CHAPTER 3 DATA COLLECTION

3.1 INTRODUCTION

In order to develop a HEC-RAS model for bendway-weir analysis, survey data were collected and a testing program was conducted to collect flow-depth measurements with and without bendway weirs. The testing program was divided into two parts: base-line testing and bendway-weir testing. A base-line testing program was conducted in order to build a HEC-RAS model without bendway weirs. A bendway-weir testing program was conducted to build a HEC-RAS model for one bendway-weir configuration. Bendway-weir configurations consisted of a set weir length, weir height, weir spacing, and orientation angle for a known meander bend geometry. All tests were conducted in a 1:12 Froude scale, rigid, concrete boundary, physical hydraulic model constructed in the Hydromachinery Laboratory at the Engineering Research Center, Colorado State University. Figure 3.1 shows the location of the Hydromachinery Laboratory at the Engineering Research Center.

Figure 3.1. Location of Hydromachinery Laboratory at the Engineering Research Center

3.2 MODEL DESCRIPTION

An undistorted 1:12 Froude scale, rigid, concrete boundary, physical hydraulic model was constructed to represent meander bends in a 29-mile study reach of the Middle Rio Grande. Figure 3.2 locates the 29-mile study reach in New Mexico. Based on planform data collected along the 29-mile reach of the Middle Rio Grande, two representative meander bends were constructed and separated by a transition section. Geometry characteristics of the Middle Rio Grande and the physical model are shown in Table 3.1 and Table 3.2, respectively. **Type I** identifies the upstream bend in the physical model and **Type III** identifies the downstream bend in the physical model. Cross-sectional geometry was trapezoidal with 1:3 side slopes. The Type I and Type III bends were connected through the transition section in order to adjust the physical model geometry from a top width of 19.2 ft to 15.0 ft. Both meander bends were designed at a bed slope of 0.000863 ft/ft.

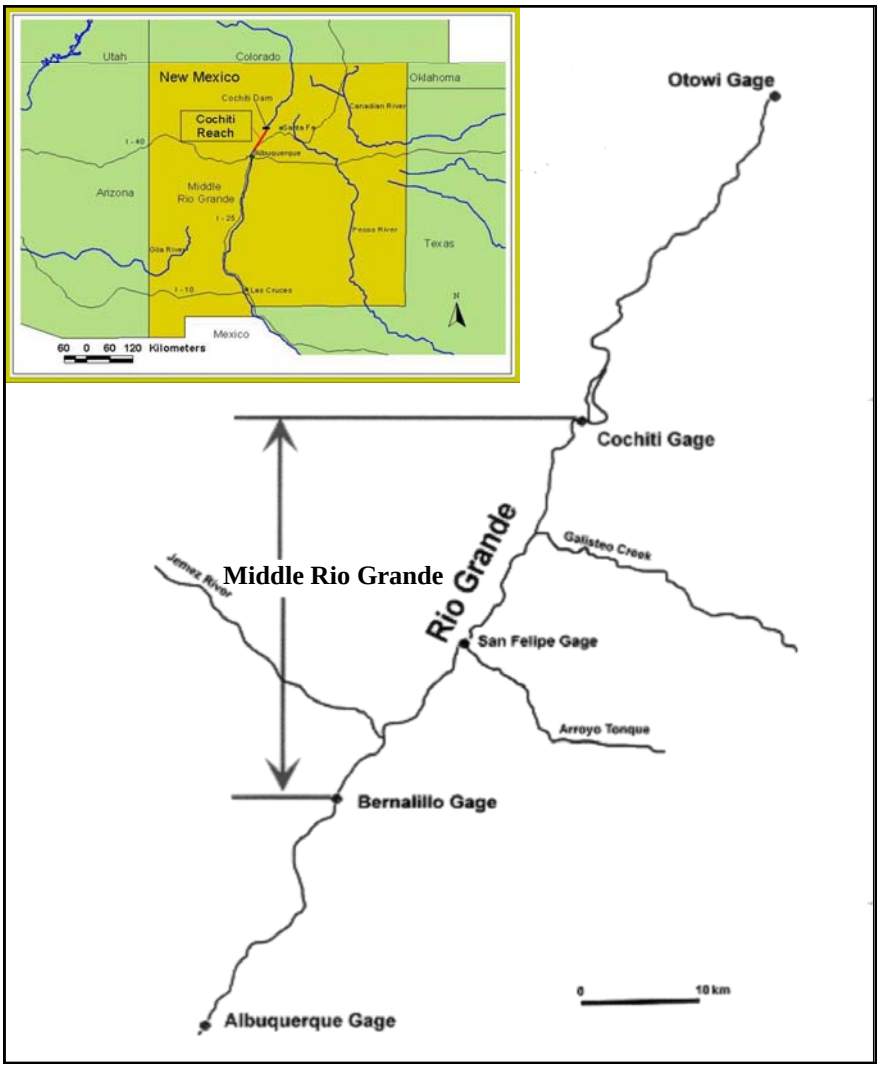

Figure 3.2. Map Locating the Middle Rio Grande (Darrow, 2004)

Table 3.1. Middle Rio Grande Geometry Characteristics (Heintz, 2002)

Type	Top Width (ft)	Radius of Curvature (ft)	Orientation Angle	Relative Curvature	Channel Length (ft)
1	230	465	125	2.02	1014
3	180	790	73	4.39	1002

Table 3.2. Physical Model Geometry Characteristics (Heintz, 2002)

Type	Top Width (ft)	Radius of Curvature (ft)	Orientation Angle	Relative Curvature	Channel Length (ft)
1	19	39	125	2.02	85
3	15	66	73	4.39	84

Eighteen cross sections were marked along the physical model. A planform view of the physical model with the eighteen marked cross sections is shown in Figure 3.3. For this analysis, an additional cross section, XS0, was included to obtain survey data and flow-depth measurements at a cross section before entering the Type I bend. A full description of the physical model is found in *Investigation of Bendway Weir Spacing* by Heintz (2002).

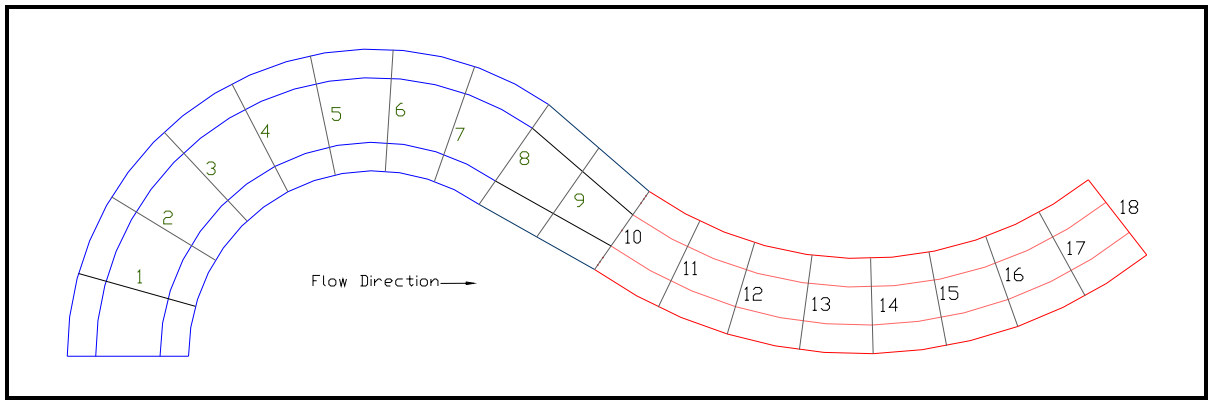

Figure 3.3. Physical Model Plan View With Defined Cross Sections (Heintz, 2002)

3.3 CROSS-SECTION DATA

In order to build a HEC-RAS model, cross-section data needed to be collected throughout the physical model. Cross-section data were collected through two types of surveying in order to obtain the best set of cross-section data. Survey data of the physical model was collected through total station and standard level instrumentation. Survey

data were collected at the nineteen cross sections. Shots included the upstream side of each piezometer, at the toe on the left and right banks, at the top of bank of the left and right banks, and against the side of the model for the overbank shot of the left and right banks. Figure 3.4 illustrates a typical cross section in the Type I and Type III bends. Rod placement for shots taken at piezometers is illustrated in Figure 3.5 and Figure 3.6.

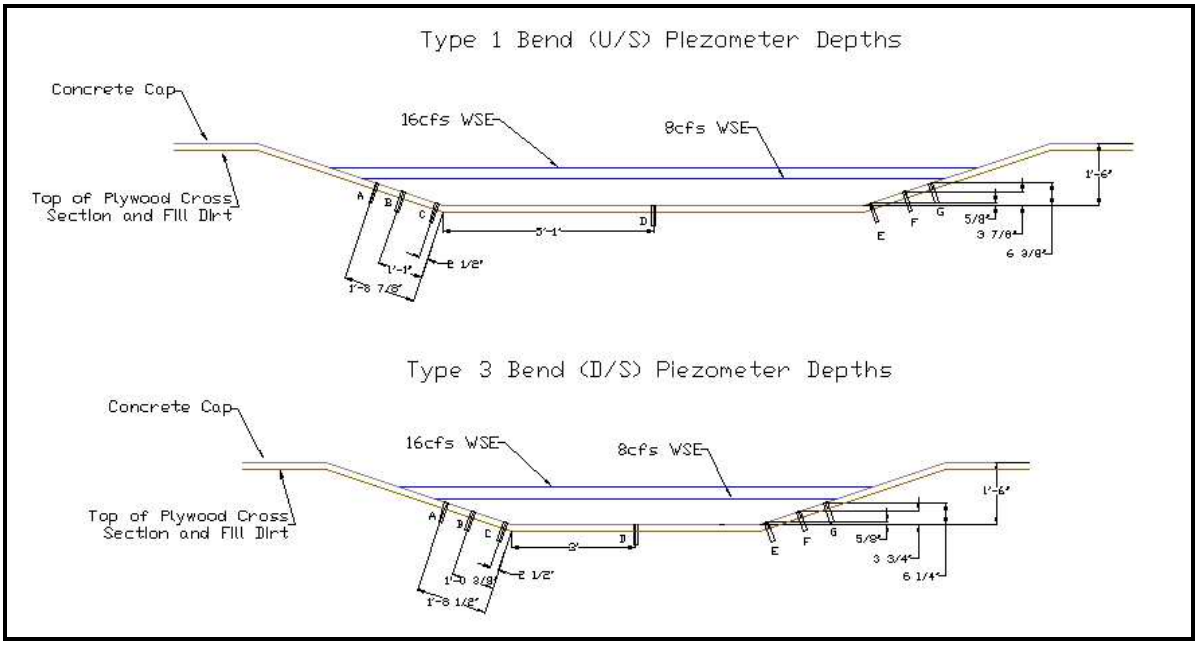

Figure 3.4. Piezometer Location Along Cross Sections in the Type I and Type III Bends (Heintz, 2002)

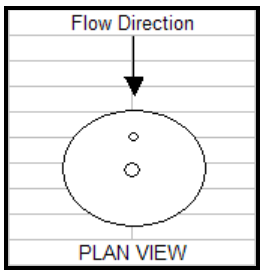

Figure 3.5. Rod Placement in Planform View

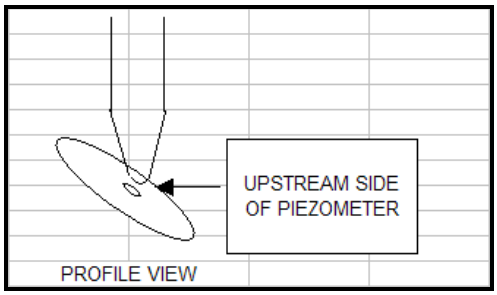

Figure 3.6. Rod Placement in Profile View

Once the cross-section data were collected using the total station and the standard level, cross-section data were compared in order to determined the best set of cross-section data for the analysis. Figure 3.7 presents the graph of survey data collected at XS5 using total station and standard level instrumentation. As Figure 3.7 indicates, the difference between the total station and standard level survey was minimal and, therefore, the total station survey was used in the analysis. Appendix A contains the survey data shot at each cross section using the total station instrumentation.

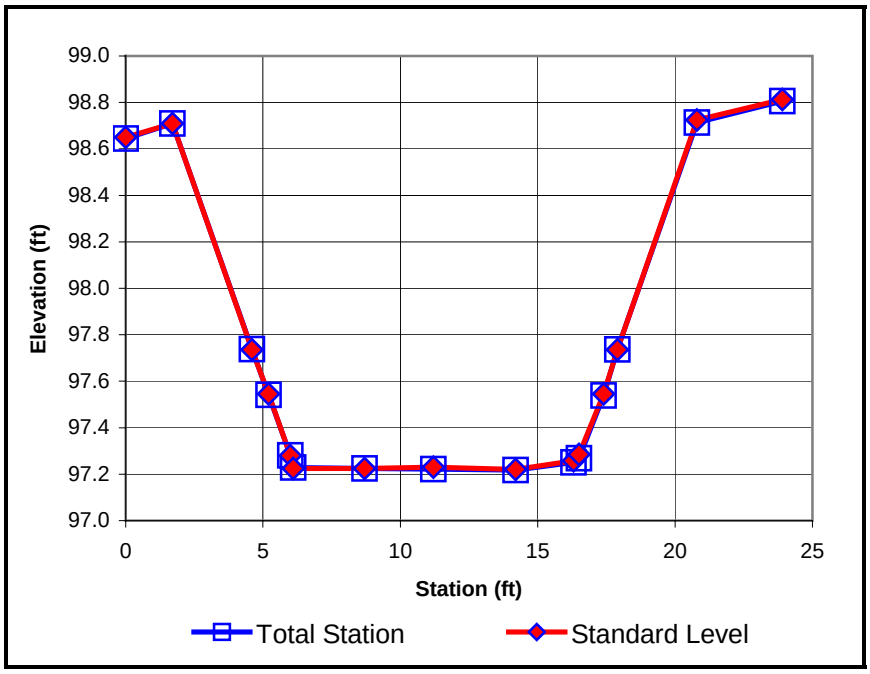

Figure 3.7. Total Station and Standard Level Survey Comparison at XS5

3.4 FLOW CONDITIONS

Discharges found in the Middle Rio Grande that were simulated in the physical model were 4,000, 6,000, and 8,000 cfs. These flow rates corresponded to design discharges of 8, 12, and 16 cfs in the physical model.

In order to determine the correct tailwater depth that simulates normal flow-depth conditions throughout the model, a stop log system was calibrated at the downstream end of the Type III bend. Detail related to the calibration method is found in *Investigation of Bendway Weir Spacing* by Heintz (2002).

3.5 TESTING PROGRAM

Flow-depth measurements were collected along the physical model with and without bendway weirs. Base-line testing program refers to flow depths measured in the physical model without weirs. Bendway-weir testing program refers to flow depths measured in the physical model with bendway weirs.

During the base-line testing program, flow depths were measured along the center of the channel without bendway weirs. Figure 3.8 is a photograph of the physical model without bendway weirs.

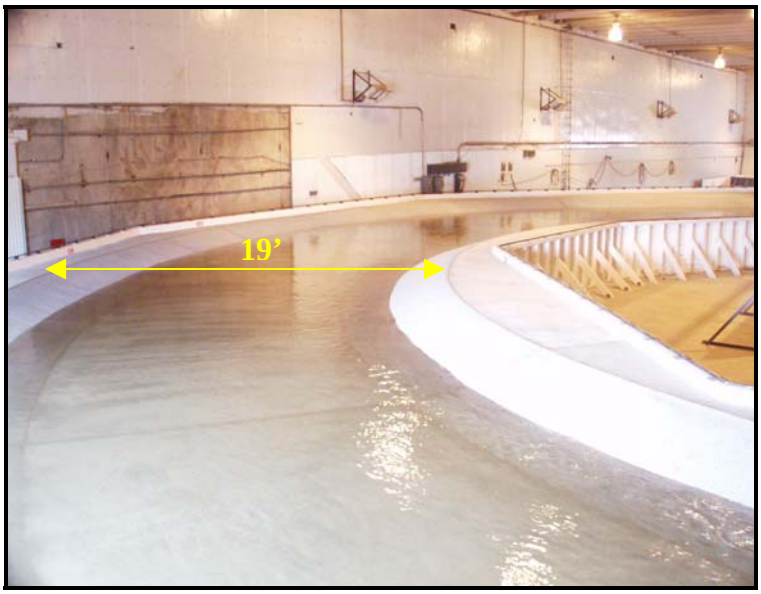

Figure 3.8. Physical Model Without Bendway Weirs (adapted from Heintz (2002))

The bendway-weir testing program measured flow depths along the center of the channel with one bendway-weir configuration. Figure 3.9 is a photograph of the physical model with bendway weirs. Bendway weirs are uniformly dimensioned in each bend. Geometry characteristics defining weirs placed in the physical model are illustrated in Figure 3.10. Weir dimensions are defined as follows:

1. L_{cw} = length of crest along bendway weir (ft);
2. L_w = total length of bendway weir (ft);
3. W_{bw} = base width of bendway weir (ft); and
4. W_{cw} = crest width of bendway weir (ft).

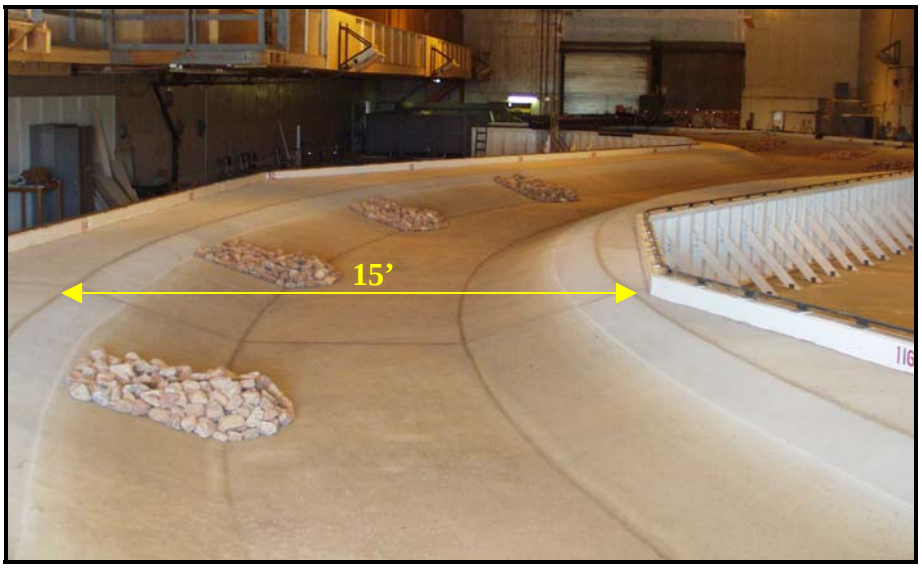

Figure 3.9. Physical Model With Bendway Weirs (adapted from Heintz (2002))

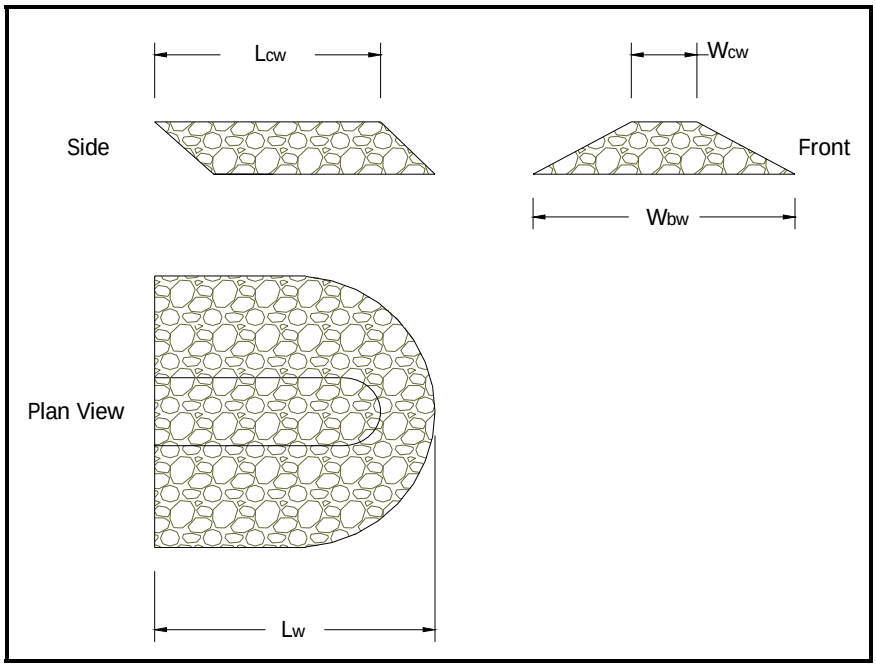

Figure 3.10. Bendway-weir Dimensions (Heintz, 2002)

Weirs are also spaced uniformly along each bend. Weirs are spaced according to the spacing ratio, which is defined by "measuring the arc length between the weirs at the

design water line along the bank" (Heintz, 2002). Spacing ratio is calculated using Equation 3.1:

$$S = \frac{r\theta_w}{L_r TW} \qquad \textbf{Equation 3.1}$$

where:

L_r = bendway-weir length ratio (ft);

r = radius of curvature (ft);

S = spacing ratio;

θ_w = orientation angle; and

TW = top width of channel (ft).

L_r is defined by Equation 3.2:

$$L_r = \frac{L_w}{TW} \qquad \textbf{Equation 3.2}$$

where:

L_r = bendway-weir length ratio;

L_w = total length of bendway weir (ft); and

TW = top width of channel along cross section (ft).

Each variable required in the calculation of spacing ratio and bendway-weir length ratio is presented in Figure 3.11. As Figure 3.11 illustrates, the orientation angle is measured from the centerline of the weir and, therefore, angles less than 90° orient the bendway weir upstream and angles greater than 90° orient the bendway weir downstream.

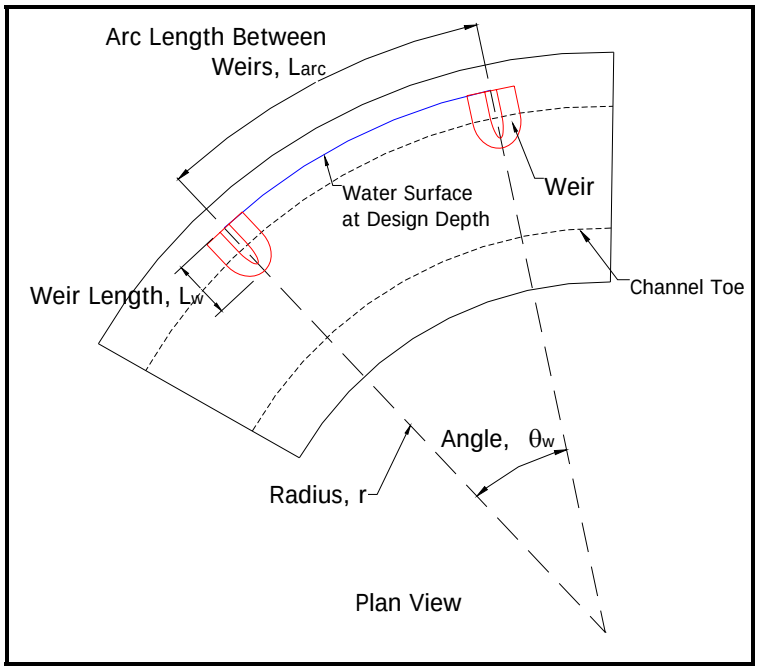

Figure 3.11. Spacing Ratio Schematic (Heintz, 2002)

In this analysis, bendway-weir configurations in the Type I and Type III bends are characterized using the dimensions, spacing ratio, and orientation angle shown in Table 3.3. As Table 3.3 presents, the Type I bend contains five bendway weirs with a spacing ratio of 4.10 and the Type III bend contains three bendway weirs with a spacing ratio of the 7.62. A planform view of the Type I and Type III bends with the bendway-weir configuration is shown in Figure 3.12.

Table 3.3. Bendway-weir Characteristics

Bend	L_{cw} (ft)	L_w (ft)	W_{cw} (ft)	W_{bw} (ft)	L_{arc} (ft)	S	Number of Weirs
1	4.29	5.06	1	4	20.03	4.1	5
3	2.96	3.74	1	4	28.53	7.62	3

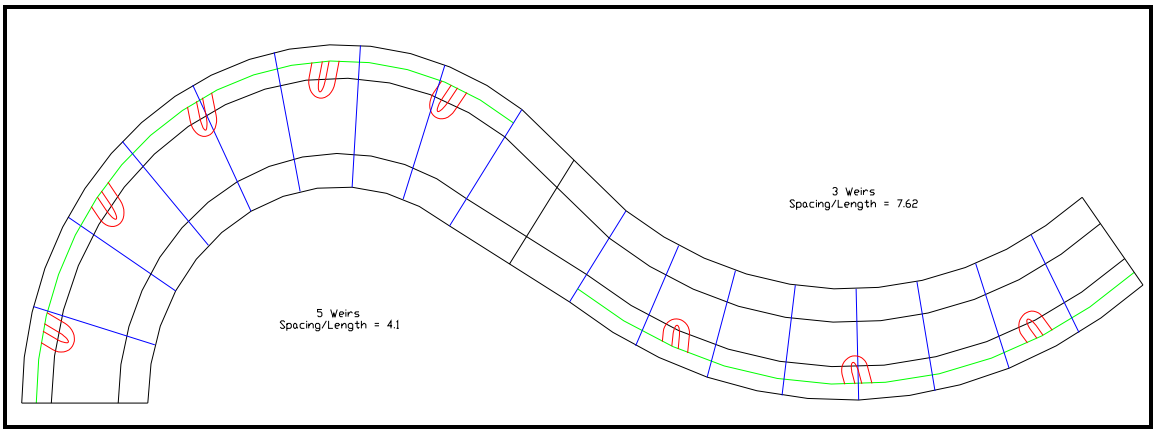

Figure 3.12. Planform View of Bendway-weir Configuration (Heintz, 2002)

3.5.1 Flow-depth Measurements

Flow-depth measurements were collected during the base-line and bendway-weir testing program. Flow-depth measurements were measured to the thousandth place using a track-mounted point gage. The track-mounted point gage was installed along a data-collection cart designed to collect data at any point along a cross section. In the base-line testing program, flow-depth measurements were collected along the center of the channel at all nineteen cross sections. Flow-depth measurements collected during the base-line test are shown in Table 3.4. Flow-depth measurements recorded at 8 cfs were collected on February 24, 2004 and flow-depth measurements recorded at 12 cfs and 16 cfs were collected on June 6, 2004.

Table 3.4. Base-line Testing Program Flow-depth Measurements

XS*	$y_{8\ cfs}$ (ft)	$y_{12\ cfs}$ (ft)	$y_{16\ cfs}$ (ft)
0 (U/S)	0.610	0.824	0.937
1	0.591	0.801	0.920
2	0.604	0.811	0.927
3	0.607	0.808	0.919
4	0.605	0.813	0.923
5	0.591	0.799	0.912
6	0.593	0.811	0.925
7	0.612	0.813	0.930
8	0.602	0.831	0.934
9	0.606	0.822	0.933
10	0.593	0.800	0.906
11	0.587	0.802	0.906
12	0.583	0.802	0.901
13	0.589	0.797	0.901
14	0.589	0.809	0.911
15	0.578	0.807	0.902
16	0.608	0.829	0.924
17	0.604	0.830	0.926
18 (D/S)	0.616	0.838	0.932

*U/S – upstream; D/S – downstream

In the bendway-weir testing program, flow-depth measurements were collected along the center of the channel for XS1 through XS17. Flow-depth measurements collected with the track-mounted point gage during the bendway-weir testing program are shown in Table 3.5. Flow-depth measurements recorded at 8 cfs were collected on June 14, 2004 and flow-depth measurements recorded at discharges of 12 cfs and 16 cfs were collected on June 15, 2004 and June 23, 2004, respectively. Appendix B contains all data sheets for the base-line testing program and the bendway-weir testing program.

Table 3.5. Bendway-weir Testing Program Flow-depth Measurements

XS	$y_{8\ cfs}$ (ft)	$y_{12\ cfs}$ (ft)	$y_{16\ cfs}$ (ft)
0 (U/S)			
1	0.700	0.890	1.008
2	0.700	0.905	1.020
3	0.698	0.886	1.000
4	0.705	0.892	1.015
5	0.689	0.886	0.995
6	0.696	0.887	1.010
7	0.687	0.901	1.012
8	0.686	0.889	0.999
9	0.740	0.920	1.021
10	0.699	0.914	1.007
11	0.698	0.912	1.010
12	0.610	0.820	0.910
13	0.632	0.858	0.930
14	0.605	0.833	0.899
15	0.594	0.831	0.891
16	0.632	0.865	0.899
17	0.570	0.810	0.884
18 (D/S)			