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Final
BRIDGE SCOUR ASSESSMENT REPORTS
TECHNICAL APPENDIX
for 16 Maricopa County Bridges

VOLUME III
Final Bridge Scour Hydraulic Calculations

July, 1996

MARICOPA COUNTY DEPARTMENT OF TRANSPORTATION (MCDOT)
Work Order No. 80407

Cannon & Associates, Inc.
Consulting Engineers

Final
BRIDGE SCOUR ASSESSMENT REPORTS
TECHNICAL APPENDIX
for 16 Maricopa County Bridges
CA 94046-1

VOLUME III
Final Bridge Scour
Hydraulic Calculations

July, 1996

Prepared for
MARICOPA COUNTY
DEPARTMENT OF
TRANSPORTATION (MCDOT)
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Consulting Engineers

MCDOT W.O. No. 80407
Maricopa County Department of Transportation
BRIDGE SCOUR ASSESSMENT

VOLUME I: FINAL BRIDGE SCOUR ASSESSMENT REPORTS
for Structure Numbers 9691, 8981, 9301, 9859, 9145, 7819, 8028, 8639

VOLUME II: FINAL BRIDGE SCOUR ASSESSMENT REPORTS
for Structure Numbers 9427, 9588, 9999, 8038, 7818, 9154, 9142, 7553

VOLUME III: TECHNICAL APPENDIX
Final Bridge Scour Hydraulic Calculations

VOLUME IV: TECHNICAL APPENDIX
Final Bridge Scour Structural Calculations

VOLUME V: TECHNICAL APPENDIX
Final Geotechnical Analysis

Cannon & Associates, Inc.
Consulting Engineers

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CERTIFICATE
13483
BRUCE J.
FRIEDHOFF
Date Signed 3-5-96
ARIZONA, U.S.A.

SUMMARY OF RESULTS

RESULTS OF BRIDGE SCOUR EVALUATIONS

Location Data				Approach Flow Data						Scour Depths (feet)							
No.	Street	Stream	SN	Control	Flow (cfs)	Depth (feet)	Velocity (fps)	Froude	Energy Slope	Contraction	Local Pier	Local Abutment	General	Total Pier	Total Abutment	Ratio 1	Ratio 2
1	Bell Road	Agua Fria	9691	Low Chord	145,631	13.49	12.39	0.59	0.00254	0.3	18.2	14.1	4.0	22.5	18.1	1.7	1.3
2	Olive Avenue	Agua Fria	8981	Q500	179,900	16.26	11.39	0.50	0.00211	0.0	27.1	None	4.0	31.1	4.0	1.9	0.2
3	Glendale Avenue	Agua Fria	9301	Low Chord	60,758	16.64	7.81	0.34	0.00205	0.0	20.5	0.1	4.0	24.5	4.1	1.5	0.2
4	Camelback Road	Agua Fria	9859	Q500	184,000	15.05	11.61	0.53	0.00234	0.2	29.2	11.4	10.0	39.4	21.4	2.6	1.4
5	Indian School Road	Agua Fria	9145	Q500	184,000	15.43	11.63	0.52	0.00155	0.0	24.1	None	0.0	24.1	0.0	1.6	0.0
6	Maricopa County Highway 85	Agua Fria	7819	Q500	184,000	13.03	13.92	0.68	0.00253	0.0	17.0	None	4.0	21.0	4.0	1.6	0.3
7	New River Road	New River	8028	Low Chord	32,664	11.10	15.31	0.81	0.00882	0.0	12.5	None	4.0	16.5	4.0	1.5	0.4
8	Interstate 17 Frontage Road	New River	8639	Q100	33,400	14.61	13.90	0.64	0.00440	0.9	31.7	5.0	4.0	36.6	9.0	2.5	0.6
9	Peoria Avenue	New River	9427	Q500	75,000	14.96	17.20	0.78	0.00460	0.0	15.5	None	1.8	17.3	1.8	1.2	0.1
10	Olive Avenue	New River	9588	Low Chord	64,327	17.19	13.48	0.57	0.00244	0.0	6.5	0.0	4.0	10.5	4.0	0.6	0.2
11	Old U.S. Highway 80	Hassayampa	9999	Low Chord	89,086	23.90	14.48	0.52	0.00290	0.0	34.6	None	4.0	38.6	4.0	1.6	0.2
12	Rittenhouse Road	Queen Creek	8038	Q500	5,147	5.58	7.82	0.58	0.00467	0.0	12.2	None	4.0	16.2	4.0	2.9	0.7
13	Hawes Road	Queen Creek	7818	Q500	5,147	6.46	8.33	0.58	0.00397	0.0	17.2	None	4.0	21.2	4.0	3.3	0.6
14	Power Road	Queen Creek	9154	Q500	5,147	9.08	8.78	0.51	0.00394	0.0	11.4	None	4.0	15.4	4.0	1.7	0.4
15	Higley Road	Queen Creek	9142	Low Chord	3,909	12.06	3.09	0.16	0.00028	0.0	15.5	12.0	4.0	19.5	16.0	1.6	1.3
16	Deer Valley Road	Unnamed	7553	Q500	8,596	9.72	7.74	0.44	0.00480	0.0	15.1	None	4.0	19.1	4.0	2.0	0.4

General Notes:

1. The controlling flow condition is either the low chord or the Q500 which ever is lower but not less than the Q100.
2. Flow depth and velocity represent the maximum approach flow conditions for a laterally migrating stream immediately upstream from the bridge pier and abutments.
3. Energy slopes were determined from the results of prior water surface profile studies over a wide range of flow conditions for rigid boundaries.
4. Scour depths were computed using the procedures described in Hec-18, 20, and HIRE.
5. General scour (long term degradation) was assumed to be 4 feet unless constrained by downstream grade control structures or influenced by up or downstream depressions.
6. Ratio 1 represents the ratio of the Total Scour Depth @ Pier / Depth of Flow. Ratio 2 represents the Total Scour Depth @ Abutment / Flow Depth.
7. The Q100 flow depth exceeds the low chord depth for Bridge No. 8 and therefore the pressure flow adjustment has been used in computing scour depths.
8. The 10 foot general scour for Bridge No. 4 is caused by downstream depressions. General scour is limited by grade control structures for Bridge Nos. 5 and 9.
9. Abutment scour for Bridge 15 (Higley Road) also includes bend scour.
10. If the D85 particle size did not exceed the required D50 rock rip rap size then armoring potential was assumed negligible.
11. There is no record of the structural details for the concrete sill for Bridge No. 10. Therefore, the sill was assumed to have been adequately designed for its purpose of protecting against scour.

FLOW ANGLES OF ATTACK ON PIERS AND ABUTMENTS

No.	Road	Stream	SN	Pier Skew		Approach		Pier Nose		Deflection	Attack		Abutment	
				Degrees	Direction	Degrees	Direction	Degrees	Direction	Degrees	Method 1	Method 2	Degrees	Direction
1	Bell Road	Agua Fria	9691	0		0		0		0	0	0	90	R
2	Olive Avenue	Agua Fria	8981	0		5	L	5	L	0	0	5	85	R
3	Glendale Avenue	Agua Fria	9301	0		10	R	30	L	40	20	10	100	R
4	Camelback Road	Agua Fria	9859	0		15	R	15	R	0	0	15	75	L
5	Indian School Road	Agua Fria	9145	11	R	20	R	15	R	5	3	9	110	R
6	Maricopa County Highway 85	Agua Fria	7819	0		0		20	R	20	10	0	90	R
7	New River Road	New River	8028	0		0		5	R	5	3	0	90	R
8	Interstate 17 Frontage Road	New River	8639	30	L	40	L	70	L	30	15	10	50	R
9	Peoria Avenue	New River	9427	25	R	25	R	25	R	0	0	0	115	R
10	Olive Avenue	New River	9588	20	R	40	R	20	R	20	10	20	130	R
11	Old U.S. Highway 80	Hassayampa	9999	15	L	25	L	20	L	5	3	10	65	R
12	Rittenhouse Road	Queen Creek	8038	15	R	20	R	30	R	10	5	5	110	R
13	Hawes Road	Queen Creek	7818	23	R	20	R	30	R	10	5	3	110	R
14	Power Road	Queen Creek	9154	0		0		5	L	5	3	0	90	R
15	Higley Road	Queen Creek	9142	40	L	20	L	90	L	70	35	20	70	R
16	Deer Valley Road	Unnamed	7553	20	L	25	L	25	L	0	0	5	65	R

General Notes:

1. "L" refers to a counter clock wise angle and "R" refers to a clock wise angle.
2. Method 1 calculates the attack angle as one half of the deflection angle (attack = deflection/2) and was not used in this analysis.
3. Method 2 calculates the attack angle as the difference between the approach angle and the skew angle and was used for this analysis.
4. All angles were measured from aerial photographs for high flow conditions by projecting a line from the center of the bridge to the center of the up or down stream approach banks.
5. Low flow conditions would result in greater angles.

RESEARCH ANALYSIS

MCDOT W.O. NO. 80407 - Bridge Scour Evaluation
Secondary Records Search Summary - UNNAMED WASH NEAR 189TH AVE.

SN	ROAD	WATERWAY	DESIGN Q Q100 (1)	Q50 (1)	Q500 (3)	FLOW MODELING RESULTS (2) Q100 (2)(3)	SECNO	CWSEL	TOPWID	DEPTH	ELMIN	VCH	XNL	WXNL	XNR	WXNR	XNCH	WXNCH	QLOB	QCH	QROB	SLOPE	WSLOPE	XLOBL	XLOBR	XLCH	NOTES
						2300	1.634						0.080	0.080	0.060	0.060	0.050	0.050	619.6	1078.4	602.0	0.002921	0.002921	620	610	615	DS SECT
						2300	1.731						0.080	0.080	0.060	0.060	0.050	0.050	871.2	1008.2	420.7	0.002804	0.002804	450	480	515	DS SECT
7553	Deer Valley Rd. 189th Ave. Wa:		3,925	N/A	N/A	2300	1.851	1388.82	905.84	3.82	1385.00	3.96	0.070	0.070	0.060	0.060	0.050	0.050	421.8	1747.1	131.2	0.005770	0.00577	570	675	595	DS SECT
						2300	1.984	1392.03	158.43	2.23	1389.80	6.53	0.250		0.250		0.250		0.0	2300.0	0.0	0.004307		600	800	700	DS FACE
						2300	1.993	1392.22	158.41	2.22	1390.00	6.56	0.250		0.250		0.250		0.0	2300.0	0.0	0.004360		48	48	48	US FACE, SB
						2300	2.125	1394.98	690.87	4.48	1390.50	3.63	0.080	0.080	0.050	0.050	0.050	0.050	326.5	1756.7	293.8	0.002581	0.002581	600	700	670	US SECT
						2300	2.242	1397.22	624.70	3.22	1394.00	3.82	0.080	0.080	0.050	0.050	0.050	0.050	27.9	464.3	1884.8	0.005781	0.005781	580	590	620	US SECT
						2300	2.367						0.080	0.080	0.050	0.050	0.050	0.050	42.2	792.7	1542.1	0.008967	0.008967	640	600	650	US SECT
												Mean n-value (w/o bridge sect.) =		0.078		0.055		0.050			Mean Se (w/o bridge sect) =		0.004804				

(1) Source: MCDOT Central Files, ADOT Engineering Records and MCDOT Review
(2) Source: HEC-2 MODELING PROVIDED BY FCDMC
Wittman Area Drainage Master Study; 100-Year Storm Event, Second Overchute West of Grand Avenue; CAP Floodplain-#2 WEST
Accompanyng worksheets by WLB Group, Inc., 12/11/86
Model run using HEC-2 Ver. 4.6.2
(3) Not reported in FIS

ADDITIONAL NOTES:
1) Published FEMA Maps do not reflect base flood elevations for this bridge.
2) Source of discharge value not given.

USGS Data
None Available.

Regression Analysis (no FEMA FIS data is published for this structure)

SN	ROAD	WATERWAY	Region	qtn.	Table	Elev (bridge)	Area (mi2)	Q FOR RECURRENCE INTERVAL (CFS) 2	5	10	25	50	100	DISCHARGE RATIOS Q5/Q2	Q10/Q5	Q25/Q10	Q50/Q25	Q100/Q50
7553	Deer Valley Rd. 189th Ave. Wa:		12		16	1400	1	41.1	211.0	419.0	828.1	1335.7	2059.0	5.13	1.99	1.98	1.61	1.54

MCDOT W.O. NO. 80407 - Bridge Scour Evaluation
Secondary Records Search Summary - HASSAYAMPA RIVER

SN	ROAD	WATERWAY	DESIGN Q Q100 (1)	Q50 (1)	Q500 (4)	Q100 (2)(3)	SECNO	CWSEL	TOPWID	DEPTH	ELMIN	VCH	XNL	XNR	XNCH	QLOB	QCH	QROB	SLOPE	WSLOPE	XLOBL	XLOBR	XLCH	NOTES
9999	Old US 8	Hassayampa R.	N/A	36,800	N/A		2.38						0.040	0.040	0.035	32170.6	25709.1	15036.4	0.002038	0.002038	485	410	500	DS SECT
							2.48						0.040	0.040	0.035	43491.2	27614.1	1860.8	0.003223	0.003223	495	520	505	DS SECT
						72966	2.57	840.61	5798.04	16.71	823.90	6.92	0.040	0.040	0.035	49402.3	19896.4	3667.2	0.001966	0.001966	495	510	500	DS SECT
						73500	2.67	842.60	3635.78	17.10	825.50	12.60	0.040	0.040	0.035	44371.9	29128.1	0.0	0.004022	0.000000	300	720	510	DS FACE
						73500	2.68	842.69	3651.38	17.19	825.50	12.15	0.040	0.040	0.035	45109.9	28390.1	0.0	0.003690	0.000000	40	40	40	US FACE, SB
						73500	2.72	844.48	4390.96	18.48	826.00	12.16	0.040	0.040	0.035	40382.8	29627.8	3439.4	0.003951	0.003951	540	65	230	US SECT
							2.78						0.040	0.040	0.035	33093.0	36462.8	3944.2	0.003306	0.003306	425	170	305	US SECT
													Mean n-value (w/o bridge sect.) =					**Mean Se (w/o bridge sect) =**		0.002897				

FLOW MODELING RESULTS (2)

(1) Source: MCDOT Central Files ADOT Engineering Records and MCDOT Review
(2) Source: HEC-2 MODELING PROVIDED BY FCDMC
FEMA Flood Insurance Re-Study of Maricopa County Arizona; Hassayampa River Job #04856-07-75; Calla Bar Associates
Accompanying worksheets by Calla Bar Assoc., 3/18/88
Model run using HEC-2 Ver. 4.6.2
(3) FEMA FIS for Maricopa County, Arizona, Revised: September 4, 1991 (Not tabulated in FEMA FIS for Maricopa County, Arizona, Revised: December 3, 1993 Vol. 1 of 9; however, detailed flow data matching HEC-2 analysis is included Vol. 2 of 9)
(4) Not reported in FIS

ADDITIONAL NOTES:
1) Published FEMA FIS reports only average floodway flow velocity
2) Source of discharge value not given
3) Encroachments not used

USGS Data

Gage Location: # 09517000 Hassayampa River Near Arlington, AZ
Max Q = 39,000 cfs, Sept. 9, 1970
Record: Water years 1961-77 (annual max only), Oct 1977 - Sept 1990 (Q above 500 cfs only), Oct 1990 - Current

Regression Analysis (no FEMA FIS data is published for this structure)

SN	ROAD	WATERWAY	Region	Eqtn.	Table	Elev (bridge)	Area (mi2)	Q FOR RECURRENCE INTERVAL (CFS) 2	5	10	25	50	100	DISCHARGE RATIOS Q5/Q2	Q10/Q5	Q25/Q10	Q50/Q25	Q100/Q50
9999	Old US 8	Hassayampa R.	13		17	840	1	123.0	295.1	457.1	724.4	955.0	1258.9	2.40	1.55	1.58	1.32	1.32

MCDOT W.O. NO. 80407 - Bridge Scour Evaluation
Secondary Records Search Summary - QUEEN CREEK

SN	ROAD	WATERWAY	DESIGN Q Q100 (1)	Q50 (1)	Q500 (3)	Q100 (2)(3)	FLOW MODELING RESULTS (2) SECNO	CWSEL	TOPWID	DEPTH	ELMIN	VCH	XNL	XNR	XNCH	QLOB	QCH	QROB	SLOPE	WSLOPE	XLOBL	XLOBR	XLCH	NOTES
9142	Higley Rd.	Queen Ck.	3,050	N/A	N/A		1.900						0.040	0.040	0.035	0.0	399.7	2610.3	0.000938	0.000938	490	490	490	DS SECT
							1.995						0.040	0.040	0.035	0.0	126.4	2883.6	0.000328	0.000328	505	505	505	DS SECT
						3010	2.090	1317.52	1447.20	4.12	1313.40	0.40	0.040	0.040	0.035	0.0	18.9	2991.1	0.000139	0.000139	600	680	640	DS SECT
						3010	2.109	1319.68	109.11	3.18	1316.50	9.49	0.025	0.025	0.025	0.0	3010.0	0.0	0.006228	0.000000	40	150	100	US FACE ASSUMED, SECT NOT ON SH
						3010	2.185	1321.23	3889.26	5.23	1316.00	0.17	0.040	0.040	0.035	39.7	56.0	2914.3	0.000004	0.000000	600	580	590	US SECT
							2.280						0.040	0.040	0.035	0.0	15.4	2994.6	0.000002	0.000002	490	505	495	US SECT
							2.375						0.040	0.040	0.035	0.0	5.7	3004.3	0.000002	0.000002	490	490	490	US SECT
											Mean n-value (w/o bridge sect.) =		**0.040**	**0.040**	**0.035**			**Mean Se (w/o bridge sect) =**		**0.000282**				
9154	Power Rd.	Queen Ck.	N/A	N/A	N/A		3.800						0.040	0.040	0.035	801.3	1013.1	1195.6	0.000134	0.000134	540	540	540	DS SECT
							3.895						0.040	0.040	0.035	29.6	975.5	2004.9	0.003319	0.003319	485	485	485	DS SECT
						3010	3.990	1341.56	79.66	5.76	135.80	10.26	0.040	0.040	0.035	0.0	3010.0	0.0	0.010462	0.010462	520	520	520	DS SECT
						3010	4.085	1341.79	111.25	3.79	1338.00	10.35	0.015	0.015	0.025	8.0	29889.8	12.1	0.007406	0.000000	650	650	650	US FACE ASSUMED
						3010	4.180	1345.43	1148.26	5.53	1339.90	5.01	0.040	0.040	0.035	2.9	1339.2	1667.9	0.002525	0.002525	500	510	505	US SECT
							4.275						0.040	0.040	0.035	351.2	1053.0	1605.8	0.002045	0.002045	500	495	500	US SECT
							4.370						0.040	0.040	0.035	2.9	1668.0	1339.2	0.005158	0.005158	500	505	505	US SECT
											Mean n-value (w/o bridge sect.) =		**0.040**	**0.040**	**0.035**			**Mean Se (w/o bridge sect) =**		**0.003941**				
7818	Hawes Rd.	Queen Ck.	3,010	N/A	N/A		6.175						0.035	0.035	0.035	0.0	3010.0	0.0	0.002024	0.002024	495	495	495	DS SECT
							6.270						0.035	0.035	0.035	0.0	3010.0	0.0	0.003190	0.003190	520	500	510	DS SECT
						3010	6.365	1377.09	88.73	5.69	1371.40	7.74	0.035	0.035	0.035	0.0	3010.0	0.0	0.004752	0.004752	540	480	500	DS SECT
						3010	6.454	1378.25	222.19	5.75	1372.50	6.87	0.015	0.015	0.015	849.2	1546.2	614.6	0.000563	0.000000	530	390	470	NO BRIDGE CARDS, APPROX. CL
						3010	6.460	1378.14	106.24	4.84	1373.30	7.24	0.035	0.035	0.034	0.0	3010.0	0.0	0.004787	0.004787	125	60	100	US SECT
						3010	6.555	1380.24	91.43	5.44	1374.80	7.82	0.035	0.035	0.035	0.0	3010.0	0.0	0.005087	0.005087	455	445	445	US SECT
											Mean n-value (w/o bridge sect.) =		**0.035**	**0.035**	**0.035**			**Mean Se (w/o bridge sect) =**		**0.003968**				
8038	Rittenhouse Rd.	Queen Ck.	N/A	N/A	N/A		9.785						0.035	0.035	0.035	0.0	3010.0	0.0	0.003331	0.003331	520	495	505	DS SECT
							9.980						0.035	0.035	0.035	0.0	3010.0	0.0	0.005213	0.005213	515	490	505	DS SECT
						3010	9.975	1438.37	265.00	2.97	1435.40	4.23	0.035	0.035	0.035	0.0	3010.0	0.0	0.002675	0.002675	495	455	480	DS SECT
						3010	10.030	1439.28	146.27	3.28	1436.00	6.88	0.025	0.025	0.025	0.0	3010.0	0.0	0.003138	0.000000	360	250	310	SB R/W
						3010	10.055	1439.76	141.38	3.56	1436.20	6.46	0.025	0.025	0.025	0.0	3010.0	0.0	0.002438	0.000000	140	140	140	SB SPRR
						3010	10.070	1440.04	156.63	3.44	1436.60	6.92	0.035	0.035	0.035	0.0	3010.0	0.0	0.006884	0.006884	50	70	90	US SPRR
						3010	10.165	1442.42	244.82	6.22	1436.20	4.10	0.035	0.035	0.035	0.0	3010.0	0.0	0.002170	0.002170	410	565	520	US SPRR
							10.260						0.035	0.035	0.035	0.0	3010.0	0.0	0.003687	0.003687	515	400	500	US SECT
							10.355						0.035	0.035	0.035	0.0	3010.0	0.0	0.008760	0.008760	500	525	505	US SECT
											Mean n-value (w/o bridge sect.) =		**0.035**	**0.035**	**0.035**			**Mean Se (w/o bridge sect) =**		**0.004674**				

NOTES:
(1) Source: MCDOT Central Files, ADOT Engineering Records and MCDOT Review
(2) Source: HEC-2 MODELING PROVIDED BY FCDMC
Queen Creek Area Drainage Master Study; Queen Creek Existing Conditions - May 1991; 100-Year, 24-Hour Floodplain Model
Accompanyng worksheets by Wood & Assoc., Inc., Oct./Nov. 1986
Model run using HEC-2 Ver. 4.6.2
(3) Not reported in FIS

ADDITIONAL NOTES:
1) Published FEMA Maps do not reflect base flood elevations for these bridges.
2) Source of discharge value not given.
3) Encroachment Method 1 used throughout.

USGS Data
Gage Location: Queen Creek at Whitlow Damsite, 4 miles NE of Florence Jtn., # 094785
Max Q = 42,900 cfs, Aug. 19, 1954
Record. 1948-1959

Regression Analysis (no FEMA FIS data is published for this structure)

SN	ROAD	WATERWAY	Region	Eqtn.	Table	Elev (bridge)	Area (mi2)	Q FOR RECURRENCE INTERVAL (CFS) 2	5	10	25	50	100	DISCHARGE RATIOS Q5/Q2	Q10/Q5	Q25/Q10	Q50/Q25	Q100/Q50
9142	Higley Rd.	Queen Ck.	13	17		1335	1	123.0	295.1	457.1	724.4	955.0	1258.9	2.40	1.55	1.58	1.32	1.32
9154	Power Rd.	Queen Ck.	13	17		1360	1	123.0	295.1	457.1	724.4	955.0	1258.9	2.40	1.55	1.58	1.32	1.32
7818	Hawes Rd.	Queen Ck.	13	17		1390	1	123.0	295.1	457.1	724.4	955.0	1258.9	2.40	1.55	1.58	1.32	1.32
8038	Rittenhouse Rd.	Queen Ck.	13	17		1455	1	123.0	295.1	457.1	724.4	955.0	1258.9	2.40	1.55	1.58	1.32	1.32

MCDOT W.O. NO. 80407 - Bridge Scour Evaluation
Secondary Records Search Summary - NEW RIVER

SN	ROAD	WATERWAY	DESIGN Q Q100 (1)	Q50 (1)	Q500 (3)	Q100 (2)(3)	FLOW MODELING RESULTS (2) SECNO	CWSEL	TOPWID	DEPTH	ELMIN	VCH	XNL	XNR	XNCH	QLOB	QCH	QROB	SLOPE	WSLOPE	XLOBL	XLOBR	XLCH	NOTES
8028	New River Rd.	New River	N/A	N/A	N/A		32.887						0.075	0.075	0.035	0.0	20984.5	11015.5	0.007410	0.007410	540	470	510	DS SECT
							32.983						0.075	0.075	0.035	5294.0	20680.6	6025.4	0.010586	0.010586	510	510	510	DS SECT
						32000	33.082	2017.97	731.29	8.67	2009.30	13.41	0.075	0.075	0.035	3141.3	20295.8	8562.9	0.011308	0.011308	520	520	520	DS SECT
						32000	33.173	2023.80	291.56	9.40	2014.40	15.31	0.075	0.075	0.035	0.0	32000.0	0.0	0.009456	0.000000	480	480	480	DS FACE
						32000	33.184	2025.13	295.73	10.93	2014.20	13.64	0.075	0.075	0.035	0.2	31999.8	0.0	0.006561	0.000000	34	34	34	US FACE
						32000	33.277	2029.03	430.72	8.63	2020.40	14.60	0.050	0.050	0.035	0.0	27720.2	4279.8	0.008905	0.008905	470	510	490	US SECT
							33.375						0.050	0.050	0.035	2460.0	19681.2	9858.8	0.005068	0.005068	550	500	520	US SECT
							33.466						0.050	0.050	0.035	4855.9	17035.9	10108.2	0.009624	0.009624	500	440	480	US SECT
											Mean n-value (w/o bridge sect.) =		**0.0625**	**0.0625**	**0.035**		**Mean Se (w/o bridge sect) =**			**0.008817**				
8639	I-17 Frontage Rc	New River	N/A	N/A	N/A		32.358						0.050	0.050	0.035	2552.9	20142.7	10704.4	0.003587	0.003587	490	490	480	DS SECT
							32.455						0.065	0.065	0.035	2290.0	31109.4	0.7	0.007639	0.007639	510	520	510	DS SECT
						33400	32.553	1996.54	367.68	15.74	1980.80	17.87	0.065	0.065	0.035	4254.9	27541.6	1603.5	0.005626	0.005626	520	520	520	DS SECT
						33400	32.585	2002.38	1017.67	16.78	1985.60	6.18	0.065	0.065	0.035	1788.8	13316.3	18294.9	0.005805	0.000000	240	240	200	DS FACE
						33400	32.601	2002.42	1018.54	16.88	1985.60	7.31	0.065	0.065	0.035	1905.9	20626.3	10967.8	0.001658	0.000000	30	30	30	US FACE
						33400	32.686	2003.09	1185.75	16.59	1986.50	10.79	0.065	0.065	0.035	22.1	14405.8	18972.1	0.002338	0.002338	400	400	450	US SECT
							32.743						0.075	0.075	0.035	4701.2	14807.2	13891.7	0.002922	0.002922	370	180	300	US SECT
							32.790						0.075	0.075	0.035	7745.6	18019.5	7634.9	0.004283	0.004283	300	180	250	US SECT
											Mean n-value (w/o bridge sect.) =		**0.066**	**0.066**	**0.035**		**Mean Se (w/o bridge sect) =**			**0.004399**				
9427	Peoria Ave.	New River	N/A	38,000	75000		277.900						0.045	0.045	0.035	0.0	41000.0	0.0	0.001884	0.001884	420	420	420	DS SECT
							281.800						0.045	0.045	0.035	0.0	41000.0	0.0	0.002408	0.002408	410	410	410	DS SECT
						41000	288.000	1102.21	294.01	10.01	1092.20	14.43	0.045	0.045	0.035	0.0	41000.0	0.0	0.005809	0.005809	600	600	600	DS SECT
						41000	290.000	1103.29	271.00	10.29	1093.00	14.91	0.045	0.045	0.035	0.0	41000.0	0.0	0.006174	0.000000	220	160	200	DS FACE ASSUMED
						41000	291.000	1104.68	271.00	11.68	1093.00	13.35	0.045	0.045	0.035	0.0	41000.0	0.0	0.004315	0.000000	77	77	77	US FACE ASSUMED
						41000	293.000	1105.08	253.16	11.08	1094.00	15.29	0.035	0.035	0.035	0.0	41000.0	0.0	0.005843	0.005843	200	200	200	US SECT
							297.000						0.035	0.035	0.035	0.0	41000.0	0.0	0.004131	0.004131	400	400	400	US SECT
							302.000						0.035	0.035	0.035	0.0	41000.0	0.0	0.007541	0.007541	530	530	530	US SECT
											Mean n-value (w/o bridge sect.) =		**0.040**	**0.040**	**0.035**		**Mean Se (w/o bridge sect) =**			**0.004603**				
9588	Olive Ave.	New River	55,000	N/A	75000	41000	209.300	1082.53	338.66	12.34	1070.19	10.19	0.035	0.035	0.035	0.0	41000.0	0.0	0.002210	0.002210	530	530	530	DS SECT
						41000	212.600	1082.93	271.86	11.93	1071.00	13.22	0.035	0.035	0.035	0.0	41000.0	0.0	0.003958	0.000000	330	330	330	DS FACE
						41000	213.500	1084.04	273.08	12.54	1071.50	12.55	0.035	0.035	0.035	0.0	41000.0	0.0	0.003353	0.000000	90	90	90	US FACE
						41000	213.700	1083.67	282.61	10.67	1073.00	14.10	0.045	0.045	0.035	0.0	41000.0	0.0	0.005143	0.005143	20	20	20	US SECT
						41000	217.500	1086.67	365.34	12.47	1074.20	9.32	0.045	0.045	0.035	0.0	41000.0	0.0	0.001809	0.001809	380	380	380	US SECT
							221.100						0.045	0.045	0.035	0.0	41000.0	0.0	0.001849	0.001849	360	360	360	US SECT
							227.500						0.045	0.045	0.035	0.0	41000.0	0.0	0.001184	0.001184	640	640	640	US SECT
											Mean n-value (w/o bridge sect.) =		**0.043**	**0.043**	**0.035**		**Mean Se (w/o bridge sect) =**			**0.002439**				

(1) Source: MCDOT Central Files, ADOT Engineering Records and MCDOT Review
(2) Source: HEC-2 MODELING PROVIDED BY FCDMC
FOR NEW RIVER RD. & I-177 FRONTAGE RD. BRIDGES:
FCDMC New River Floodplain Analysis; 100-Year Flows; New River Dam to Rock Springs
Accompanyng worksheets by Coe & Van Loo, 6/14/85
Model run using HEC-2 Ver. 4.6.2

FOR PEORIA AVE. & OLIVE AVE. BRIDGES:
New River Flood Control Channelization Project; New River: Bethany Home Alignment to Grand Avenue; 10-Year Event NRO2B
Accompanyng worksheets by Coe & Van Loo, 3/92
Model run using HEC-2 Ver. 4.6.2
(3) FEMA FIS for Maricopa County, Arizona; Revised: December 3, 1993 Vol. 1 of 9

ADDITIONAL NOTES:
1) Source of discharge value not given.
2) Published FEMA FIS for 1993 did not contain complete detailed New River section data (odd pages deleted); FCDMC advises referring to 1991 report for complete coverage if floodway/floodplain data is required.

USGS Data

Gage Location: 09513780 New River at Rock Springs, AZ (6 miles SE of Rock Springs)
Max Q = 18,600 cfs, Sept. 5, 1970
Record: Water Years 1962-65 (annual max only), Oct 1965 to Current

Gage Location: 09513910 New River Near Glendale, AZ (on DS side of bridge at Glendale Ave.)
Max Q = 19,800 cfs, Dec. 19, 1967
Record: Water Years 1961-63, 1971-79 (annual max only), Feb. 1964 to Oct. 19770, April 1990 to Current

Regression Analysis (no FEMA FIS data is published for this structure)

SN	ROAD	WATERWAY	Region	Qtn.	Table Elev (bridge)	Area (mi2)	Q FOR RECURRENCE INTERVAL (CFS) 2	5	10	25	50	100	DISCHARGE RATIOS Q5/Q2	Q10/Q5	Q25/Q10	Q50/Q25	Q100/Q50
8028	New River Rd.	New River	12	16	2030	1	41.1	184.7	361.4	718.3	1134.2	1739.4	4.49	1.96	1.99	1.58	1.53
8639	I-17 Frontage Rc	New River	12	16	2000	1	41.1	185.7	363.5	722.4	1141.7	1751.2	4.52	1.96	1.99	1.58	1.53

MCDOT W.O. NO. 80407 - Bridge Scour Evaluation
Secondary Records Search Summary - AGUA FRIA RIVER

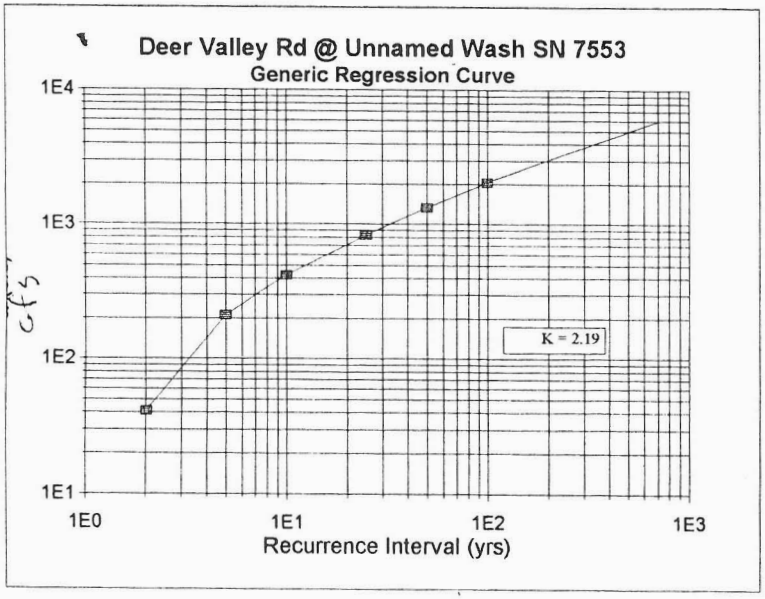
SN	ROAD	WATERWAY	DESIGN Q Q100 (1)	Q50 (1)	Q500 (3)	Q100 (2)(3)	SECNO	CWSEL	TOPWID	DEPTH	ELMIN	VCH	XNL	XNR	XNCH	QLOB	QCH	QROB	SLOPE	WSLOPE	XLOBL	XLOBR	XLCH	NOTES
9691	Bell Rd.	Agua Fria River	N/A	83,000	182,000		18.710						0.040	0.040	0.030	560.1	110979.9	0.0	0.004652	0.004652	420	540	500	DS SECT
							18.800						0.040	0.040	0.030	979.6	110560.4	0.0	0.002819	0.002819	420	510	490	DS SECT
						111,540	18.900	1159.34	1044.42	12.64	1146.70	8.86	0.040	0.040	0.030	3440.0	108100.0	0.0	0.001213	0.001213	470	520	500	DS SECT
						115,000	18.910	1159.30	1083.96	11.10	1148.10	10.36	0.040	0.040	0.030	0.0	115000.0	0.0	0.001974	0.000000	125	125	125	DS R/W EMB
						115,000	18.920	1159.19	1123.85	9.89	1149.20	11.03	0.040	0.040	0.030	0.0	115000.0	0.0	0.002869	0.000000	20	20	20	DS FACE
						115,000	18.925	1159.73	1124.80	10.45	1149.20	9.86	0.040	0.040	0.030	0.0	115000.0	0.0	0.001772	0.000000	65	65	65	US FACE
						115,000	18.940	1159.50	1089.47	10.11	1149.30	11.22	0.040	0.040	0.030	0.0	115000.0	0.0	0.002597	0.002597	35	35	35	US SECT
							18.980						0.040	0.040	0.030	0.0	115000.0	0.0	0.001641	0.001641	260	260	260	US SECT
							19.080						0.040	0.040	0.030	0.0	115000.0	0.0	0.002342	0.002342	500	490	495	US SECT
											Mean n-value (w/o bridge sect.) =		0.040	0.040	0.030			Mean Se (w/o bridge sect) =		0.002544				
8981	Olive Ave.	Agua Fria River	102,000	N/A	179900		13.130						0.040	0.045	0.030	13637.6	83252.4	0.0	0.002752	0.002752	490	490	490	DS SECT
							13.220						0.040	0.045	0.030	13568.2	83232.3	89.5	0.001438	0.001438	485	485	485	DS SECT
						96,890	13.310	1080.95	1340.00	11.17	1069.80	8.65	0.040	0.045	0.030	3308.6	93583.4	0.0	0.001576	0.001576	490	490	490	DS SECT
						98,780	13.320	1081.51	1381.45	10.42	1070.90	7.91	0.040	0.045	0.030	0.0	98780.0	0.0	0.001429	0.000000	100	100	100	DS FACE
						98,780	13.330	1081.45	1273.12	10.09	10771.50	7.07	0.040	0.045	0.030	0.0	98780.0	0.0	0.001157	0.000000	15	15	15	C/L BRIDGE
						98,780	13.335	1081.82	1273.55	10.32	1071.50	6.45	0.040	0.045	0.030	0.0	98780.0	0.0	0.000768	0.000000	60	60	60	APPROX US FACE
						98,780	13.430	1082.44	1650	9.22	1073	7.83	0.040	0.045	0.030	4912.9	93288.3	578.8	0.001762	0.001762	530	530	530	US SECT
							13.530						0.040	0.045	0.030	12169.2	86610.8	0.0	0.002236	0.002236	500	500	500	US SECT
							13.620						0.040	0.045	0.030	9938.6	88841.4	0.0	0.002893	0.002893	490	490	490	US SECT
											Mean n-value (w/o bridge sect.) =		0.040	0.045	0.030			Mean Se (w/o bridge sect) =		0.002110				
9301	Glendale Ave.	Agua Fria River	N/A	55,000	177,000		11.010						0.055	0.045	0.059	38724.7	43354.2	8621.1	0.001115	0.001115	580	500	490	DS SECT
							11.110						0.055	0.045	0.059	39532.2	48982.1	2205.7	0.002631	0.002631	320	550	500	DS SECT
						90,700	11.200	1051.49	4010.00	10.84	1040.30	6.83	0.055	0.045	0.059	58712.5	31687.6	299.9	0.004800	0.004800	320	560	516	DS SECT
						90,700	11.300	1052.41	3937.55	11.28	1041.00	6.34	0.055	0.045	0.059	56203.2	34496.8	0.0	0.003106	0.000000	100	600	520	DS FACE
						90,700	11.340	1055.55	3884.69	14.19	1041.30	5.32	0.045	0.055	0.035	50906.4	39793.6	0.0	0.000551	0.000000	145	145	145	APPROX US FACE
							11.430						0.045	0.055	0.035	61534.0	29166.0	0.0	0.000470	0.000470	480	480	480	US SECT
							11.520						0.045	0.055	0.035	75593.6	15106.4	0.0	0.001218	0.001218	500	500	500	US SECT
											Mean n-value (w/o bridge sect.) =		0.051	0.049	0.049			Mean Se (w/o bridge sect) =		0.002047				
9859	Camelback Rd.	Agua Fria River	95,000	N/A	184,000		8.830						0.032	0.032	0.028	7362.9	87637.1	0.0	0.003230	0.003230	650	350	520	DS SECT
							8.930						0.032	0.032	0.028	406.4	94593.6	0.0	0.002385	0.002385	550	390	480	DS SECT
						95,000	9.020	1023.48	1837.00	7.83	1015.50	8.02	0.032	0.032	0.028	2573.1	92426.9	0.0	0.001984	0.001984	540	490	520	DS SECT
						95,000	9.130	1024.42	1704.00	8.03	1016.20	7.42	0.022	0.022	0.022	0.0	95000.0	0.0	0.000914	0.000000	600	545	570	APPROX C/L BRIDGE
						95,000	9.135	1024.61	1705.13	8.23	10016.20	6.87	0.022	0.022	0.022	0.0	95000.0	0.0	0.000837	0.000000	60	60	60	APPROX US FACE
						95,000	9.150	1024.23	1630.00	7.79	1016.30	9.32	0.036	0.042	0.028	0.0	95000.0	0.0	0.002832	0.002832	75	75	75	US SECT
							9.250						0.036	0.042	0.028	2202.3	86830.7	5967.0	0.002249	0.002249	470	505	500	US SECT
							9.340						0.036	0.042	0.028	1712.1	83543.2	9744.7	0.001722	0.001722	480	480	485	US SECT
							9.440						0.036	0.042	0.028	338.4	74462.7	20198.9	0.001996	0.001996	480	490	490	US SECT
											Mean n-value (w/o bridge sect.) =		0.034	0.038	0.028			Mean Se (w/o bridge sect) =		0.002343				
9145	Indian School Rc	Agua Fria River	N/A	73,800	184,000		7.770						0.040	0.040	0.025	0.0	95000.0	0.0	0.001043	0.001043	510	500	500	DS SECT
							7.870						0.040	0.040	0.025	0.0	95000.0	0.0	0.001075	0.001075	650	410	500	DS SECT
						95,000	7.960	1008.33	1320.98	9.73	998.60	7.65	0.040	0.040	0.025	0.0	95000.0	0.0	0.000839	0.000839	480	470	470	DS SECT
						95,000	7.990	1008.54	1400.20	9.44	999.10	7.38	0.040	0.040	0.025	0.0	95000.0	0.0	0.000803	0.000803	175	175	175	DS SECT
						95,000	8.000	1008.48	1470.68	9.28	999.20	8.24	0.022	0.022	0.022	0.0	95000.0	0.0	0.001020	0.000000	50	50	50	APPROX DS FACE
						95,000	8.010	1009.01	1472.75	9.81	999.20	6.68	0.022	0.022	0.022	0.0	95000.0	0.0	0.000437	0.000000	75	75	75	APPROX US FACE
						95,000	8.030	1008.94	1465.85	9.64	999.30	7.34	0.040	0.040	0.025	0.0	95000.0	0.0	0.000837	0.000837	50	50	50	US SECT
						95,000	8.100	1009.34	1522.89	9.24	1000.10	7.04	0.040	0.040	0.025	0.0	95000.0	0.0	0.000768	0.000768	70	1130	410	US SECT
							8.210						0.040	0.040	0.025	0.0	95000.0	0.0	0.001367	0.001367	470	800	600	US SECT
							8.340						0.032	0.032	0.028	0.0	95000.0	0.0	0.005644	0.005644	700	560	635	US SECT
											Mean n-value (w/o bridge sect.) =		0.039	0.039	0.025			Mean Se (w/o bridge sect) =		0.001547				
7819	MC Hwy 85	Agua Fria River	N/A	60,000	184,000		3.470						0.040	0.045	0.030	8336.0	86664.0	0.0	0.002260	0.002260	200	200	200	DS SECT
							3.550						0.040	0.045	0.030	13898.6	81101.4	0.0	7.000000	0.003032	395	395	395	DS SECT
						95,000	3.640	959.66	1199.53	10.56	948.80	14.15	0.040	0.045	0.030	41.1	94958.9	0.0	0.006397	0.006397	480	480	480	DS SECT
						95,000	3.690	961.46	1044.11	10.67	951.00	11.43	0.040	0.045	0.030	1415.4	9354.6	0.0	0.003438	0.003438	240	240	240	DS SECT
						95,000	3.729	963.42	1177.77	11.19	952.20	7.25	0.040	0.045	0.030	0.0	95000.0	0.0	0.000877	0.000000	260	270	265	APPROX DS FACE
						95,000	3.734	963.33	1190.32	10.99	952.30	8.00	0.040	0.045	0.030	0.0	95000.0	0.0	0.001519	0.000000	25	25	25	APPROX C/L BRIDGE
						95,000	3.747	963.63	1190.89	11.29	952.30	7.13	0.040	0.045	0.030	0.0	95000.0	0.0	0.000836	0.000000	70	70	70	APPROX US FACE
						95,000	3.757	963.60	1119.60	11.47	952.10	7.59	0.040	0.045	0.030	0.0	95000.0	0.0	0.000945	0.000000	50	50	50	BETWEEN MC 85/SPRR
						95,000	3.767	963.25	1064.28	10.32	952.90	9.83	0.040	0.045	0.030	0.0	95000.0	0.0	0.003048	0.000000	50	50	50	APPROX DS FACE SPRR
						95,000	3.770	963.73	1066.24	10.80	952.90	8.43	0.040	0.045	0.030	0.0	95000.0	0.0	0.001390	0.000000	20	20	20	APPROX C/L SPRR
						95,000	3.780	963.89	1117.38	10.96	952.90	7.96	0.040	0.045	0.025	0.0	95000.0	0.0	0.000769	0.000000	35	35	35	US SPRR BRIDGE
						95,000	3.800	963.98	1134.92	10.86	953.10	7.97	0.040	0.045	0.025	0.0	95000.0	0.0	0.000785	0.000785	125	125	125	US SPRR BRIDGE
							3.810						0.040	0.045	0.025	0.0	95000.0	0.0	0.001107	0.001107	85	75	80	US SECT
							3.830						0.040	0.045	0.025	0.0	95000.0	0.0	0.000722	0.000722	105	15	105	US SECT
											Mean n-value (w/o bridge sect.) =		0.040	0.045	0.028			Mean Se (w/o bridge sect) =		0.00253443				

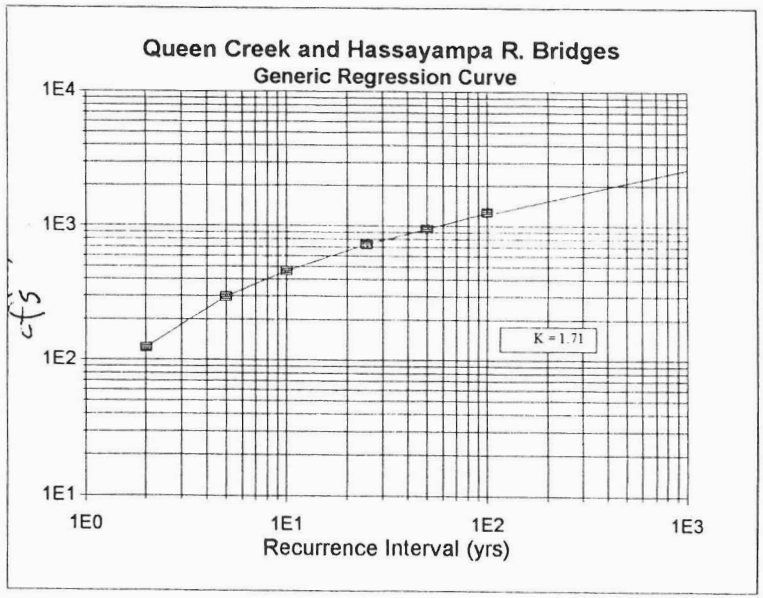
(1) Source: MCDOT Central Files, ADOT Engineering Records and MCDOT Review
(2) Source: HEC-2 MODELING PROVIDED BY FCDMC
Floodway Analysis; Agua Fria River FIS 100-Year Existing Profile; JJA Job No. 286-080.01 29Jan89
Accompanyng worksheets by Jerry R. Jones & Assoc., Inc., 2/6/89
Model run using HEC-2 Ver. 4.6.2

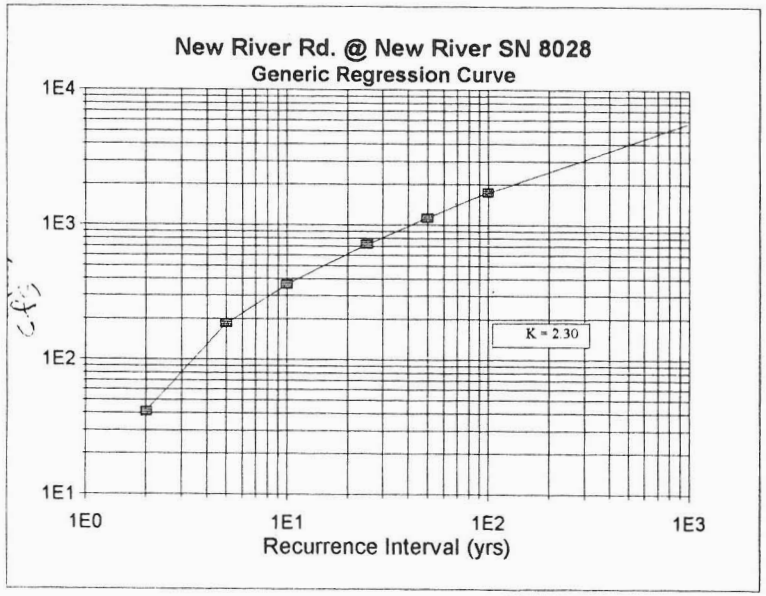
ADDITIONAL NOTES:
1) Source of discharge value not given.
2) Encroachment Methods 1 & 4 used.
3)Published FEMA FIS data list average values for velocity in floodway.

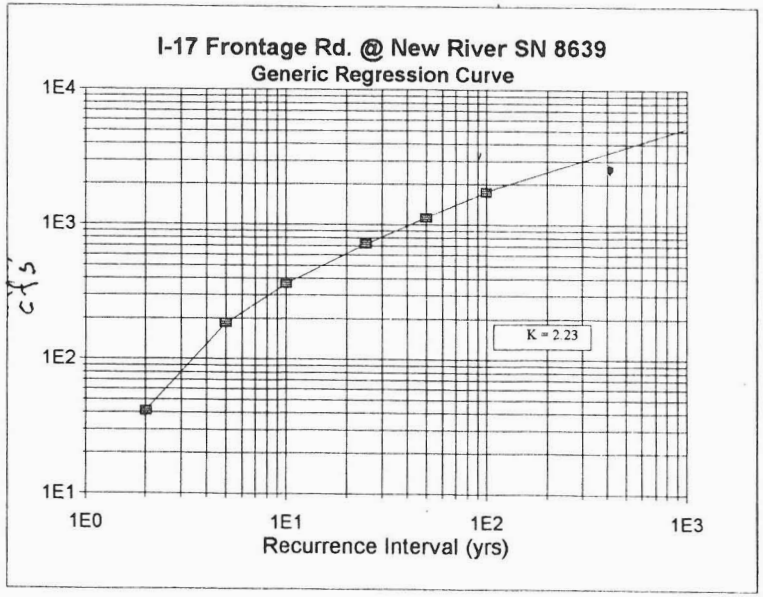
USGS Data

Gage Location: 09513650 Agua Fria River at El Mirage, AZ (Grand Avenue)
Max Q = 58,400 cfs, 12/19/78
Record: 1963-1979, 1981-1993


Deer Valley Rd @ Unnamed Wash SN 7553
Generic Regression Curve
1E4
1E3
1E2
1E1
cfs
K = 2.19
1E0
1E1
1E2
1E3
Recurrence Interval (yrs)


Queen Creek and Hassayampa R. Bridges
Generic Regression Curve
1E4
1E3
1E2
1E1
cfs
K = 1.71
1E0
1E1
1E2
1E3
Recurrence Interval (yrs)


New River Rd. @ New River SN 8028
Generic Regression Curve
1E4
1E3
1E2
1E1
cfs
K = 2.30
1E0
1E1
1E2
1E3
Recurrence Interval (yrs)


I-17 Frontage Rd. @ New River SN 8639
Generic Regression Curve
1E4
1E3
1E2
1E1
cfs
K = 2.23
1E0
1E1
1E2
1E3
Recurrence Interval (yrs)

FLOW ANALYSIS

DISCHARGE AT BRIDGE FOR VARIOUS RECURRENCE INTERVAL (cfs)

BRIDGE NO.	SN	ROADWAY	WATERWAY	Q10 (1)	Q10 (2)	Q50 (1)	Q50 (2)	Q50 (3)	Q100 (1)	Q100 (2)	Q100 (3)	Q500 (1)	Q500 (4)	SELECTED FLOWS Q100	SELECTED FLOWS Q500
1	9691	Bell Rd.	Agua Fria River	23,000	N/A	87,000	N/A	83,000	115,000	S/F	N/A	182,000	N/A	115,000	182,000
2	8981	Olive Ave.	Agua Fria River	10,970	N/A	69,700	N/A	N/A	98,780	S/F	102,000	179,900	N/A	98,780	179,900
3	9301	Glendale Ave.	Agua Fria River	18,005	N/A	66,010	N/A	55,000	90,015	90,700	N/A	177,000	N/A	90,015	177,000
4	9859	Camelback Rd.	Agua Fria River	23,000	N/A	69,000	N/A	N/A	95,000	S/F	95,000	184,000	N/A	95,000	184,000
5	9145	Indian School Rd.	Agua Fria River	23,000	N/A	69,000	N/A	73,800	95,000	S/F	N/A	184,000	N/A	95,000	184,000
6	7819	MC Hwy. 85	Agua Fria River	22,000	N/A	69,000	N/A	60,000	95,000	S/F	N/A	184,000	N/A	95,000	184,000
7	8028	New River Rd.	New River	N/A	N/A	N/A	N/A	N/A	32,000	S/F	N/A	58,537	73,600	32,000	58,537
8	8639	I-17 Frontage Rd.	New River	N/A	N/A	N/A	N/A	N/A	33,400	S/F	N/A	N/A	74,482	33,400	61,098
9	9427	Peoria Ave.	New River	13,500	S/F	31,000	N/A	38,000	41,000	S/F	N/A	75,000	N/A	41,000	75,000
10	9588	Olive Ave.	New River	13,500	S/F	31,000	N/A	N/A	41,000	S/F	55,000	75,000	N/A	41,000	75,000
11	9999	Old US 80	Hassayampa River	N/A	N/A	N/A	N/A	36,800	73,500	S/F	N/A	N/A	125,685	73,500	125,685
12	8038	Rittenhouse Rd.	Queen Creek	N/A	2,250	N/A	2,750	N/A	N/A	3,010		N/A	5,147	3,010	5,147
13	7818	Hawes Rd.	Queen Creek	N/A	2,250	N/A	2,750	N/A	N/A	3,010	3,010	N/A	5,147	3,010	5,147
14	9154	Power Rd.	Queen Creek	N/A	2,250	N/A	2,750	N/A	N/A	3,010	N/A	N/A	5,147	3,010	5,147
15	9142	Higley Rd.	Queen Creek	N/A	2,250	N/A	2,750	N/A	N/A	3,010	3,050	N/A	5,147	3,010	5,147
16	7553	Deer Valley Rd.	189th Ave. Wash	N/A	N/A	N/A	N/A	N/A	N/A	2,300	3,925	N/A	5,037	3,925	5,037

(1) Source: Published FEMA FIS REV. DEC. 3, 1993 or Sept. 4, 1991
(2) Source : FCDMC Flow Modeling Results where not published in FIS or different from value reported in FIS
(3) Source: MCDOT Central Files, ADOT Engineering Records and MCDOT Review
(4) Source: USGS Regression Equations for Ungaged Watersheds - Proportional analysis based upon FEMA (or other) Q100.

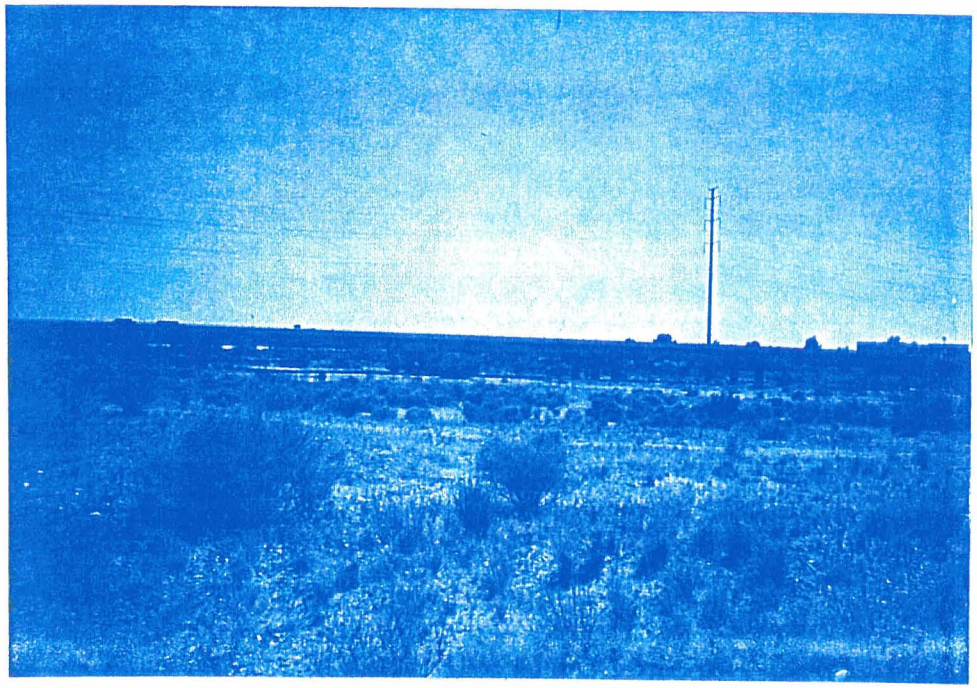
N/A NOT AVAILABLE FROM SOURCE
S/F DATA SAME AS PUBLISHED FEMA FIS INDICATED IN NOTE (1)

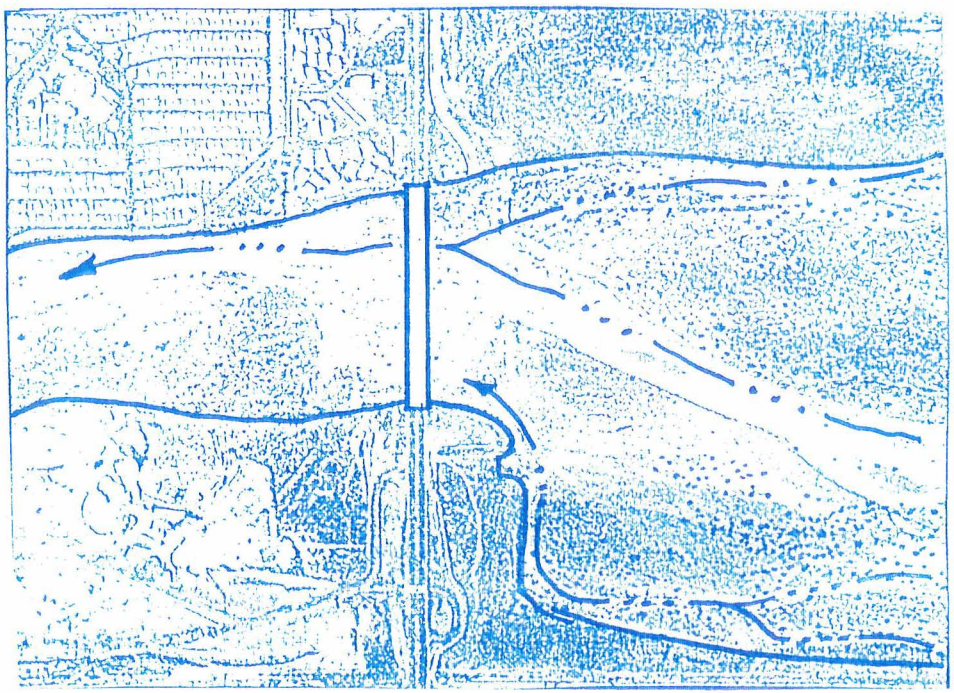
INDIVIDUAL BRIDGE HYDRAULIC & SCOUR ANALYSIS

BRIDGE 1 - BELL ROAD (SN 9691)

BELL ROAD (SN 9691)

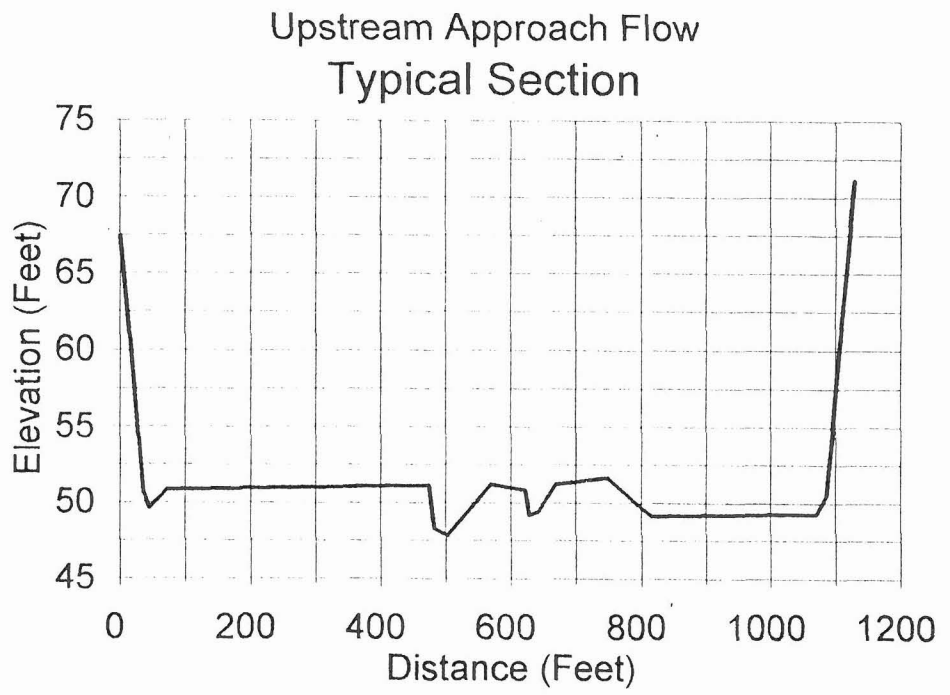
Water Course	Agua Fria River
Stream Form	Braided
Sinuosity	Not applicable
General Channelization	East side has gabion spur dike US/DS to guide flow near structure. West side channel has gabion-lined banks for short distances US/DS.
Channel Slope	Uniform
Estimated Channel Slope (ft/ft)	0.002544
Channel Contraction/Expansion	Wider US
Primary Surface Sediment Type	sand/gravel
D50 Size	3 MM
Armoring Potential	Low
Channel Vegetation	
Type/Size	Palo Verde to 10 ft., Mesquite, Ironwood; Desert Broom to 6 ft., Desert Willow, Creosote; Ephedra, Salt Bush, Brittle Bush; low grasses.
Density/Occurrence	Larger trees on established bars with low to moderate density; smaller shrubs low to moderate density in stands; smaller vegetation low density.
Relative Age	Mature
Manning's Roughness Coef.	0.030
Controls on Stream Migration	
Lateral	Limited; west side channel has gabion-lined banks for short distances US/DS.
Vertical	None
Sediment Deposits & Bars	Irregular distribution of shallow to moderate height point and middle bars.
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	No
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Land use commercial, high density residential, industrial; general assumption is for increasing urbanization.
Sand & Gravel Extraction	Significant gravel mining operation in DS LOB
Freeway Construction	No, but general roadway improvements are likely in vicinity.
Dams	New waddel controls outflows from Lake Pleasant; McMicken Dam controls tail by wash watershed to Agua Fria through outfall channel.
Drainage Channels	Sun City West drainage channel outfall just US of west abutment.





INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	67.4		
2	15	60.9	0.030	L
3	36	50.7	0.030	C
4	45	49.6	0.030	C
5	73	50.8	0.030	C
6	475	51.1	0.030	C
7	484	48.3	0.030	C
8	504	47.8	0.030	C
9	570	51.2	0.030	C
10	623	50.8	0.030	C
11	629	49.2	0.030	C
12	642	49.4	0.030	C
13	669	51.2	0.030	C
14	750	51.6	0.030	C
15	817	49.1	0.030	C
16	1072	49.3	0.030	C
17	1087	50.5	0.030	C
18	1131	71.1	0.030	R
19	1131	71.1	0.030	R
20	1131	71.1	0.030	R
21	1131	71.1	0.030	R
22	1131	71.1	0.030	R



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	61.29
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	70.21
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	61.29
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	47.80
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	61.29
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	47.80
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.002544

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	23,000	53.88	23,000	-0.00
2	Q50	87,000	58.37	87,000	-0.00
3	Q100	115,000	59.84	115,000	-0.00
4	Low Chord	145,631	61.29	145,631	0.00
5	Q500	182,000	62.85	182,000	-0.00

Abutment Scour Protection

	Is there evidence of scour protection?	Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	42.50
Ws	= Width of Scour Protection =	Feet	21.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	18.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	18.00
Material	= Material of Scour Protection =		Gabion
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		5.30

Contraction Scour Protection

	Is there evidence of scour protection?	Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

	Is there evidence of scour protection?	Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	36.50
Ws	= Width of Scour Protection =	Feet	30.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	18.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	18.00
Material	= Material of Scour Protection =		Gabion
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		11.30

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.002544
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0098	0.0098	0.0098	0.0098	0.0098
Angle	= *Angle of Attack* =	*Degrees*	0	0	0	0	0
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	5.00	5.00	5.00	5.00	5.00
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	9.00	9.00	9.00	9.00	9.00
L	= Pier Length =	ft	61.00	61.00	61.00	61.00	61.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	90	90	90	90	90

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	70.21	70.21	70.21	70.21	70.21
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	61.29	61.29	61.29	61.29	61.29
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	53.88	58.37	59.84	61.29	62.85
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	47.80	47.80	47.80	47.80	47.80
y1	= Average Depth in the Upstream Main Channel =	ft	6.08	10.57	12.04	13.49	15.05
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	1,065	1,084	1,090	1,096	1,103
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	1,058	1,067	1,070	1,072	1,072
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	22,959	86,614	114,389	144,733	180,702
Q2	= Flow in the Contracted Channel =	cfs	23,000	87,000	115,000	145,631	182,000
V1	= Mean Velocity of Flow Upstream of Pier =	fps	6.05	10.12	11.29	12.39	13.53
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.43	0.55	0.57	0.59	0.61
S1	= Energy Slope in Main Channel =		0.00254	0.00254	0.00254	0.00254	0.00254

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	3.34	3.66	3.74	3.81	3.88
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.55	0.36	0.33	0.31	0.29
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.71	0.93	0.99	1.05	1.11
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.01230	0.01230	0.01230	0.01230	0.01230
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	1.00	1.00	1.00	1.00	1.00
U/w	= Ratio of Shear Velocity to Fall Velocity =		0.71	0.93	0.99	1.05	1.11
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	6.12	10.71	12.24	13.75	15.42
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.04	0.15	0.20	0.26	0.37
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	6.10	10.28	11.50	12.66	13.92
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	1.44	5.25	6.88	8.68	10.90
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	4.33	15.74	20.65	26.05	32.71
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.04	0.15	0.20	0.26	0.37
Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	7.41	2.92	1.45	0.00	-1.56
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	6.08	10.57	12.04	13.49	15.05
L/a	= Ratio Used in Table 3 to Find K2 =		7.00	7.00	7.00	7.00	7.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.43	0.55	0.57	0.59	0.61
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.00	1.00	1.00	1.00	1.00
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.60
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	12.04	16.18	17.26	18.24	30.76
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	33.71	45.31	48.33	51.07	86.13
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	6.10	10.28	11.50	12.66	13.92
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	6.53	18.59	23.26	28.20	34.05
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	19.60	55.76	69.78	84.61	102.14
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	18.00	18.00	18.00	18.00	18.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	18.00	18.00	18.00	18.00	18.00
te	= Existing Rock Rip-Rap Thickness =	inches	18.00	18.00	18.00	18.00	18.00
We	= Existing Rock Rip-Rap Width =	Feet	30.00	30.00	30.00	30.00	30.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	12.04	16.18	17.26	18.24	30.76

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	7	17	20	23	26
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	41	386	611	897	1,287
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	3.33	5.85	6.55	7.22	7.90
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	12	66	93	124	163
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	1.69	3.93	4.67	5.40	6.18
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.00	1.00	1.00	1.00	1.00
Fr	= Froude Number = Ve/(gya)^(1/2) =		0.45	0.52	0.53	0.55	0.56
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	4.12	10.08	12.10	14.10	16.29
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	6.10	10.28	11.50	12.66	13.92
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	7.47	21.25	26.59	32.24	38.92
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	22.41	63.75	79.78	96.72	116.77
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	12.16	21.13	24.08	25.00	25.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	18.00	18.00	18.00	18.00	18.00
te	= Existing Rock Rip-Rap Thickness =	inches	18.00	18.00	18.00	18.00	18.00
We	= Existing Rock Rip-Rap Width =	Feet	21.00	21.00	21.00	21.00	21.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	4.12	10.08	12.10	14.10	16.29

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Yc	= Contraction Scour =	ft	0.04	0.15	0.20	0.26	0.37
Yl	= Local Scour Depth =	ft	12.04	16.18	17.26	18.24	30.76
Yab	= Scour Depth at Abutments	ft	4.12	10.08	12.10	14.10	16.29
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	16.08	20.33	21.46	22.50	35.13
Yat	= Total Scour at Abutment = Yab + Yg =	ft	8.12	14.08	16.10	18.10	20.29
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		2.64	1.92	1.78	1.67	2.33
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		1.33	1.33	1.34	1.34	1.35

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 53.88

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.4																						
2	15	60.9	15	-6.5	0.030					L														
3	36	50.7	21	-10.2	0.030	10.42	7.28	6.55	1.43	C	657			657	63.07			10.42			6.55			3.18
4	45	49.6	9	-1.1	0.030	33.58	9.07	9.00	3.70	C	3,994			3,994	118.94			33.58			9.00			4.28
5	73	50.8	28	1.2	0.030	103.07	28.03	28.00	3.68	C	12,203			12,203	118.39			103.07			28.00			3.08
6	475	51.1	402	0.3	0.030	1,178.33	402.00	402.00	2.93	C	119,908			119,908	101.76			1,178.33			402.00			2.78
7	484	48.3	9	-2.8	0.030	37.63	9.43	9.00	3.99	C	4,706			4,706	125.05			37.63			9.00			5.58
8	504	47.8	20	-0.5	0.030	116.62	20.01	20.00	5.83	C	18,772			18,772	160.97			116.62			20.00			6.08
9	570	51.2	66	3.4	0.030	289.16	66.09	66.00	4.38	C	38,438			38,438	132.93			289.16			66.00			2.68
10	623	50.8	53	-0.4	0.030	152.70	53.00	53.00	2.88	C	15,361			15,361	100.60			152.70			53.00			3.08
11	629	49.2	6	-1.6	0.030	23.29	6.21	6.00	3.75	C	2,793			2,793	119.94			23.29			6.00			4.68
12	642	49.4	13	0.2	0.030	59.56	13.00	13.00	4.58	C	8,162			8,162	137.06			59.56			13.00			4.48
13	669	51.2	27	1.8	0.030	96.69	27.06	27.00	3.57	C	11,229			11,229	116.13			96.69			27.00			2.68
14	750	51.6	81	0.4	0.030	200.97	81.00	81.00	2.48	C	18,299			18,299	91.05			200.97			81.00			2.28
15	817	49.1	67	-2.5	0.030	236.59	67.05	67.00	3.53	C	27,247			27,247	115.17			236.59			67.00			4.78
16	1072	49.3	255	0.2	0.030	1,193.70	255.00	255.00	4.68	C	165,991			165,991	139.06			1,193.70			255.00			4.58
17	1087	50.5	15	1.2	0.030	59.72	15.05	15.00	3.97	C	7,438			7,438	124.55			59.72			15.00			3.38
18	1131	71.1	44	20.6	0.030	12.21	7.97	7.22	1.53	R	806		806		65.99		12.21			7.22				
19	1131	71.1			0.030					R														
20	1131	71.1			0.030					R														
21	1131	71.1			0.030					R														
22	1131	71.1			0.030					R														
Total			1,131.00	3.70	0.630	3,804.23	1,067.24	1,064.77	56.92		456,005		806	455,199			12	3,792		7.22	1,057.55			
Maximum	1,131.00	71.1	402.00	20.60	0.030	1,193.70	402.00	402.00	5.83						160.97		12.21	1,193.70						6.08
Minimum		47.8		-10.20	0.030																			
Range	1,131.00	23.3	402.00	30.80		1,193.70	402.00	402.00	5.83															
Average	643.00	56.1	53.86	0.18	0.030	181.15	50.82	50.70	2.71															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q		41	22,959	23,000
V		3.33	6.05	
T		7	1,058	1,065
Y			6.08	
A		12	3,792	3,804

Solve for the 2nd Water Surface Elevation WSEL = 58.37

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.4																						
2	15	60.9	15	-6.5	0.03					L														
3	36	50.7	21	-10.2	0.03	60.52	17.55	15.79	3.45	C	6,863			6,863	113.41			60.52			15.79			7.61
4	45	49.6	9	-1.1	0.03	73.96	9.07	9.00	8.16	C	14,894			14,894	201.39			73.96			9.00			8.71
5	73	50.8	28	1.2	0.03	228.69	28.03	28.00	8.16	C	46,068			46,068	201.45			228.69			28.00			7.51
6	475	51.1	402	0.3	0.03	2,981.77	402.00	402.00	7.42	C	563,632			563,632	189.03			2,981.77			402.00			7.21
7	484	48.3	9	-2.8	0.03	78.01	9.43	9.00	8.28	C	15,863			15,863	203.35			78.01			9.00			10.01
8	504	47.8	20	-0.5	0.03	206.35	20.01	20.00	10.31	C	48,598			48,598	235.52			206.35			20.00			10.51
9	570	51.2	66	3.4	0.03	585.24	66.09	66.00	8.86	C	124,508			124,508	212.75			585.24			66.00			7.11
10	623	50.8	53	-0.4	0.03	390.47	53.00	53.00	7.37	C	73,475			73,475	188.17			390.47			53.00			7.51
11	629	49.2	6	-1.6	0.03	50.20	6.21	6.00	8.08	C	10,051			10,051	200.21			50.20			6.00			9.11
12	642	49.4	13	0.2	0.03	117.88	13.00	13.00	9.07	C	25,474			25,474	216.11			117.88			13.00			8.91
13	669	51.2	27	1.8	0.03	217.82	27.06	27.00	8.05	C	43,482			43,482	199.62			217.82			27.00			7.11
14	750	51.6	81	0.4	0.03	564.36	81.00	81.00	6.97	C	102,315			102,315	181.30			564.36			81.00			6.71
15	817	49.1	67	-2.5	0.03	537.16	67.05	67.00	8.01	C	106,895			106,895	199.00			537.16			67.00			9.21
16	1072	49.3	255	0.2	0.03	2,337.67	255.00	255.00	9.17	C	508,939			508,939	217.71			2,337.67			255.00			9.01
17	1087	50.5	15	1.2	0.03	127.01	15.05	15.00	8.44	C	26,169			26,169	206.04			127.01			15.00			7.81
18	1131	71.1	44	20.6	0.03	66.10	18.55	16.80	3.56	R	7,661		7,661		115.90		66.10			16.80				
19	1131	71.1			0.03					R														
20	1131	71.1			0.03					R														
21	1131	71.1			0.03					R														
22	1131	71.1			0.03					R														
Total			1,131.00	3.70	0.630	8,623.20	1,088.08	1,083.59	123.35		1,724,887		7,661	1,717,226			66	8,557		16.80	1,066.79			
Maximum	1,131.00	71.1	402.00	20.60	0.030	2,981.77	402.00	402.00	10.31						235.52		66.10	2,981.77						10.51
Minimum		47.8		-10.20	0.030																			
Range	1,131.00	23.3	402.00	30.80		2,981.77	402.00	402.00	10.31															
Average	643.00	56.1	53.86	0.18	0.030	410.63	51.81	51.60	5.87						146.71									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q		386	86,614	87,000
V		5.85	10.12	
T		17	1,067	1,084
Y			10.57	
A		66	8,557	8,623

Solve for the 100 Water Surface Elevation — WSEL = 159.84

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.4																						
2	15	60.9	15	-6.5	0.030					L														
3	36	50.7	21	-10.2	0.030	86.00	20.92	18.82	4.11	C	10,967			10,967	127.52			86.00			18.82			9.14
4	45	49.6	9	-1.1	0.030	87.21	9.07	9.00	9.62	C	19,606			19,606	224.81			87.21			9.00			10.24
5	73	50.8	28	1.2	0.030	269.93	28.03	28.00	9.63	C	60,736			60,736	225.00			269.93			28.00			9.04
6	475	51.1	402	0.3	0.030	3,573.96	402.00	402.00	8.89	C	762,335			762,335	213.30			3,573.96			402.00			8.74
7	484	48.3	9	-2.8	0.030	91.26	9.43	9.00	9.68	C	20,607			20,607	225.80			91.26			9.00			11.54
8	504	47.8	20	-0.5	0.030	235.81	20.01	20.00	11.79	C	60,708			60,708	257.45			235.81			20.00			12.04
9	570	51.2	66	3.4	0.030	682.47	66.09	66.00	10.33	C	160,865			160,865	235.71			682.47			66.00			8.64
10	623	50.8	53	-0.4	0.030	468.54	53.00	53.00	8.84	C	99,564			99,564	212.50			468.54			53.00			9.04
11	629	49.2	6	-1.6	0.030	59.04	6.21	6.00	9.51	C	13,171			13,171	223.08			59.04			6.00			10.64
12	642	49.4	13	0.2	0.030	137.03	13.00	13.00	10.54	C	32,740			32,740	238.93			137.03			13.00			10.44
13	669	51.2	27	1.8	0.030	257.59	27.06	27.00	9.52	C	57,508			57,508	223.25			257.59			27.00			8.64
14	750	51.6	81	0.4	0.030	683.68	81.00	81.00	8.44	C	140,863			140,863	206.04			683.68			81.00			8.24
15	817	49.1	67	-2.5	0.030	635.86	67.05	67.00	9.48	C	141,604			141,604	222.70			635.86			67.00			10.74
16	1072	49.3	255	0.2	0.030	2,713.31	255.00	255.00	10.64	C	652,449			652,449	240.46			2,713.31			255.00			10.54
17	1087	50.5	15	1.2	0.030	149.11	15.05	15.00	9.91	C	34,191			34,191	229.30			149.11			15.00			9.34
18	1131	71.1	44	20.6	0.030	93.17	22.03	19.95	4.23	R	12,109		12,109		129.96		93.17			19.95				
19	1131	71.1			0.030					R														
20	1131	71.1			0.030					R														
21	1131	71.1			0.030					R														
22	1131	71.1			0.030					R														
Total			1,131.00	3.70	0.630	10,223.98	1,094.93	1,089.77	145.16		2,280,023		12,109	2,267,915			93	10,131		19.95	1,069.82			
Maximum	1,131.00	71.1	402.00	20.60	0.030	3,573.96	402.00	402.00	11.79						257.45		93.17	3,573.96						12.04
Minimum		47.8		-10.20	0.030																			
Range	1,131.00	23.3	402.00	30.80		3,573.96	402.00	402.00	11.79															
Average	643.00	56.1	53.86	0.18	0.030	486.86	52.14	51.89	6.91						163.61									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q		611	114,389	115,000
V		6.55	11.29	
T		20	1,070	1,090
Y			12.04	
A		93	10,131	10,224

Solve for the 4th Water Surface Elevation ... WSEL = 61.29

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.4																						
2	15	60.9	15	-6.5	0.030	0.18	0.98	0.90	0.18	L	3	3			15.76	0.18			0.90			0.39		
3	36	50.7	21	-10.2	0.030	115.29	23.35	21.00	4.94	C	16,614			16,614	144.11			115.29			21.00			10.59
4	45	49.6	9	-1.1	0.030	100.26	9.07	9.00	11.06	C	24,735			24,735	246.71			100.26			9.00			11.69
5	73	50.8	28	1.2	0.030	310.52	28.03	28.00	11.08	C	76,711			76,711	247.04			310.52			28.00			10.49
6	475	51.1	402	0.3	0.030	4,156.68	402.00	402.00	10.34	C	980,611			980,611	235.91			4,156.68			402.00			10.19
7	484	48.3	9	-2.8	0.030	104.31	9.43	9.00	11.07	C	25,749			25,749	246.85			104.31			9.00			12.99
8	504	47.8	20	-0.5	0.030	264.80	20.01	20.00	13.24	C	73,653			73,653	278.15			264.80			20.00			13.49
9	570	51.2	66	3.4	0.030	778.14	66.09	66.00	11.77	C	200,188			200,188	257.27			778.14			66.00			10.09
10	623	50.8	53	-0.4	0.030	545.37	53.00	53.00	10.29	C	128,242			128,242	235.15			545.37			53.00			10.49
11	629	49.2	6	-1.6	0.030	67.74	6.21	6.00	10.91	C	16,562			16,562	244.49			67.74			6.00			12.09
12	642	49.4	13	0.2	0.030	155.87	13.00	13.00	11.99	C	40,585			40,585	260.38			155.87			13.00			11.89
13	669	51.2	27	1.8	0.030	296.73	27.06	27.00	10.97	C	72,800			72,800	245.34			296.73			27.00			10.09
14	750	51.6	81	0.4	0.030	801.09	81.00	81.00	9.89	C	183,459			183,459	229.01			801.09			81.00			9.69
15	817	49.1	67	-2.5	0.030	732.98	67.05	67.00	10.93	C	179,465			179,465	244.84			732.98			67.00			12.19
16	1072	49.3	255	0.2	0.030	3,082.95	255.00	255.00	12.09	C	807,253			807,253	261.84			3,082.95			255.00			11.99
17	1087	50.5	15	1.2	0.030	170.85	15.05	15.00	11.35	C	42,900			42,900	251.10			170.85			15.00			10.79
18	1131	71.1	44	20.6	0.030	124.34	25.45	23.05	4.89	R	17,791		17,791		143.09		124.34			23.05				
19	1131	71.1			0.030					R														
20	1131	71.1			0.030					R														
21	1131	71.1			0.030					R														
22	1131	71.1			0.030					R														
Total			1,131.00	3.70	0.630	11,808.09	1,101.75	1,095.95	166.98		2,887,320	3	17,791	2,869,527		0	124	11,684	0.90	23.05	1,072.00			
Maximum	1,131.00	71.1	402.00	20.60	0.030	4,156.68	402.00	402.00	13.24						278.15	0.18	124.34	4,156.68				0.39		13.49
Minimum		47.8		-10.20	0.030																			
Range	1,131.00	23.3	402.00	30.80		4,156.68	402.00	402.00	13.24															
Average	643.00	56.1	53.86	0.18	0.030	562.29	52.46	52.19	7.95						180.33									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	0	897	144,733	145,631
V	0.79	7.22	12.39	
T	1	23	1,072	1,096
Y	0.39		13.49	
A	0	124	11,684	11,808

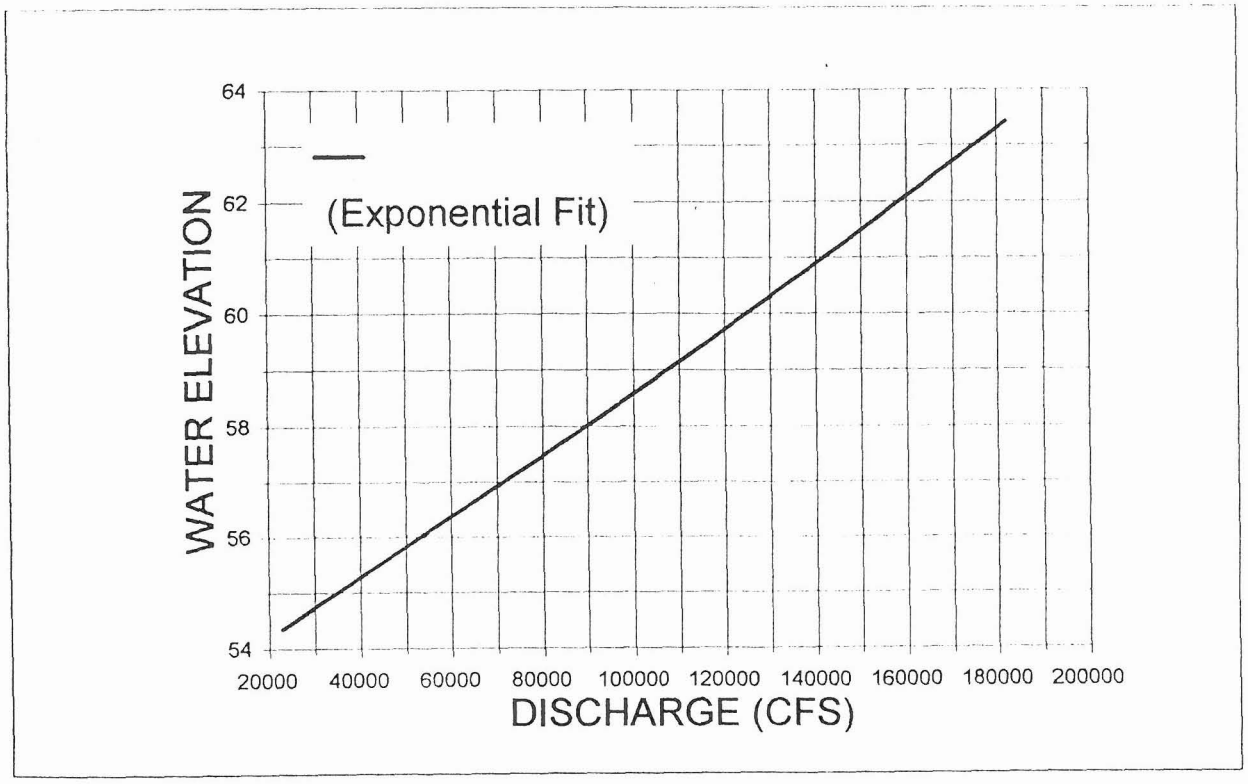
Solve for the 5th Water Surface Elevation WSEL = 62.85

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.4																						
2	15	60.9	15	-6.5	0.030	4.40	4.91	4.51	0.90	L	203	203			46.17	4.40			4.51			1.95		
3	36	50.7	21	-10.2	0.030	148.13	23.35	21.00	6.35	C	25,231			25,231	170.33			148.13			21.00			12.15
4	45	49.6	9	-1.1	0.030	114.33	9.07	9.00	12.61	C	30,791			30,791	269.30			114.33			9.00			13.25
5	73	50.8	28	1.2	0.030	354.31	28.03	28.00	12.64	C	95,579			95,579	269.76			354.31			28.00			12.05
6	475	51.1	402	0.3	0.030	4,785.36	402.00	402.00	11.90	C	1,240,121			1,240,121	259.15			4,785.36			402.00			11.75
7	484	48.3	9	-2.8	0.030	118.38	9.43	9.00	12.56	C	31,797			31,797	268.59			118.38			9.00			14.55
8	504	47.8	20	-0.5	0.030	296.08	20.01	20.00	14.80	C	88,720			88,720	299.65			296.08			20.00			15.05
9	570	51.2	66	3.4	0.030	881.36	66.09	66.00	13.34	C	246,384			246,384	279.55			881.36			66.00			11.65
10	623	50.8	53	-0.4	0.030	628.26	53.00	53.00	11.85	C	162,352			162,352	258.42			628.26			53.00			12.05
11	629	49.2	6	-1.6	0.030	77.12	6.21	6.00	12.42	C	20,560			20,560	266.59			77.12			6.00			13.65
12	642	49.4	13	0.2	0.030	176.20	13.00	13.00	13.55	C	49,788			49,788	282.56			176.20			13.00			13.45
13	669	51.2	27	1.8	0.030	338.95	27.06	27.00	12.53	C	90,876			90,876	268.11			338.95			27.00			11.65
14	750	51.6	81	0.4	0.030	927.76	81.00	81.00	11.45	C	234,326			234,326	252.57			927.76			81.00			11.25
15	817	49.1	67	-2.5	0.030	837.76	67.05	67.00	12.50	C	224,240			224,240	267.67			837.76			67.00			13.75
16	1072	49.3	255	0.2	0.030	3,481.74	255.00	255.00	13.65	C	988,729			988,729	283.98			3,481.74			255.00			13.55
17	1087	50.5	15	1.2	0.030	194.31	15.05	15.00	12.91	C	53,162			53,162	273.60			194.31			15.00			12.35
18	1131	71.1	44	20.6	0.030	162.99	29.14	26.39	5.59	R	25,525		25,525		156.60		162.99			26.39				
19	1131	71.1			0.030					R														
20	1131	71.1			0.030					R														
21	1131	71.1			0.030					R														
22	1131	71.1			0.030					R														
Total			1,131.00	3.70	0.630	13,527.46	1,109.38	1,102.90	191.55		3,608,385	203	25,525	3,582,656		4	163	13,360	4.51	26.39	1,072.00			
Maximum	1,131.00	71.1	402.00	20.60	0.030	4,785.36	402.00	402.00	14.80						299.65	4.40	162.99	4,785.36				1.95		15.05
Minimum		47.8		-10.20	0.030																			
Range	1,131.00	23.3	402.00	30.80		4,785.36	402.00	402.00	14.80															
Average	643.00	56.1	53.86	0.18	0.030	644.16	52.83	52.52	9.12						198.70									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	10	1,287	180,702	182,000
V	2.33	7.90	13.53	
T	5	26	1,072	1,103
Y	1.95		15.05	
A	4	163	13,360	13,527

DISCHARGE RATING CURVE FOR TYPICAL SECTION

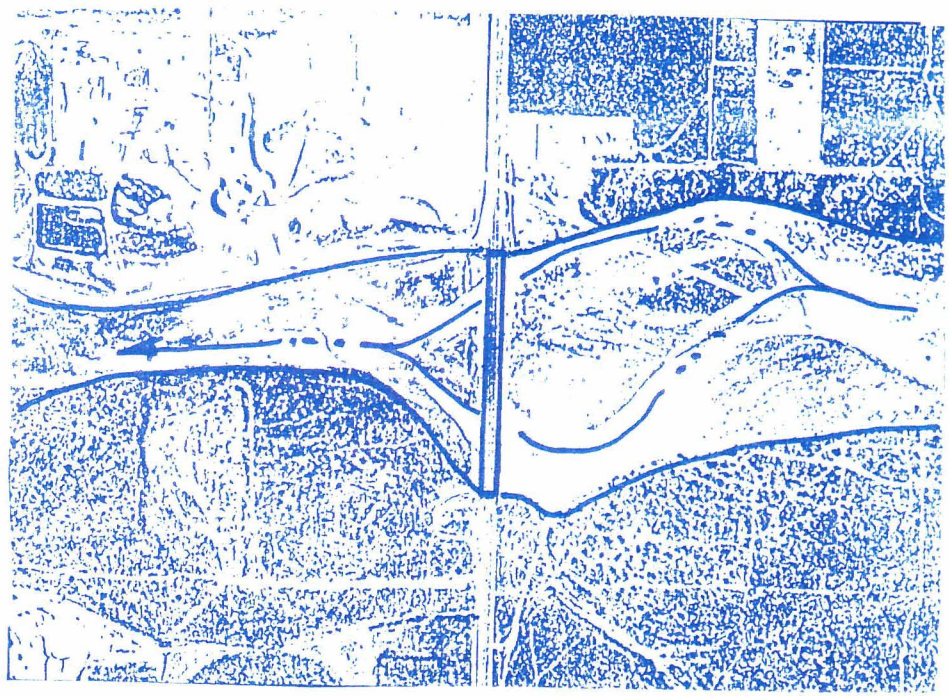
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
53.88	0	41	22,959	23,000	0.00	3.33	6.05	0.00	0.00	6.08	0	7	1,058	1,065
58.37	0	386	86,614	87,000	0.00	5.85	10.12	0.00	0.00	10.57	0	17	1,067	1,084
59.84	0	611	114,389	115,000	0.00	6.55	11.29	0.00	0.00	12.04	0	20	1,070	1,090
61.29	0	897	144,733	145,631	0.79	7.22	12.39	0.39	0.00	13.49	1	23	1,072	1,096
62.85	10	1,287	180,702	182,000	2.33	7.90	13.53	1.95	0.00	15.05	5	26	1,072	1,103



BRIDGE 2 - OLIVE AVENUE (SN 8981)

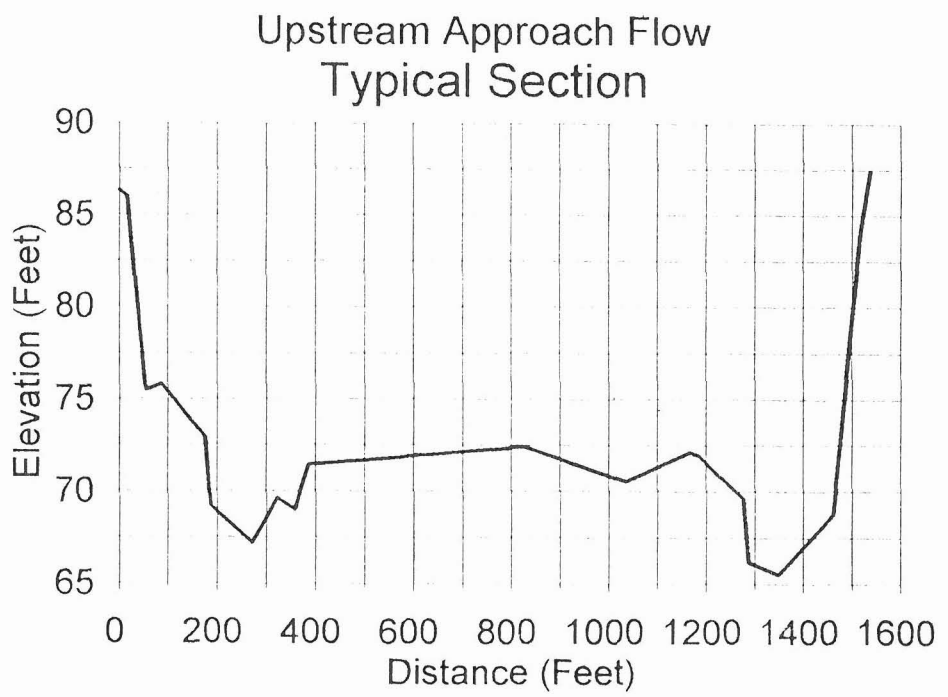
OLIVE AVENUE (SN 8981)

Water Course	Agua Fria River
Stream Form	Braided
Sinuosity	Not applicable
General Channelization	Channel DS of bridge along west bank is lined with dumped rip-rap for several hundred feet. Spur dikes US/DS east abutment guide flow near structure.
Channel Slope	Significantly steeper DS.
Estimated Channel Slope (ft/ft)	0.002110
Channel Contraction/Expansion	Wider US
Primary Surface Sediment Type	sand/gravel
D50 Size	3 MM
Armoring Potential	Low
Channel Vegetation	
Type/Size	Palo Verde to 8 ft., Desert Broom, Desert Willow, Creosote; Sage, Ephedra, Salt Bush; low dry grasses.
Density/Occurrence	Palo Verde moderate density US; smaller brush sparsely distributed US, denser DS; grasses moderately dense US, sparse DS.
Relative Age	Young to mature.
Manning's Roughness Coef.	0.030
Controls on Stream Migration	
Lateral	Channel DS of bridge along west bank lined with dumped rip-rap for several hundred feet
Vertical	No
Sediment Deposits & Bars	Irregular distribution of shallow to moderate height point and middle bars.
Evidence of Degradation	Yes, incising of channel DS of structure.
Evidence of Aggradation	No
Evidence of Scour	
Pier	Residual local scour observed to be a maximum of 2-3 feet.
Abutment	No; potential for west abutment scour high due to main channel proximity.
Land Use	
Urbanization of Upstream Watershed	Low to moderate rate; land use primarily agricultural, high density residential.
Sand & Gravel Extraction	Currently in overbanks; recently in channel immediately DS of structure.
Freeway Construction	No
Dams	No
Drainage Channels	No



INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	86.3		
2	16	86.0	0.03	C
3	55	75.5	0.03	C
4	88	75.8	0.03	C
5	176	72.9	0.03	C
6	187	69.2	0.03	C
7	272	67.2	0.03	C
8	322	69.6	0.03	C
9	359	69.0	0.03	C
10	388	71.4	0.03	C
11	827	72.4	0.03	C
12	1038	70.5	0.03	C
13	1167	72.1	0.03	C
14	1188	71.9	0.03	C
15	1277	69.6	0.03	C
16	1288	66.2	0.03	C
17	1349	65.5	0.03	C
18	1463	68.8	0.03	C
19	1519	84.1	0.03	C
20	1538	87.4	0.03	C
21	1538	87.4	0.03	C
22	1538	87.4	0.03	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	85.50
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	92.04
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	85.50
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	65.50
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	85.50
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	65.50
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00211

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	10,970	72.00	10,970	0.00
2		69,700	76.86	69,700	0.00
3	Q100	98,780	78.37	98,780	-0.00
4	Q500	179,900	81.76	179,900	-0.00
5	Low Chord	292,562	85.50	292,562	0.00

Abutment Scour Protection

	Is there evidence of scour protection?	Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	76.00
Ws	= Width of Scour Protection =	Feet	20.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	60.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	15.00
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

	Is there evidence of scour protection?	Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

	Is there evidence of scour protection?	Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	64.00
Ws	= Width of Scour Protection =	Feet	24.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	72.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	15.00
Material	= Material of Scour Protection =		Rock Apron
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		1.50

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.00211
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	Yes	No
D = Depth of Depression =	Feet	10	
A = Average Surface Area of Depression =	Sq Ft	480,000	
L1 = Distance from Bridge to Depression =	Feet	1,500	
W = Effective Width of Headcut = Width of Depression =	Feet	800	
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	1.5	0.0
	2.0	1.9	0.0
	2.5	1.9	0.0
	3.0	1.9	0.0
	3.5	1.8	0.0
	4.0	1.7	0.0
	4.5	1.6	0.0
	5.0	1.5	0.0
	5.5	1.5	0.0
	Ymax	1.9	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0098	0.0098	0.0098	0.0098	0.0098
Angle	= *Angle of Attack* =	*Degrees*	5	5	5	5	5
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	5.00	5.00	5.00	5.00	5.00
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	9.00	9.00	9.00	9.00	9.00
L	= Pier Length =	ft	115.00	115.00	115.00	115.00	115.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	85	85	85	85	85

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	92.04	92.04	92.04	92.04	92.04
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	85.50	85.50	85.50	85.50	85.50
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	72.00	76.86	78.37	81.76	85.50
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	65.50	65.50	65.50	65.50	65.50
y1	= Average Depth in the Upstream Main Channel =	ft	6.50	11.36	12.87	16.26	20.00
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	1,054	1,443	1,454	1,479	1,509
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	1,054	1,443	1,454	1,479	1,509
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	10,970	69,700	98,780	179,900	292,562
Q2	= Flow in the Contracted Channel =	cfs	10,970	69,700	98,780	179,900	292,562
V1	= Mean Velocity of Flow Upstream of Pier =	fps	5.32	8.07	9.13	11.39	13.68
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.37	0.42	0.45	0.50	0.54
S1	= Energy Slope in Main Channel =		0.00211	0.00211	0.00211	0.00211	0.00211

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	3.37	3.70	3.78	3.93	4.07
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.63	0.46	0.41	0.34	0.30
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.66	0.88	0.93	1.05	1.17
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.01230	0.01230	0.01230	0.01230	0.01230
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	1.00	1.00	1.00	1.00	1.00
U/w	= Ratio of Shear Velocity to Fall Velocity =		0.66	0.88	0.93	1.05	1.17
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	6.50	11.36	12.87	16.26	20.00
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	5.32	8.07	9.13	11.39	13.68
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	0.93	2.45	3.33	5.75	9.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	2.79	7.35	9.99	17.25	26.99
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Local Scour at Piers

Variable	Description	Unit	Trial No. 1 Value	2 Value	3 Value	4 Value	5 Value
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	13.50	8.64	7.13	3.74	0.00
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	6.50	11.36	12.87	16.26	20.00
L/a	= Ratio Used in Table 3 to Find K2 =		13.00	13.00	13.00	13.00	13.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.37	0.42	0.45	0.50	0.54
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.50	1.50	1.50	1.50	1.50
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.00
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	17.24	22.24	23.84	27.06	30.12
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	48.28	62.26	66.76	75.78	84.33
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	5.32	8.07	9.13	11.39	13.68
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	4.98	11.46	14.66	22.81	32.93
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	14.95	34.37	43.97	68.42	98.78
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	18.00	18.00	18.00	18.00	18.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	15.00	15.00	15.00	15.00	15.00
te	= Existing Rock Rip-Rap Thickness =	inches	72.00	72.00	72.00	72.00	72.00
We	= Existing Rock Rip-Rap Width =	Feet	24.00	24.00	24.00	24.00	24.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	Yes	Yes	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	1.50	1.50	1.50	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	1.50	1.50	1.50	27.06	30.12

Computed Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		0.99	0.99	0.99	0.99	0.99
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	15.00	15.00	15.00	15.00	15.00
te	= Existing Rock Rip-Rap Thickness =	inches	60.00	60.00	60.00	60.00	60.00
We	= Existing Rock Rip-Rap Width =	Feet	20.00	20.00	20.00	20.00	20.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	Yes	Yes	Yes	Yes
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	None

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	1.95	1.95	1.95	1.95	1.95
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	1.50	1.50	1.50	27.06	30.12
Yab	= Scour Depth at Abutments	ft	None	None	None	None	None
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	5.50	5.50	5.50	31.06	34.12
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	4.00
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		0.85	0.48	0.43	1.91	1.71
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.62	0.35	0.31	0.25	0.20

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Water Surface Elevation WSEL = 72.00

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		86.3																						
2	16	86.0	16	-0.3	0.030					C														
3	55	75.5	39	-10.5	0.030					C														
4	88	75.8	33	0.3	0.030					C														
5	176	72.9	88	-2.9	0.030					C														
6	187	69.2	11	-3.7	0.030	11.62	8.77	8.31	1.32	C	696			696	59.92			11.62			8.31			2.80
7	272	67.2	85	-2	0.030	322.63	85.02	85.00	3.79	C	39,001			39,001	120.88			322.63			85.00			4.80
8	322	69.6	50	2.4	0.030	179.78	50.06	50.00	3.59	C	20,950			20,950	116.53			179.78			50.00			2.40
9	359	69.0	37	-0.6	0.030	99.74	37.00	37.00	2.70	C	9,597			9,597	96.22			99.74			37.00			3.00
10	388	71.4	29	2.4	0.030	52.07	29.10	29.00	1.79	C	3,813			3,813	73.22			52.07			29.00			0.60
11	827	72.4	439	1	0.030	77.88	261.50	261.49	0.30	C	1,724			1,724	22.14			77.88			261.49			
12	1038	70.5	211	-1.9	0.030	124.21	166.10	166.10	0.75	C	5,082			5,082	40.91			124.21			166.10			1.50
13	1167	72.1	129	1.6	0.030	90.18	120.60	120.59	0.75	C	3,690			3,690	40.91			90.18			120.59			
14	1188	71.9	21	-0.2	0.030	0.48	10.04	10.04	0.05	C	3			3	6.54			0.48			10.04			0.10
15	1277	69.6	89	-2.3	0.030	110.86	89.03	89.00	1.25	C	6,374			6,374	57.49			110.86			89.00			2.40
16	1288	66.2	11	-3.4	0.030	45.05	11.51	11.00	3.91	C	5,559			5,559	123.39			45.05			11.00			5.80
17	1349	65.5	61	-0.7	0.030	374.89	61.00	61.00	6.15	C	62,506			62,506	166.73			374.89			61.00			6.50
18	1463	68.8	114	3.3	0.030	552.41	114.05	114.00	4.84	C	78,584			78,584	142.26			552.41			114.00			3.20
19	1519	84.1	56	15.3	0.030	18.69	12.13	11.70	1.54	C	1,239			1,239	66.28			18.69			11.70			
20	1538	87.4	19	3.3	0.030					C														
21	1538	87.4			0.030					C														
22	1538	87.4			0.030					C														
Total			1,538.00	1.10	0.630	2,060.49	1,055.91	1,054.23	32.73		238,817			238,817				2,060			1,054.23			
Maximum	1,538.00	87.4	439.00	15.30	0.030	552.41	261.50	261.49	6.15						166.73			552.41						6.50
Minimum		65.5		-10.50	0.030																			
Range	1,538.00	21.9	439.00	25.80		552.41	261.50	261.49	6.15															
Average	799.68	74.8	73.24	0.05	0.030	98.12	50.28	50.20	1.56															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			10,970	10,970
V			5.32	
T			1,054	1,054
Y			6.50	
A			2,060	2,060

Solve for the 2nd Water Surface Elevation WSEL = 176.86

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		86.3																						
2	16	86.0	16	-0.3	0.03					C														
3	55	75.5	39	-10.5	0.03	3.42	5.22	5.04	0.66	C	128			128	37.47			3.42			5.04			1.36
4	88	75.8	33	0.3	0.03	39.85	33.00	33.00	1.21	C	2,244			2,244	56.32			39.85			33.00			1.06
5	176	72.9	88	-2.9	0.03	220.66	88.05	88.00	2.51	C	20,226			20,226	91.66			220.66			88.00			3.96
6	187	69.2	11	-3.7	0.03	63.88	11.61	11.00	5.50	C	9,897			9,897	154.92			63.88			11.00			7.66
7	272	67.2	85	-2	0.03	735.88	85.02	85.00	8.66	C	154,182			154,182	209.52			735.88			85.00			9.66
8	322	69.6	50	2.4	0.03	422.87	50.06	50.00	8.45	C	87,178			87,178	206.16			422.87			50.00			7.26
9	359	69.0	37	-0.6	0.03	279.63	37.00	37.00	7.56	C	53,516			53,516	191.38			279.63			37.00			7.86
10	388	71.4	29	2.4	0.03	193.07	29.10	29.00	6.63	C	33,879			33,879	175.48			193.07			29.00			5.46
11	827	72.4	439	1	0.03	2,176.32	439.00	439.00	4.96	C	314,430			314,430	144.48			2,176.32			439.00			4.46
12	1038	70.5	211	-1.9	0.03	1,140.97	211.01	211.00	5.41	C	174,676			174,676	153.09			1,140.97			211.00			6.36
13	1167	72.1	129	1.6	0.03	716.91	129.01	129.00	5.56	C	111,774			111,774	155.91			716.91			129.00			4.76
14	1188	71.9	21	-0.2	0.03	102.01	21.00	21.00	4.86	C	14,538			14,538	142.52			102.01			21.00			4.96
15	1277	69.6	89	-2.3	0.03	543.56	89.03	89.00	6.11	C	90,237			90,237	166.01			543.56			89.00			7.26
16	1288	66.2	11	-3.4	0.03	98.53	11.51	11.00	8.56	C	20,490			20,490	207.95			98.53			11.00			10.66
17	1349	65.5	61	-0.7	0.03	671.45	61.00	61.00	11.01	C	165,146			165,146	245.95			671.45			61.00			11.36
18	1463	68.8	114	3.3	0.03	1,106.65	114.05	114.00	9.70	C	250,238			250,238	226.12			1,106.65			114.00			8.06
19	1519	84.1	56	15.3	0.03	118.81	30.57	29.49	3.89	C	14,593			14,593	122.82			118.81			29.49			
20	1538	87.4	19	3.3	0.03					C														
21	1538	87.4			0.03					C														
22	1538	87.4			0.03					C														
Total			1,538.00	1.10	0.630	8,634.47	1,445.25	1,442.53	101.21		1,517,370			1,517,370				8,634			1,442.53			
Maximum	1,538.00	87.4	439.00	15.30	0.030	2,176.32	439.00	439.00	11.01						245.95			2,176.32						11.36
Minimum		65.5		-10.50	0.030																			
Range	1,538.00	21.9	439.00	25.80		2,176.32	439.00	439.00	11.01															
Average	799.68	74.8	73.24	0.05	0.030	411.17	68.82	68.69	4.82						127.99									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			69,700	69,700
V			8.07	
T			1,443	1,443
Y			11.36	
A			8,634	8,634

Solve for the 3rd Water Surface Elevation WSEL = 78.37

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		86.3																						
2	16	86.0	16	-0.3	0.030					C														
3	55	75.5	39	-10.5	0.030	15.26	11.03	10.65	1.38	C	941			941	61.69			15.26			10.65			2.81
4	88	75.8	33	0.3	0.030	89.65	33.00	33.00	2.72	C	8,671			8,671	96.73			89.65			33.00			2.51
5	176	72.9	88	-2.9	0.030	353.46	88.05	88.00	4.01	C	44,363			44,363	125.51			353.46			88.00			5.41
6	187	69.2	11	-3.7	0.030	80.48	11.61	11.00	6.93	C	14,546			14,546	180.73			80.48			11.00			9.11
7	272	67.2	85	-2	0.030	864.16	85.02	85.00	10.16	C	201,541			201,541	233.22			864.16			85.00			11.11
8	322	69.6	50	2.4	0.030	498.33	50.06	50.00	9.96	C	114,625			114,625	230.02			498.33			50.00			8.71
9	359	69.0	37	-0.6	0.030	335.46	37.00	37.00	9.07	C	72,491			72,491	216.09			335.46			37.00			9.31
10	388	71.4	29	2.4	0.030	236.83	29.10	29.00	8.14	C	47,626			47,626	201.10			236.83			29.00			6.91
11	827	72.4	439	1	0.030	2,838.83	439.00	439.00	6.47	C	489,692			489,692	172.50			2,838.83			439.00			5.91
12	1038	70.5	211	-1.9	0.030	1,459.40	211.01	211.00	6.92	C	263,290			263,290	180.41			1,459.40			211.00			7.81
13	1167	72.1	129	1.6	0.030	911.59	129.01	129.00	7.07	C	166,826			166,826	183.01			911.59			129.00			6.21
14	1188	71.9	21	-0.2	0.030	133.70	21.00	21.00	6.37	C	22,824			22,824	170.71			133.70			21.00			6.41
15	1277	69.6	89	-2.3	0.030	677.88	89.03	89.00	7.61	C	130,392			130,392	192.35			677.88			89.00			8.71
16	1288	66.2	11	-3.4	0.030	115.13	11.51	11.00	10.00	C	26,562			26,562	230.71			115.13			11.00			12.11
17	1349	65.5	61	-0.7	0.030	763.51	61.00	61.00	12.52	C	204,590			204,590	267.96			763.51			61.00			12.81
18	1463	68.8	114	3.3	0.030	1,278.69	114.05	114.00	11.21	C	318,395			318,395	249.00			1,278.69			114.00			9.51
19	1519	84.1	56	15.3	0.030	167.49	36.30	35.01	4.61	C	23,067			23,067	137.73			167.49			35.01			
20	1538	87.4	19	3.3	0.030					C														
21	1538	87.4			0.030					C														
22	1538	87.4			0.030					C														
Total			1,538.00	1.10	0.630	10,819.84	1,456.78	1,453.66	125.14		2,150,442			2,150,442										
Maximum	1,538.00	87.4	439.00	15.30	0.030	2,838.83	439.00	439.00	12.52						267.96			10,820			1,453.66			
Minimum		65.5		-10.50	0.030													2,838.83						12.81
Range	1,538.00	21.9	439.00	25.80		2,838.83	439.00	439.00	12.52															
Average	799.68	74.8	73.24	0.05	0.030	515.23	69.37	69.22	5.96						149.02									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			98,780	98,780
V			9.13	
T			1,454	1,454
Y			12.87	
A			10,820	10,820

Solve for the 4th Water Surface Elevation WSEL = 81.76

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		86.3																						
2	16	86.0	16	-0.3	0.030					C														
3	55	75.5	39	-10.5	0.030	72.78	24.08	23.25	3.02	C	7,560			7,560	103.87			72.78			23.25			6.26
4	88	75.8	33	0.3	0.030	201.64	33.00	33.00	6.11	C	33,491			33,491	166.10			201.64			33.00			5.96
5	176	72.9	88	-2.9	0.030	652.11	88.05	88.00	7.41	C	123,142			123,142	188.84			652.11			88.00			8.86
6	187	69.2	11	-3.7	0.030	117.81	11.61	11.00	10.15	C	27,454			27,454	233.03			117.81			11.00			12.56
7	272	67.2	85	-2	0.030	1,152.63	85.02	85.00	13.56	C	325,759			325,759	282.62			1,152.63			85.00			14.56
8	322	69.6	50	2.4	0.030	668.02	50.06	50.00	13.34	C	186,826			186,826	279.67			668.02			50.00			12.16
9	359	69.0	37	-0.6	0.030	461.03	37.00	37.00	12.46	C	123,161			123,161	267.14			461.03			37.00			12.76
10	388	71.4	29	2.4	0.030	335.25	29.10	29.00	11.52	C	85,005			85,005	253.56			335.25			29.00			10.36
11	827	72.4	439	1	0.030	4,328.67	439.00	439.00	9.86	C	989,336			989,336	228.55			4,328.67			439.00			9.36
12	1038	70.5	211	-1.9	0.030	2,175.47	211.01	211.00	10.31	C	512,223			512,223	235.45			2,175.47			211.00			11.26
13	1167	72.1	129	1.6	0.030	1,349.38	129.01	129.00	10.46	C	320,784			320,784	237.73			1,349.38			129.00			9.66
14	1188	71.9	21	-0.2	0.030	204.97	21.00	21.00	9.76	C	46,527			46,527	227.00			204.97			21.00			9.86
15	1277	69.6	89	-2.3	0.030	979.92	89.03	89.00	11.01	C	241,011			241,011	245.95			979.92			89.00			12.16
16	1288	66.2	11	-3.4	0.030	152.46	11.51	11.00	13.24	C	42,421			42,421	278.23			152.46			11.00			15.56
17	1349	65.5	61	-0.7	0.030	970.53	61.00	61.00	15.91	C	305,192			305,192	314.46			970.53			61.00			16.26
18	1463	68.8	114	3.3	0.030	1,665.57	114.05	114.00	14.60	C	494,693			494,693	297.01			1,665.57			114.00			12.96
19	1519	84.1	56	15.3	0.030	307.40	49.18	47.44	6.25	C	51,840			51,840	168.64			307.40			47.44			
20	1538	87.4	19	3.3	0.030					C														
21	1538	87.4			0.030					C														
22	1538	87.4			0.030					C														
Total			1,538.00	1.10	0.630	15,795.63	1,482.71	1,478.69	178.97		3,916,426			3,916,426				15,796			1,478.69			
Maximum	1,538.00	87.4	439.00	15.30	0.030	4,328.67	439.00	439.00	15.91						314.46			4,328.67						16.26
Minimum		65.5		-10.50	0.030																			
Range	1,538.00	21.9	439.00	25.80		4,328.67	439.00	439.00	15.91															
Average	799.68	74.8	73.24	0.05	0.030	752.17	70.61	70.41	8.52						190.85									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			179,900	179,900
V			11.39	
T			1,479	1,479
Y			16.26	
A			15,796	15,796

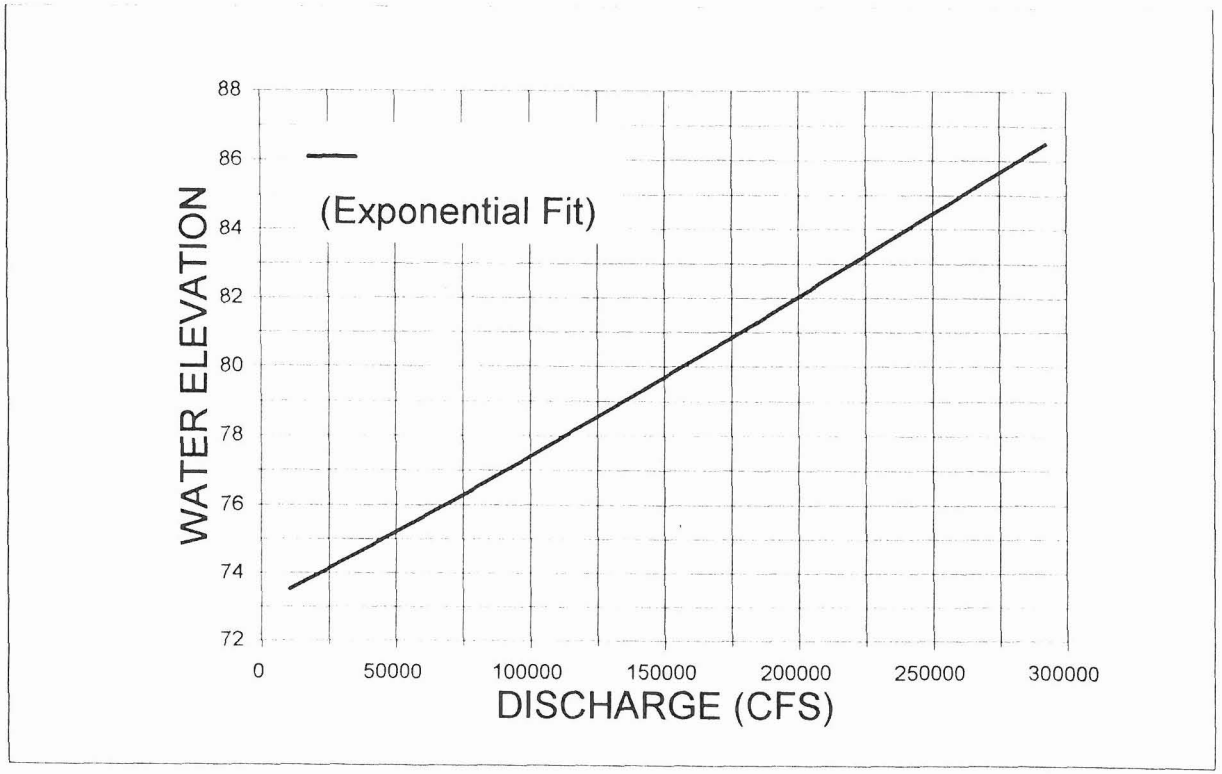
Solution for the 50yr Water Surface Elevation WSEL = 85.50

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		86.3																						
2	16	86.0	16	-0.3	0.030					C														
3	55	75.5	39	-10.5	0.030	185.71	38.47	37.14	4.83	C	26,363			26,363	141.95			185.71			37.14			10.00
4	88	75.8	33	0.3	0.030	325.05	33.00	33.00	9.85	C	74,238			74,238	228.39			325.05			33.00			9.70
5	176	72.9	88	-2.9	0.030	981.20	88.05	88.00	11.14	C	243,331			243,331	247.99			981.20			88.00			12.60
6	187	69.2	11	-3.7	0.030	158.95	11.61	11.00	13.70	C	45,231			45,231	284.56			158.95			11.00			16.30
7	272	67.2	85	-2	0.030	1,470.50	85.02	85.00	17.30	C	488,907			488,907	332.48			1,470.50			85.00			18.30
8	322	69.6	50	2.4	0.030	855.00	50.06	50.00	17.08	C	281,907			281,907	329.72			855.00			50.00			15.90
9	359	69.0	37	-0.6	0.030	599.40	37.00	37.00	16.20	C	190,761			190,761	318.25			599.40			37.00			16.50
10	388	71.4	29	2.4	0.030	443.70	29.10	29.00	15.25	C	135,630			135,630	305.68			443.70			29.00			14.10
11	827	72.4	439	1	0.030	5,970.40	439.00	439.00	13.60	C	1,690,979			1,690,979	283.23			5,970.40			439.00			13.10
12	1038	70.5	211	-1.9	0.030	2,964.55	211.01	211.00	14.05	C	858,049			858,049	289.44			2,964.55			211.00			15.00
13	1167	72.1	129	1.6	0.030	1,831.80	129.01	129.00	14.20	C	533,946			533,946	291.49			1,831.80			129.00			13.40
14	1188	71.9	21	-0.2	0.030	283.50	21.00	21.00	13.50	C	79,898			79,898	281.83			283.50			21.00			13.60
15	1277	69.6	89	-2.3	0.030	1,312.75	89.03	89.00	14.75	C	392,405			392,405	298.92			1,312.75			89.00			15.90
16	1288	66.2	11	-3.4	0.030	193.60	11.51	11.00	16.82	C	63,170			63,170	326.29			193.60			11.00			19.30
17	1349	65.5	61	-0.7	0.030	1,198.65	61.00	61.00	19.65	C	433,921			433,921	362.01			1,198.65			61.00			20.00
18	1463	68.8	114	3.3	0.030	2,091.90	114.05	114.00	18.34	C	723,319			723,319	345.77			2,091.90			114.00			16.70
19	1519	84.1	56	15.3	0.030	506.80	58.05	56.00	8.73	C	106,797			106,797	210.73			506.80			56.00			1.40
20	1538	87.4	19	3.3	0.030	5.64	8.18	8.06	0.69	C	219			219	38.77			5.64			8.06			
21	1538	87.4			0.030					C														
22	1538	87.4			0.030					C														
Total			1,538.00	1.10	0.630	21,379.11	1,514.15	1,509.20	239.66		6,369,071			6,369,071				21,379			1,509.20			
Maximum	1,538.00	87.4	439.00	15.30	0.030	5,970.40	439.00	439.00	19.65						362.01			5,970.40						20.00
Minimum		65.5		-10.50	0.030																			
Range	1,538.00	21.9	439.00	25.80		5,970.40	439.00	439.00	19.65															
Average	799.68	74.8	73.24	0.05	0.030	1,018.05	72.10	71.87	11.41						234.17									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			292,562	292,562
V			13.68	
T			1,509	1,509
Y			20.00	
A			21,379	21,379

DISCHARGE RATING CURVE FOR TYPICAL SECTION

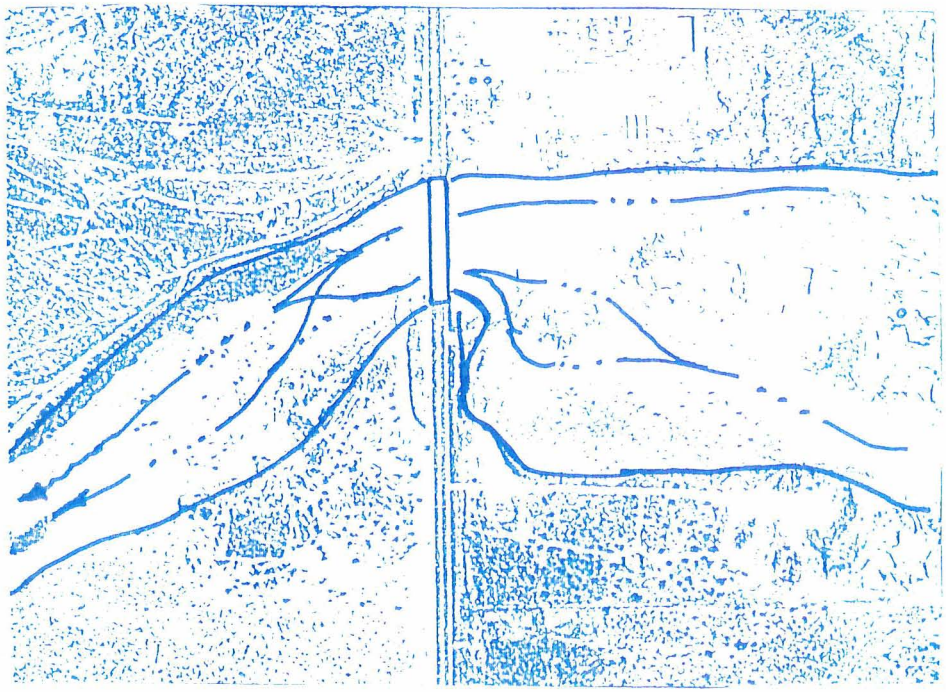
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
72.00	0	0	10,970	10,970	0.00	0.00	5.32	0.00	0.00	6.50	0	0	1,054	1,054
76.86	0	0	69,700	69,700	0.00	0.00	8.07	0.00	0.00	11.36	0	0	1,443	1,443
78.37	0	0	98,780	98,780	0.00	0.00	9.13	0.00	0.00	12.87	0	0	1,454	1,454
81.76	0	0	179,900	179,900	0.00	0.00	11.39	0.00	0.00	16.26	0	0	1,479	1,479
85.50	0	0	292,562	292,562	0.00	0.00	13.68	0.00	0.00	20.00	0	0	1,509	1,509



BRIDGE 3 - GLENDALE AVENUE (SN 9301)

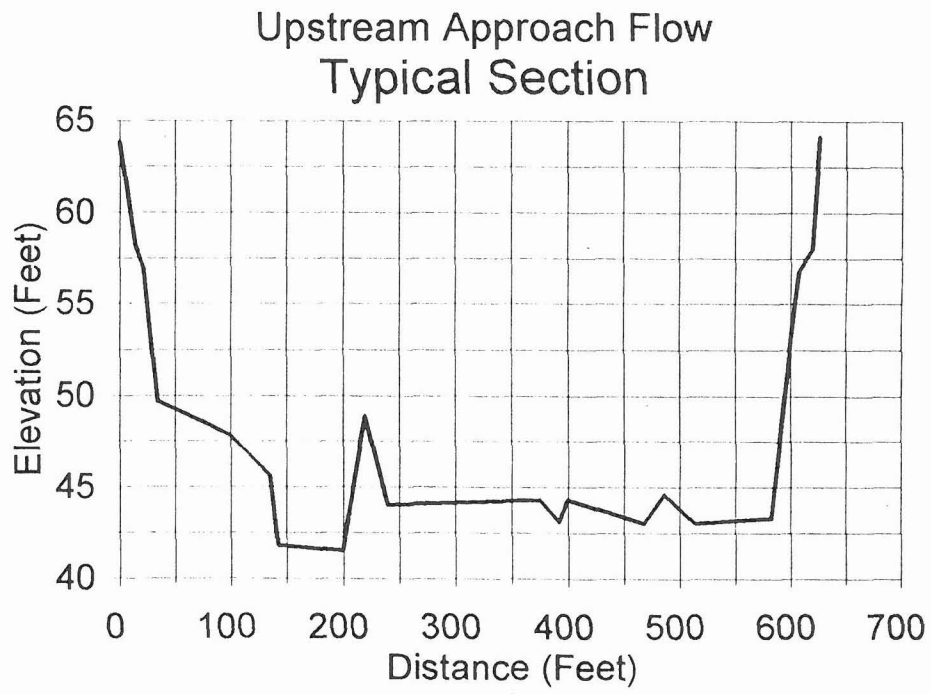
GLENDALE AVENUE (SN 9301)

Water Course	Agua Fria River
Stream Form	Braided
Sinuosity	Not applicable
General Channelization	Intermittent broken concrete rip-rap along west bank up to approximately 1000 ft. US, then approximately 1000 ft. of grouted rip-rap. Construction of shallow earthen berm intersecting bridge at pier 4 limits low flows to western 400 ft. of bridge.
Channel Slope	Uniform
Estimated Channel Slope (ft/ft)	0.002047
Channel Contraction/Expansion	Constrained channel narrower US
Primary Surface Sediment Type	sand/gravel/cobbles
D50 Size	
Armoring Potential	Low
Channel Vegetation	
Type/Size	Cottonwood to 20 ft., Mesquite, occasional Palo Verde, Ironwood; Desert Broom to 7 ft., Desert Willow, Creosote; Sage, Ephedra, Salt Bush; dry grasses.
Density/Occurrence	(US) Density of trees increases to moderate toward west abutment, elsewhere sparse; low brush primarily toward east side spur dike. (DS) Dense strand of trees, shrubs DS of west abutment signifies ponding area; east side of channel sparse to low density.
Relative Age	Mature
Manning's Roughness Coef.	0.049
Controls on Stream Migration	
Lateral	Spur dikes US/DS east abutment guide flow locally; limited slope protection on west bank
Vertical	None
Sediment Deposits & Bars	Irregular distribution of shallow point and middle bars. Sedimentation occurring in east side spans.
Evidence of Degradation	No
Evidence of Aggradation	Graffiti obscured by sand/gravel accumulation indicates local aggradation.
Evidence of Scour	
Pier	No
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Low rate; land use primarily agricultural or undeveloped, light industrial.
Sand & Gravel Extraction	Large gravel operation immediately US has significantly encroached on east side of channel and crossed east overbanks. Limited to operations in DS east overbank.
Freeway Construction	No
Dams	No
Drainage Channels	No



INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	63.8		
2	14	58.2	0.049	C
3	21	57.0	0.049	C
4	34	49.7	0.049	C
5	98	47.9	0.049	C
6	135	45.6	0.049	C
7	142	41.8	0.049	C
8	200	41.5	0.049	C
9	220	48.9	0.049	C
10	240	44.0	0.049	C
11	375	44.3	0.049	C
12	392	43.1	0.049	C
13	400	44.3	0.049	C
14	468	43.0	0.049	C
15	486	44.6	0.049	C
16	514	43.0	0.049	C
17	583	43.3	0.049	C
18	608	56.8	0.049	C
19	620	58.0	0.049	C
20	626	64.1	0.049	R
21	626	64.1	0.049	R
22	626	64.1	0.049	R



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	58.14
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	66.39
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	58.14
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	41.50
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	58.14
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	41.50
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00205

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	18,005	50.95	18,005	0.00
2	Assumed	30,000	53.38	30,000	0.00
3	Assumed	40,000	55.10	40,000	-0.00
4	Low Chord	60,758	58.14	60,758	0.00
5	Q500	177,000	70.06	177,000	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	45.00
Ws	= Width of Scour Protection =	Feet	0.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	12.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	12.00
Material	= Material of Scour Protection =		Gabion
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	
Ws	= Width of Scour Protection =	Feet	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.002047
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0066	0.0066	0.0066	0.0066	0.0066
Angle	= *Angle of Attack* =	*Degrees*	10	10	10	10	10
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		SHARP	SHARP	SHARP	SHARP	SHARP
a'	= Pier Width Shown on Plans or Measured in Field =	ft	1.67	1.67	1.67	1.67	1.67
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	5.67	5.67	5.67	5.67	5.67
L	= Pier Length =	ft	71.00	71.00	71.00	71.00	71.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	100	100	100	100	100

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	66.39	66.39	66.39	66.39	66.39
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	58.14	58.14	58.14	58.14	58.14
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	50.95	53.38	55.10	58.14	70.06
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	41.50	41.50	41.50	41.50	41.50
y1	= Average Depth in the Upstream Main Channel =	ft	9.45	11.88	13.60	16.64	28.56
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	565	574	580	606	626
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	565	574	580	606	620
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	18,005	30,000	40,000	60,758	176,746
Q2	= Flow in the Contracted Channel =	cfs	18,005	30,000	40,000	60,758	177,000
V1	= Mean Velocity of Flow Upstream of Pier =	fps	4.99	6.01	6.68	7.81	11.69
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.29	0.31	0.32	0.34	0.39
S1	= Energy Slope in Main Channel =		0.00205	0.00205	0.00205	0.00205	0.00205

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	3.14	3.26	3.33	3.45	3.77
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.63	0.54	0.50	0.44	0.32
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.79	0.89	0.95	1.05	1.37
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00820	0.00820	0.00820	0.00820	0.00820
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.94	0.94	0.94	0.94	0.94
U/w	= Ratio of Shear Velocity to Fall Velocity =		0.84	0.94	1.01	1.11	1.46
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	9.45	11.88	13.60	16.64	28.77
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.21
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	4.99	6.01	6.68	7.82	11.80
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	0.64	0.99	1.27	1.84	4.83
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	1.91	2.96	3.82	5.51	14.48
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.21

Compute Local Scour at Piers		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	7.19	4.76	3.04	0.00	-11.92
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	3.67
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	9.45	11.88	13.60	16.64	24.89
L/a	= Ratio Used in Table 3 to Find K2 =		13.00	13.00	13.00	13.00	13.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.29	0.31	0.32	0.34	0.41
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		0.90	0.90	0.90	0.90	0.90
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		2.00	2.00	2.00	2.00	2.00
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.38
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	15.68	17.51	18.67	20.52	35.43
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	43.90	49.03	52.28	57.45	99.20
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	4.99	6.01	6.68	7.82	11.80
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.70	1.70	1.70	1.70	1.70
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	5.63	8.15	10.09	13.80	31.45
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	16.90	24.45	30.28	41.39	94.34
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	11.34	11.34	11.34	11.34	11.34
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	15.68	17.51	18.67	20.52	35.43

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	6
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	254
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.18	4.70
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	54
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.07	9.01
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.01	1.01	1.01	1.01	1.01
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	0.12	0.28
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	0.10	13.37
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	7.82	11.80
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	12.28	27.99
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	36.84	83.97
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	25.00	25.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	12.00	12.00	12.00	12.00	12.00
te	= Existing Rock Rip-Rap Thickness =	inches	12.00	12.00	12.00	12.00	12.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	0.10	13.37

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.21
Yl	= Local Scour Depth =	ft	15.68	17.51	18.67	20.52	35.43
Yab	= Scour Depth at Abutments	ft	None	None	None	0.10	13.37
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	19.68	21.51	22.67	24.52	39.64
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.10	17.37
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		2.08	1.81	1.67	1.47	1.39
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.42	0.34	0.29	0.25	0.61

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 50.95

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		63.8																						
2	14	58.2	14	-5.6	0.049					C														
3	21	57.0	7	-1.2	0.049					C														
4	34	49.7	13	-7.3	0.049	1.39	2.55	2.22	0.54	C	28			28	20.26			1.39			2.22			1.25
5	98	47.9	64	-1.8	0.049	137.48	64.03	64.00	2.15	C	6,960			6,960	50.62			137.48			64.00			3.05
6	135	45.6	37	-2.3	0.049	155.33	37.07	37.00	4.19	C	12,282			12,282	79.07			155.33			37.00			5.35
7	142	41.8	7	-3.8	0.049	50.74	7.96	7.00	6.37	C	5,305			5,305	104.56			50.74			7.00			9.15
8	200	41.5	58	-0.3	0.049	539.29	58.00	58.00	9.30	C	72,565			72,565	134.56			539.29			58.00			9.45
9	220	48.9	20	7.4	0.049	114.96	21.33	20.00	5.39	C	10,754			10,754	93.54			114.96			20.00			2.05
10	240	44.0	20	-4.9	0.049	89.96	20.59	20.00	4.37	C	7,314			7,314	81.31			89.96			20.00			6.95
11	375	44.3	135	0.3	0.049	917.75	135.00	135.00	6.80	C	100,211			100,211	109.19			917.75			135.00			6.65
12	392	43.1	17	-1.2	0.049	123.22	17.04	17.00	7.23	C	14,019			14,019	113.77			123.22			17.00			7.85
13	400	44.3	8	1.2	0.049	57.98	8.09	8.00	7.17	C	6,559			6,559	113.12			57.98			8.00			6.65
14	468	43.0	68	-1.3	0.049	496.27	68.01	68.00	7.30	C	56,809			56,809	114.47			496.27			68.00			7.95
15	486	44.6	18	1.6	0.049	128.67	18.07	18.00	7.12	C	14,490			14,490	112.61			128.67			18.00			6.35
16	514	43.0	28	-1.6	0.049	200.15	28.05	28.00	7.14	C	22,574			22,574	112.79			200.15			28.00			7.95
17	583	43.3	69	0.3	0.049	538.07	69.00	69.00	7.80	C	64,385			64,385	119.66			538.07			69.00			7.65
18	608	56.8	25	13.5	0.049	54.16	16.10	14.16	3.36	C	3,700			3,700	68.31			54.16			14.16			
19	620	58.0	12	1.2	0.049					C														
20	626	64.1	6	6.1	0.049					R														
21	626	64.1			0.049					R														
22	626	64.1			0.049					R														
Total			626.00	0.30	1.029	3,605.42	570.89	565.39	86.22		397,955			397,955				3,605			565.39			
Maximum	626.00	64.1	135.00	13.50	0.049	917.75	135.00	135.00	9.30						134.56			917.75						9.45
Minimum		41.5		-7.30	0.049																			
Range	626.00	22.6	135.00	20.80		917.75	135.00	135.00	9.30															
Average	337.64	50.5	29.81	0.01	0.049	171.69	27.19	26.92	4.11															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			18,005	18,005
V			4.99	
T			565	565
Y			9.45	
A			3,605	3,605

Solve for the 2nd Water Surface Elevation WSEL = 63.38

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		63.8																						
2	14	58.2	14	-5.6	0.049					C														
3	21	57.0	7	-1.2	0.049					C														
4	34	49.7	13	-7.3	0.049	12.09	7.52	6.56	1.61	C	504			504	41.71			12.09			6.56			3.68
5	98	47.9	64	-1.8	0.049	293.40	64.03	64.00	4.58	C	24,626			24,626	83.94			293.40			64.00			5.48
6	135	45.6	37	-2.3	0.049	245.47	37.07	37.00	6.62	C	26,337			26,337	107.29			245.47			37.00			7.78
7	142	41.8	7	-3.8	0.049	67.79	7.96	7.00	8.51	C	8,599			8,599	126.85			67.79			7.00			11.58
8	200	41.5	58	-0.3	0.049	680.59	58.00	58.00	11.73	C	106,955			106,955	157.15			680.59			58.00			11.88
9	220	48.9	20	7.4	0.049	163.69	21.33	20.00	7.68	C	19,381			19,381	118.40			163.69			20.00			4.48
10	240	44.0	20	-4.9	0.049	138.69	20.59	20.00	6.74	C	15,050			15,050	108.52			138.69			20.00			9.38
11	375	44.3	135	0.3	0.049	1,246.63	135.00	135.00	9.23	C	166,975			166,975	133.94			1,246.63			135.00			9.08
12	392	43.1	17	-1.2	0.049	164.63	17.04	17.00	9.66	C	22,725			22,725	138.03			164.63			17.00			10.28
13	400	44.3	8	1.2	0.049	77.47	8.09	8.00	9.58	C	10,632			10,632	137.24			77.47			8.00			9.08
14	468	43.0	68	-1.3	0.049	661.93	68.01	68.00	9.73	C	91,823			91,823	138.72			661.93			68.00			10.38
15	486	44.6	18	1.6	0.049	172.52	18.07	18.00	9.55	C	23,626			23,626	136.95			172.52			18.00			8.78
16	514	43.0	28	-1.6	0.049	268.36	28.05	28.00	9.57	C	36,808			36,808	137.16			268.36			28.00			10.38
17	583	43.3	69	0.3	0.049	706.17	69.00	69.00	10.23	C	101,299			101,299	143.45			706.17			69.00			10.08
18	608	56.8	25	13.5	0.049	94.16	21.22	18.67	4.44	C	7,735			7,735	82.14			94.16			18.67			
19	620	58.0	12	1.2	0.049					C														
20	626	64.1	6	6.1	0.049					R														
21	626	64.1			0.049					R														
22	626	64.1			0.049					R														
Total			626.00	0.30	1.029	4,993.58	580.99	574.24	119.46		663,075			663,075				4,994			574.24			
Maximum	626.00	64.1	135.00	13.50	0.049	1,246.63	135.00	135.00	11.73						157.15			1,246.63						11.88
Minimum		41.5		-7.30	0.049																			
Range	626.00	22.6	135.00	20.80		1,246.63	135.00	135.00	11.73															
Average	337.64	50.5	29.81	0.01	0.049	237.79	27.67	27.34	5.69						85.31									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			30,000	30,000
V			6.01	
T			574	574
Y			11.88	
A			4,994	4,994

Solve for the 3rd Water Surface Elevation **WSEL = 55.10**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		63.8																						
2	14	58.2	14	-5.6	0.049					C														
3	21	57.0	7	-1.2	0.049					C														
4	34	49.7	13	-7.3	0.049	25.96	11.03	9.61	2.35	C	1,397			1,397	53.82			25.96			9.61			5.40
5	98	47.9	64	-1.8	0.049	403.14	64.03	64.00	6.30	C	41,826			41,826	103.75			403.14			64.00			7.20
6	135	45.6	37	-2.3	0.049	308.91	37.07	37.00	8.33	C	38,637			38,637	125.07			308.91			37.00			9.50
7	142	41.8	7	-3.8	0.049	79.79	7.96	7.00	10.02	C	11,284			11,284	141.42			79.79			7.00			13.30
8	200	41.5	58	-0.3	0.049	780.04	58.00	58.00	13.45	C	134,259			134,259	172.12			780.04			58.00			13.60
9	220	48.9	20	7.4	0.049	197.98	21.33	20.00	9.28	C	26,613			26,613	134.42			197.98			20.00			6.20
10	240	44.0	20	-4.9	0.049	172.98	20.59	20.00	8.40	C	21,752			21,752	125.75			172.98			20.00			11.10
11	375	44.3	135	0.3	0.049	1,478.12	135.00	135.00	10.95	C	221,801			221,801	150.06			1,478.12			135.00			10.80
12	392	43.1	17	-1.2	0.049	193.78	17.04	17.00	11.37	C	29,821			29,821	153.89			193.78			17.00			12.00
13	400	44.3	8	1.2	0.049	91.19	8.09	8.00	11.27	C	13,953			13,953	153.00			91.19			8.00			10.80
14	468	43.0	68	-1.3	0.049	778.54	68.01	68.00	11.45	C	120,341			120,341	154.57			778.54			68.00			12.10
15	486	44.6	18	1.6	0.049	203.38	18.07	18.00	11.25	C	31,084			31,084	152.84			203.38			18.00			10.50
16	514	43.0	28	-1.6	0.049	316.37	28.05	28.00	11.28	C	48,428			48,428	153.07			316.37			28.00			12.10
17	583	43.3	69	0.3	0.049	824.48	69.00	69.00	11.95	C	131,145			131,145	159.06			824.48			69.00			11.80
18	608	56.8	25	13.5	0.049	128.91	24.83	21.85	5.19	C	11,758			11,758	91.21			128.91			21.85			
19	620	58.0	12	1.2	0.049					C														
20	626	64.1	6	6.1	0.049					R														
21	626	64.1			0.049					R														
22	626	64.1			0.049					R														
Total			626.00	0.30	1.029	5,983.59	588.10	580.46	142.85		884,099			884,099				5,984			580.46			
Maximum	626.00	64.1	135.00	13.50	0.049	1,478.12	135.00	135.00	13.45						172.12			1,478.12						13.60
Minimum		41.5		-7.30	0.049																			
Range	626.00	22.6	135.00	20.80		1,478.12	135.00	135.00	13.45															
Average	337.64	50.5	29.81	0.01	0.049	284.93	28.00	27.64	6.80						96.38									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			40,000	40,000
V			6.68	
T			580	580
Y			13.60	
A			5,984	5,984

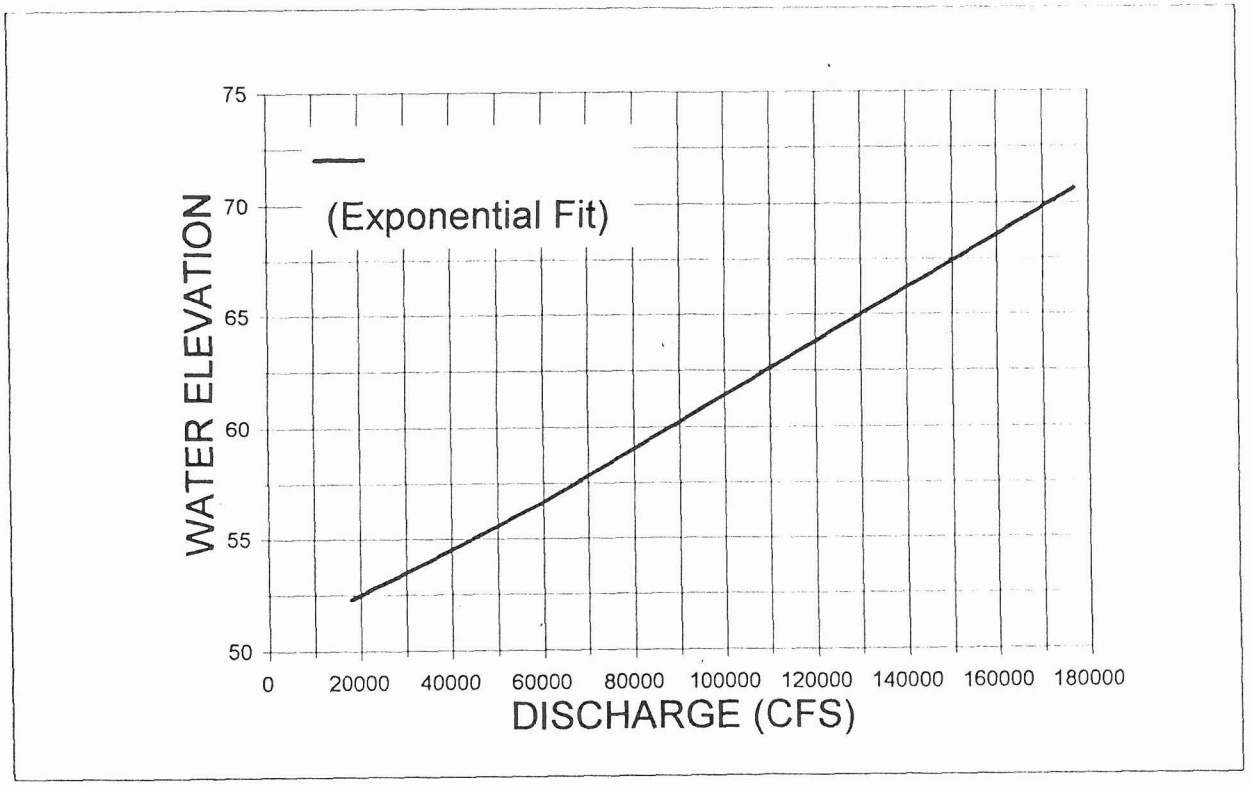
Solve for the 6th Water Surface Elevation **WSEL = 70.06**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		63.8																						
2	14	58.2	14	-5.6	0.049	126.78	15.08	14.00	8.41	C	15,952			15,952	125.82			126.78			14.00			11.86
3	21	57.0	7	-1.2	0.049	87.19	7.10	7.00	12.28	C	14,121			14,121	161.96			87.19			7.00			13.06
4	34	49.7	13	-7.3	0.049	217.18	14.91	13.00	14.57	C	39,423			39,423	181.53			217.18			13.00			20.36
5	98	47.9	64	-1.8	0.049	1,360.37	64.03	64.00	21.25	C	317,658			317,658	233.51			1,360.37			64.00			22.16
6	135	45.6	37	-2.3	0.049	862.31	37.07	37.00	23.26	C	213,892			213,892	248.04			862.31			37.00			24.46
7	142	41.8	7	-3.8	0.049	184.49	7.96	7.00	23.16	C	45,633			45,633	247.35			184.49			7.00			28.26
8	200	41.5	58	-0.3	0.049	1,647.53	58.00	58.00	28.41	C	466,921			466,921	283.41			1,647.53			58.00			28.56
9	220	48.9	20	7.4	0.049	497.12	21.33	20.00	23.31	C	123,485			123,485	248.40			497.12			20.00			21.16
10	240	44.0	20	-4.9	0.049	472.12	20.59	20.00	22.93	C	115,984			115,984	245.67			472.12			20.00			26.06
11	375	44.3	135	0.3	0.049	3,497.28	135.00	135.00	25.91	C	932,085			932,085	266.52			3,497.28			135.00			25.76
12	392	43.1	17	-1.2	0.049	448.05	17.04	17.00	26.29	C	120,592			120,592	269.15			448.05			17.00			26.96
13	400	44.3	8	1.2	0.049	210.85	8.09	8.00	26.06	C	56,423			56,423	267.60			210.85			8.00			25.76
14	468	43.0	68	-1.3	0.049	1,795.59	68.01	68.00	26.40	C	484,639			484,639	269.90			1,795.59			68.00			27.06
15	486	44.6	18	1.6	0.049	472.60	18.07	18.00	26.15	C	126,757			126,757	268.21			472.60			18.00			25.46
16	514	43.0	28	-1.6	0.049	735.16	28.05	28.00	26.21	C	197,480			197,480	268.62			735.16			28.00			27.06
17	583	43.3	69	0.3	0.049	1,856.50	69.00	69.00	26.91	C	507,445			507,445	273.33			1,856.50			69.00			26.76
18	608	56.8	25	13.5	0.049	500.14	28.41	25.00	17.60	C	103,014			103,014	205.97			500.14			25.00			13.26
19	620	58.0	12	1.2	0.049	151.87	12.06	12.00	12.59	C	25,018			25,018	164.73			151.87			12.00			12.06
20	626	64.1	6	6.1	0.049	54.03	8.56	6.00	6.32	R	5,617		5,617		103.96		54.03			6.00			5.96	
21	626	64.1			0.049					R													5.96	
22	626	64.1			0.049					R														
Total			626.00	0.30	1.029	15,177.17	638.36	626.00	398.01		3,912,140		5,617	3,906,522			54	15,123		6.00	620.00			
Maximum	626.00	64.1	135.00	13.50	0.049	3,497.28	135.00	135.00	28.41						283.41		54.03	3,497.28					5.96	28.56
Minimum		41.5		-7.30	0.049																			
Range	626.00	22.6	135.00	20.80		3,497.28	135.00	135.00	28.41															
Average	337.64	50.5	29.81	0.01	0.049	722.72	30.40	29.81	18.95						206.37									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q		254	176,746	177,000
V		4.70	11.69	
T		6	620	626
Y		5.96	28.56	
A		54	15,123	15,177

DISCHARGE RATING CURVE FOR TYPICAL SECTION

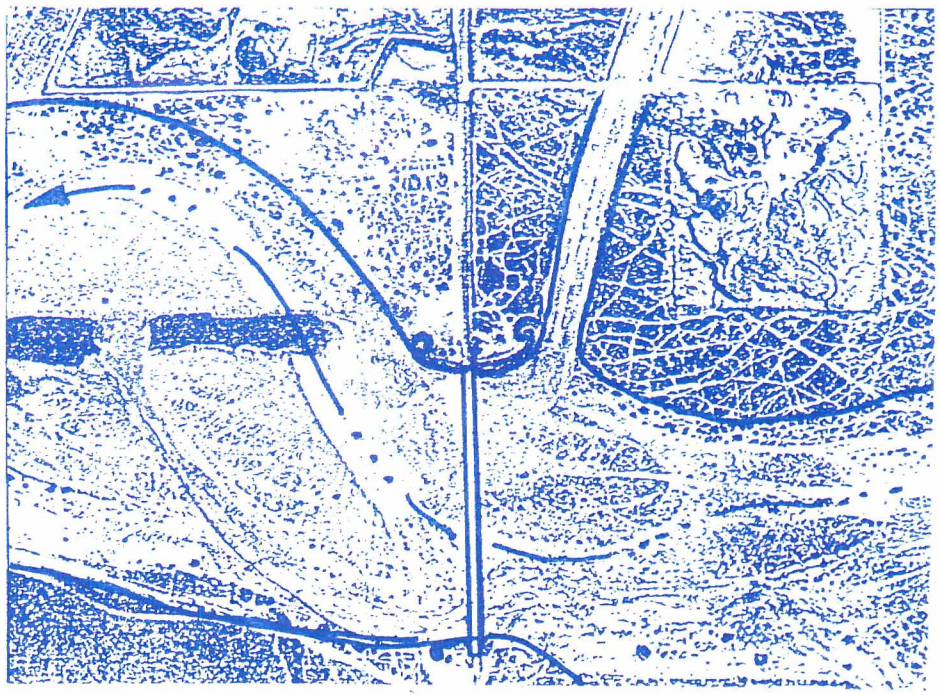
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
50.95	0	0	18,005	18,005	0.00	0.00	4.99	0.00	0.00	9.45	0	0	565	565
53.38	0	0	30,000	30,000	0.00	0.00	6.01	0.00	0.00	11.88	0	0	574	574
55.10	0	0	40,000	40,000	0.00	0.00	6.68	0.00	0.00	13.60	0	0	580	580
58.14	0	0	60,758	60,758	0.00	0.18	7.81	0.00	0.00	16.64	0	0	606	606
70.06	0	254	176,746	177,000	0.00	4.70	11.69	0.00	5.96	28.56	0	6	620	626



BRIDGE 4 - CAMELBACK ROAD (SN 9859)

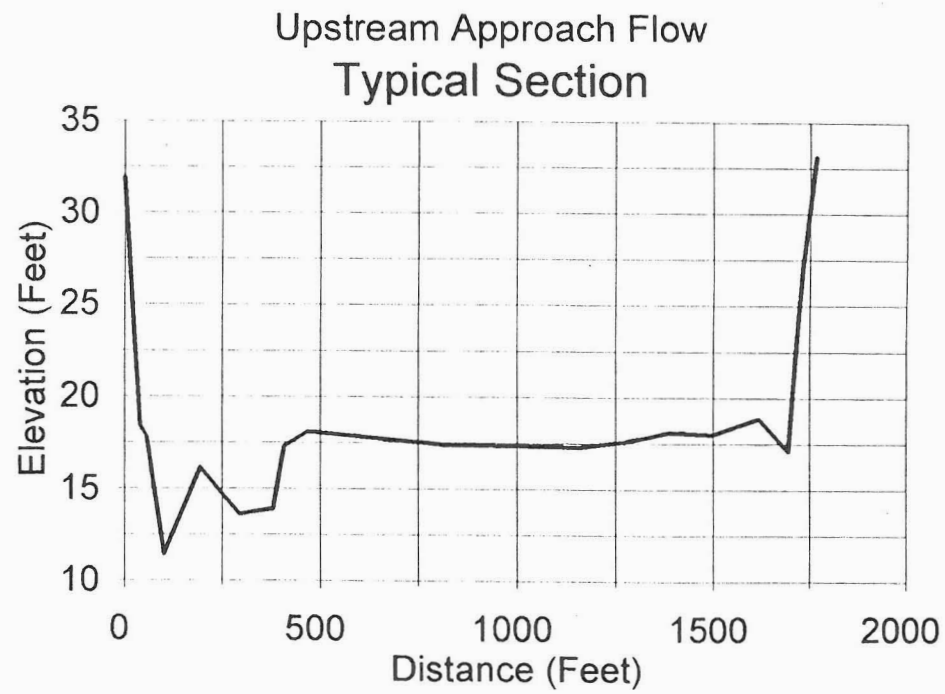
CAMELBACK ROAD (SN 9859)

Water Course	Agua Fria River
Stream Form	Braided
Sinuosity	Not applicable
General Channelization	None
Channel Slope	Steeper DS
Estimated Channel Slope (ft/ft)	0.002343
Channel Contraction/Expansion	Wider US
Primary Surface Sediment Type	sand/gravel
D50 Size	1 MM (estimate)
Armoring Potential	Low, but low flow channel US is armored.
Channel Vegetation	
Type/Size	Palo Verde to 7 ft., Desert Broom to 5 ft., Desert Willow; Creosote, Ephedra; dry grasses.
Density/Occurrence	(US) Low density vegetation occurs on bars. (DS) Nearly barren except for a few isolated stands.
Relative Age	
Manning's Roughness Coef.	0.028
Controls on Stream Migration	
Lateral	Generally none; spur dikes US/DS of abutments guide flow locally.
Vertical	None
Sediment Deposits & Bars	(US) Low to moderate height point, alternate and middle bars.
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	Some exposure due to position of low flow thalweg near east side piers.
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Low to moderate rate; land use a combination of agricultural, high density residential, and industrial. General assumption is for increasing urbanization.
Sand & Gravel Extraction	Has occurred/currently underway US/DS of bridge. Note development of elongate pond in old pit approximately 1500 ft. DS of bridge.
Freeway Construction	No
Dams	No
Drainage Channels	Colter channel joins river approximately 400 ft. west abutment.



INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	31.9		
2	40	18.4	0.028	L
3	58	17.8	0.028	C
4	103	11.4	0.028	C
5	195	16.1	0.028	C
6	296	13.6	0.028	C
7	380	13.9	0.028	C
8	409	17.3	0.028	C
9	469	18.1	0.028	C
10	815	17.4	0.028	C
11	1160	17.3	0.028	C
12	1274	17.6	0.028	C
13	1389	18.1	0.028	C
14	1496	18.0	0.028	C
15	1620	18.9	0.028	C
16	1696	17.1	0.028	C
17	1732	27.0	0.028	C
18	1766	33.1	0.028	C
19	1766	33.1	0.028	C
20	1766	33.1	0.028	C
21	1766	33.1	0.028	C
22	1766	33.1	0.028	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	27.16
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	36.36
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	27.16
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	11.40
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	27.16
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	11.40
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00234

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	23,000	19.50	23,000	-0.00
2		69,000	22.18	69,000	0.00
3	Q100	95,000	23.32	95,000	-0.00
4	Q500	184,000	26.45	184,000	-0.00
5	Low Chord	207,321	27.16	207,321	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	17.40
Ws	= Width of Scour Protection =	Feet	24.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	72.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	16.00
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	12.40
Ws	= Width of Scour Protection =	Feet	20.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	36.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	16.00
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.002343
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	Yes	No
D = Depth of Depression =	Feet	20	
A = Average Surface Area of Depression =	Sq Ft	720,000	
L1 = Distance from Bridge to Depression =	Feet	900	
W = Effective Width of Headcut = Width of Depression =	Feet	300	
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	5.6	0.0
	2.0	8.0	0.0
	2.5	9.1	0.0
	3.0	9.7	0.0
	3.5	9.9	0.0
	4.0	10.0	0.0
	4.5	10.0	0.0
	5.0	9.8	0.0
	5.5	9.7	0.0
	Ymax	10.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0033	0.0033	0.0033	0.0033	0.0033
Angle	= *Angle of Attack* =	*Degrees*	15	15	15	15	15
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	4.00	4.00	4.00	4.00	4.00
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	8.00	8.00	8.00	8.00	8.00
L	= Pier Length =	ft	50.00	50.00	50.00	50.00	50.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	75	75	75	75	75

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	36.36	36.36	36.36	36.36	36.36
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	27.16	27.16	27.16	27.16	27.16
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	19.50	22.18	23.32	26.45	27.16
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	11.40	11.40	11.40	11.40	11.40
y1	= Average Depth in the Upstream Main Channel =	ft	8.10	10.78	11.92	15.05	15.76
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	1,668	1,686	1,693	1,714	1,719
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	1,665	1,674	1,679	1,690	1,693
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	22,997	68,919	94,838	183,395	206,564
Q2	= Flow in the Contracted Channel =	cfs	23,000	69,000	95,000	184,000	207,321
V1	= Mean Velocity of Flow Upstream of Pier =	fps	5.56	8.01	9.02	11.61	12.16
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.34	0.43	0.46	0.53	0.54
S1	= Energy Slope in Main Channel =		0.00234	0.00234	0.00234	0.00234	0.00234

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	2.43	2.54	2.59	2.69	2.71
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.44	0.32	0.29	0.23	0.22
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.78	0.90	0.95	1.07	1.09
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00410	0.00410	0.00410	0.00410	0.00410
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.49	0.49	0.49	0.49	0.49
U/w	= Ratio of Shear Velocity to Fall Velocity =		1.59	1.83	1.93	2.17	2.22
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.69	0.69
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	8.11	10.84	12.00	15.24	15.98
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.01	0.06	0.08	0.19	0.22
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	5.57	8.06	9.10	11.78	12.35
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	0.95	2.50	3.42	6.61	7.44
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	2.86	7.51	10.27	19.82	22.33
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.01	0.06	0.08	0.19	0.22

Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	7.66	4.98	3.84	0.71	0.00
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	8.10	10.78	11.92	15.05	15.76
L/a	= Ratio Used in Table 3 to Find K2 =		6.00	6.00	6.00	6.00	6.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.34	0.43	0.46	0.53	0.54
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.75	1.75	1.75	1.75	1.75
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.00
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	19.56	23.78	25.37	29.19	29.95
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	54.77	66.58	71.03	81.72	83.87
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	5.57	8.06	9.10	11.78	12.35
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	5.46	11.43	14.56	24.38	26.80
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	16.38	34.28	43.67	73.14	80.41
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	16.00	16.00	16.00	16.00	16.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	16.00	16.00	16.00	16.00	16.00
te	= Existing Rock Rip-Rap Thickness =	inches	36.00	36.00	36.00	36.00	36.00
We	= Existing Rock Rip-Rap Width =	Feet	20.00	20.00	20.00	20.00	20.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	Yes	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	19.56	23.78	25.37	29.19	29.95

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	3	11	15	24	26
	Which abutment Left or Right?		Left	Left	Left	Left	Left
Qe	= Approach Flow Obstructed by Abutment =	cfs	3	81	162	605	757
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	1.67	3.80	4.53	6.29	6.66
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	2	21	36	96	114
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.55	1.89	2.46	4.03	4.38
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		0.98	0.98	0.98	0.98	0.98
Fr	= Froude Number = Ve/(gya)^(1/2) =		0.40	0.49	0.51	0.55	0.56
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	1.37	5.09	6.73	11.38	12.44
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	5.57	8.06	9.10	11.78	12.35
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	6.24	13.06	16.64	27.87	30.64
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	18.73	39.19	49.92	83.62	91.92
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	16.21	21.56	23.84	25.00	25.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	16.00	16.00	16.00	16.00	16.00
te	= Existing Rock Rip-Rap Thickness =	inches	72.00	72.00	72.00	72.00	72.00
We	= Existing Rock Rip-Rap Width =	Feet	24.00	24.00	24.00	24.00	24.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	Yes	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	1.37	5.09	6.73	11.38	12.44

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	10.00	10.00	10.00	10.00	10.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	10.00	10.00	10.00	10.00	10.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.01	0.06	0.08	0.19	0.22
Yl	= Local Scour Depth =	ft	19.56	23.78	25.37	29.19	29.95
Yab	= Scour Depth at Abutments	ft	1.37	5.09	6.73	11.38	12.44
Yg	= Long Term Degradation (General Scour) =	ft	10.00	10.00	10.00	10.00	10.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	29.57	33.84	35.45	39.37	40.17
Yat	= Total Scour at Abutment = Yab + Yg =	ft	11.37	15.09	16.73	21.38	22.44
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		3.65	3.14	2.97	2.62	2.55
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		1.40	1.40	1.40	1.42	1.42

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 19.50

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		31.9																						
2	40	18.4	40	-13.5	0.028	1.80	3.45	3.27	0.52	L	62	62			34.52	1.80			3.27			1.10		
3	58	17.8	18	-0.6	0.028	25.26	18.01	18.00	1.40	C	1,684			1,684	66.68			25.26			18.00			1.70
4	103	11.4	45	-6.4	0.028	220.65	45.45	45.00	4.85	C	33,681			33,681	152.65			220.65			45.00			8.10
5	195	16.1	92	4.7	0.028	529.30	92.12	92.00	5.75	C	90,411			90,411	170.81			529.30			92.00			3.40
6	296	13.6	101	-2.5	0.028	469.98	101.03	101.00	4.65	C	69,730			69,730	148.37			469.98			101.00			5.90
7	380	13.9	84	0.3	0.028	483.28	84.00	84.00	5.75	C	82,620			82,620	170.96			483.28			84.00			5.60
8	409	17.3	29	3.4	0.028	113.20	29.20	29.00	3.88	C	14,872			14,872	131.38			113.20			29.00			2.20
9	469	18.1	60	0.8	0.028	108.20	60.01	60.00	1.80	C	8,531			8,531	78.85			108.20			60.00			1.40
10	815	17.4	346	-0.7	0.028	606.64	346.00	346.00	1.75	C	46,948			46,948	77.39			606.64			346.00			2.10
11	1160	17.3	345	-0.1	0.028	742.89	345.00	345.00	2.15	C	65,938			65,938	88.76			742.89			345.00			2.20
12	1274	17.6	114	0.3	0.028	234.08	114.00	114.00	2.05	C	20,128			20,128	85.99			234.08			114.00			1.90
13	1389	18.1	115	0.5	0.028	190.13	115.00	115.00	1.65	C	14,149			14,149	74.42			190.13			115.00			1.40
14	1496	18.0	107	-0.1	0.028	155.50	107.00	107.00	1.45	C	10,618			10,618	68.28			155.50			107.00			1.50
15	1620	18.9	124	0.9	0.028	130.61	124.00	124.00	1.05	C	7,195			7,195	55.09			130.61			124.00			0.60
16	1696	17.1	76	-1.8	0.028	114.25	76.02	76.00	1.50	C	7,978			7,978	69.83			114.25			76.00			2.40
17	1732	27.0	36	9.9	0.028	10.50	9.06	8.74	1.16	C	617			617	58.71			10.50			8.74			
18	1766	33.1	34	6.1	0.028					C														
19	1766	33.1			0.028					C														
20	1766	33.1			0.028					C														
21	1766	33.1			0.028					C														
22	1766	33.1			0.028					C														
Total			1,766.00	1.20	0.588	4,136.28	1,669.36	1,668.01	41.39		475,162	62		475,100		2		4,134	3.27		1,664.74			
Maximum	1,766.00	33.1	346.00	9.90	0.028	742.89	346.00	346.00	5.75						170.96	1.80		742.89				1.10		8.10
Minimum		11.4		-13.50	0.028																			
Range	1,766.00	21.7	346.00	23.40		742.89	346.00	346.00	5.75															
Average	998.27	21.6	84.10	0.06	0.028	196.97	79.49	79.43	1.97															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	3		22,997	23,000
V	1.67		5.56	
T	3		1,665	1,668
Y	1.10		8.10	
A	2		4,134	4,136

Solve for the 2nd Water Surface Elevation **WSEL = 22.18**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		31.9																						
2	40	18.4	40	-13.5	0.028	21.19	11.83	11.21	1.79	L	1,664	1,664			78.51	21.19			11.21			3.78		
3	58	17.8	18	-0.6	0.028	73.47	18.01	18.00	4.08	C	9,987			9,987	135.93			73.47			18.00			4.38
4	103	11.4	45	-6.4	0.028	341.18	45.45	45.00	7.51	C	69,651			69,651	204.15			341.18			45.00			10.71
5	195	16.1	92	4.7	0.028	775.73	92.12	92.00	8.42	C	170,984			170,984	220.42			775.73			92.00			6.08
6	296	13.6	101	-2.5	0.028	740.52	101.03	101.00	7.33	C	148,790			148,790	200.93			740.52			101.00			8.58
7	380	13.9	84	0.3	0.028	708.28	84.00	84.00	8.43	C	156,251			156,251	220.61			708.28			84.00			8.28
8	409	17.3	29	3.4	0.028	190.87	29.20	29.00	6.54	C	35,534			35,534	186.16			190.87			29.00			4.88
9	469	18.1	60	0.8	0.028	268.91	60.01	60.00	4.48	C	38,917			38,917	144.72			268.91			60.00			4.08
10	815	17.4	346	-0.7	0.028	1,533.43	346.00	346.00	4.43	C	220,275			220,275	143.65			1,533.43			346.00			4.71
11	1160	17.3	345	-0.1	0.028	1,667.00	345.00	345.00	4.83	C	253,670			253,670	152.17			1,667.00			345.00			4.88
12	1274	17.6	114	0.3	0.028	539.43	114.00	114.00	4.73	C	80,949			80,949	150.06			539.43			114.00			4.58
13	1389	18.1	115	0.5	0.028	498.17	115.00	115.00	4.33	C	70,480			70,480	141.48			498.17			115.00			4.08
14	1496	18.0	107	-0.1	0.028	442.11	107.00	107.00	4.13	C	60,608			60,608	137.09			442.11			107.00			4.11
15	1620	18.9	124	0.9	0.028	462.75	124.00	124.00	3.73	C	59,272			59,272	128.08			462.75			124.00			3.28
16	1696	17.1	76	-1.8	0.028	317.82	76.02	76.00	4.18	C	43,912			43,912	138.17			317.82			76.00			5.08
17	1732	27.0	36	9.9	0.028	46.96	19.17	18.48	2.45	C	4,542			4,542	96.74			46.96			18.48			
18	1766	33.1	34	6.1	0.028					C														
19	1766	33.1			0.028					C														
20	1766	33.1			0.028					C														
21	1766	33.1			0.028					C														
22	1766	33.1			0.028					C														
Total			1,766.00	1.20	0.588	8,627.84	1,687.84	1,685.69	81.40		1,425,486	1,664		1,423,822		21		8,607	11.21		1,674.48			
Maximum	1,766.00	33.1	346.00	9.90	0.028	1,667.00	346.00	346.00	8.43						220.61	21.19		1,667.00				3.78		10.71
Minimum		11.4		-13.50	0.028																			
Range	1,766.00	21.7	346.00	23.40		1,667.00	346.00	346.00	8.43															
Average	998.27	21.6	84.10	0.06	0.028	410.85	80.37	80.27	3.88						118.04									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	81		68,919	69,000
V	3.80		8.01	
T	11		1,674	1,686
Y	3.78		10.78	
A	21		8,607	8,628

Solve for the 3rd Water Surface Elevation WSEL = 23.32

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		31.9																						
2	40	18.4	40	-13.5	0.028	35.86	15.38	14.58	2.33	L	3,355	3,355			93.57	35.86			14.58			4.92		
3	58	17.8	18	-0.6	0.028	93.95	18.01	18.00	5.22	C	15,047			15,047	160.15			93.95			18.00			5.5
4	103	11.4	45	-6.4	0.028	392.39	45.45	45.00	8.63	C	87,934			87,934	224.10			392.39			45.00			11.9
5	195	16.1	92	4.7	0.028	880.41	92.12	92.00	9.56	C	211,152			211,152	239.83			880.41			92.00			7.2
6	296	13.6	101	-2.5	0.028	855.44	101.03	101.00	8.47	C	189,242			189,242	221.22			855.44			101.00			9.7
7	380	13.9	84	0.3	0.028	803.85	84.00	84.00	9.57	C	192,958			192,958	240.04			803.85			84.00			9.4
8	409	17.3	29	3.4	0.028	223.87	29.20	29.00	7.67	C	46,353			46,353	207.05			223.87			29.00			6.0
9	469	18.1	60	0.8	0.028	337.18	60.01	60.00	5.62	C	56,745			56,745	168.29			337.18			60.00			5.2
10	815	17.4	346	-0.7	0.028	1,927.11	346.00	346.00	5.57	C	322,407			322,407	167.30			1,927.11			346.00			5.9
11	1160	17.3	345	-0.1	0.028	2,059.54	345.00	345.00	5.97	C	360,877			360,877	175.22			2,059.54			345.00			6.0
12	1274	17.6	114	0.3	0.028	669.15	114.00	114.00	5.87	C	115,935			115,935	173.26			669.15			114.00			5.7
13	1389	18.1	115	0.5	0.028	629.01	115.00	115.00	5.47	C	103,970			103,970	165.29			629.01			115.00			5.2
14	1496	18.0	107	-0.1	0.028	563.86	107.00	107.00	5.27	C	90,913			90,913	161.23			563.86			107.00			5.3
15	1620	18.9	124	0.9	0.028	603.84	124.00	124.00	4.87	C	92,365			92,365	152.96			603.84			124.00			4.4
16	1696	17.1	76	-1.8	0.028	404.30	76.02	76.00	5.32	C	65,586			65,586	162.22			404.30			76.00			6.2
17	1732	27.0	36	9.9	0.028	70.34	23.46	22.62	3.00	C	7,786			7,786	110.69			70.34			22.62			
18	1766	33.1	34	6.1	0.028					C														
19	1766	33.1			0.028					C														
20	1766	33.1			0.028					C														
21	1766	33.1			0.028					C														
22	1766	33.1			0.028					C														
Total			1,766.00	1.20	0.588	10,550.11	1,695.69	1,693.19	98.40		1,962,626	3,355		1,959,270		36		10,514	14.58		1,678.62			
Maximum	1,766.00	33.1	346.00	9.90	0.028	2,059.54	346.00	346.00	9.57						240.04	35.86		2,059.54				4.92		11.9
Minimum		11.4		-13.50	0.028																			
Range	1,766.00	21.7	346.00	23.40		2,059.54	346.00	346.00	9.57															
Average	998.27	21.6	84.10	0.06	0.028	502.39	80.75	80.63	4.69						134.40									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	162		94,838	95,000
V	4.53		9.02	
T	15		1,679	1,693
Y	4.92		11.92	
A	36		10,514	10,550

Solve for the 4th Water Surface Elevation **WSEL = 26.45**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		31.9																						
2	40	18.4	40	-13.5	0.028	96.11	25.19	23.87	3.82	L	12,495	12,495			130.00	96.11			23.87			8.05		
3	58	17.8	18	-0.6	0.028	150.38	18.01	18.00	8.35	C	32,960			32,960	219.18			150.38			18.00			8.65
4	103	11.4	45	-6.4	0.028	533.46	45.45	45.00	11.74	C	146,728			146,728	275.05			533.46			45.00			15.05
5	195	16.1	92	4.7	0.028	1,168.83	92.12	92.00	12.69	C	338,644			338,644	289.73			1,168.83			92.00			10.35
6	296	13.6	101	-2.5	0.028	1,172.07	101.03	101.00	11.60	C	319,891			319,891	272.93			1,172.07			101.00			12.85
7	380	13.9	84	0.3	0.028	1,067.19	84.00	84.00	12.70	C	309,465			309,465	289.98			1,067.19			84.00			12.55
8	409	17.3	29	3.4	0.028	314.78	29.20	29.00	10.78	C	81,813			81,813	259.90			314.78			29.00			9.15
9	469	18.1	60	0.8	0.028	525.28	60.01	60.00	8.75	C	118,813			118,813	226.19			525.28			60.00			8.35
10	815	17.4	346	-0.7	0.028	3,011.81	346.00	346.00	8.70	C	678,686			678,686	225.34			3,011.81			346.00			9.05
11	1160	17.3	345	-0.1	0.028	3,141.10	345.00	345.00	9.10	C	729,354			729,354	232.20			3,141.10			345.00			9.15
12	1274	17.6	114	0.3	0.028	1,026.53	114.00	114.00	9.00	C	236,607			236,607	230.49			1,026.53			114.00			8.85
13	1389	18.1	115	0.5	0.028	989.53	115.00	115.00	8.60	C	221,270			221,270	223.61			989.53			115.00			8.35
14	1496	18.0	107	-0.1	0.028	899.30	107.00	107.00	8.40	C	197,964			197,964	220.13			899.30			107.00			8.45
15	1620	18.9	124	0.9	0.028	992.58	124.00	124.00	8.00	C	211,501			211,501	213.08			992.58			124.00			7.55
16	1696	17.1	76	-1.8	0.028	642.55	76.02	76.00	8.45	C	141,980			141,980	220.96			642.55			76.00			9.35
17	1732	27.0	36	9.9	0.028	159.11	35.28	34.02	4.51	C	23,123			23,123	145.33			159.11			34.02			
18	1766	33.1	34	6.1	0.028					C														
19	1766	33.1			0.028					C														
20	1766	33.1			0.028					C														
21	1766	33.1			0.028					C														
22	1766	33.1			0.028					C														
Total			1,766.00	1.20	0.588	15,890.61	1,717.31	1,713.88	145.22		3,801,296	12,495		3,788,801		96		15,794	23.87		1,690.02			
Maximum	1,766.00	33.1	346.00	9.90	0.028	3,141.10	346.00	346.00	12.70						289.98	96.11		3,141.10				8.05		15.05
Minimum		11.4		-13.50	0.028																			
Range	1,766.00	21.7	346.00	23.40		3,141.10	346.00	346.00	12.70															
Average	998.27	21.6	84.10	0.06	0.028	756.70	81.78	81.61	6.92						174.96									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	605		183,395	184,000
V	6.29		11.61	
T	24		1,690	1,714
Y	8.05		15.05	
A	96		15,794	15,891

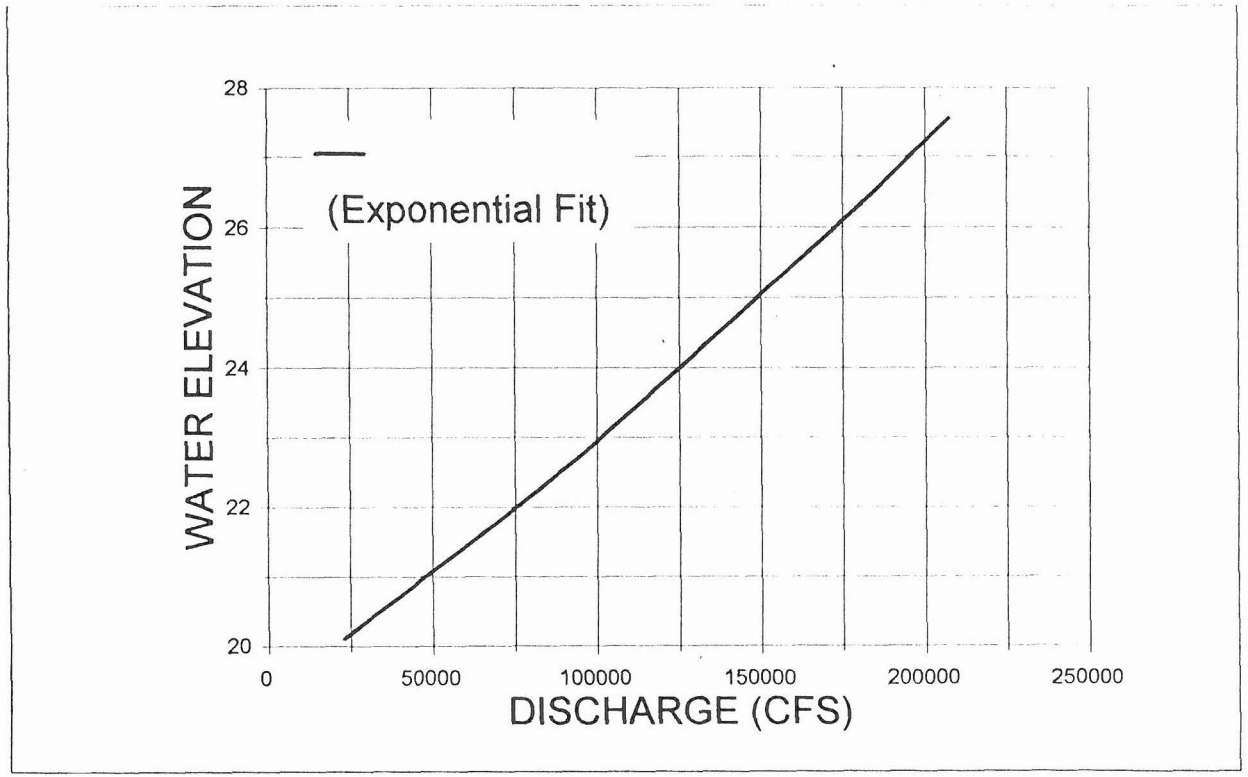
Solve for the 5th Water Surface Elevation **WSEL = 27.16**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		31.9																						
2	40	18.4	40	-13.5	0.028	113.69	27.39	25.96	4.15	L	15,630	15,630			137.49	113.69			25.96			8.76		
3	58	17.8	18	-0.6	0.028	163.08	18.01	18.00	9.05	C	37,729			37,729	231.35			163.08			18.00			9.3%
4	103	11.4	45	-6.4	0.028	565.20	45.45	45.00	12.43	C	161,568			161,568	285.86			565.20			45.00			15.7%
5	195	16.1	92	4.7	0.028	1,233.72	92.12	92.00	13.39	C	370,563			370,563	300.36			1,233.72			92.00			11.0%
6	296	13.6	101	-2.5	0.028	1,243.31	101.03	101.00	12.31	C	352,956			352,956	283.88			1,243.31			101.00			13.5%
7	380	13.9	84	0.3	0.028	1,126.44	84.00	84.00	13.41	C	338,633			338,633	300.62			1,126.44			84.00			13.2%
8	409	17.3	29	3.4	0.028	335.24	29.20	29.00	11.48	C	90,866			90,866	271.05			335.24			29.00			9.8%
9	469	18.1	60	0.8	0.028	567.60	60.01	60.00	9.46	C	135,196			135,196	238.19			567.60			60.00			9.0%
10	815	17.4	346	-0.7	0.028	3,255.86	346.00	346.00	9.41	C	772,819			772,819	237.36			3,255.86			346.00			9.7%
11	1160	17.3	345	-0.1	0.028	3,384.45	345.00	345.00	9.81	C	825,961			825,961	244.05			3,384.45			345.00			9.8%
12	1274	17.6	114	0.3	0.028	1,106.94	114.00	114.00	9.71	C	268,304			268,304	242.38			1,106.94			114.00			9.5%
13	1389	18.1	115	0.5	0.028	1,070.65	115.00	115.00	9.31	C	252,326			252,326	235.68			1,070.65			115.00			9.0%
14	1496	18.0	107	-0.1	0.028	974.77	107.00	107.00	9.11	C	226,427			226,427	232.29			974.77			107.00			9.1%
15	1620	18.9	124	0.9	0.028	1,080.04	124.00	124.00	8.71	C	243,474			243,474	225.43			1,080.04			124.00			8.2%
16	1696	17.1	76	-1.8	0.028	696.16	76.02	76.00	9.16	C	162,271			162,271	233.09			696.16			76.00			10.0%
17	1732	27.0	36	9.9	0.028	183.96	37.34	36.00	4.93	C	28,360			28,360	154.17			183.96			36.00			0.1%
18	1766	33.1	34	6.1	0.028	0.07	0.91	0.89	0.08	C	1			1	9.77			0.07			0.89			
19	1766	33.1			0.028					C														
20	1766	33.1			0.028					C														
21	1766	33.1			0.028					C														
22	1766	33.1			0.028					C														
Total			1,766.00	1.20	0.588	17,101.18	1,722.48	1,718.85	155.91		4,283,085	15,630		4,267,454		114		16,987	25.96		1,692.89			
Maximum	1,766.00	33.1	346.00	9.90	0.028	3,384.45	346.00	346.00	13.41						300.62	113.69		3,384.45				8.76		15.7%
Minimum		11.4		-13.50	0.028																			
Range	1,766.00	21.7	346.00	23.40		3,384.45	346.00	346.00	13.41															
Average	998.27	21.6	84.10	0.06	0.028	814.34	82.02	81.85	7.42						183.95									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	757		206,564	207,321
V	6.66		12.16	
T	26		1,693	1,719
Y	8.76		15.76	
A	114		16,987	17,101

DISCHARGE RATING CURVE FOR TYPICAL SECTION

WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
19.50	3	0	22,997	23,000	1.67	0.00	5.56	1.10	0.00	8.10	3	0	1,665	1,668
22.18	81	0	68,919	69,000	3.80	0.00	8.01	3.78	0.00	10.78	11	0	1,674	1,686
23.32	162	0	94,838	95,000	4.53	0.00	9.02	4.92	0.00	11.92	15	0	1,679	1,693
26.45	605	0	183,395	184,000	6.29	0.00	11.61	8.05	0.00	15.05	24	0	1,690	1,714
27.16	757	0	206,564	207,321	6.66	0.00	12.16	8.76	0.00	15.76	26	0	1,693	1,719



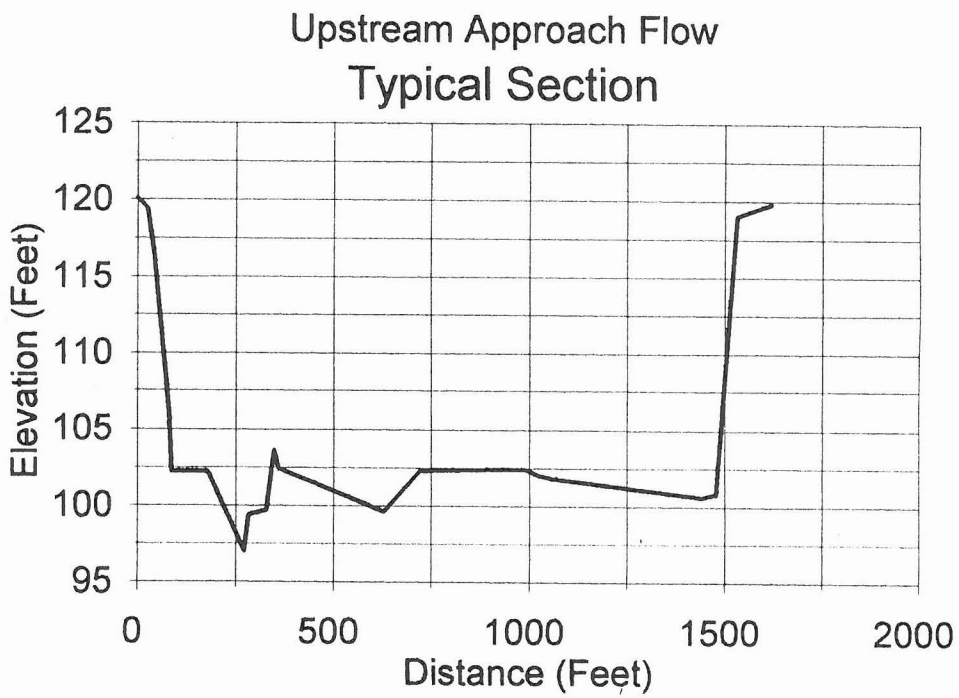
BRIDGE 5 - INDIAN SCHOOL ROAD (SN 9145)

INDIAN SCHOOL ROAD (SN 9145)

Water Course	Agua Fria River
Stream Form	Braided
Sinuosity	Not applicable
General Channelization	Soil cement-lined channel US/DS of bridge. Large soil-cement spur dikes on east side US of bridge.
Channel Slope	Uniform
Estimated Channel Slope (ft/ft)	0.001547
Channel Contraction/Expansion	Wider US
Primary Surface Sediment Type	sand/gravel
D50 Size	1.5 MM (estimate)
Armoring Potential	Low
Channel Vegetation	
Type/Size	Desert Broom to 4 ft., Desert Willow; Creosote, Salt Bush, Ephedra; low grasses.
Density/Occurrence	Generally very sparse US/DS.
Relative Age	Young
Manning's Roughness Coef.	0.025
Controls on Stream Migration	
Lateral	Soil cement-lined channel US/DS of bridge.
Vertical	Possible broken grade control structure approximately 150 ft. DS of bridge.
Sediment Deposits & Bars	Irregular distribution of point and middle bars.
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	Maximum residual scour 3-4 ft. observed at some solid piers.
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Low to moderate rate; land use a combination of agricultural and industrial. General assumption is for increasing urbanization.
Sand & Gravel Extraction	Past excavation of US/DS channel. Current excavation of US/DS overbanks with channel used as haul road.
Freeway Construction	No
Dams	No
Drainage Channels	No. Roosevelt Irrigation District (RID) canal DS of structure.

INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	120.1		
2	26	119.4	0.025	L
3	44	116.3	0.025	C
4	81	106.2	0.025	C
5	88	102.2	0.025	C
6	180	102.2	0.025	C
7	273	97.0	0.025	C
8	284	99.4	0.025	C
9	329	99.7	0.025	C
10	350	103.6	0.025	C
11	360	102.4	0.025	C
12	630	99.6	0.025	C
13	720	102.3	0.025	C
14	990	102.4	0.025	C
15	1025	102.0	0.025	C
16	1057	101.8	0.025	C
17	1440	100.6	0.025	C
18	1479	100.8	0.025	C
19	1533	119.0	0.025	C
20	1620	119.8	0.025	R
21	1620	119.8	0.025	R
22	1620	119.8	0.025	R



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	115.03
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	123.15
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	115.03
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	97.00
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	115.03
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	97.00
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00155

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	23,000	104.44	23,000	0.00
2	Q100	95,000	108.79	95,000	0.00
3	Q500	184,000	112.43	184,000	0.00
4	Q500	184,000	112.43	184,000	0.00
5	Low Chord	261,628	115.03	261,628	(0.00)

Abutment Scour Protection

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Full or Part?	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ws = Width of Scour Protection =	Full or Part?	
Ls = Length of Scour Protection =	Full or Part?	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection (or "None") =	Feet	
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Full or Part?	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	Yes
ELs = Top Elevation of Scour Protection =	Feet	100.00
Ds = Distance Downstream =	Feet	157
S = Average Channel Slope = Average Energy Slope =		0.001547
Ws = Width of Scour Protection =	Feet	44
Ls = Length of Scour Protection =	Feet	Full
Ts = Thickness of Scour Protection =	Inches	216.00
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	216.00
Material = Material of Scour Protection =		Soil Cement
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		0.00

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	Yes
D = Depth of Depression =	Feet		20
A = Average Surface Area of Depression =	Sq Ft		720,000
L1 = Distance from Bridge to Depression =	Feet		2,400
W = Effective Width of Headcut = Width of Depression =	Feet		1,200
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	1.7
	2.0	0.0	2.0
	2.5	0.0	2.0
	3.0	0.0	1.9
	3.5	0.0	1.8
	4.0	0.0	1.7
	4.5	0.0	1.6
	5.0	0.0	1.5
	5.5	0.0	1.4
	Ymax	0.0	2.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0033	0.0033	0.0033	0.0033	0.0033
Angle	= *Angle of Attack* =	*Degrees*	10	10	10	10	10
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		SHARP	SHARP	SHARP	ROUND	SHARP
a'	= Pier Width Shown on Plans or Measured in Field =	ft	1.67	1.67	1.67	4.00	1.67
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	5.67	5.67	5.67	8.00	5.67
L	= Pier Length =	ft	72.00	72.00	72.00	72.00	59.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	110	110	110	110	110

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	123.15	123.15	123.15	123.15	123.15
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	115.03	115.03	115.03	115.03	115.03
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	104.44	108.79	112.43	112.43	115.03
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	97.00	97.00	97.00	97.00	97.00
y1	= Average Depth in the Upstream Main Channel =	ft	7.44	11.79	15.43	15.43	18.03
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	1,406	1,431	1,455	1,455	1,473
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	1,406	1,431	1,455	1,455	1,473
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	23,000	95,000	184,000	184,000	261,628
Q2	= Flow in the Contracted Channel =	cfs	23,000	95,000	184,000	184,000	261,628
V1	= Mean Velocity of Flow Upstream of Pier =	fps	5.22	8.99	11.63	11.63	13.33
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.34	0.46	0.52	0.52	0.55
S1	= Energy Slope in Main Channel =		0.00155	0.00155	0.00155	0.00155	0.00155

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	2.39	2.58	2.70	2.70	2.77
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.46	0.29	0.23	0.23	0.21
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.61	0.77	0.88	0.88	0.95
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00410	0.00410	0.00410	0.00410	0.00410
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.49	0.49	0.49	0.49	0.49
U/w	= Ratio of Shear Velocity to Fall Velocity =		1.24	1.56	1.78	1.78	1.93
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	7.44	11.79	15.43	15.43	18.03
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	5.22	8.99	11.63	11.63	13.33
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	0.82	3.33	6.29	6.29	8.76
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	2.46	9.98	18.87	18.87	26.29
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00
Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	10.59	6.24	2.60	2.60	(0.00)
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	7.44	11.79	15.43	15.43	18.03
L/a	= Ratio Used in Table 3 to Find K2 =		13.00	13.00	13.00	9.00	10.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.34	0.46	0.52	0.52	0.55
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		0.90	0.90	0.90	1.00	0.90
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		2.00	2.00	2.00	1.75	1.83
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.54
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	15.48	20.81	24.10	29.31	36.94
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	43.35	58.26	67.48	82.06	103.43
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	5.22	8.99	11.63	11.63	13.33
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.70	1.70	1.70	1.50	1.70
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	6.16	18.27	30.56	23.79	40.15
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	18.49	54.82	91.68	71.38	120.46
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	11.34	11.34	11.34	11.34	11.34
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	15.48	20.81	24.10	29.31	36.94

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
a'	:= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	:= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	:= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	:= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	:= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	:= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	:= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.03	1.03	1.03	1.03	1.03
Fr	:= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	None

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	2.00	2.00	2.00	2.00	2.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	0.00	0.00	0.00	0.00	0.00
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	15.48	20.81	24.10	29.31	36.94
Yab	= Scour Depth at Abutments	ft	None	None	None	None	None
Yg	= Long Term Degradation (General Scour) =	ft	0.00	0.00	0.00	0.00	0.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	15.48	20.81	24.10	29.31	36.94
Yat	= Total Scour at Abutment = Yab + Yg =	ft	0.00	0.00	0.00	0.00	0.00
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		2.08	1.76	1.56	1.90	2.05
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.00	0.00	0.00	0.00	0.00

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 104.44

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		120.1																						
2	26	119.4	26	-0.7	0.025					L														
3	44	118.3	18	-3.1	0.025					C														
4	81	106.2	37	-10.1	0.025					C														
5	88	102.2	7	-4	0.025	4.41	4.52	3.93	0.97	C	258			258	58.58			4.41			3.93			2.24
6	180	102.2	92		0.025	206.52	92.00	92.00	2.24	C	21,109			21,109	102.21			206.52			92.00			2.24
7	273	97.0	93	-5.2	0.025	450.57	93.15	93.00	4.84	C	76,849			76,849	170.56			450.57			93.00			7.44
8	284	99.4	11	2.4	0.025	68.69	11.26	11.00	6.10	C	13,678			13,678	199.12			68.69			11.00			5.04
9	329	99.7	45	0.3	0.025	220.27	45.00	45.00	4.89	C	37,866			37,866	171.91			220.27			45.00			4.74
10	350	103.6	21	3.9	0.025	58.69	21.36	21.00	2.75	C	6,865			6,865	116.96			58.69			21.00			0.84
11	360	102.4	10	-1.2	0.025	14.45	10.07	10.00	1.43	C	1,095			1,095	75.82			14.45			10.00			2.04
12	630	99.6	270	-2.8	0.025	930.11	270.01	270.00	3.44	C	126,489			126,489	135.99			930.11			270.00			4.84
13	720	102.3	90	2.7	0.025	314.54	90.04	90.00	3.49	C	43,177			43,177	137.27			314.54			90.00			2.14
14	990	102.4	270	0.1	0.025	565.61	270.00	270.00	2.09	C	55,204			55,204	97.60			565.61			270.00			2.04
15	1025	102.0	35	-0.4	0.025	78.57	35.00	35.00	2.24	C	8,030			8,030	102.20			78.57			35.00			2.44
16	1057	101.8	32	-0.2	0.025	81.43	32.00	32.00	2.54	C	9,050			9,050	111.13			81.43			32.00			2.64
17	1440	100.6	383	-1.2	0.025	1,242.77	383.00	383.00	3.24	C	162,406			162,406	130.68			1,242.77			383.00			3.84
18	1479	100.8	39	0.2	0.025	146.05	39.00	39.00	3.74	C	21,000			21,000	143.79			146.05			39.00			3.64
19	1533	119.0	54	18.2	0.025	19.71	11.41	10.81	1.73	C	1,691			1,691	85.81			19.71			10.81			
20	1620	119.8	87	0.8	0.025					R														
21	1620	119.8			0.025					R														
22	1620	119.8			0.025					R														
Total			1,620.00	(0.30)	0.525	4,402.38	1,407.83	1,405.74	45.77		584,787			584,787				4,402			1,405.74			
Maximum	1,520.00	120.1	383.00	18.20	0.025	1,242.77	383.00	383.00	6.10						199.12			1,242.77						7.44
Minimum		97.0		(10.10)	0.025																			
Range	1,520.00	23.1	383.00	28.30		1,242.77	383.00	383.00	6.10															
Average	715.86	107.1	77.14	(0.01)	0.025	209.84	67.04	66.94	2.18															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			23,000	23,000
V			5.22	
T			1,406	1,406
Y			7.44	
A			4,402	4,402

Solve for the 2nd Water Surface Elevation WSEL = 108.79

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		120.1																						
2	26	119.4	26	-0.7	0.025					L														
3	44	116.3	18	-3.1	0.025					C														
4	81	106.2	37	-10.1	0.025	12.29	9.84	9.49	1.25	C	850			850	69.14			12.29			9.49			2.59
5	88	102.2	7	-4	0.025	32.13	8.06	7.00	3.99	C	4,816			4,816	149.89			32.13			7.00			6.59
6	180	102.2	92		0.025	606.30	92.00	92.00	6.59	C	127,098			127,098	209.63			606.30			92.00			6.59
7	273	97.0	93	-5.2	0.025	854.69	93.15	93.00	9.16	C	223,429			223,429	261.42			854.69			93.00			11.79
8	284	99.4	11	2.4	0.025	116.49	11.26	11.00	10.35	C	32,993			32,993	283.22			116.49			11.00			9.39
9	329	99.7	45	0.3	0.025	415.81	45.00	45.00	9.24	C	109,205			109,205	262.63			415.81			45.00			9.09
10	350	103.6	21	3.9	0.025	149.94	21.36	21.00	7.02	C	32,786			32,786	218.66			149.94			21.00			5.19
11	360	102.4	10	-1.2	0.025	57.90	10.07	10.00	5.75	C	11,081			11,081	191.38			57.90			10.00			6.39
12	630	99.6	270	-2.8	0.025	2,103.35	270.01	270.00	7.79	C	492,954			492,954	234.37			2,103.35			270.00			9.19
13	720	102.3	90	2.7	0.025	705.62	90.04	90.00	7.84	C	166,036			166,036	235.31			705.62			90.00			6.49
14	990	102.4	270	0.1	0.025	1,738.85	270.00	270.00	6.44	C	358,960			358,960	206.43			1,738.85			270.00			6.39
15	1025	102.0	35	-0.4	0.025	230.86	35.00	35.00	6.59	C	48,350			48,350	209.62			230.86			35.00			6.79
16	1057	101.8	32	-0.2	0.025	220.49	32.00	32.00	6.89	C	47,613			47,613	215.94			220.49			32.00			6.99
17	1440	100.8	383	-1.2	0.025	2,907.05	383.00	383.00	7.59	C	669,616			669,616	230.34			2,907.05			383.00			8.19
18	1479	100.8	39	0.2	0.025	315.52	39.00	39.00	8.09	C	75,836			75,836	240.35			315.52			39.00			7.99
19	1533	119.0	54	18.2	0.025	94.71	25.02	23.71	3.79	C	13,718			13,718	144.84			94.71			23.71			
20	1620	119.8	87	0.8	0.025					R														
21	1620	119.8			0.025					R														
22	1620	119.8			0.025					R														
Total			1,620.00	(0.30)	0.525	10,561.81	1,434.81	1,431.20	108.37		2,415,341			2,415,341				10,562			1,431.20			
Maximum	1,620.00	120.1	383.00	18.20	0.025	2,907.05	383.00	383.00	10.35						283.22			2,907.05						11.79
Minimum		97.0		(10.10)	0.025																			
Range	1,620.00	23.1	383.00	28.30		2,907.05	383.00	383.00	10.35															
Average	715.86	107.1	77.14	(0.01)	0.025	502.94	68.32	68.15	5.16						160.15									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			95,000	95,000
V			8.99	
T			1,431	1,431
Y			11.79	
A			10,562	10,562

Solve for the 3rd Water Surface Elevation WSEL = 112.43

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		120.1																						
2	26	119.4	26	-0.7	0.025					L														
3	44	116.3	18	-3.1	0.025					C														
4	81	106.2	37	-10.1	0.025	71.13	23.66	22.83	3.01	C	8,834			8,834	124.18			71.13			22.83			6.23
5	88	102.2	7	-4	0.025	57.62	8.06	7.00	7.15	C	12,751			12,751	221.29			57.62			7.00			10.23
6	180	102.2	92		0.025	941.33	92.00	92.00	10.23	C	264,621			264,621	281.12			941.33			92.00			10.23
7	273	97.0	93	-5.2	0.025	1,193.36	93.15	93.00	12.81	C	389,756			389,756	326.60			1,193.36			93.00			15.43
8	284	99.4	11	2.4	0.025	156.55	11.26	11.00	13.90	C	53,999			53,999	344.93			156.55			11.00			13.03
9	329	99.7	45	0.3	0.025	579.68	45.00	45.00	12.88	C	190,013			190,013	327.79			579.68			45.00			12.73
10	350	103.6	21	3.9	0.025	226.42	21.36	21.00	10.60	C	65,170			65,170	287.83			226.42			21.00			8.83
11	360	102.4	10	-1.2	0.025	94.32	10.07	10.00	9.36	C	24,993			24,993	264.99			94.32			10.00			10.03
12	630	99.6	270	-2.8	0.025	3,086.59	270.01	270.00	11.43	C	934,268			934,268	302.69			3,086.59			270.00			12.83
13	720	102.3	90	2.7	0.025	1,033.36	90.04	90.00	11.48	C	313,614			313,614	303.49			1,033.36			90.00			10.13
14	990	102.4	270	0.1	0.025	2,722.09	270.00	270.00	10.08	C	757,718			757,718	278.36			2,722.09			270.00			10.03
15	1025	102.0	35	-0.4	0.025	358.11	35.00	35.00	10.23	C	100,667			100,667	281.10			358.11			35.00			10.43
16	1057	101.8	32	-0.2	0.025	337.02	32.00	32.00	10.53	C	96,583			96,583	286.58			337.02			32.00			10.63
17	1440	100.6	383	-1.2	0.025	4,301.78	383.00	383.00	11.23	C	1,286,893			1,286,893	299.15			4,301.78			383.00			11.83
18	1479	100.8	39	0.2	0.025	457.54	39.00	39.00	11.73	C	140,909			140,909	307.97			457.54			39.00			11.63
19	1533	119.0	54	18.2	0.025	200.72	36.42	34.51	5.51	C	37,346			37,346	186.06			200.72			34.51			
20	1620	119.8	87	0.8	0.025					R														
21	1620	119.8			0.025					R														
22	1620	119.8			0.025					R														
Total			1,620.00	(0.30)	0.525	15,817.60	1,460.94	1,455.34	182.15		4,676,134			4,676,134				15,818			1,455.34			
Maximum	1,620.00	120.1	383.00	18.20	0.025	4,301.78	383.00	383.00	13.90						344.93			4,301.78						15.43
Minimum		97.0		(10.10)	0.025																			
Range	1,620.00	23.1	383.00	28.30		4,301.78	383.00	383.00	13.90															
Average	715.88	107.1	77.14	(0.01)	0.025	753.22	69.53	69.30	7.72						210.67									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			184,000	184,000
V			11.63	
T			1,455	1,455
Y			15.43	
A			15,818	15,818

Solve for the 4th Water Surface Elevation WSEL = 112.43

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		120.1																						
2	26	119.4	26	-0.7	0.025					L														
3	44	116.3	18	-3.1	0.025					C														
4	81	106.2	37	-10.1	0.025	71.13	23.66	22.83	3.01	C	8,834			8,834	124.18			71.13			22.83			6.23
5	88	102.2	7	-4	0.025	57.62	8.06	7.00	7.15	C	12,751			12,751	221.29			57.62			7.00			10.23
6	180	102.2	92		0.025	941.33	92.00	92.00	10.23	C	264,621			264,621	281.12			941.33			92.00			10.23
7	273	97.0	93	-5.2	0.025	1,193.36	93.15	93.00	12.81	C	389,756			389,756	326.60			1,193.36			93.00			15.43
8	284	99.4	11	2.4	0.025	156.55	11.26	11.00	13.90	C	53,999			53,999	344.93			156.55			11.00			13.03
9	329	99.7	45	0.3	0.025	579.68	45.00	45.00	12.88	C	190,013			190,013	327.79			579.68			45.00			12.73
10	350	103.6	21	3.9	0.025	226.42	21.36	21.00	10.60	C	65,170			65,170	287.83			226.42			21.00			8.83
11	360	102.4	10	-1.2	0.025	94.32	10.07	10.00	9.38	C	24,993			24,993	264.99			94.32			10.00			10.03
12	630	99.6	270	-2.8	0.025	3,086.59	270.01	270.00	11.43	C	934,268			934,268	302.69			3,086.59			270.00			12.83
13	720	102.3	90	2.7	0.025	1,033.36	90.04	90.00	11.48	C	313,614			313,614	303.49			1,033.36			90.00			10.13
14	990	102.4	270	0.1	0.025	2,722.09	270.00	270.00	10.08	C	757,718			757,718	278.36			2,722.09			270.00			10.03
15	1025	102.0	35	-0.4	0.025	358.11	35.00	35.00	10.23	C	100,667			100,667	281.10			358.11			35.00			10.43
16	1057	101.8	32	-0.2	0.025	337.02	32.00	32.00	10.53	C	96,583			96,583	286.58			337.02			32.00			10.63
17	1440	100.6	383	-1.2	0.025	4,301.78	383.00	383.00	11.23	C	1,286,893			1,286,893	299.15			4,301.78			383.00			11.83
18	1479	100.8	39	0.2	0.025	457.54	39.00	39.00	11.73	C	140,909			140,909	307.97			457.54			39.00			11.63
19	1533	119.0	54	18.2	0.025	200.72	36.42	34.51	5.51	C	37,346			37,346	186.06			200.72			34.51			
20	1620	119.8	87	0.8	0.025					R														
21	1620	119.8			0.025					R														
22	1620	119.8			0.025					R														
Total			1,620.00	(0.30)	0.525	15,817.60	1,460.04	1,455.34	182.18		4,678,134			4,678,134				15,818			1,455.34			
Maximum	1,620.00	120.1	383.00	18.20	0.025	4,301.78	383.00	383.00	13.90						344.93			4,301.78						15.43
Minimum		97.0		(10.10)	0.025																			
Range	1,620.00	23.1	383.00	28.30		4,301.78	383.00	383.00	13.90															
Average	715.86	107.1	77.14	(0.01)	0.025	753.22	69.53	69.35	7.72						210.67									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			184,000	184,000
V			11.63	
T			1,455	1,455
Y			15.43	
A			15,818	15,818

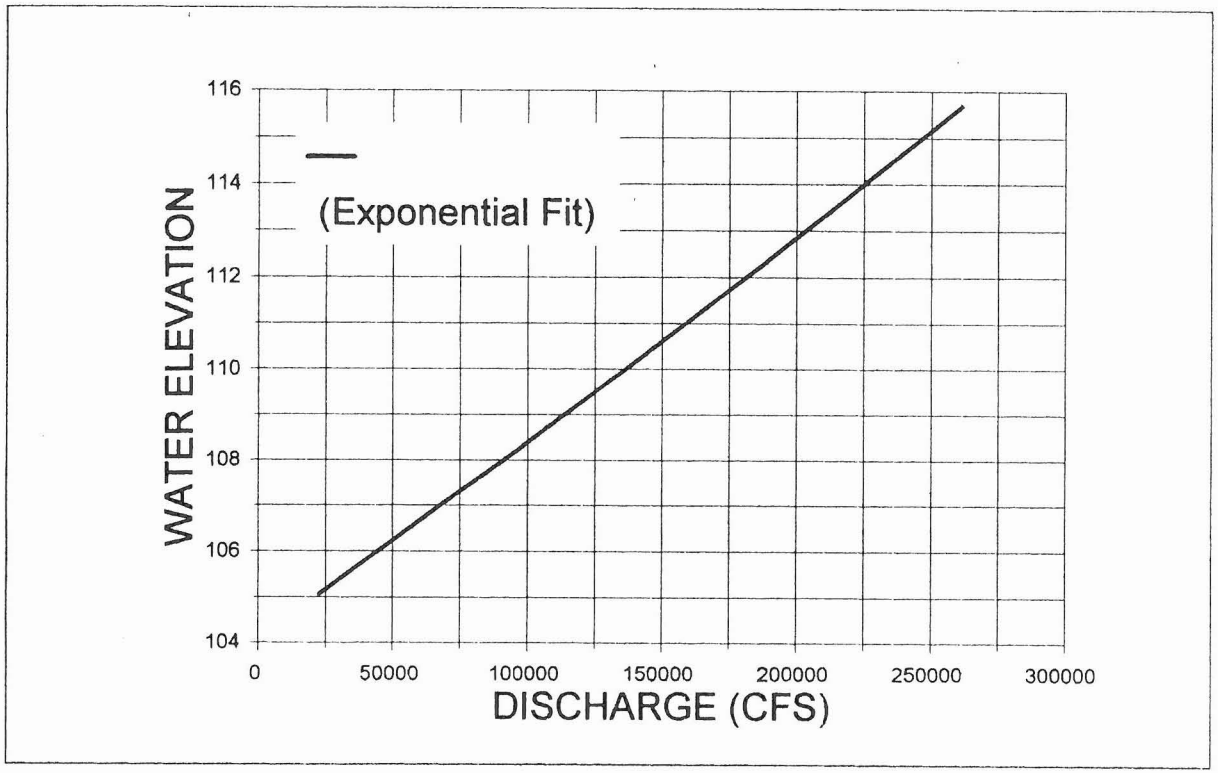
Solve for the 5th Water Surface Elevation WSEL = 115.03

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		120.1																						
2	26	119.4	26	-0.7	0.025					L														
3	44	116.3	18	-3.1	0.025					C														
4	81	106.2	37	-10.1	0.025	142.81	33.53	32.35	4.26	C	22,376			22,376	156.68			142.81			32.35			8.83
5	88	102.2	7	-4	0.025	75.81	8.06	7.00	9.40	C	20,144			20,144	265.72			75.81			7.00			12.83
6	180	102.2	92		0.025	1,180.36	92.00	92.00	12.83	C	385,876			385,876	326.91			1,180.36			92.00			12.83
7	273	97.0	93	-5.2	0.025	1,434.99	93.15	93.00	15.41	C	530,009			530,009	369.35			1,434.99			93.00			18.03
8	284	99.4	11	2.4	0.025	185.13	11.26	11.00	16.44	C	71,414			71,414	385.75			185.13			11.00			15.63
9	329	99.7	45	0.3	0.025	696.60	45.00	45.00	15.48	C	258,108			258,108	370.52			696.60			45.00			15.33
10	350	103.6	21	3.9	0.025	280.98	21.36	21.00	13.16	C	93,402			93,402	332.42			280.98			21.00			11.43
11	360	102.4	10	-1.2	0.025	120.30	10.07	10.00	11.94	C	37,495			37,495	311.68			120.30			10.00			12.63
12	630	99.6	270	-2.8	0.025	3,788.10	270.01	270.00	14.03	C	1,314,437			1,314,437	346.99			3,788.10			270.00			15.43
13	720	102.3	90	2.7	0.025	1,267.20	90.04	90.00	14.07	C	440,635			440,635	347.72			1,267.20			90.00			12.73
14	990	102.4	270	0.1	0.025	3,423.60	270.00	270.00	12.68	C	1,110,478			1,110,478	324.36			3,423.60			270.00			12.63
15	1025	102.0	35	-0.4	0.025	449.05	35.00	35.00	12.83	C	146,794			146,794	326.90			449.05			35.00			13.03
16	1057	101.8	32	-0.2	0.025	420.16	32.00	32.00	13.13	C	139,488			139,488	331.99			420.16			32.00			13.23
17	1440	100.6	383	-1.2	0.025	5,296.89	383.00	383.00	13.83	C	1,820,516			1,820,516	343.70			5,296.89			383.00			14.43
18	1479	100.8	39	0.2	0.025	558.87	39.00	39.00	14.33	C	196,684			196,684	351.93			558.87			39.00			14.23
19	1533	119.0	54	18.2	0.025	300.40	44.55	42.22	8.74	C	63,939			63,939	212.85			300.40			42.22			
20	1620	119.8	87	0.8	0.025					R														
21	1620	119.8			0.025					R														
22	1620	119.8			0.025					R														
Total			1,620.00	(0.30)	0.525	19,621.26	1,478.04	1,472.57	200.56		6,651,798			6,651,798				19,621			1,472.57			
Maximum	1,620.00	120.1	383.00	18.20	0.025	5,296.89	383.00	383.00	16.44						385.75			5,296.89						18.03
Minimum		97.0		(10.10)	0.025																			
Range	1,620.00	23.1	383.00	28.30		5,296.89	383.00	383.00	16.44															
Average	715.88	107.1	77.14	(0.01)	0.025	894.35	70.38	70.12	9.55						243.12									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			261,628	261,628
V			13.33	
T			1,473	1,473
Y			18.03	
A			19,621	19,621

DISCHARGE RATING CURVE FOR TYPICAL SECTION

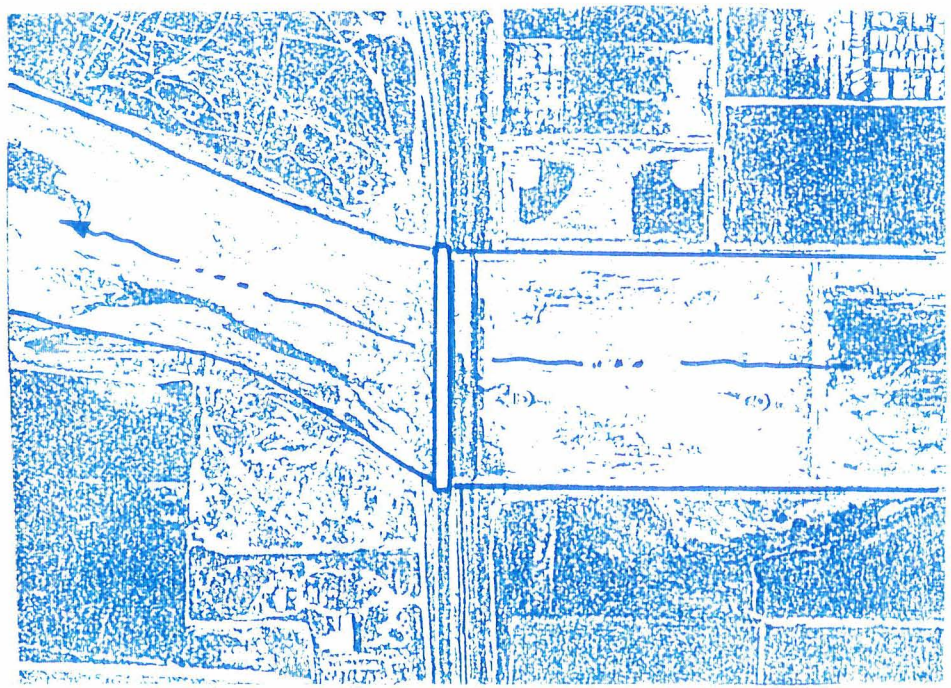
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
104.44	0	0	23,000	23,000	0.00	0.00	5.22	0.00	0.00	7.44	0	0	1,406	1,406
108.79	0	0	95,000	95,000	0.00	0.00	8.99	0.00	0.00	11.79	0	0	1,431	1,431
112.43	0	0	184,000	184,000	0.00	0.00	11.63	0.00	0.00	15.43	0	0	1,455	1,455
112.43	0	0	184,000	184,000	0.00	0.00	11.63	0.00	0.00	15.43	0	0	1,455	1,455
115.03	0	0	261,628	261,628	0.00	0.00	13.33	0.00	0.00	18.03	0	0	1,473	1,473



BRIDGE 6 - MARICOPA HIGHWAY 85 (SN 7819)

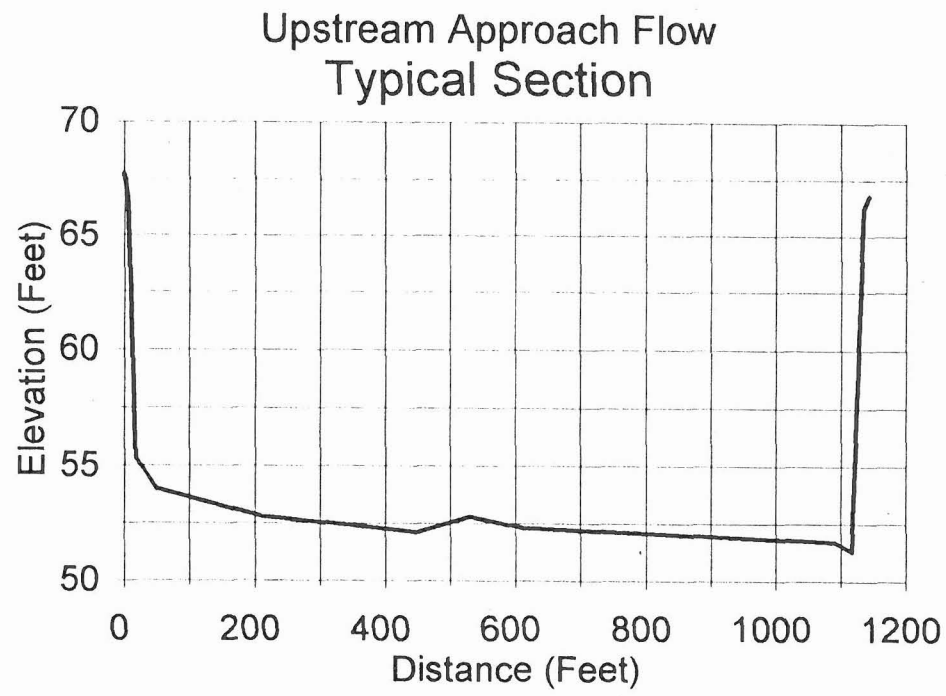
MARICOPA COUNTY HIGHWAY 85 (SN 7819)

Water Course	Agua Fria River
Stream Form	Braided to straight
Sinuosity	Not applicable
General Channelization	Soil cement-lined channel US of bridge and along west bank DS. Unlined on east.
Channel Slope	Steeper DS
Estimated Channel Slope (ft/ft)	0.002534
Channel Contraction/Expansion	Main channel narrower DS
Primary Surface Sediment Type	silt/sand/gravel
D50 Size	1 MM (estimate)
Armoring Potential	Low to moderate (locally)
Channel Vegetation	
Type/Size	Salt Bush, Ephedra, tall grasses, low dry grasses.
Density/Occurrence	(US) Very sparse low brush; dry grasses toward banks; moist grasses beneath bridge near east abutment. (DS) Dry grasses.
Relative Age	Mature
Manning's Roughness Coef.	0.028
Controls on Stream Migration	
Lateral	Soil cement-lined channel US and along west bank DS.
Vertical	Large diameter rip-rap placed around piers across channel bottom extending 25 ft. US/DS of pier; grade control structure approximately 2000 ft. US of structure.
Sediment Deposits & Bars	(US) No significant bar formation. (DS) Primarily low to moderate elongate middle bars.
Evidence of Degradation	Incised channel DS; headcutting of rip-rap DS.
Evidence of Aggradation	No
Evidence of Scour	
Pier	No
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Moderate rate; land use west of channel primarily high density residential and commercial; land use to east primarily agricultural; general assumption is for increasing urbanization to the east.
Sand & Gravel Extraction	Past operations in channel US/DS of bridge. Channel currently undergoing rapid adjustment to operations in channel immediately DS of bridge.
Freeway Construction	No
Dams	No
Drainage Channels	No



INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	67.7		
2	6	66.4	0.028	C
3	18	55.3	0.028	C
4	50	54.0	0.028	C
5	211	52.8	0.028	C
6	451	52.1	0.028	C
7	531	52.8	0.028	C
8	611	52.3	0.028	C
9	1091	51.7	0.028	C
10	1118	51.3	0.028	C
11	1135	66.2	0.028	C
12	1144	66.8	0.028	C
13	1144	66.8	0.028	C
14	1144	66.8	0.028	C
15	1144	66.8	0.028	C
16	1144	66.8	0.028	C
17	1144	66.8	0.028	C
18	1144	66.8	0.028	C
19	1144	66.8	0.028	C
20	1144	66.8	0.028	C
21	1144	66.8	0.028	C
22	1144	66.8	0.028	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	66.25
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	73.77
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	66.25
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	51.30
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	66.25
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	51.30
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00253

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	22,000	55.74	22,000	0.00
2		69,000	59.04	69,000	0.00
3	Q100	95,000	60.44	95,000	0.00
4	Q500	184,000	64.33	184,000	0.00
5	Low Chord	236,201	66.25	236,201	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	37.06
Ws	= Width of Scour Protection =	Feet	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	Unknown
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		14.24

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	37.06
Ws	= Width of Scour Protection =	Full or Part?	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	Unknown
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		14.24

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	37.06
Ws	= Width of Scour Protection =	Feet	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	Unknown
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		14.24

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	Yes
ELs = Top Elevation of Scour Protection =	Feet	37.06
Ds = Distance Downstream =	Feet	0
S = Average Channel Slope = Average Energy Slope =		0.002534
Ws = Width of Scour Protection =	Feet	Full
Ls = Length of Scour Protection =	Feet	Full
Ts = Thickness of Scour Protection =	Inches	Unknown
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material = Material of Scour Protection =		Rock
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		14.24

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0025	0.0025	0.0025	0.0025	0.0025
Angle	= *Angle of Attack* =	*Degrees*	0	0	0	0	0
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	3.50	3.50	3.50	3.50	3.50
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	7.50	7.50	7.50	7.50	7.50
L	= Pier Length =	ft	60.00	60.00	60.00	60.00	60.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	90	90	90	90	90

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	73.77	73.77	73.77	73.77	73.77
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	66.25	66.25	66.25	66.25	66.25
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	55.74	59.04	60.44	64.33	66.25
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	51.30	51.30	51.30	51.30	51.30
y1	= Average Depth in the Upstream Main Channel =	ft	4.44	7.74	9.14	13.03	14.95
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	1,106	1,113	1,116	1,125	1,130
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	1,106	1,113	1,116	1,125	1,130
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	22,000	69,000	95,000	184,000	236,201
Q2	= Flow in the Contracted Channel =	cfs	22,000	69,000	95,000	184,000	236,201
V1	= Mean Velocity of Flow Upstream of Pier =	fps	6.05	9.45	10.72	13.92	15.36
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.51	0.60	0.62	0.68	0.70
S1	= Energy Slope in Main Channel =		0.00253	0.00253	0.00253	0.00253	0.00253

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	1.99	2.19	2.25	2.39	2.44
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.33	0.23	0.21	0.17	0.16
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.60	0.79	0.86	1.03	1.10
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00307	0.00307	0.00307	0.00307	0.00307
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.37	0.37	0.37	0.37	0.37
U/w	= Ratio of Shear Velocity to Fall Velocity =		1.63	2.15	2.34	2.80	2.99
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.69	0.69	0.69	0.69
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	4.44	7.74	9.14	13.03	14.95
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	6.05	9.45	10.72	13.92	15.36
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	1.65	4.76	6.40	11.72	14.70
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	4.95	14.29	19.20	35.16	44.10
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Local Scour at Piers

Variable	Description	Trial No. / Unit	1 Value	2 Value	3 Value	4 Value	5 Value
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	10.51	7.21	5.81	1.92	0.00
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	4.44	7.74	9.14	13.03	14.95
L/a	= Ratio Used in Table 3 to Find K2 =		8.00	8.00	8.00	8.00	8.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.51	0.60	0.62	0.68	0.70
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.00	1.00	1.00	1.00	1.00
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.00
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	10.24	13.38	14.45	16.95	18.02
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	28.69	37.47	40.45	47.47	50.45
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	6.05	9.45	10.72	13.92	15.36
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	6.43	15.71	20.21	34.05	41.46
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	19.30	47.12	60.64	102.15	124.37
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	15.00	15.00	15.00	15.00	15.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	10.24	13.38	14.45	16.95	18.02

Compute Local Scour at Abutments		Trial No	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.00	1.00	1.00	1.00	1.00
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	None

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	14.24	14.24	14.24	14.24	14.24
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	10.24	13.38	14.45	16.95	18.02
Yab	= Scour Depth at Abutments	ft	None	None	None	None	None
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	14.24	17.38	18.45	20.95	22.02
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	4.00
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		3.21	2.25	2.02	1.61	1.47
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.90	0.52	0.44	0.31	0.27

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 55.74

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.7																						
2	6	66.4	6	-1.3	0.028					C														
3	18	55.3	12	-11.1	0.028	0.10	0.64	0.47	0.16	C	2			2	15.69			0.10			0.47			0.41
4	50	54.0	32	-1.3	0.028	34.77	32.03	32.00	1.09	C	1,954			1,954	56.21			34.77			32.00			1.74
5	211	52.8	161	-1.2	0.028	376.16	161.00	161.00	2.34	C	35,255			35,255	93.72			376.16			161.00			2.94
6	451	52.1	240	-0.7	0.028	788.74	240.00	240.00	3.29	C	92,815			92,815	117.67			788.74			240.00			3.64
7	531	52.8	80	0.7	0.028	262.91	80.00	80.00	3.29	C	30,937			30,937	117.67			262.91			80.00			2.94
8	611	52.3	80	-0.5	0.028	254.91	80.00	80.00	3.19	C	29,385			29,385	115.27			254.91			80.00			3.44
9	1091	51.7	480	-0.6	0.028	1,793.48	480.00	480.00	3.74	C	229,907			229,907	128.19			1,793.48			480.00			4.04
10	1118	51.3	27	-0.4	0.028	114.38	27.00	27.00	4.24	C	15,943			15,943	139.38			114.38			27.00			4.44
11	1135	66.2	17	14.9	0.028	11.23	6.73	5.06	1.67	C	841			841	74.86			11.23			5.06			
12	1144	66.8	9	0.6	0.028					C														
13	1144	66.8			0.028					C														
14	1144	66.8			0.028					C														
15	1144	66.8			0.028					C														
16	1144	66.8			0.028					C														
17	1144	66.8			0.028					C														
18	1144	66.8			0.028					C														
19	1144	66.8			0.028					C														
20	1144	66.8			0.028					C														
21	1144	66.8			0.028					C														
22	1144	66.8			0.028					C														
Total			1,144.00	-0.90	0.588	3,636.69	1,107.41	1,105.53	22.98		437,038			437,038				3,637			1,105.53			
Maximum	1,144.00	67.7	480.00	14.90	0.028	1,793.48	480.00	480.00	4.24						139.38			1,793.48						4.44
Minimum		51.3		-11.10	0.028																			
Range	1,144.00	16.4	480.00	26.00		1,793.48	480.00	480.00	4.24															
Average	809.36	61.7	54.48	-0.04	0.028	173.18	52.73	52.64	1.09															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			22,000	22,000
V			6.05	
T			1,106	1,106
Y			4.44	
A			3,637	3,637

Solve for the 2nd Water Surface Elevation WSEL = 59.04

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.7																						
2	6	66.4	6	-1.3	0.028					C														
3	18	55.3	12	-11.1	0.028	7.56	5.51	4.04	1.37	C	497			497	65.73			7.56			4.04			3.74
4	50	54.0	32	-1.3	0.028	140.46	32.03	32.00	4.39	C	20,036			20,036	142.65			140.46			32.00			5.04
5	211	52.8	161	-1.2	0.028	907.93	161.00	161.00	5.64	C	153,157			153,157	168.69			907.93			161.00			6.24
6	451	52.1	240	-0.7	0.028	1,581.43	240.00	240.00	6.59	C	295,967			295,967	187.15			1,581.43			240.00			6.94
7	531	52.8	80	0.7	0.028	527.14	80.00	80.00	6.59	C	98,653			98,653	187.15			527.14			80.00			6.24
8	611	52.3	80	-0.5	0.028	519.14	80.00	80.00	6.49	C	96,171			96,171	185.25			519.14			80.00			6.74
9	1091	51.7	480	-0.6	0.028	3,378.86	480.00	480.00	7.04	C	660,847			660,847	195.58			3,378.86			480.00			7.34
10	1118	51.3	27	-0.4	0.028	203.56	27.00	27.00	7.54	C	41,675			41,675	204.73			203.56			27.00			7.74
11	1135	66.2	17	14.9	0.028	34.17	11.74	8.83	2.91	C	3,708			3,708	108.51			34.17			8.83			
12	1144	66.8	9	0.6	0.028					C														
13	1144	66.8			0.028					C														
14	1144	66.8			0.028					C														
15	1144	66.8			0.028					C														
16	1144	66.8			0.028					C														
17	1144	66.8			0.028					C														
18	1144	66.8			0.028					C														
19	1144	66.8			0.028					C														
20	1144	66.8			0.028					C														
21	1144	66.8			0.028					C														
22	1144	66.8			0.028					C														
Total			1,144.00	-0.90	0.588	7,300.25	1,117.29	1,112.87	48.55		1,370,711			1,370,711				7,300			1,112.87			
Maximum	1,144.00	67.7	480.00	14.90	0.028	3,378.86	480.00	480.00	7.54						204.73			3,378.86						7.74
Minimum		51.3		-11.10	0.028																			
Range	1,144.00	16.4	480.00	26.00		3,378.86	480.00	480.00	7.54															
Average	809.36	61.7	54.48	-0.04	0.028	347.63	53.20	52.99	2.31						68.83									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			69,000	69,000
V			9.45	
T			1,113	1,113
Y			7.74	
A			7,300	7,300

Solve for the 3rd Water Surface Elevation WSEL = 60.44

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.7																						
2	6	66.4	6	-1.3	0.028					C														
3	18	55.3	12	-11.1	0.028	14.28	7.57	5.56	1.89	C	1,160			1,160	81.26			14.28			5.56			5.14
4	50	54.0	32	-1.3	0.028	185.26	32.03	32.00	5.78	C	31,787			31,787	171.58			185.26			32.00			6.44
5	211	52.8	161	-1.2	0.028	1,133.34	161.00	161.00	7.04	C	221,660			221,660	195.58			1,133.34			161.00			7.64
6	451	52.1	240	-0.7	0.028	1,917.45	240.00	240.00	7.99	C	408,064			408,064	212.82			1,917.45			240.00			8.34
7	531	52.8	80	0.7	0.028	639.15	80.00	80.00	7.99	C	136,018			136,018	212.81			639.15			80.00			7.64
8	611	52.3	80	-0.5	0.028	631.15	80.00	80.00	7.89	C	133,194			133,194	211.03			631.15			80.00			8.14
9	1091	51.7	480	-0.6	0.028	4,050.91	480.00	480.00	8.44	C	894,190			894,190	220.74			4,050.91			480.00			8.74
10	1118	51.3	27	-0.4	0.028	241.36	27.00	27.00	8.94	C	55,359			55,359	229.36			241.36			27.00			9.14
11	1135	66.2	17	14.9	0.028	47.65	13.87	10.43	3.44	C	5,777			5,777	121.23			47.65			10.43			
12	1144	66.8	9	0.6	0.028					C														
13	1144	66.8			0.028					C														
14	1144	66.8			0.028					C														
15	1144	66.8			0.028					C														
16	1144	66.8			0.028					C														
17	1144	66.8			0.028					C														
18	1144	66.8			0.028					C														
19	1144	66.8			0.028					C														
20	1144	66.8			0.028					C														
21	1144	66.8			0.028					C														
22	1144	66.8			0.028					C														
Total			1,144.00	-0.90	0.588	8,860.56	1,121.47	1,115.98	59.39		1,887,210			1,887,210				8,861			1,115.98			
Maximum	1,144.00	67.7	480.00	14.90	0.028	4,050.91	480.00	480.00	8.94						229.36			4,050.91						9.14
Minimum		51.3		-11.10	0.028																			
Range	1,144.00	16.4	480.00	26.00		4,050.91	480.00	480.00	8.94															
Average	809.36	61.7	54.48	-0.04	0.028	421.93	53.40	53.14	2.83						78.88									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			95,000	95,000
V			10.72	
T			1,116	1,116
Y			9.14	
A			8,861	8,861

Solve for the 4th Water Surface Elevation WSEL = 64.33

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.7																						
2	6	66.4	6	-1.3	0.028					C														
3	18	55.3	12	-11.1	0.028	44.10	13.30	9.76	3.32	C	5,220			5,220	118.37			44.10			9.76			9.03
4	50	54.0	32	-1.3	0.028	309.84	32.03	32.00	9.67	C	74,918			74,918	241.79			309.84			32.00			10.33
5	211	52.8	161	-1.2	0.028	1,760.14	161.00	161.00	10.93	C	461,738			461,738	262.33			1,760.14			161.00			11.53
6	451	52.1	240	-0.7	0.028	2,851.81	240.00	240.00	11.88	C	790,884			790,884	277.33			2,851.81			240.00			12.23
7	531	52.8	80	0.7	0.028	950.60	80.00	80.00	11.88	C	263,622			263,622	277.32			950.60			80.00			11.53
8	611	52.3	80	-0.5	0.028	942.60	80.00	80.00	11.78	C	259,937			259,937	275.77			942.60			80.00			12.03
9	1091	51.7	480	-0.6	0.028	5,919.63	480.00	480.00	12.33	C	1,682,886			1,682,886	284.29			5,919.63			480.00			12.63
10	1118	51.3	27	-0.4	0.028	346.48	27.00	27.00	12.83	C	101,139			101,139	291.90			346.48			27.00			13.03
11	1135	66.2	17	14.9	0.028	96.89	19.77	14.87	4.90	C	14,884			14,884	153.61			96.89			14.87			
12	1144	66.8	9	0.6	0.028					C														
13	1144	66.8			0.028					C														
14	1144	66.8			0.028					C														
15	1144	66.8			0.028					C														
16	1144	66.8			0.028					C														
17	1144	66.8			0.028					C														
18	1144	66.8			0.028					C														
19	1144	66.8			0.028					C														
20	1144	66.8			0.028					C														
21	1144	66.8			0.028					C														
22	1144	66.8			0.028					C														
Total			1,144.00	-0.90	0.588	13,222.11	1,133.11	1,124.63	89.53		3,655,228			3,655,228				13,222			1,124.63			
Maximum	1,144.00	67.7	480.00	14.90	0.028	5,919.63	480.00	480.00	12.83						291.90			5,919.63						13.03
Minimum		51.3		-11.10	0.028																			
Range	1,144.00	16.4	480.00	26.00		5,919.63	480.00	480.00	12.83															
Average	809.36	61.7	54.48	-0.04	0.028	629.62	53.96	53.55	4.26						103.94									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			184,000	184,000
V			13.92	
T			1,125	1,125
Y			13.03	
A			13,222	13,222

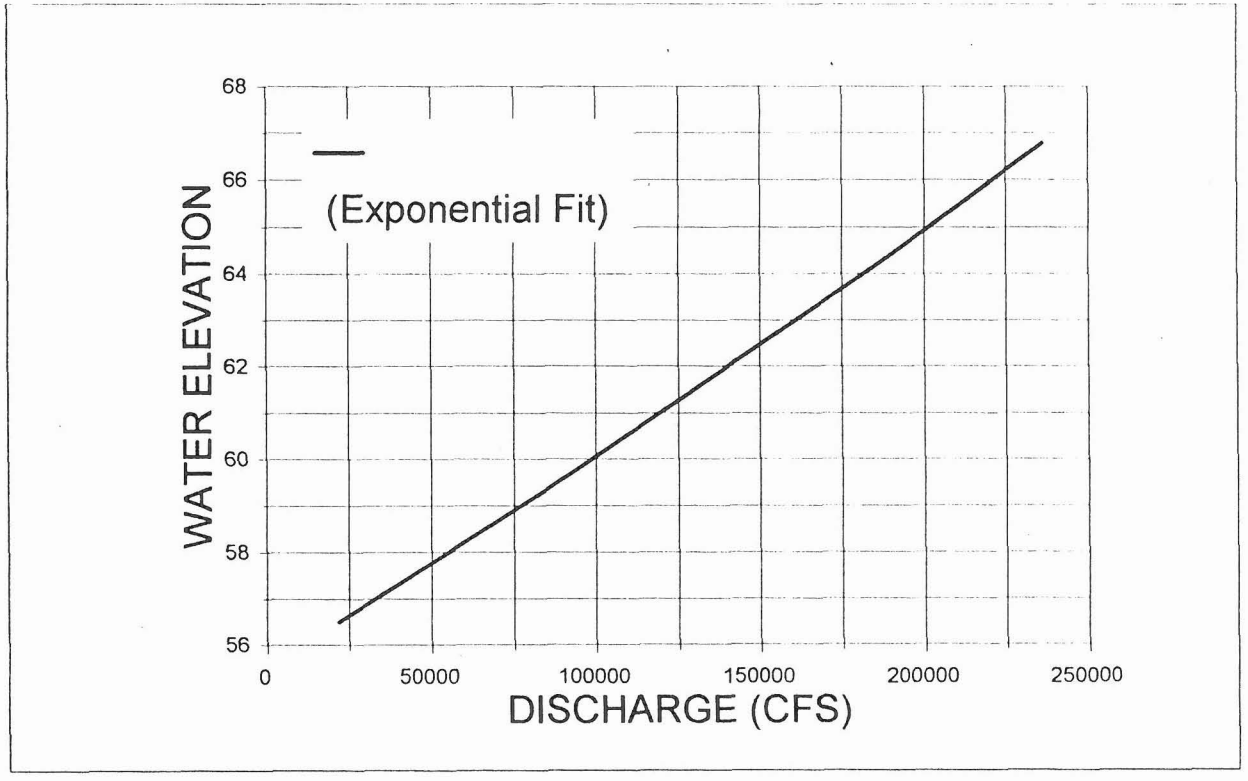
Solve for the 5th Water Surface Elevation WSEL = 66.25

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		67.7																						
2	6	66.4	6	-1.3	0.028					C														
3	18	55.3	12	-11.1	0.028	64.81	16.13	11.84	4.02	C	8,723			8,723	134.58			64.81			11.84			10.95
4	50	54.0	32	-1.3	0.028	371.20	32.03	32.00	11.59	C	101,249			101,249	272.76			371.20			32.00			12.25
5	211	52.8	161	-1.2	0.028	2,068.85	161.00	161.00	12.85	C	604,488			604,488	292.19			2,068.85			161.00			13.45
6	451	52.1	240	-0.7	0.028	3,312.00	240.00	240.00	13.80	C	1,014,885			1,014,885	306.43			3,312.00			240.00			14.15
7	531	52.8	80	0.7	0.028	1,104.00	80.00	80.00	13.80	C	338,287			338,287	306.42			1,104.00			80.00			13.45
8	611	52.3	80	-0.5	0.028	1,096.00	80.00	80.00	13.70	C	334,215			334,215	304.94			1,096.00			80.00			13.95
9	1091	51.7	480	-0.6	0.028	6,840.00	480.00	480.00	14.25	C	2,141,305			2,141,305	313.06			6,840.00			480.00			14.55
10	1118	51.3	27	-0.4	0.028	398.25	27.00	27.00	14.75	C	127,566			127,566	320.32			398.25			27.00			14.95
11	1135	66.2	17	14.9	0.028	127.50	22.61	17.00	5.64	C	21,511			21,511	168.71			127.50			17.00			0.05
12	1144	66.8	9	0.6	0.028	0.02	0.75	0.75	0.02	C	0			0	4.54			0.02			0.75			
13	1144	66.8			0.028					C														
14	1144	66.8			0.028					C														
15	1144	66.8			0.028					C														
16	1144	66.8			0.028					C														
17	1144	66.8			0.028					C														
18	1144	66.8			0.028					C														
19	1144	66.8			0.028					C														
20	1144	66.8			0.028					C														
21	1144	66.8			0.028					C														
22	1144	66.8			0.028					C														
Total			1,144.00	-0.90	0.588	15,382.63	1,139.52	1,129.59	104.42		4,692,229			4,692,229				15,383			1,129.59			
Maximum	1,144.00	67.7	480.00	14.90	0.028	6,840.00	480.00	480.00	14.75						320.32			6,840.00						14.95
Minimum		51.3		-11.10	0.028																			
Range	1,144.00	16.4	480.00	26.00		6,840.00	480.00	480.00	14.75															
Average	809.36	61.7	54.48	-0.04	0.028	732.51	54.26	53.79	4.97						115.43									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			236,201	236,201
V			15.36	
T			1,130	1,130
Y			14.95	
A			15,383	15,383

DISCHARGE RATING CURVE FOR TYPICAL SECTION

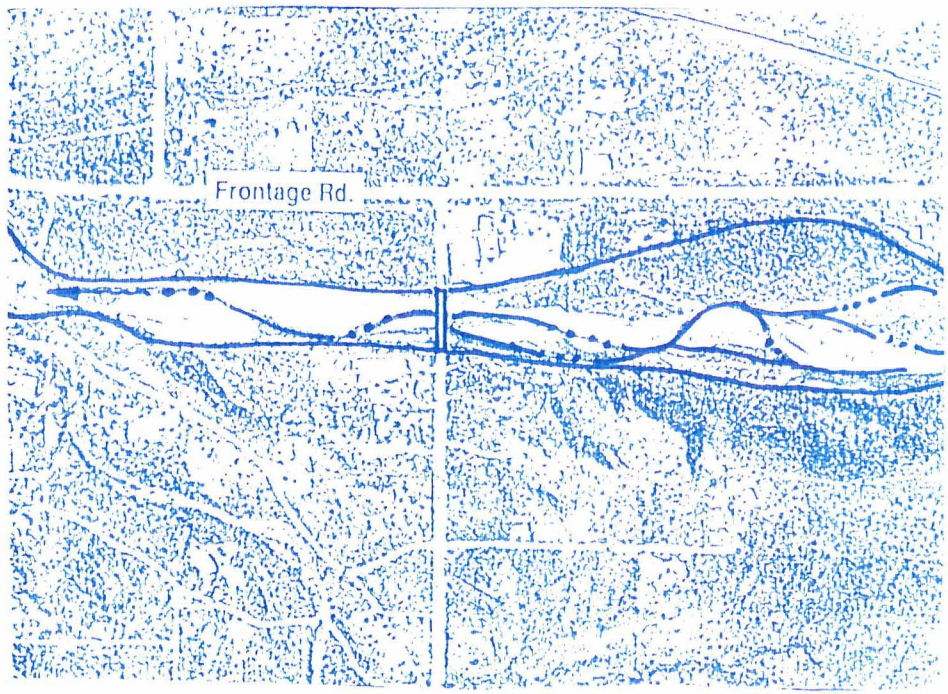
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
55.74	0	0	22,000	22,000	0.00	0.00	6.05	0.00	0.00	4.44	0	0	1,106	1,106
59.04	0	0	69,000	69,000	0.00	0.00	9.45	0.00	0.00	7.74	0	0	1,113	1,113
60.44	0	0	95,000	95,000	0.00	0.00	10.72	0.00	0.00	9.14	0	0	1,116	1,116
64.33	0	0	184,000	184,000	0.00	0.00	13.92	0.00	0.00	13.03	0	0	1,125	1,125
66.25	0	0	236,201	236,201	0.00	0.00	15.36	0.00	0.00	14.95	0	0	1,130	1,130



BRIDGE 7 - NEW RIVER ROAD (SN 8028)

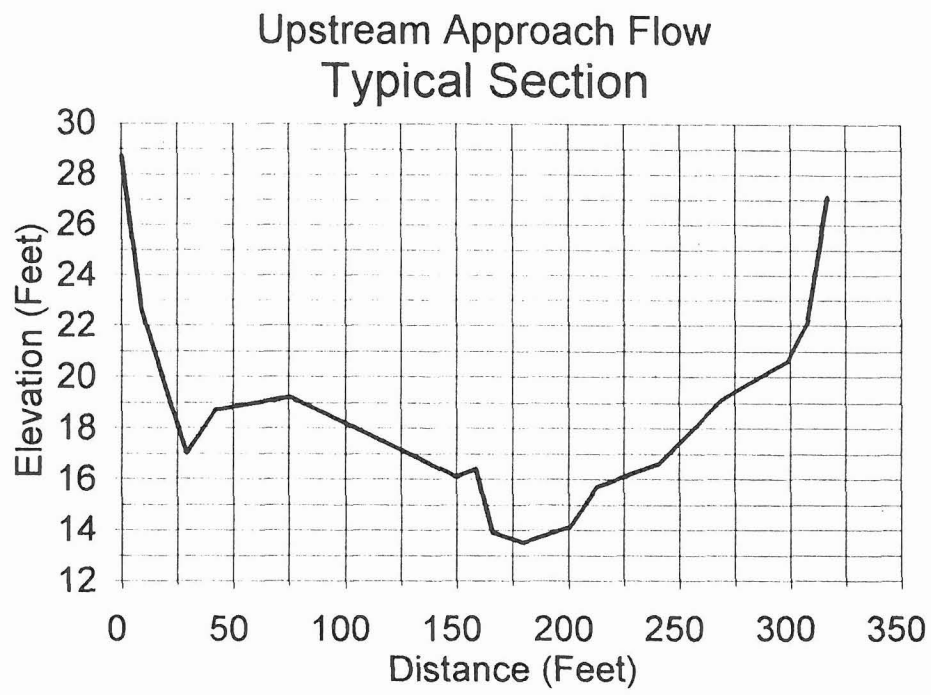
NEW RIVER ROAD (SN 8028)

Water Course	New River
Stream Form	Braided (first order low flow channel sinuous)
Sinuosity	Not applicable
General Channelization	Low earthen levees occasionally broken/missing) along channel banks.
Channel Slope	Steeper US
Estimated Channel Slope (ft/ft)	0.008817
Channel Contraction/Expansion	None
Primary Surface Sediment Type	sand/gravel/cobbles/boulders
D50 Size	
Armoring Potential	Moderate to high (locally)
Channel Vegetation	
Type/Size	Primarily Desert Broom to 5 ft., Desert Willow to 5 ft., Creosote to 4 ft., occasional Ephedra, others.
Density/Occurrence	Moderately dense on banks; sparse in main channel.
Relative Age	Young to mature.
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	Some control along US LB due to rock out crop; otherwise earthen levees relatively low/poor condition.
Vertical	None
Sediment Deposits & Bars	Low to moderate point, alternate and middle bars forming in braided condition. Characteristic of large sediment sizes and relatively steep slope. Reduced clearance in waterway toward west abutment due to sedimentation.
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	Low flow channel has incised alongside mid-span piers.
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Low to moderate rate; generally low density residential and light commercial.
Sand & Gravel Extraction	No
Freeway Construction	No
Dams	No
Drainage Channels	No



INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	28.7		
2	9	22.6	0.035	C
3	29	17.0	0.035	C
4	42	18.7	0.035	C
5	76	19.2	0.035	C
6	150	16.1	0.035	C
7	159	16.4	0.035	C
8	166	13.9	0.035	C
9	180	13.5	0.035	C
10	201	14.1	0.035	C
11	213	15.7	0.035	C
12	241	16.6	0.035	C
13	269	19.1	0.035	C
14	299	20.6	0.035	C
15	308	22.1	0.035	C
16	317	27.1	0.035	C
17	317	27.1	0.035	C
18	317	27.1	0.035	C
19	317	27.1	0.035	C
20	317	27.1	0.035	C
21	317	27.1	0.035	C
22	317	27.1	0.035	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	24.60
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	31.10
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	24.60
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	13.50
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	24.60
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	13.50
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00882

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Assumed	21,909	23.00	21,909	0.00
2	Assumed	28,405	24.00	28,405	0.00
3	Q100	32,000	24.51	32,000	-0.00
4	Low Chord	32,664	24.60	32,664	0.00
5	Q500	73,600	29.19	73,600	-0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Feet	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	
Ws	= Width of Scour Protection =	Feet	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.008817
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.1640	0.1640	0.1640	0.1640	0.1640
Angle	= *Angle of Attack* =	*Degrees*	0	0	0	0	0
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		SHARP	SHARP	SHARP	SHARP	SHARP
a'	= Pier Width Shown on Plans or Measured in Field =	ft	1.33	1.33	1.33	1.33	1.33
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	5.33	5.33	5.33	5.33	5.33
L	= Pier Length =	ft	32.00	32.00	32.00	32.00	32.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	90	90	90	90	90

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	31.10	31.10	31.10	31.10	31.10
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	24.60	24.60	24.60	24.60	24.60
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	23.00	24.00	24.51	24.60	29.19
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	13.50	13.50	13.50	13.50	13.50
y1	= Average Depth in the Upstream Main Channel =	ft	9.50	10.50	11.01	11.10	15.69
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	301	304	306	306	317
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	301	304	306	306	317
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	21,909	28,405	32,000	32,664	73,600
Q2	= Flow in the Contracted Channel =	cfs	21,909	28,405	32,000	32,664	73,600
V1	= Mean Velocity of Flow Upstream of Pier =	fps	13.30	14.57	15.20	15.31	20.62
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.76	0.79	0.81	0.81	0.92
S1	= Energy Slope in Main Channel =		0.00882	0.00882	0.00882	0.00882	0.00882

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	9.18	9.33	9.40	9.42	9.98
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.69	0.64	0.62	0.62	0.48
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	1.64	1.73	1.77	1.78	2.11
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.20500	0.20500	0.20500	0.20500	0.20500
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	1.00	1.00	1.00	1.00	1.00
U/w	= Ratio of Shear Velocity to Fall Velocity =		1.64	1.73	1.77	1.78	2.11
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.69
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	9.50	10.50	11.01	11.10	15.69
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	13.30	14.57	15.20	15.31	20.62
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	11.99	14.98	16.62	16.92	34.75
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	35.96	44.93	49.85	50.75	104.25
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	1.60	0.60	0.09	0.00	-4.59
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	9.50	10.50	11.01	11.10	15.69
L/a	= Ratio Used in Table 3 to Find K2 =		6.00	6.00	6.00	6.00	6.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.76	0.79	0.81	0.81	0.92
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		0.90	0.90	0.90	0.90	0.90
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.00	1.00	1.00	1.00	1.00
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.60
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	11.48	12.10	12.41	12.46	23.74
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	32.16	33.89	34.74	34.89	66.48
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	13.30	14.57	15.20	15.31	20.62
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.70	1.70	1.70	1.70	1.70
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	39.96	47.93	52.18	52.95	96.03
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	119.88	143.78	156.54	158.86	288.09
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	10.66	10.66	10.66	10.66	10.66
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	11.48	12.10	12.41	12.46	23.74

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		1.00	1.00	1.00	1.00	1.00
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.00	1.00	1.00	1.00	1.00
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		1.02	1.02	0.69	0.69	0.69
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	0.14	0.14	0.14
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	None

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	11.48	12.10	12.41	12.46	23.74
Yab	= Scour Depth at Abutments	ft	None	None	None	None	None
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	15.48	16.10	16.41	16.46	27.74
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	4.00
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		1.63	1.53	1.49	1.48	1.77
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.42	0.38	0.36	0.36	0.25

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation **WSEL = 23.00**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		28.7																						
2	9	22.6	9	-6.1	0.035	0.12	0.71	0.59	0.17	C	2			2	12.83			0.12			0.59			0.40
3	29	17.0	20	-5.6	0.035	64.00	20.77	20.00	3.08	C	5,772			5,772	90.18			64.00			20.00			6.00
4	42	18.7	13	1.7	0.035	66.95	13.11	13.00	5.11	C	8,456			8,456	126.31			66.95			13.00			4.30
5	76	19.2	34	0.5	0.035	137.70	34.00	34.00	4.05	C	14,900			14,900	108.21			137.70			34.00			3.80
6	150	16.1	74	-3.1	0.035	395.90	74.06	74.00	5.35	C	51,554			51,554	130.22			395.90			74.00			6.90
7	159	16.4	9	0.3	0.035	60.75	9.00	9.00	6.75	C	9,240			9,240	152.09			60.75			9.00			6.60
8	166	13.9	7	-2.5	0.035	54.95	7.43	7.00	7.39	C	8,883			8,883	161.66			54.95			7.00			9.10
9	180	13.5	14	-0.4	0.035	130.20	14.01	14.00	9.30	C	24,524			24,524	188.36			130.20			14.00			9.50
10	201	14.1	21	0.6	0.035	193.20	21.01	21.00	9.20	C	36,129			36,129	187.00			193.20			21.00			8.90
11	213	15.7	12	1.6	0.035	97.20	12.11	12.00	8.03	C	16,603			16,603	170.81			97.20			12.00			7.30
12	241	16.6	28	0.9	0.035	191.80	28.01	28.00	6.85	C	29,459			29,459	153.59			191.80			28.00			6.40
13	269	19.1	28	2.5	0.035	144.20	28.11	28.00	5.13	C	18,269			18,269	126.69			144.20			28.00			3.90
14	299	20.6	30	1.5	0.035	94.50	30.04	30.00	3.15	C	8,641			8,641	91.44			94.50			30.00			2.40
15	308	22.1	9	1.5	0.035	14.85	9.12	9.00	1.63	C	875			875	58.91			14.85			9.00			0.90
16	317	27.1	9	5	0.035	0.73	1.85	1.62	0.39	C	17			17	22.85			0.73			1.62			
17	317	27.1			0.035					C														
18	317	27.1			0.035					C														
19	317	27.1			0.035					C														
20	317	27.1			0.035					C														
21	317	27.1			0.035					C														
22	317	27.1			0.035					C														
Total			317.00	-1.60	0.735	1,647.05	303.36	301.21	75.55		233,323			233,323				1,647			301.21			
Maximum	317.00	28.7	74.00	5.00	0.035	395.90	74.06	74.00	9.30						188.36			395.90						9.50
Minimum		13.5		-6.10	0.035																			
Range	317.00	15.2	74.00	11.10		395.90	74.06	74.00	9.30															
Average	207.32	21.1	15.10	-0.08	0.035	78.43	14.45	14.34	3.60															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			21,909	21,909
V			13.30	
T			301	301
Y			9.50	
A			1,647	1,647

Solve for the 2nd Water Surface Elevation WSEL = 24.00

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		28.7																						
2	9	22.6	9	-6.1	0.035	1.45	2.50	2.07	0.58	C	43			43	29.58			1.45			2.07			1.40
3	29	17.0	20	-5.6	0.035	84.00	20.77	20.00	4.04	C	9,082			9,082	108.12			84.00			20.00			7.00
4	42	18.7	13	1.7	0.035	79.95	13.11	13.00	6.10	C	11,367			11,367	142.18			79.95			13.00			5.30
5	76	19.2	34	0.5	0.035	171.70	34.00	34.00	5.05	C	21,525			21,525	125.37			171.70			34.00			4.80
6	150	16.1	74	-3.1	0.035	469.90	74.06	74.00	6.34	C	68,599			68,599	145.99			469.90			74.00			7.90
7	159	16.4	9	0.3	0.035	69.75	9.00	9.00	7.75	C	11,632			11,632	166.77			69.75			9.00			7.60
8	166	13.9	7	-2.5	0.035	61.95	7.43	7.00	8.33	C	10,849			10,849	175.12			61.95			7.00			10.10
9	180	13.5	14	-0.4	0.035	144.20	14.01	14.00	10.30	C	29,076			29,076	201.63			144.20			14.00			10.50
10	201	14.1	21	0.6	0.035	214.20	21.01	21.00	10.20	C	42,910			42,910	200.33			214.20			21.00			9.90
11	213	15.7	12	1.6	0.035	109.20	12.11	12.00	9.02	C	20,159			20,159	184.61			109.20			12.00			8.30
12	241	16.6	28	0.9	0.035	219.80	28.01	28.00	7.85	C	36,972			36,972	168.21			219.80			28.00			7.40
13	269	19.1	28	2.5	0.035	172.20	28.11	28.00	6.13	C	24,557			24,557	142.61			172.20			28.00			4.90
14	299	20.6	30	1.5	0.035	124.50	30.04	30.00	4.14	C	13,682			13,682	109.90			124.50			30.00			3.40
15	308	22.1	9	1.5	0.035	23.85	9.12	9.00	2.61	C	1,927			1,927	80.81			23.85			9.00			1.90
16	317	27.1	9	5	0.035	3.25	3.91	3.42	0.83	C	122			122	37.61			3.25			3.42			
17	317	27.1			0.035					C														
18	317	27.1			0.035					C														
19	317	27.1			0.035					C														
20	317	27.1			0.035					C														
21	317	27.1			0.035					C														
22	317	27.1			0.035					C														
Total			317.00	-1.60	0.735	1,949.89	307.20	304.49	89.27		302,504			302,504				1,950			304.49			
Maximum	317.00	28.7	74.00	5.00	0.035	469.90	74.06	74.00	10.30						201.63			469.90						10.50
Minimum		13.5		-6.10	0.035																			
Range	317.00	15.2	74.00	11.10		469.90	74.06	74.00	10.30															
Average	207.32	21.1	15.10	-0.08	0.035	92.85	14.63	14.50	4.25						96.13									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			28,405	28,405
V			14.57	
T			304	304
Y			10.50	
A			1,950	1,950

Solve for the 3rd Water Surface Elevation WSEL = 24.51

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		28.7																						
2	9	22.6	9	-6.1	0.035	2.69	3.40	2.82	0.79	C	98			98	36.38			2.69			2.82			1.91
3	29	17.0	20	-5.6	0.035	94.18	20.77	20.00	4.53	C	10,989			10,989	116.69			94.18			20.00			7.51
4	42	18.7	13	1.7	0.035	86.57	13.11	13.00	6.60	C	12,978			12,978	149.92			86.57			13.00			5.81
5	76	19.2	34	0.5	0.035	189.00	34.00	34.00	5.56	C	25,262			25,262	133.66			189.00			34.00			5.31
6	150	16.1	74	-3.1	0.035	507.56	74.06	74.00	6.85	C	78,007			78,007	153.69			507.56			74.00			8.41
7	159	16.4	9	0.3	0.035	74.33	9.00	9.00	8.25	C	12,933			12,933	174.00			74.33			9.00			8.11
8	166	13.9	7	-2.5	0.035	65.51	7.43	7.00	8.81	C	11,909			11,909	181.78			65.51			7.00			10.61
9	180	13.5	14	-0.4	0.035	151.32	14.01	14.00	10.80	C	31,510			31,510	208.22			151.32			14.00			11.01
10	201	14.1	21	0.6	0.035	224.89	21.01	21.00	10.70	C	46,538			46,538	206.94			224.89			21.00			10.41
11	213	15.7	12	1.6	0.035	115.31	12.11	12.00	9.52	C	22,073			22,073	191.43			115.31			12.00			8.81
12	241	16.6	28	0.9	0.035	234.05	28.01	28.00	8.35	C	41,053			41,053	175.41			234.05			28.00			7.91
13	269	19.1	28	2.5	0.035	186.45	28.11	28.00	6.63	C	28,037			28,037	150.38			186.45			28.00			5.41
14	299	20.6	30	1.5	0.035	139.77	30.04	30.00	4.65	C	16,592			16,592	118.71			139.77			30.00			3.91
15	308	22.1	9	1.5	0.035	28.43	9.12	9.00	3.12	C	2,583			2,583	90.85			28.43			9.00			2.41
16	317	27.1	9	5	0.035	5.22	4.96	4.34	1.05	C	230			230	44.06			5.22			4.34			
17	317	27.1			0.035					C														
18	317	27.1			0.035					C														
19	317	27.1			0.035					C														
20	317	27.1			0.035					C														
21	317	27.1			0.035					C														
22	317	27.1			0.035					C														
Total			317.00	-1.60	0.735	2,105.27	309.16	306.15	96.25		340,792			340,792				2,105			306.15			
Maximum	317.00	28.7	74.00	5.00	0.035	507.56	74.06	74.00	10.80						208.22			507.56						11.01
Minimum		13.5		-6.10	0.035																			
Range	317.00	15.2	74.00	11.10		507.56	74.06	74.00	10.80															
Average	207.32	21.1	15.10	-0.08	0.035	100.25	14.72	14.58	4.58						101.53									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			32,000	32,000
V			15.20	
T			306	306
Y			11.01	
A			2,105	2,105

Solve for the 4th Water Surface Elevation WSEL = 24.60

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		28.7																						
2	9	22.6	9	-6.1	0.035	2.95	3.56	2.95	0.83	C	111			111	37.53			2.95			2.95			2.00
3	29	17.0	20	-5.6	0.035	96.00	20.77	20.00	4.62	C	11,346			11,346	118.19			96.00			20.00			7.60
4	42	18.7	13	1.7	0.035	87.75	13.11	13.00	6.69	C	13,276			13,276	151.29			87.75			13.00			5.90
5	76	19.2	34	0.5	0.035	192.10	34.00	34.00	5.65	C	25,956			25,956	135.11			192.10			34.00			5.40
6	150	16.1	74	-3.1	0.035	514.30	74.06	74.00	6.94	C	79,742			79,742	155.05			514.30			74.00			8.50
7	159	16.4	9	0.3	0.035	75.15	9.00	9.00	8.35	C	13,172			13,172	175.28			75.15			9.00			8.20
8	166	13.9	7	-2.5	0.035	66.15	7.43	7.00	8.90	C	12,102			12,102	182.95			66.15			7.00			10.70
9	180	13.5	14	-0.4	0.035	152.60	14.01	14.00	10.90	C	31,953			31,953	209.39			152.60			14.00			11.10
10	201	14.1	21	0.6	0.035	226.80	21.01	21.00	10.80	C	47,199			47,199	208.11			226.80			21.00			10.50
11	213	15.7	12	1.6	0.035	116.40	12.11	12.00	9.61	C	22,423			22,423	192.64			116.40			12.00			8.90
12	241	16.6	28	0.9	0.035	236.60	28.01	28.00	8.45	C	41,802			41,802	176.68			236.60			28.00			8.00
13	269	19.1	28	2.5	0.035	189.00	28.11	28.00	6.72	C	28,680			28,680	151.74			189.00			28.00			5.50
14	299	20.6	30	1.5	0.035	142.50	30.04	30.00	4.74	C	17,137			17,137	120.26			142.50			30.00			4.00
15	308	22.1	9	1.5	0.035	29.25	9.12	9.00	3.21	C	2,708			2,708	92.59			29.25			9.00			2.50
16	317	27.1	9	5	0.035	5.63	5.15	4.50	1.09	C	254			254	45.16			5.63			4.50			
17	317	27.1			0.035					C														
18	317	27.1			0.035					C														
19	317	27.1			0.035					C														
20	317	27.1			0.035					C														
21	317	27.1			0.035					C														
22	317	27.1			0.035					C														
Total			317.00	-1.60	0.735	2,133.18	309.51	306.45	97.50		347,861			347,861				2,133			306.45			
Maximum	317.00	28.7	74.00	5.00	0.035	514.30	74.06	74.00	10.90						209.39			514.30						11.10
Minimum		13.5		-6.10	0.035																			
Range	317.00	15.2	74.00	11.10		514.30	74.06	74.00	10.90															
Average	207.32	21.1	15.10	-0.08	0.035	101.58	14.74	14.59	4.64						102.48									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			32,664	32,664
V			15.31	
T			306	306
Y			11.10	
A			2,133	2,133

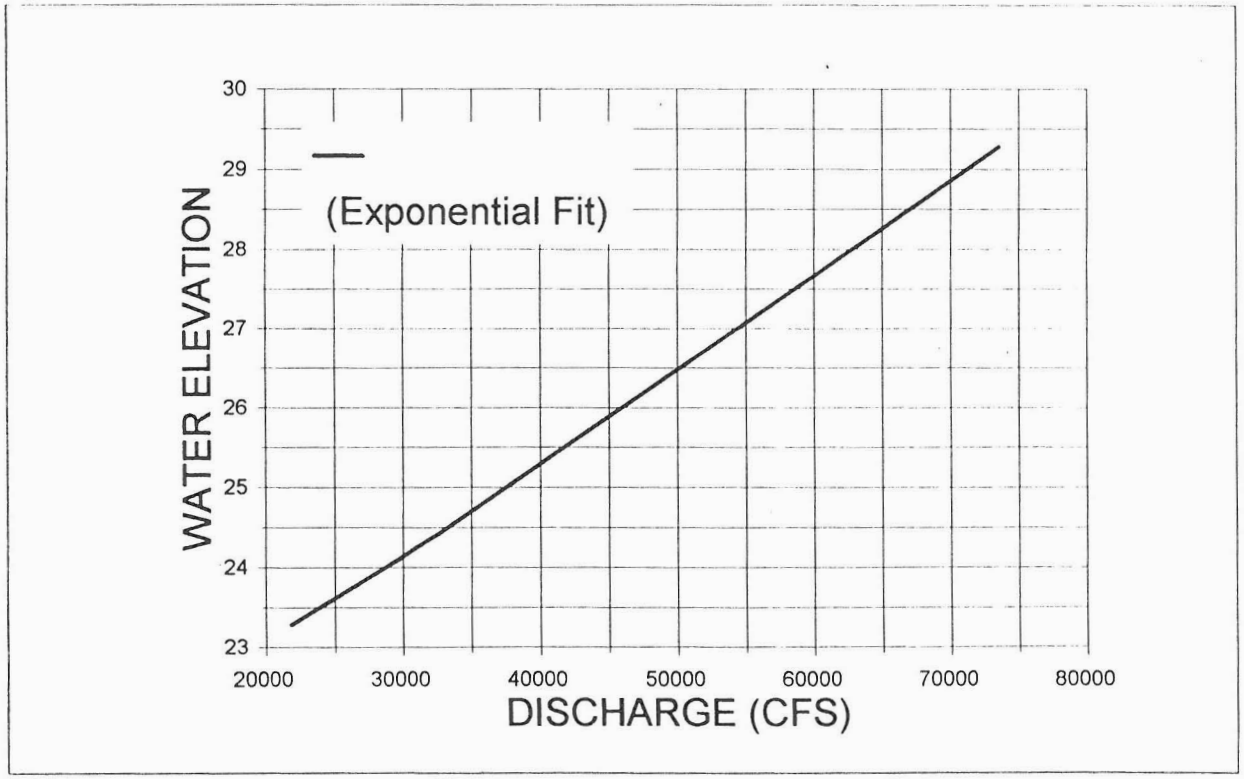
Solve for the 5th Water Surface Elevation WSEL = 29.19

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		28.7																						
2	9	22.6	9	-6.1	0.035	31.83	10.87	9.00	2.93	C	2,775			2,775	87.16			31.83			9.00			6.59
3	29	17.0	20	-5.6	0.035	187.74	20.77	20.00	9.04	C	34,708			34,708	184.87			187.74			20.00			12.19
4	42	18.7	13	1.7	0.035	147.38	13.11	13.00	11.24	C	31,511			31,511	213.80			147.38			13.00			10.49
5	76	19.2	34	0.5	0.035	348.06	34.00	34.00	10.24	C	69,910			69,910	200.85			348.06			34.00			9.99
6	150	16.1	74	-3.1	0.035	853.75	74.06	74.00	11.53	C	185,617			185,617	217.41			853.75			74.00			13.09
7	159	16.4	9	0.3	0.035	116.43	9.00	9.00	12.93	C	27,330			27,330	234.72			116.43			9.00			12.79
8	166	13.9	7	-2.5	0.035	98.26	7.43	7.00	13.22	C	23,407			23,407	238.21			98.26			7.00			15.29
9	180	13.5	14	-0.4	0.035	216.82	14.01	14.00	15.48	C	57,387			57,387	264.67			216.82			14.00			15.69
10	201	14.1	21	0.6	0.035	323.13	21.01	21.00	15.38	C	85,156			85,156	263.53			323.13			21.00			15.09
11	213	15.7	12	1.6	0.035	171.45	12.11	12.00	14.16	C	42,761			42,761	249.41			171.45			12.00			13.49
12	241	16.6	28	0.9	0.035	365.04	28.01	28.00	13.03	C	86,127			86,127	235.94			365.04			28.00			12.59
13	269	19.1	28	2.5	0.035	317.44	28.11	28.00	11.29	C	68,075			68,075	214.45			317.44			28.00			10.09
14	299	20.6	30	1.5	0.035	280.12	30.04	30.00	9.33	C	52,872			52,872	188.75			280.12			30.00			8.59
15	308	22.1	9	1.5	0.035	70.53	9.12	9.00	7.73	C	11,748			11,748	166.55			70.53			9.00			7.09
16	317	27.1	9	5	0.035	41.28	10.30	9.00	4.01	C	4,438			4,438	107.50			41.28			9.00			2.09
17	317	27.1			0.035					C														2.09
18	317	27.1			0.035					C														2.09
19	317	27.1			0.035					C														2.09
20	317	27.1			0.035					C														2.09
21	317	27.1			0.035					C														2.09
22	317	27.1			0.035					C														
Total			317.00	-1.60	0.735	3,569.29	321.96	317.00	161.53		783,822			783,822				3,569			317.00			
Maximum	317.00	28.7	74.00	5.00	0.035	853.75	74.06	74.00	15.48						264.67			853.75						15.69
Minimum		13.5		-6.10	0.035																			
Range	317.00	15.2	74.00	11.10		853.75	74.06	74.00	15.48															
Average	207.32	21.1	15.10	-0.08	0.035	169.97	15.33	15.10	7.69						146.09									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			73,600	73,600
V			20.62	
T			317	317
Y			15.69	
A			3,569	3,569

DISCHARGE RATING CURVE FOR TYPICAL SECTION

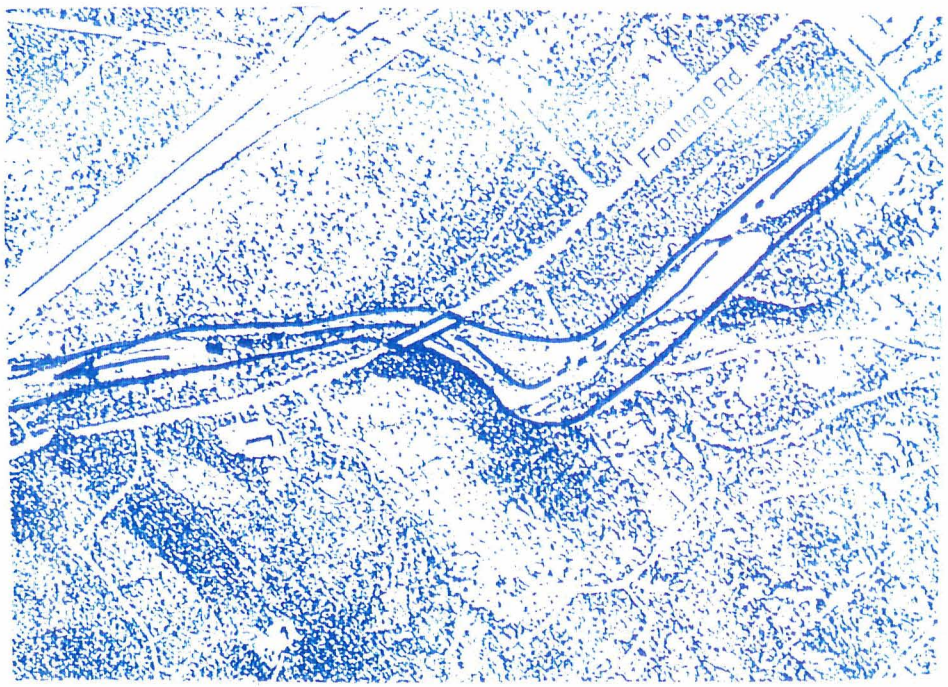
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
23.00	0	0	21,909	21,909	0.00	0.00	13.30	0.00	0.00	9.50	0	0	301	301
24.00	0	0	28,405	28,405	0.00	0.00	14.57	0.00	0.00	10.50	0	0	304	304
24.51	0	0	32,000	32,000	0.00	0.00	15.20	0.00	0.00	11.01	0	0	306	306
24.60	0	0	32,664	32,664	0.00	0.00	15.31	0.00	0.00	11.10	0	0	306	306
29.19	0	0	73,600	73,600	0.00	0.00	20.62	0.00	0.00	15.69	0	0	317	317



BRIDGE 8 - INTERSTATE 17 FRONTAGE ROAD (SN 8639)

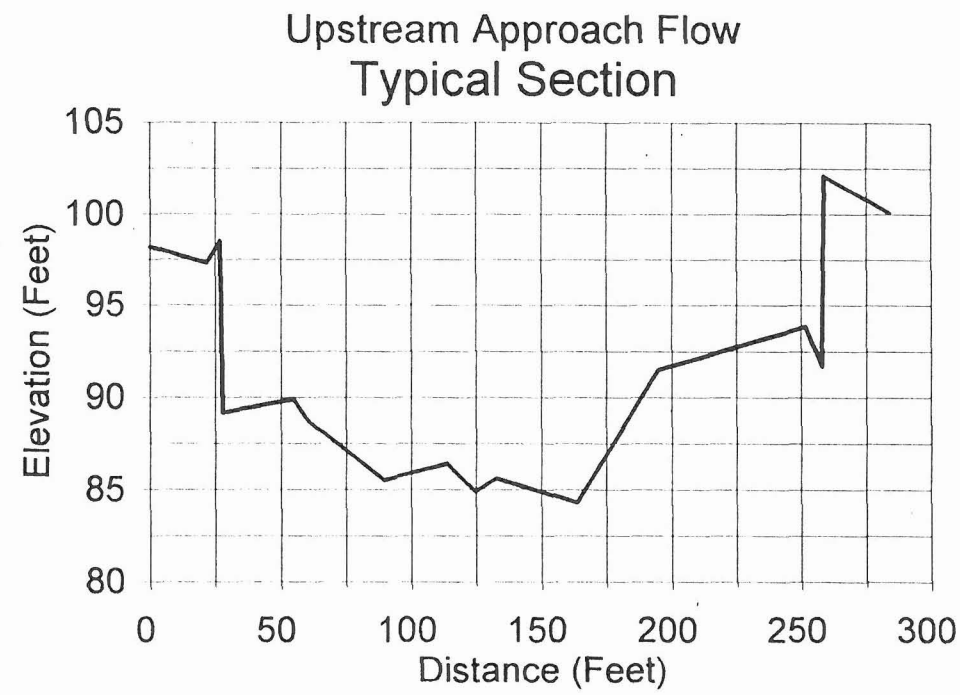
INTERSTATE 17 FRONTAGE ROAD (SN 8639)

Water Course	New River
Stream Form	Braided to straight
Sinuosity	Not applicable
General Channelization	None
Channel Slope	Uniform
Estimated Channel Slope (ft/ft)	0.004399
Channel Contraction/Expansion	Clear channel wider DS.
Primary Surface Sediment Type	sand/gravel/cobbles/boulders
D50 Size	50 MM
Armoring Potential	Moderate to high (locally)
Channel Vegetation	
Type/Size	Various trees to 20 ft., Desert Willow, Desert Broom, Ephedra dominate smaller vegetation; low to medium height grasses.
Density/Occurrence	Upstream channel/banks densely overgrown; downstream somewhat clearer with sparse growth in channel becoming dense toward banks.
Relative Age	Mature to old.
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	South side - rocky hillside directs flow sharply westward.
Vertical	Broken concrete slab in channel may function as limited grade control; otherwise none.
Sediment Deposits & Bars	Low bars forming in response to obstructions mainly sedimentation reducing waterway toward north and south abutments.
[illegible]	No
[illegible]	No
[illegible]	
Pier	Mid-span piers show 2-3 ft. residual scour developed largely by flow angle and debris accumulated.
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Low to moderate rate; generally low density residential and light commercial.
Sand & Gravel Extraction	No
Freeway Construction	No
Dams	No
Drainage Channels	Smaller channel joins upstream of structure; no rapid flow variations anticipated at present.



INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	98.2		
2	22	97.3	0.066	L
3	27	98.5	0.035	C
4	28	89.2	0.035	C
5	55	89.9	0.035	C
6	61	88.7	0.035	C
7	90	85.5	0.035	C
8	114	86.4	0.035	C
9	125	84.9	0.035	C
10	133	85.6	0.035	C
11	164	84.3	0.035	C
12	195	91.5	0.035	C
13	252	93.8	0.035	C
14	258	91.7	0.035	C
15	259	102.1	0.035	C
16	284	100.1	0.066	R
17	284	100.1	0.066	R
18	284	100.1	0.066	R
19	284	100.1	0.066	R
20	284	100.1	0.066	R
21	284	100.1	0.066	R
22	284	100.1	0.066	R



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	94.93
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	103.30
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	94.93
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	84.30
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	94.93
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	84.30
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00440

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Assumed	10,000	93.07	10,000	0.00
2	Assumed	12,754	94.00	12,754	0.00
3	Low Chord	15,933	94.93	15,933	0.00
4	Q100	33,400	98.91	33,400	0.00
5	Q500	74,482	105.36	74,482	0.00

Abutment Scour Protection

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Full or Part?	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ws = Width of Scour Protection =	Full or Part?	
Ls = Length of Scour Protection =	Full or Part?	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection (or "None") =	Feet	
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Full or Part?	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.004399
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.1640	0.1640	0.1640	0.1640	0.1640
Angle	= *Angle of Attack* =	*Degrees*	10	10	10	10	10
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		SHARP	SHARP	SHARP	SHARP	SHARP
a'	= Pier Width Shown on Plans or Measured in Field =	ft	1.00	1.00	1.00	1.00	1.00
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	5.00	5.00	5.00	5.00	5.00
L	= Pier Length =	ft	41.00	41.00	41.00	41.00	41.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	50	50	50	50	50

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	103.30	103.30	103.30	103.30	103.30
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	94.93	94.93	94.93	94.93	94.93
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	93.07	94.00	94.93	98.91	105.36
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	84.30	84.30	84.30	84.30	84.30
y1	= Average Depth in the Upstream Main Channel =	ft	8.77	9.70	10.63	14.61	21.06
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	210	231	231	259	284
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	210	231	231	237	237
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	10,000	12,754	15,933	33,358	73,095
Q2	= Flow in the Contracted Channel =	cfs	10,000	12,754	15,933	33,400	74,482
V1	= Mean Velocity of Flow Upstream of Pier =	fps	9.51	10.13	10.81	13.90	18.61
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.57	0.57	0.58	0.64	0.71
S1	= Energy Slope in Main Channel =		0.00440	0.00440	0.00440	0.00440	0.00440

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	9.05	9.21	9.35	9.86	10.48
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.95	0.91	0.86	0.71	0.56
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	1.11	1.17	1.23	1.44	1.73
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.20500	0.20500	0.20500	0.20500	0.20500
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	1.00	1.00	1.00	1.00	1.00
U/w	= Ratio of Shear Velocity to Fall Velocity =		1.11	1.17	1.23	1.44	1.73
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	8.77	9.70	10.63	15.48	24.02
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.87	2.97
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	9.51	10.13	10.81	15.20	22.31
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	4.57	5.24	6.08	14.41	37.97
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	13.70	15.72	18.25	43.23	113.91
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.87	2.97

Compute Local Scour at Piers

Variable	Description	Unit	Trial No. 1 Value	2 Value	3 Value	4 Value	5 Value
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	1.86	0.93	0.00	-3.98	-10.43
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	2.06
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	8.77	9.70	10.63	14.61	19.00
L/a	= Ratio Used in Table 3 to Find K2 =		8.00	8.00	8.00	8.00	8.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.57	0.57	0.58	0.64	0.75
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		0.90	0.90	0.90	0.90	0.90
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.67	1.67	1.67	1.67	1.67
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.60	1.60
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	15.73	16.38	17.05	31.74	37.28
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	44.03	45.86	47.75	88.86	104.38
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	9.51	10.13	10.81	15.20	22.31
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.70	1.70	1.70	1.70	1.70
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	20.44	23.17	26.40	52.15	112.38
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	61.33	69.52	79.19	156.45	337.13
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	10.00	10.00	10.00	10.00	10.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	15.73	16.38	17.05	31.74	37.28

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	22	25
	Which abutment Left or Right?		Right	Right	Right	Left	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	42	418
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	1.65	3.93
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	25	106
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	1.16	4.26
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		1.00	1.00	1.00	1.00	1.00
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		0.93	0.93	0.93	0.93	0.93
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	0.27	0.34
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	5.05	14.10
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	15.20	22.31
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		1.02	1.02	1.02	1.02	1.02
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	53.20	114.63
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	159.59	343.89
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	25.00	25.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	5.05	14.10

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.87	2.97
Yl	= Local Scour Depth =	ft	15.73	16.38	17.05	31.74	37.28
Yab	= Scour Depth at Abutments	ft	None	None	None	5.05	14.10
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	19.73	20.38	21.05	36.61	44.25
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	9.05	18.10
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		2.25	2.10	1.98	2.51	2.10
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.46	0.41	0.38	0.62	0.86

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation **WSEL = 93.07**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.2																						
2	22	97.3	22	-0.9	0.066					L														
3	27	98.5	5	1.2	0.035					C														
4	28	89.2	1	-9.3	0.035	0.80	3.89	0.42	0.21	C	12			12	14.87			0.80			0.42			3.87
5	55	89.9	27	0.7	0.035	94.93	27.01	27.00	3.51	C	9,346			9,346	98.45			94.93			27.00			3.17
6	61	88.7	6	-1.2	0.035	22.59	6.12	6.00	3.69	C	2,299			2,299	101.75			22.59			6.00			4.37
7	90	85.5	29	-3.2	0.035	173.01	29.18	29.00	5.93	C	24,144			24,144	139.55			173.01			29.00			7.57
8	114	86.4	24	0.9	0.035	170.78	24.02	24.00	7.11	C	26,902			26,902	157.52			170.78			24.00			6.67
9	125	84.9	11	-1.5	0.035	81.57	11.10	11.00	7.35	C	13,134			13,134	161.01			81.57			11.00			8.17
10	133	85.6	8	0.7	0.035	62.53	8.03	8.00	7.79	C	10,464			10,464	167.35			62.53			8.00			7.47
11	164	84.3	31	-1.3	0.035	251.59	31.03	31.00	8.11	C	43,260			43,260	171.94			251.59			31.00			8.77
12	195	91.5	31	7.2	0.035	160.14	31.83	31.00	5.03	C	20,030			20,030	125.08			160.14			31.00			1.57
13	252	93.8	57	2.3	0.035	30.38	38.84	38.81	0.78	C	1,098			1,098	36.14			30.38			38.81			
14	258	91.7	6	-2.1	0.035	2.66	4.13	3.90	0.64	C	85			85	31.76			2.66			3.90			1.37
15	259	102.1	1	10.4	0.035	0.09	1.37	0.13	0.07	C	1			1	6.90			0.09			0.13			
16	284	100.1	25	-2	0.066					R														
17	284	100.1			0.066					R														
18	284	100.1			0.066					R														
19	284	100.1			0.066					R														
20	284	100.1			0.066					R														
21	284	100.1			0.066					R														
22	284	100.1			0.066					R														
Total			284.00	1.90	0.983	1,051.08	216.54	210.25	50.22		150,773			150,773				1,051			210.25			
Maximum	284.00	102.1	57.00	10.40	0.066	251.59	38.84	38.81	8.11						171.94			251.59						8.77
Minimum		84.3		-9.30	0.035																			
Range	284.00	17.8	57.00	19.70	0.031	251.59	38.84	38.81	8.11															
Average	171.41	94.0	13.52	0.09	0.047	50.05	10.31	10.01	2.39															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			10,000	10,000
V			9.51	
T			210	210
Y			8.77	
A			1,051	1,051

Solve for the 2nd Water Surface Elevation **WSEL = 94.00**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.2																						
2	22	97.3	22	-0.9	0.066					L														
3	27	98.5	5	1.2	0.035					C														
4	28	89.2	1	-9.3	0.035	1.24	4.83	0.52	0.26	C	21			21	17.18			1.24			0.52			4.80
5	55	89.9	27	0.7	0.035	120.15	27.01	27.00	4.45	C	13,842			13,842	115.21			120.15			27.00			4.10
6	61	88.7	6	-1.2	0.035	28.20	6.12	6.00	4.61	C	3,326			3,326	117.96			28.20			6.00			5.30
7	90	85.5	29	-3.2	0.035	200.10	29.18	29.00	6.86	C	30,770			30,770	153.77			200.10			29.00			8.50
8	114	86.4	24	0.9	0.035	193.20	24.02	24.00	8.04	C	33,044			33,044	171.03			193.20			24.00			7.60
9	125	84.9	11	-1.5	0.035	91.85	11.10	11.00	8.27	C	16,006			16,006	174.27			91.85			11.00			9.10
10	133	85.6	8	0.7	0.035	70.00	8.03	8.00	8.72	C	12,631			12,631	180.44			70.00			8.00			8.40
11	164	84.3	31	-1.3	0.035	280.55	31.03	31.00	9.04	C	51,875			51,875	184.90			280.55			31.00			9.70
12	195	91.5	31	7.2	0.035	189.10	31.83	31.00	5.94	C	26,425			26,425	139.74			189.10			31.00			2.50
13	252	93.8	57	2.3	0.035	76.95	57.05	57.00	1.35	C	4,000			4,000	51.98			76.95			57.00			0.20
14	258	91.7	6	-2.1	0.035	7.50	6.36	6.00	1.18	C	357			357	47.54			7.50			6.00			2.30
15	259	102.1	1	10.4	0.035	0.25	2.31	0.22	0.11	C	2			2	9.77			0.25			0.22			
16	284	100.1	25	-2	0.066					R														
17	284	100.1			0.066					R														
18	284	100.1			0.066					R														
19	284	100.1			0.066					R														
20	284	100.1			0.066					R														
21	284	100.1			0.066					R														
22	284	100.1			0.066					R														
Total			284.00	1.90	0.983	1,259.09	238.85	230.74	58.83		192,299			192,299				1,259			230.74			
Maximum	284.00	102.1	57.00	10.40	0.066	280.55	57.05	57.00	9.04						184.90			280.55						9.70
Minimum		84.3		-9.30	0.035																			
Range	284.00	17.8	57.00	19.70	0.031	280.55	57.05	57.00	9.04															
Average	171.41	94.0	13.52	0.09	0.047	59.96	11.37	10.99	2.80						64.94									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			12,754	12,754
V			10.13	
T			231	231
Y			9.70	
A			1,259	1,259

Solve for the 3rd Water Surface Elevation WSEL = 94.93

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.2																						
2	22	97.3	22	-0.9	0.066					L														
3	27	98.5	5	1.2	0.035					C														
4	28	89.2	1	-9.3	0.035	1.77	5.76	0.62	0.31	C	34			34	19.34			1.77			0.62			5.73
5	55	89.9	27	0.7	0.035	145.26	27.01	27.00	5.38	C	18,993			18,993	130.75			145.26			27.00			5.03
6	61	88.7	6	-1.2	0.035	33.78	6.12	6.00	5.52	C	4,495			4,495	133.05			33.78			6.00			6.23
7	90	85.5	29	-3.2	0.035	227.07	29.18	29.00	7.78	C	37,990			37,990	167.30			227.07			29.00			9.43
8	114	86.4	24	0.9	0.035	215.52	24.02	24.00	8.97	C	39,649			39,649	183.97			215.52			24.00			8.53
9	125	84.9	11	-1.5	0.035	102.08	11.10	11.00	9.19	C	19,087			19,087	186.98			102.08			11.00			10.03
10	133	85.6	8	0.7	0.035	77.44	8.03	8.00	9.64	C	14,947			14,947	193.02			77.44			8.00			9.33
11	164	84.3	31	-1.3	0.035	309.38	31.03	31.00	9.97	C	61,063			61,063	197.37			309.38			31.00			10.63
12	195	91.5	31	7.2	0.035	217.93	31.83	31.00	6.85	C	33,477			33,477	153.61			217.93			31.00			3.43
13	252	93.8	57	2.3	0.035	129.96	57.05	57.00	2.28	C	9,582			9,582	73.73			129.96			57.00			1.13
14	258	91.7	6	-2.1	0.035	13.08	6.36	6.00	2.06	C	901			901	68.89			13.08			6.00			3.23
15	259	102.1	1	10.4	0.035	0.50	3.24	0.31	0.15	C	6			6	12.25			0.50			0.31			
16	284	100.1	25	-2	0.066					R														
17	284	100.1			0.066					R														
18	284	100.1			0.066					R														
19	284	100.1			0.066					R														
20	284	100.1			0.066					R														
21	284	100.1			0.066					R														
22	284	100.1			0.066					R														
Total			284.00	1.90	0.983	1,473.77	240.72	230.93	68.11		240,224			240,224				1,474			230.93			
Maximum	284.00	102.1	57.00	10.40	0.066	309.38	57.05	57.00	9.97						197.37			309.38						10.63
Minimum		84.3		-9.30	0.035																			
Range	284.00	17.8	57.00	19.70	0.031	309.38	57.05	57.00	9.97															
Average	171.41	94.0	13.52	0.09	0.047	70.18	11.46	11.00	3.24						72.39									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			15,933	15,933
V			10.81	
T			231	231
Y			10.63	
A			1,474	1,474

Solve for the 4th Water Surface Elevation **WSEL = 98.91**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.2																						
2	22	97.3	22	-0.9	0.066	25.50	22.02	22.00	1.16	L	635	635			24.90	25.50			22.00			1.61		
3	27	98.5	5	1.2	0.035	5.04	5.14	5.00	0.98	C	212			212	42.03			5.04			5.00			0.41
4	28	89.2	1	-9.3	0.035	5.06	9.35	1.00	0.54	C	143			143	28.25			5.06			1.00			9.71
5	55	89.9	27	0.7	0.035	252.69	27.01	27.00	9.36	C	47,799			47,799	189.16			252.69			27.00			9.01
6	61	88.7	6	-1.2	0.035	57.65	6.12	6.00	9.42	C	10,957			10,957	190.06			57.65			6.00			10.21
7	90	85.5	29	-3.2	0.035	342.46	29.18	29.00	11.74	C	75,360			75,360	220.05			342.46			29.00			13.41
8	114	86.4	24	0.9	0.035	311.01	24.02	24.00	12.95	C	73,077			73,077	234.96			311.01			24.00			12.51
9	125	84.9	11	-1.5	0.035	145.85	11.10	11.00	13.14	C	34,599			34,599	237.23			145.85			11.00			14.01
10	133	85.6	8	0.7	0.035	109.27	8.03	8.00	13.61	C	26,536			26,536	242.85			109.27			8.00			13.31
11	164	84.3	31	-1.3	0.035	432.73	31.03	31.00	13.95	C	106,830			106,830	246.88			432.73			31.00			14.61
12	195	91.5	31	7.2	0.035	341.28	31.83	31.00	10.72	C	70,707			70,707	207.18			341.28			31.00			7.41
13	252	93.8	57	2.3	0.035	356.76	57.05	57.00	6.25	C	51,585			51,585	144.59			356.76			57.00			5.11
14	258	91.7	6	-2.1	0.035	36.95	6.36	6.00	5.81	C	5,089			5,089	137.72			36.95			6.00			7.21
15	259	102.1	1	10.4	0.035	2.50	7.24	0.69	0.34	C	52			52	20.93			2.50			0.69			
16	284	100.1	25	-2	0.066					R														
17	284	100.1			0.066					R														
18	284	100.1			0.066					R														
19	284	100.1			0.066					R														
20	284	100.1			0.066					R														
21	284	100.1			0.066					R														
22	284	100.1			0.066					R														
Total			284.00	1.90	0.983	2,424.75	275.46	258.69	109.97		503,581	635		502,946		25		2,399	22.00		236.69			
Maximum	284.00	102.1	57.00	10.40	0.066	432.73	57.05	57.00	13.95						246.88	25.50		432.73				1.61		14.61
Minimum		84.3		-9.30	0.035																			
Range	284.00	17.8	57.00	19.70	0.031	432.73	57.05	57.00	13.95															
Average	171.41	94.0	13.52	0.09	0.047	115.46	13.12	12.32	5.24						103.18									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	42		33,358	33,400
V	1.65		13.90	
T	22		237	259
Y	1.61		14.61	
A	25		2,399	2,425

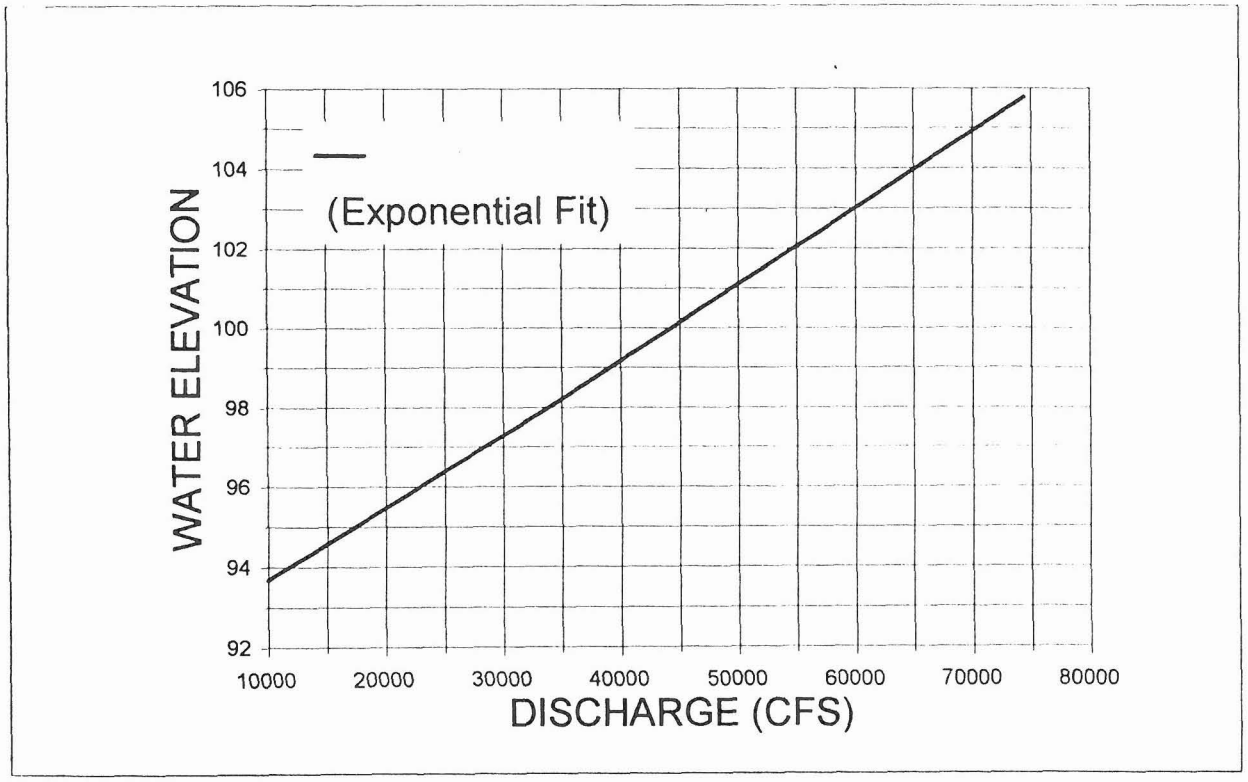
Solve for the 5th Water Surface Elevation **WSEL = 105.36**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.2																						
2	22	97.3	22	-0.9	0.066	167.33	22.02	22.00	7.60	L	14,612	14,612			87.32	167.33			22.00			8.06		
3	27	98.5	5	1.2	0.035	37.28	5.14	5.00	7.25	C	5,949			5,949	159.58			37.28			5.00			6.86
4	28	89.2	1	-9.3	0.035	11.51	9.35	1.00	1.23	C	562			562	48.88			11.51			1.00			16.16
5	55	89.9	27	0.7	0.035	426.76	27.01	27.00	15.80	C	114,504			114,504	268.31			426.76			27.00			15.46
6	61	88.7	6	-1.2	0.035	96.34	6.12	6.00	15.74	C	25,786			25,786	267.67			96.34			6.00			16.66
7	90	85.5	29	-3.2	0.035	529.42	29.18	29.00	18.15	C	155,786			155,786	294.25			529.42			29.00			19.86
8	114	86.4	24	0.9	0.035	465.74	24.02	24.00	19.39	C	143,257			143,257	307.59			465.74			24.00			18.96
9	125	84.9	11	-1.5	0.035	216.77	11.10	11.00	19.53	C	66,979			66,979	308.99			216.77			11.00			20.46
10	133	85.6	8	0.7	0.035	160.85	8.03	8.00	20.03	C	50,553			50,553	314.29			160.85			8.00			19.76
11	164	84.3	31	-1.3	0.035	632.59	31.03	31.00	20.39	C	201,183			201,183	318.03			632.59			31.00			21.06
12	195	91.5	31	7.2	0.035	541.14	31.83	31.00	17.00	C	152,473			152,473	281.76			541.14			31.00			13.86
13	252	93.8	57	2.3	0.035	724.24	57.05	57.00	12.70	C	167,935			167,935	231.88			724.24			57.00			11.56
14	258	91.7	6	-2.1	0.035	75.64	6.36	6.00	11.90	C	16,796			16,796	222.06			75.64			6.00			13.66
15	259	102.1	1	10.4	0.035	8.46	10.45	1.00	0.81	C	313			313	36.97			8.46			1.00			3.26
16	284	100.1	25	-2	0.066	106.40	25.08	25.00	4.24	R	6,298		6,298		59.19		106.40			25.00			5.26	
17	284	100.1			0.066					R													5.26	
18	284	100.1			0.066					R													5.26	
19	284	100.1			0.066					R													5.26	
20	284	100.1			0.066					R													5.26	
21	284	100.1			0.066					R													5.26	
22	284	100.1			0.066					R														
Total			284.00	1.90	0.983	4,200.46	303.75	284.00	191.76		1,122,986	14,612	6,298	1,102,076		167	106	3,927	22.00	25.00	237.00			
Maximum	284.00	102.1	57.00	10.40	0.066	724.24	57.05	57.00	20.39						318.03	167.33	106.40	724.24				8.06	5.26	21.06
Minimum		84.3		-9.30	0.035																			
Range	284.00	17.8	57.00	19.70	0.031	724.24	57.05	57.00	20.39															
Average	171.41	94.0	13.52	0.09	0.047	200.02	14.46	13.52	9.13						152.70									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	969	418	73,095	74,482
V	5.79	3.93	18.61	
T	22	25	237	284
Y	8.06	5.26	21.06	
A	167	106	3,927	4,200

DISCHARGE RATING CURVE FOR TYPICAL SECTION

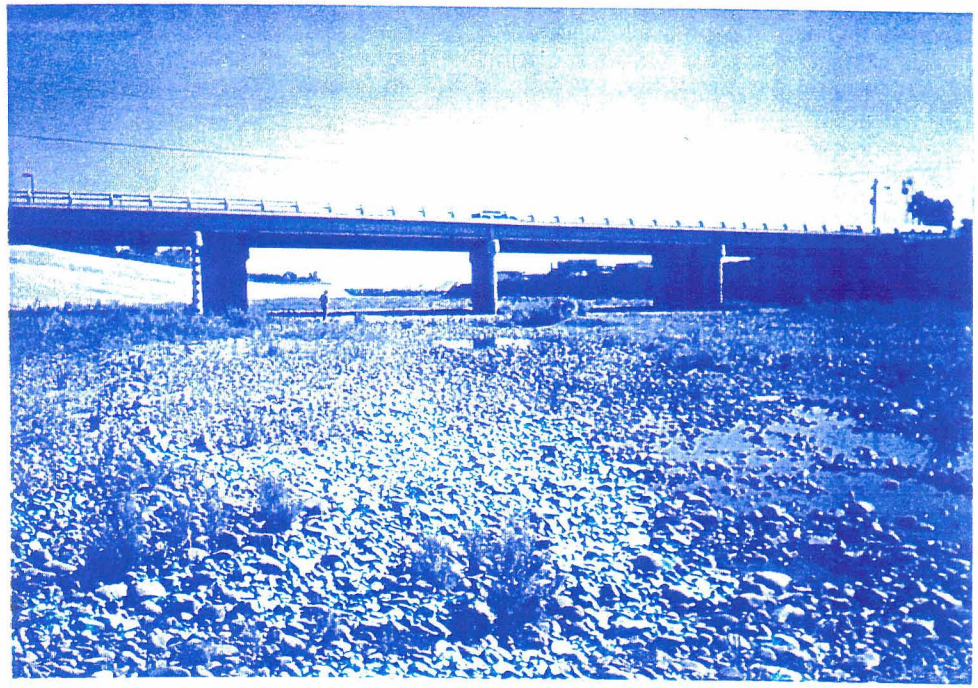
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
93.07	0	0	10,000	10,000	0.00	0.00	9.51	0.00	0.00	8.77	0	0	210	210
94.00	0	0	12,754	12,754	0.00	0.00	10.13	0.00	0.00	9.70	0	0	231	231
94.93	0	0	15,933	15,933	0.00	0.00	10.81	0.00	0.00	10.63	0	0	231	231
98.91	42	0	33,358	33,400	1.65	0.00	13.90	1.61	0.00	14.61	22	0	237	259
105.36	969	418	73,095	74,482	5.79	3.93	18.61	8.06	5.26	21.06	22	25	237	284

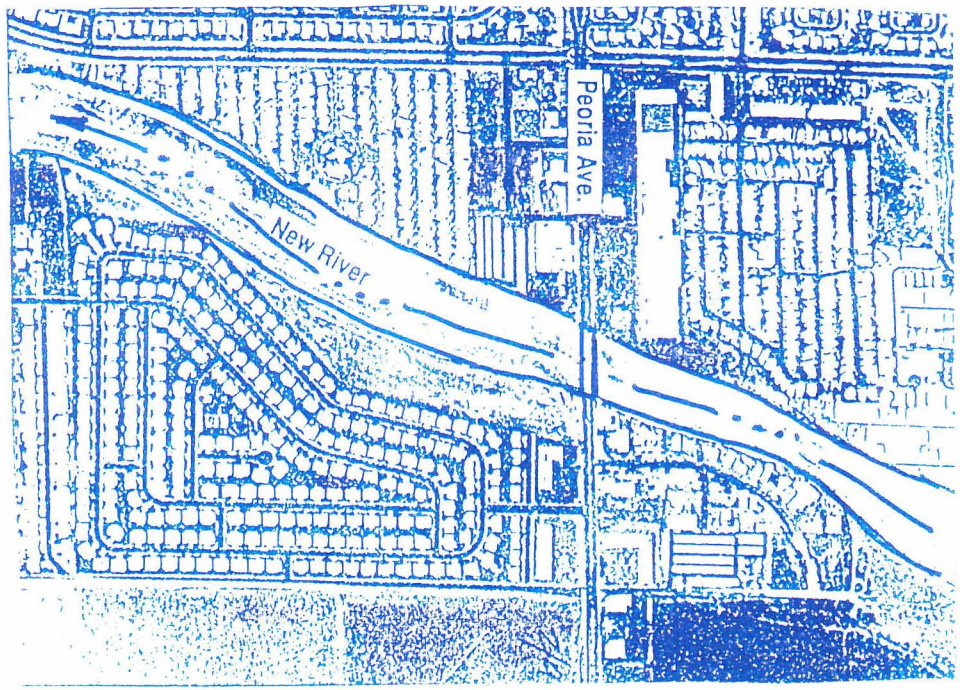


BRIDGE 9 - PEORIA AVENUE (SN 9427)

PEORIA AVENUE

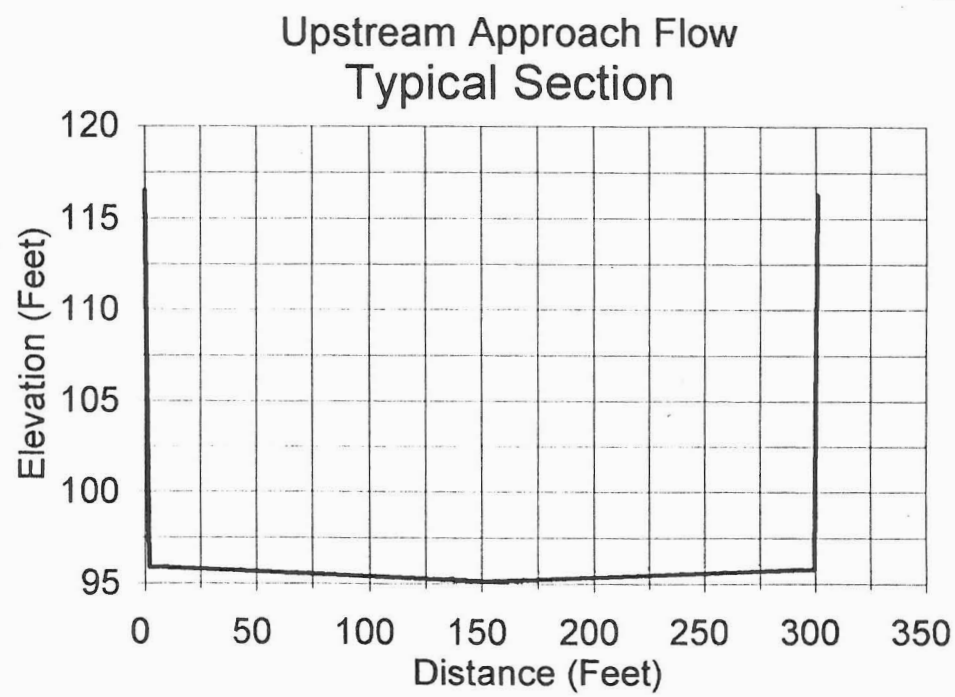
Water Course	New River
Stream Form	Straight to braided
Sinuosity	Not applicable
General Channelization	Sides of channel US and DS of bridge lined with soil cement forming trapezoidal section with 0.25:1 sideslopes.
Channel Slope	Uniform
Estimated Channel Slope (ft/ft)	0.004603
Channel Contraction/Expansion	Narrower at US grade control, slowly expands toward/through bridge section.
Primary Surface Sediment Type	sand/gravel/cobbles
D50 Size	8 MM (estimate)
Armoring Potential	Moderate
Channel Vegetation	
Type/Size	Small bush, low grasses.
Density/Occurrence	Very sparse.
Relative Age	Young
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	Soil cement banks.
Vertical	Grouted rip-rap sill at bridge extending approximately 36 ft. US/DS; grade control structure approximately 800 ft. US.
Sediment Deposits & Bars	Occasional low bars forming along channel flow direction. Channel sediments generally accumulate and become finer toward banks.
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	No
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Land use commercial, medium to high density residential with some undeveloped land along Agua Fria Freeway; general assumption is for increasing urbanization.
Sand & Gravel Extraction	Evidence of former instream gravel operation approximately 1500 ft. DS.
Freeway Construction	No, but general roadway improvements are likely in vicinity.
Dams	New River dam several miles US near Jomax Road.
Drainage Channels	Small diameter storm drain outfalls on both sides of channel near bridge.





INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	116.5		
2	2	95.9	0.035	C
3	152	95.1	0.035	C
4	300	95.8	0.035	C
5	301	116.3	0.035	C
6	301	116.3	0.035	C
7	301	116.3	0.035	C
8	301	116.3	0.035	C
9	301	116.3	0.035	C
10	301	116.3	0.035	C
11	301	116.3	0.035	C
12	301	116.3	0.035	C
13	301	116.3	0.035	C
14	301	116.3	0.035	C
15	301	116.3	0.035	C
16	301	116.3	0.035	C
17	301	116.3	0.035	C
18	301	116.3	0.035	C
19	301	116.3	0.035	C
20	301	116.3	0.035	C
21	301	116.3	0.035	C
22	301	116.3	0.035	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	113.89
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	123.50
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	113.89
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	95.10
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	113.89
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	95.10
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00460

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	13,500	100.69	13,500	0.00
2		38,000	105.17	38,000	0.00
3	Q100	41,000	105.63	41,000	0.00
4	Q500	75,000	110.06	75,000	0.00
5	Low Chord	110,688	113.89	110,688	0.00

Abutment Scour Protection

	Is there evidence of scour protection?	Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	93.30
Ws	= Width of Scour Protection =	Feet	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	15.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	15.00
Material	= Material of Scour Protection =		Grouted Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		1.80

Contraction Scour Protection

	Is there evidence of scour protection?	Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	93.30
Ws	= Width of Scour Protection =	Full or Part?	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	15.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	15.00
Material	= Material of Scour Protection =		Grouted Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		1.80

Pier (Local) Scour Protection

	Is there evidence of scour protection?	Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	93.30
Ws	= Width of Scour Protection =	Feet	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	15.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	15.00
Material	= Material of Scour Protection =		Grouted Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		1.80

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	Yes
ELs = Top Elevation of Scour Protection =	Feet	93.30
Ds = Distance Downstream =	Feet	0
S = Average Channel Slope = Average Energy Slope =		0.004603
Ws = Width of Scour Protection =	Feet	Full
Ls = Length of Scour Protection =	Feet	Full
Ts = Thickness of Scour Protection =	Inches	15.00
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	15.00
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		1.80

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0263	0.0263	0.0263	0.0263	0.0263
Angle	= *Angle of Attack* =	*Degrees*	0	0	0	0	0
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	1.50	1.50	1.50	1.50	1.50
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	5.50	5.50	5.50	5.50	5.50
L	= Pier Length =	ft	77.00	77.00	77.00	77.00	77.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	115	115	115	115	115

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	123.50	123.50	123.50	123.50	123.50
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	113.89	113.89	113.89	113.89	113.89
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	100.69	105.17	105.63	110.06	113.89
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	95.10	95.10	95.10	95.10	95.10
y1	= Average Depth in the Upstream Main Channel =	ft	5.59	10.07	10.53	14.96	18.79
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	299	299	299	300	301
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	299	299	299	300	301
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	13,500	38,000	41,000	75,000	110,688
Q2	= Flow in the Contracted Channel =	cfs	13,500	38,000	41,000	75,000	110,688
V1	= Mean Velocity of Flow Upstream of Pier =	fps	8.68	13.12	13.52	17.20	20.08
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.65	0.73	0.73	0.78	0.82
S1	= Energy Slope in Main Channel =		0.00460	0.00460	0.00460	0.00460	0.00460

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	4.56	5.03	5.07	5.38	5.59
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.53	0.38	0.38	0.31	0.28
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.91	1.22	1.25	1.49	1.67
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.03288	0.03288	0.03288	0.03288	0.03288
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	1.00	1.00	1.00	1.00	1.00
U/w	= Ratio of Shear Velocity to Fall Velocity =		0.91	1.22	1.25	1.49	1.67
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	5.59	10.07	10.53	14.96	18.79
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	8.68	13.12	13.52	17.20	20.08
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	4.34	11.17	11.97	20.66	29.34
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	13.03	33.51	35.90	61.99	88.01
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	15.00	15.00	15.00	15.00	15.00
te	= Existing Rock Rip-Rap Thickness =	inches	15.00	15.00	15.00	15.00	15.00
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	1.80	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	13.20	8.72	8.26	3.83	0.00
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	5.59	10.07	10.53	14.96	18.79
L/a	= Ratio Used in Table 3 to Find K2 =		14.00	14.00	14.00	14.00	14.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.65	0.73	0.73	0.78	0.82
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.00	1.00	1.00	1.00	1.00
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.00
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	10.09	13.05	13.30	15.47	17.05
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	28.25	36.54	37.24	43.30	47.73
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	8.68	13.12	13.52	17.20	20.08
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	13.25	30.27	32.16	52.03	70.92
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	39.75	90.80	96.47	156.10	212.77
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	11.00	11.00	11.00	11.00	11.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	15.00	15.00	15.00	15.00	15.00
te	= Existing Rock Rip-Rap Thickness =	inches	15.00	15.00	15.00	15.00	15.00
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	10.09	13.05	13.30	15.47	17.05

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		1.00	1.00	1.00	1.00	1.00
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.03	1.03	1.03	1.03	1.03
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		1.02	1.02	1.02	1.02	0.69
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	0.14
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	15.00	15.00	15.00	15.00	15.00
te	= Existing Rock Rip-Rap Thickness =	inches	15.00	15.00	15.00	15.00	15.00
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	None

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	1.80	1.80	1.80	1.80	1.80
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	1.80	1.80	1.80	1.80	1.80

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	10.09	13.05	13.30	15.47	17.05
Yab	= Scour Depth at Abutments	ft	None	None	None	None	None
Yg	= Long Term Degradation (General Scour) =	ft	1.80	1.80	1.80	1.80	1.80
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	11.89	14.85	15.10	17.27	18.85
Yat	= Total Scour at Abutment = Yab + Yg =	ft	1.80	1.80	1.80	1.80	1.80
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		2.13	1.47	1.43	1.15	1.00
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.32	0.18	0.17	0.12	0.10

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation **WSEL = 100.69**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		116.5																						
2	2	95.9	2	-20.6	0.035	1.11	4.81	0.46	0.23	C	18			18	16.04			1.11			0.46			4.79
3	152	95.1	150	-0.8	0.035	778.27	150.00	150.00	5.19	C	99,351			99,351	127.66			778.27			150.00			5.59
4	300	95.8	148	0.7	0.035	775.29	148.00	148.00	5.24	C	99,607			99,607	128.48			775.29			148.00			4.89
5	301	116.3	1	20.5	0.035	0.58	4.89	0.24	0.12	C	6			6	10.30			0.58			0.24			
6	301	116.3			0.035					C														
7	301	116.3			0.035					C														
8	301	116.3			0.035					C														
9	301	116.3			0.035					C														
10	301	116.3			0.035					C														
11	301	116.3			0.035					C														
12	301	116.3			0.035					C														
13	301	116.3			0.035					C														
14	301	116.3			0.035					C														
15	301	116.3			0.035					C														
16	301	116.3			0.035					C														
17	301	116.3			0.035					C														
18	301	116.3			0.035					C														
19	301	116.3			0.035					C														
20	301	116.3			0.035					C														
21	301	116.3			0.035					C														
22	301	116.3			0.035					C														
Total			301.00	-0.20	0.735	1,555.25	307.71	298.70	10.78		198,982			198,982				1,555			298.70			
Maximum	301.00	116.5	150.00	20.50	0.035	778.27	150.00	150.00	5.24						128.48			778.27						5.59
Minimum		95.1		-20.60	0.035																			
Range	301.00	21.4	150.00	41.10		778.27	150.00	150.00	5.24															
Average	266.91	113.5	14.33	-0.01	0.035	74.06	14.65	14.22	0.51															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			13,500	13,500
V			8.68	
T			299	299
Y			5.59	
A			1,555	1,555

Solve for the 2nd Water Surface Elevation WSEL = 105.17

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		116.5																						
2	2	95.9	2	-20.6	0.035	4.17	9.32	0.90	0.45	C	104			104	24.92			4.17			0.90			9.27
3	152	95.1	150	-0.8	0.035	1,451.02	150.00	150.00	9.67	C	280,655			280,655	193.42			1,451.02			150.00			10.07
4	300	95.8	148	0.7	0.035	1,439.08	148.00	148.00	9.72	C	279,304			279,304	194.09			1,439.08			148.00			9.37
5	301	116.3	1	20.5	0.035	2.14	9.38	0.46	0.23	C	34			34	15.90			2.14			0.46			
6	301	116.3			0.035					C														
7	301	116.3			0.035					C														
8	301	116.3			0.035					C														
9	301	116.3			0.035					C														
10	301	116.3			0.035					C														
11	301	116.3			0.035					C														
12	301	116.3			0.035					C														
13	301	116.3			0.035					C														
14	301	116.3			0.035					C														
15	301	116.3			0.035					C														
16	301	116.3			0.035					C														
17	301	116.3			0.035					C														
18	301	116.3			0.035					C														
19	301	116.3			0.035					C														
20	301	116.3			0.035					C														
21	301	116.3			0.035					C														
22	301	116.3			0.035					C														
Total			301.00	-0.20	0.735	2,896.42	316.71	299.36	20.07		560,097			560,097				2,896			299.36			
Maximum	301.00	116.5	150.00	20.50	0.035	1,451.02	150.00	150.00	9.72						194.09			1,451.02						10.07
Minimum		95.1		-20.60	0.035																			
Range	301.00	21.4	150.00	41.10		1,451.02	150.00	150.00	9.72															
Average	266.91	113.5	14.33	-0.01	0.035	137.92	15.08	14.26	0.96						20.40									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			38,000	38,000
V			13.12	
T			299	299
Y			10.07	
A			2,896	2,896

Solve for the 3rd Water Surface Elevation WSEL = 105.63

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		116.5																						
2	2	95.9	2	-20.6	0.035	4.59	9.77	0.94	0.47	C	118			118	25.72			4.59			0.94			9.73
3	152	95.1	150	-0.8	0.035	1,518.86	150.00	150.00	10.13	C	302,866			302,866	199.40			1,518.86			150.00			10.53
4	300	95.8	148	0.7	0.035	1,506.01	148.00	148.00	10.18	C	301,292			301,292	200.06			1,506.01			148.00			9.83
5	301	116.3	1	20.5	0.035	2.35	9.84	0.48	0.24	C	39			39	16.40			2.35			0.48			
6	301	116.3			0.035					C														
7	301	116.3			0.035					C														
8	301	116.3			0.035					C														
9	301	116.3			0.035					C														
10	301	116.3			0.035					C														
11	301	116.3			0.035					C														
12	301	116.3			0.035					C														
13	301	116.3			0.035					C														
14	301	116.3			0.035					C														
15	301	116.3			0.035					C														
16	301	116.3			0.035					C														
17	301	116.3			0.035					C														
18	301	116.3			0.035					C														
19	301	116.3			0.035					C														
20	301	116.3			0.035					C														
21	301	116.3			0.035					C														
22	301	116.3			0.035					C														
Total			301.00	-0.20	0.735	3,031.81	317.61	299.42	21.01		604,315			604,315				3,032			299.42			
Maximum	301.00	116.5	150.00	20.50	0.035	1,518.86	150.00	150.00	10.18						200.06			1,518.86						10.53
Minimum		95.1		-20.60	0.035																			
Range	301.00	21.4	150.00	41.10		1,518.86	150.00	150.00	10.18															
Average	266.91	113.5	14.33	-0.01	0.035	144.37	15.12	14.26	1.00						21.03									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			41,000	41,000
V			13.52	
T			299	299
Y			10.53	
A			3,032	3,032

Solve for the 4th Water Surface Elevation WSEL = 110.06

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		116.5																						
2	2	95.9	2	-20.6	0.035	9.73	14.22	1.37	0.68	C	321			321	33.04			9.73			1.37			14.16
3	152	95.1	150	-0.8	0.035	2,183.45	150.00	150.00	14.56	C	554,643			554,643	254.02			2,183.45			150.00			14.96
4	300	95.8	148	0.7	0.035	2,161.74	148.00	148.00	14.61	C	550,386			550,386	254.60			2,161.74			148.00			14.26
5	301	116.3	1	20.5	0.035	4.96	14.27	0.70	0.35	C	104			104	21.03			4.96			0.70			
6	301	116.3			0.035					C														
7	301	116.3			0.035					C														
8	301	116.3			0.035					C														
9	301	116.3			0.035					C														
10	301	116.3			0.035					C														
11	301	116.3			0.035					C														
12	301	116.3			0.035					C														
13	301	116.3			0.035					C														
14	301	116.3			0.035					C														
15	301	116.3			0.035					C														
16	301	116.3			0.035					C														
17	301	116.3			0.035					C														
18	301	116.3			0.035					C														
19	301	116.3			0.035					C														
20	301	116.3			0.035					C														
21	301	116.3			0.035					C														
22	301	116.3			0.035					C														
Total			301.00	-0.20	0.735	4,359.87	326.50	300.07	30.19		1,105,454			1,105,454				4,360			300.07			
Maximum	301.00	116.5	150.00	20.50	0.035	2,183.45	150.00	150.00	14.61						254.60			2,183.45						14.96
Minimum		95.1		-20.60	0.035																			
Range	301.00	21.4	150.00	41.10		2,183.45	150.00	150.00	14.61															
Average	266.91	113.5	14.33	-0.01	0.035	207.61	15.55	14.29	1.44						26.80									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			75,000	75,000
V			17.20	
T			300	300
Y			14.96	
A			4,360	4,360

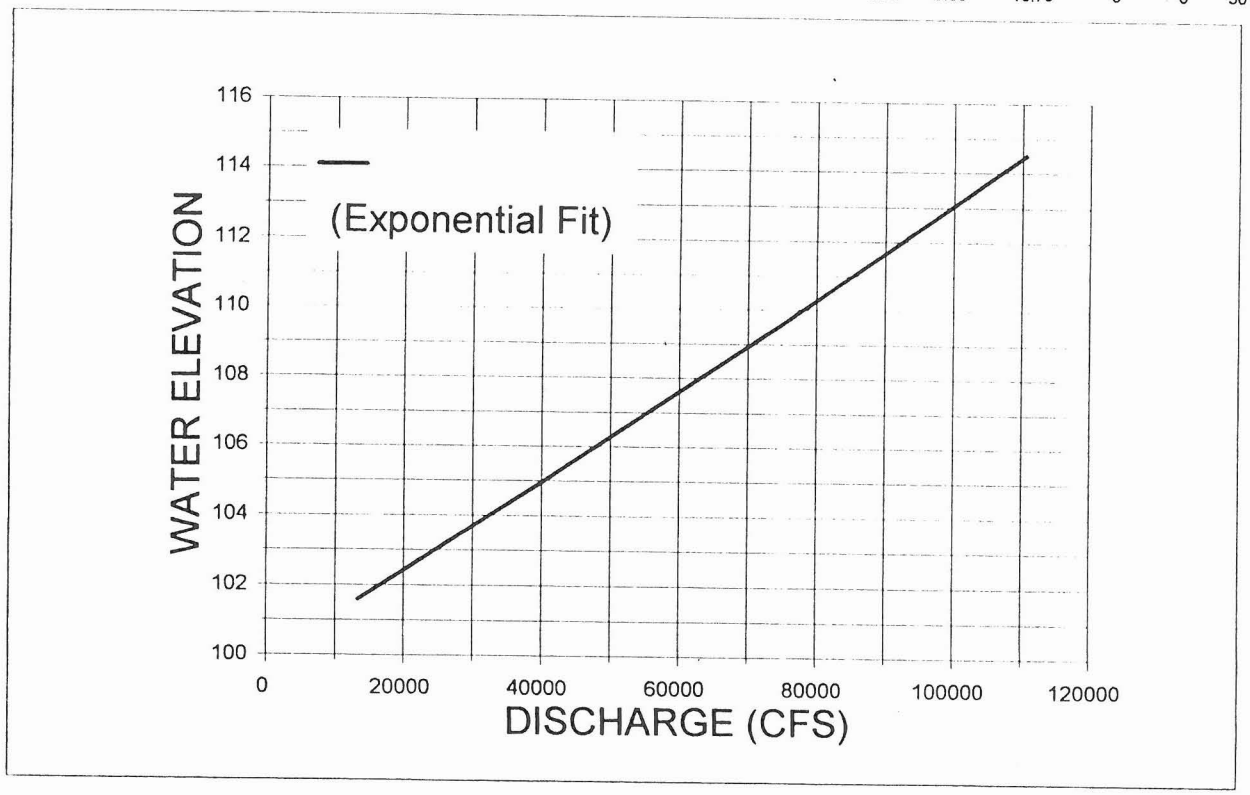
Solve for the 5th Water Surface Elevation **WSEL = 113.89**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		116.5																						
2	2	95.9	2	-20.6	0.035	15.71	18.07	1.75	0.87	C	609			609	38.77			15.71			1.75			17.99
3	152	95.1	150	-0.8	0.035	2,758.50	150.00	150.00	18.39	C	818,961			818,961	296.89			2,758.50			150.00			18.79
4	300	95.8	148	0.7	0.035	2,729.12	148.00	148.00	18.44	C	811,709			811,709	297.43			2,729.12			148.00			18.09
5	301	116.3	1	20.5	0.035	7.98	18.11	0.88	0.44	C	197			197	24.65			7.98			0.88			
6	301	116.3			0.035					C														
7	301	116.3			0.035					C														
8	301	116.3			0.035					C														
9	301	116.3			0.035					C														
10	301	116.3			0.035					C														
11	301	116.3			0.035					C														
12	301	116.3			0.035					C														
13	301	116.3			0.035					C														
14	301	116.3			0.035					C														
15	301	116.3			0.035					C														
16	301	116.3			0.035					C														
17	301	116.3			0.035					C														
18	301	116.3			0.035					C														
19	301	116.3			0.035					C														
20	301	116.3			0.035					C														
21	301	116.3			0.035					C														
22	301	116.3			0.035					C														
Total			301.00	-0.20	0.735	5,511.31	334.19	300.63	38.14		1,631,475			1,631,475				5,511			300.63			
Maximum	301.00	116.5	150.00	20.50	0.035	2,758.50	150.00	150.00	18.44						297.43			2,758.50						18.79
Minimum		95.1		-20.60	0.035																			
Range	301.00	21.4	150.00	41.10		2,758.50	150.00	150.00	18.44															
Average	266.91	113.5	14.33	-0.01	0.035	262.44	15.91	14.32	1.82						31.32									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			110,688	110,688
V			20.08	
T			301	301
Y			18.79	
A			5,511	5,511

DISCHARGE RATING CURVE FOR TYPICAL SECTION

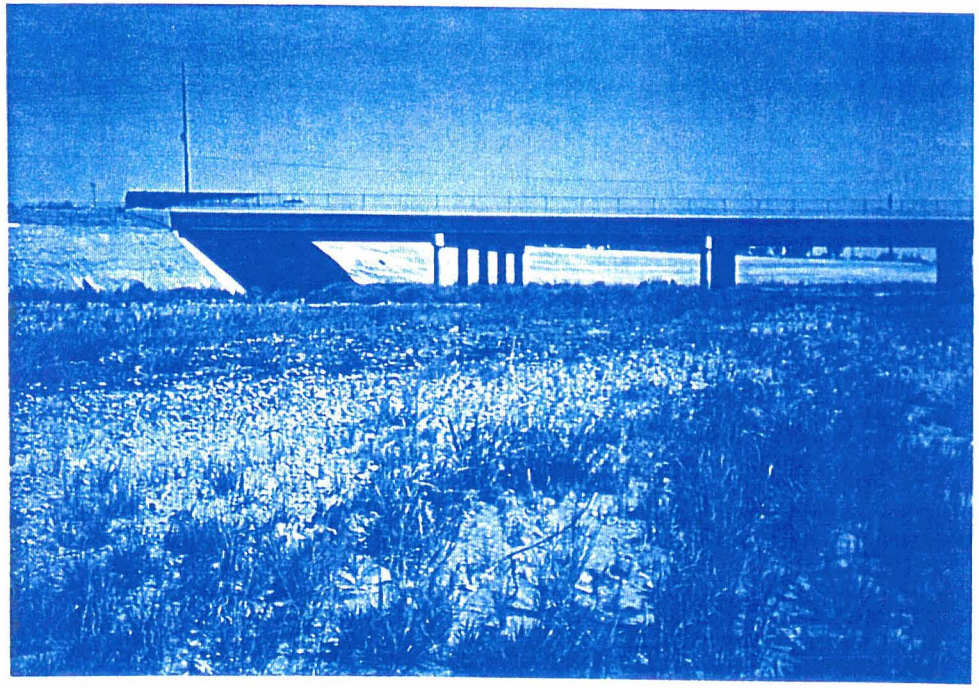
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
100.69	0	0	13,500	13,500	0.00	0.00	8.68	0.00	0.00	5.59	0	0	299	299
105.17	0	0	38,000	38,000	0.00	0.00	13.12	0.00	0.00	10.07	0	0	299	299
105.63	0	0	41,000	41,000	0.00	0.00	13.52	0.00	0.00	10.53	0	0	299	299
110.06	0	0	75,000	75,000	0.00	0.00	17.20	0.00	0.00	14.96	0	0	300	300
113.89	0	0	110,688	110,688	0.00	0.00	20.08	0.00	0.00	18.79	0	0	301	301

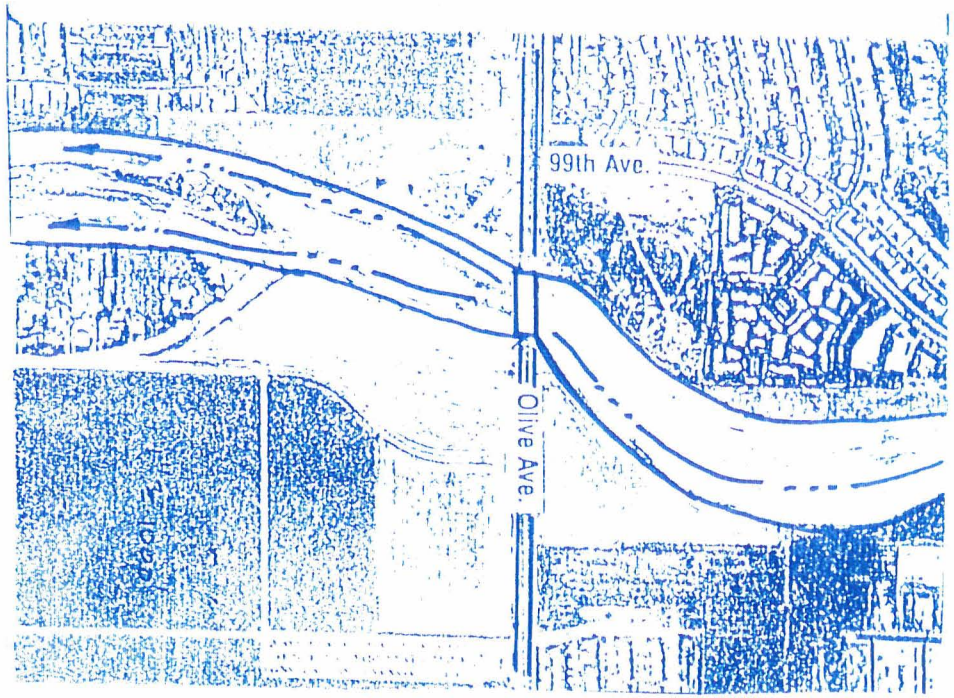


BRIDGE 10 - OLIVE AVENUE (SN 9588)

OLIVE AVENUE (SN 9588)

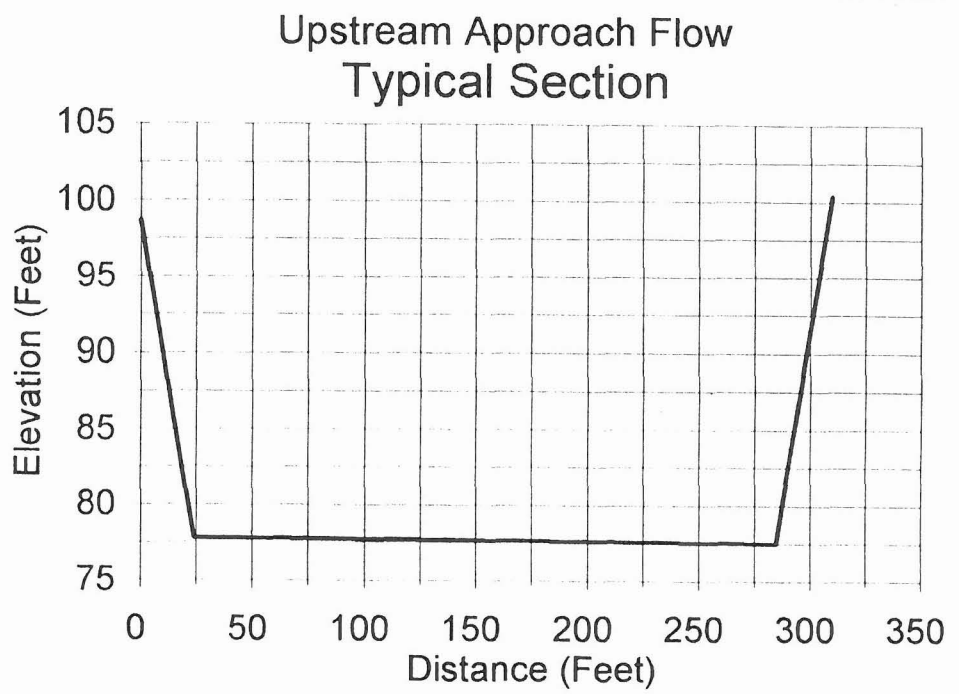
Water Course	New River
Stream Form	(US) Braided to meandering (DS) Braided to straight
Sinuosity	(US) 1.06
General Channelization	Sides of channel US and DS of bridge lined with soil cement forming trapezoidal section with 0.25:1 sideslopes.
Channel Slope	Stepped at bridge.
Estimated Channel Slope (ft/ft)	0.002439
Channel Contraction/Expansion	Wider US; contracted at bridge; slow expansion DS.
Primary Surface Sediment Type	sand/gravel/cobbles
D50 Size	
Armoring Potential	Moderate (locally)
Channel Vegetation	
Type/Size	Small bush to 3 ft., grasses.
Density/Occurrence	Moderately dense stand immediately DS of concrete sill; otherwise vegetation sparse.
Relative Age	Young
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	Soil cement banks.
Vertical	Concrete sill extending approximately 29 ft US and 25 ft. DS of structure; possible grade control structure approximately 2000 ft. US.
Sediment Deposits & Bars	(US) Low point, alternate and poorly developed middle bars. (DS) Occasional low elongate bars forming along channel flow direction. Sand accumulation in dropped section of concrete sill
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	No
Abutment	US east abutment showing some erosion due to flow angle.
Land Use	
Urbanization of Upstream Watershed	Land use commercial, high density residential and some agricultural in DS LOB. General assumption is for increasing urbanization.
Sand & Gravel Extraction	Possible former gravel operations US and DS; elongate "island" in mid-channel forces flow toward banks.
Freeway Construction	No, but general roadway improvements are likely in vicinity.
Dams	New River dam several miles US near Jomax Road.
Drainage Channels	Small diameter storm drain outfalls on both sides of channel near bridge.





INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	98.7		
2	24	77.8	0.035	C
3	285	77.5	0.035	C
4	310	100.3	0.035	C
5	310	100.3	0.035	C
6	310	100.3	0.035	C
7	310	100.3	0.035	C
8	310	100.3	0.035	C
9	310	100.3	0.035	C
10	310	100.3	0.035	C
11	310	100.3	0.035	C
12	310	100.3	0.035	C
13	310	100.3	0.035	C
14	310	100.3	0.035	C
15	310	100.3	0.035	C
16	310	100.3	0.035	C
17	310	100.3	0.035	C
18	310	100.3	0.035	C
19	310	100.3	0.035	C
20	310	100.3	0.035	C
21	310	100.3	0.035	C
22	310	100.3	0.035	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	94.69
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	104.60
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	94.69
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	77.50
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	94.69
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	77.50
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00244

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	13,500	84.42	13,500	0.00
2	Assumed	20,000	86.20	20,000	0.00
3	Q100	41,000	90.72	41,000	-0.00
4	Low Chord	64,327	94.69	64,327	0.00
5	Q500	75,000	96.30	75,000	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	71.00
Ws	= Width of Scour Protection =	Feet	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	Unknown
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Concrete
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		6.50

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	71.00
Ws	= Width of Scour Protection =	Full or Part?	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	Unknown
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Concrete
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		6.50

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	71.00
Ws	= Width of Scour Protection =	Feet	Full
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	Unknown
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Concrete
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		6.50

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	Yes
ELs = Top Elevation of Scour Protection =	Feet	71.00
Ds = Distance Downstream =	Feet	0
S = Average Channel Slope = Average Energy Slope =		0.002439
Ws = Width of Scour Protection =	Feet	Full
Ls = Length of Scour Protection =	Feet	Full
Ts = Thickness of Scour Protection =	Inches	Unknown
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material = Material of Scour Protection =		Concrete
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		6.50

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0263	0.0263	0.0263	0.0263	0.0263
Angle	= *Angle of Attack* =	*Degrees*	20	20	20	20	20
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	3.00	3.00	3.00	3.00	3.00
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	7.00	7.00	7.00	7.00	7.00
L	= Pier Length =	ft	84.00	84.00	84.00	84.00	84.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	130	130	130	130	130

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	104.60	104.60	104.60	104.60	104.60
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	94.69	94.69	94.69	94.69	94.69
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	84.42	86.20	90.72	94.69	96.30
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	77.50	77.50	77.50	77.50	77.50
y1	= Average Depth in the Upstream Main Channel =	ft	6.92	8.70	13.22	17.19	18.80
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	276	280	290	299	303
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	276	280	290	299	303
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	13,500	20,000	41,000	64,327	75,000
Q2	= Flow in the Contracted Channel =	cfs	13,500	20,000	41,000	64,327	75,000
V1	= Mean Velocity of Flow Upstream of Pier =	fps	7.43	8.65	11.38	13.48	14.27
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.50	0.52	0.55	0.57	0.58
S1	= Energy Slope in Main Channel =		0.00244	0.00244	0.00244	0.00244	0.00244

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	4.73	4.91	5.27	5.50	5.59
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.64	0.57	0.46	0.41	0.39
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.74	0.83	1.02	1.16	1.21
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.03288	0.03288	0.03288	0.03288	0.03288
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	1.00	1.00	1.00	1.00	1.00
U/w	= Ratio of Shear Velocity to Fall Velocity =		0.74	0.83	1.02	1.16	1.21
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	6.92	8.70	13.22	17.19	18.80
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	7.43	8.65	11.38	13.48	14.27
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	2.44	3.44	6.36	9.27	10.52
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	7.33	10.32	19.08	27.81	31.56
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	Yes	Yes	Yes	Yes
Ymax	= Maximum Depth Limited by Scour Protection =	ft	6.50	6.50	6.50	6.50	6.50
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00
Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	10.27	8.49	3.97	0.00	-1.61
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	6.92	8.70	13.22	17.19	18.80
L/a	= Ratio Used in Table 3 to Find K2 =		12.00	12.00	12.00	12.00	12.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.50	0.52	0.55	0.57	0.58
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		2.83	2.83	2.83	2.83	2.83
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.58
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	32.19	35.44	42.20	47.03	76.87
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	90.12	99.23	118.16	131.67	215.25
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	7.43	8.65	11.38	13.48	14.27
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	9.70	13.14	22.76	31.94	35.80
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	29.09	39.43	68.29	95.81	107.40
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	14.00	14.00	14.00	14.00	14.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	Yes	Yes	Yes	Yes
Ymax	= Maximum Depth Limited by Scour Protection =	ft	6.50	6.50	6.50	6.50	6.50
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	6.50	6.50	6.50	6.50	6.50

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		1.00	1.00	1.00	1.00	1.00
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.05	1.05	1.05	1.05	1.05
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		1.02	1.02	1.02	1.02	1.02
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
We	= Existing Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	Yes	Yes	Yes	Yes
Ymax	= Maximum Depth Limited by Scour Protection =	ft	6.50	6.50	6.50	6.50	6.50
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	6.50	6.50	6.50	6.50	6.50
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	6.50	6.50	6.50	6.50	6.50
Yab	= Scour Depth at Abutments	ft	0.00	0.00	0.00	0.00	0.00
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	10.50	10.50	10.50	10.50	10.50
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	4.00
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		1.52	1.21	0.79	0.61	0.56
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.58	0.46	0.30	0.23	0.21

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 84.42

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.7																						
2	24	77.8	24	-20.9	0.035	25.15	10.08	7.60	2.50	C	1,971			1,971	78.35			25.15			7.60			6.62
3	285	77.5	261	-0.3	0.035	1,766.68	261.00	261.00	6.77	C	269,298			269,298	152.43			1,766.68			261.00			6.92
4	310	100.3	25	22.82	0.035	26.22	10.26	7.58	2.56	C	2,087			2,087	79.59			26.22			7.58			
5	310	100.3			0.035					C														
6	310	100.3			0.035					C														
7	310	100.3			0.035					C														
8	310	100.3			0.035					C														
9	310	100.3			0.035					C														
10	310	100.3			0.035					C														
11	310	100.3			0.035					C														
12	310	100.3			0.035					C														
13	310	100.3			0.035					C														
14	310	100.3			0.035					C														
15	310	100.3			0.035					C														
16	310	100.3			0.035					C														
17	310	100.3			0.035					C														
18	310	100.3			0.035					C														
19	310	100.3			0.035					C														
20	310	100.3			0.035					C														
21	310	100.3			0.035					C														
22	310	100.3			0.035					C														
Total			310.00	1.62	0.735	1,818.06	281.34	276.18	11.82		273,356			273,356				1,818			276.18			
Maximum	310.00	100.3	261.00	22.82	0.035	1,766.68	261.00	261.00	6.77						152.43			1,766.68						6.92
Minimum		77.5		-20.90	0.035																			
Range	310.00	22.8	261.00	43.72		1,766.68	261.00	261.00	6.77															
Average	281.77	98.2	14.76	0.08	0.035	86.57	13.40	13.15	0.56															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			13,500	13,500
V			7.43	
T			276	276
Y			6.92	
A			1,818	1,818

Solve for the 2nd Water Surface Elevation WSEL = 86.20

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.7																						
2	24	77.8	24	-20.9	0.035	40.50	12.79	9.64	3.17	C	3,720			3,720	91.84			40.50			9.64			8.40
3	285	77.5	261	-0.3	0.035	2,231.21	261.00	261.00	8.55	C	397,409			397,409	178.11			2,231.21			261.00			8.70
4	310	100.3	25	22.82	0.035	41.45	12.90	9.53	3.21	C	3,843			3,843	92.72			41.45			9.53			
5	310	100.3			0.035					C														
6	310	100.3			0.035					C														
7	310	100.3			0.035					C														
8	310	100.3			0.035					C														
9	310	100.3			0.035					C														
10	310	100.3			0.035					C														
11	310	100.3			0.035					C														
12	310	100.3			0.035					C														
13	310	100.3			0.035					C														
14	310	100.3			0.035					C														
15	310	100.3			0.035					C														
16	310	100.3			0.035					C														
17	310	100.3			0.035					C														
18	310	100.3			0.035					C														
19	310	100.3			0.035					C														
20	310	100.3			0.035					C														
21	310	100.3			0.035					C														
22	310	100.3			0.035					C														
Total			310.00	1.62	0.735	2,313.16	286.69	280.17	14.93		404,971			404,971				2,313			280.17			
Maximum	310.00	100.3	261.00	22.82	0.035	2,231.21	261.00	261.00	8.55						178.11			2,231.21						8.70
Minimum		77.5		-20.90	0.035																			
Range	310.00	22.8	261.00	43.72		2,231.21	261.00	261.00	8.55															
Average	281.77	98.2	14.76	0.08	0.035	110.15	13.65	13.34	0.71						17.27									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			20,000	20,000
V			8.65	
T			280	280
Y			8.70	
A			2,313	2,313

Solve for the 3rd Water Surface Elevation WSEL = 90.72

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.7																						
2	24	77.8	24	-20.9	0.035	95.88	19.68	14.84	4.87	C	11,737			11,737	122.42			95.88			14.84			12.92
3	285	77.5	261	-0.3	0.035	3,411.88	261.00	261.00	13.07	C	806,713			806,713	236.44			3,411.88			261.00			13.22
4	310	100.3	25	22.82	0.035	95.77	19.61	14.49	4.88	C	11,740			11,740	122.59			95.77			14.49			
5	310	100.3			0.035					C														
6	310	100.3			0.035					C														
7	310	100.3			0.035					C														
8	310	100.3			0.035					C														
9	310	100.3			0.035					C														
10	310	100.3			0.035					C														
11	310	100.3			0.035					C														
12	310	100.3			0.035					C														
13	310	100.3			0.035					C														
14	310	100.3			0.035					C														
15	310	100.3			0.035					C														
16	310	100.3			0.035					C														
17	310	100.3			0.035					C														
18	310	100.3			0.035					C														
19	310	100.3			0.035					C														
20	310	100.3			0.035					C														
21	310	100.3			0.035					C														
22	310	100.3			0.035					C														
Total			310.00	1.62	0.735	3,603.52	300.29	290.32	22.83		830,191			830,191				3,604			290.32			
Maximum	310.00	100.3	261.00	22.82	0.035	3,411.88	261.00	261.00	13.07						236.44			3,411.88						13.22
Minimum		77.5		-20.90	0.035																			
Range	310.00	22.8	261.00	43.72		3,411.88	261.00	261.00	13.07															
Average	281.77	98.2	14.76	0.08	0.035	171.60	14.30	13.82	1.09						22.93									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			41,000	41,000
V			11.38	
T			290	290
Y			13.22	
A			3,604	3,604

Solve for the 4th Water Surface Elevation WSEL = 94.69

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.7																						
2	24	77.8	24	-20.9	0.035	163.79	25.72	19.40	6.37	C	23,972			23,972	146.36			163.79			19.40			16.89
3	285	77.5	261	-0.3	0.035	4,447.44	261.00	261.00	17.04	C	1,254,927			1,254,927	282.17			4,447.44			261.00			17.19
4	310	100.3	25	22.82	0.035	161.86	25.50	18.83	6.35	C	23,639			23,639	146.04			161.86			18.83			
5	310	100.3			0.035					C														
6	310	100.3			0.035					C														
7	310	100.3			0.035					C														
8	310	100.3			0.035					C														
9	310	100.3			0.035					C														
10	310	100.3			0.035					C														
11	310	100.3			0.035					C														
12	310	100.3			0.035					C														
13	310	100.3			0.035					C														
14	310	100.3			0.035					C														
15	310	100.3			0.035					C														
16	310	100.3			0.035					C														
17	310	100.3			0.035					C														
18	310	100.3			0.035					C														
19	310	100.3			0.035					C														
20	310	100.3			0.035					C														
21	310	100.3			0.035					C														
22	310	100.3			0.035					C														
Total			310.00	1.62	0.735	4,773.10	312.22	299.23	29.76		1,302,538			1,302,538				4,773			299.23			
Maximum	310.00	100.3	261.00	22.82	0.035	4,447.44	261.00	261.00	17.04						282.17			4,447.44						17.19
Minimum		77.5		-20.90	0.035																			
Range	310.00	22.8	261.00	43.72		4,447.44	261.00	261.00	17.04															
Average	281.77	98.2	14.76	0.08	0.035	227.29	14.87	14.25	1.42						27.36									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			64,327	64,327
V			13.48	
T			299	299
Y			17.19	
A			4,773	4,773

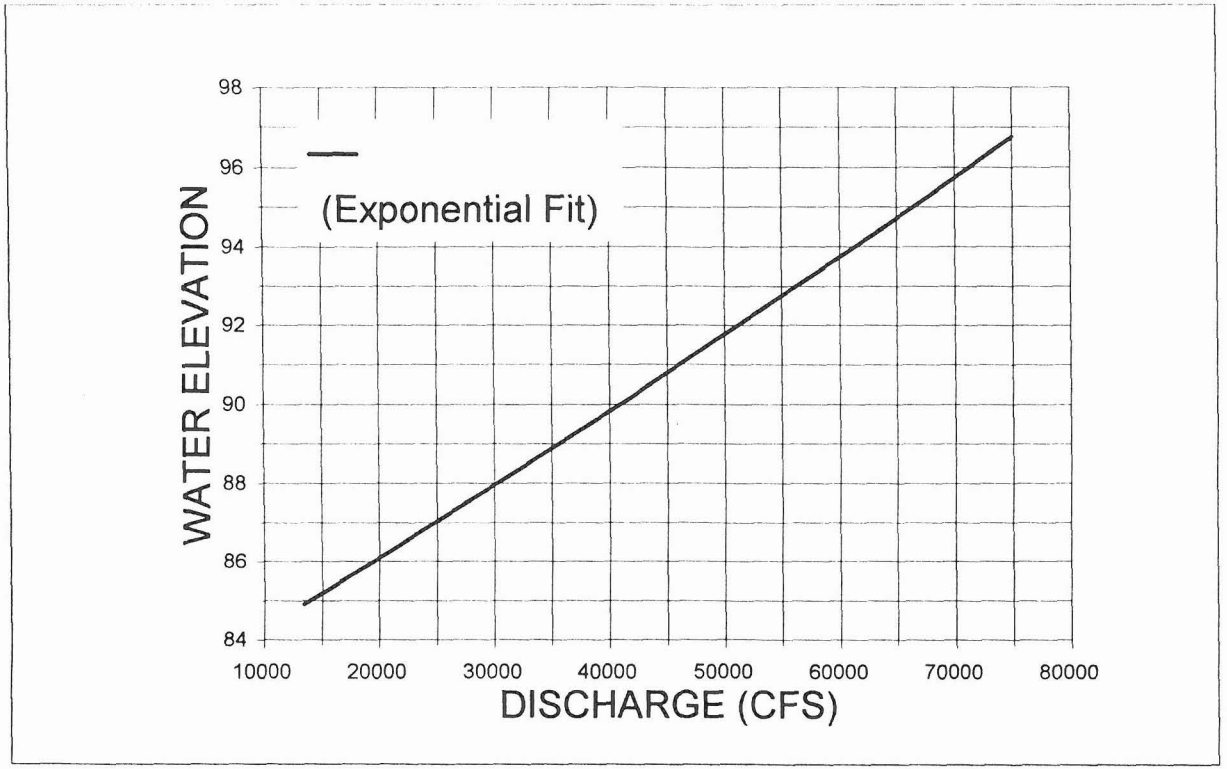
Solve for the 5th Water Surface Elevation | **WSEL = 98.30**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		98.7																						
2	24	77.8	24	-20.9	0.035	196.40	28.16	21.24	6.97	C	30,540			30,540	155.49			196.40			21.24			18.50
3	285	77.5	261	-0.3	0.035	4,866.37	261.00	261.00	18.65	C	1,458,109			1,458,109	299.63			4,866.37			261.00			18.80
4	310	100.3	25	22.82	0.035	193.50	27.88	20.59	6.94	C	29,993			29,993	155.00			193.50			20.59			
5	310	100.3			0.035					C														
6	310	100.3			0.035					C														
7	310	100.3			0.035					C														
8	310	100.3			0.035					C														
9	310	100.3			0.035					C														
10	310	100.3			0.035					C														
11	310	100.3			0.035					C														
12	310	100.3			0.035					C														
13	310	100.3			0.035					C														
14	310	100.3			0.035					C														
15	310	100.3			0.035					C														
16	310	100.3			0.035					C														
17	310	100.3			0.035					C														
18	310	100.3			0.035					C														
19	310	100.3			0.035					C														
20	310	100.3			0.035					C														
21	310	100.3			0.035					C														
22	310	100.3			0.035					C														
Total			310.00	1.62	0.735	5,256.28	317.04	302.83	32.56		1,518,642			1,518,642				5,256			302.83			
Maximum	310.00	100.3	261.00	22.82	0.035	4,866.37	261.00	261.00	18.65						299.63			4,866.37						18.80
Minimum		77.5		-20.90	0.035																			
Range	310.00	22.8	261.00	43.72		4,866.37	261.00	261.00	18.65															
Average	281.77	98.2	14.76	0.08	0.035	250.30	15.10	14.42	1.55						29.05									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			75,000	75,000
V			14.27	
T			303	303
Y			18.80	
A			5,256	5,256

DISCHARGE RATING CURVE FOR TYPICAL SECTION

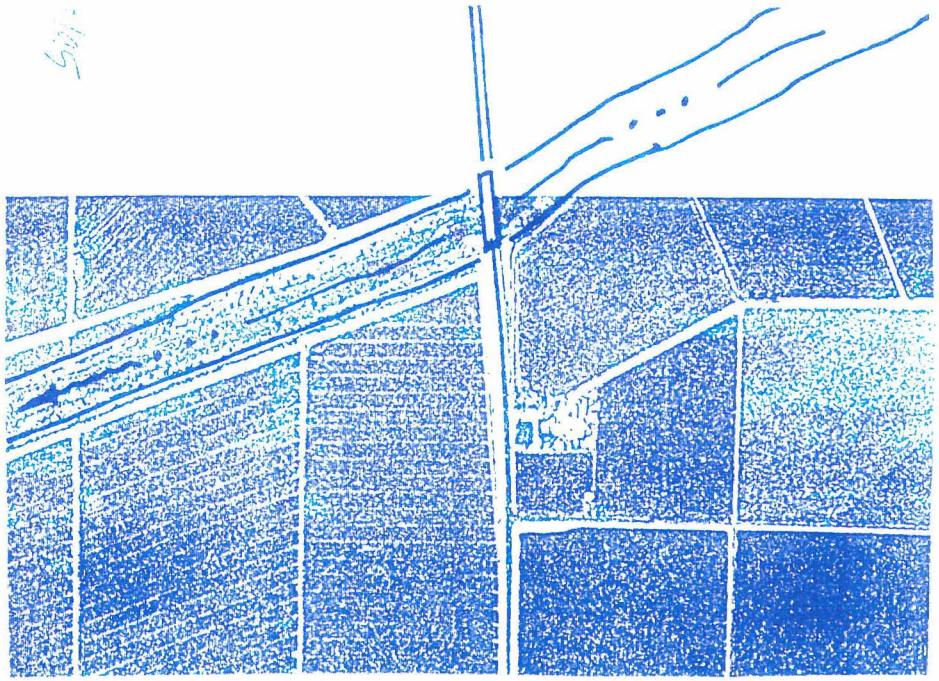
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
84.42	0	0	13,500	13,500	0.00	0.00	7.43	0.00	0.00	6.92	0	0	276	276
86.20	0	0	20,000	20,000	0.00	0.00	8.65	0.00	0.00	8.70	0	0	280	280
90.72	0	0	41,000	41,000	0.00	0.00	11.38	0.00	0.00	13.22	0	0	290	290
94.69	0	0	64,327	64,327	0.00	0.00	13.48	0.00	0.00	17.19	0	0	299	299
96.30	0	0	75,000	75,000	0.00	0.00	14.27	0.00	0.00	18.80	0	0	303	303



BRIDGE 11 - OLD U.S. HIGHWAY 80 (SN 9999)

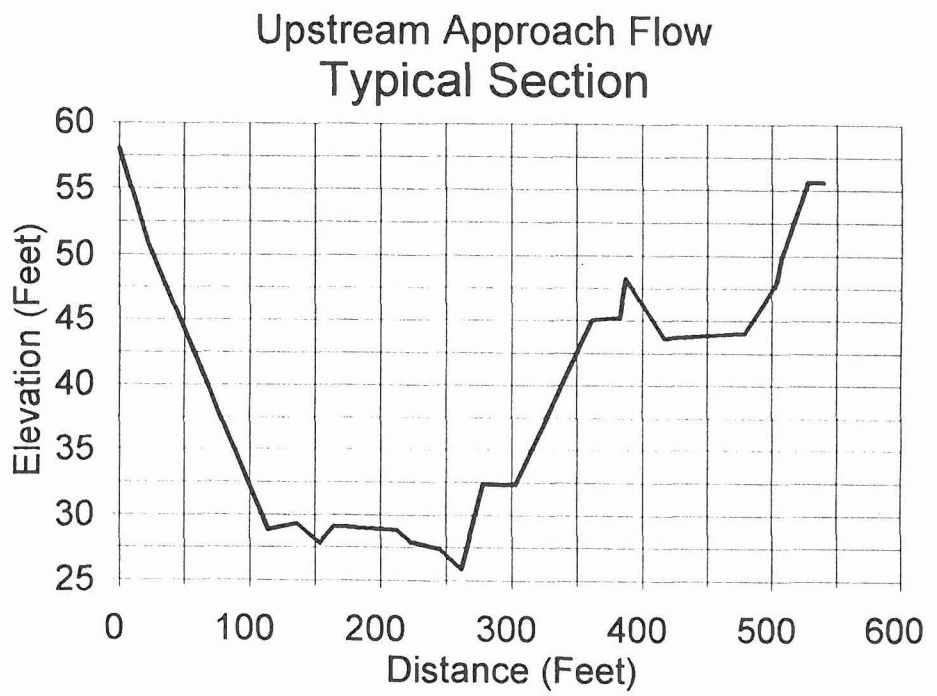
OLD U.S. HIGHWAY 80 (SN 9999)

Water Course	Hassayampa
Stream Form	Straight (US) Braided Characteristics (DS) Straight
Sinuosity	Not applicable
General Channelization	Non-structural (agricultural), trapezoidal, earthen levees.
Channel Slope	Uniform
Estimated Channel Slope (ft/ft)	0.002897
Channel Contraction/Expansion	Main channel slightly wider US
Primary Surface Sediment Type	silt/sand
D50 Size	0.30 MM (estimate)
Armoring Potential	Low
Channel Vegetation	
Type/Size	Desert Willow to 15 ft., Cottonwood to 15 ft., Palo Verde, Mesquite to 9 ft., Ironwood; Broom to 6 ft., Creosote, Ephedra, Brittle Bush, Sage; dry grasses.
Density/Occurrence	Larger trees occur sparsely on bars and on banks; smaller brush occurs mainly on bank sideslopes with low to moderate density; dry grasses occur on bank sideslopes with low to moderate density.
Relative Age	
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	Non-structural, earthen levees.
Vertical	No
Sediment Deposits & Bars	US: Low to moderate point, alternate and middle bars forming in braided condition. DS: Slight point and alternating bars forming in a generally straight condition.
Evidence of Degradation	Steep cut banks may indicate potential for incision, otherwise none.
Evidence of Aggradation	No
Evidence of Scour	
Pier	Primary low flow crosses pier 2 indicating potential for scour, none otherwise.
Abutment	None
Land Use	
Urbanization of Upstream Watershed	Low rate; land use primarily agriculturalor very low density residential.
Sand & Gravel Extraction	No
Freeway Construction	None locally.
Dams	None locally.
Drainage Channels	Side channel from west may contribute small to moderate flow; possible irrigation inflows US/DS.



INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	58.0		
2	22	51.0	0.035	L
3	115	28.8	0.035	C
4	137	29.3	0.035	C
5	154	27.8	0.035	C
6	165	29.1	0.035	C
7	213	28.8	0.035	C
8	223	27.9	0.035	C
9	245	27.4	0.035	C
10	262	25.8	0.035	C
11	278	32.3	0.035	C
12	303	32.3	0.035	C
13	362	45.0	0.035	C
14	383	45.2	0.035	C
15	388	48.2	0.035	C
16	417	43.6	0.035	C
17	479	44.0	0.035	C
18	504	47.9	0.035	C
19	508	49.9	0.035	C
20	528	55.6	0.035	R
21	530	55.6	0.035	R
22	540	55.6	0.035	R



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	49.70
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	61.00
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	49.70
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	25.80
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	49.70
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	25.80
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00290

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q50	36,800	42.25	36,800	0.00
2		40,000	42.88	40,000	0.00
3	Q100	73,500	47.92	73,500	0.00
4	Low Chord	89,086	49.70	89,086	0.00
5	Q500	125,685	53.19	125,685	0.00

Abutment Scour Protection

	Is there evidence of scour protection?	Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Feet	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = ELg - ELs =		None

Contraction Scour Protection

	Is there evidence of scour protection?	Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

	Is there evidence of scour protection?	Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	25.00
Ws	= Width of Scour Protection =	Feet	20.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	60.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	12.00
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		0.80

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.002897
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0010	0.0010	0.0010	0.0010	0.0010
Angle	= *Angle of Attack* =	*Degrees*	10	10	10	10	10
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	5.50	5.50	5.50	5.50	5.50
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	9.50	9.50	9.50	9.50	9.50
L	= Pier Length =	ft	66.00	66.00	66.00	66.00	66.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	65	65	65	65	65

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	61.00	61.00	61.00	61.00	61.00
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	49.70	49.70	49.70	49.70	49.70
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	42.25	42.88	47.92	49.70	53.19
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	25.80	25.80	25.80	25.80	25.80
y1	= Average Depth in the Upstream Main Channel =	ft	16.45	17.08	22.12	23.90	27.39
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	291	296	467	480	504
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	291	296	467	480	486
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	36,800	40,000	73,500	89,086	125,608
Q2	= Flow in the Contracted Channel =	cfs	36,800	40,000	73,500	89,086	125,685
V1	= Mean Velocity of Flow Upstream of Pier =	fps	11.84	12.15	13.84	14.48	16.01
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.51	0.52	0.52	0.52	0.54
S1	= Energy Slope in Main Channel =		0.00290	0.00290	0.00290	0.00290	0.00290

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	1.83	1.84	1.92	1.95	1.99
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.15	0.15	0.14	0.13	0.12
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	1.24	1.26	1.44	1.49	1.60
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00123	0.00123	0.00123	0.00123	0.00123
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.15	0.15	0.15	0.15	0.15
U/w	= Ratio of Shear Velocity to Fall Velocity =		8.40	8.56	9.74	10.13	10.84
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.69	0.69	0.69	0.69	0.69
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	16.45	17.08	22.12	23.90	28.12
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.73
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	11.84	12.15	13.84	14.48	16.62
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	6.42	6.81	8.86	9.75	13.77
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	19.25	20.43	26.57	29.25	41.31
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.73

Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	7.45	6.82	1.78	0.00	-3.49
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	16.45	17.08	22.12	23.90	27.39
L/a	= Ratio Used in Table 3 to Find K2 =		7.00	7.00	7.00	7.00	7.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.51	0.52	0.52	0.52	0.54
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.58	1.58	1.58	1.58	1.58
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.53
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	30.13	30.62	33.55	34.56	56.13
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	84.36	85.74	93.93	96.76	157.15
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	11.84	12.15	13.84	14.48	16.62
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	24.63	25.95	33.70	36.87	48.57
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	73.89	77.85	101.10	110.62	145.70
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	19.00	19.00	19.00	19.00	19.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	12.00	12.00	12.00	12.00	12.00
te	= Existing Rock Rip-Rap Thickness =	inches	60.00	60.00	60.00	60.00	60.00
We	= Existing Rock Rip-Rap Width =	Feet	20.00	20.00	20.00	20.00	20.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	30.13	30.62	33.55	34.56	56.13

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	12
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	59
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	3.11
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	19
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	1.65
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		0.96	0.96	0.96	0.96	0.96
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	0.43
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	4.35
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	16.62
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	55.52
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	166.57
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	25.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	4.35

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.73
Yl	= Local Scour Depth =	ft	30.13	30.62	33.55	34.56	56.13
Yab	= Scour Depth at Abutments	ft	None	None	None	None	4.35
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	34.13	34.62	37.55	38.56	60.85
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	8.35
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		2.07	2.03	1.70	1.61	2.22
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.24	0.23	0.18	0.17	0.31

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 42.25

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		58.0																						
2	22	51.0	22	-7	0.035					L														
3	115	28.8	93	-22.2	0.035	379.06	57.94	56.36	6.54	C	56,484			56,484	149.01			379.06			56.36			13.45
4	137	29.3	22	0.5	0.035	290.46	22.01	22.00	13.20	C	69,120			69,120	237.97			290.46			22.00			12.95
5	154	27.8	17	-1.5	0.035	232.94	17.07	17.00	13.65	C	56,688			56,688	243.36			232.94			17.00			14.45
6	165	29.1	11	1.3	0.035	151.83	11.08	11.00	13.71	C	37,052			37,052	244.04			151.83			11.00			13.15
7	213	28.8	48	-0.3	0.035	638.52	48.00	48.00	13.30	C	152,740			152,740	239.21			638.52			48.00			13.45
8	223	27.9	10	-0.9	0.035	139.03	10.04	10.00	13.85	C	34,158			34,158	245.69			139.03			10.00			14.35
9	245	27.4	22	-0.5	0.035	321.26	22.01	22.00	14.60	C	81,765			81,765	254.52			321.26			22.00			14.85
10	262	25.8	17	-1.6	0.035	266.09	17.08	17.00	15.58	C	70,740			70,740	265.85			266.09			17.00			16.45
11	278	32.3	16	6.5	0.035	211.24	17.27	16.00	12.23	C	47,780			47,780	226.19			211.24			16.00			9.95
12	303	32.3	25		0.035	248.81	25.00	25.00	9.95	C	49,047			49,047	197.12			248.81			25.00			9.95
13	362	45.0	59	12.7	0.035	230.08	47.30	46.24	4.86	C	28,137			28,137	122.29			230.08			46.24			
14	383	45.2	21	0.2	0.035					C														
15	388	48.2	5	3	0.035					C														
16	417	43.6	29	-4.6	0.035					C														
17	479	44.0	62	0.4	0.035					C														
18	504	47.9	25	3.9	0.035					C														
19	508	49.9	4	2	0.035					C														
20	528	55.6	20	5.7	0.035					R														
21	530	55.6	2		0.035					R														
22	540	55.6	10		0.035					R														
Total			540.00	-2.40	0.735	3,109.33	294.77	290.59	131.48		683,713			683,713				3,109			290.59			
Maximum	540.00	58.0	93.00	12.70	0.035	638.52	57.94	56.36	15.58						265.85			638.52						16.45
Minimum		25.8	2.00	-22.20	0.035																			
Range	540.00	32.2	91.00	34.90		638.52	57.94	56.36	15.58															
Average	307.09	40.4	25.71	-0.11	0.035	148.06	14.04	13.84	6.26															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			36,800	36,800
V			11.84	
T			291	291
Y			16.45	
A			3,109	3,109

Solve for the 2nd Water Surface Elevation WSEL = 42.88

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		58.0																						
2	22	51.0	22	-7	0.035					L														
3	115	28.8	93	-22.2	0.035	415.08	60.63	58.97	6.85	C	63,752			63,752	153.59			415.08			58.97			14.08
4	137	29.3	22	0.5	0.035	304.20	22.01	22.00	13.82	C	74,656			74,656	245.42			304.20			22.00			13.58
5	154	27.8	17	-1.5	0.035	243.56	17.07	17.00	14.27	C	61,061			61,061	250.70			243.56			17.00			15.08
6	165	29.1	11	1.3	0.035	158.70	11.08	11.00	14.33	C	39,889			39,889	251.35			158.70			11.00			13.78
7	213	28.8	48	-0.3	0.035	668.50	48.00	48.00	13.93	C	164,881			164,881	246.64			668.50			48.00			14.08
8	223	27.9	10	-0.9	0.035	145.27	10.04	10.00	14.47	C	36,754			36,754	253.00			145.27			10.00			14.98
9	245	27.4	22	-0.5	0.035	335.00	22.01	22.00	15.22	C	87,878			87,878	261.73			335.00			22.00			15.48
10	262	25.8	17	-1.6	0.035	276.71	17.08	17.00	16.21	C	75,507			75,507	272.87			276.71			17.00			17.08
11	278	32.3	16	6.5	0.035	221.23	17.27	16.00	12.81	C	51,608			51,608	233.27			221.23			16.00			10.58
12	303	32.3	25		0.035	264.43	25.00	25.00	10.58	C	54,285			54,285	205.29			264.43			25.00			10.58
13	362	45.0	59	12.7	0.035	259.87	50.26	49.14	5.17	C	33,096			33,096	127.36			259.87			49.14			
14	383	45.2	21	0.2	0.035					C														
15	388	48.2	5	3	0.035					C														
16	417	43.6	29	-4.6	0.035					C														
17	479	44.0	62	0.4	0.035					C														
18	504	47.9	25	3.9	0.035					C														
19	508	49.9	4	2	0.035					C														
20	528	55.6	20	5.7	0.035					R														
21	530	55.6	2		0.035					R														
22	540	55.6	10		0.035					R														
Total			540.00	-2.40	0.735	3,292.54	300.43	296.11	137.65		743,166			743,166				3,293			296.11			
Maximum	540.00	58.0	93.00	12.70	0.035	668.50	60.63	58.97	16.21						272.87			668.50						17.08
Minimum		25.8	2.00	-22.20	0.035																			
Range	540.00	32.2	91.00	34.90		668.50	60.63	58.97	16.21															
Average	307.09	40.4	25.71	-0.11	0.035	156.79	14.31	14.10	6.55						119.11									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			40,000	40,000
V			12.15	
T			296	296
Y			17.08	
A			3,293	3,293

Solve for the 3rd Water Surface Elevation WSEL = 47.92

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC f
1		58.0																						
2	22	51.0	22	-7	0.035					L														
3	115	28.8	93	-22.2	0.035	766.04	82.36	80.11	9.30	C	144,333			144,333	188.41			766.04			80.11			19.1
4	137	29.3	22	0.5	0.035	415.22	22.01	22.00	18.87	C	125,408			125,408	302.02			415.22			22.00			18.6
5	154	27.8	17	-1.5	0.035	329.36	17.07	17.00	19.30	C	100,979			100,979	306.60			329.36			17.00			20.1
6	165	29.1	11	1.3	0.035	214.21	11.08	11.00	19.34	C	65,768			65,768	307.02			214.21			11.00			18.8
7	213	28.8	48	-0.3	0.035	910.74	48.00	48.00	18.97	C	276,082			276,082	303.14			910.74			48.00			19.1
8	223	27.9	10	-0.9	0.035	195.74	10.04	10.00	19.50	C	60,419			60,419	308.67			195.74			10.00			20.0
9	245	27.4	22	-0.5	0.035	446.02	22.01	22.00	20.27	C	141,295			141,295	316.79			446.02			22.00			20.5
10	262	25.8	17	-1.6	0.035	362.51	17.08	17.00	21.23	C	118,443			118,443	326.73			362.51			17.00			22.1
11	278	32.3	16	6.5	0.035	301.98	17.27	16.00	17.49	C	86,691			86,691	287.07			301.98			16.00			15.6
12	303	32.3	25		0.035	390.60	25.00	25.00	15.62	C	104,016			104,016	266.30			390.60			25.00			15.6
13	362	45.0	59	12.7	0.035	547.16	60.35	59.00	9.07	C	101,352			101,352	185.23			547.16			59.00			2.9
14	383	45.2	21	0.2	0.035	59.30	21.00	21.00	2.82	C	5,045			5,045	85.08			59.30			21.00			2.7
15	388	48.2	5	3	0.035	6.18	5.29	4.54	1.17	C	292			292	47.21			6.18			4.54			
16	417	43.6	29	-4.6	0.035	58.93	27.60	27.26	2.14	C	4,161			4,161	70.61			58.93			27.26			4.3
17	479	44.0	62	0.4	0.035	255.68	62.00	62.00	4.12	C	28,003			28,003	109.53			255.68			62.00			3.9
18	504	47.9	25	3.9	0.035	49.35	25.30	25.00	1.95	C	3,280			3,280	66.47			49.35			25.00			0.0
19	508	49.9	4	2	0.035	0.00	0.05	0.05	0.01	C	0			0	2.06			0.00			0.05			
20	528	55.6	20	5.7	0.035					R														
21	530	55.6	2		0.035					R														
22	540	55.6	10		0.035					R														
Total			540.00	-2.40	0.735	5,309.01	473.51	466.96	201.16		1,365,567			1,365,567				5,309			466.96			
Maximum	540.00	58.0	93.00	12.70	0.035	910.74	82.36	80.11	21.23						326.73			910.74						22.1
Minimum		25.8	2.00	-22.20	0.035																			
Range	540.00	32.2	91.00	34.90		910.74	82.36	80.11	21.23															
Average	307.09	40.4	25.71	-0.11	0.035	252.81	22.55	22.24	9.58						165.86									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			73,500	73,500
V			13.84	
T			467	467
Y			22.12	
A			5,309	5,309

Solve for the 4th Water Surface Elevation WSEL = 49.70

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		58.0																						
2	22	51.0	22	-7	0.035					L														
3	115	28.8	93	-22.2	0.035	914.94	90.01	87.55	10.16	C	182,909			182,909	199.91			914.94			87.55			20.9
4	137	29.3	22	0.5	0.035	454.30	22.01	22.00	20.64	C	145,693			145,693	320.70			454.30			22.00			20.4
5	154	27.8	17	-1.5	0.035	359.55	17.07	17.00	21.07	C	116,879			116,879	325.07			359.55			17.00			21.9
6	165	29.1	11	1.3	0.035	233.75	11.08	11.00	21.10	C	76,069			76,069	325.43			233.75			11.00			20.6
7	213	28.8	48	-0.3	0.035	996.00	48.00	48.00	20.75	C	320,496			320,496	321.78			996.00			48.00			20.9
8	223	27.9	10	-0.9	0.035	213.50	10.04	10.00	21.26	C	69,832			69,832	327.08			213.50			10.00			21.8
9	245	27.4	22	-0.5	0.035	485.10	22.01	22.00	22.04	C	162,528			162,528	335.04			485.10			22.00			22.3
10	262	25.8	17	-1.6	0.035	392.70	17.08	17.00	23.00	C	135,341			135,341	344.64			392.70			17.00			23.9
11	278	32.3	16	6.5	0.035	330.40	17.27	16.00	19.13	C	100,713			100,713	304.82			330.40			16.00			17.4
12	303	32.3	25		0.035	435.00	25.00	25.00	17.40	C	124,467			124,467	286.13			435.00			25.00			17.4
13	362	45.0	59	12.7	0.035	651.95	60.35	59.00	10.80	C	135,736			135,736	208.20			651.95			59.00			4.7
14	383	45.2	21	0.2	0.035	96.60	21.00	21.00	4.60	C	11,380			11,380	117.81			96.60			21.00			4.5
15	388	48.2	5	3	0.035	15.00	5.83	5.00	2.57	C	1,199			1,199	79.95			15.00			5.00			1.5
16	417	43.6	29	-4.6	0.035	110.20	29.36	29.00	3.75	C	11,335			11,335	102.86			110.20			29.00			6.1
17	479	44.0	62	0.4	0.035	365.80	62.00	62.00	5.90	C	50,876			50,876	139.08			365.80			62.00			5.7
18	504	47.9	25	3.9	0.035	93.75	25.30	25.00	3.71	C	9,561			9,561	101.98			93.75			25.00			1.8
19	508	49.9	4	2	0.035	3.24	4.02	3.60	0.80	C	119			119	36.84			3.24			3.60			
20	528	55.6	20	5.7	0.035					R														
21	530	55.6	2		0.035					R														
22	540	55.6	10		0.035					R														
Total			540.00	-2.40	0.735	6,151.78	487.43	480.15	228.71		1,655,134			1,655,134				6,152			480.15			
Maximum	540.00	58.0	93.00	12.70	0.035	996.00	90.01	87.55	23.00						344.64			996.00						23.9
Minimum		25.8	2.00	-22.20	0.035																			
Range	540.00	32.2	91.00	34.90		996.00	90.01	87.55	23.00															
Average	307.09	40.4	25.71	-0.11	0.035	292.94	23.21	22.86	10.89						184.83									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			89,086	89,086
V			14.48	
T			480	480
Y			23.90	
A			6,152	6,152

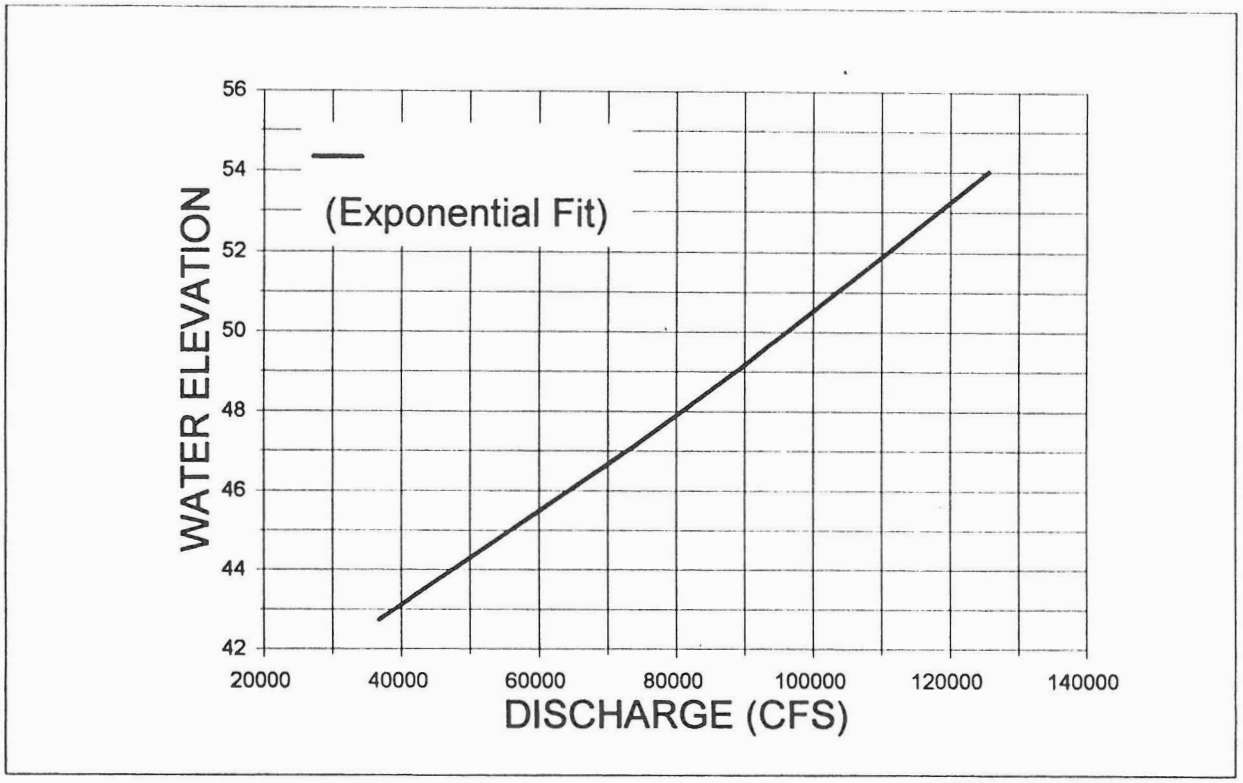
Solve for the 5th Water Surface Elevation WSEL = 53.19

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		58.0																						
2	22	51.0	22	-7	0.035	7.54	7.22	6.88	1.04	L	330	330			43.80	7.54			6.88			2.19		
3	115	28.8	93	-22.2	0.035	1,235.99	95.61	93.00	12.93	C	290,069			290,069	234.69			1,235.99			93.00			24.39
4	137	29.3	22	0.5	0.035	531.08	22.01	22.00	24.13	C	189,014			189,014	355.90			531.08			22.00			23.89
5	154	27.8	17	-1.5	0.035	418.88	17.07	17.00	24.54	C	150,770			150,770	359.93			418.88			17.00			25.39
6	165	29.1	11	1.3	0.035	272.14	11.08	11.00	24.57	C	98,018			98,018	360.17			272.14			11.00			24.09
7	213	28.8	48	-0.3	0.035	1,163.53	48.00	48.00	24.24	C	415,313			415,313	356.94			1,163.53			48.00			24.39
8	223	27.9	10	-0.9	0.035	248.40	10.04	10.00	24.74	C	89,882			89,882	361.84			248.40			10.00			25.29
9	245	27.4	22	-0.5	0.035	561.88	22.01	22.00	25.53	C	207,639			207,639	369.54			561.88			22.00			25.79
10	262	25.8	17	-1.6	0.035	452.03	17.08	17.00	26.47	C	171,120			171,120	378.56			452.03			17.00			27.39
11	278	32.3	16	6.5	0.035	386.24	17.27	16.00	22.37	C	130,660			130,660	338.28			386.24			16.00			20.89
12	303	32.3	25		0.035	522.25	25.00	25.00	20.89	C	168,811			168,811	323.24			522.25			25.00			20.89
13	362	45.0	59	12.7	0.035	857.87	60.35	59.00	14.21	C	214,493			214,493	250.03			857.87			59.00			8.19
14	383	45.2	21	0.2	0.035	169.89	21.00	21.00	8.09	C	29,167			29,167	171.68			169.89			21.00			7.99
15	388	48.2	5	3	0.035	32.45	5.83	5.00	5.57	C	4,341			4,341	133.77			32.45			5.00			4.99
16	417	43.6	29	-4.6	0.035	211.42	29.36	29.00	7.20	C	33,582			33,582	158.84			211.42			29.00			9.59
17	479	44.0	62	0.4	0.035	582.19	62.00	62.00	9.39	C	110,396			110,396	189.62			582.19			62.00			9.19
18	504	47.9	25	3.9	0.035	181.00	25.30	25.00	7.15	C	28,627			28,627	158.16			181.00			25.00			5.29
19	508	49.9	4	2	0.035	17.16	4.47	4.00	3.84	C	1,791			1,791	104.39			17.16			4.00			3.29
20	528	55.6	20	5.7	0.035	18.99	12.00	11.54	1.58	R	1,098		1,098		57.81		18.99			11.54				
21	530	55.6	2		0.035					R														
22	540	55.6	10		0.035					R														
Total			540.00	-2.40	0.735	7,870.96	512.70	504.43	288.49		2,335,120	330	1,098	2,333,692		8	19	7,844	6.88	11.54	486.00			
Maximum	540.00	58.0	93.00	12.70	0.035	1,235.99	95.61	93.00	26.47						378.56	7.54	18.99	1,235.99				2.19		27.39
Minimum		25.8	2.00	-22.20	0.035																			
Range	540.00	32.2	91.00	34.90		1,235.99	95.61	93.00	26.47															
Average	307.09	40.4	25.71	-0.11	0.035	374.81	24.41	24.02	13.74						224.15									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	18	59	125,608	125,685
V	2.36	3.11	16.01	
T	7	12	486	504
Y	2.19		27.39	
A	8	19	7,844	7,871

DISCHARGE RATING CURVE FOR TYPICAL SECTION

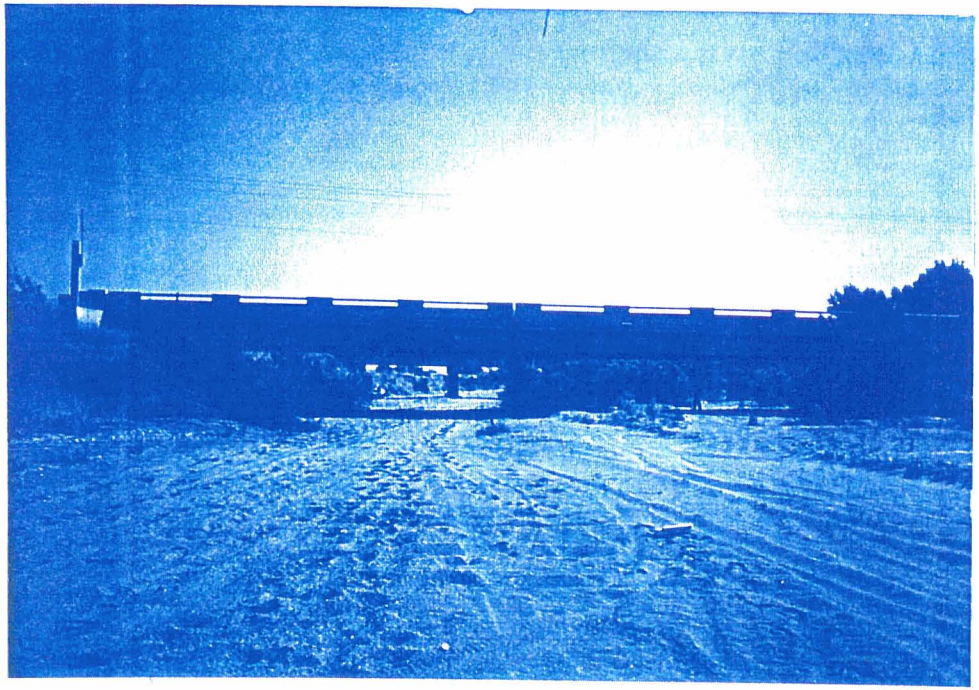
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
42.25	0	0	36,800	36,800	0.00	0.00	11.84	0.00	0.00	16.45	0	0	291	291
42.88	0	0	40,000	40,000	0.00	0.00	12.15	0.00	0.00	17.08	0	0	296	296
47.92	0	0	73,500	73,500	0.00	0.00	13.84	0.00	0.00	22.12	0	0	467	467
49.70	0	0	89,086	89,086	0.00	0.00	14.48	0.00	0.00	23.90	0	0	480	480
53.19	18	59	125,608	125,685	2.36	3.11	16.01	2.19	0.00	27.39	7	12	486	504

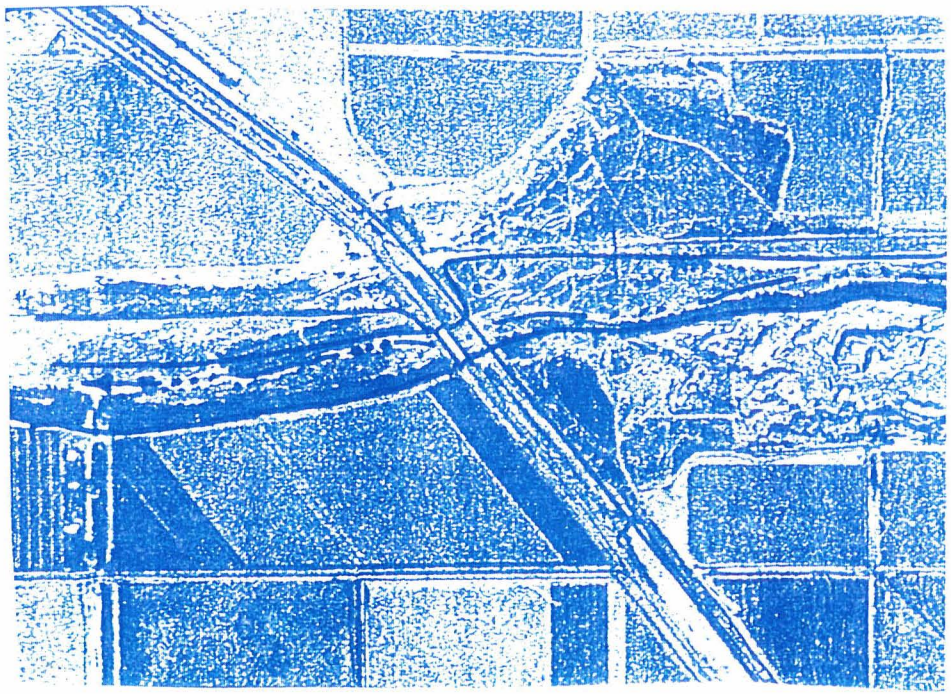


BRIDGE 12 - RITTENHOUSE ROAD (SN 8038)

RITTENHOUSE ROAD (SN 8038)

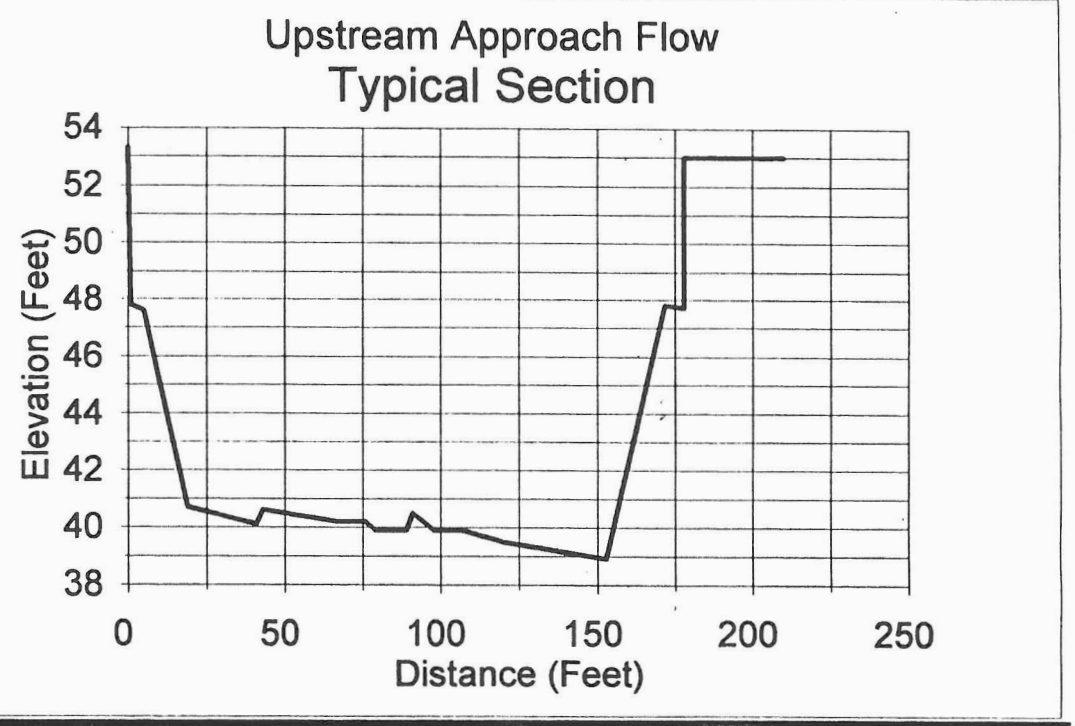
Water Course	Queen Creek
Stream Form	Transitional (US) Braided (DS) Slow Meander
Sinuosity	(DS) 1.06
General Channelization	Minor (see lateral controls)
Channel Slope	Steeper US
Estimated Channel Slope (ft/ft)	0.004674
Channel Contraction/Expansion	Main channel wider US
Primary Surface Sediment Type	sand/gravel
D50 Size	
Armoring Potential	Low
Channel Vegetation	
Type/Size	Trees include Mesquite, Palo Verde, Ironwood to 20 ft., occasional Desert Willow; Brush dominated by Desert Broom to 8 ft., also including Creosote, Ephedra, Chuparosa; dry grasses.
Density/Occurrence	Larger vegetation occurs primarily on bars with a relatively dense stand located mid-channel US of structure. Main channel is relatively clear. Dry grasses and smaller varieties occur on banks and occasionally on bars.
Relative Age	Mature
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	Minor: Rubber tire deflector dikes on US north bank; minor bank protection.
Vertical	None
Sediment Deposits & Bars	US: Low point, alternate and middle bars forming in braided condition. DS: Low point and alternating bars forming in a slightly meandering condition.
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	No
Abutment	Undercutting of sacked concrete and trowelled concrete bank protection.
Land Use	
Urbanization of Upstream Watershed	Low rate; land use primarily agricultural or low density residential.
Sand & Gravel Extraction	Some evidence in overbanks US in past; no current extraction.
Freeway Construction	No
Dams	No
Drainage Channels	Rail road embankment drainage does provide inflows near structure.





INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	53.3		
2	1	47.8	0.035	C
3	5	47.6	0.035	C
4	19	40.7	0.035	C
5	41	40.1	0.035	C
6	43	40.6	0.035	C
7	67	40.2	0.035	C
8	76	40.2	0.035	C
9	79	39.9	0.035	C
10	89	39.9	0.035	C
11	91	40.5	0.035	C
12	98	39.9	0.035	C
13	107	39.9	0.035	C
14	120	39.5	0.035	C
15	153	38.9	0.035	C
16	172	47.8	0.035	C
17	178	47.7	0.035	C
18	178	53.0	0.035	C
19	180	53.0	0.035	C
20	190	53.0	0.035	C
21	200	53.0	0.035	C
22	210	53.0	0.035	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	49.00
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	56.26
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	49.00
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	38.90
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	49.00
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	38.90
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00467

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	2,250	42.71	2,250	-0.00
2		2,750	43.07	2,750	0.00
3	Q100	3,010	43.24	3,010	0.00
4	Q500	5,147	44.48	5,147	-0.00
5	Low Chord	16,902	49.00	16,902	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	39.00
Ws	= Width of Scour Protection =	Feet	Unknown
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	Unknown
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Concrete Sacks
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	
Ws	= Width of Scour Protection =	Feet	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.004674
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0014	0.0014	0.0014	0.0014	0.0014
Angle	= *Angle of Attack* =	*Degrees*	5	5	5	5	5
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	1.33	1.33	1.33	1.33	1.33
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	5.33	5.33	5.33	5.33	5.33
L	= Pier Length =	ft	35.00	35.00	35.00	35.00	35.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	110	110	110	110	110

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	56.26	56.26	56.26	56.26	56.26
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	49.00	49.00	49.00	49.00	49.00
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	42.71	43.07	43.24	44.48	49.00
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	38.90	38.90	38.90	38.90	38.90
y1	= Average Depth in the Upstream Main Channel =	ft	3.81	4.17	4.34	5.58	10.10
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	146	148	148	154	177
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	146	148	148	154	177
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	2,250	2,750	3,010	5,147	16,902
Q2	= Flow in the Contracted Channel =	cfs	2,250	2,750	3,010	5,147	16,902
V1	= Mean Velocity of Flow Upstream of Pier =	fps	5.74	6.19	6.40	7.82	12.04
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.52	0.53	0.54	0.58	0.67
S1	= Energy Slope in Main Channel =		0.00467	0.00467	0.00467	0.00467	0.00467

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	1.60	1.63	1.64	1.71	1.88
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.28	0.26	0.26	0.22	0.16
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.76	0.79	0.81	0.92	1.23
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00172	0.00172	0.00172	0.00172	0.00172
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.21	0.21	0.21	0.21	0.21
U/w	= Ratio of Shear Velocity to Fall Velocity =		3.67	3.83	3.91	4.44	5.97
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.69	0.69	0.69	0.69	0.69
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	3.81	4.17	4.34	5.58	10.10
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	5.74	6.19	6.40	7.82	12.04
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	1.52	1.82	1.98	3.18	8.63
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	4.57	5.47	5.93	9.54	25.88
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Local Scour at Piers

Variable	Description	Unit	Trial No. 1 Value	2 Value	3 Value	4 Value	5 Value
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	6.29	5.93	5.76	4.52	0.00
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	3.81	4.17	4.34	5.58	10.10
L/a	= Ratio Used in Table 3 to Find K2 =		7.00	7.00	7.00	7.00	7.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.52	0.53	0.54	0.58	0.67
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.29	1.29	1.29	1.29	1.29
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.00
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	10.15	10.61	10.83	12.21	15.92
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	28.43	29.72	30.32	34.19	44.59
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	5.74	6.19	6.40	7.82	12.04
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	5.80	6.74	7.21	10.76	25.50
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	17.40	20.21	21.62	32.27	76.51
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	10.66	10.66	10.66	10.66	10.66
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	10.15	10.61	10.83	12.21	15.92

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.03	1.03	1.03	1.03	1.03
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
We	= Existing Rock Rip-Rap Width =	Feet	Unknown	Unknown	Unknown	Unknown	Unknown
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	None

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	10.15	10.61	10.83	12.21	15.92
Yab	= Scour Depth at Abutments	ft	None	None	None	None	None
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	14.15	14.61	14.83	16.21	19.92
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	4.00
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		3.72	3.51	3.42	2.90	1.97
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		1.05	0.96	0.92	0.72	0.40

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 42.71

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		53.3																						
2	1	47.8	1	-5.5	0.035					C														
3	5	47.6	4	-0.2	0.035					C														
4	19	40.7	14	-6.9	0.035	4.09	4.54	4.07	0.90	C	162			162	39.70			4.09			4.07			2.01
5	41	40.1	22	-0.6	0.035	50.78	22.01	22.00	2.31	C	3,775			3,775	74.35			50.78			22.00			2.61
6	43	40.6	2	0.5	0.035	4.72	2.06	2.00	2.29	C	349			349	73.93			4.72			2.00			2.11
7	67	40.2	24	-0.4	0.035	55.39	24.00	24.00	2.31	C	4,119			4,119	74.36			55.39			24.00			2.51
8	76	40.2	9		0.035	22.57	9.00	9.00	2.51	C	1,774			1,774	78.61			22.57			9.00			2.51
9	79	39.9	3	-0.3	0.035	7.97	3.01	3.00	2.64	C	649			649	81.44			7.97			3.00			2.81
10	89	39.9	10		0.035	28.08	10.00	10.00	2.81	C	2,380			2,380	84.76			28.08			10.00			2.81
11	91	40.5	2	0.6	0.035	5.02	2.09	2.00	2.40	C	383			383	76.38			5.02			2.00			2.21
12	98	39.9	7	-0.6	0.035	17.56	7.03	7.00	2.50	C	1,377			1,377	78.42			17.56			7.00			2.81
13	107	39.9	9		0.035	25.27	9.00	9.00	2.81	C	2,142			2,142	84.76			25.27			9.00			2.81
14	120	39.5	13	-0.4	0.035	39.10	13.01	13.00	3.01	C	3,469			3,469	88.72			39.10			13.00			3.21
15	153	38.9	33	-0.6	0.035	115.77	33.01	33.00	3.51	C	11,382			11,382	98.32			115.77			33.00			3.81
16	172	47.8	19	8.9	0.035	15.48	8.98	8.13	1.72	C	948			948	61.23			15.48			8.13			
17	178	47.7	6	-0.1	0.035					C														
18	178	53.0		5.3	0.035					C														
19	180	53.0	2		0.035					C														
20	190	53.0	10		0.035					C														
21	200	53.0	10		0.035					C														
22	210	53.0	10		0.035					C														
Total			210.00	-0.30	0.735	391.80	147.73	146.20	31.71		32,911			32,911				392			146.20			
Maximum	210.00	53.3	33.00	8.90	0.035	115.77	33.01	33.00	3.51						98.32			115.77						3.81
Minimum		38.9		-6.90	0.035																			
Range	210.00	14.4	33.00	15.80		115.77	33.01	33.00	3.51															
Average	104.41	45.0	10.00	-0.01	0.035	18.66	7.03	6.96	1.51															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			2,250	2,250
V			5.74	
T			146	146
Y			3.81	
A			392	392

Solve for the 2nd Water Surface Elevation WSEL = 43.07

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		53.3																						
2	1	47.8	1	-5.5	0.035					C														
3	5	47.6	4	-0.2	0.035					C														
4	19	40.7	14	-6.9	0.035	5.67	5.35	4.80	1.06	C	251			251	44.28			5.67			4.80			2.37
5	41	40.1	22	-0.6	0.035	58.63	22.01	22.00	2.66	C	4,798			4,798	81.84			58.63			22.00			2.97
6	43	40.6	2	0.5	0.035	5.43	2.06	2.00	2.63	C	441			441	81.22			5.43			2.00			2.47
7	67	40.2	24	-0.4	0.035	63.96	24.00	24.00	2.66	C	5,235			5,235	81.85			63.96			24.00			2.87
8	76	40.2	9		0.035	25.79	9.00	9.00	2.87	C	2,215			2,215	85.91			25.79			9.00			2.87
9	79	39.9	3	-0.3	0.035	9.05	3.01	3.00	3.00	C	801			801	88.59			9.05			3.00			3.17
10	89	39.9	10		0.035	31.65	10.00	10.00	3.17	C	2,906			2,906	91.81			31.65			10.00			3.17
11	91	40.5	2	0.6	0.035	5.73	2.09	2.00	2.74	C	478			478	83.47			5.73			2.00			2.57
12	98	39.9	7	-0.6	0.035	20.06	7.03	7.00	2.85	C	1,719			1,719	85.70			20.06			7.00			3.17
13	107	39.9	9		0.035	28.49	9.00	9.00	3.17	C	2,615			2,615	91.81			28.49			9.00			3.17
14	120	39.5	13	-0.4	0.035	43.75	13.01	13.00	3.36	C	4,182			4,182	95.61			43.75			13.00			3.57
15	153	38.9	33	-0.6	0.035	127.55	33.01	33.00	3.86	C	13,378			13,378	104.88			127.55			33.00			4.17
16	172	47.8	19	8.9	0.035	18.52	9.82	8.89	1.89	C	1,204			1,204	65.00			18.52			8.89			
17	178	47.7	6	-0.1	0.035					C														
18	178	53.0		5.3	0.035					C														
19	180	53.0	2		0.035					C														
20	190	53.0	10		0.035					C														
21	200	53.0	10		0.035					C														
22	210	53.0	10		0.035					C														
Total			210.00	-0.30	0.735	444.26	149.38	147.69	35.93		40,224			40,224				444			147.69			
Maximum	210.00	53.3	33.00	8.90	0.035	127.55	33.01	33.00	3.86						104.88			127.55						4.17
Minimum		38.9		-6.90	0.035																			
Range	210.00	14.4	33.00	15.80		127.55	33.01	33.00	3.86															
Average	104.41	45.0	10.00	-0.01	0.035	21.18	7.11	7.03	1.71						51.52									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			2,750	2,750
V			6.19	
T			148	148
Y			4.17	
A			444	444

Solve for the 3rd Water Surface Elevation **WSEL = 43.24**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		53.3																						
2	1	47.8	1	-5.5	0.035					C														
3	5	47.6	4	-0.2	0.035					C														
4	19	40.7	14	-6.9	0.035	6.54	5.74	5.15	1.14	C	304			304	46.43			6.54			5.15			2.54
5	41	40.1	22	-0.6	0.035	62.47	22.01	22.00	2.84	C	5,334			5,334	85.38			62.47			22.00			3.14
6	43	40.6	2	0.5	0.035	5.78	2.06	2.00	2.80	C	489			489	84.67			5.78			2.00			2.64
7	67	40.2	24	-0.4	0.035	68.15	24.00	24.00	2.84	C	5,820			5,820	85.39			68.15			24.00			3.04
8	76	40.2	9		0.035	27.36	9.00	9.00	3.04	C	2,445			2,445	89.36			27.36			9.00			3.04
9	79	39.9	3	-0.3	0.035	9.57	3.01	3.00	3.17	C	880			880	91.98			9.57			3.00			3.34
10	89	39.9	10		0.035	33.40	10.00	10.00	3.34	C	3,178			3,178	95.15			33.40			10.00			3.34
11	91	40.5	2	0.6	0.035	6.08	2.09	2.00	2.91	C	528			528	86.83			6.08			2.00			2.74
12	98	39.9	7	-0.6	0.035	21.28	7.03	7.00	3.03	C	1,897			1,897	89.15			21.28			7.00			3.34
13	107	39.9	9		0.035	30.06	9.00	9.00	3.34	C	2,860			2,860	95.15			30.06			9.00			3.34
14	120	39.5	13	-0.4	0.035	46.02	13.01	13.00	3.54	C	4,550			4,550	98.89			46.02			13.00			3.74
15	153	38.9	33	-0.6	0.035	133.31	33.01	33.00	4.04	C	14,400			14,400	108.02			133.31			33.00			4.34
16	172	47.8	19	8.9	0.035	20.10	10.23	9.26	1.96	C	1,343			1,343	66.80			20.10			9.26			
17	178	47.7	6	-0.1	0.035					C														
18	178	53.0		5.3	0.035					C														
19	180	53.0	2		0.035					C														
20	190	53.0	10		0.035					C														
21	200	53.0	10		0.035					C														
22	210	53.0	10		0.035					C														
Total			210.00	-0.30	0.735	470.11	150.19	148.42	38.00		44,027			44,027				470			148.42			
Maximum	210.00	53.3	33.00	8.90	0.035	133.31	33.01	33.00	4.04						108.02			133.31						4.34
Minimum		38.9		-8.90	0.035																			
Range	210.00	14.4	33.00	15.80		133.31	33.01	33.00	4.04															
Average	104.41	45.0	10.00	-0.01	0.035	22.39	7.15	7.07	1.81						53.49									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			3,010	3,010
V			6.40	
T			148	148
Y			4.34	
A			470	470

Solve for the 4th Water Surface Elevation **WSEL = 44.48**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		53.3																						
2	1	47.8	1	-5.5	0.035					C														
3	5	47.6	4	-0.2	0.035					C														
4	19	40.7	14	-6.9	0.035	14.53	8.56	7.68	1.70	C	880			880	60.58			14.53			7.68			3.78
5	41	40.1	22	-0.6	0.035	89.85	22.01	22.00	4.08	C	9,776			9,776	108.80			89.85			22.00			4.38
6	43	40.6	2	0.5	0.035	8.27	2.06	2.00	4.01	C	889			889	107.52			8.27			2.00			3.88
7	67	40.2	24	-0.4	0.035	98.02	24.00	24.00	4.08	C	10,666			10,666	108.82			98.02			24.00			4.28
8	76	40.2	9		0.035	38.56	9.00	9.00	4.28	C	4,332			4,332	112.35			38.56			9.00			4.28
9	79	39.9	3	-0.3	0.035	13.30	3.01	3.00	4.41	C	1,524			1,524	114.58			13.30			3.00			4.58
10	89	39.9	10		0.035	45.84	10.00	10.00	4.58	C	5,388			5,388	117.54			45.84			10.00			4.58
11	91	40.5	2	0.6	0.035	8.57	2.09	2.00	4.10	C	935			935	109.17			8.57			2.00			3.98
12	98	39.9	7	-0.6	0.035	29.99	7.03	7.00	4.27	C	3,361			3,361	112.08			29.99			7.00			4.58
13	107	39.9	9		0.035	41.26	9.00	9.00	4.58	C	4,850			4,850	117.54			41.26			9.00			4.58
14	120	39.5	13	-0.4	0.035	62.20	13.01	13.00	4.78	C	7,519			7,519	120.90			62.20			13.00			4.98
15	153	38.9	33	-0.6	0.035	174.38	33.01	33.00	5.28	C	22,532			22,532	129.21			174.38			33.00			5.58
16	172	47.8	19	8.9	0.035	33.29	13.16	11.92	2.53	C	2,631			2,631	79.04			33.29			11.92			
17	178	47.7	6	-0.1	0.035					C														
18	178	53.0		5.3	0.035					C														
19	180	53.0	2		0.035					C														
20	190	53.0	10		0.035					C														
21	200	53.0	10		0.035					C														
22	210	53.0	10		0.035					C														
Total			210.00	-0.30	0.735	658.06	155.94	153.60	52.71		75,285			75,285				658			153.60			
Maximum	210.00	53.3	33.00	8.90	0.035	174.38	33.01	33.00	5.28						129.21			174.38						5.58
Minimum		38.9		-6.90	0.035																			
Range	210.00	14.4	33.00	15.80		174.38	33.01	33.00	5.28															
Average	104.41	45.0	10.00	-0.01	0.035	31.34	7.43	7.31	2.51						66.58									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			5,147	5,147
V			7.82	
T			154	154
Y			5.58	
A			658	658

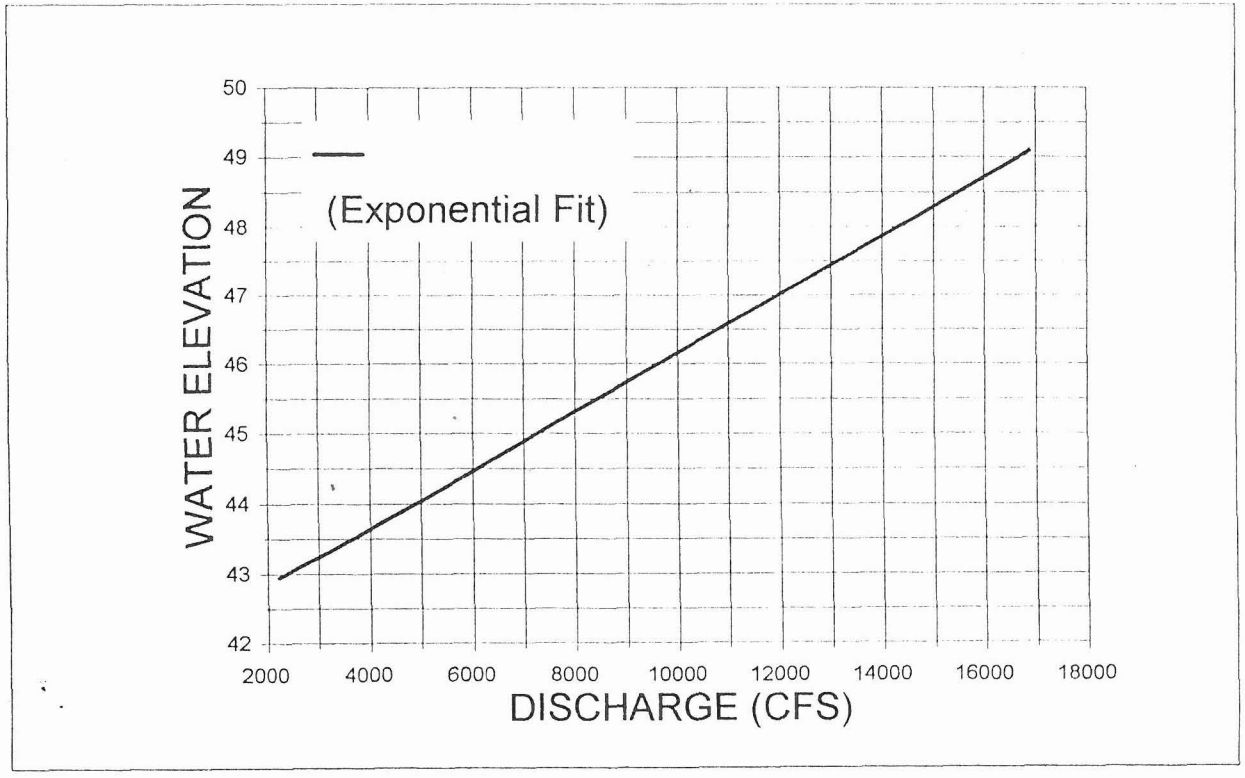
Solve for the 6th Water Surface Elevation WSEL = 49.00

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		53.3																						
2	1	47.8	1	-5.5	0.035	0.13	1.22	0.22	0.11	C	1			1	9.61			0.13			0.22			1.20
3	5	47.6	4	-0.2	0.035	5.20	4.00	4.00	1.30	C	263			263	50.67			5.20			4.00			1.40
4	19	40.7	14	-6.9	0.035	67.90	15.61	14.00	4.35	C	7,707			7,707	113.50			67.90			14.00			8.30
5	41	40.1	22	-0.6	0.035	189.20	22.01	22.00	8.60	C	33,825			33,825	178.78			189.20			22.00			8.90
6	43	40.6	2	0.5	0.035	17.30	2.06	2.00	8.39	C	3,044			3,044	175.92			17.30			2.00			8.40
7	67	40.2	24	-0.4	0.035	206.40	24.00	24.00	8.60	C	36,906			36,906	178.81			206.40			24.00			8.80
8	76	40.2	9		0.035	79.20	9.00	9.00	8.80	C	14,382			14,382	181.59			79.20			9.00			8.80
9	79	39.9	3	-0.3	0.035	26.85	3.01	3.00	8.91	C	4,915			4,915	183.04			26.85			3.00			9.10
10	89	39.9	10		0.035	91.00	10.00	10.00	9.10	C	16,898			16,898	185.69			91.00			10.00			9.10
11	91	40.5	2	0.6	0.035	17.60	2.09	2.00	8.43	C	3,105			3,105	176.44			17.60			2.00			8.50
12	98	39.9	7	-0.6	0.035	61.60	7.03	7.00	8.77	C	11,159			11,159	181.15			61.60			7.00			9.10
13	107	39.9	9		0.035	81.90	9.00	9.00	9.10	C	15,208			15,208	185.69			81.90			9.00			9.10
14	120	39.5	13	-0.4	0.035	120.90	13.01	13.00	9.30	C	22,771			22,771	188.35			120.90			13.00			9.50
15	153	38.9	33	-0.6	0.035	323.40	33.01	33.00	9.80	C	63,090			63,090	195.08			323.40			33.00			10.10
16	172	47.8	19	8.9	0.035	107.35	20.98	19.00	5.12	C	13,577			13,577	126.47			107.35			19.00			1.20
17	178	47.7	6	-0.1	0.035	7.50	6.00	6.00	1.25	C	370			370	49.40			7.50			6.00			1.30
18	178	53.0		5.3	0.035		1.30			C														
19	180	53.0	2		0.035					C														
20	190	53.0	10		0.035					C														
21	200	53.0	10		0.035					C														
22	210	53.0	10		0.035					C														
Total			210.00	-0.30	0.735	1,403.43	183.33	177.22	109.91		247,222			247,222				1,403			177.22			
Maximum	210.00	53.3	33.00	8.90	0.035	323.40	33.01	33.00	9.80						195.08			323.40						10.10
Minimum		38.9		-6.90	0.035																			
Range	210.00	14.4	33.00	15.80		323.40	33.01	33.00	9.80															
Average	104.41	45.0	10.00	-0.01	0.035	66.83	8.73	8.44	5.23						112.39									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			16,902	16,902
V			12.04	
T			177	177
Y			10.10	
A			1,403	1,403

DISCHARGE RATING CURVE FOR TYPICAL SECTION

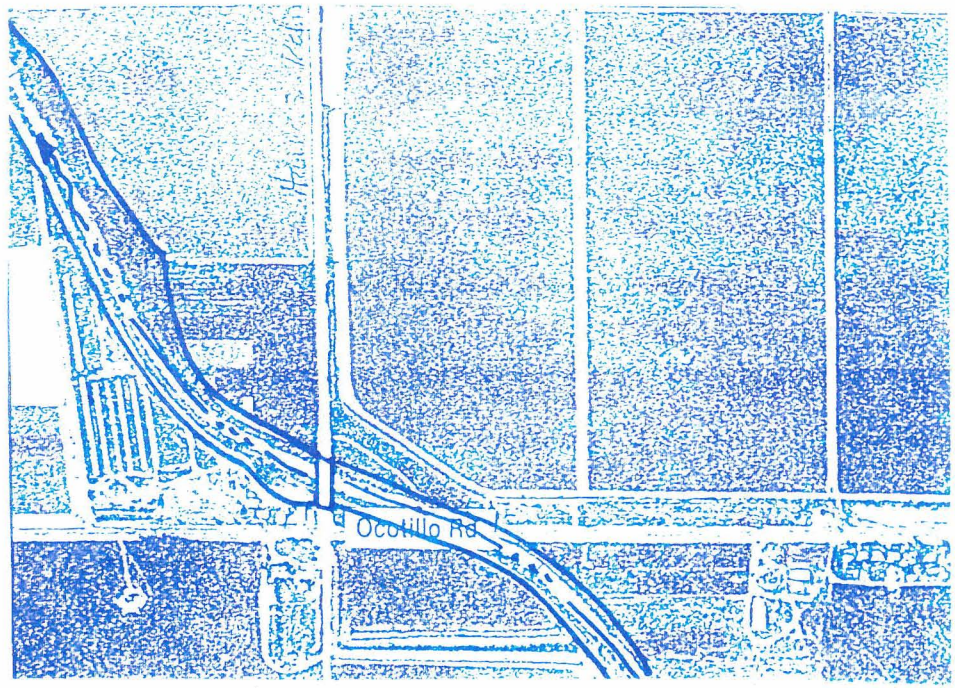
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
42.71	0	0	2,250	2,250	0.00	0.00	5.74	0.00	0.00	3.81	0	0	146	146
43.07	0	0	2,750	2,750	0.00	0.00	6.19	0.00	0.00	4.17	0	0	148	148
43.24	0	0	3,010	3,010	0.00	0.00	6.40	0.00	0.00	4.34	0	0	148	148
44.48	0	0	5,147	5,147	0.00	0.00	7.82	0.00	0.00	5.58	0	0	154	154
49.00	0	0	16,902	16,902	0.00	0.00	12.04	0.00	0.00	10.10	0	0	177	177



BRIDGE 13 - HAWES ROAD (SN 7818)

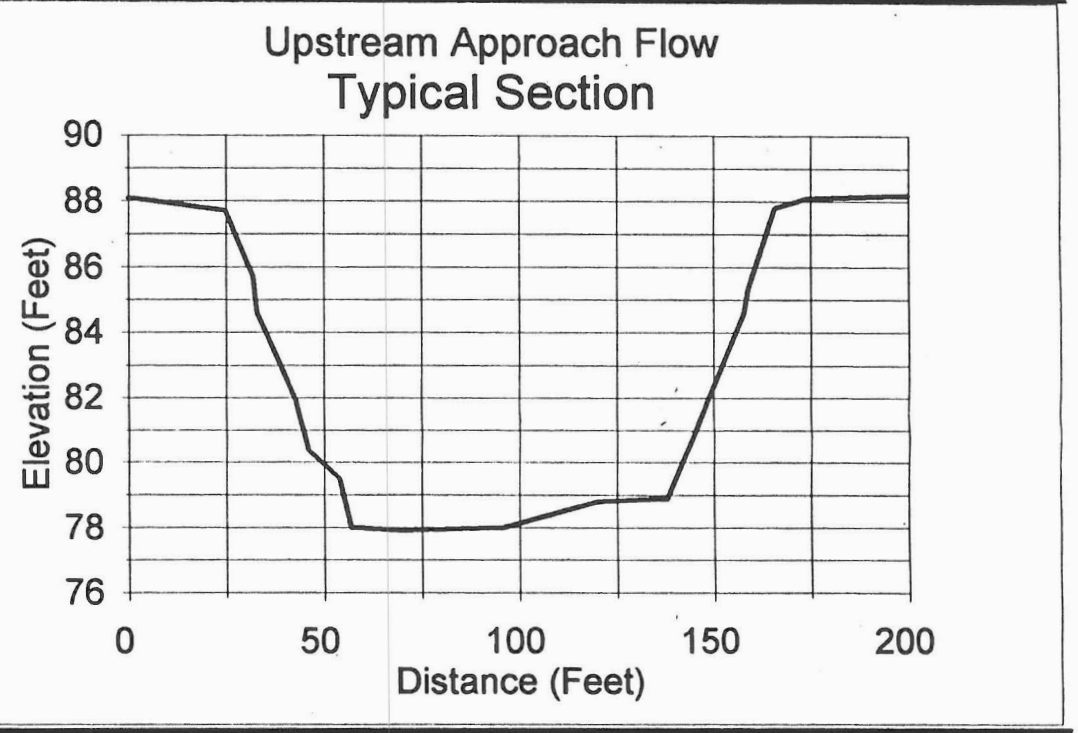
HAWES ROAD (SN 7818)

Water Course	Queen Creek
Stream Form	Straight
Sinuosity	1.04
General Channelization	Non-structural (agricultural), trapezoidal, earthen levees
Channel Slope	Uniform
Estimated Channel Slope (ft/ft)	0.003968
Channel Contraction/Expansion	Main channel narrower US
Primary Surface Sediment Type	Silt/sand
D50 Size	0.040 MM
Armoring Potential	Low
Channel Vegetation	
Type/Size	Channel bottom rel. clear; banks sparse to moderate coverage including Palo Verde to 8 ft.; Desert Broom and Ironwood to 6 ft.; Occ. saltbush, creosote, ephedra; dry grasses dominate banks.
Density/Occurrence	Vegetation occurs on banks, sparse in channel; denser growth occurs DS of structure.
Relative Age	New to mature growth.
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	Non-Structural, earthen levees
Vertical	None
Sediment Deposits & Bars	US: Bars not well established; shallow point bar forming US of north abutment. DS: Channel generally clear.
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	North side shows 1-2 ft. residual scour.
Abutment	Rip-Rap placed along US side of south abutment is being destabilized by flow.
Land Use	
Urbanization of Upstream Watershed	Low rate; land use primarily agricultural
Sand & Gravel Extraction	No commercial extraction in vicinity
Freeway Construction	No
Dams	No
Drainage Channels	No



INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	88.1		
2	25	87.7	0.035	L
3	32	85.7	0.035	L
4	33	84.6	0.035	L
5	43	81.9	0.035	C
6	46	80.4	0.035	C
7	54	79.5	0.035	C
8	57	78.0	0.035	C
9	70	77.9	0.035	C
10	96	78.0	0.035	C
11	120	78.8	0.035	C
12	138	78.9	0.035	C
13	158	84.6	0.035	C
14	159	85.3	0.035	C
15	166	87.8	0.035	C
16	174	88.1	0.035	R
17	200	88.2	0.035	R
18	200	88.2	0.035	R
19	200	88.2	0.035	R
20	200	88.2	0.035	R
21	200	88.2	0.035	R
22	200	88.2	0.035	R



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	85.67
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	91.20
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	85.67
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	77.90
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	85.67
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	77.90
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00397

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	2,250	82.11	2,250	0.00
2		2,750	82.57	2,750	0.00
3	Q100	3,010	82.79	3,010	0.00
4	Q500	5,147	84.36	5,147	0.00
5	Low Chord	7,394	85.67	7,394	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	70.00
Ws	= Width of Scour Protection =	Feet	Unknown
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	18.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Grouted Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		7.90

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	77.30
Ws	= Width of Scour Protection =	Feet	20.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	36.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		0.60

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.003968
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0013	0.0013	0.0013	0.0013	0.0013
Angle	= *Angle of Attack* =	*Degrees*	5	5	5	5	5
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	3.00	3.00	3.00	3.00	3.00
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	7.00	7.00	7.00	7.00	7.00
L	= Pier Length =	ft	77.00	77.00	77.00	77.00	77.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	110	110	110	110	110

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	91.20	91.20	91.20	91.20	91.20
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	85.67	85.67	85.67	85.67	85.67
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	82.11	82.57	82.79	84.36	85.67
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	77.90	77.90	77.90	77.90	77.90
y1	= Average Depth in the Upstream Main Channel =	ft	4.21	4.67	4.89	6.46	7.77
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	107	110	112	123	128
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	107	110	112	123	127
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	2,250	2,750	3,010	5,147	7,393
Q2	= Flow in the Contracted Channel =	cfs	2,250	2,750	3,010	5,147	7,394
V1	= Mean Velocity of Flow Upstream of Pier =	fps	6.28	6.74	6.95	8.33	9.46
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.54	0.55	0.55	0.58	0.60
S1	= Energy Slope in Main Channel =		0.00397	0.00397	0.00397	0.00397	0.00397

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	1.60	1.63	1.65	1.72	1.78
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.26	0.24	0.24	0.21	0.19
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.73	0.77	0.79	0.91	1.00
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00164	0.00165	0.00165	0.00165	0.00165
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.20	0.20	0.20	0.20	0.20
U/w	= Ratio of Shear Velocity to Fall Velocity =		3.73	3.90	3.99	4.59	5.03
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.69	0.69	0.69	0.69	0.69
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	4.21	4.67	4.89	6.46	7.81
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.04
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	6.28	6.74	6.95	8.33	9.53
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	1.89	2.22	2.38	3.57	4.87
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	5.68	6.66	7.15	10.72	14.61
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.04

Compute Local Scour at Piers

Variable	Description	Unit	Trial No. 1 Value	2 Value	3 Value	4 Value	5 Value
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	3.56	3.10	2.88	1.31	0.00
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	4.21	4.67	4.89	6.46	7.77
L/a	= Ratio Used in Table 3 to Find K2 =		11.00	11.00	11.00	11.00	11.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.54	0.55	0.55	0.58	0.60
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.46	1.46	1.46	1.46	1.46
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.00
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	14.41	15.06	15.37	17.25	18.67
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	40.36	42.18	43.02	48.30	52.28
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	6.28	6.74	6.95	8.33	9.53
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	6.93	7.98	8.49	12.21	15.96
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	20.79	23.93	25.48	36.63	47.89
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	14.00	14.00	14.00	14.00	14.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	36.00	36.00	36.00	36.00	36.00
We	= Existing Rock Rip-Rap Width =	Feet	20.00	20.00	20.00	20.00	20.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	14.41	15.06	15.37	17.25	18.67

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	1
	Which abutment Left or Right?		Right	Right	Right	Right	Left
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	1
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	1.36
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	1
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.54
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.03	1.03	1.03	1.03	1.03
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	0.33
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	0.98
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	9.53
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	18.25
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	54.75
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	15.54
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	18.00	18.00	18.00	18.00	18.00
We	= Existing Rock Rip-Rap Width =	Feet	Unknown	Unknown	Unknown	Unknown	Unknown
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	0.98

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.04
Yl	= Local Scour Depth =	ft	14.41	15.06	15.37	17.25	18.67
Yab	= Scour Depth at Abutments	ft	None	None	None	None	0.98
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	18.41	19.06	19.37	21.25	22.71
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	4.98
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		4.37	4.08	3.96	3.29	2.92
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.95	0.86	0.82	0.62	0.64

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation **WSEL = 82.11**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		88.1																						
2	25	87.7	25	-0.4	0.035					L														
3	32	85.7	7	-2	0.035					L														
4	33	84.6	1	-1.1	0.035					L														
5	43	81.9	10	-2.7	0.035	0.08	0.81	0.78	0.10	C	1			1	9.26			0.08			0.78			0.21
6	46	80.4	3	-1.5	0.035	2.88	3.35	3.00	0.86	C	111			111	38.47			2.88			3.00			1.71
7	54	79.5	8	-0.9	0.035	17.28	8.05	8.00	2.15	C	1,225			1,225	70.87			17.28			8.00			2.61
8	57	78.0	3	-1.5	0.035	10.08	3.35	3.00	3.01	C	894			894	88.70			10.08			3.00			4.11
9	70	77.9	13	-0.1	0.035	54.09	13.00	13.00	4.16	C	5,959			5,959	110.17			54.09			13.00			4.21
10	96	78.0	26	0.1	0.035	108.17	26.00	26.00	4.16	C	11,918			11,918	110.18			108.17			26.00			4.11
11	120	78.8	24	0.8	0.035	89.05	24.01	24.00	3.71	C	9,087			9,087	102.04			89.05			24.00			3.31
12	138	78.9	18	0.1	0.035	58.69	18.00	18.00	3.26	C	5,496			5,496	93.64			58.69			18.00			3.21
13	158	84.6	20	5.7	0.035	18.08	11.71	11.26	1.54	C	1,028			1,028	56.87			18.08			11.26			
14	159	85.3	1	0.7	0.035					C														
15	166	87.8	7	2.5	0.035					C														
16	174	88.1	8	0.3	0.035					R														
17	200	88.2	26	0.1	0.035					R														
18	200	88.2			0.035					R														
19	200	88.2			0.035					R														
20	200	88.2			0.035					R														
21	200	88.2			0.035					R														
22	200	88.2			0.035					R														
Total			200.00	0.10	0.735	358.41	108.29	107.04	22.95		35,719			35,719				358			107.04			
Maximum	200.00	88.2	26.00	5.70	0.035	108.17	26.00	26.00	4.16						110.18			108.17						4.21
Minimum		77.9		-2.70	0.035																			
Range	200.00	10.3	26.00	8.40		108.17	26.00	26.00	4.16															
Average	116.86	84.3	9.52	0.00	0.035	17.07	5.16	5.10	1.09															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			2,250	2,250
V			6.28	
T			107	107
Y			4.21	
A			358	358

Solve for the 2nd Water Surface Elevation WSEL = 82.57

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		88.1																						
2	25	87.7	25	-0.4	0.035					L														
3	32	85.7	7	-2	0.035					L														
4	33	84.6	1	-1.1	0.035					L														
5	43	81.9	10	-2.7	0.035	0.83	2.57	2.48	0.32	C	17			17	20.04			0.83			2.48			0.67'
6	46	80.4	3	-1.5	0.035	4.26	3.35	3.00	1.27	C	213			213	49.92			4.26			3.00			2.17'
7	54	79.5	8	-0.9	0.035	20.95	8.05	8.00	2.60	C	1,688			1,688	80.58			20.95			8.00			3.07'
8	57	78.0	3	-1.5	0.035	11.46	3.35	3.00	3.42	C	1,107			1,107	96.60			11.46			3.00			4.57'
9	70	77.9	13	-0.1	0.035	60.05	13.00	13.00	4.62	C	7,094			7,094	118.14			60.05			13.00			4.67'
10	96	78.0	26	0.1	0.035	120.10	26.00	26.00	4.62	C	14,189			14,189	118.14			120.10			26.00			4.57'
11	120	78.8	24	0.8	0.035	100.06	24.01	24.00	4.17	C	11,036			11,036	110.29			100.06			24.00			3.77'
12	138	78.9	18	0.1	0.035	66.95	18.00	18.00	3.72	C	6,845			6,845	102.24			66.95			18.00			3.67'
13	158	84.6	20	5.7	0.035	23.62	13.39	12.87	1.76	C	1,469			1,469	62.17			23.62			12.87			
14	159	85.3	1	0.7	0.035					C														
15	166	87.8	7	2.5	0.035					C														
16	174	88.1	8	0.3	0.035					R														
17	200	88.2	26	0.1	0.035					R														
18	200	88.2			0.035					R														
19	200	88.2			0.035					R														
20	200	88.2			0.035					R														
21	200	88.2			0.035					R														
22	200	88.2			0.035					R														
Total			200.00	0.10	0.735	408.28	111.73	110.35	26.50		43,656			43,656				408			110.35			
Maximum	200.00	88.2	26.00	5.70	0.035	120.10	26.00	26.00	4.62						118.14			120.10						4.67'
Minimum		77.9		-2.70	0.035																			
Range	200.00	10.3	26.00	8.40		120.10	26.00	26.00	4.62															
Average	116.86	84.3	9.52	0.00	0.035	19.44	5.32	5.25	1.26						36.10									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			2,750	2,750
V			6.74	
T			110	110
Y			4.67	
A			408	408

Solve for the 3rd Water Surface Elevation WSEL = 82.79

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		88.1																						
2	25	87.7	25	-0.4	0.035					L														
3	32	85.7	7	-2	0.035					L														
4	33	84.6	1	-1.1	0.035					L														
5	43	81.9	10	-2.7	0.035	1.48	3.42	3.31	0.43	C	36			36	24.28			1.48			3.31			0.89
6	46	80.4	3	-1.5	0.035	4.93	3.35	3.00	1.47	C	271			271	55.02			4.93			3.00			2.39
7	54	79.5	8	-0.9	0.035	22.74	8.05	8.00	2.82	C	1,935			1,935	85.10			22.74			8.00			3.29
8	57	78.0	3	-1.5	0.035	12.13	3.35	3.00	3.62	C	1,217			1,217	100.33			12.13			3.00			4.79
9	70	77.9	13	-0.1	0.035	62.95	13.00	13.00	4.84	C	7,675			7,675	121.91			62.95			13.00			4.89
10	96	78.0	26	0.1	0.035	125.91	26.00	26.00	4.84	C	15,350			15,350	121.92			125.91			26.00			4.79
11	120	78.8	24	0.8	0.035	105.42	24.01	24.00	4.39	C	12,038			12,038	114.19			105.42			24.00			3.99
12	138	78.9	18	0.1	0.035	70.97	18.00	18.00	3.94	C	7,543			7,543	106.29			70.97			18.00			3.89
13	158	84.6	20	5.7	0.035	26.58	14.20	13.66	1.87	C	1,719			1,719	64.67			26.58			13.66			
14	159	85.3	1	0.7	0.035					C														
15	166	87.8	7	2.5	0.035					C														
16	174	88.1	8	0.3	0.035					R														
17	200	88.2	26	0.1	0.035					R														
18	200	88.2			0.035					R														
19	200	88.2			0.035					R														
20	200	88.2			0.035					R														
21	200	88.2			0.035					R														
22	200	88.2			0.035					R														
Total			200.00	0.10	0.735	433.10	113.40	111.96	28.23		47,784			47,784				433			111.96			
Maximum	200.00	88.2	26.00	5.70	0.035	125.91	26.00	26.00	4.84						121.92			125.91						4.89
Minimum		77.9		-2.70	0.035																			
Range	200.00	10.3	26.00	8.40		125.91	26.00	26.00	4.84															
Average	116.86	84.3	9.52	0.00	0.035	20.62	5.40	5.33	1.34						37.80									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			3,010	3,010
V			6.95	
T			112	112
Y			4.89	
A			433	433

Solve for the 4th Water Surface Elevation WSEL = 84.36

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		88.1																						
2	25	87.7	25	-0.4	0.035					L														
3	32	85.7	7	-2	0.035					L														
4	33	84.6	1	-1.1	0.035					L														
5	43	81.9	10	-2.7	0.035	11.22	9.44	9.12	1.19	C	536			536	47.76			11.22			9.12			2.46
6	46	80.4	3	-1.5	0.035	9.63	3.35	3.00	2.87	C	829			829	86.05			9.63			3.00			3.96
7	54	79.5	8	-0.9	0.035	35.29	8.05	8.00	4.38	C	4,026			4,026	114.09			35.29			8.00			4.86
8	57	78.0	3	-1.5	0.035	16.83	3.35	3.00	5.02	C	2,102			2,102	124.86			16.83			3.00			6.36
9	70	77.9	13	-0.1	0.035	83.35	13.00	13.00	6.41	C	12,253			12,253	147.01			83.35			13.00			6.46
10	96	78.0	26	0.1	0.035	166.70	26.00	26.00	6.41	C	24,506			24,506	147.01			166.70			26.00			6.36
11	120	78.8	24	0.8	0.035	143.07	24.01	24.00	5.96	C	20,030			20,030	140.00			143.07			24.00			5.56
12	138	78.9	18	0.1	0.035	99.21	18.00	18.00	5.51	C	13,185			13,185	132.90			99.21			18.00			5.46
13	158	84.6	20	5.7	0.035	52.33	19.93	19.16	2.63	C	4,242			4,242	81.06			52.33			19.16			
14	159	85.3	1	0.7	0.035					C														
15	166	87.8	7	2.5	0.035					C														
16	174	88.1	8	0.3	0.035					R														
17	200	88.2	26	0.1	0.035					R														
18	200	88.2			0.035					R														
19	200	88.2			0.035					R														
20	200	88.2			0.035					R														
21	200	88.2			0.035					R														
22	200	88.2			0.035					R														
Total			200.00	0.10	0.735	617.63	125.14	123.28	40.38		81,709			81,709				618			123.28			
Maximum	200.00	88.2	26.00	5.70	0.035	166.70	26.00	26.00	6.41						147.01			166.70						6.46
Minimum		77.9		-2.70	0.035																			
Range	200.00	10.3	26.00	8.40		166.70	26.00	26.00	6.41															
Average	116.86	84.3	9.52	0.00	0.035	29.41	5.96	5.87	1.92						48.61									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			5,147	5,147
V			8.33	
T			123	123
Y			6.46	
A			618	618

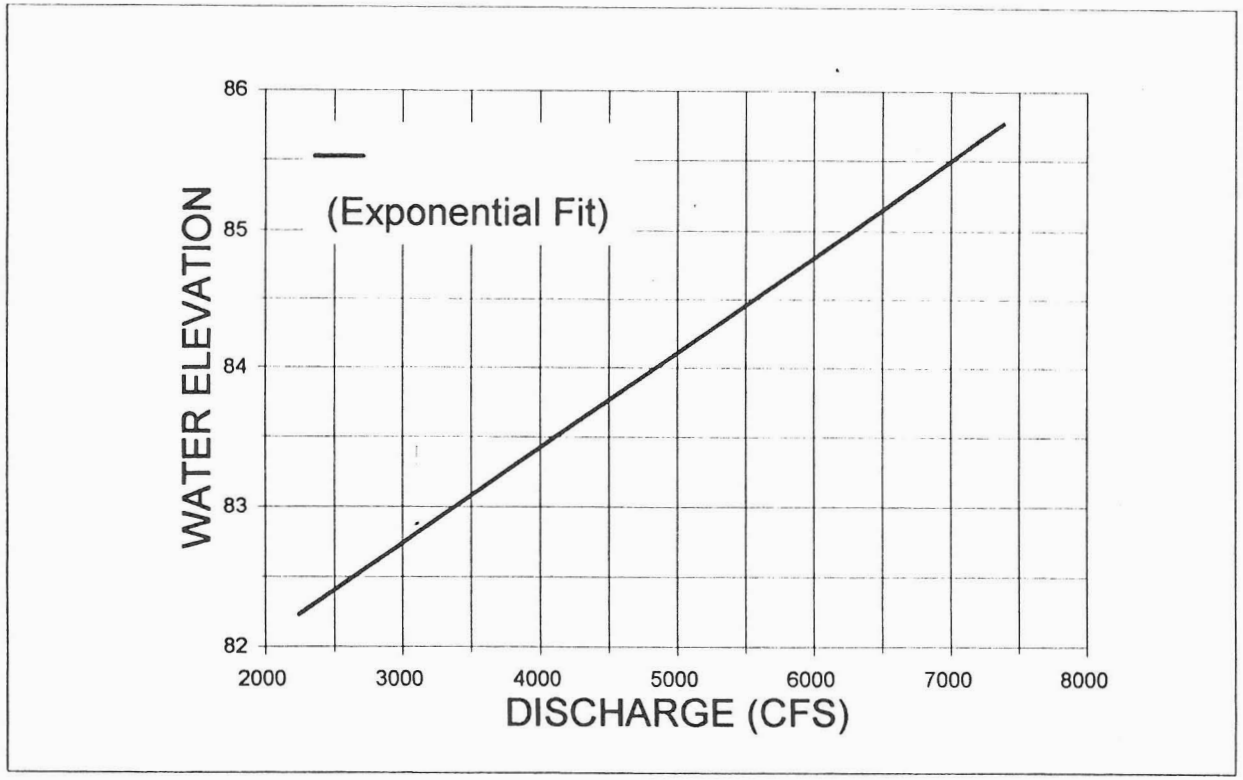
Solve for the 5th Water Surface Elevation WSEL = 85.67

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		88.1																						
2	25	87.7	25	-0.4	0.035					L														
3	32	85.7	7	-2	0.035					L														
4	33	84.6	1	-1.1	0.035	0.52	1.45	0.97	0.36	L	11	11			21.53	0.52			0.97			1.07		
5	43	81.9	10	-2.7	0.035	24.20	10.36	10.00	2.34	C	1,814			1,814	74.98			24.20			10.00			3.77'
6	46	80.4	3	-1.5	0.035	13.56	3.35	3.00	4.04	C	1,466			1,466	108.09			13.56			3.00			5.27'
7	54	79.5	8	-0.9	0.035	45.76	8.05	8.00	5.68	C	6,208			6,208	135.67			45.76			8.00			6.17'
8	57	78.0	3	-1.5	0.035	20.76	3.35	3.00	6.19	C	2,981			2,981	143.60			20.76			3.00			7.67'
9	70	77.9	13	-0.1	0.035	100.36	13.00	13.00	7.72	C	16,700			16,700	166.40			100.36			13.00			7.77'
10	96	78.0	26	0.1	0.035	200.72	26.00	26.00	7.72	C	33,400			33,400	166.40			200.72			26.00			7.67'
11	120	78.8	24	0.8	0.035	174.48	24.01	24.00	7.27	C	27,883			27,883	159.81			174.48			24.00			6.87'
12	138	78.9	18	0.1	0.035	122.76	18.00	18.00	6.82	C	18,806			18,806	153.20			122.76			18.00			6.77'
13	158	84.6	20	5.7	0.035	78.40	20.80	20.00	3.77	C	8,088			8,088	103.16			78.40			20.00			1.07'
14	159	85.3	1	0.7	0.035	0.72	1.22	1.00	0.59	C	22			22	29.94			0.72			1.00			0.37'
15	166	87.8	7	2.5	0.035	0.19	1.10	1.04	0.17	C	3			3	13.27			0.19			1.04			
16	174	88.1	8	0.3	0.035					R														
17	200	88.2	26	0.1	0.035					R														
18	200	88.2			0.035					R														
19	200	88.2			0.035					R														
20	200	88.2			0.035					R														
21	200	88.2			0.035					R														
22	200	88.2			0.035					R														
Total			200.00	0.10	0.735	782.43	130.69	128.01	52.67		117,382	11		117,371		1		782	0.97		127.04			
Maximum	200.00	88.2	26.00	5.70	0.035	200.72	26.00	26.00	7.72						166.40	0.52		200.72				1.07		7.77'
Minimum		77.9		-2.70	0.035																			
Range	200.00	10.3	26.00	8.40		200.72	26.00	26.00	7.72															
Average	116.86	84.3	9.52	0.00	0.035	37.26	6.22	6.10	2.51						60.76									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q	1		7,393	7,394
V	1.36		9.46	
T	1		127	128
Y	1.07		7.77	
A	1		782	782

DISCHARGE RATING CURVE FOR TYPICAL SECTION

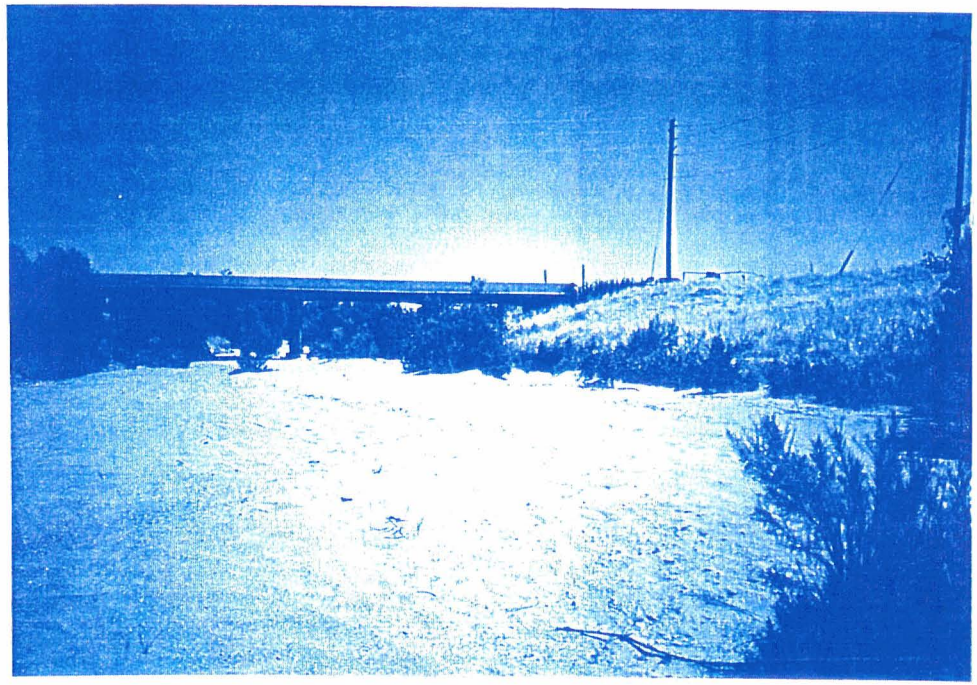
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
82.11	0	0	2,250	2,250	0.00	0.00	6.28	0.00	0.00	4.21	0	0	107	107
82.57	0	0	2,750	2,750	0.00	0.00	6.74	0.00	0.00	4.67	0	0	110	110
82.79	0	0	3,010	3,010	0.00	0.00	6.95	0.00	0.00	4.89	0	0	112	112
84.36	0	0	5,147	5,147	0.00	0.00	8.33	0.00	0.00	6.46	0	0	123	123
85.67	1	0	7,393	7,394	1.36	0.00	9.46	1.07	0.00	7.77	1	0	127	128

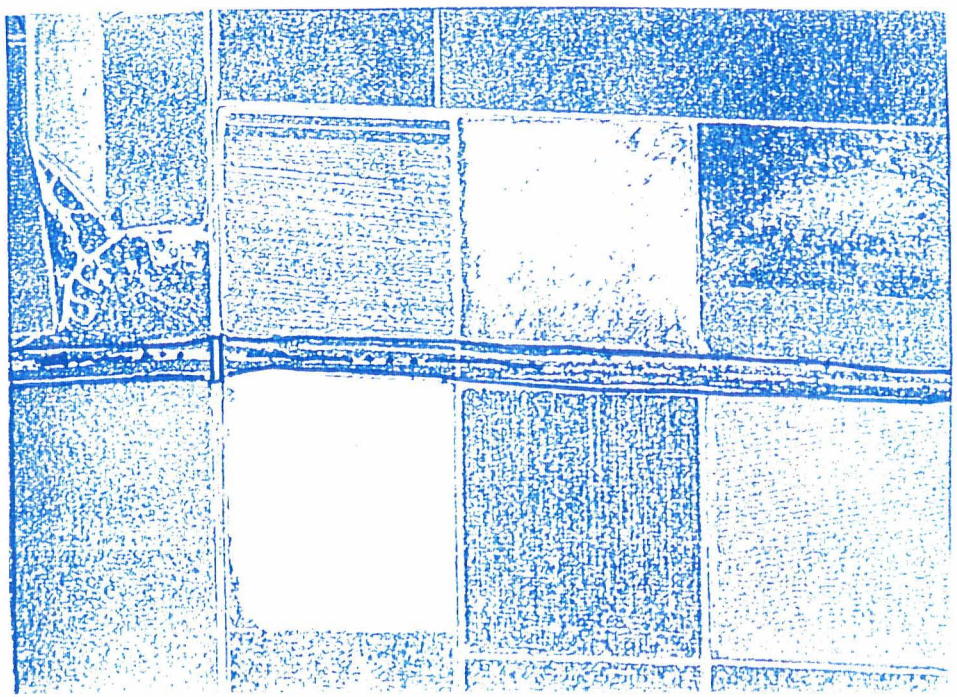


BRIDGE 14 - POWER ROAD (SN 9154)

POWER ROAD (SN 9154)

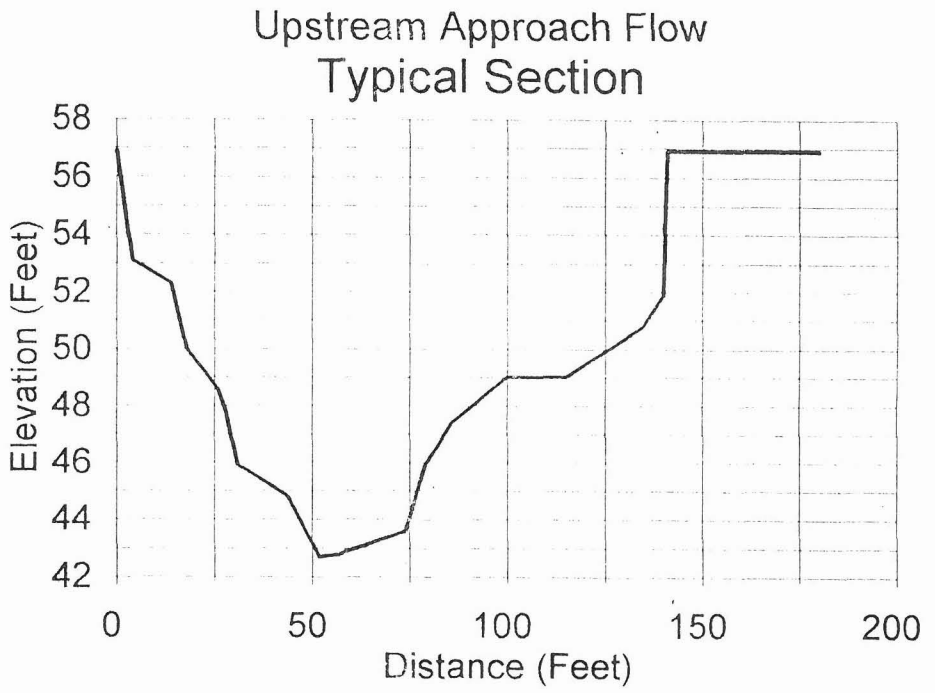
Water Course	Queen Creek
Stream Form	Straight
Sinuosity	Not Applicable
General Channelization	Non-structural (agricultural), trapezoidal, earthen levees
Channel Slope	Steeper US
Estimated Channel Slope (ft/ft)	0.003941
Channel Contraction/Expansion	Main (clear) channel narrower US
Primary Surface Sediment Type	Silt/sand
D50 Size	0.040 MM
Armoring Potential	Low
Channel Vegetation	
Type/Size	Trees include Palo Verde, Mesquite, Ironwood to 15 ft.; brush includes Desert Broom, Creosote, Ephedra; dry grasses.
Density/Occurrence	Vegetation occurs as low to medium density on banks, sparse in channel; denser growth occurs US of structure. Dry grasses generally cover banks.
Relative Age	Mature
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	Non-Structural, earthen levees
Vertical	None
Sediment Deposits & Bars	Regular bar formation is not established, occasional low bars form US and DS. Sediment deposition near structure has reduced clearance toward abutments.
Evidence of Degradation	Occasional cut banks visible US but little evidence of vertical incision.
Evidence of Aggradation	No
Evidence of Scour	
Pier	Exposed pile cap at pier 2.
Abutment	No
Land Use	
Urbanization of Upstream Watershed	Low rate; land use primarily agricultural.
Sand & Gravel Extraction	No commercial extraction in vicinity.
Freeway Construction	No
Dams	No
Drainage Channels	Possible irrigation inflows.





INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	56.9		
2	4	53.1	0.035	C
3	14	52.3	0.035	C
4	18	50.0	0.035	C
5	26	48.6	0.035	C
6	28	47.8	0.035	C
7	31	45.9	0.035	C
8	44	44.8	0.035	C
9	52	42.7	0.035	C
10	57	42.8	0.035	C
11	74	43.6	0.035	C
12	79	45.9	0.035	C
13	86	47.4	0.035	C
14	100	49.0	0.035	C
15	115	49.0	0.035	C
16	135	50.8	0.035	C
17	140	51.9	0.035	C
18	141	56.9	0.035	C
19	150	56.9	0.035	C
20	160	56.9	0.035	C
21	170	56.9	0.035	C
22	180	56.9	0.035	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	55.35
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	59.85
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	55.35
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	42.70
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	55.35
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	42.70
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00394

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	2,250	49.27	2,250	-0.00
2		2,750	49.82	2,750	-0.00
3	Q100	3,010	50.08	3,010	-0.00
4	Q500	5,147	51.78	5,147	-0.00
5	Low Chord	11,964	55.35	11,964	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Feet	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	
Ws	= Width of Scour Protection =	Feet	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.003941
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0013	0.0013	0.0013	0.0013	0.0013
Angle	= *Angle of Attack =*	*Degrees*	0	0	0	0	0
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		SHARP	SHARP	SHARP	SHARP	SHARP
a'	= Pier Width Shown on Plans or Measured in Field =	ft	3.00	3.00	3.00	3.00	3.00
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	7.00	7.00	7.00	7.00	7.00
L	= Pier Length =	ft	26.00	26.00	26.00	26.00	26.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11) =*	*Degrees*	90	90	90	90	90

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	59.85	59.85	59.85	59.85	59.85
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	55.35	55.35	55.35	55.35	55.35
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	49.27	49.82	50.08	51.78	55.35
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	42.70	42.70	42.70	42.70	42.70
y1	= Average Depth in the Upstream Main Channel =	ft	6.57	7.12	7.38	9.08	12.65
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	96	105	109	125	139
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	96	105	109	125	139
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	2,250	2,750	3,010	5,147	11,964
Q2	= Flow in the Contracted Channel =	cfs	2,250	2,750	3,010	5,147	11,964
V1	= Mean Velocity of Flow Upstream of Pier =	fps	7.46	7.69	7.81	8.78	11.22
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.51	0.51	0.51	0.51	0.56
S1	= Energy Slope in Main Channel =		0.00394	0.00394	0.00394	0.00394	0.00394

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	1.73	1.75	1.76	1.83	1.93
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.23	0.23	0.23	0.21	0.17
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.91	0.95	0.97	1.07	1.27
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00165	0.00165	0.00165	0.00165	0.00165
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.20	0.20	0.20	0.20	0.20
U/w	= Ratio of Shear Velocity to Fall Velocity =		4.61	4.80	4.89	5.42	6.40
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.69	0.69	0.69	0.69	0.69
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	6.57	7.12	7.38	9.08	12.65
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	7.46	7.69	7.81	8.78	11.22
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	2.54	2.67	2.75	3.52	6.24
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	7.62	8.02	8.25	10.57	18.72
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	6.08	5.53	5.27	3.57	0.00
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	6.57	7.12	7.38	9.08	12.65
L/a	= Ratio Used in Table 3 to Find K2 =		4.00	4.00	4.00	4.00	4.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.51	0.51	0.51	0.51	0.56
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		0.90	0.90	0.90	0.90	0.90
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.00	1.00	1.00	1.00	1.00
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.00
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	10.17	10.42	10.54	11.40	13.25
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	28.48	29.18	29.51	31.91	37.09
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	7.46	7.69	7.81	8.78	11.22
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.70	1.70	1.70	1.70	1.70
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	12.56	13.36	13.77	17.40	28.45
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	37.68	40.07	41.31	52.21	85.35
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	14.00	14.00	14.00	14.00	14.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	10.17	10.42	10.54	11.40	13.25

Estimate Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		1.00	1.00	1.00	1.00	1.00
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	None

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	10.17	10.42	10.54	11.40	13.25
Yab	= Scour Depth at Abutments	ft	None	None	None	None	None
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	14.17	14.42	14.54	15.40	17.25
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	4.00
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		2.16	2.02	1.97	1.70	1.36
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		0.61	0.56	0.54	0.44	0.32

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Section 1 Water Surface Elevation WSEL 1927

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		56.9																						
2	4	53.1	4	-3.8	0.035					C														
3	14	52.3	10	-0.8	0.035					C														
4	18	50.0	4	-2.3	0.035					C														
5	26	48.6	8	-1.4	0.035	1.27	3.87	3.81	0.33	C	26			26	20.27			1.27			3.81			0.67
6	28	47.8	2	-0.8	0.035	2.13	2.15	2.00	0.99	C	90			90	42.31			2.13			2.00			1.47
7	31	45.9	3	-1.9	0.035	7.25	3.55	3.00	2.04	C	497			497	68.54			7.25			3.00			3.37
8	44	44.8	13	-1.1	0.035	50.92	13.05	13.00	3.90	C	5,377			5,377	105.59			50.92			13.00			4.47
9	52	42.7	8	-2.1	0.035	44.14	8.27	8.00	5.34	C	5,741			5,741	130.08			44.14			8.00			6.57
10	57	42.8	5	0.1	0.035	32.59	5.00	5.00	6.52	C	4,843			4,843	148.61			32.59			5.00			6.47
11	74	43.6	17	0.8	0.035	103.14	17.02	17.00	6.06	C	14,605			14,605	141.60			103.14			17.00			5.67
12	79	45.9	5	2.3	0.035	22.59	5.50	5.00	4.10	C	2,466			2,466	109.17			22.59			5.00			3.37
13	86	47.4	7	1.5	0.035	18.32	7.16	7.00	2.56	C	1,460			1,460	79.67			18.32			7.00			1.87
14	100	49.0	14	1.6	0.035	14.94	14.09	14.00	1.06	C	661			661	44.27			14.94			14.00			0.27
15	115	49.0	15		0.035	4.01	15.00	15.00	0.27	C	71			71	17.66			4.01			15.00			0.27
16	135	50.8	20	1.8	0.035	0.40	2.98	2.97	0.13	C	4			4	11.09			0.40			2.97			
17	140	51.9	5	1.1	0.035					C														
18	141	56.9	1	5	0.035					C														
19	150	56.9	9		0.035					C														
20	160	56.9	10		0.035					C														
21	170	56.9	10		0.035					C														
22	180	56.9	10		0.035					C														
Total			180.00		0.735	301.71	97.65	95.78	33.30		35,841			35,841				302			95.78			
Maximum	180.00	56.9	20.00	5.00	0.035	103.14	17.02	17.00	6.52						148.61			103.14						6.57
Minimum		42.7	1.00	-3.80	0.035																			
Range	180.00	14.2	19.00	8.80		103.14	17.02	17.00	6.52															
Average	82.00	50.3	8.57		0.035	14.37	4.65	4.56	1.59															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			2,250	2,250
V			7.46	
T			96	96
Y			6.57	
A			302	302

Solution for the 2nd Water Surface Elevation WSEL = 49.92

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		56.9																						
2	4	53.1	4	-3.8	0.035					C														
3	14	52.3	10	-0.8	0.035					C														
4	18	50.0	4	-2.3	0.035					C														
5	26	48.6	8	-1.4	0.035	4.28	7.10	6.99	0.60	C	130			130	30.37			4.28			6.99			1.22
6	28	47.8	2	-0.8	0.035	3.25	2.15	2.00	1.51	C	182			182	55.98			3.25			2.00			2.02
7	31	45.9	3	-1.9	0.035	8.92	3.55	3.00	2.51	C	702			702	78.70			8.92			3.00			3.92
8	44	44.8	13	-1.1	0.035	58.16	13.05	13.00	4.46	C	6,709			6,709	115.37			58.16			13.00			5.02
9	52	42.7	8	-2.1	0.035	48.59	8.27	8.00	5.87	C	6,739			6,739	138.68			48.59			8.00			7.12
10	57	42.8	5	0.1	0.035	35.37	5.00	5.00	7.07	C	5,551			5,551	156.95			35.37			5.00			7.02
11	74	43.6	17	0.8	0.035	112.60	17.02	17.00	6.62	C	16,905			16,905	150.13			112.60			17.00			6.22
12	79	45.9	5	2.3	0.035	25.37	5.50	5.00	4.61	C	2,993			2,993	117.97			25.37			5.00			3.92
13	86	47.4	7	1.5	0.035	22.22	7.16	7.00	3.10	C	2,013			2,013	90.61			22.22			7.00			2.42
14	100	49.0	14	1.6	0.035	22.73	14.09	14.00	1.61	C	1,331			1,331	58.57			22.73			14.00			0.82
15	115	49.0	15		0.035	12.35	15.00	15.00	0.82	C	462			462	37.40			12.35			15.00			0.82
16	135	50.8	20	1.8	0.035	3.77	9.19	9.15	0.41	C	89			89	23.49			3.77			9.15			
17	140	51.9	5	1.1	0.035					C														
18	141	56.9	1	5	0.035					C														
19	150	56.9	9		0.035					C														
20	160	56.9	10		0.035					C														
21	170	56.9	10		0.035					C														
22	180	56.9	10		0.035					C														
Total			180.00		0.735	357.60	107.08	105.14	39.20		43,806			43,806				358			105.14			
Maximum	180.00	56.9	20.00	5.00	0.035	112.60	17.02	17.00	7.07						156.95			112.60						7.12
Minimum		42.7	1.00	-3.80	0.035																			
Range	180.00	14.2	19.00	8.80		112.60	17.02	17.00	7.07															
Average	82.00	50.3	8.57		0.035	17.03	5.10	5.01	1.87						50.20									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			2,750	2,750
V			7.69	
T			105	105
Y			7.12	
A			358	358

Solution for the Water Surface Elevation WSEL = 50.08

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		56.9																						
2	4	53.1	4	-3.8	0.035					C														
3	14	52.3	10	-0.8	0.035					C														
4	18	50.0	4	-2.3	0.035	0.01	0.17	0.15	0.04	C	0			0	4.65			0.01			0.15			0.08
5	26	48.6	8	-1.4	0.035	6.27	8.12	8.00	0.77	C	224			224	35.81			6.27			8.00			1.48
6	28	47.8	2	-0.8	0.035	3.77	2.15	2.00	1.75	C	233			233	61.80			3.77			2.00			2.28
7	31	45.9	3	-1.9	0.035	9.70	3.55	3.00	2.73	C	807			807	83.22			9.70			3.00			4.18
8	44	44.8	13	-1.1	0.035	61.53	13.05	13.00	4.72	C	7,371			7,371	119.79			61.53			13.00			5.28
9	52	42.7	8	-2.1	0.035	50.67	8.27	8.00	6.13	C	7,226			7,226	142.61			50.67			8.00			7.38
10	57	42.8	5	0.1	0.035	36.67	5.00	5.00	7.33	C	5,895			5,895	160.78			36.67			5.00			7.28
11	74	43.6	17	0.8	0.035	117.02	17.02	17.00	6.88	C	18,025			18,025	154.03			117.02			17.00			6.48
12	79	45.9	5	2.3	0.035	26.67	5.50	5.00	4.85	C	3,252			3,252	121.96			26.67			5.00			4.18
13	86	47.4	7	1.5	0.035	24.03	7.16	7.00	3.36	C	2,295			2,295	95.49			24.03			7.00			2.68
14	100	49.0	14	1.6	0.035	26.37	14.09	14.00	1.87	C	1,705			1,705	64.66			26.37			14.00			1.08
15	115	49.0	15		0.035	16.25	15.00	15.00	1.08	C	730			730	44.91			16.25			15.00			1.08
16	135	50.8	20	1.8	0.035	6.52	12.09	12.04	0.54	C	184			184	28.21			6.52			12.04			
17	140	51.9	5	1.1	0.035					C														
18	141	56.9	1	5	0.035					C														
19	150	56.9	9		0.035					C														
20	160	56.9	10		0.035					C														
21	170	56.9	10		0.035					C														
22	180	56.9	10		0.035					C														
Total			180.00		0.735	385.47	111.17	109.18	42.03		47,947			47,947				385			109.18			
Maximum	180.00	56.9	20.00	5.00	0.035	117.02	17.02	17.00	7.33						160.78			117.02						7.38
Minimum		42.7	1.00	-3.80	0.035																			
Range	180.00	14.2	19.00	8.80		117.02	17.02	17.00	7.33															
Average	82.00	50.3	8.57		0.035	18.36	5.29	5.20	2.00						53.23									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			3,010	3,010
V			7.81	
T			109	109
Y			7.38	
A			385	385

Step 10: the 4th Water Surface Elevation WSEL = 51.78

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		56.9																						
2	4	53.1	4	-3.8	0.035					C														
3	14	52.3	10	-0.8	0.035					C														
4	18	50.0	4	-2.3	0.035	2.76	3.58	3.10	0.77	C	99			99	35.84			2.76			3.10			1.78
5	26	48.6	8	-1.4	0.035	19.86	8.12	8.00	2.45	C	1,535			1,535	77.29			19.86			8.00			3.18
6	28	47.8	2	-0.8	0.035	7.16	2.15	2.00	3.33	C	680			680	94.90			7.16			2.00			3.98
7	31	45.9	3	-1.9	0.035	14.80	3.55	3.00	4.17	C	1,632			1,632	110.29			14.80			3.00			5.88
8	44	44.8	13	-1.1	0.035	83.62	13.05	13.00	6.41	C	12,291			12,291	146.98			83.62			13.00			6.98
9	52	42.7	8	-2.1	0.035	64.26	8.27	8.00	7.77	C	10,738			10,738	167.11			64.26			8.00			9.08
10	57	42.8	5	0.1	0.035	45.16	5.00	5.00	9.03	C	8,344			8,344	184.75			45.16			5.00			8.98
11	74	43.6	17	0.8	0.035	145.90	17.02	17.00	8.57	C	26,036			26,036	178.45			145.90			17.00			8.18
12	79	45.9	5	2.3	0.035	35.16	5.50	5.00	6.39	C	5,157			5,157	146.67			35.16			5.00			5.88
13	86	47.4	7	1.5	0.035	35.93	7.16	7.00	5.02	C	4,486			4,486	124.85			35.93			7.00			4.38
14	100	49.0	14	1.6	0.035	50.15	14.09	14.00	3.56	C	4,979			4,979	99.28			50.15			14.00			2.78
15	115	49.0	15		0.035	41.74	15.00	15.00	2.78	C	3,516			3,516	84.25			41.74			15.00			2.78
16	135	50.8	20	1.8	0.035	37.65	20.08	20.00	1.87	C	2,437			2,437	64.74			37.65			20.00			0.98
17	140	51.9	5	1.1	0.035	2.19	4.57	4.47	0.48	C	57			57	26.08			2.19			4.47			
18	141	56.9	1	5	0.035					C														
19	150	56.9	9		0.035					C														
20	160	56.9	10		0.035					C														
21	170	56.9	10		0.035					C														
22	180	56.9	10		0.035					C														
Total			180.00		0.735	586.35	127.15	124.57	62.60		81,988			81,988				586			124.57			
Maximum	180.00	56.9	20.00	5.00	0.035	145.90	20.08	20.00	9.03						184.75			145.90						9.08
Minimum		42.7	1.00	-3.80	0.035																			
Range	180.00	14.2	19.00	8.80		145.90	20.08	20.00	9.03															
Average	82.00	50.3	8.57		0.035	27.92	6.05	5.93	2.98						73.40									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			5,147	5,147
V			8.78	
T			125	125
Y			9.08	
A			586	586

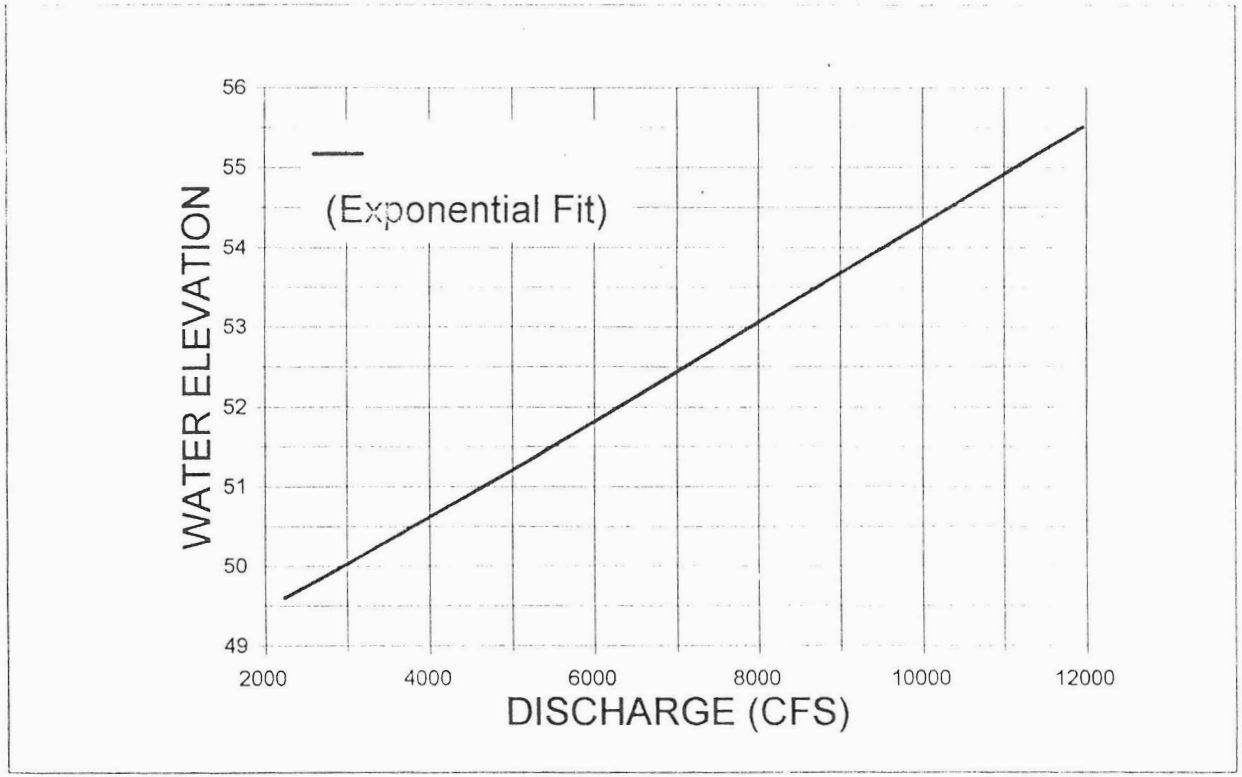
Bank Station Bkt Water Surface Elevation WSEL = 55.35

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		56.9																						
2	4	53.1	4	-3.8	0.035	2.66	3.27	2.37	0.82	C	99			99	37.16			2.66			2.37			2.25
3	14	52.3	10	-0.8	0.035	26.50	10.03	10.00	2.64	C	2,156			2,156	81.38			26.50			10.00			3.05
4	18	50.0	4	-2.3	0.035	16.80	4.61	4.00	3.64	C	1,693			1,693	100.80			16.80			4.00			5.35
5	26	48.6	8	-1.4	0.035	48.40	8.12	8.00	5.96	C	6,777			6,777	140.02			48.40			8.00			6.75
6	28	47.8	2	-0.8	0.035	14.30	2.15	2.00	6.64	C	2,152			2,152	150.47			14.30			2.00			7.55
7	31	45.9	3	-1.9	0.035	25.50	3.55	3.00	7.18	C	4,043			4,043	158.56			25.50			3.00			9.45
8	44	44.8	13	-1.1	0.035	130.00	13.05	13.00	9.96	C	25,647			25,647	197.28			130.00			13.00			10.55
9	52	42.7	8	-2.1	0.035	92.80	8.27	8.00	11.22	C	19,816			19,816	213.53			92.80			8.00			12.65
10	57	42.8	5	0.1	0.035	63.00	5.00	5.00	12.60	C	14,533			14,533	230.68			63.00			5.00			12.55
11	74	43.6	17	0.8	0.035	206.55	17.02	17.00	12.14	C	46,477			46,477	225.01			206.55			17.00			11.75
12	79	45.9	5	2.3	0.035	53.00	5.50	5.00	9.63	C	10,221			10,221	192.84			53.00			5.00			9.45
13	86	47.4	7	1.5	0.035	60.90	7.16	7.00	8.51	C	10,812			10,812	177.53			60.90			7.00			7.95
14	100	49.0	14	1.6	0.035	100.10	14.09	14.00	7.10	C	15,758			15,758	157.42			100.10			14.00			6.35
15	115	49.0	15		0.035	95.25	15.00	15.00	6.35	C	13,913			13,913	146.07			95.25			15.00			6.35
16	135	50.8	20	1.8	0.035	109.00	20.08	20.00	5.43	C	14,340			14,340	131.56			109.00			20.00			4.55
17	140	51.9	5	1.1	0.035	20.00	5.12	5.00	3.91	C	2,113			2,113	105.64			20.00			5.00			3.45
18	141	56.9	1	5	0.035	1.19	3.52	0.69	0.34	C	25			25	20.66			1.19			0.69			
19	150	56.9	9		0.035					C														
20	160	56.9	10		0.035					C														
21	170	56.9	10		0.035					C														
22	180	56.9	10		0.035					C														
Total			180.00		0.735	1,065.95	145.55	139.06	114.06		190,573			190,573				1,066			139.06			
Maximum	180.00	56.9	20.00	5.00	0.035	206.55	20.08	20.00	12.60						230.68			206.55						12.65
Minimum		42.7	1.00	-3.80	0.035																			
Range	180.00	14.2	19.00	8.80		206.55	20.08	20.00	12.60															
Average	82.00	50.3	8.57		0.035	50.76	6.93	6.62	5.43						117.46									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			11,964	11,964
V			11.22	
T			139	139
Y			12.65	
A			1,066	1,066

DISCHARGE RATING CURVE FOR TYPICAL SECTION

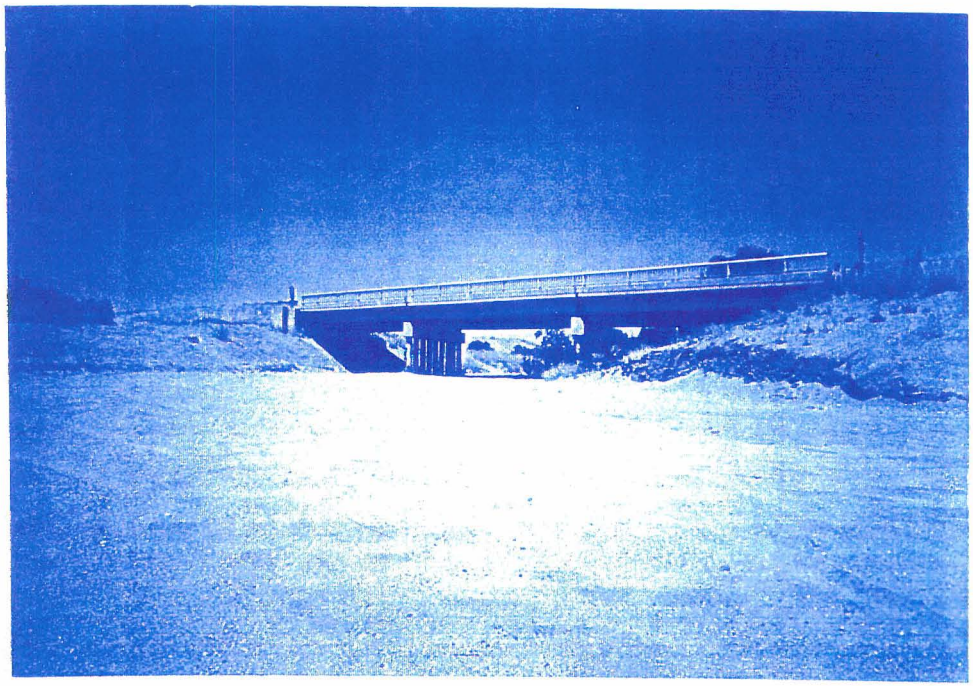
[illegible]	QL	QR	Qc	Q	VL	VR	VG	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
49.27	0	0	2,250	2,250	0.00	0.00	7.46	0.00	0.00	6.57	0	0	96	96
49.82	0	0	2,750	2,750	0.00	0.00	7.69	0.00	0.00	7.12	0	0	105	105
50.08	0	0	3,010	3,010	0.00	0.00	7.81	0.00	0.00	7.38	0	0	109	109
51.78	0	0	5,147	5,147	0.00	0.00	8.78	0.00	0.00	9.08	0	0	125	125
55.35	0	0	11,964	11,964	0.00	0.00	11.22	0.00	0.00	12.65	0	0	139	139

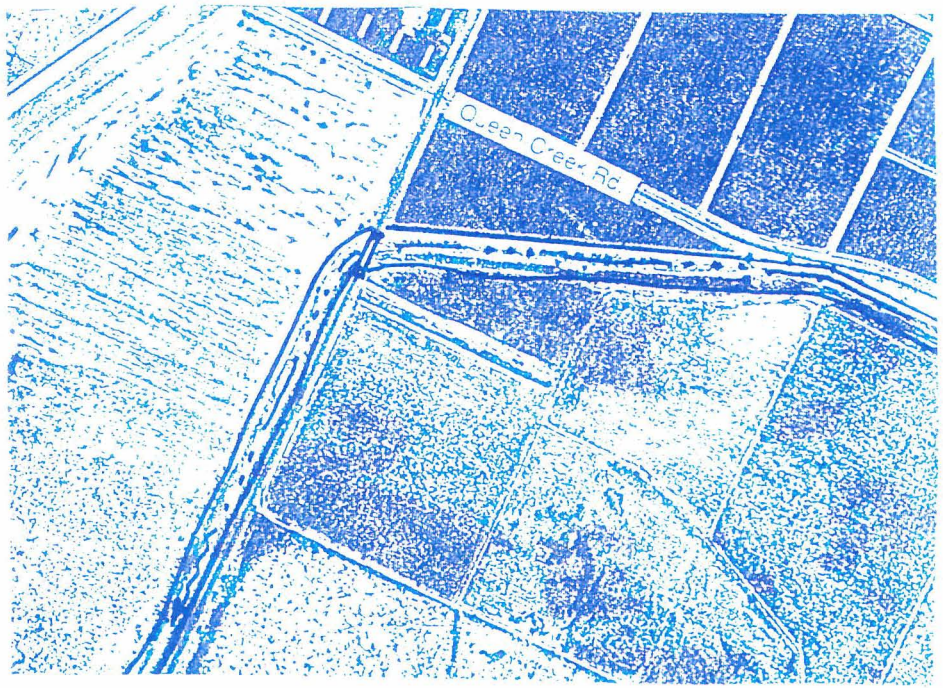


BRIDGE 15 - HIGLEY ROAD (SN 9142)

HIGLEY ROAD (SN 9142)

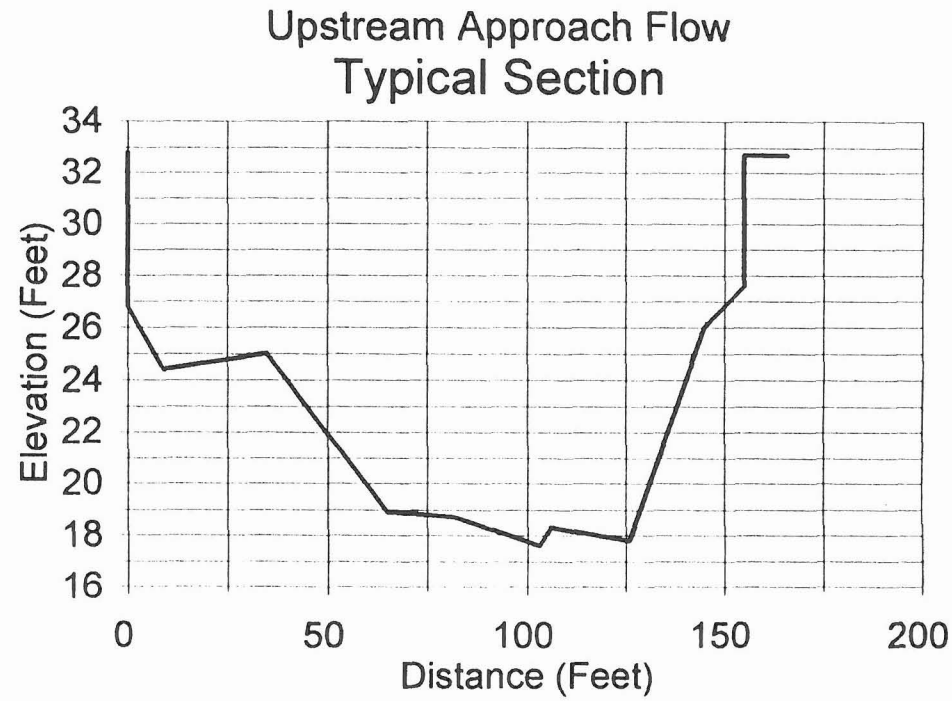
Water Course	Queen Creek
Stream Form	Straight (slight meandering of clear channel.)
Sinuosity	Not Applicable
General Channelization	(US) Non-structural (agricultural), trapezoidal, earthen levees. (DS) Banks trapezoidal - East: earthen r/w embankment. West: wire-mesh reinforced grouted rip-rap.
Channel Slope	Uniform
Estimated Channel Slope (ft/ft)	0.000282
Channel Contraction/Expansion	Channel expands DS
Primary Surface Sediment Type	Silt/sand
D50 Size	0.040 MM
Armoring Potential	Low
Channel Vegetation	
Type/Size	Cottonwood to 35 ft., Palo Verde to 10 ft., Desert Broom to 5 ft., Desert Willow, Creosote, Brittle Bush; dry grasses.
Density/Occurrence	Vegetation occurs on banks. Larger trees occur sparsely near main channel bottom; shrubs are sparse also. Banks dominated by dry grasses.
Relative Age	Mature
Manning's Roughness Coef.	0.035
Controls on Stream Migration	
Lateral	Some bank protection along northwest bank; earthen levees elsewhere.
Vertical	None
Sediment Deposits & Bars	No significant bar development; significant sediment deposition between south abutment and nearest pier.
Evidence of Degradation	No
Evidence of Aggradation	No
Evidence of Scour	
Pier	No
Abutment	Some scour and undercutting on north abutment slope protection.
Land Use	
Urbanization of Upstream Watershed	Low rate; land use primarily agricultural.
Sand & Gravel Extraction	No commercial extraction in vicinity.
Freeway Construction	No
Dams	No
Drainage Channels	Possible irrigation inflows.





INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	32.8		
2	0	26.8	0.035	C
3	9	24.4	0.035	C
4	35	25.0	0.035	C
5	65	18.9	0.035	C
6	82	18.7	0.035	C
7	103	17.6	0.035	C
8	106	18.3	0.035	C
9	126	17.8	0.035	C
10	145	26.0	0.035	C
11	155	27.6	0.035	C
12	155	32.7	0.035	C
13	156	32.7	0.035	C
14	158	32.7	0.035	C
15	159	32.7	0.035	C
16	160	32.7	0.035	C
17	161	32.7	0.035	C
18	162	32.7	0.035	C
19	163	32.7	0.035	C
20	164	32.7	0.035	C
21	165	32.7	0.035	C
22	166	32.7	0.035	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	29.66
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	36.50
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	29.66
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	17.60
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	29.66
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	17.60
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00028

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	2,250	27.08	2,250	0.00
2		2,750	27.94	2,750	0.00
3	Q100	3,010	28.35	3,010	0.00
4	Low Chord	3,909	29.66	3,909	0.00
5	Q500	5,147	31.25	5,147	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	70.00
Ws	= Width of Scour Protection =	Feet	Unknown
Ls	= Length of Scour Protection =	Full or Part?	Unknown
Ts	= Thickness of Scour Protection =	Inches	Unknown
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	Unknown
Material	= Material of Scour Protection =		Rock & Rail
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	
Ws	= Width of Scour Protection =	Feet	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.000282
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0013	0.0013	0.0013	0.0013	0.0013
Angle	= *Angle of Attack* =	*Degrees*	20	20	20	20	20
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	1.17	1.17	1.17	1.17	1.17
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	5.17	5.17	5.17	5.17	5.17
L	= Pier Length =	ft	43.00	43.00	43.00	43.00	43.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	70	70	70	70	70
Shape'	= Shape of Abutment from Hec-18, Pg. 49, Fig. 10 (Vertical, Wings, or Spill) =		SPILL	SPILL	SPILL	SPILL	SPILL
Yg	= Long Term Degradation (General Scour) = Historical Data or Assumed Value =	ft	4	4	4	4	4
Phi	= Dynamic Friction Angle of Bed Material (Normally 30 Degrees for Sand) =	*Degrees*	30	30	30	30	30
Alpha	= Centerline to Bank Deflection Angle Used in the Modified Englund Equation =	*Degrees*	36	36	36	36	36
	= Min of 18, Max of 60, or actual =	*Degrees*	36	36	36	36	36

Results from Hydraulic Analysis

Variable	Description	Unit	Trial No. 1 Value	2 Value	3 Value	4 Value	5 Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	36.50	36.50	36.50	36.50	36.50
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	29.66	29.66	29.66	29.66	29.66
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	27.08	27.94	28.35	29.66	31.25
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	17.60	17.60	17.60	17.60	17.60
y1	= Average Depth in the Upstream Main Channel =	ft	9.48	10.34	10.75	12.06	13.65
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	152	155	155	155	155
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	152	155	155	155	155
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	2,250	2,750	3,010	3,909	5,147
Q2	= Flow in the Contracted Channel =	cfs	2,250	2,750	3,010	3,909	5,147
V1	= Mean Velocity of Flow Upstream of Pier =	fps	2.59	2.75	2.83	3.09	3.40
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.15	0.15	0.15	0.16	0.16
S1	= Energy Slope in Main Channel =		0.00028	0.00028	0.00028	0.00028	0.00028

Compute Critical Velocity to Check for Clear Water Scour

Variable	Description	Unit	Trial No. 1 Value	2 Value	3 Value	4 Value	5 Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	1.84	1.87	1.88	1.91	1.95
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		0.71	0.68	0.66	0.62	0.57
Check	Clear Water Scour?		No	No	No	No	No

Compute Contraction Scour

Variable	Description	Unit	Trial No. 1 Value	2 Value	3 Value	4 Value	5 Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.29	0.31	0.31	0.33	0.35
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.00165	0.00165	0.00165	0.00165	0.00165
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	0.20	0.20	0.20	0.20	0.20
U/w	= Ratio of Shear Velocity to Fall Velocity =		1.48	1.55	1.58	1.67	1.78
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	9.48	10.34	10.75	12.06	13.65
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	NA	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	2.59	2.75	2.83	3.09	3.40
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	0.09	0.10	0.11	0.13	0.17
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	0.27	0.30	0.33	0.40	0.50
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	2.58	1.72	1.31	0.00	-1.59
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	9.48	10.34	10.75	12.06	13.65
L/a	= Ratio Used in Table 3 to Find K2 =		8.00	8.00	8.00	8.00	8.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.15	0.15	0.15	0.16	0.16
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		2.25	2.25	2.25	2.25	2.25
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.07
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	13.93	14.46	14.71	15.51	17.68
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	39.00	40.48	41.19	43.43	49.49
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	2.59	2.75	2.83	3.09	3.40
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	1.18	1.33	1.41	1.68	2.03
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	3.54	3.99	4.22	5.03	6.10
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	10.34	10.34	10.34	10.34	10.34
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	13.93	14.46	14.71	15.51	17.68

Variable	Description	Unit	Value	Value	Value	Value	Value
yb	= Bend Scour from Modified Englund Equation if Alpha > "0"						
	= y1*[(.95+2sin(Alpha/2)^2/cos(Alpha))^(7tan(Phi))-1] =	ft	9.42	10.27	10.68	11.98	13.55
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		0.97	0.97	0.97	0.97	0.97
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24) + Bend Scour						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya +yb =	ft	9.42	10.27	10.68	11.98	13.55
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
te	= Existing Rock Rip-Rap Thickness =	inches	Unknown	Unknown	Unknown	Unknown	Unknown
We	= Existing Rock Rip-Rap Width =	Feet	Unknown	Unknown	Unknown	Unknown	Unknown
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	9.42	10.27	10.68	11.98	13.55

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	13.93	14.46	14.71	15.51	17.68
Yab	= Scour Depth at Abutments	ft	9.42	10.27	10.68	11.98	13.55
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	17.93	18.46	18.71	19.51	21.68
Yat	= Total Scour at Abutment = Yab + Yg =	ft	13.42	14.27	14.68	15.98	17.55
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		1.89	1.79	1.74	1.62	1.59
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		1.41	1.38	1.37	1.32	1.29

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 27.08

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		32.8																						
2		26.8		-6	0.035		0.28			C														0.28
3	9	24.4	9	-2.4	0.035	13.35	9.31	9.00	1.43	C	723			723	54.12			13.35			9.00			2.68
4	35	25.0	26	0.6	0.035	61.97	26.01	26.00	2.38	C	4,708			4,708	75.97			61.97			26.00			2.08
5	65	18.9	30	-6.1	0.035	154.00	30.61	30.00	5.03	C	19,258			19,258	125.05			154.00			30.00			8.18
6	82	18.7	17	-0.2	0.035	140.82	17.00	17.00	8.26	C	24,558			24,558	174.40			140.82			17.00			8.38
7	103	17.6	21	-1.1	0.035	187.60	21.03	21.00	8.92	C	34,378			34,378	183.25			187.60			21.00			9.48
8	106	18.3	3	0.7	0.035	27.40	3.08	3.00	8.89	C	5,011			5,011	182.89			27.40			3.00			8.78
9	126	17.8	20	-0.5	0.035	180.67	20.01	20.00	9.03	C	33,378			33,378	184.75			180.67			20.00			9.28
10	145	26.0	19	8.2	0.035	98.48	20.69	19.00	4.76	C	11,868			11,868	120.51			98.48			19.00			1.08
11	155	27.6	10	1.6	0.035	3.67	6.86	6.77	0.53	C	103			103	28.05			3.67			6.77			
12	155	32.7		5.1	0.035					C														
13	156	32.7	1		0.035					C														
14	158	32.7	2		0.035					C														
15	159	32.7	1		0.035					C														
16	160	32.7	1		0.035					C														
17	161	32.7	1		0.035					C														
18	162	32.7	1		0.035					C														
19	163	32.7	1		0.035					C														
20	164	32.7	1		0.035					C														
21	165	32.7	1		0.035					C														
22	166	32.7	1		0.035					C														
Total			166.00	-0.10	0.735	867.96	154.89	151.77	49.27		133,986			133,986				868			151.77			
Maximum	166.00	32.8	30.00	8.20	0.035	187.60	30.61	30.00	9.03						184.75			187.60						9.48
Minimum		17.6		-6.10	0.035																			
Range	166.00	15.2	30.00	14.30		187.60	30.61	30.00	9.03															
Average	117.95	27.9	7.90	-0.00	0.035	41.33	7.38	7.23	2.35															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			2,250	2,250
V			2.59	
T			152	152
Y			9.48	
A			868	868

Solve for the 2nd Water Surface Elevation WSEL = 27.94

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		32.8																						
2		26.8		-6	0.035		1.14			C														1.14
3	9	24.4	9	-2.4	0.035	21.06	9.31	9.00	2.26	C	1,545			1,545	73.35			21.06			9.00			3.54
4	35	25.0	26	0.6	0.035	84.23	26.01	26.00	3.24	C	7,853			7,853	93.23			84.23			26.00			2.94
5	65	18.9	30	-6.1	0.035	179.69	30.61	30.00	5.87	C	24,906			24,906	138.61			179.69			30.00			9.04
6	82	18.7	17	-0.2	0.035	155.38	17.00	17.00	9.14	C	28,935			28,935	186.23			155.38			17.00			9.24
7	103	17.6	21	-1.1	0.035	205.58	21.03	21.00	9.78	C	40,046			40,046	194.79			205.58			21.00			10.34
8	106	18.3	3	0.7	0.035	29.97	3.08	3.00	9.73	C	5,819			5,819	194.15			29.97			3.00			9.64
9	126	17.8	20	-0.5	0.035	197.79	20.01	20.00	9.89	C	38,818			38,818	196.25			197.79			20.00			10.14
10	145	26.0	19	8.2	0.035	114.76	20.69	19.00	5.55	C	15,314			15,314	133.45			114.76			19.00			1.94
11	155	27.6	10	1.6	0.035	11.40	10.13	10.00	1.13	C	525			525	46.06			11.40			10.00			0.34
12	155	32.7		5.1	0.035		0.34			C														
13	156	32.7	1		0.035					C														
14	158	32.7	2		0.035					C														
15	159	32.7	1		0.035					C														
16	160	32.7	1		0.035					C														
17	161	32.7	1		0.035					C														
18	162	32.7	1		0.035					C														
19	163	32.7	1		0.035					C														
20	164	32.7	1		0.035					C														
21	165	32.7	1		0.035					C														
22	166	32.7	1		0.035					C														
Total			166.00	-0.10	0.735	999.86	159.35	155.00	56.57		163,760			163,760				1,000			155.00			
Maximum	166.00	32.8	30.00	8.20	0.035	205.58	30.61	30.00	9.89						196.25			205.58						10.34
Minimum		17.6		-6.10	0.035																			
Range	166.00	15.2	30.00	14.30		205.58	30.61	30.00	9.89															
Average	117.95	27.9	7.90	-0.00	0.035	47.61	7.59	7.38	2.69						59.82									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			2,750	2,750
V			2.75	
T			155	155
Y			10.34	
A			1,000	1,000

Solve for the 3rd Water Surface Elevation **WSEL = 28.35**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		32.8																						
2		26.8		-6	0.035		1.55			C														1.55
3	9	24.4	9	-2.4	0.035	24.77	9.31	9.00	2.66	C	2,025			2,025	81.74			24.77			9.00			3.95
4	35	25.0	26	0.6	0.035	94.96	26.01	26.00	3.65	C	9,590			9,590	100.99			94.96			26.00			3.35
5	65	18.9	30	-6.1	0.035	192.07	30.61	30.00	6.27	C	27,831			27,831	144.90			192.07			30.00			9.45
6	82	18.7	17	-0.2	0.035	162.39	17.00	17.00	9.55	C	31,145			31,145	191.79			162.39			17.00			9.65
7	103	17.6	21	-1.1	0.035	214.25	21.03	21.00	10.19	C	42,898			42,898	200.23			214.25			21.00			10.75
8	106	18.3	3	0.7	0.035	31.21	3.08	3.00	10.13	C	6,225			6,225	199.46			31.21			3.00			10.05
9	126	17.8	20	-0.5	0.035	206.05	20.01	20.00	10.30	C	41,554			41,554	201.68			206.05			20.00			10.55
10	145	26.0	19	8.2	0.035	122.59	20.69	19.00	5.92	C	17,097			17,097	139.46			122.59			19.00			2.35
11	155	27.6	10	1.6	0.035	15.52	10.13	10.00	1.53	C	879			879	56.60			15.52			10.00			0.75
12	155	32.7		5.1	0.035		0.75			C														
13	156	32.7	1		0.035					C														
14	158	32.7	2		0.035					C														
15	159	32.7	1		0.035					C														
16	160	32.7	1		0.035					C														
17	161	32.7	1		0.035					C														
18	162	32.7	1		0.035					C														
19	163	32.7	1		0.035					C														
20	164	32.7	1		0.035					C														
21	165	32.7	1		0.035					C														
22	166	32.7	1		0.035					C														
Total			166.00	-0.10	0.735	1,063.80	160.18	155.00	60.21		179,243			179,243				1,064			155.00			
Maximum	166.00	32.8	30.00	8.20	0.035	214.25	30.61	30.00	10.30						201.68			214.25						10.75
Minimum		17.6		-6.10	0.035																			
Range	166.00	15.2	30.00	14.30		214.25	30.61	30.00	10.30															
Average	117.95	27.9	7.90	-0.00	0.035	50.66	7.63	7.38	2.87						62.71									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			3,010	3,010
V			2.83	
T			155	155
Y			10.75	
A			1,064	1,064

Solve for the 4th Water Surface Elevation WSEL = 29.66

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		32.8																						
2		26.8		-6	0.035		2.86			C														2.86
3	9	24.4	9	-2.4	0.035	36.54	9.31	9.00	3.92	C	3,871			3,871	105.94			36.54			9.00			5.26
4	35	25.0	26	0.6	0.035	128.96	26.01	26.00	4.96	C	15,973			15,973	123.86			128.96			26.00			4.66
5	65	18.9	30	-6.1	0.035	231.30	30.61	30.00	7.56	C	37,939			37,939	164.03			231.30			30.00			10.76
6	82	18.7	17	-0.2	0.035	184.62	17.00	17.00	10.86	C	38,572			38,572	208.93			184.62			17.00			10.96
7	103	17.6	21	-1.1	0.035	241.71	21.03	21.00	11.49	C	52,451			52,451	217.00			241.71			21.00			12.06
8	106	18.3	3	0.7	0.035	35.13	3.08	3.00	11.40	C	7,583			7,583	215.86			35.13			3.00			11.36
9	126	17.8	20	-0.5	0.035	232.20	20.01	20.00	11.61	C	50,715			50,715	218.41			232.20			20.00			11.86
10	145	26.0	19	8.2	0.035	147.44	20.69	19.00	7.12	C	23,256			23,256	157.73			147.44			19.00			3.66
11	155	27.6	10	1.6	0.035	28.60	10.13	10.00	2.82	C	2,433			2,433	85.09			28.60			10.00			2.06
12	155	32.7		5.1	0.035		2.06			C														
13	156	32.7	1		0.035					C														
14	158	32.7	2		0.035					C														
15	159	32.7	1		0.035					C														
16	160	32.7	1		0.035					C														
17	161	32.7	1		0.035					C														
18	162	32.7	1		0.035					C														
19	163	32.7	1		0.035					C														
20	164	32.7	1		0.035					C														
21	165	32.7	1		0.035					C														
22	166	32.7	1		0.035					C														
Total			166.00	-0.10	0.735	1,266.50	162.79	155.00	71.75		232,794			232,794				1,267			155.00			
Maximum	166.00	32.8	30.00	8.20	0.035	241.71	30.61	30.00	11.61						218.41			241.71						12.06
Minimum		17.6		-6.10	0.035																			
Range	166.00	15.2	30.00	14.30		241.71	30.61	30.00	11.61															
Average	117.95	27.9	7.90	-0.00	0.035	60.31	7.75	7.38	3.42						71.28									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			3,909	3,909
V			3.09	
T			155	155
Y			12.06	
A			1,267	1,267

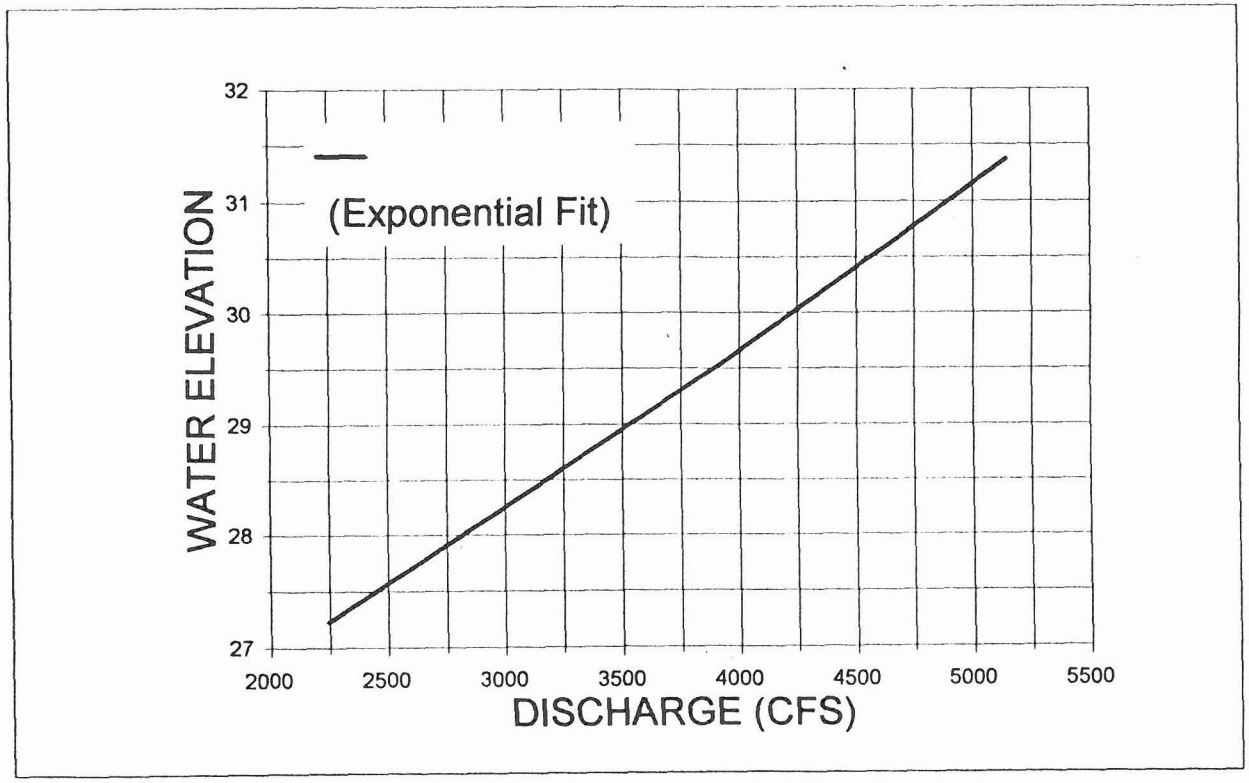
Solve for the 5th Water Surface Elevation WSEL = 31.25

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		32.8																						
2		26.8		-6	0.035		4.45			C														4.45
3	9	24.4	9	-2.4	0.035	50.85	9.31	9.00	5.46	C	6,716			6,716	132.07			50.85			9.00			6.85
4	35	25.0	26	0.6	0.035	170.31	26.01	26.00	6.55	C	25,393			25,393	149.10			170.31			26.00			6.25
5	65	18.9	30	-6.1	0.035	279.01	30.61	30.00	9.11	C	51,862			51,862	185.88			279.01			30.00			12.35
6	82	18.7	17	-0.2	0.035	211.65	17.00	17.00	12.45	C	48,440			48,440	228.87			211.65			17.00			12.55
7	103	17.6	21	-1.1	0.035	275.10	21.03	21.00	13.08	C	65,079			65,079	236.56			275.10			21.00			13.65
8	106	18.3	3	0.7	0.035	39.90	3.08	3.00	12.95	C	9,376			9,376	234.99			39.90			3.00			12.95
9	126	17.8	20	-0.5	0.035	264.00	20.01	20.00	13.20	C	62,815			62,815	237.93			264.00			20.00			13.45
10	145	26.0	19	8.2	0.035	177.65	20.69	19.00	8.58	C	31,732			31,732	178.61			177.65			19.00			5.25
11	155	27.6	10	1.6	0.035	44.50	10.13	10.00	4.39	C	5,085			5,085	114.27			44.50			10.00			3.65
12	155	32.7		5.1	0.035		3.65			C														
13	156	32.7	1		0.035					C														
14	158	32.7	2		0.035					C														
15	159	32.7	1		0.035					C														
16	160	32.7	1		0.035					C														
17	161	32.7	1		0.035					C														
18	162	32.7	1		0.035					C														
19	163	32.7	1		0.035					C														
20	164	32.7	1		0.035					C														
21	165	32.7	1		0.035					C														
22	166	32.7	1		0.035					C														
Total			166.00	-0.10	0.735	1,512.98	165.97	155.00	85.78		306,499			306,499				1,513			155.00			
Maximum	166.00	32.8	30.00	8.20	0.035	279.01	30.61	30.00	13.20						237.93			279.01						13.65
Minimum		17.6		-6.10	0.035																			
Range	166.00	15.2	30.00	14.30		279.01	30.61	30.00	13.20															
Average	117.95	27.9	7.90	-0.00	0.035	72.05	7.90	7.38	4.08						80.87									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			5,147	5,147
V			3.40	
T			155	155
Y			13.65	
A			1,513	1,513

DISCHARGE RATING CURVE FOR TYPICAL SECTION

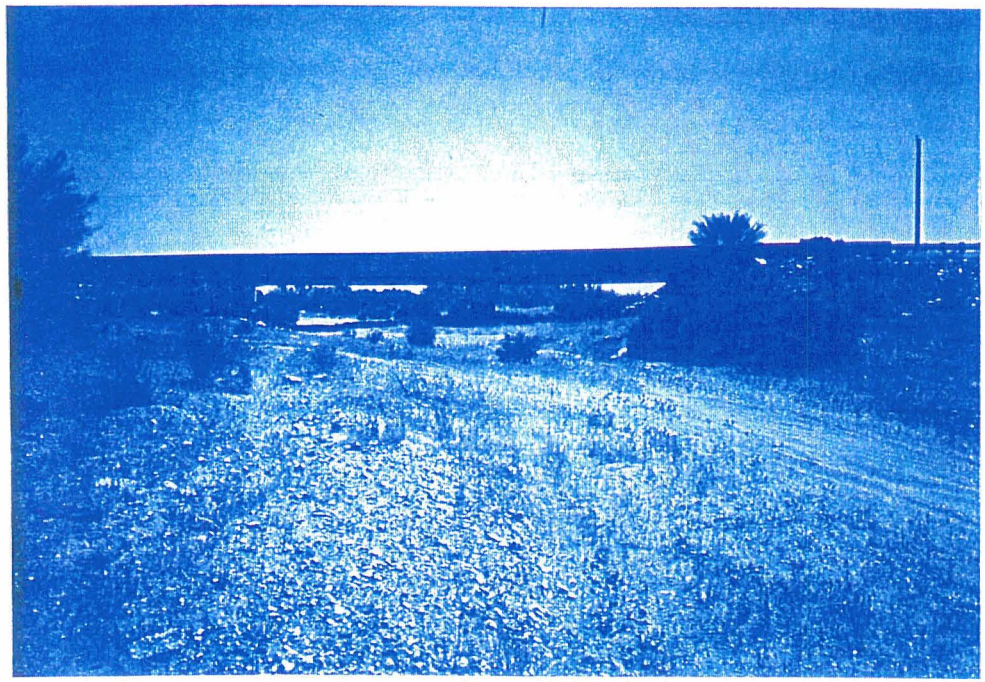
WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
27.08	0	0	2,250	2,250	0.00	0.00	2.59	0.00	0.00	9.48	0	0	152	152
27.94	0	0	2,750	2,750	0.00	0.00	2.75	0.00	0.00	10.34	0	0	155	155
28.35	0	0	3,010	3,010	0.00	0.00	2.83	0.00	0.00	10.75	0	0	155	155
29.66	0	0	3,909	3,909	0.00	0.00	3.09	0.00	0.00	12.06	0	0	155	155
31.25	0	0	5,147	5,147	0.00	0.00	3.40	0.00	0.00	13.65	0	0	155	155

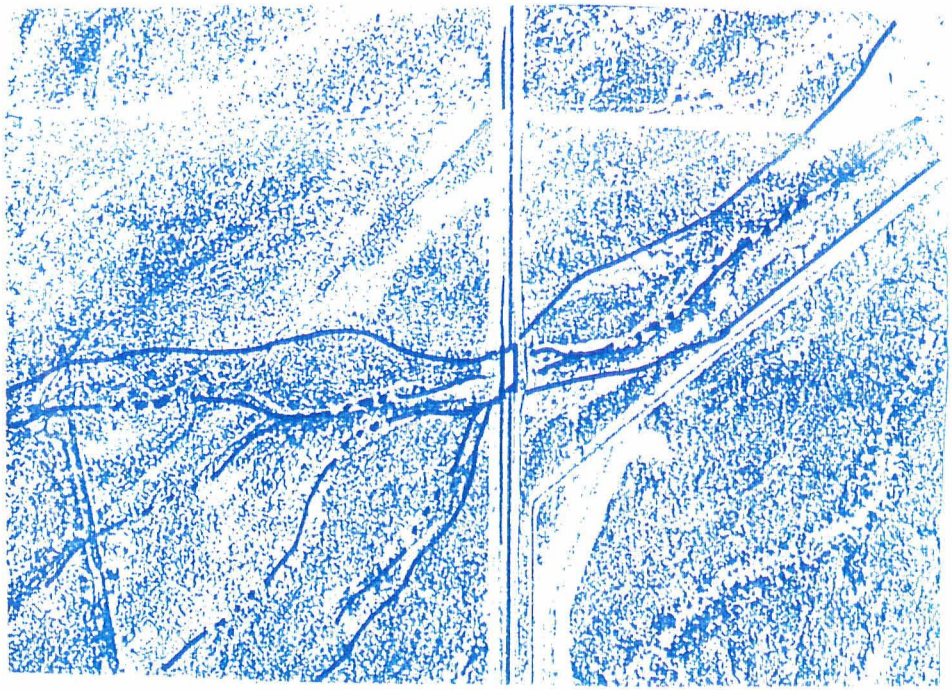


BRIDGE 16 - DEER VALLEY ROAD near 189th AVENUE (SN 7553)

DEER VALLEY ROAD near 189th AVE. (SN 7553)

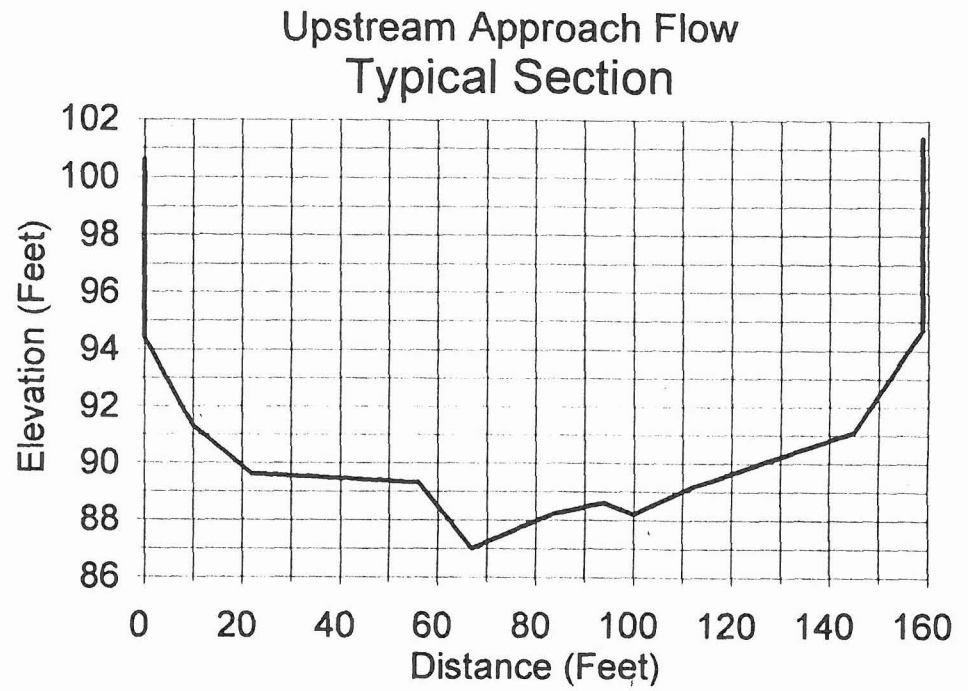
Water Course	Unnamed Wash near 189th Avenue
Stream Form	Braided (channel poorly defined US; secondary channel created by r/w embankment from west).
Sinuosity	Not Applicable
General Channelization	None; spur dike installed along US east abutment.
Channel Slope	(US) channel defined; (DS) uniform.
Estimated Channel Slope (ft/ft)	0.004804
Channel Contraction/Expansion	(DS) channel defined; (US) shallow channel flow to sheet wash.
Primary Surface Sediment Type	sand/gravel
D50 Size	5.0 MM
Armoring Potential	Low
Channel Vegetation	
Type/Size	Palo Verde to 10 ft., Mesquite to 8 ft., Desert Broom to 5 ft., Creosote to 5 ft., Brittle Bush, Salt Bush, Ephedra to 2 ft.; dry grasses.
Density/Occurrence	Trees sparse to moderate along channels; Desert Broom along rip-rap; others uniformly distributed with moderate density; dry grasses occur outside channels with moderate density.
Relative Age	Mature
Manning's Roughness Coef.	0.050
Controls on Stream Migration	
Lateral	None, spur dikes/roadway embankment guide flow near structure.
Vertical	None
Sediment Deposits & Bars	(US) No bar development. (DS) Very low point and alternate bars occurring as of [illegible] shallow channel.
Evidence of Aggradation	No
Evidence of Scour	
Pier	Low flow channel has undercut and destabilized rip-rap along west side of pier 2.
Abutment	Channel paralleling r/w embankment has potential to destabilize rip-rap along north side of west abutment.
Land Use	
Urbanization of Upstream Watershed	Low rate; land generally undeveloped range.
Sand & Gravel Extraction	No
Freeway Construction	No
Dams	No
Drainage Channels	Channel created by r/w embankment.





INPUT DATA FOR SCOUR EVALUATION

Point No.	X ft	Y ft	N-Value	Location L, R, or C
1	0	100.6		
2	0	94.4	0.050	C
3	10	91.3	0.050	C
4	22	89.6	0.050	C
5	56	89.3	0.050	C
6	67	87.0	0.050	C
7	83	88.2	0.050	C
8	94	88.6	0.050	C
9	100	88.2	0.050	C
10	111	89.1	0.050	C
11	145	91.1	0.050	C
12	159	94.7	0.050	C
13	159	101.4	0.050	C
14	159	101.4	0.050	C
15	159	101.4	0.050	C
16	159	101.4	0.050	C
17	159	101.4	0.050	C
18	159	101.4	0.050	C
19	159	101.4	0.050	C
20	159	101.4	0.050	C
21	159	101.4	0.050	C
22	159	101.4	0.050	C



Input Data for Bridge Structure

Variable	Description	Unit	Value
ELpc	= Elevation of Pier Cap =	Feet	97.13
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	Feet	105.25
ELb	= Elevation of the Bottom of the Bridge (Low Chord) = ELpc =	Feet	97.13
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	Feet	87.00
HWSE	= High Water Surface Elevation = Lessor of ELb or Max Cross Section Elevations =	Feet	97.13
LWSE	= Low Water Surface Elevation = Minimum of Crossection Elevations =	Feet	87.00
S	= Energy Slope = Channel Slope or Record Hec-2 Results from Prior Studies =		0.00480

Solve for Water Surface Elevation for Specified Flows

SOLVE

No.		Q	WSEL	Q'	Diff(Q-Q')
1	Q10	785	90.87	785	-0.00
2		3,000	93.25	3,000	0.00
3	Q100	3,925	93.96	3,925	0.00
4	Q500	8,596	96.72	8,596	0.00
5	Low Chord	9,418	97.13	9,418	0.00

Abutment Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection =	Feet	89.50
Ws	= Width of Scour Protection =	Feet	10.00
Ls	= Length of Scour Protection =	Full or Part?	Full
Ts	= Thickness of Scour Protection =	Inches	66.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	11.00
Material	= Material of Scour Protection =		Rock Toe
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Contraction Scour Protection

Is there evidence of scour protection?		Yes or No	No
ELs	= Top Elevation of Scour Protection =	Feet	
Ws	= Width of Scour Protection =	Full or Part?	
Ls	= Length of Scour Protection =	Full or Part?	
Ts	= Thickness of Scour Protection =	Inches	
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material	= Material of Scour Protection =		
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Pier (Local) Scour Protection

Is there evidence of scour protection?		Yes or No	Yes
ELs	= Top Elevation of Scour Protection (or "None") =	Feet	89.50
Ws	= Width of Scour Protection =	Feet	20.00
Ls	= Length of Scour Protection =	Full or Part?	Part
Ts	= Thickness of Scour Protection =	Inches	36.00
D50	= Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	11.00
Material	= Material of Scour Protection =		Rock
Ymax	= Maximum Depth of Scour = (ELg - ELs) or (None) If ELg-ELs<0 =		None

Downstream Grade Control Structure

Is there evidence of scour protection?	Yes or No	No
ELs = Top Elevation of Scour Protection =	Feet	
Ds = Distance Downstream =	Feet	
S = Average Channel Slope = Average Energy Slope =		0.004804
Ws = Width of Scour Protection =	Feet	
Ls = Length of Scour Protection =	Feet	
Ts = Thickness of Scour Protection =	Inches	
D50 = Effective Mean Diameter of Rock, Gabion, or Other Material =	Inches	
Material = Material of Scour Protection =		
Ymax = Maximum Depth of Scour = ELg - (ELs+s*Ds) =		None

Headcut Potential from Downstream or Upstream Depressions

		Downstream	Upstream
Is there a sufficient depression that will cause headcutting?	Yes or No	No	No
D = Depth of Depression =	Feet		
A = Average Surface Area of Depression =	Sq Ft		
L1 = Distance from Bridge to Depression =	Feet		
W = Effective Width of Headcut = Width of Depression =	Feet		
L2 = Distance from Depression to Point of Progression	L2/L1	Cut	Cut
	1.0	0.0	0.0
	1.5	0.0	0.0
	2.0	0.0	0.0
	2.5	0.0	0.0
	3.0	0.0	0.0
	3.5	0.0	0.0
	4.0	0.0	0.0
	4.5	0.0	0.0
	5.0	0.0	0.0
	5.5	0.0	0.0
	Ymax	0.0	0.0

Input Data for Scour Calculations		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Bed	= Bed Condition from Hec-18, Pg. 39, Table 1						
	= (Clear, Plane, Anti , Small, Medium, or Large) Dunes =		SMALL	SMALL	SMALL	SMALL	SMALL
D50	= Median Diameter of Bed Material =	ft	0.0164	0.0164	0.0164	0.0164	0.0164
Angle	= *Angle of Attack* =	*Degrees*	5	5	5	5	5
Shape	= Pier Shape from Hec-18, Pg. 40, Fig. 7						
	= (Square, Round, Cylinder, Sharp, or Group) =		ROUND	ROUND	ROUND	ROUND	ROUND
a'	= Pier Width Shown on Plans or Measured in Field =	ft	3.00	3.00	3.00	3.00	3.00
Wd	= Width of Debris on Piers =	ft	4.00	4.00	4.00	4.00	4.00
a	= Adjusted Pier Width = a' + Wd =	ft	7.00	7.00	7.00	7.00	7.00
L	= Pier Length =	ft	42.00	42.00	42.00	42.00	42.00
Angle'	= *Abutment Angle of Inclination of to Flow (Hec-18, Pg. 51, Fig. 11)* =	*Degrees*	65	65	65	65	65

Results from Hydraulic Analysis		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
ELt	= Elevation of the Top of the Bridge (Railing or Deck) =	ft	105.25	105.25	105.25	105.25	105.25
ELb	= Elevation of the Bottom of the Bridge (Low Chord) =	ft	97.13	97.13	97.13	97.13	97.13
ELw	= Elevation of Water Surface in Approach Flow Section =	ft	90.87	93.25	93.96	96.72	97.13
ELg	= Elevation of the Lowest Ground in the Approach Flow Section =	ft	87.00	87.00	87.00	87.00	87.00
y1	= Average Depth in the Upstream Main Channel =	ft	3.87	6.25	6.96	9.72	10.13
W1	= Bottom (Top) Width of the Upstream Main Channel =	ft	128	150	155	159	159
W2	= Bottom (Top) Width of the Main Channel in the Contracted Section =	ft	128	150	155	159	159
Q1	= Flow in the Upstream Channel Transporting Sediment =	cfs	785	3,000	3,925	8,596	9,418
Q2	= Flow in the Contracted Channel =	cfs	785	3,000	3,925	8,596	9,418
V1	= Mean Velocity of Flow Upstream of Pier =	fps	3.43	5.31	5.83	7.74	8.01
Fr1	= Froude Number in the Upstream Main Channel = V1/sqrt(gy1) =		0.31	0.37	0.39	0.44	0.44
S1	= Energy Slope in Main Channel =		0.00480	0.00480	0.00480	0.00480	0.00480

Compute Critical Velocity to Check for Clear Water Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Vc	= Critical Velocity that Will Transport Bed Materials of Size D50 and smaller						
	= Neill's Equation (Hec-18, Pg. 31, Eq. 14) = 11.52 y1^(1/6) D50^(1/3) =	fps	3.67	3.97	4.04	4.28	4.31
Vc/V1	= Ratio of Critical Velocity to Approach Velocity =		1.07	0.75	0.69	0.55	0.54
Check	Clear Water Scour?		Yes	No	No	No	No

Compute Contraction Scour		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
U	= Shear Velocity = (g y1 S1)^0.5 =	fps	0.77	0.98	1.04	1.23	1.25
Dm	= Effective Mean Diameter of bed material = 1.25*D50 =	ft	0.02049	0.02050	0.02050	0.02050	0.02050
w	= Fall Velocity of D50 Bed Material at 60 Degree F from Hec-18, Pg. 34, Fig. 3 =	fps	1.00	1.00	1.00	1.00	1.00
U/w	= Ratio of Shear Velocity to Fall Velocity =		0.77	0.98	1.04	1.23	1.25
k1	= Exponent from Table (Hec-18, Page 33) =	ft	0.64	0.64	0.64	0.64	0.64
y2	= Average Depth in Contracted Section for Live Bed Scour (Pg. 33,Eq. 16)						
	= y1(Q2/Q1)^(6/7)(W1/W2)^k1 =	ft	NA	6.25	6.96	9.72	10.13
y2	= Average Depth in Contracted Section for Clear Water Scour (Pg. 35,Eq. 18)						
	= [Q2^2/120/Dm^(2/3)/ W2^2]^(3/7) =	ft	1.85	NA	NA	NA	NA
Yc	= Contraction Scour = y2 - y1 =	ft	0.00	0.00	0.00	0.00	0.00
Va	= Accelerated Velocity Through the Contracted Section = V1*W1/W2 =	fps	3.43	5.31	5.83	7.74	8.01
D50	= Required Mean Rock Rip-Rap Size to Resist Motion (Hec-18, Pg. 31, Eq. 14) * SF=2						

	= 2*12*(Va/11.52/Y1^(1/6))^3 =	inches	0.32	0.94	1.18	2.33	2.54
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	0.96	2.83	3.54	7.00	7.61
wr	= Required Rock Rip-Rap Width =	Feet	Full	Full	Full	Full	Full
De	= Existing Rock Rip-Rap Mean Diameter =	inches	0.00	0.00	0.00	0.00	0.00
te	= Existing Rock Rip-Rap Thickness =	inches	0.00	0.00	0.00	0.00	0.00
We	= Existing Rock Rip-Rap Width =	Feet	0.00	0.00	0.00	0.00	0.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yc	= Contraction Scour = Lesser of Yc or Ymax =	ft	0.00	0.00	0.00	0.00	0.00

Compute Local Scour at Piers		**Trial No.**	**1**	**2**	**3**	**4**	**5**
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
FB	= Freeboard Depth Between Bottom of Bridge Deck and Water Surface = ELb-ELw =	ft	6.26	3.88	3.17	0.41	0.00
Yo	= Depth of Flow Over the Top of the Bridge = ELw - ELt =	ft	0.00	0.00	0.00	0.00	0.00
y	= Depth of Approach Flow = Lesser of y1 or ELt-ELg =	ft	3.87	6.25	6.96	9.72	10.13
L/a	= Ratio Used in Table 3 to Find K2 =		6.00	6.00	6.00	6.00	6.00
Fr	= Froude Number = V1/(gy)^(1/2) =		0.31	0.37	0.39	0.44	0.44
K1	= Correction Factor for Pier Nose Shape (Hec-18, Pg. 40, Table 2) =		1.00	1.00	1.00	1.00	1.00
K2	= Correction Factor for Angle of Attack (Hec-18, Pg. 40, Table 3) =		1.25	1.25	1.25	1.25	1.25
K3	= Correction Factor for Dune Height (Hec-18, Pg. 39, Table 1) =		1.10	1.10	1.10	1.10	1.10
K4	= Correction Factor for Particle Size (Proposed by Richardson) =		1.00	1.00	1.00	1.00	1.00
Kp	= Pressure Flow Adjustment Factor (If FB<0) = [1.2 (Fr-0.1) + 1] < 1.6 =		1.00	1.00	1.00	1.00	1.00
Yl	= Local Scour Depth (Pg. 39,Eq. 21) = 2 Kp K1 K2 K3 K4 (a/y)^0.65 Fr^0.43 y =	ft	9.41	12.13	12.81	15.13	15.45
Ws	= Top Width of Scour Hole = 2.8 yl =	ft	26.36	33.96	35.86	42.38	43.25
Va	= Accelerated Velocity Around Pier = V1*W1/W2 =	fps	3.43	5.31	5.83	7.74	8.01
K	= 1.5 for Round-Nose Pier or 1.7 for Rectangular (Hec-18, Pg.122) =		1.50	1.50	1.50	1.50	1.50
D50	= Required Mean Rock Size (Hec-18, Eq. 95) = 12*.692*(KVa)^2/(2.65-1)/2/32.2 =	inches	2.06	4.96	5.98	10.54	11.29
t	= Required Rock Rip-Rap Thickness (Hec-18, Pg. 123) = 3*D50 =	inches	6.19	14.89	17.93	31.61	33.87
wr	= Required Rock Rip-Rap Width (Hec-18, Pg. 123) = 2*a =	Feet	14.00	14.00	14.00	14.00	14.00
De	= Existing Rock Rip-Rap Mean Diameter =	inches	11.00	11.00	11.00	11.00	11.00
te	= Existing Rock Rip-Rap Thickness =	inches	36.00	36.00	36.00	36.00	36.00
We	= Existing Rock Rip-Rap Width =	Feet	20.00	20.00	20.00	20.00	20.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	No	No	No	No	No
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yl	= Local Scour = Lesser of Yl or Ymax =	ft	9.41	12.13	12.81	15.13	15.45

Compute Local Scour at Abutments		Trial No.	1	2	3	4	5
Variable	**Description**	**Unit**	**Value**	**Value**	**Value**	**Value**	**Value**
a'	= Length of Abutment Projected Normal to Flow = Top Width (TL or TR) =	ft	0	0	0	0	0
	Which abutment Left or Right?		Right	Right	Right	Right	Right
Qe	= Approach Flow Obstructed by Abutment =	cfs	0	0	0	0	0
Ve	= Mean Velocity of Approach Flow Obstructed by Abutment = Qe/Ae =	fps	0.00	0.00	0.00	0.00	0.00
Ae	= Area of Approach Flow Obstructed by Abutment =	sq ft	0	0	0	0	0
ya	= Average Depth of Approach Flow Obstructed by Abutment = Ae/a' =	ft	0.00	0.00	0.00	0.00	0.00
Ka1	= Coefficient for Abutment Shape (Hec-18, Pg. 50, Tbl. 4) =		0.55	0.55	0.55	0.55	0.55
Ka2	= Coefficient for Angle of Embankment to Flow = (Angle'/90)^0.13 =		0.96	0.96	0.96	0.96	0.96
Fr	= Froude Number = Ve/(gya)^(1/2) =		None	None	None	None	None
Yab	= Scour Depth at Abutments (Hec-18, Pg. 49, Eq. 24)						
	= [2.27 Ka1 Ka2 (a'/ya)^0.43 Fr^0.61 + 1] ya =	ft	None	None	None	None	None
Va	= Accelerated Velocity Around Abutment (Assume SBR = 1) = V1*W1/W2 =	fps	None	None	None	None	None
K1	= Adjustment Factor for Type of Abutment (Hec-18, Eq. 93, Pg. 118) =		0.89	0.89	0.89	0.89	0.89
K2	= Adjustment Exponent for Froude Number (Hec-18, Eq. 93, Pg. 118) =		1.00	1.00	1.00	1.00	1.00
D50	= Required Mean Rock Size (Hec-18, Eq. 93 or 94) = 12*y1*K1(Va^2/g/y1)^K2/(2.65-1) =	inches	0.00	0.00	0.00	0.00	0.00
t	= Required Rock Rip-Rap Thickness = 3*D50 =	inches	None	None	None	None	None
wr	= Required Rock Rip-Rap Width = Lessor of 2*y1 or 25 =	Feet	None	None	None	None	None
De	= Existing Rock Rip-Rap Mean Diameter =	inches	11.00	11.00	11.00	11.00	11.00
te	= Existing Rock Rip-Rap Thickness =	inches	66.00	66.00	66.00	66.00	66.00
We	= Existing Rock Rip-Rap Width =	Feet	10.00	10.00	10.00	10.00	10.00
Question?	Is the existing rock rip-rap diameter and thickness adequate to protect against scour?	Answer	Yes	Yes	Yes	Yes	Yes
Ymax	= Maximum Depth Limited by Scour Protection =	ft	None	None	None	None	None
Yab	= Scour Depth at Abutment = Lesser of Yab or Ymax =	ft	None	None	None	None	None

Compute Long Term Degradation (General Scour)		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Y	= Assumed Long Term General Scour =	ft	4.00	4.00	4.00	4.00	4.00
Yus	= Headcut Depth Caused by Upstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Yds	= Headcut Depth Caused by Downstream Depression =	ft	0.00	0.00	0.00	0.00	0.00
Ymax	= Maximum Depth Controlled by Downstream Grade Control Structure =	ft	None	None	None	None	None
Yg	= Long Term Degradation = Greater of Y or (Yus+Yds) or Lessor of Ymax =	ft	4.00	4.00	4.00	4.00	4.00

Summary of Scour Depths		Trial No.	1	2	3	4	5
Variable	Description	Unit	Value	Value	Value	Value	Value
Yc	= Contraction Scour =	ft	0.00	0.00	0.00	0.00	0.00
Yl	= Local Scour Depth =	ft	9.41	12.13	12.81	15.13	15.45
Yab	= Scour Depth at Abutments	ft	None	None	None	None	None
Yg	= Long Term Degradation (General Scour) =	ft	4.00	4.00	4.00	4.00	4.00
Yt	= Total Scour at Piers = Yc + Yl + Yg =	ft	13.41	16.13	16.81	19.13	19.45
Yat	= Total Scour at Abutment = Yab + Yg =	ft	4.00	4.00	4.00	4.00	4.00
Yt/Y1	= Ratio of Pier Scour to Depth of Flow =		3.47	2.58	2.41	1.97	1.92
Yat/Y1	= Ratio of Abutment Scour to Depth of Flow =		1.03	0.64	0.57	0.41	0.39

HYDRAULIC CALCULATIONS FOR TYPICAL SECTION

Solve for the 1st Water Surface Elevation WSEL = 90.87

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		100.6																						
2		94.4		-6.2	0.050					C														
3	10	91.3	10	-3.1	0.050					C														
4	22	89.6	12	-1.7	0.050	5.68	9.04	8.96	0.63	C	124			124	21.85			5.68			8.96			1.27
5	56	89.3	34	-0.3	0.050	48.24	34.00	34.00	1.42	C	1,815			1,815	37.63			48.24			34.00			1.57
6	67	87.0	11	-2.3	0.050	29.91	11.24	11.00	2.66	C	1,712			1,712	57.24			29.91			11.00			3.87
7	83	88.2	16	1.2	0.050	52.30	16.04	16.00	3.26	C	3,428			3,428	65.54			52.30			16.00			2.67
8	94	88.6	11	0.4	0.050	27.16	11.01	11.00	2.47	C	1,478			1,478	54.43			27.16			11.00			2.27
9	100	88.2	6	-0.4	0.050	14.81	6.01	6.00	2.46	C	805			805	54.37			14.81			6.00			2.67
10	111	89.1	11	0.9	0.050	24.41	11.04	11.00	2.21	C	1,235			1,235	50.59			24.41			11.00			1.77
11	145	91.1	34	2	0.050	26.59	30.12	30.07	0.88	C	729			729	27.42			26.59			30.07			
12	159	94.7	14	3.6	0.050					C														
13	159	101.4		6.7	0.050					C														
14	159	101.4			0.050					C														
15	159	101.4			0.050					C														
16	159	101.4			0.050					C														
17	159	101.4			0.050					C														
18	159	101.4			0.050					C														
19	159	101.4			0.050					C														
20	159	101.4			0.050					C														
21	159	101.4			0.050					C														
22	159	101.4			0.050					C														
Total			159.00	0.80	1.050	229.08	128.51	128.02	15.99		11,326			11,326				229			128.02			
Maximum	159.00	101.4	34.00	6.70	0.050	52.30	34.00	34.00	3.26						65.54			52.30						3.87
Minimum		87.0		-6.20	0.050																			
Range	159.00	14.4	34.00	12.90		52.30	34.00	34.00	3.26															
Average	110.77	95.7	7.57	0.04	0.050	10.91	6.12	6.10	0.76															

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			785	785
V			3.43	
T			128	128
Y			3.87	
A			229	229

Solve for the 2nd Water Surface Elevation WSEL = 93.25

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		100.6																						
2		94.4		-6.2	0.05					C														
3	10	91.3	10	-3.1	0.05	6.13	6.59	6.29	0.93	C	174			174	28.42			6.13			6.29			1.95
4	22	89.6	12	-1.7	0.05	33.60	12.12	12.00	2.77	C	1,977			1,977	58.83			33.60			12.00			3.65
5	56	89.3	34	-0.3	0.05	129.21	34.00	34.00	3.80	C	9,380			9,380	72.60			129.21			34.00			3.95
6	67	87.0	11	-2.3	0.05	56.10	11.24	11.00	4.99	C	4,886			4,886	87.09			56.10			11.00			6.25
7	83	88.2	16	1.2	0.05	90.40	16.04	16.00	5.63	C	8,535			8,535	94.41			90.40			16.00			5.05
8	94	88.6	11	0.4	0.05	53.35	11.01	11.00	4.85	C	4,556			4,556	85.39			53.35			11.00			4.65
9	100	88.2	6	-0.4	0.05	29.10	6.01	6.00	4.84	C	2,482			2,482	85.30			29.10			6.00			5.05
10	111	89.1	11	0.9	0.05	50.60	11.04	11.00	4.58	C	4,164			4,164	82.28			50.60			11.00			4.15
11	145	91.1	34	2	0.05	107.11	34.06	34.00	3.14	C	6,854			6,854	63.99			107.11			34.00			2.15
12	159	94.7	14	3.6	0.05	8.99	8.63	8.36	1.04	C	275			275	30.61			8.99			8.36			
13	159	101.4		6.7	0.05					C														
14	159	101.4			0.05					C														
15	159	101.4			0.05					C														
16	159	101.4			0.05					C														
17	159	101.4			0.05					C														
18	159	101.4			0.05					C														
19	159	101.4			0.05					C														
20	159	101.4			0.05					C														
21	159	101.4			0.05					C														
22	159	101.4			0.05					C														
Total			159.00	0.80	1.050	564.59	150.74	149.65	36.59		43,283			43,283				565			149.65			
Maximum	159.00	101.4	34.00	6.70	0.050	129.21	34.06	34.00	5.63						94.41			129.21						6.25
Minimum		87.0		-6.20	0.050																			
Range	159.00	14.4	34.00	12.90		129.21	34.06	34.00	5.63															
Average	110.77	95.7	7.57	0.04	0.050	26.89	7.18	7.13	1.74						32.81									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			3,000	3,000
V			5.31	
T			150	150
Y			6.25	
A			565	565

Solve for the 3rd Water Surface Elevation **WSEL = 93.96**

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		100.6																						
2		94.4		-6.2	0.050					C														
3	10	91.3	10	-3.1	0.050	11.44	9.00	8.59	1.27	C	400			400	34.99			11.44			8.59			2.66
4	22	89.6	12	-1.7	0.050	42.16	12.12	12.00	3.48	C	2,886			2,886	68.45			42.16			12.00			4.36
5	56	89.3	34	-0.3	0.050	153.46	34.00	34.00	4.51	C	12,495			12,495	81.43			153.46			34.00			4.66
6	67	87.0	11	-2.3	0.050	63.95	11.24	11.00	5.69	C	6,077			6,077	95.04			63.95			11.00			6.96
7	83	88.2	16	1.2	0.050	101.82	16.04	16.00	6.35	C	10,406			10,406	102.20			101.82			16.00			5.76
8	94	88.6	11	0.4	0.050	61.20	11.01	11.00	5.56	C	5,727			5,727	93.58			61.20			11.00			5.36
9	100	88.2	6	-0.4	0.050	33.38	6.01	6.00	5.55	C	3,120			3,120	93.48			33.38			6.00			5.76
10	111	89.1	11	0.9	0.050	58.45	11.04	11.00	5.30	C	5,295			5,295	90.59			58.45			11.00			4.86
11	145	91.1	34	2	0.050	131.36	34.06	34.00	3.86	C	9,631			9,631	73.32			131.36			34.00			2.86
12	159	94.7	14	3.6	0.050	15.94	11.50	11.14	1.39	C	591			591	37.06			15.94			11.14			
13	159	101.4		6.7	0.050					C														
14	159	101.4			0.050					C														
15	159	101.4			0.050					C														
16	159	101.4			0.050					C														
17	159	101.4			0.050					C														
18	159	101.4			0.050					C														
19	159	101.4			0.050					C														
20	159	101.4			0.050					C														
21	159	101.4			0.050					C														
22	159	101.4			0.050					C														
Total			159.00	0.80	1.050	673.15	156.01	154.73	42.95		56,629			56,629				673			154.73			
Maximum	159.00	101.4	34.00	6.70	0.050	153.46	34.06	34.00	6.35						102.20			153.46						6.96
Minimum		87.0		-6.20	0.050																			
Range	159.00	14.4	34.00	12.90		153.46	34.06	34.00	6.35															
Average	110.77	95.7	7.57	0.04	0.050	32.05	7.43	7.37	2.05						36.67									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			3,925	3,925
V			5.83	
T			155	155
Y			6.96	
A			673	673

Solve for the 4th Water Surface Elevation | **WSEL =** | **96.72**

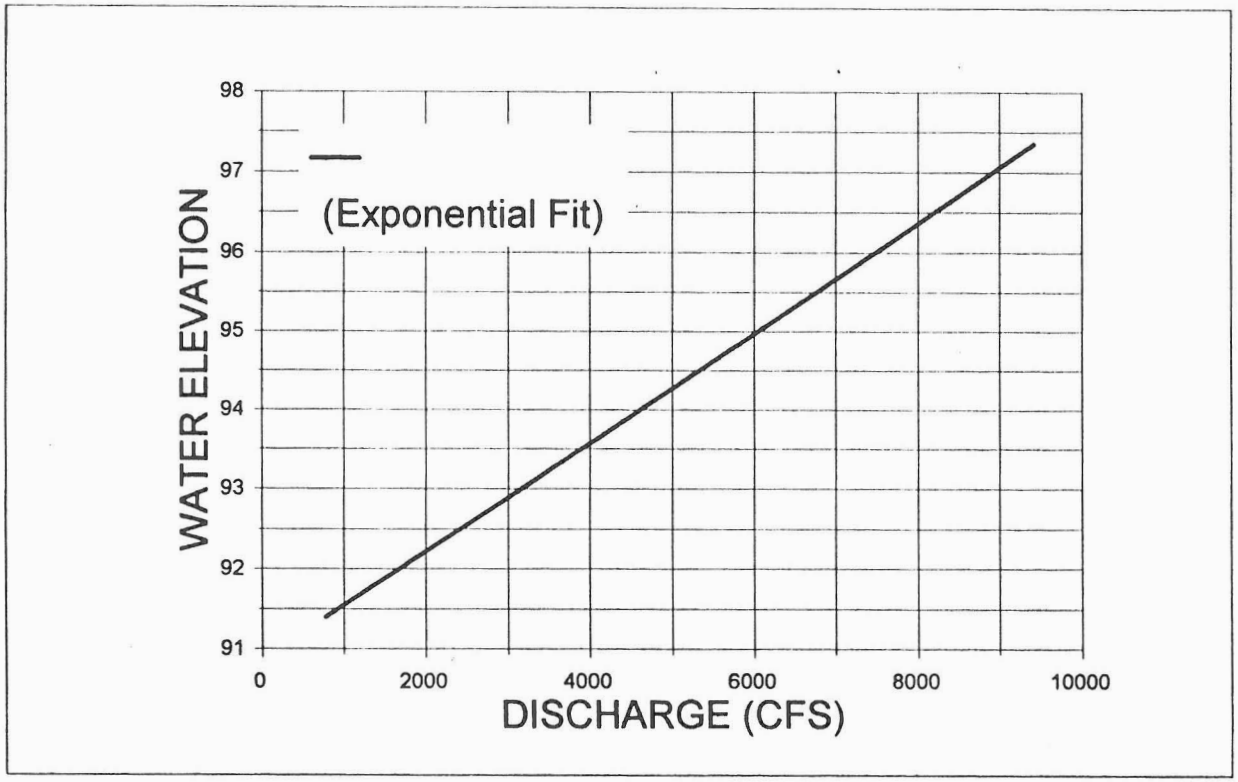
Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		100.6																						
2		94.4		-6.2	0.050		2.32			C														2.32
3	10	91.3	10	-3.1	0.050	38.73	10.47	10.00	3.70	C	2,761			2,761	71.31			38.73			10.00			5.42
4	22	89.6	12	-1.7	0.050	75.27	12.12	12.00	6.21	C	7,584			7,584	100.75			75.27			12.00			7.12
5	56	89.3	34	-0.3	0.050	247.27	34.00	34.00	7.27	C	27,678			27,678	111.93			247.27			34.00			7.42
6	67	87.0	11	-2.3	0.050	94.30	11.24	11.00	8.39	C	11,612			11,612	123.14			94.30			11.00			9.72
7	83	88.2	16	1.2	0.050	145.96	16.04	16.00	9.10	C	18,969			18,969	129.96			145.96			16.00			8.52
8	94	88.6	11	0.4	0.050	91.55	11.01	11.00	8.32	C	11,207			11,207	122.42			91.55			11.00			8.12
9	100	88.2	6	-0.4	0.050	49.94	6.01	6.00	8.30	C	6,107			6,107	122.29			49.94			6.00			8.52
10	111	89.1	11	0.9	0.050	88.80	11.04	11.00	8.05	C	10,633			10,633	119.74			88.80			11.00			7.62
11	145	91.1	34	2	0.050	225.17	34.06	34.00	6.61	C	23,652			23,652	105.04			225.17			34.00			5.62
12	159	94.7	14	3.6	0.050	53.52	14.46	14.00	3.70	C	3,818			3,818	71.35			53.52			14.00			2.02
13	159	101.4		6.7	0.050		2.02			C														
14	159	101.4			0.050					C														
15	159	101.4			0.050					C														
16	159	101.4			0.050					C														
17	159	101.4			0.050					C														
18	159	101.4			0.050					C														
19	159	101.4			0.050					C														
20	159	101.4			0.050					C														
21	159	101.4			0.050					C														
22	159	101.4			0.050					C														
Total			159.00	0.80	1.050	1,110.51	164.79	159.00	69.65		124,021			124,021				1,111			159.00			
Maximum	159.00	101.4	34.00	6.70	0.050	247.27	34.06	34.00	9.10						129.96			247.27						9.72
Minimum		87.0		-6.20	0.050																			
Range	159.00	14.4	34.00	12.90		247.27	34.06	34.00	9.10															
Average	110.77	95.7	7.57	0.04	0.050	52.88	7.85	7.57	3.32						51.33									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			8,596	8,596
V			7.74	
T			159	159
Y			9.72	
A			1,111	1,111

Solve for the 5th Water Surface Elevation WSEL = 97.13

Point No.	X ft	Y ft	delta(x) ft	delta(y) ft	N	A sq ft	P ft	T ft	R ft	Location L,R, or C	K cfs	KL cfs	KR cfs	KC cfs	K' fps	AL sq ft	AR sq ft	AC sq ft	TL ft	TR ft	TC ft	YL ft	YR ft	YC ft
1		100.6																						
2		94.4		-6.2	0.050		2.73			C														2.73
3	10	91.3	10	-3.1	0.050	42.80	10.47	10.00	4.09	C	3,262			3,262	76.23			42.80			10.00			5.83
4	22	89.6	12	-1.7	0.050	80.16	12.12	12.00	6.61	C	8,422			8,422	105.07			80.16			12.00			7.53
5	56	89.3	34	-0.3	0.050	261.12	34.00	34.00	7.68	C	30,310			30,310	116.08			261.12			34.00			7.83
6	67	87.0	11	-2.3	0.050	98.78	11.24	11.00	8.79	C	12,547			12,547	127.01			98.78			11.00			10.13
7	83	88.2	16	1.2	0.050	152.48	16.04	16.00	9.50	C	20,402			20,402	133.80			152.48			16.00			8.93
8	94	88.6	11	0.4	0.050	96.03	11.01	11.00	8.72	C	12,136			12,136	126.38			96.03			11.00			8.53
9	100	88.2	6	-0.4	0.050	52.38	6.01	6.00	8.71	C	6,613			6,613	126.25			52.38			6.00			8.93
10	111	89.1	11	0.9	0.050	93.28	11.04	11.00	8.45	C	11,542			11,542	123.73			93.28			11.00			8.03
11	145	91.1	34	2	0.050	239.02	34.06	34.00	7.02	C	26,126			26,126	109.30			239.02			34.00			6.03
12	159	94.7	14	3.6	0.050	59.22	14.46	14.00	4.10	C	4,520			4,520	76.33			59.22			14.00			2.43
13	159	101.4		6.7	0.050		2.43			C														
14	159	101.4			0.050					C														
15	159	101.4			0.050					C														
16	159	101.4			0.050					C														
17	159	101.4			0.050					C														
18	159	101.4			0.050					C														
19	159	101.4			0.050					C														
20	159	101.4			0.050					C														
21	159	101.4			0.050					C														
22	159	101.4			0.050					C														
Total			159.00	0.80	1.050	1,175.27	165.61	159.00	73.68		135,880			135,880				1,175			159.00			
Maximum	159.00	101.4	34.00	6.70	0.050	261.12	34.06	34.00	9.50						133.80			261.12						10.13
Minimum		87.0		-6.20	0.050																			
Range	159.00	14.4	34.00	12.90		261.12	34.06	34.00	9.50															
Average	110.77	95.7	7.57	0.04	0.050	55.97	7.89	7.57	3.51						53.34									

SUMMARY	LEFT	RIGHT	CHANNEL	TOTAL
Q			9,418	9,418
V			8.01	
T			159	159
Y			10.13	
A			1,175	1,175

DISCHARGE RATING CURVE FOR TYPICAL SECTION

WSEL	QL	QR	QC	Q	VL	VR	VC	YL	YR	YC	TL	TR	TC	T
	cfs	cfs	cfs	cfs	fps	fps	fps	ft	ft	ft	ft	ft	ft	ft
90.87	0	0	785	785	0.00	0.00	3.43	0.00	0.00	3.87	0	0	128	128
93.25	0	0	3,000	3,000	0.00	0.00	5.31	0.00	0.00	6.25	0	0	150	150
93.96	0	0	3,925	3,925	0.00	0.00	5.83	0.00	0.00	6.96	0	0	155	155
96.72	0	0	8,596	8,596	0.00	0.00	7.74	0.00	0.00	9.72	0	0	159	159
97.13	0	0	9,418	9,418	0.00	0.00	8.01	0.00	0.00	10.13	0	0	159	159