago freeway crossing. Upstream of the Hayden Road Bridge, the maximum increase in water-surface elevation above baseline conditions was 0.2 feet. This occurs downstream of the Outer Loop crossing (cross-section 239.00). The highest average velocity was 12.7 feet per second at cross-section 233.00. This average velocity is essentially the same as baseline conditions (13.0 feet per second) for this cross-section. The maximum increase in average velocity above baseline conditions was 4.0 feet per second, which occurred immediately upstream of the Old Scottsdale Landfill (cross-section 234.00).

A comparison of water-surface elevations for the proposed alternatives shows that Alternative 4 will result in lower water-surface elevations upstream of the Old Scottsdale Landfill. As a result, average channel velocities between the Hayden Road bridge and the Outer Loop crossing are generally higher for Alternative 4 than for the other alternatives. Concept conditions for Alternative 4 provide stability to the north bank, while minimizing the resultant increase in water-surface elevations over baseline conditions. Figure 4 shows plots of the water-surface profiles for the proposed alternatives for the northern alignment of Section 6 of the East Papago Freeway.

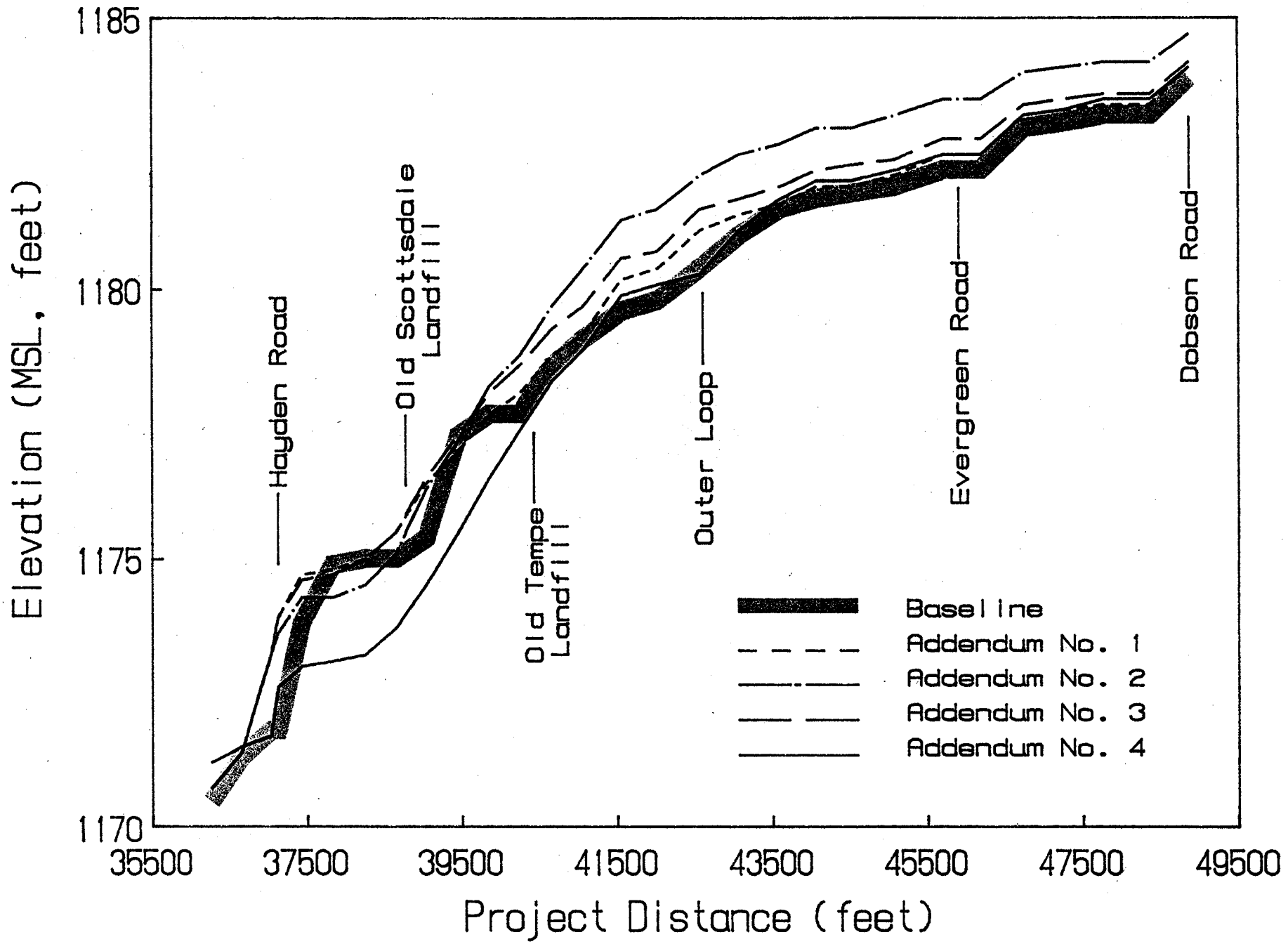

Figure 4. Water-Surface Profiles for the Northern Alignment
East Papago Freeway - Section 6

VI. SUMMARY

This addendum has presented the preliminary results of a hydraulic and local-scour analysis for Alternative 4 of the East Papago Freeway crossing of the Salt River. This alternative consists of a northern alignment of Section 6 of the East Papago Freeway, which is planned to be entirely on structure from Hayden Road to the Red Mountain Interchange. The channel configuration for Alternative 4 includes a leveed south bank, and a north bank with bank protection provided to the top of the existing north main channel bank (approximately elevation 1170 feet), extending from Hayden Road through the Outer Loop Highway crossing of the Salt River.

Concept conditions for Alternative 4 were analyzed both with and without debris buildup on bridge piers. Estimates of local scour at bridge piers have been preformed, based on current bridge configurations, and total-scour depths for bridge piers provided. In addition, a comparison of alternatives has been provided as part of this addendum.

In summary, the results presented in this addendum show that the proposed northern alignment, under the concept conditions of Alternative 4, will not significantly increase water-surface elevations above baseline conditions. Upstream impacts associated with Alternative 4 are less, in general, than impacts associated with the three other alternatives considered for the northern alignment of Section 6 of the East Papago. Between the Hayden Road bridge and the Outer Loop Highway crossing, the maximum increase in water-surface elevation is 0.2 feet. Flooding on the north overbank will not be increased, since water-surface elevations for Alternative 4 concept conditions are at or below baseline conditions. Although velocities are slightly higher than for other alternatives investigated, stability of both the north bank and the south bank is provided. Upstream of the Outer Loop Highway crossing, the increase in water-surface elevations remains below 0.2 feet, and gradually diminishes to baseline conditions around Dobson Road.

VII. REFERENCES

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