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U.S. Army Corps of Engineers
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Rio Salado Environmental Restoration Project
Tempe Reach: Indian Bend Wash and Salt River
Tempe, Arizona

Hydraulic & Hydrologic Design Analysis Report for the Indian Bend Wash Flood Control Improvements

An Analysis of Various Habitat Restoration Scenarios for Indian Bend Wash Reach of Tempe Rio Salado Environmental Restoration Project

November 2001

Prepared by
McGann & Associates Inc. / Novak Environmental Inc., Joint-Venture

HYDRAULIC & HYDROLOGIC DESIGN ANALYSIS REPORT FOR THE INDIAN BEND WASH FLOOD CONTROL IMPROVEMENTS

AN ANALYSIS OF VARIOUS HABITAT RESTORATION SCENARIOS FOR INDIAN BEND WASH REACH OF TEMPE RIO SALADO ENVIRONMENTAL RESTORATION PROJECT

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
LOS ANGELES DISTRICT

Prepared by:

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Contract No: DACW09-00-D-0006
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November 30, 2001

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I INTRODUCTION

1.1 Purpose

1.1.1 Purpose

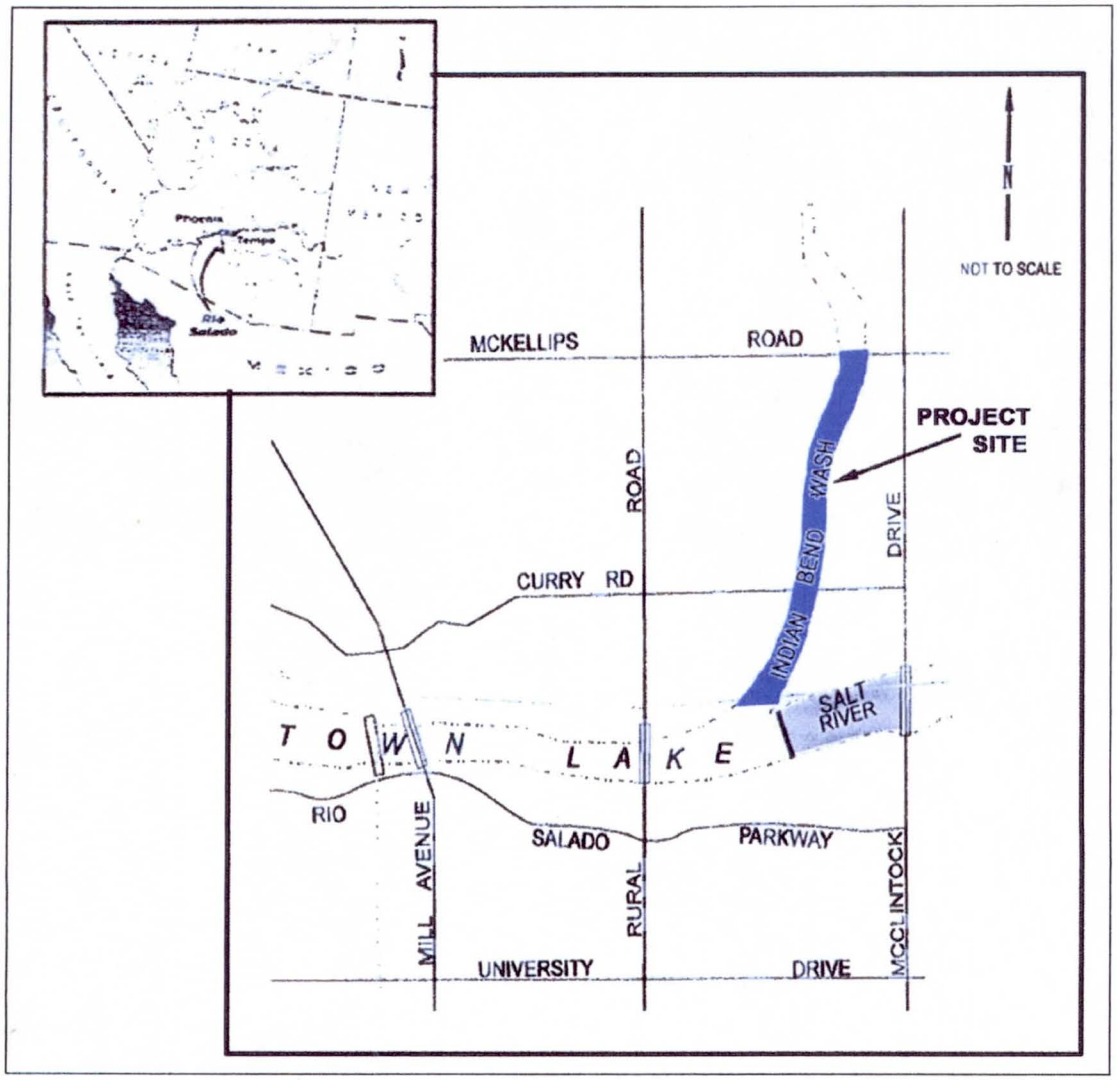
The purpose of this report is to present the results of hydraulic analyses for two proposed habitat restoration design alternatives. The analyses assessed the impact of the proposed habitat restoration vegetation on flow velocities, water surface elevations and available levee freeboard. Recommendations are provided for levee modifications, which will be required to contain the design storm in IBW after habitat improvements have been installed and to comply with Corps of Engineers and FEMA levee freeboard standards. The two alternatives evaluated include, one design as derived from the Rio Salado Feasibility Report (US Army Corps of Engineers, 1998) and another design concept as proposed by McGann & Associates, Inc. / Novak Environmental, Inc. Joint Venture. This updated hydraulic analysis uses a more current topographic map and uses various habitat restoration design alternatives in order to examine projected effects on the required freeboard.

1.1.2 Study Area Description

The Indian Bend Wash reach extends between McKellips Road and the confluence with Salt River (see Figure 1). In the late 1970's, the Corps of Engineers, in cooperation with the City of Tempe, completed construction of the IBW floodway channel. The project design features included a 120-foot bottom width low-flow channel having a depth of approximately 6 feet and 3:1 sideslopes. The low-flow channel is bounded on both sides by floodway terrace and levee structures, which are

designed to contain 30,000 cfs plus freeboard. Today, the terraces are used as a golf course but still convey floodwaters during storms that exceed the 5-year return period event.

Figure 1: Project location map.



The design plan for the IBW reach of the Tempe Rio Salado Environmental Restoration Project as depicted in The Feasibility Study (April,1998) proposes development of a

riparian habitat area within the low flow channel consisting of cottonwoods, willows, mesquite bosque, aquatic strand, wetland marsh and open space.

1.2 Project Background Information

1.2.1 Study Authorization

The Rio Salado Project, Tempe, Arizona, has been conducted under the authority given in public law 761, 75th Congress, known as Section 6 of the Flood Control Act of 1938 and appropriated under the 1994 Senate Energy and Water Development Bill. The work presented in this report has been conducted by the McGann Associated/Novak Environmental, Inc. Joint Venture under contract #DACW09-00-D-0006, Task Order #0001 – Modification 01.

1.2.2 Previous Studies

A complete list of the previous studies and references used in conjunction with this report is given in Section IV. A brief discussion of previous reports that guide the hydraulic design element of the project is given below.

U.S. Army Corps of Engineers, Los Angeles District Design Memorandum #1

In recognition of the flood problem that exists along IBW in Scottsdale and Tempe, Arizona, Congress authorized a flood control project consisting of a 7-mile long concrete-lined channel for IBW in 1965. At the request of local interests, the authorized plan was reformulated in the report entitled, Design Memorandum #1, General Design Memorandum B Phase I, Plan Formulation for IBW published in

October 1973. The reformulated plan, approved by OCE in April 1974, included recreation as a project purpose and provided a combination of structural and non-structural measures in lieu of the concrete-lined channel along IBW. The Phase II General Design Memorandum and Design Memorandum #2 (Master Plan for Recreation) was prepared concurrently and provides sufficient technical and supporting data to confirm project justification and to establish a reliable cost estimate for the flood control and recreational features of the entire project.

Rio Salado Feasibility Report

The Rio Salado (Salt River), Arizona Feasibility Report was completed by the Corps of Engineers in April 1998. The purpose of the feasibility phase was to conduct the studies necessary to determine the feasibility of restoring riparian habitat along the Salt River at Rio Salado and IBW. During the study, measures were identified that would restore riparian habitat that was lost as a result of federal water control projects. The results of the study support additional federal (Corps) involvement in detailed studies of riparian habitat restoration measures at two locations in the Tempe reach and the Phoenix reach of the Salt River and along IBW. In addition to riparian habitat benefits, water quality and incidental recreational benefits have also been identified.

Federal Flood Insurance Studies

The Federal Emergency Management Agency (FEMA) completed the flood insurance study for IBW in 1998. This study identified the regulatory (100-year) floodplain limits and the floodway for IBW channel. The 100-year discharge rate used by FEMA to conduct the study for the segment of IBW south of McKellips Road was 20,000 cfs. The Flood Control District of Maricopa County (FCDMC) uses FEMA floodplain and

floodway maps to regulate activities within the channel and adjoining floodplain areas. The available freeboard for the levees which form the banks of the IBW channel is presently 3-feet or more for the FEMA discharge of 20,000 cfs.

Previous Hydraulic Design Study

The Draft Hydraulic Design Report for Indian Bend Wash Reach of Tempe Rio Salado Environmental Restoration Project was prepared by McGann & Associates, Inc./Novak Environmental, Inc Joint Venture (MA/NE) and submitted to the Corps of Engineers, Los Angeles District in September 2000. This previous study reported the results of a sensitivity analysis of Manning's n-value for different proposed vegetation densities in IBW and serves as background for data used in the current study. The previous report also provides the basis for Manning's n-values used in the model to represent proposed planting regimes.

1.2.3 Hydraulic Modeling Data

The following information was obtained and used to conduct the hydraulic analyses that were completed as a part of this study.

1. U.S. Army Corps of Engineers Plan #DACW 09-76 S-0007, IBW Between McKellips Road and Salt River Outlet (November 14, 1979)
2. Federal Emergency Management Agency Flood Insurance Study Workmaps dated September 19, 1997
3. Federal Emergency Management Agency Flood Insurance Study HEC-II Model, September 19, 1997

4. Low-Flow Channel Design Analysis for Rio Salado (Salt River), Arizona, Final Report, West Consultants, Inc., January 11, 2000

5. Digital 3-D Topographic Data, Army Corps of Engineers, Datum: 1983 horizontal, 1988 vertical.

6. Corrected Topographic Data, source: (a) Army Corps of Engineers ordered ground survey of southwest portion of Curry Road and IBW, (b) hand digitizing of golf course lake and ancillary culture form aerial photos.

7. Field-corrected Topographic Data, source: October 2001 field verification resulted in correction of topographic data in two locations, the slope of IBW low-flow channel at downstream edge of McKellips bridge and the low flow channel bottom around golf course lake.

II HYDRAULIC ANALYSES

2.1 Background

Two earlier hydraulic analyses have been performed on IBW, results of which are reported in The Army Corps of Engineers Design Memorandum (GDM) #1 and in The FEMA Flood Insurance Study. The GDM states a minimum freeboard of 2.5 feet should be maintained for the IBW reach south of McKellips Road with Q_{100} = 30,000cfs. The FEMA study states a minimum freeboard of 3.0 feet should be maintained with Q_{100} = 20,000cfs. The previous Hydraulic Design Report (MA/NE, 2000) provides background information on existing conditions at the time of these studies and other compulsory information as it applies to this study.

Furthermore, the MA/NE 2000 study showed, at current conditions there are deficiencies in the GDM freeboard of 2.5 feet. Because of this deficiency, the Army Corps of Engineers have requested a new study with updated topographic information be conduced for the IBW reach.

2.2 Methodology

This new study utilizes the updated, corrected topography and BOSS RiverCAD 2000 to obtain cross-section station data for input into a HEC-RAS model. Original cross-section locations were obtained from the HEC-II model used in the Flood Insurance Study. This study utilized all original locations, with supplemental cross-sections added for increased detail. Appendix A contains an aerial photo of the project site with locations of the cross sections.

Water surface modeling of Indian Bend Wash was performed utilizing the HEC-RAS program. Three models were made to represent three unique scenarios; existing conditions, the Feasibility Study planting scheme and a Recommended planting scheme. Manning's n-values for existing conditions were taken from the FEMA model. The Feasibility Study Plan and the Recommended Plan hydraulic modeling was based upon modifications to the existing conditions model prepared for this study. Each model was then run using Q_{100} from both the GDM (30,000cfs) and FEMA Study (20,000cfs). Results from each model run were analyzed in order to establish water surface elevations, flow velocities, levee freeboard and design features that will occur in conjunction with implementation of the IBW reach of the Tempe Rio Salado

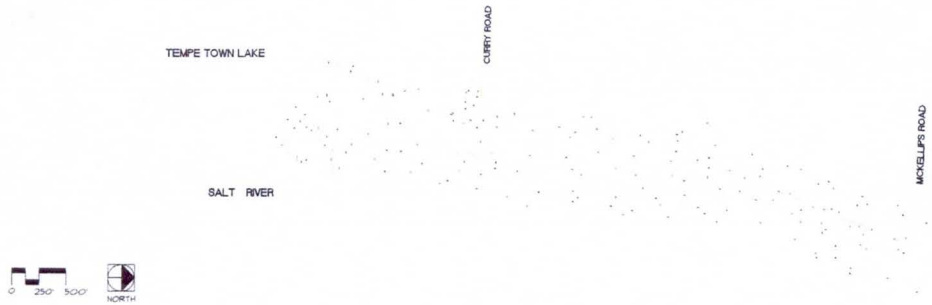
Environmental Restoration Project. In addition, a comparison of available freeboard to the required levee freeboard was made for each scenario modeled.

2.3 Existing Conditions

The existing conditions model contains Manning's n-values that reflect the current vegetative conditions at Indian Bend Wash (predominately turf grass). These n-values were obtained from the original HEC-II model. The hydraulic model was run at discharges of 20,000 and 30,000 cfs to determine current conditions water surface elevations for both the U.S. Army Corps of Engineers design discharge rate and the FEMA Study design discharge rate. Existing conditions 100-year water surface elevation and available levee freeboard for both flows are summarized by cross section within the project reach in Table 1 of this report. HEC-RAS output summary tables and water surface profiles for existing conditions at both discharge rates are provided in Appendix B.

FEMA requires a minimum of 3 feet of freeboard for levee structures that contain the regulatory flood within the levees. As previously indicated the design freeboard for the IBW outlet channel is stated in the GDM as 2.5 feet. Table 1 confirms that in some locations, the available freeboard does not comply with either the FEMA or U.S. Army Corps of Engineers criteria. A graphical illustration of available freeboard is provided in Figure 2.

Rio Salado Environmental Restoration Project - Tempe Reach
Indian Bend Wash Project Area



Habitat Distribution - Existing Conditions

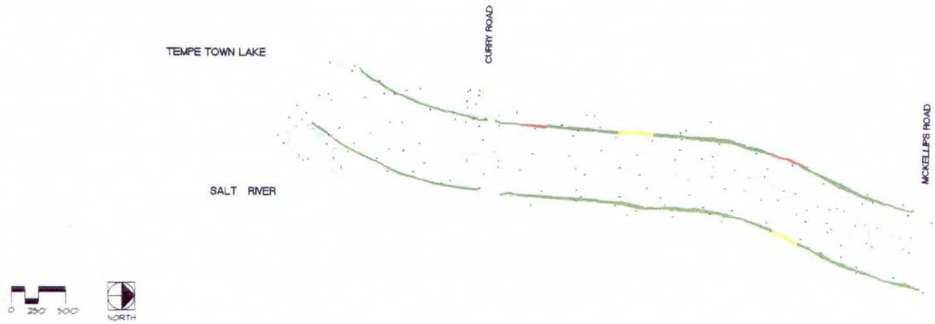
LEGEND (HABITAT)

- Aquatic Strand
- Wetland Marsh
- Mesquite Bosque
- Cottonwood / Willow
- Open Space

Freeboard Conditions Based on 30,000 CFS / 2.5' Min. Freeboard (Corps of Engineers)

LEGEND (FREEBOARD)

- Freeboard ≥ 2.5 feet
- Freeboard ≥ 1.5 < 2.5 feet
- Freeboard < 1.5 feet



Freeboard Conditions Based on 20,000 CFS / 3.0' Min. Freeboard (M.C.F.C.D.)

LEGEND (FREEBOARD)

- Freeboard ≥ 3.0 feet
- Freeboard ≥ 2.0 < 3.0 feet
- Freeboard < 2.0 feet

Figure 2
Baseline / Existing Conditions

SUMMARY:

HABITAT TYPE	TREE DENSITY PER ACRE	"N" VALUE USED IN HYDRAULIC MODEL	ACRES	HABITAT UNITS PER ACRE	HABITAT UNITS
COTTONWOOD - WILLOW	100 - 150	0.08	0	0.7	0
MESQUITE BOSQUE	LESS THAN 100	0.07	0	0.5	0
WETLAND MARSH	NOT APPLICABLE	0.03	0	0.6	0
AQUATIC STRAND	NOT APPLICABLE	0.03	0	0.7	0
OPEN SPACE	NOT APPLICABLE	0.03	0	0.3	0
HABITAT TOTAL			0		0
GOLF COURSE TERRACE		0.035			

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Table 1: Summary of existing conditions water surface elevations and levee freeboard. Red indicates required freeboard not met.

Cross-section	Top of Levee (ft)	Existing Conditions			
		$CWSEL_{20000}$	Freeboard (ft) Q_{20000}	$CWSEL_{30000}$	Freeboard (ft) Q_{30000}
0.475	n/a	n/a	n/a	n/a	n/a
0.532	1170.5	1165.3	5.19	1166.6	3.94
0.568	1172.0	1165.9	6.07	1167.4	4.65
0.614	1173.0	1166.9	6.08	1168.4	4.56
0.663	1174.0	1168.9	5.13	1170.2	3.79
0.707	1175.0	1169.9	5.13	1171.4	3.65
0.758	1177.0	1171.1	5.91	1171.9	5.15
0.776	n/a	n/a	n/a	n/a	n/a
0.791	n/a	n/a	n/a	n/a	n/a
0.812	1177.0	1173.9	3.09	1175.2	1.85
0.852	1176.5	1174.8	1.73	1176.5	-0.01
0.903	1180.0	1176.1	3.89	1177.4	2.64
0.947	1181.5	1177.3	4.20	1178.6	2.88
0.987	1182.0	1179.0	3.03	1180.5	1.52
1.040	1183.0	1180.8	2.18	1182.0	1.01
1.087	1186.5	1182.3	4.25	1183.6	2.87
1.136	1186.5	1182.7	3.75	1184.2	2.35
1.19	1187.5	1184.3	3.26	1185.7	1.76
1.231	1188.0	1184.8	3.19	1186.3	1.73
1.283	1187.0	1185.5	1.52	1187.1	-0.08
1.326	1188.0	1185.7	2.34	1187.3	0.71
1.381	1190.5	1185.6	4.95	1186.9	3.59
1.42	1191.5	1187.4	4.09	1190.1	1.37
1.478	1192.5	1186.8	5.68	1189.3	3.22
1.515	1193.0	1188.8	4.24	1190.3	2.72
1.554	n/a	n/a	n/a	n/a	n/a

n/a = Cross-section at Salt River confluence or roadway dip section

$CWSEL_{20000}$ = Computed water surface elevation at 20,000 cfs

$CWSEL_{30000}$ = Computed water surface elevation at 30,000 cfs

Q_{20000} = 20,000cfs flow Q_{30000} = 30,000cfs flow

2.4 Feasibility Study

The hydraulic design parameters and assumptions used for the IBW reach of the Tempe Rio Salado Environmental Restoration Project are given in the U.S. Army Corps of Engineers Rio Salado Feasibility Report, Technical Appendix B, Hydraulics, April 1998. The Feasibility Study proposes a dense planting of mesquite bosque with some wetland marsh and open space to achieve the desired habitat units. The planting, all of which will occur within the low-flow channel, proposes tree densities that average 100 plants (or less) per acre. A planting scheme was derived from the Feasibility Study and modeled using Manning's n-values as determined by the 2000 MA/NE Hydraulic Design Report.

The proposed habitat types and their corresponding Manning's roughness coefficients used for modeling the Feasibility Study concept design are as follows; Mesquite Bosque-0.07, Wetland Marsh-0.03, Aquatic Strand-0.03 and Open Space-0.03. As was previously indicated, these are consistent with the Manning's roughness coefficients that were determined in the 2000 MA/NE Hydraulic Study to accurately represent projected tree densities along Indian Bend Wash.

Table 2 provides a summary of Feasibility Study water surface elevations using above stated Manning's roughness coefficients for proposed habitat types. Table 2 also lists the available levee freeboard for both the 20,000 and 30,000 cfs discharge rates.

Table 2: Summary of project conditions water surface elevations and levee freeboard for Feasibility Study. Red indicates required freeboard not met.

Cross-section	Top of Levee (ft)	Feasibility Study			
		$CWSEL_{20000}$	Freeboard (ft) Q_{20000}	$CWSEL_{30000}$	Freeboard (ft) Q_{30000}
0.475	na	n/a	n/a	n/a	n/a
0.532	1170.5	1165.4	5.08	1166.58	3.92
0.568	1172.0	1168.5	3.53	1170.1	1.90
0.614	1173.0	1168.7	4.28	1170.3	2.75
0.663	1174.0	1170.3	3.74	1172.1	1.90
0.707	1175.0	1171.5	3.56	1173.1	1.87
0.758	1177.0	1172.9	4.11	1174.7	2.30
0.776	na	n/a	n/a	n/a	n/a
0.791	na	n/a	n/a	n/a	n/a
0.812	1177.0	1174.7	2.35	1175.8	1.24
0.852	1176.5	1175.8	0.68	1177.2	-0.71
0.903	1180.0	1176.7	3.27	1178.1	1.90
0.947	1181.5	1177.8	3.67	1179.2	2.32
0.987	1182.0	1179.5	2.54	1180.8	1.16
1.040	1183.0	1180.7	2.27	1181.8	1.20
1.087	1186.5	1183.3	3.23	1184.7	1.81
1.136	1186.5	1184.1	2.40	1185.6	0.93
1.19	1187.5	1185.0	2.52	1186.5	1.01
1.231	1188.0	1185.7	2.35	1187.2	0.78
1.283	1187.0	1186.4	0.59	1188.1	-1.12
1.326	1188.0	1186.9	1.07	1188.7	-0.65
1.381	1190.5	1187.4	3.06	1189.1	1.38
1.42	1191.5	1188.8	2.73	1190.6	0.94
1.478	1192.5	1189.3	3.17	1191.2	1.33
1.515	1193.0	1190.1	2.89	1191.8	1.16
1.554	na	n/a	n/a	n/a	n/a

n/a = Cross-section at Salt River confluence or roadway dip section

$CWSEL_{20000}$ = Computed water surface elevation at 20,000 cfs

$CWSEL_{30000}$ = Computed water surface elevation at 30,000 cfs

Q_{20000} = 20,000cfs flow Q_{30000} = 30,000cfs flow

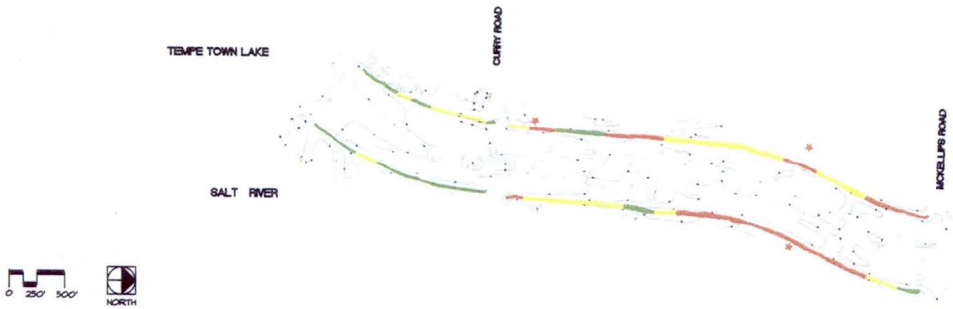
For the U.S. Army Corps of Engineers design storm of 30,000 cfs, the minimum desired freeboard of 2.5 feet will be achieved only along a portion of the project reach downstream from Curry Road (see Figure 3). Upstream of Curry Road, the levee is freeboard deficient along much of this reach and three locations have negative freeboard, up to 1.12 feet (see Table 2). For the 20,000 cfs (FEMA) discharge, the existing levee downstream of Curry Road is adequate. Upstream of Curry Road the

Rio Salado Environmental Restoration Project - Tempe Reach
Indian Bend Wash Project Area

Figure 3
Feasibility Study

LEGEND (HABITAT)
- Aquatic Strand
- Wetland Marsh
- Mesquite Bosque
- Cottonwood / Willow
- Open Space

Habitat Distribution - Feasibility Study



LEGEND (FREEBOARD)
- Freeboard ≥ 2.5 feet
- Freeboard ≥ 1.5 < 2.5 feet
- Freeboard < 1.5 feet
- Negative Freeboard

Freeboard Conditions Based on 30,000 CFS / 2.5' Min. Freeboard (Corps of Engineers)

LEGEND (FREEBOARD)
- Freeboard ≥ 3.0 feet
- Freeboard ≥ 2.0 < 3.0 feet
- Freeboard < 2.0 feet

Freeboard Conditions Based on 20,000 CFS / 3.0' Min. Freeboard (M.C.F.C.D.)

SUMMARY:

HABITAT TYPE	TREE DENSITY PER ACRE	"N" VALUE USED IN HYDRAULIC MODEL	ACRES	HABITAT UNITS PER ACRE	HABITAT UNITS
COTTONWOOD - WILLOW	100 - 150	0.08	0	0.7	0
MESQUITE BOSQUE	LESS THAN 100	0.07	29.31	0.5	14.66
WETLAND MARSH	NOT APPLICABLE	0.03	3.3	0.6	1.98
AQUATIC STRAND	NOT APPLICABLE	0.03	3.91	0.7	2.74
OPEN SPACE	NOT APPLICABLE	0.03	3.95	0.3	1.19
HABITAT TOTAL			40.47		20.57
GOLF COURSE TERRACE		0.035			

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existing levee is substantially deficient for the FEMA discharge. See Appendix C for detail HEC-RAS summary tables and water surface profiles of the Feasibility Study model for both discharge rates.

2.5 Recommended Alternative

This alternative to the Feasibility Study proposed design still contains a dense planting of mesquite with and added cottonwood-willow habitat and a slightly different configuration (see Figure 4). The planting scheme incorporates some cottonwood-willow habitat on the edges of wetland marsh areas as well as mesquite bosque and open space. The planting, all of which will occur within the low-flow channel, proposes tree densities for cotton-willow habitat of 100-150 plants per acre and for mesquite bosque habitat of less than 100 trees per acre. Example photos of this density are presented in Appendix D.

Tree densities were modeled using Manning's n-values corresponding to those determined by the 2000 MA/NE Hydraulic Design Report. The planting scheme of the recommended alternative is projected to create 19.66 habitat units, very close to the Feasibility Study recommendation of 20.57 habitat units.

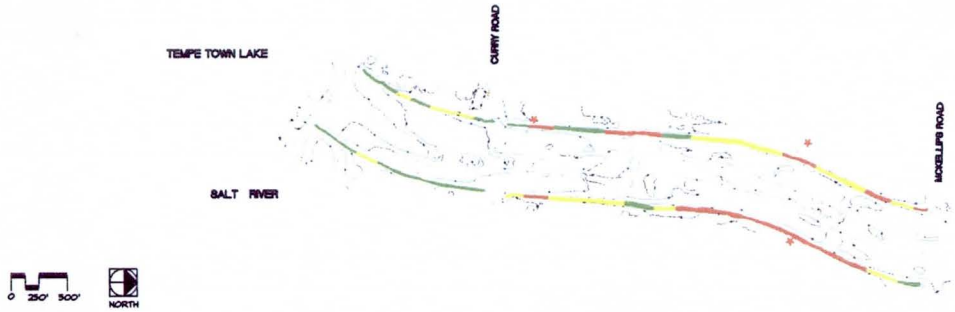
The proposed habitat types and their corresponding Manning's roughness coefficients used for modeling the recommended alternative concept design are as follows; Cottonwood-Willow-0.08, Mesquite Bosque-0.07, Wetland Marsh-0.03, Aquatic Strand-0.03 and Open Space-0.03. As was previously indicated, this is consistent with the

Rio Salado Environmental Restoration Project - Tempe Reach
Indian Bend Wash Project Area

Figure 4
Recommended Alternative

LEGEND (HABITAT)
- Aquatic Strand
- Wetland Marsh
- Mesquite Bosque
- Cottonwood / Willow
- Open Space

Habitat Distribution - Recommended Alternative



LEGEND (FREEBOARD)
- Freeboard ≥ 2.5 feet
- Freeboard ≥ 1.5 < 2.5 feet
- Freeboard < 1.5 feet
- Negative Freeboard

Freeboard Conditions Based on 30,000 CFS / 2.5' Min. Freeboard (Corps of Engineers)

LEGEND (FREEBOARD)
- Freeboard ≥ 3.0 feet
- Freeboard ≥ 2.0 < 3.0 feet
- Freeboard < 2.0 feet

Freeboard Conditions Based on 20,000 CFS / 3.0' Min. Freeboard (M.C.F.C.D.)

SUMMARY:

HABITAT TYPE	TREE DENSITY PER ACRE	"N" VALUE USED IN HYDRAULIC MODEL	ACRES	HABITAT UNITS PER ACRE	HABITAT UNITS
COTTONWOOD - WILLOW	100 - 150	0.08	3.62	0.7	2.53
MESQUITE BOSQUE	LESS THAN 100	0.07	27.33	0.5	13.67
WETLAND MARSH	NOT APPLICABLE	0.03	2.01	0.6	1.21
AQUATIC STRAND	NOT APPLICABLE	0.03	0	0.7	0
OPEN SPACE	NOT APPLICABLE	0.03	7.50	0.3	2.25
HABITAT TOTAL			40.47		19.66
GOLF COURSE TERRACE		0.035			

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Manning's roughness coefficients that were determined in the 2000 MA/NE Hydraulic Study to accurately represent projected tree densities.

Table 3: Summary of project conditions water surface elevations and levee freeboard for Recommended Alternative. Red indicates required freeboard is not met.

Cross-Section	Top of Levee (ft)	Recommended Alternative			
		$CWSEL_{20000}$	Freeboard (ft) Q_{20000}	$CWSEL_{30000}$	Freeboard (ft) Q_{30000}
0.475	n/a	n/a	n/a	n/a	n/a
0.532	1170.5	1165.9	4.56	1167.2	3.30
0.568	1172.0	1168.0	4.04	1169.6	2.41
0.614	1173.0	1168.7	4.34	1170.3	2.71
0.663	1174.0	1169.9	4.12	1171.5	2.46
0.707	1175.0	1171.4	3.64	1172.9	2.12
0.758	1177.0	1172.4	4.65	1173.9	3.10
0.776	n/a	n/a	n/a	n/a	n/a
0.791	n/a	n/a	n/a	n/a	n/a
0.812	1177.0	1173.9	3.09	1175.2	1.82
0.852	1176.5	1176.0	0.52	1177.7	-1.18
0.903	1180.0	1176.8	3.19	1178.4	1.63
0.947	1181.5	1177.9	3.59	1179.3	2.18
0.987	1182.0	1179.2	2.84	1180.5	1.48
1.040	1183.0	1180.7	2.35	1181.7	1.31
1.087	1186.5	1183.1	3.45	1184.5	2.02
1.136	1186.5	1183.8	2.75	1185.2	1.27
1.19	1187.5	1184.9	2.65	1186.4	1.13
1.231	1188.0	1185.5	2.50	1187.1	0.94
1.283	1187.0	1186.2	0.82	1187.9	-0.89
1.326	1188.0	1186.6	1.38	1188.4	-0.35
1.381	1190.5	1175.0	3.35	1188.9	1.63
1.42	1191.5	1188.6	2.88	1190.4	1.08
1.478	1192.5	1176.0	3.40	1191.0	1.53
1.515	1193.0	1190.1	2.90	1191.8	1.23
1.554	n/a	n/a	n/a	n/a	n/a

n/a = Cross-section at Salt River confluence or roadway dip section

$CWSEL_{20000}$ = Computed water surface elevation at 20,000 cfs

$CWSEL_{30000}$ = Computed water surface elevation at 30,000 cfs

Q_{20000} = 20,000cfs flow Q_{30000} = 30,000cfs flow

Table 3 provides a summary of the Recommended Alternative water surface elevations using above stated Manning's roughness coefficients for proposed habitat types. Table 3 also lists the available levee freeboard for both the 20,000 and 30,000 cfs discharge rates. The minimum freeboard requirement of 3 feet for the FEMA discharge rate of

20,000 cfs is met in more locations than the required 2.5 feet for the Army Corps discharge rate of 30,000 cfs but there are still significant lengths of IBW where neither required freeboard is met. A negative freeboard is projected at several cross-section locations for the Crops discharge of 30,000 cfs.

2.6 Summary of Results

In order to determine the magnitude and location of available freeboard, modeling of the Indian Bend Wash portion of the Tempe Rio Salado Environmental Restoration Project was performed using the HEC-RAS program and best available, updated topographic data. Three planting scenarios were modeled at two different discharge rates; the FCDMC discharge of 20,000 cfs and the USACE design discharge of 30,000 cfs. The three planting scenarios included existing conditions, a planting concept derived from the 1998 Feasibility Study and a Recommended Alternative planting concept. The two conceptual planting scenarios were modeled by adjusting Manning's n-values in the existing conditions model.

Adjustments to vegetation densities (Manning's n-values) generally resulted in not meeting required freeboard for either the 20,000 cfs or 30,000 cfs design flow. For the Recommended Alternative deficiencies in the USACE 2.5-feet freeboard occur along approximately 6,500 feet of the Indian Bend Wash banks. These deficiencies range from 0.5 to 3.6 feet with the average freeboard deficiency being 1.5-feet. Modeled flow velocities generally ranged from 7.3 fps to 13.51 fps for the recommended alternative at a discharge rate of 30,000. At these velocities, it is believed that the Recommended

Alternative, with 75-150 trees per acre consisting of cottonwood, willow and mesquite bosque habitat, is prone to only minimal loss during high magnitude flows (given that the trees are mature). Some damage and loss however of wetland marsh areas and emergent vegetation will occur.

III RECOMMENDATIONS

Additional freeboard is required to comply with the USACE and FEMA criteria. The identified alternatives include raising the existing levee by a berm adjoining the existing structure or by building a floodwall. The most efficient method appears to be a combination of these two alternatives, which was the preferred method expressed by both USACE staff and local sponsor representatives. In locations where the elevation needs to be raised only a few inches, earthwork and berming could achieve the desired results. This approach would work best along the banks downstream of Curry Road.

In contrast, locations where the levee will require to be raised more than a foot the large footprint required to construct a berm restricts the areas in which it can be used (see Appendix F). Because the existing levee lies close to the property line, extensions would have to be made to the channel side of the levee (see Appendix F). This method would intrude on to the adjacent golf course and negatively affect channel capacity. In these situations, the preferred solution is a floodwall constructed on the property line side of the levee with minimal adjustments for existing infrastructure such as bike path, lighting and irrigation. Appendix G contains an illustration of a typical levee wall and an order-of-magnitude cost estimate per linear foot of wall. Both the drawings and cost

estimate provided in appendix G are preliminary. Specifications for a floodwall are subject to structural certification for compliance with FEMA floodwall criteria.

IV REFERENCES

Phillips, J.V. and T.L. Ingersoll. 1998. Verification of roughness coefficients for selected natural and constructed stream channels in Arizona. U.S. Geological Survey Professional Paper 1584, 77p.

U. S. Army Corps of Engineers, Los Angeles District. 1975. Gila River Basin, Arizona Indian Bend Wash design memorandum phase II. Project design for Indian Bend Wash.

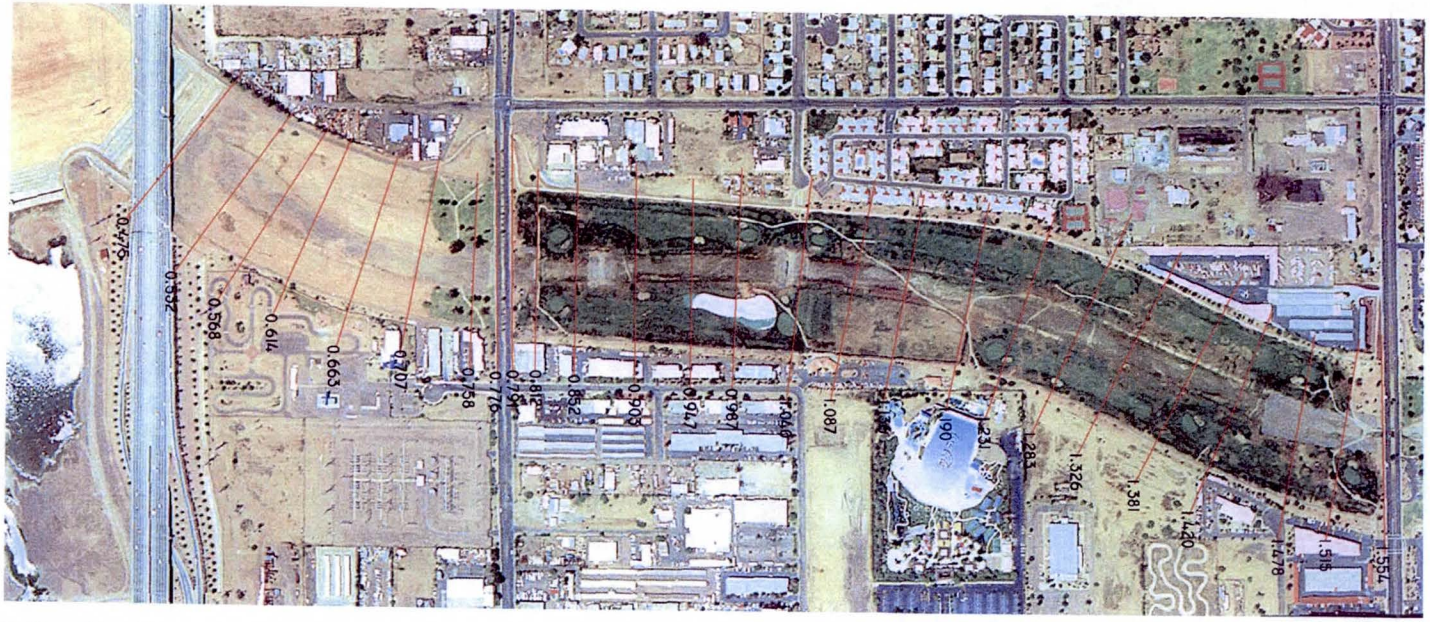
U.S. Army Corps of Engineers, Los Angeles District. 1998. Rio Salado Salt River, Arizona Feasibility Report and Environmental Impact Statement.

McGann & Associates, Inc. /Novak Environmental, Inc. Joint Venture. 2000. Draft Hydraulic Design Report for Indian Bend Wash Reach of Tempe Rio Salado Environmental Restoration Project.

APPENDIX A

Cross Section Location Map

Rio Salado Environmental Restoration Project - Tempe Reach
Indian Bend Wash Project Area



0 150 300

NORTH

Cross Section Locations

U.S. Army Corps of Engineers
Los Angeles District

in cooperation with
The City of Tempe

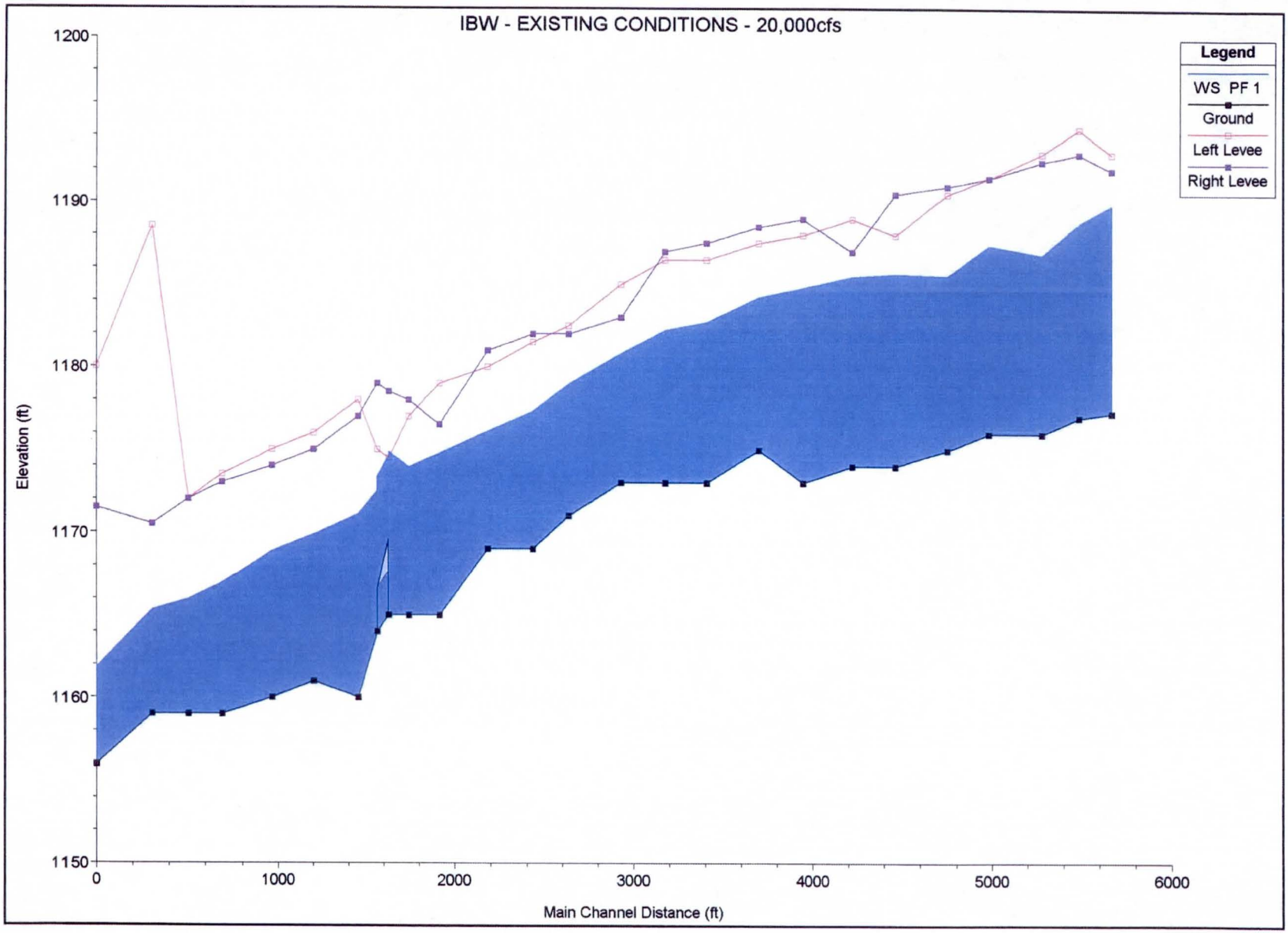
McGann & Associates / Novak Environmental Joint Venture
November 2001

APPENDEX B

HEC-RAS Output Summary Table for Existing Conditions

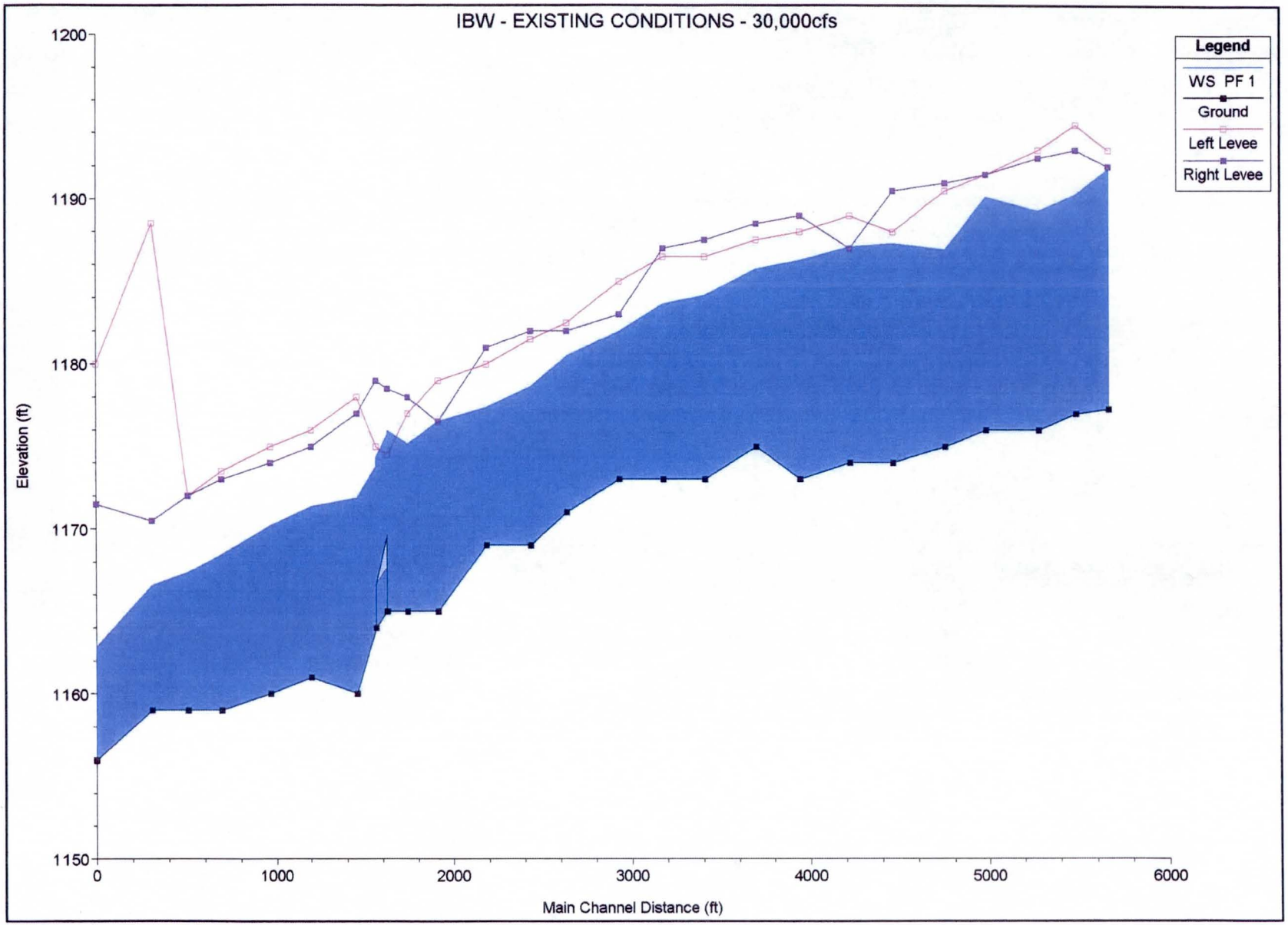
INDIAN BEND WASH
EXISTING CONDITIONS - 20,000cfs

HEC-RAS Plan: adj-base-20 River: Reach #1 Reach: Reach #1 Profile: PF 1														
River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Levee El Left	Levee El Right	L. Levee Frbrd	R. Levee Frbrd
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)	(ft)	(ft)
1.554	20000	1177.29	1189.89	1189.89	1191.62	0.001284	11.62	2395.46	735.48	0.67	1193.00	1192.00	3.11	2.11
1.515	20000	1177	1188.76	1188.76	1190.85	0.003459	12.32	2112.51	569.54	0.73	1194.50	1193.00	5.74	4.24
1.478	20000	1176	1186.82	1185.61	1189.35	0.004154	12.80	1630.36	379.94	0.79	1193.00	1192.50	6.18	5.68
1.42	20000	1176	1187.41	1185.28	1188.44	0.001708	8.63	2813.13	569.74	0.52	1191.50	1191.50	4.09	4.09
1.381	20000	1175	1185.55	1183.71	1187.59	0.003482	11.46	1762.81	296.37	0.72	1190.50	1191.00	4.95	5.45
1.326	20000	1174	1185.66	1183.54	1186.86	0.001882	9.28	2667.52	572.97	0.54	1188.00	1190.50	2.34	4.84
1.283	20000	1174	1185.48	1183.62	1186.4	0.001645	8.30	2996.14	582.81	0.50	1189.00	1187.00	3.52	1.52
1.231	20000	1173	1184.81	1182.95	1185.89	0.001672	8.98	2844.54	572.69	0.52	1188.00	1189.00	3.19	4.19
1.19	20000	1175	1184.25	1183.17	1185.39	0.002303	9.35	2699.51	580.44	0.59	1187.50	1188.50	3.26	4.26
1.136	20000	1173	1182.72	1182.4	1184.41	0.003455	11.18	2263.36	567.79	0.72	1186.50	1187.50	3.78	4.78
1.087	20000	1173	1182.25	1181.62	1183.65	0.002871	10.44	2489.36	576.46	0.66	1186.50	1187.00	4.25	4.75
1.04	20000	1173	1180.82	1180.82	1182.62	0.004888	12.03	2160.57	581.73	0.83	1185.00	1183.00	4.18	2.18
0.987	20000	1171	1178.97	1178.14	1180.19	0.00308	9.78	2540.74	570.12	0.66	1182.50	1182.00	3.53	3.03
0.947	20000	1169	1177.3	1177.3	1179.23	0.004439	11.88	2092.57	549.61	0.80	1181.50	1182.00	4.20	4.70
0.903	20000	1169	1176.11	1176.11	1177.89	0.005392	12.02	2134.51	565.14	0.86	1180.00	1181.00	3.89	4.89
0.852	20000	1165	1174.77	1174.77	1176.68	0.003581	12.31	2246.34	569.92	0.74	1179.00	1176.50	4.23	1.73
0.812	20000	1165	1173.91	1173.91	1175.82	0.004148	11.91	2129.36	555.38	0.78	1177.00	1178.00	3.09	4.09
0.791	20000	1165	1174.85	1171.97	1175.38	0.000434	6.30	3778.43	738.07	0.39	1174.50	1178.50	-0.34	3.66
0.79	Bridge													
0.776	20000	1164	1172.5	1172.5	1174.32	0.002503	11.18	1999.2	600.04	0.85	1175.00	1179.00	2.50	6.50
0.758	20000	1160	1171.09	1168.68	1172.7	0.001704	10.42	2266.48	549.53	0.62	1178.00	1177.00	6.91	5.91
0.707	20000	1161	1169.87	1169.87	1172	0.002932	12.30	2069.45	548.12	0.79	1176.00	1175.00	6.13	5.13
0.663	20000	1160	1168.87	1168.87	1170.82	0.002972	11.90	2095.79	563.01	0.79	1175.00	1174.00	6.13	5.13
0.614	20000	1159	1166.92	1166.92	1169.04	0.00346	11.97	1906.11	541.44	0.84	1173.50	1173.00	6.58	6.08
0.568	20000	1159	1165.93	1165.93	1167.96	0.003784	11.74	1926.5	547.63	0.86	1172.00	1172.00	6.07	6.07
0.532	20000	1159	1165.31	1165.31	1167.18	0.003807	11.64	2048.58	551.46	0.86	1188.50	1170.50	23.19	5.19
0.475	20000	1156	1161.82	1161.82	1163.44	0.016592	11.28	2032.04	605.35	0.96	1180.00	1171.50	18.18	9.68


IBW - EXISTING CONDITIONS - 20,000cfs
Legend
WS PF 1
Ground
Left Levee
Right Levee
Elevation (ft)
1200
1190
1180
1170
1160
1150
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)

INDIAN BEND WASH
EXISTING CONDITIONS - 30,000cfs

HEC-RAS Plan: 30-adj-base River: Reach #1 Reach: Reach #1 Profile: PF 1														
River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Levee El Left	Levee El Right	L. Levee Frbrd	R. Levee Frbrd
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)	(ft)	(ft)
1.554	30000	1177.29	1191.84	1191.14	1193.21	0.00	11.25	3975.96	888.96	0.59	1193.00	1192.00	1.16	0.16
1.515	30000	1177	1190.28	1190.28	1192.63	0.00	13.78	3010.25	607.50	0.76	1194.50	1193.00	4.22	2.72
1.478	30000	1176	1189.28	1188.81	1191.75	0.00	13.26	2835.97	608.45	0.72	1193.00	1192.50	3.72	3.22
1.42	30000	1176	1190.13	1187.2	1191.06	0.00	8.58	4419.53	611.76	0.45	1191.50	1191.50	1.37	1.37
1.381	30000	1175	1186.91	1186.91	1189.95	0.00	14.21	2346.67	500.07	0.83	1190.50	1191.00	3.59	4.09
1.326	30000	1174	1187.29	1185.78	1188.75	0.00	10.66	3620.74	597.65	0.57	1188.00	1190.50	0.71	3.21
1.283	30000	1174	1187.08	1185.06	1188.27	0.00	9.72	3961.46	647.54	0.54	1189.00	1187.00	1.92	-0.08
1.231	30000	1173	1186.27	1184.68	1187.68	0.00	10.62	3696.05	593.67	0.57	1188.00	1189.00	1.73	2.73
1.19	30000	1175	1185.74	1184.43	1187.15	0.00	10.7	3578.41	598.89	0.62	1187.50	1188.50	1.76	2.76
1.136	30000	1173	1184.15	1183.74	1186.15	0.00	12.63	3089.63	589.30	0.74	1186.50	1187.50	2.35	3.35
1.087	30000	1173	1183.64	1182.9	1185.37	0.00	11.97	3302.38	596.25	0.69	1186.50	1187.00	2.87	3.37
1.04	30000	1173	1181.99	1181.99	1184.24	0.01	13.83	2848.08	596.77	0.88	1185.00	1183.00	3.01	1.01
0.987	30000	1171	1180.48	1179.37	1181.95	0.00	10.94	3421.9	591.55	0.67	1182.50	1182.00	2.02	1.52
0.947	30000	1169	1178.62	1178.62	1180.96	0.00	13.53	2835.77	576.67	0.83	1181.50	1182.00	2.88	3.38
0.903	30000	1169	1177.36	1177.25	1179.52	0.01	13.5	2853.86	582.91	0.88	1180.00	1181.00	2.64	3.64
0.852	30000	1165	1176.51	1176.51	1178.42	0.00	12.98	3258.66	592.83	0.71	1179.00	1176.50	2.49	-0.01
0.812	30000	1165	1175.15	1175.15	1177.55	0.00	13.79	2832.03	575.98	0.83	1177.00	1178.00	1.85	2.85
0.791	30000	1165	1175.98	1173.41	1176.76	0.00	7.74	4627.19	756.96	0.45	1174.50	1178.50	-1.48	2.52
0.79	Bridge													
0.776	30000	1164	1173.81	1173.81	1175.89	0.00	12.33	2857.32	702.54	0.84	1175.00	1179.00	1.19	5.19
0.758	30000	1160	1171.85	1171.78	1174.6	0.00	13.85	2689.16	564.39	0.79	1178.00	1177.00	6.15	5.15
0.707	30000	1161	1171.35	1171.35	1173.88	0.00	13.96	2900.92	576.43	0.82	1176.00	1175.00	4.65	3.65
0.663	30000	1160	1170.21	1170.21	1172.55	0.00	13.5	2870.59	584.75	0.82	1175.00	1174.00	4.79	3.79
0.614	30000	1159	1168.44	1168.44	1170.84	0.00	13.22	2761.72	578.14	0.83	1173.50	1173.00	5.06	4.56
0.568	30000	1159	1167.35	1167.35	1169.71	0.00	13.03	2733.85	580.30	0.86	1172.00	1172.00	4.65	4.65
0.532	30000	1159	1166.56	1166.56	1168.88	0.00	13.27	2759.69	583.90	0.89	1188.50	1170.50	21.94	3.94
0.475	30000	1156	1162.82	1162.82	1164.93	0.02	12.81	2639.57	612.05	0.98	1180.00	1171.50	17.18	8.68

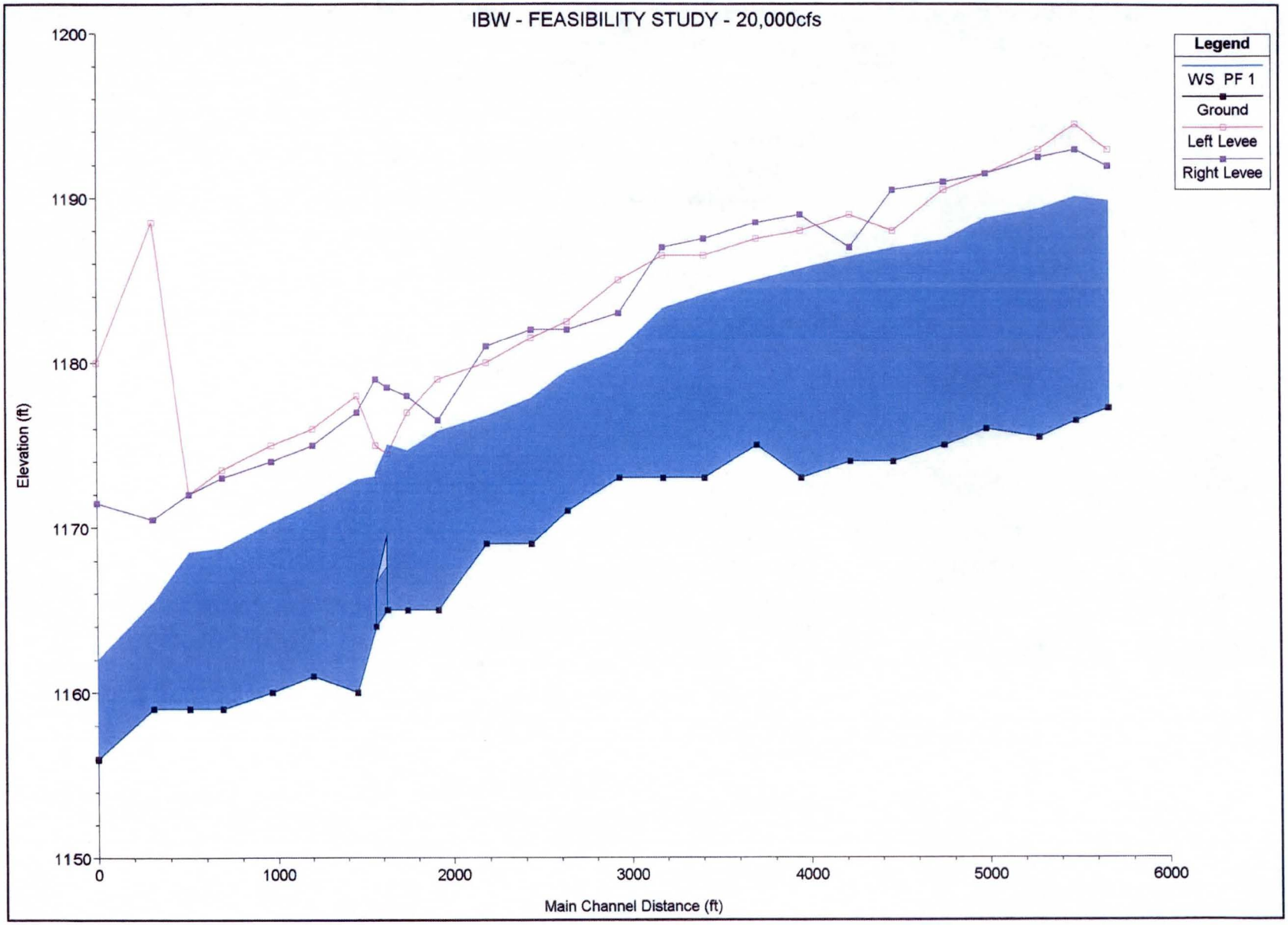

IBW - EXISTING CONDITIONS - 30,000cfs
Legend
WS PF 1
Ground
Left Levee
Right Levee
Elevation (ft)
1200
1190
1180
1170
1160
1150
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)

APPENDIX C

HEC-RAS Output Summary Table for Feasibility Study Conditions

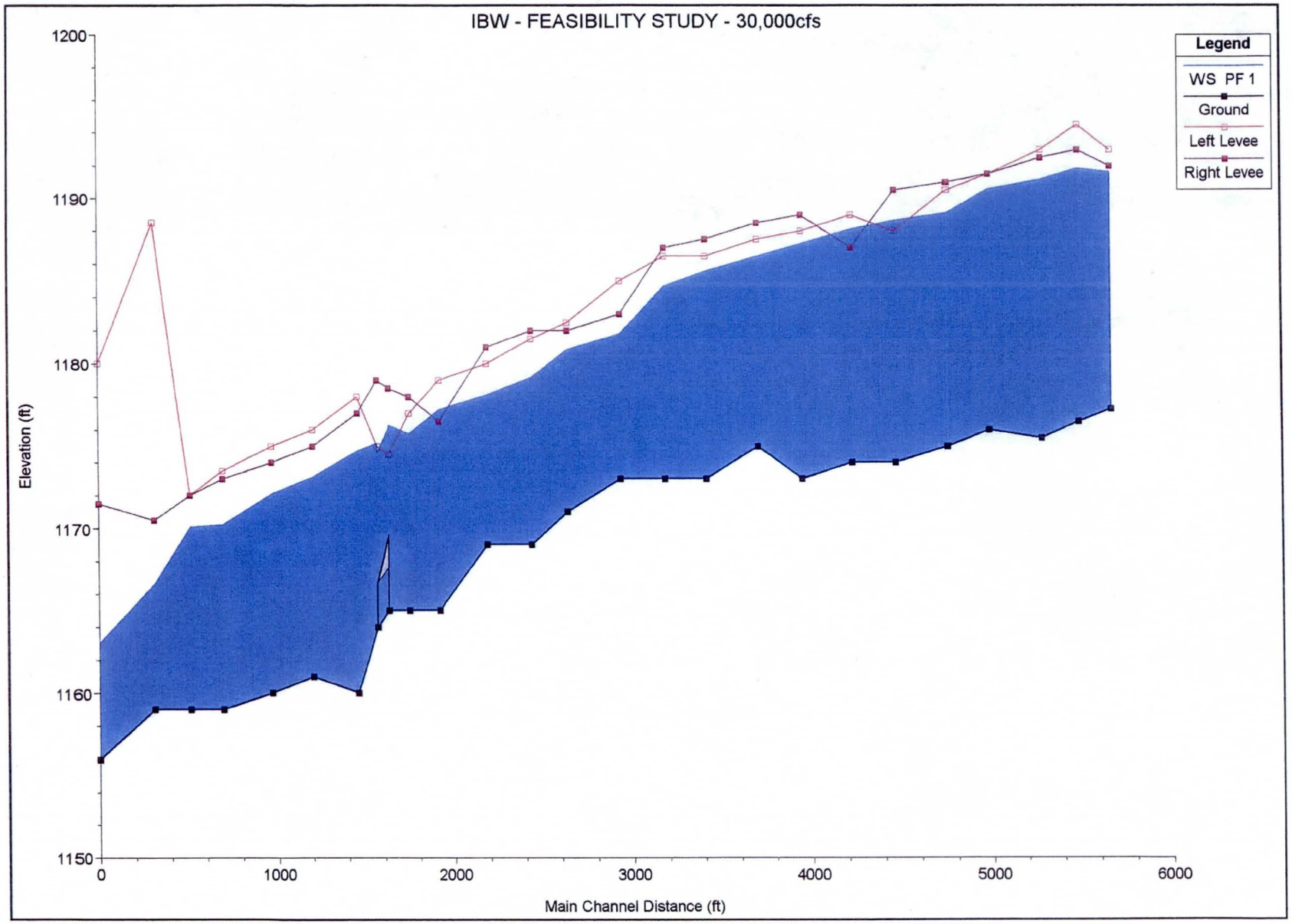
INDIAN BEND WASH
FEASIBILITY STUDY - 20,000cfs

HEC-RAS Plan: feas-stdy-20 River: Reach #1 Reach: Reach #1 Profile: PF 1														
River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Levee El Left	Levee El Right	L. Levee Frbrd	R. Levee Frbrd
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)	(ft)	(ft)
1.554	20000	1177.29	1189.89	1189.89	1191.62	0.001284	11.62	2395.46	735.48	0.67	1193	1192	3.11	2.11
1.515	20000	1176.5	1190.11	1188.68	1190.95	0.003369	8.23	2928.02	604.86	0.45	1194.5	1193	4.39	2.89
1.478	20000	1175.5	1189.33	1185.29	1190.15	0.004486	7.72	2912.31	609.07	0.41	1193	1192.5	3.67	3.17
1.42	20000	1176	1188.77	1185.51	1189.28	0.001923	6.2	3605.2	590.37	0.34	1191.5	1191.5	2.73	2.73
1.381	20000	1175	1187.44	1183.7	1188.47	0.00456	8.41	2620.08	517.96	0.48	1190.5	1191	3.06	3.56
1.326	20000	1174	1186.93	1183.95	1187.5	0.002495	6.54	3409.08	591.76	0.36	1188	1190.5	1.07	3.57
1.283	20000	1174	1186.41	1183.63	1186.92	0.002291	6.14	3549.52	605.77	0.35	1189	1187	2.59	0.59
1.231	20000	1173	1185.65	1183.11	1186.28	0.00209	6.96	3349.55	584.99	0.38	1188	1189	2.35	3.35
1.19	20000	1175	1184.98	1183.14	1185.68	0.002618	7.39	3128.97	589.55	0.44	1187.5	1188.5	2.52	3.52
1.136	20000	1173	1184.1	1182.29	1184.79	0.003683	7.11	3061.28	588.73	0.42	1186.5	1187.5	2.4	3.4
1.087	20000	1173	1183.27	1181.44	1183.94	0.003614	6.98	3084.68	591.12	0.41	1186.5	1187	3.23	3.73
1.04	20000	1173	1180.73	1180.73	1182.39	0.007604	11.43	2103.62	580.26	0.8	1185	1183	4.27	2.27
0.987	20000	1171	1179.46	1177.96	1180.26	0.004335	7.64	2829.17	577.09	0.5	1182.5	1182	3.04	2.54
0.947	20000	1169	1177.83	1177.24	1179.13	0.00527	10	2375.88	562.01	0.65	1181.5	1182	3.67	4.17
0.903	20000	1169	1176.73	1175.97	1177.84	0.004926	9.45	2488.65	574.1	0.65	1180	1181	3.27	4.27
0.852	20000	1165	1175.82	1174.46	1176.62	0.003999	7.93	2865.11	584.71	0.45	1179	1176.5	3.18	0.68
0.812	20000	1165	1174.65	1173.75	1175.69	0.005802	8.89	2547.2	566.75	0.55	1177	1178	2.35	3.35
0.791	20000	1165	1175.03	1171.97	1175.52	0.000394	6.09	3914.47	742.62	0.37	1174.5	1178.5	-0.53	3.47
0.79	Bridge													
0.776	20000	1164	1173.08	1172.55	1174.46	0.010068	9.83	2365.75	650.94	0.71	1175	1179	1.93	5.93
0.758	20000	1160	1172.89	1168.67	1173.66	0.004942	7.59	3283.31	583.52	0.41	1178	1177	5.11	4.11
0.707	20000	1161	1171.45	1169.76	1172.44	0.004334	8.83	2974.14	578.05	0.52	1176	1175	4.56	3.56
0.663	20000	1160	1170.26	1168.64	1171.07	0.008029	7.88	2921.79	585.38	0.48	1175	1174	4.74	3.74
0.614	20000	1159	1168.72	1166.78	1169.82	0.002938	8.86	2922.45	582.51	0.55	1173.5	1173	4.78	4.28
0.568	20000	1159	1168.47	1166	1169.11	0.004499	6.97	3386.42	596.16	0.43	1172	1172	3.53	3.53
0.532	20000	1159	1165.42	1165.3	1167.16	0.018458	11.29	2105.81	554.33	0.83	1188.5	1170.5	23.08	5.08
0.475	20000	1156	1161.97	1161.97	1163.65	0.007672	11.77	2122.29	606.64	0.98	1180	1171.5	18.03	9.53


IBW - FEASIBILITY STUDY - 20,000cfs
Legend
WS PF 1
Ground
Left Levee
Right Levee
Elevation (ft)
1200
1190
1180
1170
1160
1150
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)

INDIAN BEND WASH
FEASIBILITY STUDY - 30,000cfs

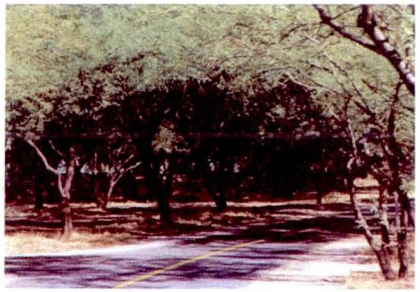
HEC-RAS Plan: feas-stdy-30 River: Reach #1 Reach: Reach #1 Profile: PF 1														
River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Levee El Left	Levee El Right	L. Levee Frbrd	R. Levee Frbrd
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)	(ft)	(ft)
1.554	30000	1177.29	1191.63	1191.14	1193.14	0.001041	11.74	3791.56	871.68	0.62	1193.00	1192.00	1.37	0.37
1.515	30000	1176.5	1191.84	1189.91	1192.78	0.003107	8.71	3997.19	629.59	0.44	1194.50	1193.00	2.66	1.16
1.478	30000	1175.5	1191.17	1188.75	1192.06	0.003955	8.05	4051.97	632.97	0.4	1193.00	1192.50	1.83	1.33
1.42	30000	1176	1190.56	1187.15	1191.22	0.00199	6.99	4688.1	616.35	0.36	1191.50	1191.50	0.94	0.94
1.381	30000	1175	1189.12	1187.2	1190.36	0.004704	9.51	3543.4	582.25	0.5	1190.50	1191.00	1.38	1.88
1.326	30000	1174	1188.65	1185.68	1189.38	0.00256	7.34	4467.15	642.64	0.37	1188.00	1190.50	-0.65	1.85
1.283	30000	1174	1188.12	1184.87	1188.78	0.002345	6.94	4643.35	658.15	0.37	1189.00	1187.00	0.88	-1.12
1.231	30000	1173	1187.23	1184.57	1188.06	0.00243	8.19	4295.54	650.56	0.42	1188.00	1189.00	0.78	1.78
1.19	30000	1175	1186.49	1184.27	1187.41	0.002749	8.43	4034.56	608.58	0.47	1187.50	1188.50	1.01	2.01
1.136	30000	1173	1185.57	1183.4	1186.48	0.003778	7.98	3937.17	605.35	0.44	1186.50	1187.50	0.93	1.93
1.087	30000	1173	1184.69	1182.48	1185.6	0.003786	7.89	3940.04	611.37	0.43	1186.50	1187.00	1.81	2.31
1.04	30000	1173	1181.8	1181.8	1183.91	0.008254	13.03	2734.3	594.38	0.84	1185.00	1183.00	3.2	1.2
0.987	30000	1171	1180.84	1179.03	1181.91	0.004408	8.74	3635.22	596.8	0.53	1182.50	1182.00	1.66	1.16
0.947	30000	1169	1179.18	1178.41	1180.76	0.005341	11.21	3151.21	585.08	0.67	1181.50	1182.00	2.32	2.82
0.903	30000	1169	1178.1	1177.03	1179.49	0.004761	10.51	3292.24	592.67	0.65	1180.00	1181.00	1.9	2.9
0.852	30000	1165	1177.21	1175.5	1178.25	0.004148	8.78	3688.84	596.57	0.47	1179.00	1176.50	1.79	-0.71
0.812	30000	1165	1175.76	1174.78	1177.2	0.00672	10.45	3189.81	592.2	0.61	1177.00	1178.00	1.24	2.24
0.791	30000	1165	1176.29	1173.41	1176.99	0.000482	7.39	4862.46	771.55	0.42	1174.50	1178.50	-1.79	2.21
0.79	Bridge													
0.776	30000	1164	1175.21	1173.89	1176.3	0.006598	9.03	3911.53	784.42	0.56	1175.00	1179.00	-0.21	3.79
0.758	30000	1160	1174.7	1171.84	1175.66	0.005293	8.72	4366.57	610.69	0.44	1178.00	1177.00	3.3	2.3
0.707	30000	1161	1173.13	1171.17	1174.36	0.004533	10.12	3971.73	605.65	0.54	1176.00	1175.00	2.87	1.87
0.663	30000	1160	1172.1	1169.81	1173.02	0.007067	8.42	4018.98	609.29	0.46	1175.00	1174.00	2.9	1.9
0.614	30000	1159	1170.25	1168.49	1171.73	0.003362	10.54	3829.51	603.45	0.6	1173.50	1173.00	3.25	2.75
0.568	30000	1159	1170.1	1167.35	1170.94	0.004749	8.02	4379.66	617.82	0.45	1172.00	1172.00	1.9	1.9
0.532	30000	1159	1166.58	1166.58	1168.81	0.019473	13.03	2767.46	584.22	0.87	1188.50	1170.50	21.92	3.92
0.475	30000	1156	1163.02	1163.02	1165.2	0.007564	13.45	2761.56	613.29	1.01	1180.00	1171.50	16.98	8.48


IBW - FEASIBILITY STUDY - 30,000cfs
Legend
WS PF 1
Ground
Left Levee
Right Levee
Elevation (ft)
1200
1190
1180
1170
1160
1150
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)

APPENDIX D

Example of Tree Density of 90 trees per acre

Rio Salado Environmental Restoration Project - Tempe Reach
Indian Bend Wash Project Area



Photos of Mesquite Bosque
(Planting density = 90 trees/acre)

U.S. Army Corps of Engineers
Los Angeles District

in cooperation with
The City of Tempe

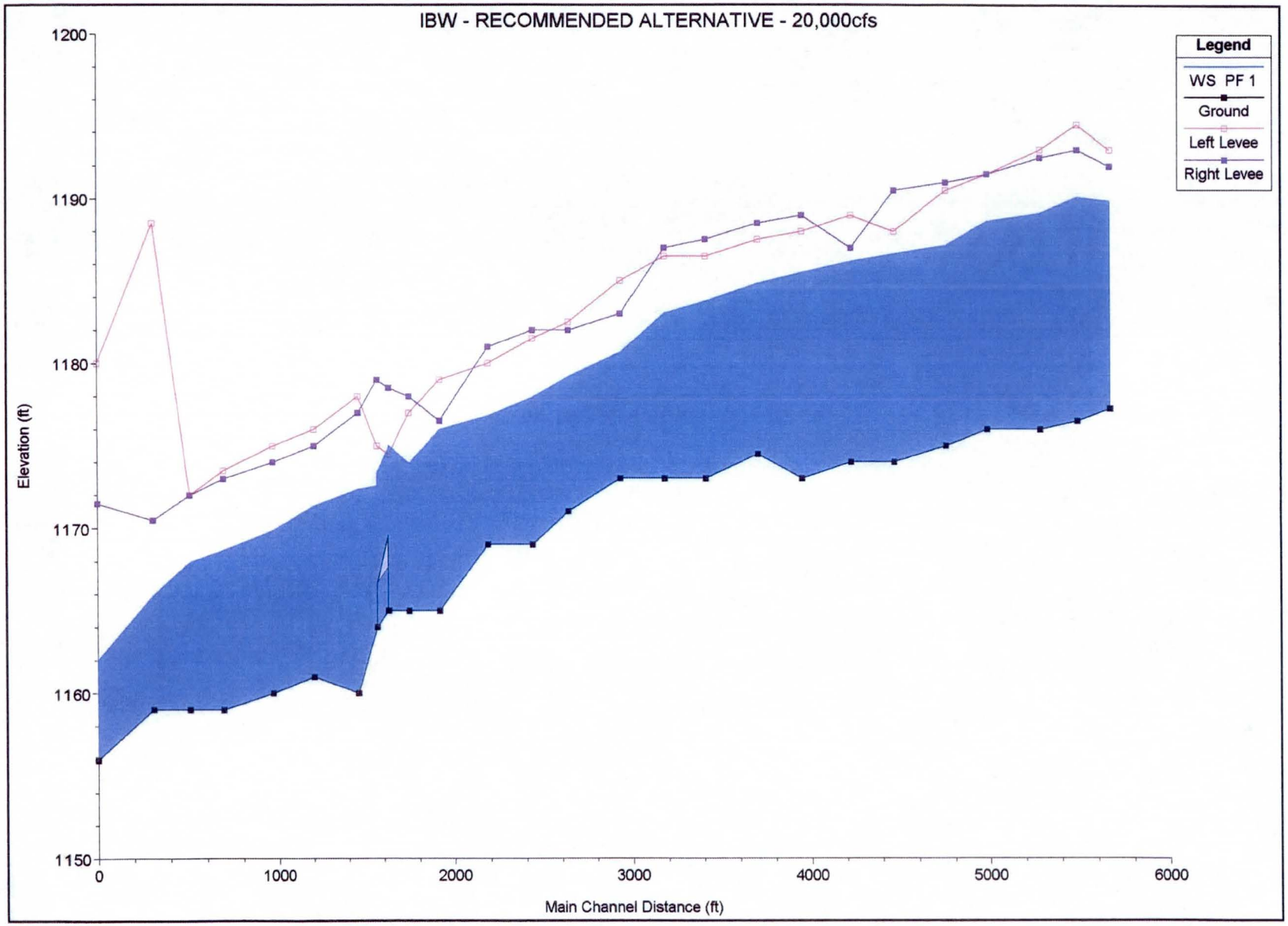
McGann & Associates / Novak Environmental Joint Venture

APPENDIX E

HEC-RAS Output Summary Table for Recommended Alternative

INDIAN BEND WASH
RECOMMENDED ALTERNATIVE - 20,000cfs

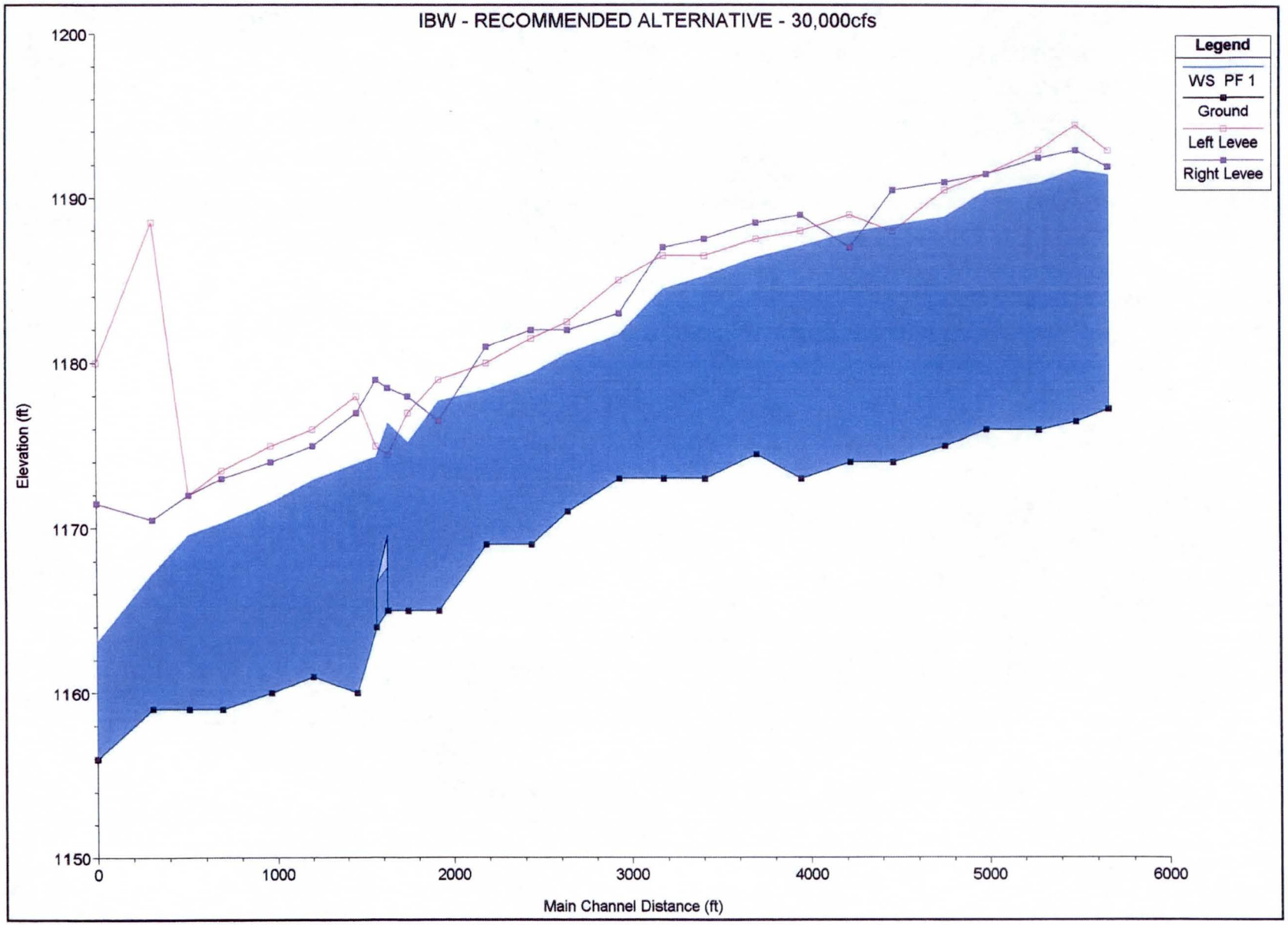
HEC-RAS Plan: 20-proposd-2 River: Reach #1 Reach: Reach #1 Profile: PF 1														
River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Levee El Left	Levee El Right	L. Levee Frbrd	R. Levee Frbrd
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)	(ft)	(ft)
1.554	20000	1177.29	1189.89	1189.89	1191.62	0.001284	11.62	2395.46	735.48	0.67	1193	1192	3.11	2.11
1.515	20000	1176.5	1190.1	1188.64	1190.92	0.003605	8.1	2927.45	604.67	0.44	1194.5	1193	4.4	2.9
1.478	20000	1176	1189.1	1185.42	1190.05	0.004536	8.3	2750.51	606.17	0.45	1193	1192.5	3.9	3.4
1.42	20000	1176	1188.62	1185.52	1189.18	0.001888	6.49	3507.29	588.07	0.36	1191.5	1191.5	2.88	2.88
1.381	20000	1175	1187.15	1183.71	1188.29	0.005549	8.85	2468.68	508.8	0.51	1190.5	1191	3.35	3.85
1.326	20000	1174	1186.62	1183.86	1187.3	0.002339	7.21	3229.91	587.47	0.4	1188	1190.5	1.38	3.88
1.283	20000	1174	1186.18	1183.63	1186.77	0.002006	6.74	3415.32	599.43	0.39	1189	1187	2.82	0.82
1.231	20000	1173	1185.5	1182.97	1186.17	0.002119	7.23	3265.54	582.85	0.4	1188	1189	2.5	3.5
1.19	20000	1174.5	1184.85	1183.03	1185.56	0.002839	7.4	3095.1	587.93	0.44	1187.5	1188.5	2.65	3.65
1.136	20000	1173	1183.75	1182.35	1184.61	0.003385	8.22	2858.87	583.78	0.49	1186.5	1187.5	2.75	3.75
1.087	20000	1173	1183.05	1181.52	1183.84	0.00323	7.85	2957.86	588.1	0.47	1186.5	1187	3.45	3.95
1.04	20000	1173	1180.65	1180.65	1182.29	0.009812	11.11	2061.52	579.17	0.78	1185	1183	4.35	2.35
0.987	20000	1171	1179.16	1178.04	1180.14	0.004059	8.74	2649.66	572.92	0.59	1182.5	1182	3.34	2.84
0.947	20000	1169	1177.91	1177.22	1179.14	0.00511	9.72	2431.51	563.92	0.63	1181.5	1182	3.59	4.09
0.903	20000	1169	1176.81	1175.93	1177.85	0.005042	9.05	2535.09	575.27	0.62	1180	1181	3.19	4.19
0.852	20000	1165	1175.98	1174.6	1176.8	0.003013	8.27	2957.31	586.82	0.47	1179	1176.5	3.02	0.52
0.812	20000	1165	1173.91	1173.91	1175.84	0.003966	11.95	2132.01	555.46	0.78	1177	1178	3.09	4.09
0.791	20000	1165	1175.03	1171.97	1175.53	0.000393	6.09	3918.46	742.7	0.37	1174.5	1178.5	-0.53	3.47
0.79	Bridge													
0.776	20000	1164	1172.56	1172.56	1174.4	0.012047	11.2	2039.47	605.75	0.85	1175	1179	2.44	6.44
0.758	20000	1160	1172.35	1168.68	1173.38	0.003555	8.6	2970.08	573.61	0.48	1178	1177	5.65	4.65
0.707	20000	1161	1171.36	1169.93	1172.37	0.004594	8.89	2909.71	576.69	0.52	1176	1175	4.64	3.64
0.663	20000	1160	1169.88	1168.93	1171.02	0.006908	9.39	2671.3	580.08	0.58	1175	1174	5.12	4.12
0.614	20000	1159	1168.66	1166.91	1169.5	0.004593	7.92	2937.46	581.59	0.49	1173.5	1173	4.84	4.34
0.568	20000	1159	1167.96	1165.95	1168.68	0.004359	7.18	3115.33	589.47	0.45	1172	1172	4.04	4.04
0.532	20000	1159	1165.94	1165.3	1167.38	0.006883	10.29	2402.58	568.74	0.72	1188.5	1170.5	22.56	4.56
0.475	20000	1156	1162	1162	1163.67	0.024661	11.82	2131.41	606.88	0.99	1180	1171.5	18	9.5


IBW - RECOMMENDED ALTERNATIVE - 20,000cfs
Legend
WS PF 1
Ground
Left Levee
Right Levee
Elevation (ft)
1200
1190
1180
1170
1160
1150
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Cl
Main Br DS 202nd	29290	PF 1	2400	1379.41	1384.89	1382.3	1385.12	0.002015	3.86	621.5	146.83	0.33
Main Br DS 202nd	29209.9		Bridge									
Main Br DS 202nd	29130	PF 1	2400	1379	1384.5		1384.74	0.002027	3.91	614.26	143.11	0.33
Main Br DS 202nd	28900	PF 1	2000	1378.4	1384.04		1384.27	0.001997	3.83	521.69	123.56	0.33
Main Br DS 202nd	28700	PF 1	2000	1377.88	1383.53		1383.82	0.002509	4.32	463.19	108.6	0.37
Main Br DS 202nd	28500	PF 1	2000	1377.36	1383.02		1383.32	0.002521	4.35	459.29	106.63	0.37
Main Br DS 202nd	28300	PF 1	2000	1376.83	1382.53		1382.82	0.002449	4.3	465.04	107.67	0.36
Main Br DS 202nd	28100	PF 1	2000	1376.31	1382.06		1382.33	0.002341	4.21	475.01	109.82	0.36
Main Br DS 202nd	27900	PF 1	2000	1375.79	1381.63		1381.87	0.002198	3.94	508.23	124.17	0.34
Main Br DS 202nd	27800	PF 1	2000	1375.53	1381.47		1381.67	0.001578	3.57	560.13	123.47	0.3
Main Br DS 202nd	27716.05	PF 1	2000	1375.32	1381.09	1378.35	1381.46	0.002224	4.9	407.87	140.45	0.37
Main Br DS 202nd	27631.2		Culvert									
Main Br DS 202nd	27547	PF 1	2100	1374.63	1380.53	1377.51	1380.88	0.001936	4.74	442.6	139.25	0.34
Main Br DS 202nd	27400	PF 1	2100	1373.99	1380.44		1380.57	0.001019	2.97	708.02	148.78	0.24
Main Br DS 202nd	27300	PF 1	2100	1374.1	1380.27		1380.44	0.001629	3.26	644.8	167.3	0.29
Main Br DS 202nd	27100	PF 1	2100	1373.68	1379.91		1380.11	0.0016	3.59	585.18	184.29	0.35
Main Br DS 202nd	26900	PF 1	2100	1373.12	1379.33		1379.62	0.003942	4.35	482.94	182.78	0.47
Main Br DS 202nd	26700	PF 1	2100	1372.84	1378.67		1378.97	0.002797	4.37	480.84	153.7	0.44
Main Br DS 202nd	26500	PF 1	2100	1372.38	1378.12		1378.38	0.002953	4.12	509.79	199.08	0.45

INDIAN BEND WASH
RECOMMENDED ALTERNATIVE - 30,000cfs

HEC-RAS Plan: 30-proposd-2 River: Reach #1 Reach: Reach #1 Profile: PF 1														
River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Levee El Left	Levee El Right	L. Levee Frbrd	R. Levee Frbrd
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(ft)	(ft)	(ft)	(ft)
1.554	30000	1177.29	1191.47	1191.14	1193.11	0.00113	12.12	3660.56	859.2	0.65	1193	1192	1.53	0.53
1.515	30000	1176.5	1191.77	1189.87	1192.72	0.003352	8.63	3962	628.71	0.44	1194.5	1193	2.73	1.23
1.478	30000	1176	1190.97	1188.8	1191.96	0.00394	8.63	3905.15	630.62	0.43	1193	1192.5	2.03	1.53
1.42	30000	1176	1190.42	1187.19	1191.12	0.001952	7.3	4591.97	614.86	0.38	1191.5	1191.5	1.08	1.08
1.381	30000	1175	1188.87	1187.21	1190.21	0.005517	9.87	3395.21	573.39	0.52	1190.5	1191	1.63	2.13
1.326	30000	1174	1188.35	1185.77	1189.19	0.002437	8.08	4283.02	641	0.42	1188	1190.5	-0.35	2.15
1.283	30000	1174	1187.89	1184.96	1188.64	0.002106	7.65	4496.33	655.71	0.41	1189	1187	1.11	-0.89
1.231	30000	1173	1187.06	1184.55	1187.96	0.002473	8.51	4194.47	645.33	0.44	1188	1189	0.94	1.94
1.19	30000	1174.5	1186.37	1184.18	1187.29	0.002956	8.4	4002.95	606.97	0.46	1187.5	1188.5	1.13	2.13
1.136	30000	1173	1185.23	1183.54	1186.31	0.003503	9.21	3736.25	601.85	0.51	1186.5	1187.5	1.27	2.27
1.087	30000	1173	1184.48	1182.62	1185.5	0.003424	8.92	3808.58	608.25	0.5	1186.5	1187	2.02	2.52
1.04	30000	1173	1181.69	1181.69	1183.8	0.010543	12.6	2669.07	593	0.82	1185	1183	3.31	1.31
0.987	30000	1171	1180.52	1179.18	1181.79	0.004135	9.95	3445.38	592.14	0.61	1182.5	1182	1.98	1.48
0.947	30000	1169	1179.32	1178.38	1180.8	0.005038	10.79	3245.38	586.7	0.64	1181.5	1182	2.18	2.68
0.903	30000	1169	1178.37	1176.96	1179.59	0.004406	9.72	3449.43	595.3	0.6	1180	1181	1.63	2.63
0.852	30000	1165	1177.68	1175.68	1178.63	0.00282	8.85	3965.08	598.18	0.46	1179	1176.5	1.32	-1.18
0.812	30000	1165	1175.18	1175.18	1177.57	0.00432	13.78	2846.59	576.64	0.83	1177	1178	1.82	2.82
0.791	30000	1165	1176.36	1173.41	1177.05	0.000467	7.31	4918.82	775.17	0.41	1174.5	1178.5	-1.86	2.14
0.79	Bridge													
0.776	30000	1164	1174.31	1173.91	1175.99	0.009543	11.16	3216.62	734.69	0.74	1175	1179	0.7	4.7
0.758	30000	1160	1173.9	1171.78	1175.3	0.004365	10.33	3879.82	598.9	0.53	1178	1177	4.1	3.1
0.707	30000	1161	1172.88	1171.33	1174.12	0.004954	10.15	3803.97	601.4	0.55	1176	1175	3.12	2.12
0.663	30000	1160	1171.54	1170.18	1172.81	0.006433	10.15	3652.83	602.16	0.57	1175	1174	3.46	2.46
0.614	30000	1159	1170.29	1168.24	1171.33	0.004637	8.87	3906.86	604.08	0.5	1173.5	1173	3.21	2.71
0.568	30000	1159	1169.59	1167.19	1170.5	0.004346	8.06	4094.67	611.01	0.46	1172	1172	2.41	2.41
0.532	30000	1159	1167.2	1166.63	1169.09	0.007418	12.06	3136.06	598.77	0.77	1188.5	1170.5	21.3	3.3
0.475	30000	1156	1163.05	1163.05	1165.2	0.024574	13.51	2770.26	613.44	1.01	1180	1171.5	16.95	8.45

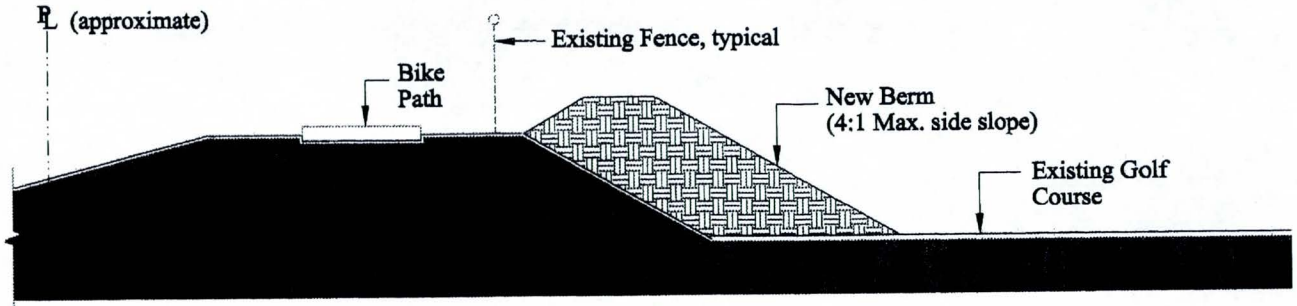

IBW - RECOMMENDED ALTERNATIVE - 30,000cfs
Legend
WS PF 1
Ground
Left Levee
Right Levee
Elevation (ft)
1200
1190
1180
1170
1160
1150
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (ft)

APPENDIX F

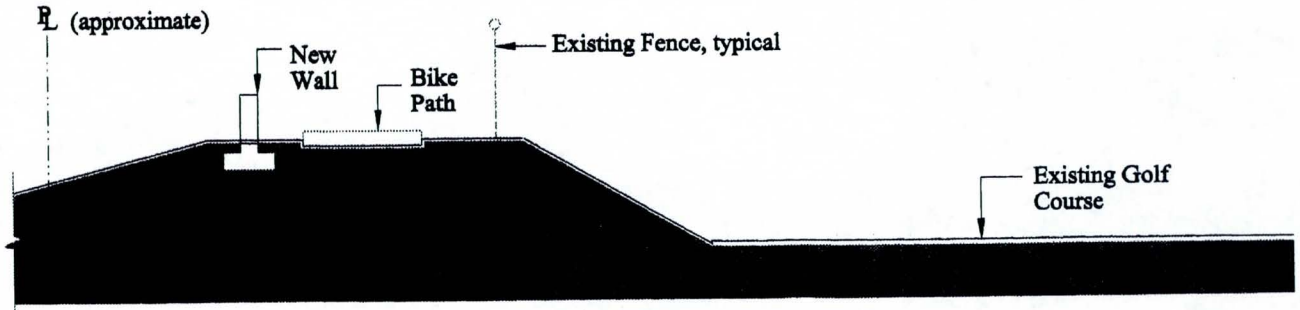
Alternatives for Raising Levee Elevation

Rio Salado Environmental Restoration Project - Tempe Reach
Indian Bend Wash Project Area

Alternatives for Raising Levee Elevation



Berm used to raise levee height (N.T.S.)



Wall used to raise levee height (N.T.S.)

U.S. Army Corps of Engineers
Los Angeles District

in cooperation with
The City of Tempe

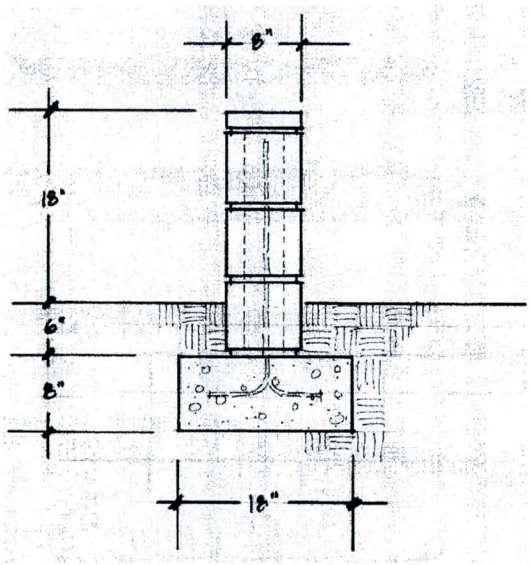
McGann & Associates / Novak Environmental Joint Venture
November 2001

APPENDIX G

Levee Wall Illustration and Order-of-Magnitude Cost Estimate

Rio Salado Environmental Restoration Project - Tempe Reach
Indian Bend Wash Project Area

Levee Wall Order-of-Magnitude Cost Estimate



ORDER-OF-MAGITUDE COST ESTIMATE
CMU WALL AT TOP OF LEVEE - 1,000 LINEAR FEET

FOOTING EXCAVATION	65	C.Y.	@	$5.70	PER C.Y.	$370.50
CONCRETE (FOOTING)	37	C.Y.	@	$71.00	PER C.Y.	$2,627.00
CONCRETE PLACEMENT	37	C.Y.	@	$21.00	PER C.Y.	$777.00
MASONRY	2000	S.F.	@	$6.35	PER S.F.	$12,700.00
SUBTOTAL						$16,474.50
MARK-UP FOR ADDITIONAL REINFORCING (25%)						**$4,118.63**
ESTIMATED COST PER 1,000 L.F. WALL						**$20,593.13**
ESTIMATED COST PER LINEAR FOOT OF WALL						**$20.60**

Data from Means 2001 Site Work and Landscape Cost Data

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