SECTION 205 FEASIBILITY REPORT

ADA, MINNESOTA

WILD RICE AND MARSH RIVERS, MINNESOTA

APPENDIX B

HYDRAULIC ANALYSIS AND INTERIOR FLOOD CONTROL

HYDRAULIC ANALYSIS AND
INTERIOR FLOOD CONTROL DESIGN

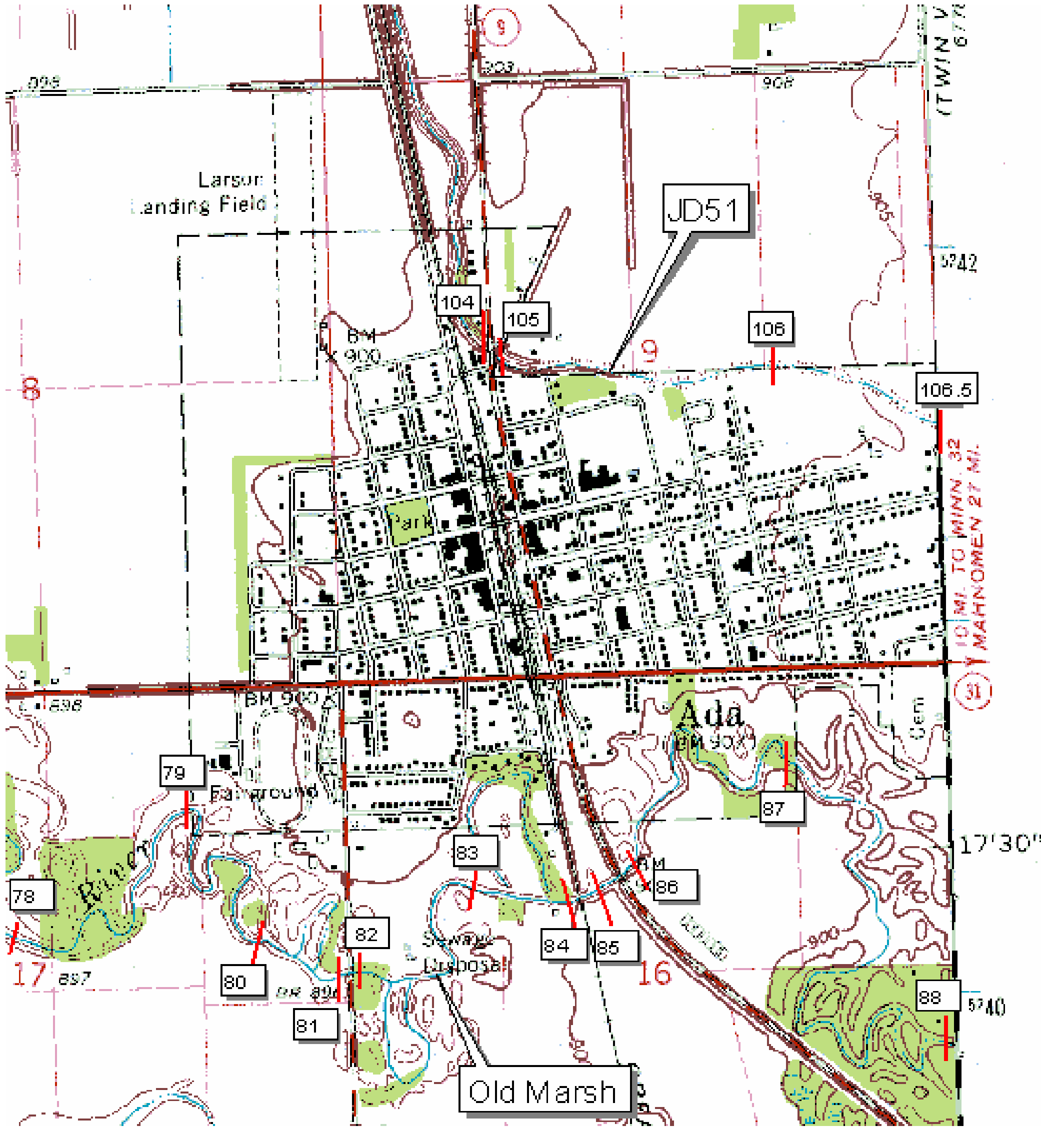
Introduction

Flooding within the town of Ada is caused Judicial Ditch 51 (JD51) flowing past the north side of Ada, and the Old Marsh River flowing along the south side of Ada. Ice jams are common during spring flood events, and debris jams complicate the flooding situation at Ada. The Hydraulics Section modified existing water surface profile models for the Marsh River and JD51 to produce water surface profiles that could be used to design a levee system for the City of Ada, and to determine the costs and benefits of the proposed levels of protection.

Hydraulic Models

The HEC-2 model, which was updated by Houston Engineering in 1998 and used for the Initial Assessment for Flood Damage Reduction in 1999, was converted to HEC-RAS. From this HEC-RAS model, three hydraulic models were prepared in order to assess the probable water surface profiles for a given flood. The models define the water surface profiles for three scenarios that are defined in the following paragraphs. Figure 1 shows the HEC-RAS cross-sections within the study area.

Figure 1
City of Ada – HEC-2 Cross Section Locations



Minus 2 Standard Deviation Condition. The HEC-RAS model was used directly to simulate an "unblocked average condition." The –2 standard deviation rating curve represents an optimistic flow condition with minimal constriction and obstructions. The HEC-RAS model for the –2 standard deviation was modified by decreasing Mannings "n" by 25 percent for each of the flood profiles.

Plus 2 Standard Deviation Condition. The +2 standard deviation rating curve was developed for a condition with a large degree of obstruction, including the effects of ice and debris jams. The 1997 flood event was greatly influenced by ice effects. The 1997 flood is considered to represent at +2 standard deviation condition for the 500-year flood. The HEC-RAS model was calibrated to USACE high water marks (Table 1) documented and surveyed at river crossings after the 1997 flood. The "+2 Standard Deviation" HEC-RAS model was modified as shown in Table 2.

Existing Condition. An unmodified HEC-RAS model was run to determine existing water surface elevations.

TABLE 1
1997 FLOOD – CORPS OF ENGINEERS HIGH WATER MARKS

Marsh River				**Judicial Ditch 51**		
Reference Point	HEC-RAS x-section	Elevation (ft)		Reference Point	HEC-RAS x-section	Elevation (ft)
15	50/51	885.07		18 Div	99/100	896.92
17	59/60	888.12		19 Div	99/100	898.60
19	67/68	892.16		20 Div	104/105	904.72
20	75/76	895.30		21 Div	108	912.01
23	85/86	902.73		22	111/112	902.52
24	89	905.12				

TABLE 2
CALIBRATION OF THE +2 STANDARD DEVIATION

	Wild Rice	Marsh	Old Marsh	JD 51
Mannings "n" was increased	+25%	+30%	+30%	+30%
Ice Cover	+2 feet (1)	2 feet	None	2 feet

Notes:
(1) The two feet of ice cover was applied from the downstream end up to x-section 82.

Water Surface Profiles for Flood Damages

Existing condition water surface profiles through the City of Ada were needed to determine the urban damages caused by flood events ranging from the 2-year to the 500-year flood. Determination of the water surface profiles within the city was complicated by the interaction of the two rivers passing Ada. Elevation frequency curves were plotted together for selected index stations on JD51 and the Old Marsh River to help sort out the relationship of flows between the two rivers.
Residents of several buildings within the City of Ada were contacted to relate approximate flood depths within town. The COE inventory of structure first floor and ground elevations was used to translate the flooding depths to an elevation. These spot elevations (Table 3) were used to get an understanding of the controlling water surface elevations caused by flow from the two rivers.

A profile baseline for overland flow was drawn across the City of Ada and five reference points were set (Figure 2). Reference sections were drawn north to south across the City of Ada to help determine a relationship between the overland flow profile baseline and the HEC-RAS cross sections (Figure 1) on JD51 and the Old Marsh River. Using the HEC-RAS water surface profiles and observed 1997 flood elevations, the overland flow profile was determined for the five reference points. The +2 standard deviation condition elevation frequency curves were plotted first. The +2 standard deviation elevation frequency curves illustrated that the Marsh River controlled up to about a 10-year event. Water surface elevations on JD51 controlled for events greater than a 10-year event. A tabulation of the controlling water surface elevations for the +2 standard deviation condition is included in Table 6. Figure 3 illustrates the water surface profiles through the City of Ada for events ranging from the 2-year to the 500-year event.

The existing condition elevation frequency curves were plotted and were evaluated in a similar way. Table 7 is a summary of the controlling water surface elevations for the existing condition. Figure 4 shows the water surface profiles through the City of Ada for events ranging from the 2-year to the 500-year event for the existing condition.

Finally, the –2 standard deviation condition elevation frequency curves were plotted. Table 8 summarizes the controlling water surface elevations for the –2 standard deviation condition. Water surface profiles through the City of Ada for the –2 standard deviation condition are shown in Figure 5.

TABLE 3 **1997 OBSERVED FLOOD ELEVATIONS – CITY OF ADA**					
Description of Flooding	COE Invntry Point	Ground Elevation (Ref. COE)	First Floor Elevation (Ref. COE)	1997 Flood Elevation (Est.)	REF PT.
Al's Café/ Lana Jo's 2' deep		903.3	903.5	905.5	C
404 E 5th Avenue 2' in Garage. Not to 1st floor	827	906.5	908.0	907.5/908	C
Lowell Thompson, Main floor flooding	828	906.8	908.3	907.5/908	D
City Office 18" above floor	572	903.5	903.5	905.0	C
Sanitary sewer fills up. Backs up 2' on street	118 121 122 173	900.5 901.0 901.0 901.5	903.0 903.0 903.0 902.8	903	B
West side of Ada Street flooding, Basement flooding	17 18 19 20 21 23 27 28	902.0 902.0 901.5 904.0 901.5 899.0 899.0 900.0	904.0 904.5 897.0 906.5 898.5 896.0 902.5 901.5	900	A

Figure 2
City of Ada – Overland Flow Profile Baseline and Reference Points

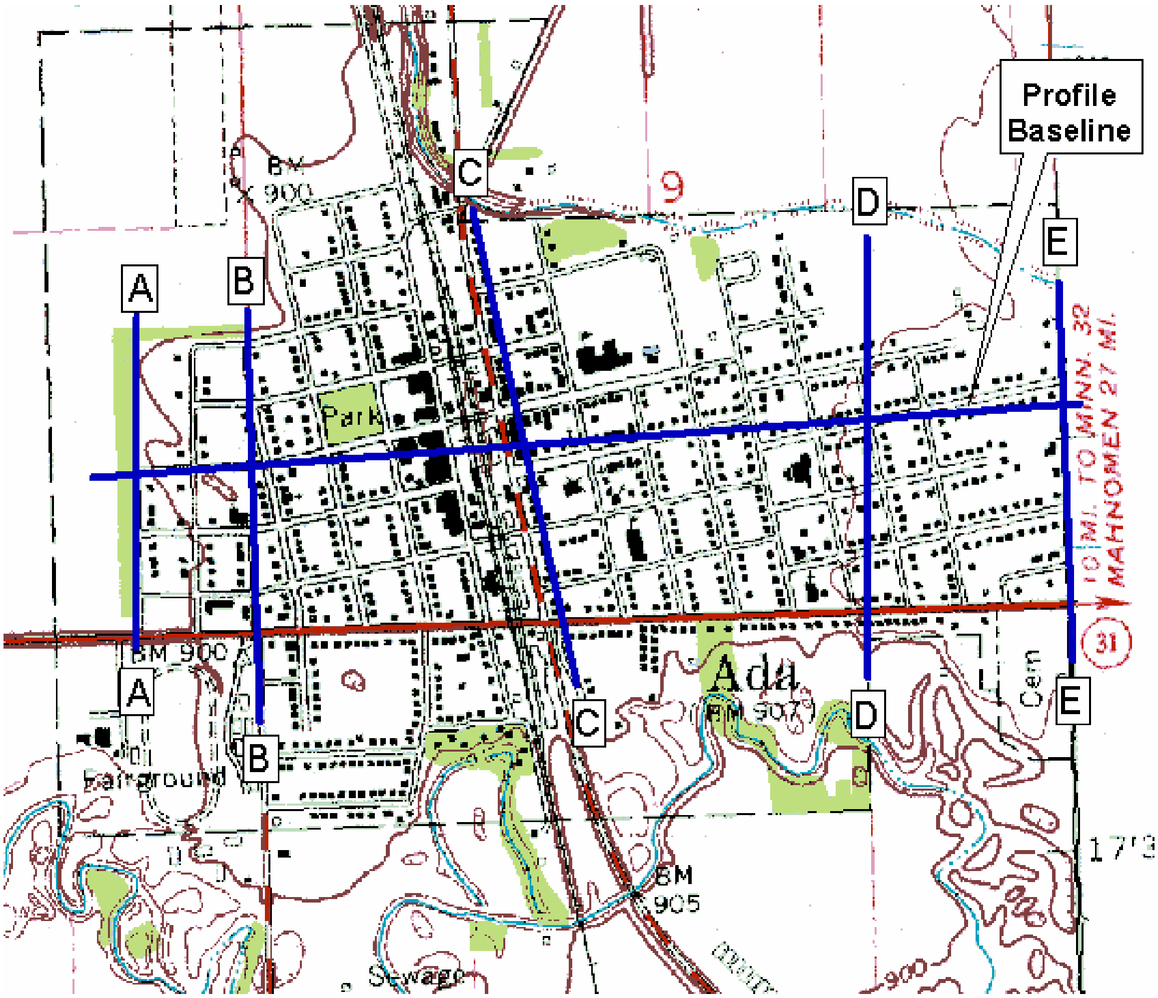
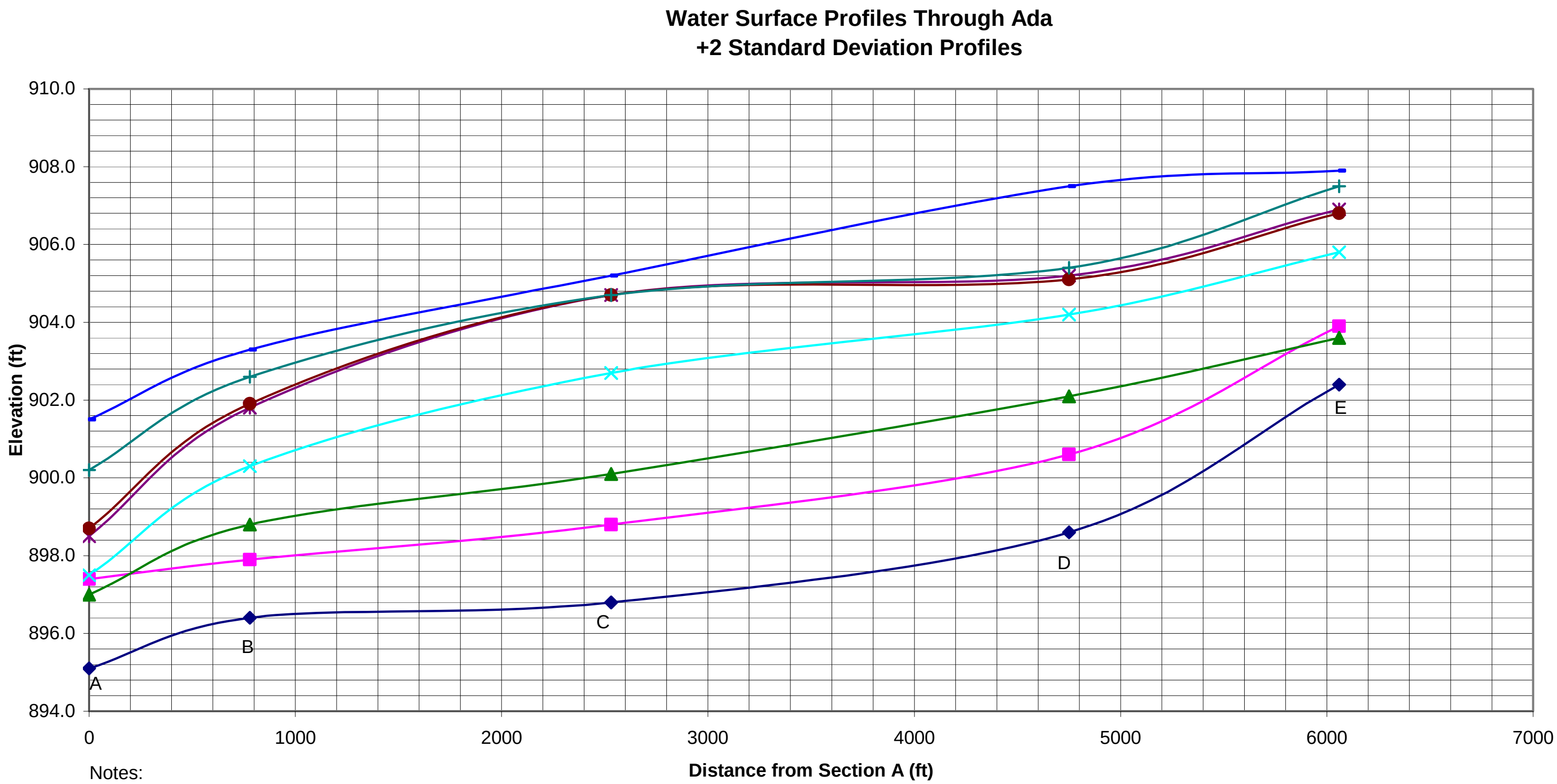


TABLE 4 ELEVATION-FREQUENCY CURVES IN ADA +2 STANDARD DEVIATION				
Reference Point	Levee Area	Frequency	Elevation (ft)	Source
A		5Y	897.4	Marsh Section 80
		10Y	897.0	Marsh Section 80
		20Y	897.5	Marsh Section 80
		50Y	898.5	Marsh Section 80
		100Y	898.7	Marsh Section 80
		200Y	900.2	Marsh Section 80
		500Y	901.5	Adjusted for 1997 High Water Marks
B	3	5Y	897.9	Interpolated between sections 82 & 105
	3	10Y	898.8	Interpolated between sections 82 & 105
	3	20Y	900.3	Interpolated between sections 82 & 105
	3	50Y	901.8	Interpolated between sections 82 & 105
	3	100Y	901.9	Interpolated between sections 82 & 105
	3	200Y	902.6	Interpolated between sections 82 & 105
	3	500Y	903.3	Adjusted for 1997 High Water Marks
C	2A & 1B	5Y	898.8	Marsh Section 86
	2A & 1B	10Y	900.1	JD51 Section 105
	2A & 1B	20Y	902.7	JD51 Section 105
	2A & 1B	50Y	904.5	JD51 Section 105
	2A & 1B	100Y	904.6	JD51 Section 105
	2A & 1B	200Y	904.7	JD51 Section 105
	2A & 1B	500Y	905.2	Adjusted for 1997 High Water Marks
D	1A & 2A	5Y	900.6	Marsh Section 87
	1A & 2A	10Y	902.1	JD51 Section 106
	1A & 2A	20Y	904.2	JD51 Section 106
	1A & 2A	50Y	905.2	JD51 Section 106
	1A & 2A	100Y	905.3	JD51 Section 106
	1A & 2A	200Y	905.4	JD51 Section 106
	1A & 2A	500Y	907.5	Adjusted for 1997 High Water Marks
E	4	5Y	903.9	Marsh Section 88
	4	10Y	903.6	Marsh Section 88
	4	20Y	905.8	JD51 Section 106.5
	4	50Y	906.9	JD51 Section 106.5
	4	100Y	907.0	JD51 Section 106.5
	4	200Y	907.5	JD51 Section 106.5
	4	500Y	907.9	Adjusted for 1997 High Water Marks

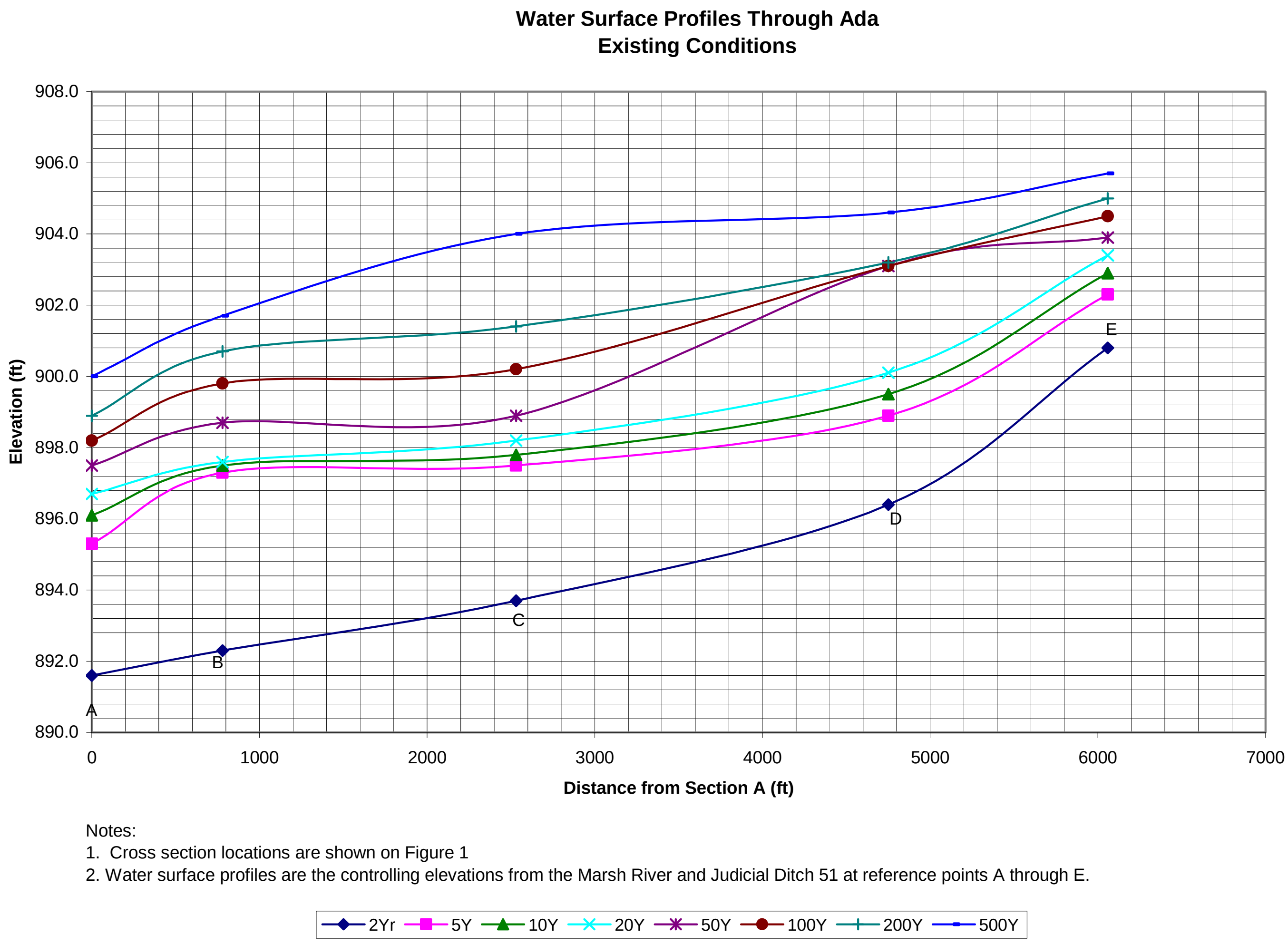
FIGURE 3



Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.

TABLE 5 ELEVATION-FREQUENCY CURVES IN ADA EXISTING CONDITIONS				
Reference Point	Levee Area	Frequency	Elevation (ft)	Source
A		5Y	895.3	Marsh Section 80
		10Y	896.1	Marsh Section 80
		20Y	896.7	Marsh Section 80
		50Y	897.5	Marsh Section 80
		100Y	898.2	Marsh Section 80
		200Y	898.9	Marsh Section 80
		500Y	900.0	Marsh Section 80
B	3	5Y	897.3	Marsh Section 82
	3	10Y	897.5	Marsh Section 82
	3	20Y	897.6	Marsh Section 82
	3	50Y	898.7	Interpolated between sections 82 & 105
	3	100Y	899.8	Interpolated between sections 82 & 105
	3	200Y	900.7	Interpolated between sections 82 & 105
	3	500Y	901.7	Interpolated between sections 82 & 105
C	2A & 1B	5Y	897.5	Marsh Section 86
	2A & 1B	10Y	897.8	Marsh Section 86
	2A & 1B	20Y	898.2	Marsh Section 86
	2A & 1B	50Y	898.9	Marsh Section 86
	2A & 1B	100Y	900.2	Marsh Section 86
	2A & 1B	200Y	901.4	Marsh Section 86
	2A & 1B	500Y	904.0	Marsh Section 86
D	1A & 2A	5Y	898.9	Marsh Section 87
	1A & 2A	10Y	899.5	Marsh Section 87
	1A & 2A	20Y	900.1	Marsh Section 87
	1A & 2A	50Y	903.0	JD51 Section 106
	1A & 2A	100Y	903.1	JD51 Section 106
	1A & 2A	200Y	903.2	JD51 Section 106
	1A & 2A	500Y	904.6	JD51 Section 106
E	4	5Y	902.3	Marsh Section 88
	4	10Y	902.9	Marsh Section 88
	4	20Y	903.4	Marsh Section 88
	4	50Y	903.9	Marsh Section 88
	4	100Y	904.5	Marsh Section 88
	4	200Y	905.0	Marsh Section 88
	4	500Y	905.7	Marsh Section 88

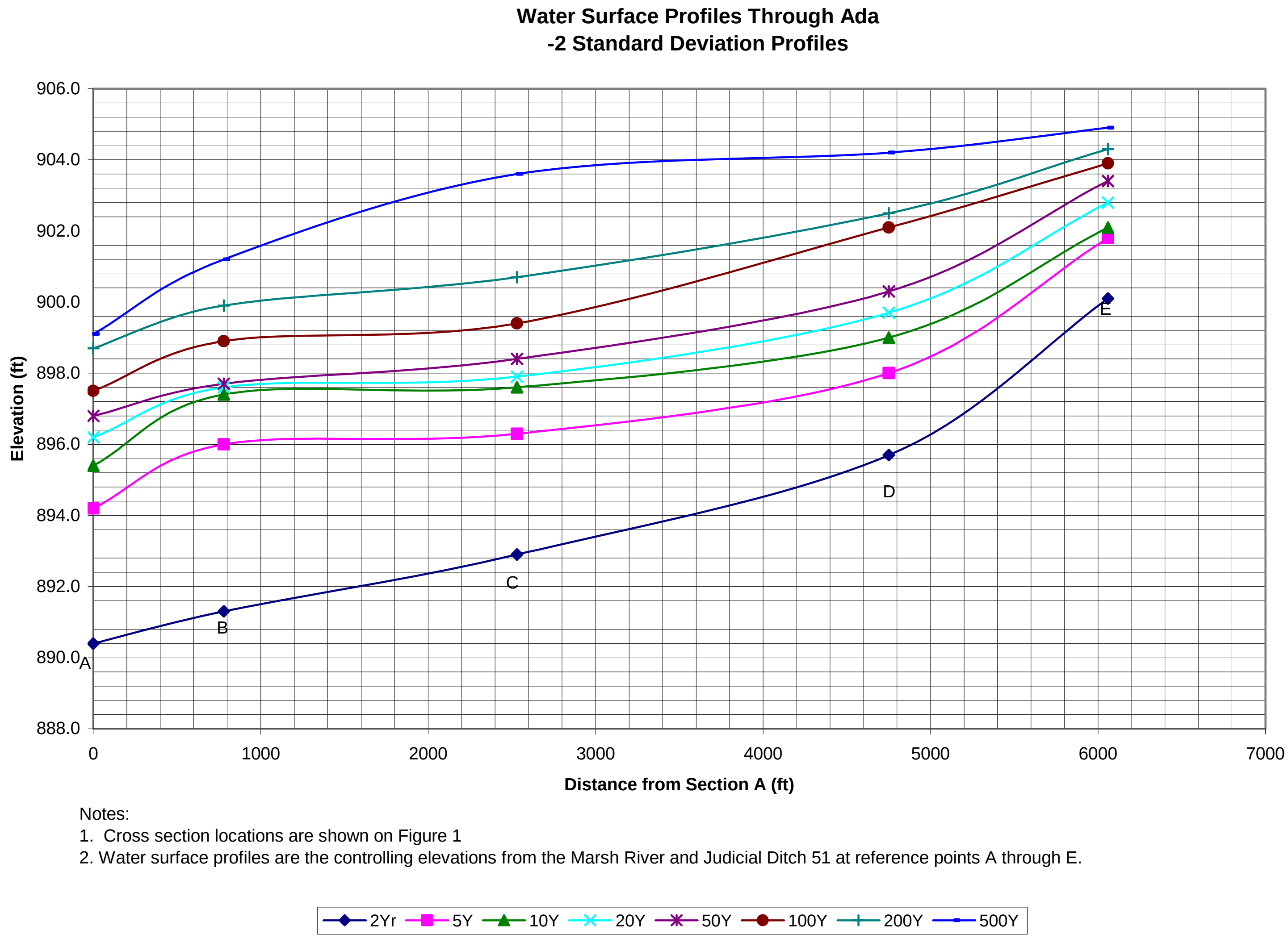
FIGURE 4



Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.

TABLE 6 ELEVATION-FREQUENCY CURVES IN ADA -2 STANDARD DEVIATION				
Reference Point	Levee Area	Frequency	Elevation (ft)	Source
A		5Y	894.2	Marsh Section 80
		10Y	895.4	Marsh Section 80
		20Y	896.2	Marsh Section 80
		50Y	896.8	Marsh Section 80
		100Y	896.8	Marsh Section 80
		200Y	898.7	Marsh Section 80
		500Y	899.1	Marsh Section 80
B	3	5Y	896.0	Marsh Section 82
	3	10Y	897.4	Marsh Section 82
	3	20Y	897.6	Marsh Section 82
	3	50Y	897.7	Marsh Section 82
	3	100Y	898.9	Interpolated between sections 82 & 105
	3	200Y	899.9	Interpolated between sections 82 & 105
	3	500Y	901.2	Interpolated between sections 82 & 105
C	2A & 1B	5Y	896.3	Marsh Section 86
	2A & 1B	10Y	897.6	Marsh Section 86
	2A & 1B	20Y	897.9	Marsh Section 86
	2A & 1B	50Y	898.4	Marsh Section 86
	2A & 1B	100Y	899.4	Marsh Section 86
	2A & 1B	200Y	900.7	Marsh Section 86
	2A & 1B	500Y	903.6	Marsh Section 86
D	1A & 2A	5Y	898.0	Marsh Section 87
	1A & 2A	10Y	899.0	Marsh Section 87
	1A & 2A	20Y	899.7	Marsh Section 87
	1A & 2A	50Y	900.3	Marsh Section 87
	1A & 2A	100Y	902.1	JD51 Section 106
	1A & 2A	200Y	902.5	JD51 Section 106
	1A & 2A	500Y	904.2	JD51 Section 106
E	4	5Y	901.8	Marsh Section 88
	4	10Y	902.1	Marsh Section 88
	4	20Y	902.8	Marsh Section 88
	4	50Y	903.4	Marsh Section 88
	4	100Y	903.9	Marsh Section 88
	4	200Y	904.3	Marsh Section 88
	4	500Y	904.9	Marsh Section 88

FIGURE 5



Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.

Figures 6 through 12 illustrate the existing, plus and minus 2 standard deviation water surface profiles through the City of Ada for each of the flood events. These water surface profiles were used by the Economics Section to determine the urban damages associated with flooding in Ada.

Figure 6

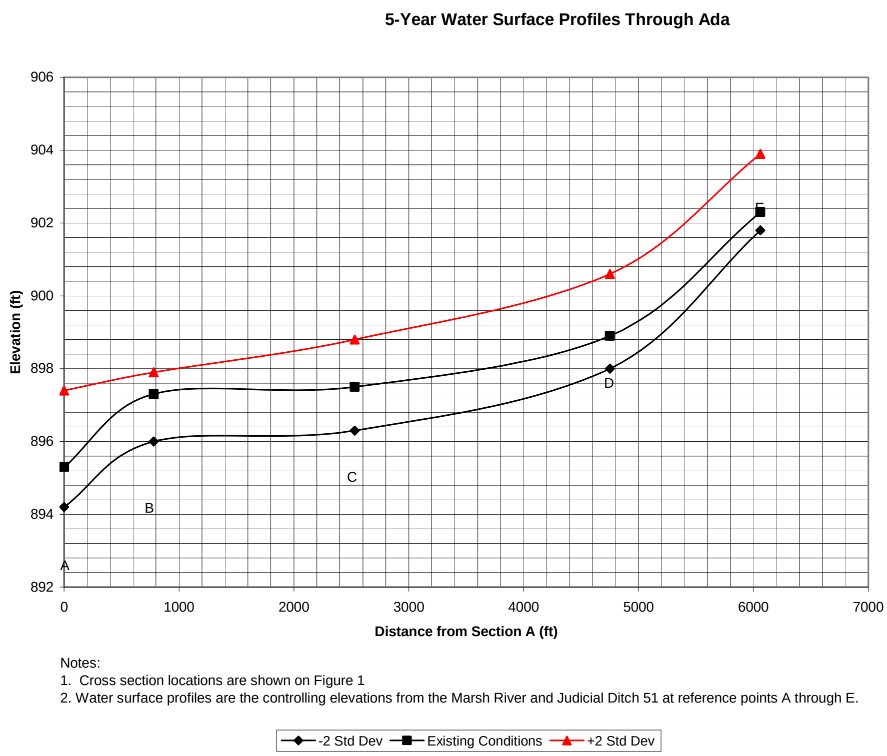
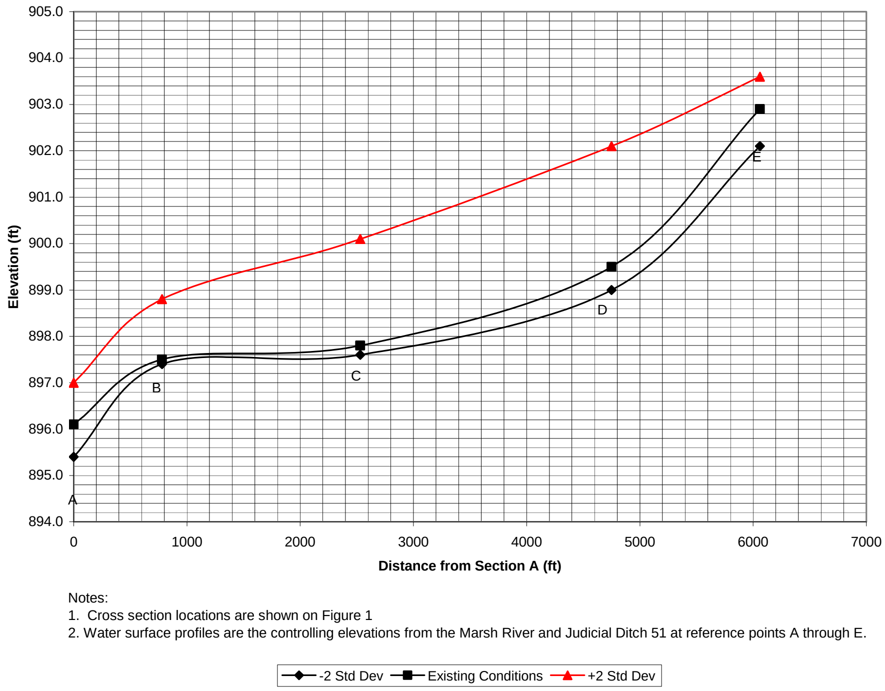


Figure 7

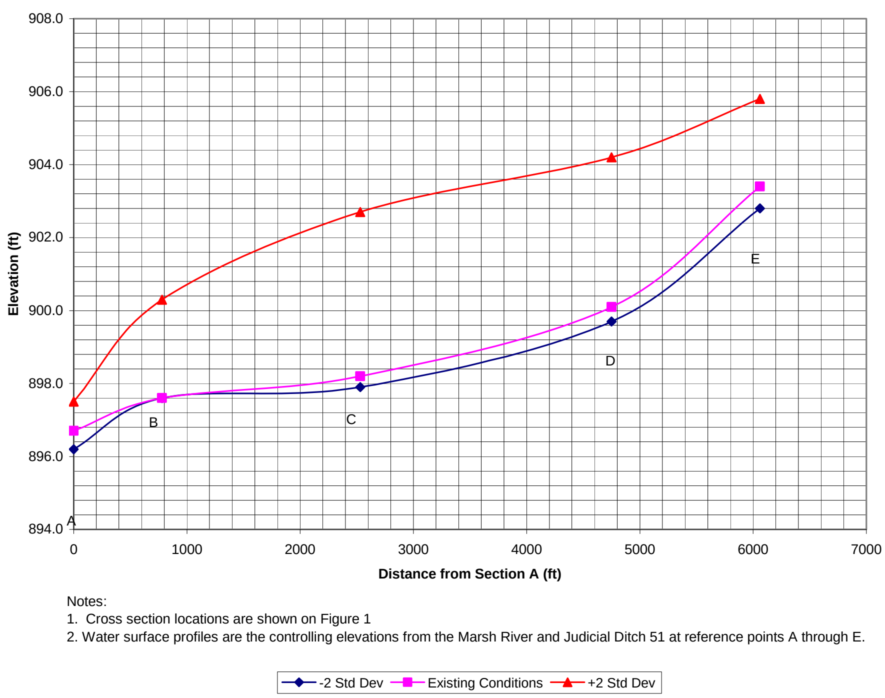
10-Year Water Surface Profiles Through Ada



Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.

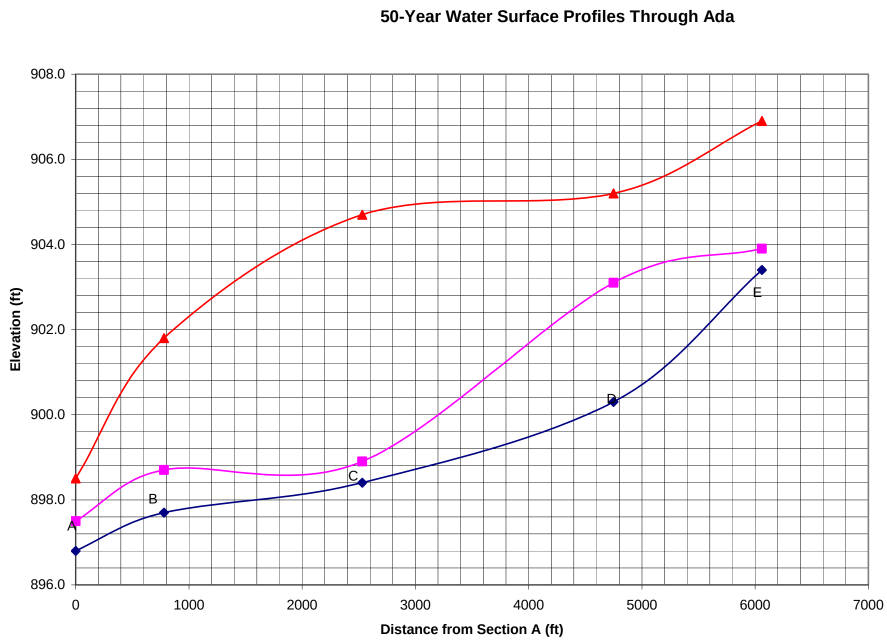
Figure 8

20-Year Water Surface Profiles Through Ada



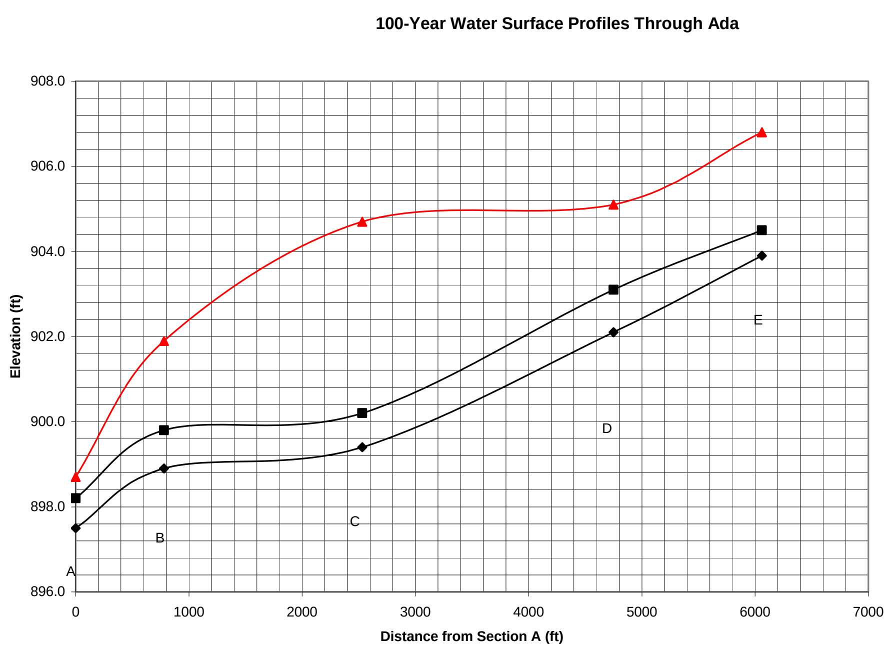
Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.

Figure 9



Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.

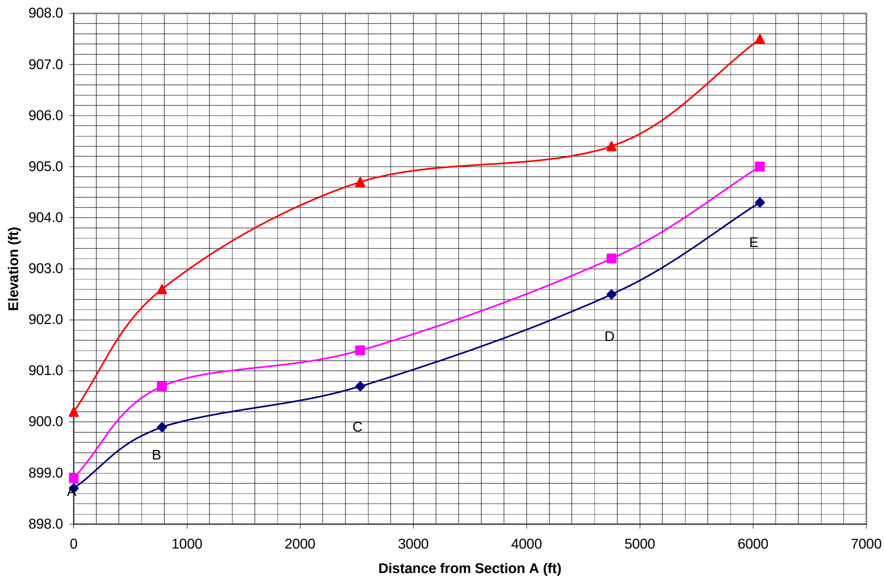
Figure 10



Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.

Figure 11

200-Year Water Surface Profiles Through Ada



Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.

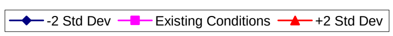
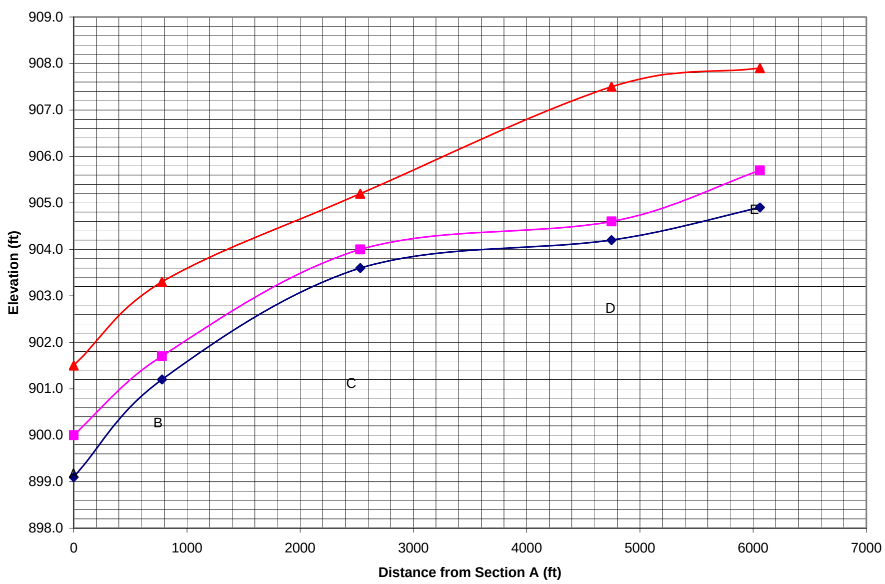
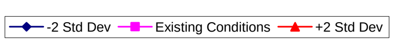


Figure 12

500-Year Water Surface Profiles Through Ada



Notes:
1. Cross section locations are shown on Figure 1
2. Water surface profiles are the controlling elevations from the Marsh River and Judicial Ditch 51 at reference points A through E.



Water Surface Profiles for Levee Design

The Hydraulics Section developed levee design profiles for the Marsh River and Judicial Ditch 51 (JD51). Flood events were simulated using the HEC-RAS Water Surface Profile model. Two portions of the existing condition HEC-RAS model for the Marsh River were extracted to generate profiles for the City of Ada. The first model segment for Ada extended from Section 101 to 107 on Judicial Ditch 51 (JD51). The second segment for Ada extended from Section 79 to 90 on the Old Marsh River. Rating curves were plotted (Figures 14 and 15) for the average and +2 standard deviation flow conditions at the downstream section in the two Ada models. The average condition rating curves were extended graphically beyond the 500-year event. Four levee designs were determined from the rating curves. Three feet were added to the flood elevation and projected to the average condition rating curve. The corresponding discharges were then input to the HEC-RAS model. The results from the HEC-RAS runs are listed in Tables 7 and 8.

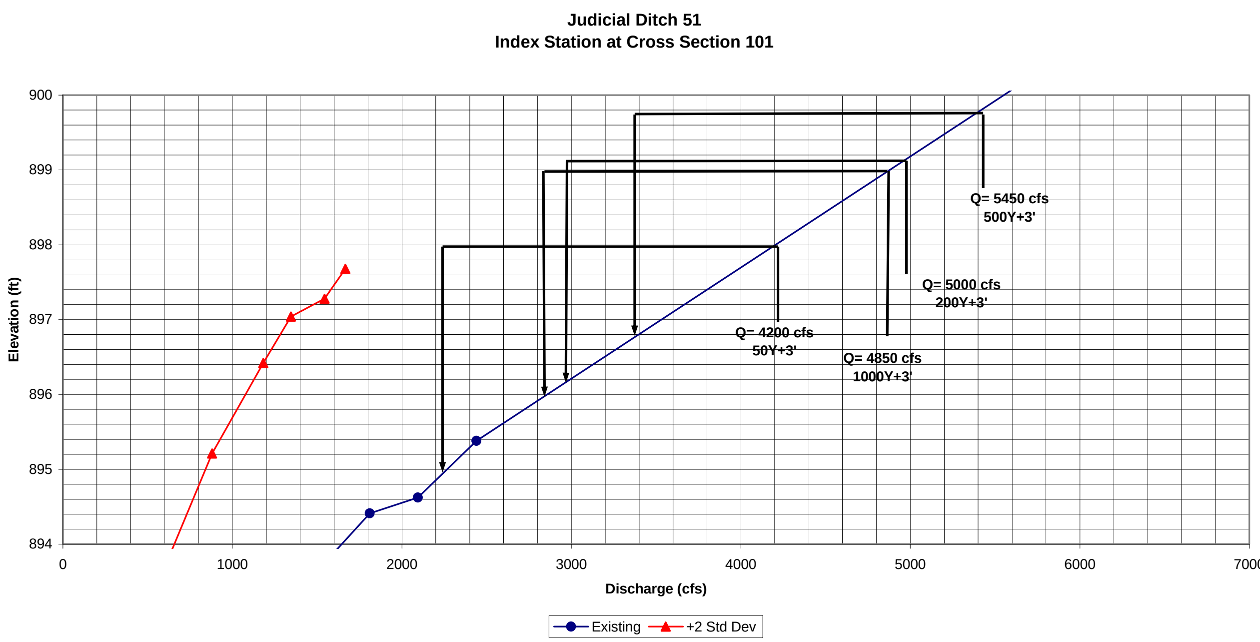
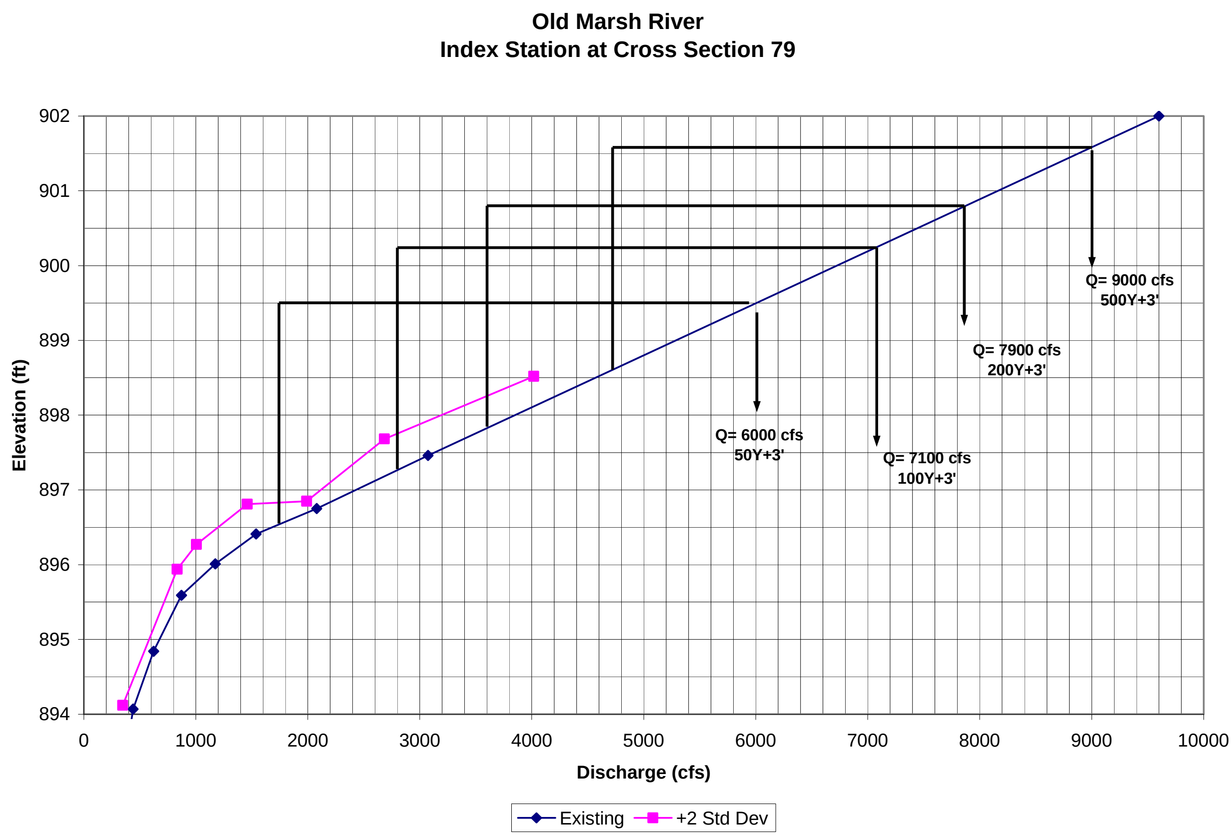


Figure 14



Old Marsh River
Index Station at Cross Section 79
902
901
900
899
898
897
896
895
894
Elevation (ft)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Discharge (cfs)
Q= 9000 cfs
500Y+3'
Q= 7900 cfs
200Y+3'
Q= 6000 cfs
50Y+3'
Q= 7100 cfs
100Y+3'
Existing
+2 Std Dev

Figure 15

Several reference points around the City of Ada were selected for the levee design. Figure 16 illustrates the levee reference points used to describe the levee profile. Since the proposed levee design does not follow the existing river alignment in the HEC-RAS model, the water surface profiles were projected and interpolated for the levee reference points. Tables 9 and 10 list the levee design elevations for the reference points.

Figure 16

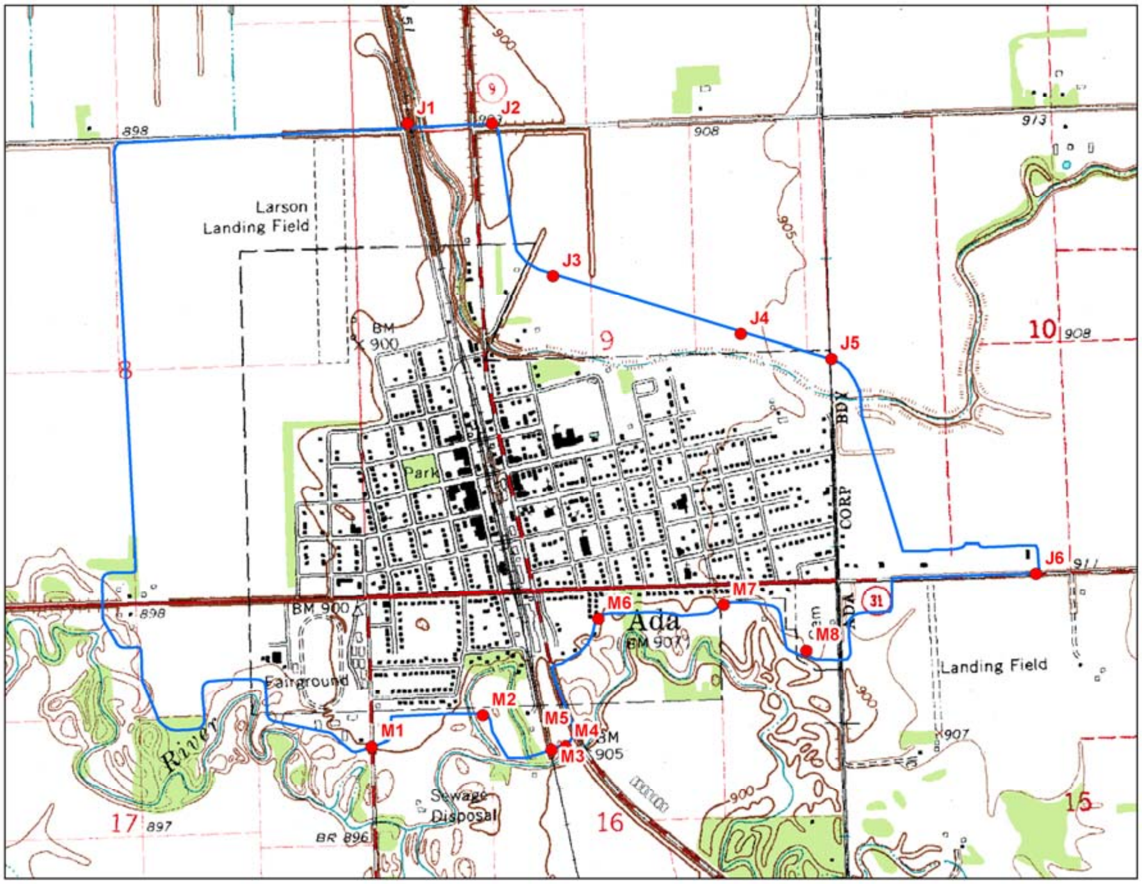

J1
J2
J3
J4
J5
J6
M1
M2
M3
M4
M5
M6
M7
M8
Larson
Landing Field
Park
Fairground
River
Sewage
Disposal
Ada
Landing Field
BDY
CORP
BM 900
BM 907
898
908
913
905
911
907
897
BR 896
8
9
10
15
16
17

TABLE 7 OLD MARSH RIVER LEVEE DESIGN – WATER SURFACE PROFILES					
HEC-RAS SECTION NUMBER	**ELMIN Ch. Invt.**	**CWSEL Q=6000 50Y+3’**	**CWSEL Q=7100 100Y+3’**	**CWSEL Q=7400 200Y+3’**	**CWSEL Q=9000 500Y+3’**
79	886.80	899.55	900.23	900.73	901.63
80	888.40	900.51	901.30	901.94	903.08
81	888.60	900.88	901.66	902.31	903.47
81.1	888.60	900.88	901.66	902.31	903.48
81.2	888.60	900.88	901.68	902.30	903.50
82	888.10	900.96	901.74	902.36	903.53
83	890.30	901.27	902.07	902.72	903.90
84	889.90	901.41	902.21	902.86	904.06
84.1	891.30	901.33	901.97	902.29	902.81
84.2	891.30	901.48	902.25	902.87	904.71
85	891.00	901.87	902.95	904.13	906.75
85.1	891.40	902.02	903.07	904.22	906.58
85.2	891.40	902.04	903.13	904.29	906.83
86	891.40	902.06	903.32	904.65	907.36
87	892.80	904.01	904.88	905.81	907.72
88	898.00	907.26	907.89	908.46	909.13
88.1	898.00	907.37	907.94	908.50	909.18
88.2	897.70	908.36	908.68	909.03	909.43

TABLE 8 JUDICIAL DITCH 51 LEVEE DESIGN – WATER SURFACE PROFILES					
HEC-RAS SECTION NUMBER	**ELMIN Ch. Invert**	**CWSEL Q=4200 50Y+3’**	**CWSEL Q=4850 100Y+3’**	**CWSEL Q=5000 200Y+3’**	**CWSEL Q=5450 500Y+3’**
101	880.70	897.91	898.82	899.13	899.75
102	885.00	898.96	899.89	900.24	900.93
102.1	885.00	899.00	899.93	900.28	900.96
102.2	885.00	899.04	899.98	900.35	901.11
103	885.40	899.18	900.12	900.50	901.30
103.5	887.00	901.00	901.92	902.29	903.02
104.	888.20	901.47	902.34	902.64	903.36
104.1	888.20	901.50	902.37	902.68	903.40
104.2	887.10	902.67	904.06	905.23	906.13
105	887.10	902.70	904.15	905.33	906.20
106	889.40	905.70	906.41	906.46	906.85
106.5	892.00	907.53	908.24	908.43	909.00
107	896.80	911.32	912.08	912.37	913.02

TABLE 9 OLD MARSH RIVER LEVEE REFERENCE POINTS					
Control Point	50Y+3’	100Y+3’	200Y+3’	500Y+3’	Description
M1	900.96	901.74	902.36	903.53	Levee at Cnty Hwy 1
M2	901.27	902.07	902.72	903.90	
M3	901.41	902.21	902.86	904.06	DS side of RR
M4	902.02	903.07	904.22	906.58	Between Hwy 9 and RR
M5	902.04	903.13	904.29	906.83	US side of Hwy 9
M6	902.06	903.32	904.65	907.36	
M7	904.01	904.88	905.81	907.72	
M8	907.26	907.89	908.46	909.13	US end of levee at T Hwy 200

Notes:
M1 = Elevation at Section 82
M2 = Elevation at section 83
M3 = Elevation at Section 84
M4 = Elevation at section 85.1
M5 = Elevation at Section 85.2
M6 = Elevation at section 86
M7 = Elevation at Section 87
M8 = Elevation at section 88

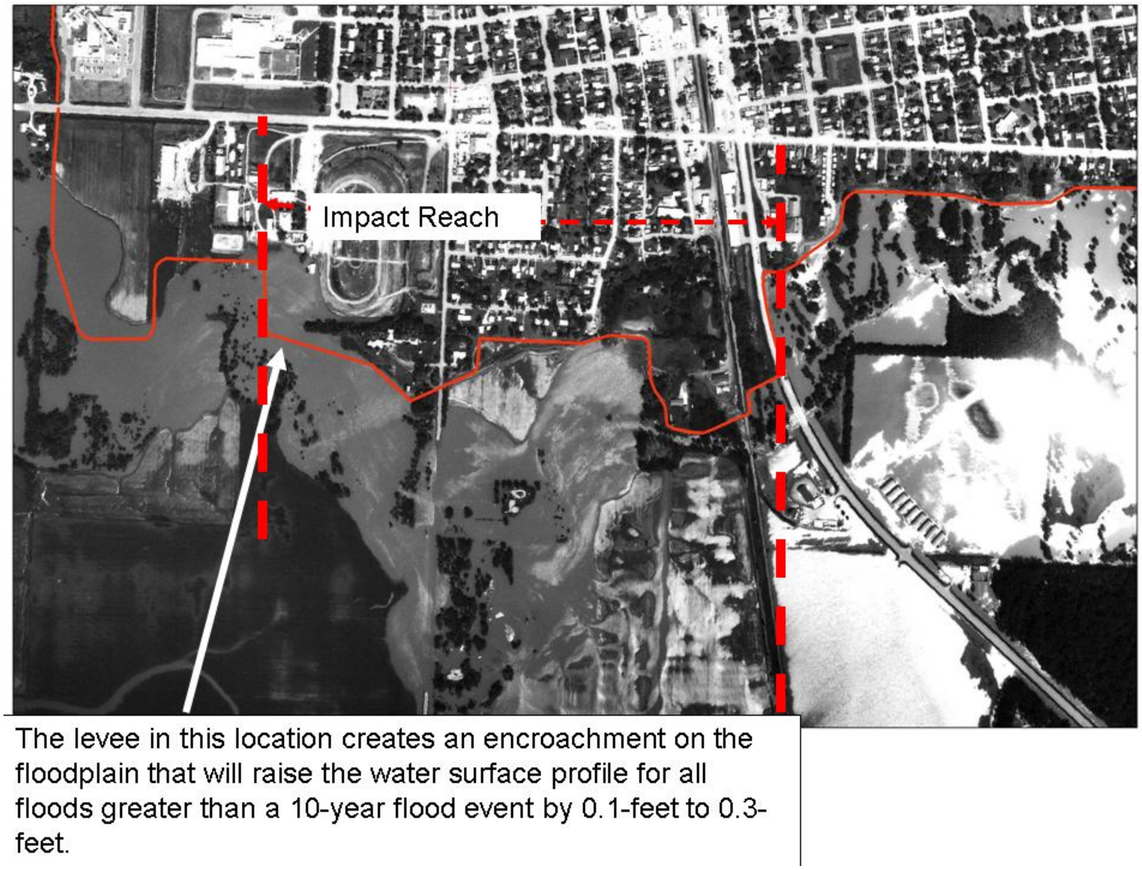
TABLE 10
JUDICIAL DITCH 51
LEVEE REFERENCE POINTS

Additional Comments

In looking at Alternative 2, the re-route of JD-51, a few assumptions were made in the analysis. These assumptions will be looked at in more detail during the plans and specifications phase. The first assumption is that the re-route of the ditch will allow for the same flow of water through JD 51. The cross-section that was used is the original cross-section from when JD 51 was first constructed. The cross-section would have a 12 foot base width with 1V:3H side slopes. Secondly, the location where the re-route will flow under Hwy 9, 2-12x12 box culverts will be constructed. These box culverts were chosen to match the box culverts located on the existing ditch where it flows under Hwy 9 just south of the new location.

Floodplain Impacts

Flow distribution during flood events will not change with the selected plan. Levees will be constructed outside the effective flow limits of the Marsh River, except is short reach near the baseball field West of south Jamison Drive. The area effect is bounded by South Jamison Ave on the West, Highway 9 on the East, The sewage treatment lagoons on the south, and the levee on the north. The levee in this reach creates an encroachment on the floodplain that will raise the water surface profile for all floods greater than a 10-year flood event by 0.1-feet to 0.3-feet. The impact reach extends from the encroachment upstream to HWY 9.



Project Performance

Given the uncertainty associated with the various hydraulic, hydrologic, and economic relationships used in the flood damage analysis, there is likewise some uncertainty regarding a project's ability to provide a given level of protection. FDA measures a project's performance by calculating the probability that flood stages will exceed the project's capacity. The project is generally designed so that there is a 90-95 percent probability it contains the design flood. Table 12 shows the probability that the 200-year levee project will contain selected flood levels. For example, the levee in Reaches 1a and 2a will contain the 100-year flood (1% event) with a probability of 98.61 percent. Because of the ranges of uncertainty, the 200-year project also has the ability to contain the 500-year flood (probability of 81.68 percent). On the other hand, there is some risk that the project may not necessarily contain the 200-year flood. There is still a 2.47 percent probability (1 – 0.9753) that the 200-year flood will overtop the 200-year project in Reaches 3 and 4.

Table X - Probability of Levee Overtop by Event						
	Top of Levee	Conditional Non-Exceedence Probability by Events				
Reach	Elevation	4.0%	2.0%	1.0%	0.5%	0.2%
1a, 2a	906.2	0.9995	0.9994	0.9861	0.9084	0.8168
1b, 2b	904.4	0.9998	0.9965	0.9618	0.7706	0.547
3, 4	903.7	0.9999	0.9999	0.9989	0.9753	0.9126

In addition to considering the probability of a particular event overtopping a levee as above, one can consider the probability of a levee being overtopped over a given period of time (say 10, 25, or 50 years). Table 13 presents project performance in this manner for the 200-year levee in each Reach. Based on the data presented in the table, the levee along Reaches 1b and 2b will have a 6.91 percent chance of being overtopped within a period of 25 years. As the period of time increases in length, the probability for an overtopping event for the levee increases.

Table X – Long-term Risk of 200-Year Levee Alternative				
	Expected Annual	Probability of Exceedance		
	Probability of Design	Over Indicated Time Period		
Reach	Being Exceeded	10 Years	25 Years	50 Years
1a, 2a	0.000	0.0090	0.0223	0.0440
1b, 2b	0.003	0.0282	0.0691	0.1335
3, 4	0.001	0.0032	0.0081	0.0161

INTERIOR FLOOD CONTROL

Introduction

The city of Ada experiences flooding from two sources; Judicial Ditch 51 and the Old Marsh River. Control of flooding from Judicial Ditch 51 is proposed to be from levees and interior flood control features, such as pumping or ponding. Flooding from the Old Marsh is to be controlled with levees. The interior drainage area has been divided into 9 sub-watersheds. Because of the alternative of moving JD 51 to the east, areas 1, 4, and 6, which are those areas that outlet into JD 51, need to be looked at as alternative 1 and alternative 2. Figure 1 and Figure 2 show the 7 sub-watersheds for alternatives 1 and 2, respectively. Table 1 gives the hydrologic description for each of these contributing sub-watersheds.

TABLE 1
DETERMINATION OF LAND USES, TIME OF CONCENTRATIONS, AND SCS CURVE NUMBERS

Location	Watershed Area		Flow Length (ft)	Outflow Location	Tc (min) (1)	Lag (hrs) (2)	Land Use (%)			SCS Curve Number (3)
	Acres	Sq. Mi.					Bus.	Resid.	Park	
1	186.0	0.291	5000	JD51	51.7	0.517	10	90	0	82.3
2a	54.0	0.084	2400	Old Marsh	30.0	0.300	20	80	0	83.6
2b	30.0	0.047	1200	Old Marsh	20.0	0.200	0	100	0	81.0
3	158.0	0.247	4400	Old Marsh	46.7	0.467	10	80	10	82.1
4	74.0	0.116	3200	JD51	36.7	0.367	10	90	0	82.3
5	149.0	0.233	4000	Old Marsh	43.3	0.433	20	10	70	82.2
6 – alt#1	11.0	0.017	2700	JD51	32.5	0.325	20	50	30	83.0
6 – alt #2	25.0	0.039	2700	JD51	32.5	0.325	20	30	50	82.6

Notes:

(1) Tc, the estimated time of concentration was obtained assuming a 10 minute travel time to the nearest inlet, plus an average flow rate of 2 feet per second in each storm sewer.

(2) The estimated lag time is equal to time of concentration in minutes, divided by 100.

(3) The study area consists of soils of Hydrologic Class Type C. The weighted SCS curve number was, therefore, obtained assuming an average curve number of:

94 for commercial and industrial areas
81 for residential areas (1/3 acre average lot size assumed)
79 for park and undeveloped areas (fair condition with grass cover 50% to 75%)

Gravity Outlets

The gravity outlets for both alternatives 1 and 2 are summarized in Table 2. The locations of the outlets from Table 2 are shown on Figures 1 and 2, in addition to the plan plates. The outlets were designed to keep the 100-year rainfall event from reaching the determined zero damage elevation for each sub-watershed area. Table 2a contains additional outlets that are needed to provide adequate drainage through the levee for street side ditches.

Alternative 1. This alternative evaluates the interior drainage issues if JD 51 is not re-routed.

Alternative 2. The relocation of JD 51 to the east allows for increased volume of interior ponding. This ponding can be used for storage of interior runoff for areas 1, 4, and 6. The gravity outlet for area 6 provides the capacity needed to handle the interior runoff that is routed from areas 1 and 4 through the ditch and combined with the runoff from area 6. Because of past history with interior flooding in area 4, the storm sewer capacity from this area to the JD 51 storage pond was increased from a 24" pipe to a 48" pipe.

TABLE 2
PROPOSED GRAVITY OUTLETS

Location	Outlet No.	Pipe Diameter (in)	Inlet Elevation (ft)	Outlet Elevation (ft)	Pipe Length (ft)	Ground Elevation (ft)	Outlet Location	Outlet Bottom Elevation (ft)
Area 1-alt #1	17	2-60	891.0	890.0	435	901.0	JD 51	888.0
Area 2a	12	48	894.6	894.1	325	901.0	OMR	892.1
Area 2b	13	48	895.3	894.8	290	900.0	OMR	892.8
Area 3	8	22-60	892.8	892.3	85	901.0	OMR	890.3
Area 4-alt #1	1	2-54	891.0	890.0	315	901.0	JD 51	888.0
Area 4-alt #2	2	48	891.0	890.0	315	901.0	JD 51	888.0
Area 5	5	48	890.8	889.8	175	900.0	OMR	886.8
Area 6-alt #1	14	24	890.0	889.0	315	901.0	JD 51	887.0
Area 6-alt #2	18	54	887.0	886.0	90	901.0	JD 51	887.0

TABLE 2A ADDITIONAL OUTLETS			
Outlet Number	Pipe Diameter (in)	Pipe Length (ft)	Location
3	24	90	Hospital Levee, North of Hwy 200
4	24	65	Hospital Levee, South of Hwy 200
6	24	40	South Levee, West of Jamison Drive
7	24	40	South Levee, East of Jamison Drive
9	24	50	South Levee, West of Railroad
10	36	75	South Levee, West of Hwy 9
11	36	75	South Levee, East of Hwy 9
15	24	45	North Levee, West of Hwy 9
16	24	20	North Levee, West of Hwy 9

Note: The inverts will be determined during the feasibility stage.

Pump Stations

It was determined that the 1997 rainfall was the most significant event on record and therefore was used to size the pumping stations. The summary for the pumping stations is summarized in Table 3. The proposed locations of the pumping stations are located on Figure 1. Due to the gain in storage in relocating JD 51, the pumping stations that were required for alternative 1 are eliminated for alternative 2. No pumping stations are required along the south levee where there is enough interior storage below the zero damage elevation to store runoff during blocked gravity conditions for both alternatives.

TABLE 3 PROPOSED PUMP STATIONS					
Location	Number of Pumps	Size of Pump (gpm)	Total Station Capacity (gpm)	Pump On Elevations (ft)	Pump Off Elevations (ft)
Area 1	2	5,000	10,000	897/898	895/895
Area 4	2	5,000	10,000	896/897	895/895

Interceptors

Interceptor sewer pipes are used to collect runoff from existing storm sewers or ditches and convey it to the proposed outlet. Interceptor sewer pipes are included in area 1. Alternative 1 interceptors propose 3,150 feet of interceptor sewers having a diameter of 24 inches. In addition to the interceptor sewers, this plan will require 5 manholes to connect the sewers. Alternative 2 interceptors propose 2,000 feet of interceptor sewers having a diameter of 24 inches. This plan requires 3 manholes to connect the sewers. The interceptor sewers are shown on Figures 1 and 2. The existing storm sewer inverts were not available and will need to be determined prior to any future efforts into this study. For this analysis, the inverts were calculated by determining existing ground elevation and subtracting an assumed 6 feet of cover and the pipe size.

Figure 1
Alternative #1 – Interior Flood Control Features

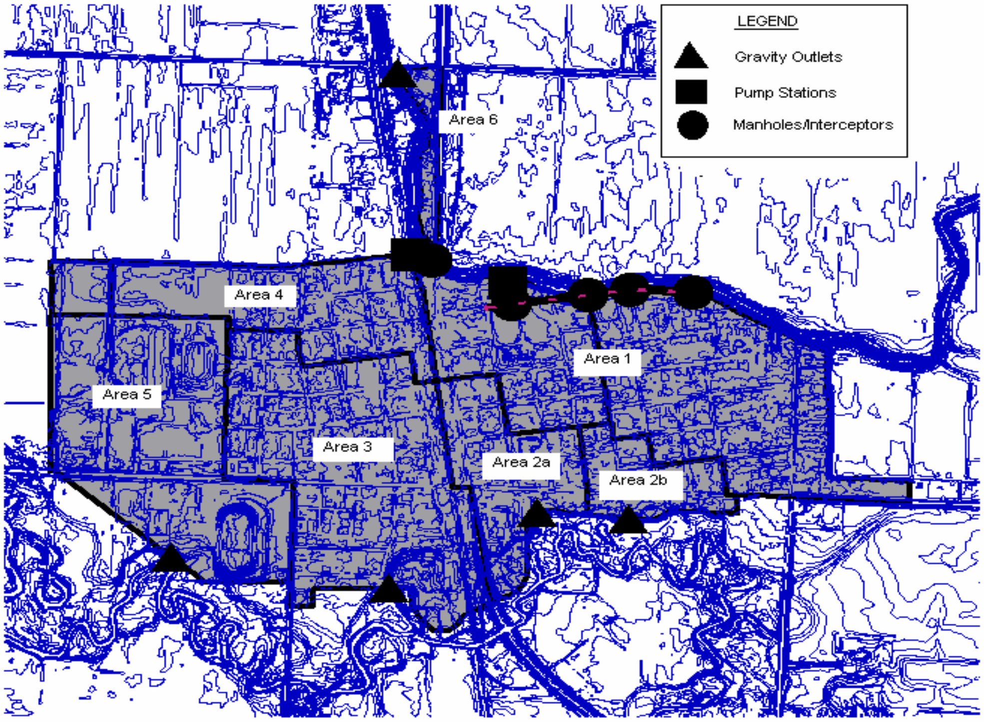
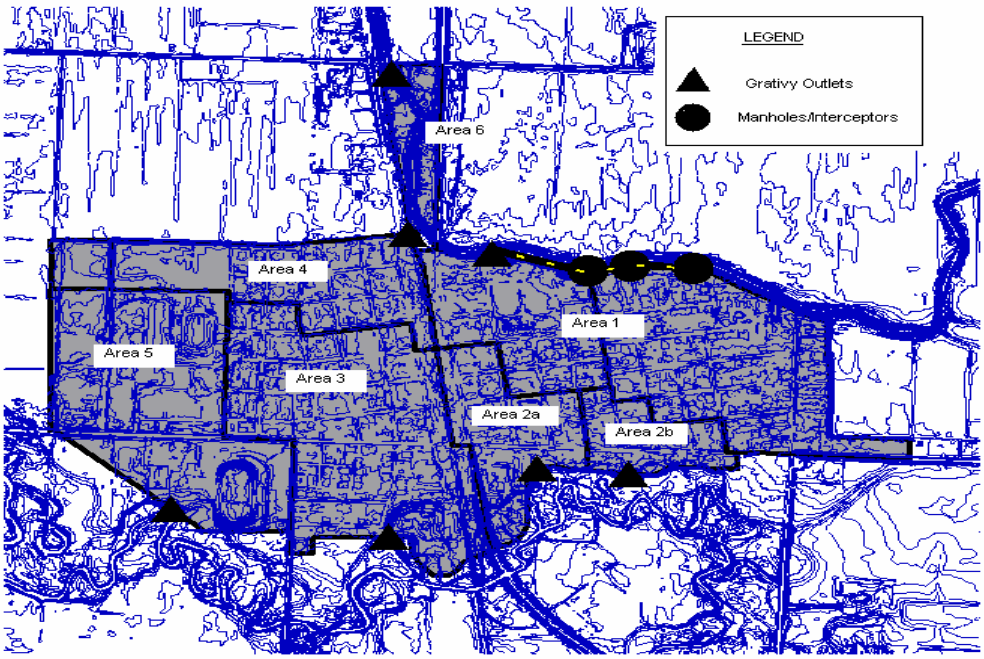


Figure 2
Alternative #2 – Interior Flood Control Features



Legend

- Analyis Points
- North Levee
- South Levee, West Reach
- South Levee, East Reach
- Analysis Area Boundary

Ada, MN
Credit To Existing Levees

0 255 510 1,020 1,530 2,040 Feet