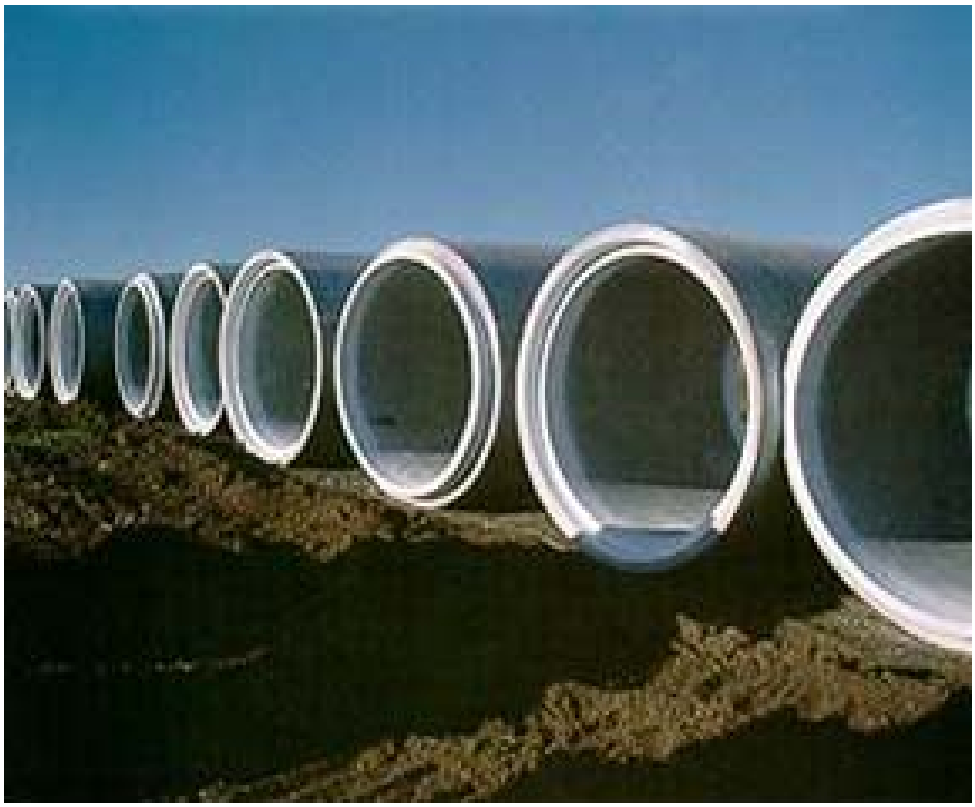
PIPELINE HYDRAULICS STUDY

FOR THE

CANAL REHABILITATION PROJECT



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SECTION 1.0: INTRODUCTION

This report provides support for a canal rehabilitation and improvement project within the Harlingen Irrigation District Cameron County No.1 (HIDCC1), which serves 38,000 acres of irrigated farmland in Cameron County, Texas. The District has identified the Citrus, Taylor, Wyrick, and Bowmen canals as canals that would experience great benefit in performance and efficiency from rehabilitation and improvement work. Of greatest concern, is the overall performance of the canals measured by the flow rate at the turnouts in the fields and the seepage from structurally failed concrete sections. The concerns can be addressed by either enclosing portions of the canals with PVC or RCP pipe or applying polyurethane lining where feasible. These improvements will not only conserve water through the elimination of seepage but also improve the hydraulic efficiency of the water transport system thus improving on-farm irrigation performance. This report presents the recommended proposed improvements along with their corresponding hydrologic and hydraulic calculations. Refer to Exhibit A for a depiction of the proposed canal improvement sites.

SECTION 2.0: METHODOLOGY

The proposed improvements to the various canals were modeled using EPANET. EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. The creation of the EPANET model involved creating the distribution network, determining the amount of available head, defining the amount of demand, and designing the improved pipe network. A brief description of each of these processes is provided in the following.

Distribution Network

The distribution network is composed of the entire canal system including earth, concrete, and pipeline sections as well as checks, turnouts, pump stations, and storage reservoirs. The information used to create the network in EPANET was gathered using a combination of aerial photographs, USGS maps, HID No.1 maps, and site visits. Refer to Exhibits B through D for a depiction of the distribution networks for the various canals.

Water Demand

The water demands for the canals were determined using two factors; the acreage of farmland served and the number of existing turnouts.

- Every 40 acres of irrigatable farmland requires service of 3 cfs per irrigation with a maximum of 1/3 of farmland irrigated at any given time
- Expected performance for each turnout was assumed at 3cfs

Available Head

The amount of available head was determined through the use of GPS surveying techniques. A Trimble 5700 receiver was used to provide elevations of flow lines at key turnouts along the Citrus, Taylor, and Wyrick canals as well as the normal water surface elevation of the water supplying canal. The elevations are based on the NAD 1983 (Conus) datum and are depicted on Exhibits A through D.

Design
Enclosed sections will use PVC (poly-vinyl chloride) irrigation pressure pipe for sizes up to and including 24-inches with larger RCP (re-enforced concrete pipe) used for pipe sections larger than 24-inches. Trapezoidal canal sections are modeled in the EPANET model with an equivalent pipe.

SECTION 3.0: CITRUS CANAL

The Citrus Canal serves 667 acres of farmland located southeast of the intersection Rio Hondo Rd and FM-1595. A depiction of the canal's location and alignment as well as its service area is provided in Exhibit B. The concrete lined canal is 6,667 ft in length with numerous segments experiencing structural failure with broken and collapsing concrete. The canal receives its water from Canal No. 6 and is currently servicing fourteen turnouts. The water surface elevation ranges from 36.0 to 37.5 feet in Canal No. 6 providing only between 1.0 and 3.0 feet of available head for gravity flow irrigation. With a starting water surface elevation of 37.0 feet in Canal No.6, the enclosure of the Citrus canal with PVC and RCP pipe is possible for its entire length. A design as specified in the below table would provide each turnout with a minimum of 3 cfs per irrigation. For a detailed summary of the input and output of the EPANET model refer to Appendix A.

Table 3.1: Citrus Canal Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (in.)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
C1	1,384	36	RCP	0.012	4	12
C2	1,315	36	RCP	0.012	4	12
C3	833	36	RCP	0.012	4	12
C4	171	36	RCP	0.012	4	12
C5	644	24	PVC	0.009	3	9
C6	145	24	PVC	0.009	3	9
C7	846	24	PVC	0.009	3	9
C8	936	24	PVC	0.009	2	6
C9	393	15	PVC	0.009	1	3
C10	1,027	18	PVC	0.009	2	6
Total	**7,694**					

SECTION 4.0: TAYLOR CANAL

The Taylor Canal serves 1,019 acres of farmland bounded by Gomez Rd to the north, Schmoker Rd and FM 509 to the west, Rio Hondo Rd. to the south and the HIDCC1 boundary to the east. A depiction of the canal's location and alignment is provided in Exhibits C-1 and C-2. The concrete lined canal is 9,831 ft in length and is experiencing structural failures in numerous sections with broken and collapsing concrete. The Taylor Canal receives its water from Canal No.6 and serves eleven turnouts with irrigation water. A water surface elevation of 37.0 feet in Canal No. 6 provides between 5.5 and 7.0 feet of available head for gravity flow irrigation. The entire length of the Taylor Canal can be enclosed with PVC and RCP pipe as specified below in Table 4.1 providing each turnout with a minimum of 3 cfs per irrigation. For a detailed summary of the input and output of the EPANET model refer to Appendix B.

Table 4.1: Taylor Canal Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (in.)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
T1	1,462	42	RCP	0.012	7	21
T2	1,277	42	RCP	0.012	7	21
T3	314	42	RCP	0.012	7	21
T4	539	42	RCP	0.012	7	21
T5	1,687	36	RCP	0.012	7	21
T6	1,007	36	RCP	0.012	5	15
T7	947	36	RCP	0.012	4	12
T8	1,295	24	PVC	0.009	3	9
T9	1,303	24	PVC	0.009	3	9
Total	**9,831**					

SECTION 5.0: WYRICK CANAL

The Wyrick Canal serves 2,066 acres of farmland located northeast of the intersection FM-508 and Bouldin Rd. The Wyrick canal serves several large laterals referred to in this report as the Bouldin Lateral, Wyrick Lateral A, and Wyrick Lateral B. The Wyrick canal and its laterals are depicted in Exhibits D-1 through D-3. The Wyrick canal feeds off of Canal No.1 and extends north 11,336 feet. A normal water surface elevation of 38.0 feet in Canal No. 1 provides generally between 4.0 and 7.0 feet of available head for gravity flow irrigation. The entire canal length currently consists of concrete sections with approximately the first 1,000 feet lined with polyurethane. Fifty-five turnouts receive water from the Wyrick canal, which includes the Bouldin, Wyrick A, and Wyrick B laterals.

The large service area of the Wyrick canal makes enclosure cost prohibitive. The current section consists of a concrete trapezoidal channel with a 2-foot base width, 1.5 ft/ft side slopes, and a normal water surface depth of 2.5 feet. The trapezoidal section was modeled in EPANET using an equivalent 54-inch pipe (refer to Table 5.1 below).

Table 5.1: Equivalent Pipe

Q = 1.49/n * c * S^.5

Existing Concrete Channel	
Manning's "n"	0.012
Base Width, (ft)	2
Depth, (ft)	2.5
Side Slope, (ft/ft)	1.5
Cross Sectional Area, (sq.ft.)	14.38
Wetted Perimeter, (ft)	11.01
c	17.17

Equivalent Pipe	
Manning's "n"	0.012
Diameter, (in.)	54
Cross Sectional Area, (sq.ft.)	15.90
Wetted Perimeter, (ft)	14.13
c	17.19

The Wyrick was designed to provide 10 irrigations or 30 cfs. The number of irrigations supported by each segment are provided in Table 5.2.

Table 5.2: Wyrick Canal Hydraulics

Segment I.D.	Segment Length (ft)	B.W. (ft)	Side Slope (ft)	Depth (ft)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
W1	1,549	2	1.5	3	Concrete	0.012	10	30
W2	104	2	1.5	3	Concrete	0.012	10	30
W3	190	2	1.5	3	Concrete	0.012	10	30
W4	59	2	1.5	3	Concrete	0.012	10	30
W5	279	2	1.5	3	Concrete	0.012	10	30
W6	216	2	1.5	3	Concrete	0.012	10	30
W7	880	2	1.5	3	Concrete	0.012	10	30
W8	175	2	1.5	3	Concrete	0.012	10	30
W9	258	2	1.5	3	Concrete	0.012	10	30
W10	368	2	1.5	3	Concrete	0.012	10	30
W11	448	2	1.5	3	Concrete	0.012	10	30
W12	336	2	1.5	3	Concrete	0.012	10	30
W13	2,030	2	1.5	3	Concrete	0.012	10	30
W14	1,217	2	1.5	3	Concrete	0.012	10	30
W15	841	2	1.5	3	Concrete	0.012	10	30
W16	36	2	1.5	3	Concrete	0.012	10	30
W17	142	2	1.5	3	Concrete	0.012	10	30
W18	80	2	1.5	3	Concrete	0.012	10	30
W19	743	2	1.5	3	Concrete	0.012	10	30
W20	474	2	1.5	3	Concrete	0.012	10	30
W21	198	2	1.5	3	Concrete	0.012	10	30
W22	713	2	1.5	3	Concrete	0.012	10	30
W23	525	2	1.5	3	Concrete	0.012	10	30
W24	86	2	1.5	3	Concrete	0.012	7	21
W25	342	2	1.5	3	Concrete	0.012	6	18
W26	2,214	2	1.5	3	Concrete	0.012	5	15
W27	42	2	1.5	3	Concrete	0.012	5	15
Total	**14,545**							

SECTION 5.1: BOULDIN LATERAL

The Bouldin Lateral runs west from the Wyrick canal approximately 8,950 feet north of the Wyrick check serving 243 acres of farmland. A depiction of the canal's and its service area is provided in Exhibit D-2. The concrete lined lateral is 3,076 feet in length and currently serves three turnouts. The Bouldin lateral can be enclosed with PVC and RCP pipe as specified below in Table 5.1.1. The Bouldin Lateral was designed to provide simultaneous service to all three turnouts while still meeting the minimal service requirements of 3 cfs per irrigation.

Table 5.1.1: Wyrick Canal - Bouldin Lateral Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (ft)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
B1	1,706	36	RCP	0.012	3	9
B2	783	24	PVC	0.009	2	6
B3	587	24	PVC	0.009	1	3
Total	**3,076**					

SECTION 5.2: WYRICK LATERAL A

The Wyrick Lateral A is located 11,861 feet north of the Wyrick check serving 432 acres west of the Wyrick canal. The concrete lined lateral is 5,229 feet and serves 10 turnouts. The entire Wyrick Lateral A can be enclosed with PVC and RCP pipe as specified in Table 5.2.1 below. The Wyrick Canal Lateral A was designed to provide each turnout with a minimum of 3 cfs.

Table 5.2.1: Lateral A Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (ft)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
WA1	1,351	36	RCP	0.012	4	12
WA2	1,269	36	RCP	0.012	3	9
WA3	1,318	24	PVC	0.009	2	6
WA4	1,291	18	PVC	0.009	1	3
WA5	1,346	18	PVC	0.009	1	3
WA6	70	18	PVC	0.009	2	6
WA7	1,271	18	PVC	0.009	2	6
Total	**7,916**					

SECTION 5.3: WYRICK CANAL LATERAL B

Wyrick Canal Lateral B is located 14,545 feet north of the Wyrick check and serves 363 acres of farmland east of the Wyrick Canal. The concrete lined lateral is 5,259 feet in length serving 10 turnouts. The lateral can be enclosed with PVC pipe as described below in Table 5.3.1. The lateral was designed to provide each turnout with a minimum of 3 cfs per irrigation.

Table 5.3.1: Lateral B Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (ft)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
WB1	1,291	36	RCP	0.012	4	12
WB2	944	36	RCP	0.012	4	12
WB3	423	36	RCP	0.012	4	12
WB4	335	36	RCP	0.012	3	9
WB5	738	36	RCP	0.012	3	9
WB6	250	24	PVC	0.009	2	6
WB7	654	24	PVC	0.009	2	6
WB8	624	18	PVC	0.009	1	3
Total	**5,259**					

SECTION 6.0: BOWMAN CANAL

The Bowman Canal is located east of the intersection of F.M. 800 and U.S. 83 along the border of the Harlingen Irrigation District. The proposed improvements to the Bowman Canal consist of enclosing a concrete lined section from the Bowmen check north 2,000 feet to F.M. 106. The concrete lining within this section of the canal has cracked causing considerable seepage during irrigations.

Hydraulic parameters were obtained through surveyed cross-section and site visits to determine an equivalent pipe size to replace the existing concrete lined canal section. A freeboard of 0.5 feet below the top edge of the concrete lining was assumed to determine the depth of flow within the canal. The following calculations propose a hydraulically equivalent pipe to enclose this portion of the canal. Cross-sections of the existing concrete lined canal are provided in Appendix D.

Table 6.1: Equivalent Pipe

Q = 1.49/n * c * S^.5

Existing Concrete Channel	
Manning's "n"	0.012
Base Width, (ft)	3
Depth, (ft)	2.5
Side Slope, (ft/ft)	1
Cross Sectional Area, (sq.ft.)	13.75
Wetted Perimeter, (ft)	10.07
c	16.92
Slope of Canal, (ft/ft)	0.00137
Flow Rate, (cfs)	77.8

Equivalent Pipe	
Q = 1.49/n * c * S^.5	
Manning's "n"	0.012
Diameter, (in.)	54
Cross Sectional Area, (sq.ft.)	15.90
Wetted Perimeter, (ft)	14.13
c	17.19
Slope of Canal, (ft/ft)	0.00137
Flow Rate, (cfs)	79.0

APPENDIX A
CITRUS CANAL
EPANET OUTPUT

CITRUS CANAL

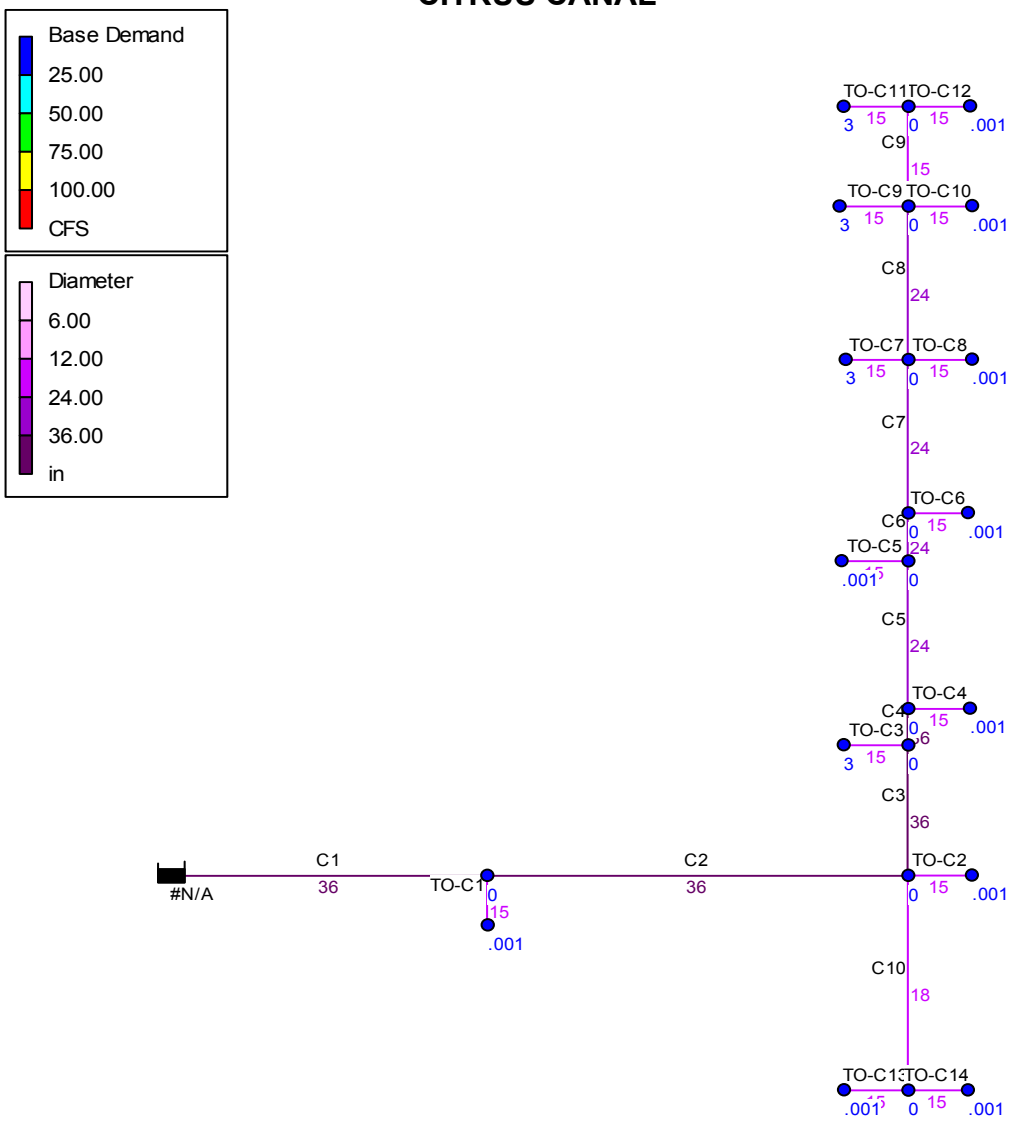

Table 3.1: Citrus Canal Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (in.)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
C1	1,384	36	RCP	0.012	4	12
C2	1,315	36	RCP	0.012	4	12
C3	833	36	RCP	0.012	4	12
C4	171	36	RCP	0.012	4	12
C5	644	24	PVC	0.009	3	9
C6	145	24	PVC	0.009	3	9
C7	846	24	PVC	0.009	3	9
C8	936	24	PVC	0.009	2	6
C9	393	15	PVC	0.009	1	3
C10	1,027	18	PVC	0.009	2	6
Total	**7,694**					

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*                          E P A N E T                           *
*                   Hydraulic and Water Quality                  *
*                   Analysis for Pipe Networks                   *
*                         Version 2.0                            *
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Input File: CITRUS-C.NET

Link - Node Table:

Link ID	Start Node	End Node	Length ft	Diameter in
C1	CANAL	C1	1384	36
C2	C1	C2	1315	36
C3	C2	C3	833	36
C4	C3	C4	171	36
C5	C4	C5	644	24
C6	C5	C6	145	24
C7	C6	C7	846	24
C8	C7	C8	936	24
C9	C8	C9	383	15
TO-C1	C1	TO-C1	60	15
C10	C2	C10	1027	18
TO-C13	C10	TO-C13	40	15
TO-C14	C10	TO-C14	80	15
TO-C2	C2	TO-C2	60	15
TO-C3	C3	TO-C3	80	15
TO-C4	C4	TO-C4	40	15
TO-C5	C5	TO-C5	80	15
TO-C6	C6	TO-C6	40	15
TO-C8	C7	TO-C8	40	15
TO-C7	C7	TO-C7	80	15
TO-C10	C8	TO-C10	40	15
TO-C9	C8	TO-C9	80	15
TO-C12	C9	TO-C12	40	15
TO-C11	C9	TO-C11	80	15

Node Results:

Node ID	Demand CFS	Head ft	Pressure psi	Quality
C1	0.00	36.62	0.70	0.00
C2	0.00	36.26	0.55	0.00
C10	0.00	36.26	0.55	0.00
C3	0.00	36.03	0.45	0.00
C4	0.00	36.00	0.43	0.00
C5	0.00	35.52	0.22	0.00
C6	0.00	35.41	0.18	0.00

Node Results: (continued)

Node ID	Demand CFS	Head ft	Pressure psi	Quality	
C7	0.00	34.77	-0.10	0.00	
C8	0.00	34.45	-0.24	0.00	
C9	0.00	34.06	-0.41	0.00	
TO-C11	3.00	33.98	0.01	0.00	
TO-C9	3.00	34.37	0.13	0.00	
TO-C7	3.00	34.69	0.13	0.00	
TO-C5	0.00	35.52	0.35	0.00	
TO-C3	3.00	35.95	0.41	0.00	
TO-C2	0.00	36.26	0.42	0.00	
TO-C14	0.00	36.26	8.68	0.00	
TO-C4	0.00	36.00	0.43	0.00	
TO-C6	0.00	35.41	0.31	0.00	
TO-C8	0.00	34.77	0.16	0.00	
TO-C1	0.00	36.62	0.80	0.00	
TO-C12	0.00	34.06	0.05	0.00	
TO-C10	0.00	34.45	0.16	0.00	
TO-C13	0.00	36.26	8.68	0.00	
CANAL	-12.01	37.00	0.00	0.00	Reservoir

Link Results:

Link ID	Flow CFS	Velocity fps	Unit Headloss ft/Kft	Status
C1	12.01	1.70	0.27	Open
C2	12.01	1.70	0.27	Open
C3	12.01	1.70	0.27	Open
C4	9.01	1.27	0.15	Open
C5	9.01	2.87	0.76	Open
C6	9.00	2.87	0.76	Open
C7	9.00	2.87	0.75	Open
C8	6.00	1.91	0.34	Open
C9	3.00	2.45	1.03	Open
TO-C1	0.00	0.00	0.00	Open
C10	0.00	0.00	0.00	Open
TO-C13	0.00	0.00	0.00	Open
TO-C14	0.00	0.00	0.00	Open
TO-C2	0.00	0.00	0.00	Open
TO-C3	3.00	2.44	1.03	Open
TO-C4	0.00	0.00	0.00	Open
TO-C5	0.00	0.00	0.00	Open
TO-C6	0.00	0.00	0.00	Open
TO-C8	0.00	0.00	0.00	Open
TO-C7	3.00	2.44	1.03	Open
TO-C10	0.00	0.00	0.00	Open
TO-C9	3.00	2.44	1.03	Open
TO-C12	0.00	0.00	0.00	Open

Link Results: (continued)

Link ID	Flow CFS	Velocity fps	Unit Headloss ft/Kft	Status
TO-C11	3.00	2.44	1.03	Open

APPENDIX B
TAYLOR CANAL
EPANET OUTPUT

TAYLOR CANAL

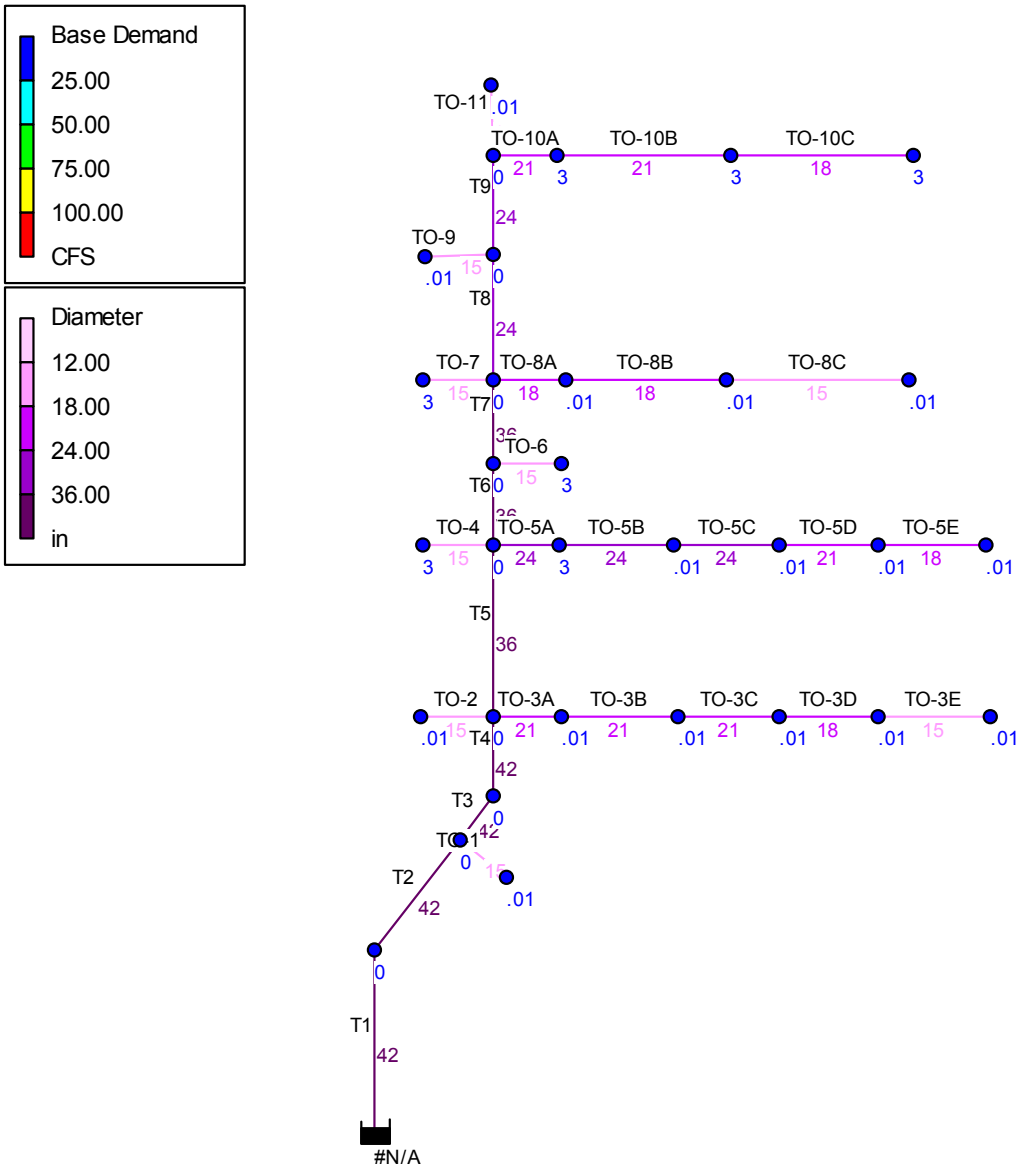

Table 4.1: Taylor Canal

Segment I.D.	Segment Length (ft)	Pipe Dia. (in.)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
T1	1462	42	RCP	0.012	7	21
T2	1277	42	RCP	0.012	7	21
T3	314	42	RCP	0.012	7	21
T4	539	42	RCP	0.012	7	21
T5	1687	36	RCP	0.012	7	21
T6	1007	36	RCP	0.012	5	15
T7	947	36	RCP	0.012	4	12
T8	1295	24	PVC	0.009	3	9
T9	1303	24	PVC	0.009	3	9

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*                          E P A N E T                           *
*                   Hydraulic and Water Quality                  *
*                   Analysis for Pipe Networks                   *
*                         Version 2.0                            *
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Input File: Taylor-C.NET
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Link - Node Table:

Link ID	Start Node	End Node	Length ft	Diameter in
T1	1	T1	1462	42
T2	T1	T2	1277	42
T3	T2	T3	314	42
T4	T3	T4	539	42
T5	T4	T5	1687	36
T6	T5	T6	1007	36
T7	T6	T7	947	36
T8	T7	T8	1295	24
T9	T8	T9	1303	24
TO-11	T9	TO-11	40	15
TO-1	TO-1	T2	40	15
TO-3A	TO-3A	T4	40	21
TO-2	TO-2	T4	60	15
TO-5A	TO-5A	T5	40	24
TO-4	TO-4	T5	60	15
TO-6	TO-6	T6	40	15
TO-8A	TO-8A	T7	40	18
TO-7	TO-7	T7	60	15
TO-9	TO-9	T8	60	15
TO-10A	TO-10A	T9	40	21
TO-10B	TO-10A	TO-10B	1271	21
TO-10C	TO-10B	TO-10C	1332	18
TO-8B	TO-8A	TO-8B	1598	18
TO-8C	TO-8B	TO-8C	985	15
TO-5B	TO-5A	TO-5B	650	24
TO-5C	TO-5B	TO-5C	650	24
TO-5D	TO-5C	TO-5D	650	21
TO-5E	TO-5D	TO-5E	650	18
TO-3B	TO-3A	TO-3B	650	21
TO-3C	TO-3B	TO-3C	650	21
TO-3D	TO-3C	TO-3D	650	18
TO-3E	TO-3D	TO-3E	650	15

Node Results:

Node ID	Demand CFS	Head ft	Pressure psi	Quality	
T1	0.00	36.48	1.51	0.00	
T2	0.00	36.00	1.30	0.00	
T3	0.00	35.89	1.25	0.00	
T4	0.00	35.68	1.16	0.00	
T5	0.00	34.25	0.54	0.00	
T6	0.00	33.82	0.36	0.00	
T7	0.00	33.56	0.24	0.00	
T8	0.00	32.58	-0.18	0.00	
T9	0.00	31.59	-0.61	0.00	
TO-11	0.01	31.59	0.05	0.00	
TO-1	0.01	36.00	2.48	0.00	
TO-3A	0.01	35.68	2.45	0.00	
TO-2	0.01	35.68	1.13	0.00	
TO-4	3.00	34.19	0.48	0.00	
TO-5A	3.00	34.25	1.43	0.00	
TO-6	3.00	33.78	1.25	0.00	
TO-7	3.00	33.50	0.94	0.00	
TO-8A	0.01	33.56	1.90	0.00	
TO-9	0.01	32.58	0.37	0.00	
TO-10A	3.00	31.53	0.62	0.00	
TO-10B	3.00	30.66	0.24	0.00	
TO-10C	3.00	30.14	0.01	0.00	
TO-8B	0.01	33.56	1.90	0.00	
TO-8C	0.01	33.56	1.90	0.00	
TO-5B	0.01	34.25	1.43	0.00	
TO-5C	0.01	34.25	1.43	0.00	
TO-5D	0.01	34.25	1.43	0.00	
TO-5E	0.01	34.25	1.43	0.00	
TO-3B	0.01	35.68	2.45	0.00	
TO-3C	0.01	35.68	2.45	0.00	
TO-3D	0.01	35.68	2.45	0.00	
TO-3E	0.01	35.68	2.45	0.00	
1	-21.16	37.03	0.00	0.00	Reservoir

Link Results:

Link ID	Flow CFS	Velocity fps	Unit Headloss ft/Kft	Status
T1	21.16	2.20	0.37	Open
T2	21.16	2.20	0.37	Open
T3	21.15	2.20	0.37	Open
T4	21.15	2.20	0.37	Open
T5	21.09	2.98	0.85	Open
T6	15.05	2.13	0.43	Open
T7	12.05	1.70	0.28	Open
T8	9.02	2.87	0.76	Open

Link Results: (continued)

Link ID	Flow CFS	Velocity fps	Unit Headloss ft/Kft	Status
T9	9.01	2.87	0.76	Open
TO-11	0.01	0.01	0.00	Open
TO-1	-0.01	0.01	0.00	Open
TO-3A	-0.05	0.02	0.00	Open
TO-2	-0.01	0.01	0.00	Open
TO-5A	-3.04	0.97	0.09	Open
TO-4	-3.00	2.44	1.03	Open
TO-6	-3.00	2.44	1.03	Open
TO-8A	-0.03	0.02	0.00	Open
TO-7	-3.00	2.44	1.03	Open
TO-9	-0.01	0.01	0.00	Open
TO-10A	-9.00	3.74	1.54	Open
TO-10B	6.00	2.49	0.68	Open
TO-10C	3.00	1.70	0.39	Open
TO-8B	0.02	0.01	0.00	Open
TO-8C	0.01	0.01	0.00	Open
TO-5B	0.04	0.01	0.00	Open
TO-5C	0.03	0.01	0.00	Open
TO-5D	0.02	0.01	0.00	Open
TO-5E	0.01	0.01	0.00	Open
TO-3B	0.04	0.02	0.00	Open
TO-3C	0.03	0.01	0.00	Open
TO-3D	0.02	0.01	0.00	Open
TO-3E	0.01	0.01	0.00	Open

APPENDIX C
WYRICK CANAL
EPANET OUTPUT

WYRICK CANAL

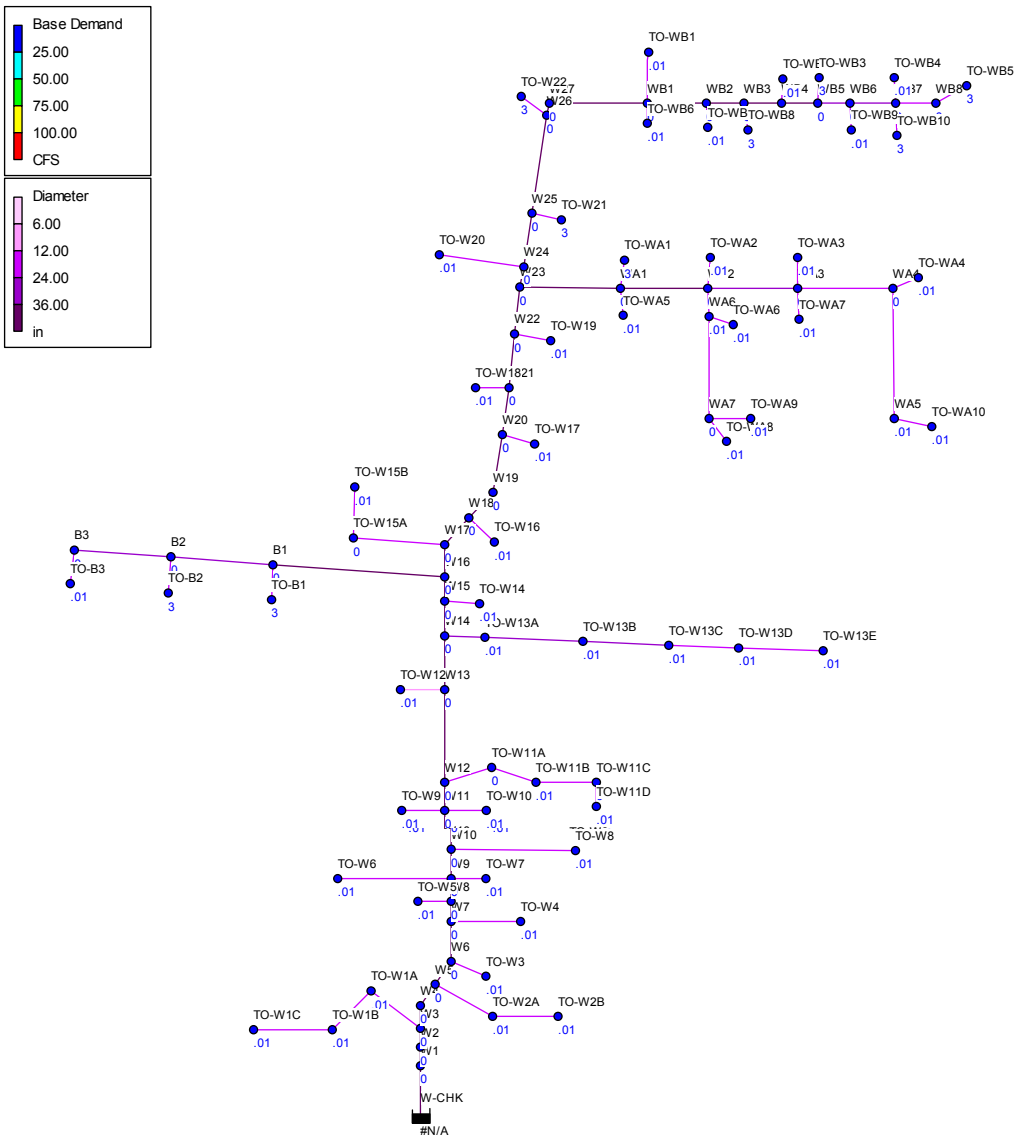

Table 5.2: Wyrick Canal Hydraulics

Segment I.D.	Segment Length (ft)	B.W. (ft)	Side Slope (ft)	Depth (ft)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
W1	1,549	2	1.5	3	Concrete	0.012	10	30
W2	104	2	1.5	3	Concrete	0.012	10	30
W3	190	2	1.5	3	Concrete	0.012	10	30
W4	59	2	1.5	3	Concrete	0.012	10	30
W5	279	2	1.5	3	Concrete	0.012	10	30
W6	216	2	1.5	3	Concrete	0.012	10	30
W7	880	2	1.5	3	Concrete	0.012	10	30
W8	175	2	1.5	3	Concrete	0.012	10	30
W9	258	2	1.5	3	Concrete	0.012	10	30
W10	368	2	1.5	3	Concrete	0.012	10	30
W11	448	2	1.5	3	Concrete	0.012	10	30
W12	336	2	1.5	3	Concrete	0.012	10	30
W13	2,030	2	1.5	3	Concrete	0.012	10	30
W14	1,217	2	1.5	3	Concrete	0.012	10	30
W15	841	2	1.5	3	Concrete	0.012	10	30
W16	36	2	1.5	3	Concrete	0.012	10	30
W17	142	2	1.5	3	Concrete	0.012	10	30
W18	80	2	1.5	3	Concrete	0.012	10	30
W19	743	2	1.5	3	Concrete	0.012	10	30
W20	474	2	1.5	3	Concrete	0.012	10	30
W21	198	2	1.5	3	Concrete	0.012	10	30
W22	713	2	1.5	3	Concrete	0.012	10	30
W23	525	2	1.5	3	Concrete	0.012	10	30
W24	86	2	1.5	3	Concrete	0.012	7	21
W25	342	2	1.5	3	Concrete	0.012	6	18
W26	2,214	2	1.5	3	Concrete	0.012	5	15
W27	42	2	1.5	3	Concrete	0.012	5	15
Total	**14,545**							

Table 5.1.1: Wyrick Canal - Bouldin Lateral Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (ft)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
B1	1,706	36	RCP	0.012	3	9
B2	783	24	PVC	0.009	2	6
B3	587	24	PVC	0.009	1	3
Total	**3,076**					

Table 5.2.1: Lateral A Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (ft)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
WA1	1,351	36	RCP	0.012	4	12
WA2	1,269	36	RCP	0.012	3	9
WA3	1,318	24	PVC	0.009	2	6
WA4	1,291	18	PVC	0.009	1	3
WA5	1,346	18	PVC	0.009	1	3
WA6	70	18	PVC	0.009	2	6
WA7	1,271	18	PVC	0.009	2	6
Total	**7,916**					

Table 5.3.1: Lateral B Hydraulics

Segment I.D.	Segment Length (ft)	Pipe Dia. (ft)	Pipe Material	Manning's "n"	# of Irrigations	Design Q (cfs)
WB1	1,291	36	RCP	0.012	4	12
WB2	944	36	RCP	0.012	4	12
WB3	423	36	RCP	0.012	4	12
WB4	335	36	RCP	0.012	3	9
WB5	738	36	RCP	0.012	3	9
WB6	250	24	PVC	0.009	2	6
WB7	654	24	PVC	0.009	2	6
WB8	624	18	PVC	0.009	1	3
Total	**5,259**					

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*************************************************************************
*                            E P A N E T                                *
*                      Hydraulic and Water Quality                      *
*                      Analysis for Pipe Networks                       *
*                            Version 2.0                                *
*************************************************************************
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Input File: Wyrick-C.NET

Wyrick

Link - Node Table:

Link ID	Start Node	End Node	Length ft	Diameter in
W2	W1	W2	104	54
W3	W2	W3	190	54
W4	W3	W4	59	54
W5	W4	W5	279	54
W6	W5	W6	216	54
W7	W6	W7	880	54
W8	W7	W8	175	54
W9	W8	W9	258	54
W10	W9	W10	365	54
W11	W10	W11	448	54
W12	W11	W12	336	54
W13	W12	W13	2030	54
W14	W13	W14	1217	54
W15	W14	W15	841	54
W16	W15	W16	36	54
W1	W-CHK	W1	1549	54
W17	W16	W17	142	54
W18	W17	W18	80	54
W19	W18	W19	743	54
W20	W19	W20	474	54
W21	W20	W21	198	54
W22	W21	W22	713	54
W23	W22	W23	525	54
W24	W23	W24	86	54
W25	W24	W25	342	54
W26	W25	W26	2214	54
W27	W26	W27	42	54
WB1	W27	WB1	1291	36
WB2	WB1	WB2	944	36
WB3	WB2	WB3	423	36
WB4	WB3	WB4	335	36
WB5	WB4	WB5	738	36
WB6	WB5	WB6	250	24
WB7	WB6	WB7	654	24
WB8	WB7	WB8	624	18
WA1	W23	WA1	1351	36
WA2	WA1	WA2	1269	36

Link - Node Table: (continued)

Link ID	Start Node	End Node	Length ft	Diameter in
WA3	WA2	WA3	1318	24
WA4	WA3	WA4	1291	18
B1	W16	B1	1706	36
B2	B1	B2	783	24
B3	B2	B3	587	24
WA6	WA2	WA6	70	18
TO-W1A	TO-W1A	W3	192	18
TO-W2A	W5	TO-W2A	550	15
TO-W2B	TO-W2A	TO-W2B	438	15
TO-W3	W6	TO-W3	60	15
TO-W4	W7	TO-W4	500	15
TO-W5	TO-W5	W8	60	15
TO-W7	W9	TO-W7	60	15
TO-W6	W9	TO-W6	900	15
TO-W8	W10	TO-W8	845	15
TO-W10	W11	TO-W10	60	15
TO-W9	W11	TO-W9	60	15
TO-W11A	W12	TO-W11A	419	18
TO-W11B	TO-W11A	TO-W11B	360	15
TO-W11C	TO-W11B	TO-W11C	328	15
TO-W11D	TO-W11C	TO-W11D	186	15
TO-W12	TO-W12	W13	60	8
TO-W13A	W14	TO-W13A	66	30
TO-W13B	TO-W13A	TO-W13B	1021	30
TO-W13C	TO-W13B	TO-W13C	1019	24
TO-W13D	TO-W13C	TO-W13D	268	18
TO-W13E	TO-W13D	TO-W13E	814	15
TO-W14	W15	TO-W14	60	15
TO-B1	B1	TO-B1	40	18
TO-B2	B2	TO-B2	40	18
TO-B3	B3	TO-B3	30	18
TO-W15A	W17	TO-W15A	833	15
TO-W15B	TO-W15A	TO-W15B	461	15
TO-W16	W18	TO-W16	60	15
TO-W17	W20	TO-W17	60	15
TO-W18	W21	TO-W18	60	15
TO-W19	W22	TO-W19	60	15
TO-WA5	WA1	TO-WA5	40	15
TO-WA1	WA1	TO-WA1	40	15
TO-WA2	WA2	TO-WA2	70	15
WA7	WA6	WA7	1271	18
TO-WA9	WA7	TO-WA9	343	15
TO-WA8	WA7	TO-WA8	90	15
TO-WA3	WA3	TO-WA3	70	15
TO-WA7	WA3	TO-WA7	60	15
TO-WA4	WA4	TO-WA4	50	15
TO-W20	W24	TO-W20	1320	15

Link - Node Table: (continued)

Link ID	Start Node	End Node	Length ft	Diameter in
TO-W21	W25	TO-W21	60	15
TO-W22	TO-W22	W26	60	15
TO-WB6	WB1	TO-WB6	45	15
TO-WB1	WB1	TO-WB1	1143	15
TO-WB7	WB2	TO-WB7	100	15
TO-WB8	WB3	TO-WB8	95	15
TO-WB2	WB4	TO-WB2	20	15
TO-WB3	TO-WB3	WB5	20	15
TO-WB9	WB6	TO-WB9	100	15
TO-WB10	WB7	TO-WB10	100	15
TO-WB4	WB7	TO-WB4	40	15
TO-WB5	WB8	TO-WB5	60	15
TO-WA10	TO-WA10	WA5	30	15
TO-WA6	WA6	TO-WA6	30	15
TO-W1B	TO-W1A	TO-W1B	215	15
TO-W1C	TO-W1B	TO-W1C	594	15
WA5	WA4	WA5	1346	18

Node Results:

Node ID	Demand CFS	Head ft	Pressure psi	Quality
W1	0.00	37.76	1.20	0.00
W2	0.00	37.75	1.19	0.00
W3	0.00	37.72	1.18	0.00
W4	0.00	37.71	1.17	0.00
W5	0.00	37.66	1.15	0.00
W6	0.00	37.62	1.14	0.00
W7	0.00	37.48	1.07	0.00
W8	0.00	37.45	1.06	0.00
W9	0.00	37.41	1.04	0.00
W10	0.00	37.35	1.02	0.00
W11	0.00	37.27	0.99	0.00
W12	0.00	37.22	0.96	0.00
W13	0.00	36.89	0.82	0.00
W14	0.00	36.69	0.73	0.00
W15	0.00	36.55	0.67	0.00
W16	0.00	36.55	0.67	0.00
B1	0.00	36.43	0.62	0.00
B2	0.00	36.31	0.57	0.00
B3	0.00	36.31	0.57	0.00
W17	0.00	36.53	0.66	0.00
W18	0.00	36.52	0.66	0.00
W19	0.00	36.45	0.63	0.00
W20	0.00	36.40	0.61	0.00
W21	0.00	36.39	0.60	0.00

Node Results: (continued)

Node ID	Demand CFS	Head ft	Pressure psi	Quality
W22	0.00	36.31	0.57	0.00
W23	0.00	36.26	0.55	0.00
W24	0.00	36.26	0.54	0.00
W25	0.00	36.23	0.53	0.00
W26	0.00	36.12	0.49	0.00
W27	0.00	36.12	0.49	0.00
WB1	0.00	35.76	0.33	0.00
WB2	0.00	35.50	0.22	0.00
WB3	0.00	35.39	0.17	0.00
WB4	0.00	35.33	0.14	0.00
WB5	0.00	35.22	0.10	0.00
WB6	0.00	35.14	0.06	0.00
WB7	0.00	34.92	-0.04	0.00
WB8	0.00	34.67	-0.14	0.00
TO-WB5	3.00	34.61	0.30	0.00
WA1	0.00	36.24	0.54	0.00
WA2	0.00	36.24	0.54	0.00
WA3	0.00	36.24	0.54	0.00
WA4	0.00	36.24	0.54	0.00
WA6	0.01	36.24	1.40	0.00
TO-W1A	0.01	37.72	2.04	0.00
TO-W2A	0.01	37.66	2.02	0.00
TO-W2B	0.01	37.66	2.02	0.00
TO-W3	0.01	37.62	2.00	0.00
TO-W4	0.01	37.48	1.94	0.00
TO-W5	0.01	37.45	1.93	0.00
TO-W6	0.01	37.41	1.91	0.00
TO-W7	0.01	37.41	1.91	0.00
TO-W8	0.01	37.35	1.88	0.00
TO-W9	0.01	37.27	1.85	0.00
TO-W10	0.01	37.27	1.85	0.00
TO-W11A	0.00	37.22	1.83	0.00
TO-W11B	0.01	37.22	1.83	0.00
TO-W11C	0.00	37.22	1.83	0.00
TO-W11D	0.01	37.22	1.83	0.00
TO-W12	0.01	36.89	1.68	0.00
TO-W13A	0.01	36.69	1.60	0.00
TO-W13B	0.01	36.69	1.60	0.00
TO-W13C	0.01	36.69	1.60	0.00
TO-W13D	0.01	36.69	1.60	0.00
TO-W13E	0.01	36.69	1.60	0.00
TO-W14	0.01	36.55	1.54	0.00
TO-B3	0.01	36.31	0.50	0.00
TO-B2	3.00	36.30	0.93	0.00
TO-B1	3.00	36.41	1.32	0.00
TO-W15A	0.00	36.53	1.41	0.00
TO-W15B	0.01	36.53	1.41	0.00

Node Results: (continued)

Node ID	Demand CFS	Head ft	Pressure psi	Quality	
TO-W16	0.01	36.52	1.53	0.00	
TO-W17	0.01	36.40	1.48	0.00	
TO-W18	0.01	36.39	1.47	0.00	
TO-W19	0.01	36.31	1.44	0.00	
TO-WA5	0.01	36.24	1.34	0.00	
TO-WA1	3.00	36.20	1.75	0.00	
TO-WA2	0.01	36.24	2.14	0.00	
WA7	0.00	36.24	1.40	0.00	
TO-WA8	0.01	36.24	1.77	0.00	
TO-WA9	0.01	36.24	1.77	0.00	
TO-WA3	0.01	36.24	2.35	0.00	
TO-WA7	0.01	36.24	2.26	0.00	
TO-WA4	0.01	36.24	2.24	0.00	
WA5	0.01	36.24	1.40	0.00	
TO-W20	0.01	36.26	1.41	0.00	
TO-W21	3.00	36.17	1.37	0.00	
TO-W22	3.00	36.06	1.33	0.00	
TO-WB6	0.01	35.76	1.04	0.00	
TO-WB1	0.01	35.76	1.20	0.00	
TO-WB7	0.01	35.50	1.07	0.00	
TO-WB8	3.00	35.29	1.08	0.00	
TO-WB2	0.01	35.33	0.61	0.00	
TO-WB3	3.00	35.20	0.55	0.00	
TO-WB9	0.01	35.14	1.66	0.00	
TO-WB4	0.01	34.92	0.43	0.00	
TO-WB10	3.00	34.81	1.52	0.00	
TO-WA10	0.01	36.24	2.24	0.00	
TO-WA6	0.01	36.24	1.77	0.00	
TO-W1B	0.01	37.72	2.04	0.00	
TO-W1C	0.01	37.72	2.04	0.00	
W-CHK	-27.46	38.02	0.00	0.00	Reservoir

Link Results:

Link ID	Flow CFS	Velocity fps	Unit Headloss ft/Kft	Status
W2	27.46	1.73	0.17	Open
W3	27.46	1.73	0.17	Open
W4	27.43	1.72	0.16	Open
W5	27.43	1.72	0.16	Open
W6	27.41	1.72	0.16	Open
W7	27.40	1.72	0.16	Open
W8	27.39	1.72	0.16	Open
W9	27.38	1.72	0.16	Open
W10	27.36	1.72	0.16	Open
W11	27.35	1.72	0.16	Open

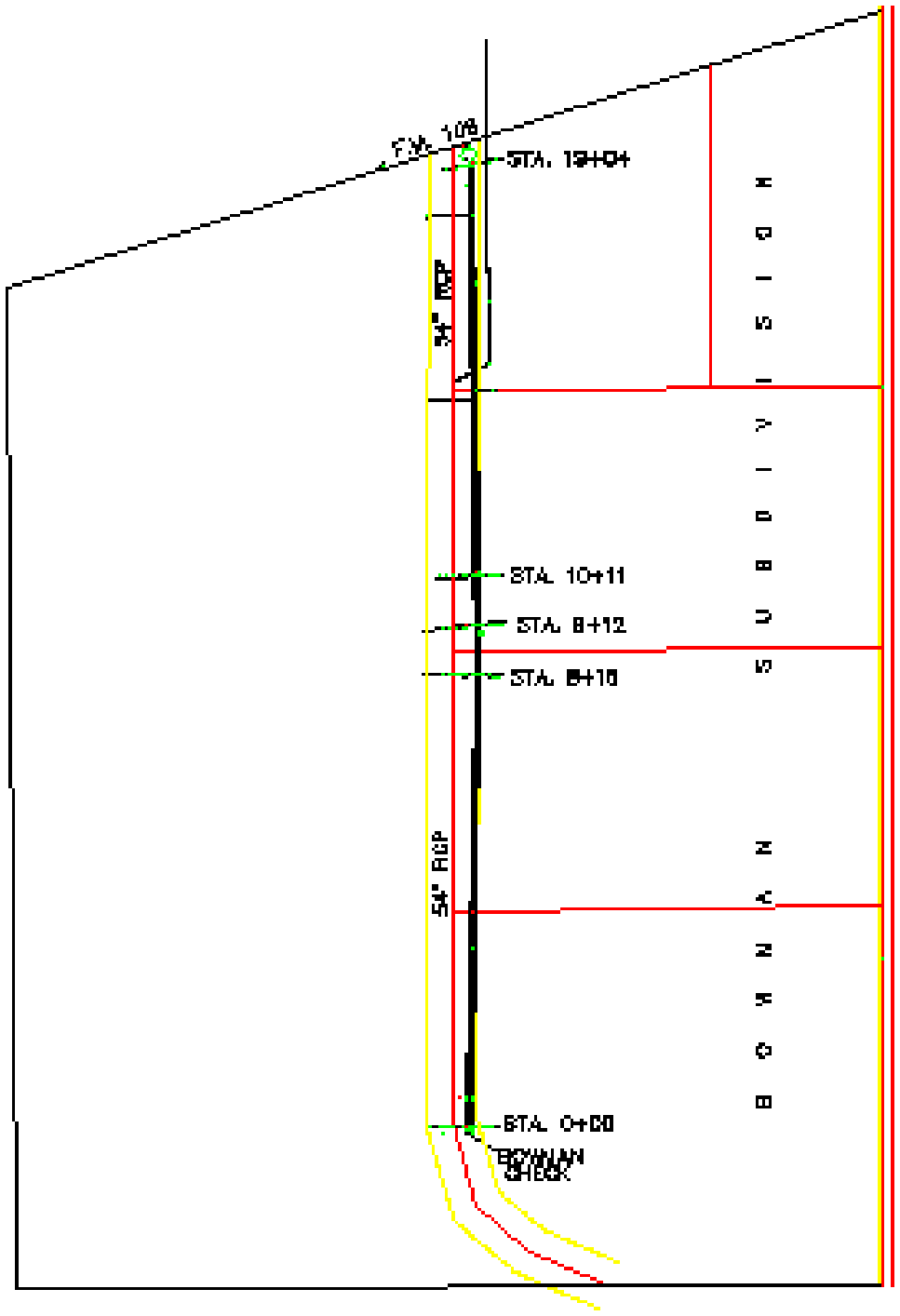
Link Results: (continued)

Link ID	Flow CFS	Velocity fps	Unit Headloss ft/Kft	Status
W12	27.33	1.72	0.16	Open
W13	27.31	1.72	0.16	Open
W14	27.30	1.72	0.16	Open
W15	27.25	1.71	0.16	Open
W16	27.24	1.71	0.16	Open
W1	27.46	1.73	0.17	Open
W17	21.23	1.33	0.10	Open
W18	21.22	1.33	0.10	Open
W19	21.21	1.33	0.10	Open
W20	21.21	1.33	0.10	Open
W21	21.20	1.33	0.10	Open
W22	21.19	1.33	0.10	Open
W23	21.18	1.33	0.10	Open
W24	18.07	1.14	0.07	Open
W25	18.06	1.14	0.07	Open
W26	15.06	0.95	0.05	Open
W27	12.06	0.76	0.03	Open
WB1	12.06	1.71	0.28	Open
WB2	12.04	1.70	0.28	Open
WB3	12.03	1.70	0.28	Open
WB4	9.03	1.28	0.16	Open
WB5	9.02	1.28	0.15	Open
WB6	6.02	1.92	0.34	Open
WB7	6.01	1.91	0.34	Open
WB8	3.00	1.70	0.39	Open
WA1	3.11	0.44	0.02	Open
WA2	0.10	0.01	0.00	Open
WA3	0.05	0.02	0.00	Open
WA4	0.03	0.02	0.00	Open
B1	6.01	0.85	0.07	Open
B2	3.01	0.96	0.15	Open
B3	0.01	0.00	0.00	Open
WA6	0.04	0.02	0.00	Open
TO-W1A	-0.03	0.02	0.00	Open
TO-W2A	0.02	0.02	0.00	Open
TO-W2B	0.01	0.01	0.00	Open
TO-W3	0.01	0.01	0.00	Open
TO-W4	0.01	0.01	0.00	Open
TO-W5	-0.01	0.01	0.00	Open
TO-W7	0.01	0.01	0.00	Open
TO-W6	0.01	0.01	0.00	Open
TO-W8	0.01	0.01	0.00	Open
TO-W10	0.01	0.01	0.00	Open
TO-W9	0.01	0.01	0.00	Open
TO-W11A	0.02	0.01	0.00	Open
TO-W11B	0.02	0.02	0.00	Open
TO-W11C	0.01	0.01	0.00	Open

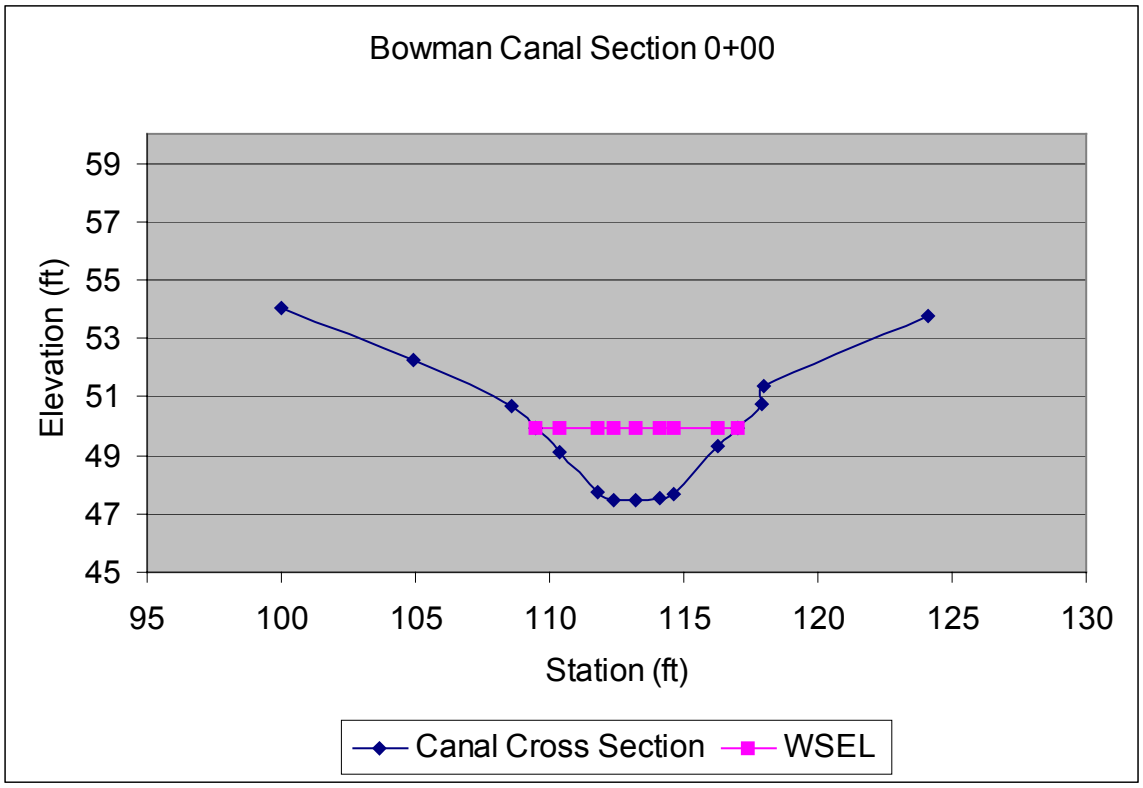
Link Results: (continued)

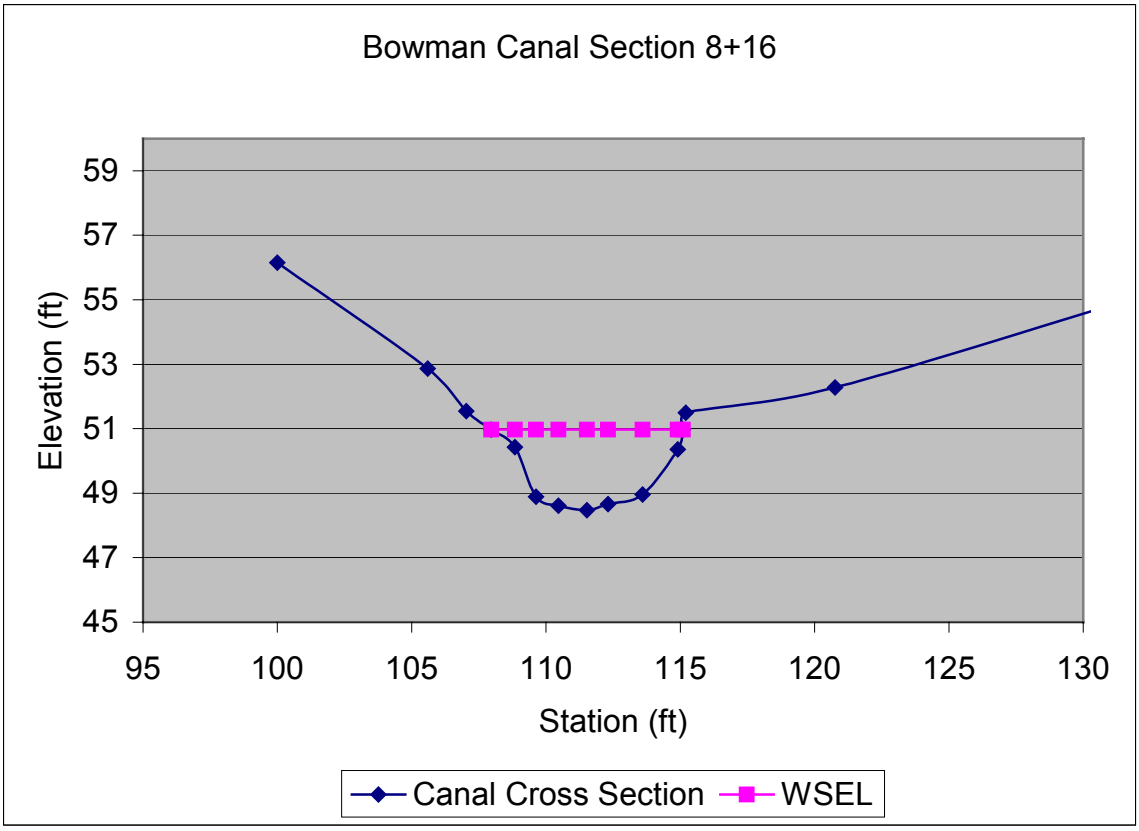
Link ID	Flow CFS	Velocity fps	Unit Headloss ft/Kft	Status
TO-W11D	0.01	0.01	0.00	Open
TO-W12	-0.01	0.03	0.00	Open
TO-W13A	0.05	0.01	0.00	Open
TO-W13B	0.04	0.01	0.00	Open
TO-W13C	0.03	0.01	0.00	Open
TO-W13D	0.02	0.01	0.00	Open
TO-W13E	0.01	0.01	0.00	Open
TO-W14	0.01	0.01	0.00	Open
TO-B1	3.00	1.70	0.39	Open
TO-B2	3.00	1.70	0.39	Open
TO-B3	0.01	0.01	0.00	Open
TO-W15A	0.01	0.01	0.00	Open
TO-W15B	0.01	0.01	0.00	Open
TO-W16	0.01	0.01	0.00	Open
TO-W17	0.01	0.01	0.00	Open
TO-W18	0.01	0.01	0.00	Open
TO-W19	0.01	0.01	0.00	Open
TO-WA5	0.01	0.01	0.00	Open
TO-WA1	3.00	2.44	1.03	Open
TO-WA2	0.01	0.01	0.00	Open
WA7	0.02	0.01	0.00	Open
TO-WA9	0.01	0.01	0.00	Open
TO-WA8	0.01	0.01	0.00	Open
TO-WA3	0.01	0.01	0.00	Open
TO-WA7	0.01	0.01	0.00	Open
TO-WA4	0.01	0.01	0.00	Open
TO-W20	0.01	0.01	0.00	Open
TO-W21	3.00	2.44	1.03	Open
TO-W22	-3.00	2.44	1.03	Open
TO-WB6	0.01	0.01	0.00	Open
TO-WB1	0.01	0.01	0.00	Open
TO-WB7	0.01	0.01	0.00	Open
TO-WB8	3.00	2.44	1.03	Open
TO-WB2	0.01	0.01	0.00	Open
TO-WB3	-3.00	2.44	1.03	Open
TO-WB9	0.01	0.01	0.00	Open
TO-WB10	3.00	2.44	1.03	Open
TO-WB4	0.01	0.01	0.00	Open
TO-WB5	3.00	2.44	1.03	Open
TO-WA10	-0.01	0.01	0.00	Open
TO-WA6	0.01	0.01	0.00	Open
TO-W1B	0.02	0.02	0.00	Open
TO-W1C	0.01	0.01	0.00	Open
WA5	0.02	0.01	0.00	Open

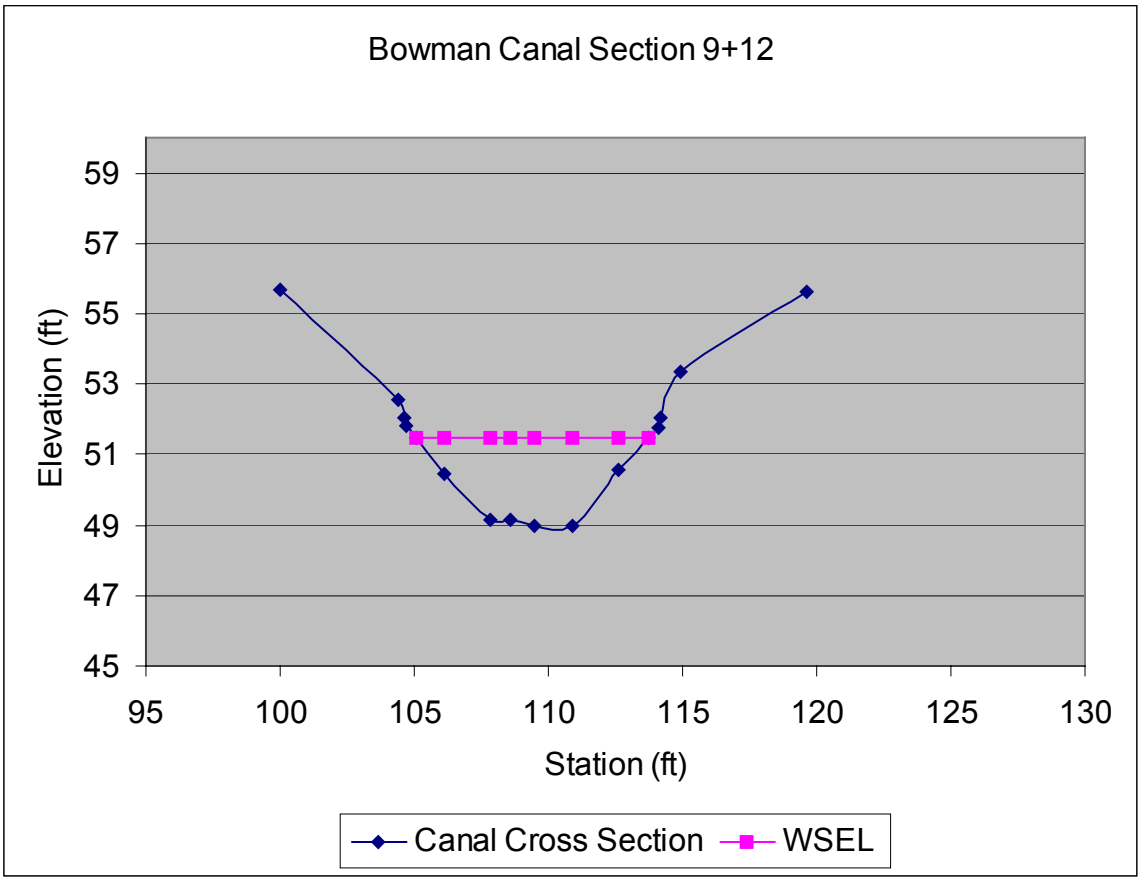
APPENDIX D
BOWMEN CANAL
CROSS-SECTIONS

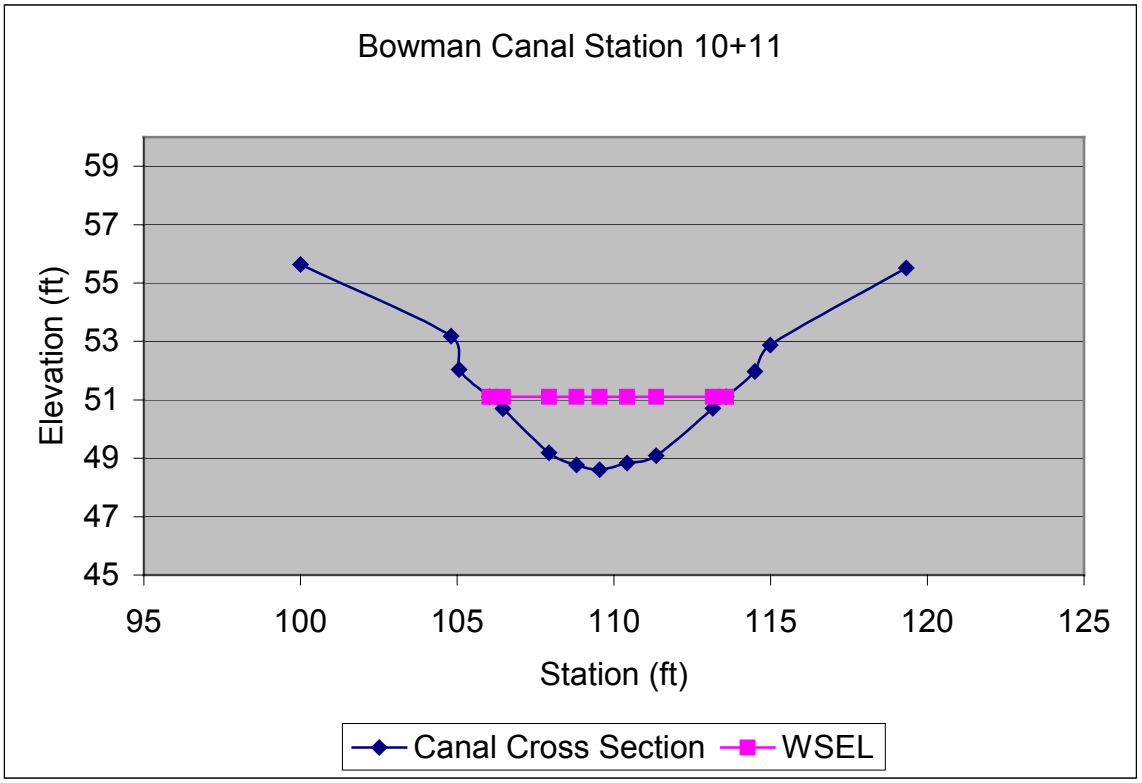


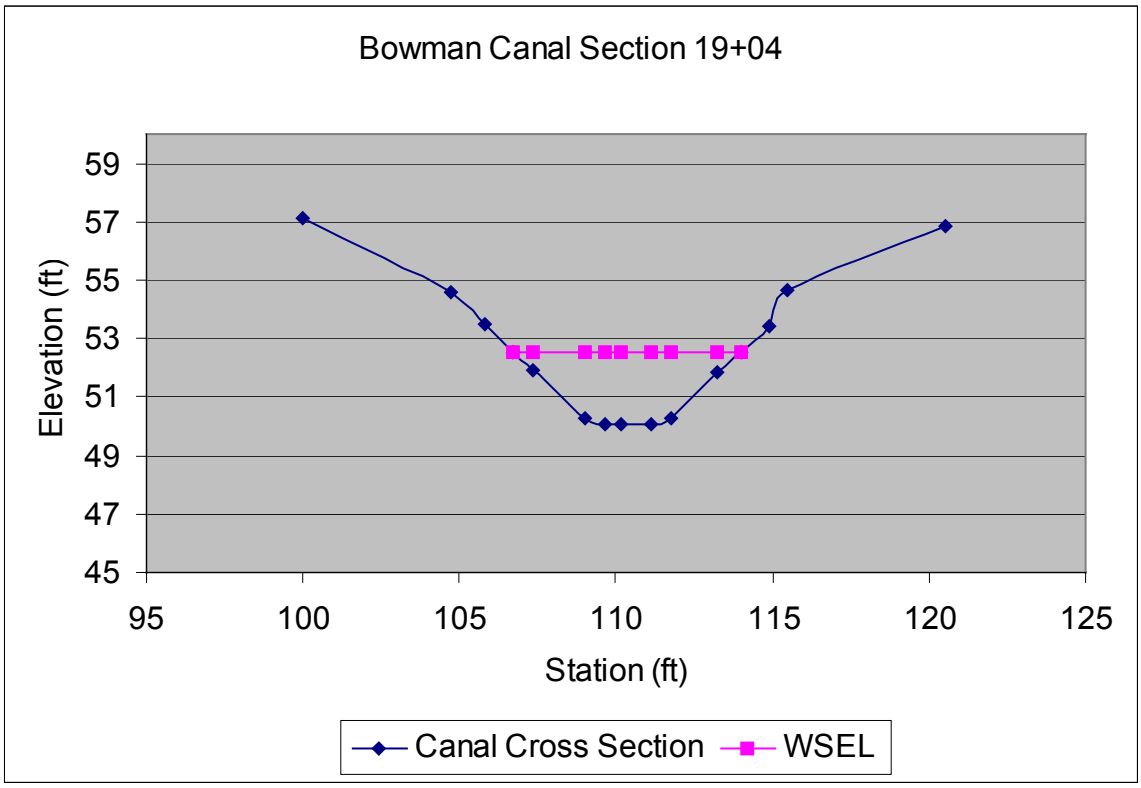
BOWMAN CANAL CROSS-SECTIONS


Bowman Canal Section 0+00
Elevation (ft)
59
57
55
53
51
49
47
45
95
100
105
110
115
120
125
130
Station (ft)
Canal Cross Section
WSEL


Bowman Canal Section 8+16
Elevation (ft)
59
57
55
53
51
49
47
45
95
100
105
110
115
120
125
130
Station (ft)
Canal Cross Section
WSEL


Bowman Canal Section 9+12
Elevation (ft)
59
57
55
53
51
49
47
45
95
100
105
110
115
120
125
130
Station (ft)
Canal Cross Section
WSEL


Bowman Canal Station 10+11
Elevation (ft)
59
57
55
53
51
49
47
45
95
100
105
110
115
120
125
Station (ft)
Canal Cross Section
WSEL


Bowman Canal Section 19+04
59
57
55
53
51
49
47
45
Elevation (ft)
95
100
105
110
115
120
125
Station (ft)
Canal Cross Section
WSEL