McIntyre Creek STREAM RESTORATION PROJECT
As-Built Survey and Comparative Analysis

Charlotte (MECKLENBURG COUNTY), North Carolina
NCEEP Project # D09024S
SCO# 01-0546102

Prepared for
North Carolina Ecosystem Enhancement Program
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Ecosystem Enhancement PROGRAM

Introduction

The North Carolina Ecosystem Enhancement Program (NCEEP) hired WK Dickson to provide an as-built survey and comparative analysis of the recently constructed McIntyre Creek Stream Restoration Project in Charlotte, North Carolina. This report includes that survey in both a hard copy and electronic format (Appendix A) and the comparative analysis. The McIntyre Creek project was designed by KCI Associates, and constructed by United Construction, Inc. WK Dickson's as-built channel and floodplain survey included the following:

- Horizontal position of the channel including rock structures such as cross vanes, j-hooks and step pools (Appendix B).
- Profile of the thalweg for the entire restored channel (Appendix B).
- Cross sectional shape of the channel at thirty (30) locations (Appendix C).
- Finished grade of the floodplain including cut/fill volume calculations.
- Vertical elevations for rock structures (cross vanes, j-hooks and step pools).

The purpose of this report is to provide an independent determination as to whether the as-built channel was built as proposed and to determine how much cut and fill were involved with construction. This report does not include an evaluation by WK Dickson of the KCI proposed design including hydrologic and hydraulic calculations or the natural channel design parameters.

Site and Proposed Design Information

McIntyre Creek is located in Hornets Nest Park which is a City maintained park located on the north side of Charlotte (Figure 1). The site is located on the downstream side of Beatties Ford Road approximately 1 mile north of the intersection of Sunset Road and Beatties Ford Road.

The restored channel was constructed in November 2007 and plantings installed in February 2008. An electronic copy of the KCI design was provided to WK Dickson in two emails received on January 13, 2009. A copy of the electronic versions of the KCI data is provided in Appendix A. These plans and design parameters included plan form of the stream centerline, horizontal location of the rock structures, a stream profile and tabular morphological design parameters. The following table summarizes the morphological design parameters used in the design of the channel:

Table 1: KCI Morphological Design Parameters

Reach	Channel Station	Drainage Area (acres)	Bankfull Width (feet)	Max Bankfull Depth (feet)	Bankfull Area (sq. feet)
1	10+00 to 48+30	1.79	18.7	4.0	42 to 50
2	48+30 to 63+75	2.55	22.9	3.3 to 3.5	64 to 70

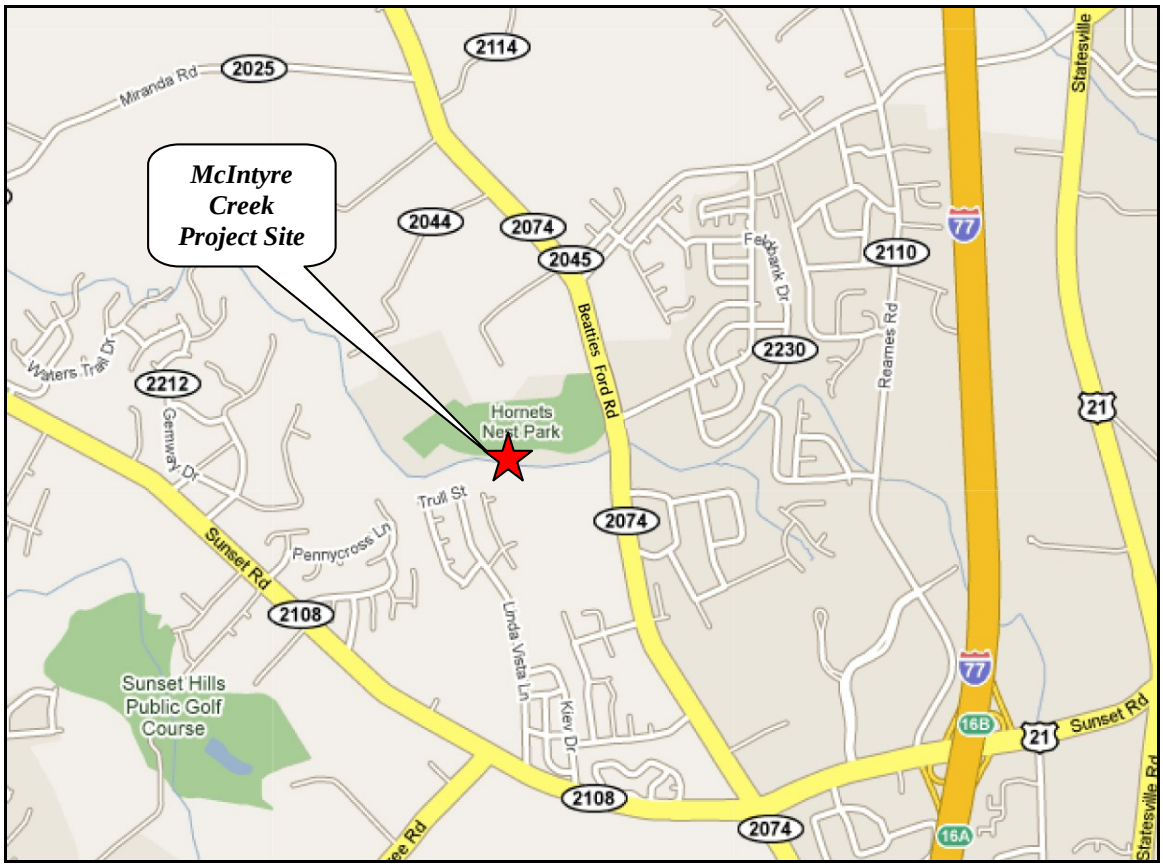


Figure 1. McIntyre Creek General Location Map

WK Dickson As-Built Survey and Field Inspection

On January 19, 2009 WK Dickson completed an as-built survey of the channel and floodplain (Appendix A). As described in the January 14, 2009 contract with NCEEP, the survey includes the following:

- 0.2-foot contour interval topographic mapping of the floodplain from channel station 44+ 60 to 63+ 75.
- Survey of 30 cross sections at 15 representative riffles and pools.
- Survey of 38 rock structures.
- Thalweg survey shots at close enough spacings to accurately depict changes in grades for riffles and pools throughout the project from 10+00 to 63+75.

The horizontal and vertical datum for this survey was provided by KCI and verified by WK Dickson field personnel and is based on NAD 83 horizontal and NAVD 88 vertical. Bench marks of the subject control were placed by KCI, some of which are nails in concrete.

Comparative Analysis

A comparative analysis was performed to determine if the as-built channel and floodplain were built as proposed. This analysis included a comparison of planform, vertical and horizontal location of rock structures, thalweg elevation, top-of-bank elevation, cross section

area, cross section depth, cross section width, and cut/fill quantities. The following sections detail the comparisons of the as-built survey to the KCI proposed design data and existing conditions topographic data.

Proposed vs As-Built Planform

The planform of the stream centerline and horizontal location of rock structures were superimposed on each other for the proposed and as-built conditions (Appendix B). As shown in Appendix B, the as-built thalweg of the channel was built very closely to the proposed centerline location. In general, the as-built channel was built with less sinuosity than the proposed channel. Additionally, the thalweg on the outside of bends in the as-built channel is quite often inside the proposed centerline location.

To make a direct comparison with channel lengths, a line was drawn on the proposed stream alignment to depict the proposed thalweg. This line matches exactly at riffles and per the design sections tend to be approximately 7.3 to 8.7 feet from the outside top-of-bank for pool sections. The following table summarizes the differences in distances when comparing the as-built thalweg to the estimated proposed thalweg.

Table 2: Comparison of Thalweg Distances

Estimated Proposed Thalweg Length (feet)	As-Built Thalweg Length (feet)	Difference in Length (feet)
5626	5252	-374

As shown in Table 2, the as-built channel is less sinuous and had less stream length then the proposed channel. Given a floodplain length of 4659 feet, the sinuosity of the as-built channel is 1.13 which is outside the design range (1.3 to 1.5) provided in the KCI morphological design table found in Appendix D.

Proposed vs As-Built Profile

To determine if the thalweg and top of bank elevations were constructed as proposed, a profile was prepared that compared the KCI proposed and WK Dickson as-built data (Appendix B). The following table provides a tabular summary of the comparison of these profiles:

Table 3: Summary of Profile Comparison

Station	Maximum Thalweg Elevation Difference (feet)	Average Thalweg Elevation Difference at Riffles (feet)	Maximum Top of Bank Elevation Difference (feet)	Typical Top of Bank Elevation Difference (feet)
10+00 to 20+00	1.3	0.3	0.6	0.25
20+00 to 30+00	1.25	0.49	0.8	0.6
30+00 to 40+00	1.5	0.87	0.6	0.1
40+00 to 50+00	4.3	0.96	1.3	0.4
50+00 to 60+00	2.5	0.93	1.3	0.8
60+00 to 63+75	3.2	0.93	1.0	0.8

Due to the natural variations that are found with pools, variations caused by natural stream morphology, habitat creation and flood storage; a riffle comparison was computed between the profiles of the designed stream and the as-built. An average of the Thalweg elevations difference of these riffles was found between each major station.

The following conclusions can be drawn from Table 3 and Appendix B:

- The as-built upstream reach (above Station 48+ 30) more closely matches with the proposed thalweg and top of bank than the downstream reach.
- The channel is beginning to incise in the lower reach downstream of station 48+30.
- The top of bank is typically 0.6 to 1.3 feet lower than the proposed top of bank downstream of station 16+00.
- The as-built thalweg progressively becomes lower than the proposed thalweg the further downstream a comparison is made. Typical differences in riffle thalweg elevations are 1.0 feet.

A detailed comparison of channel depths is provided in a later section of the report.

Proposed vs As-Built Cross Sections

Cross sections provide a useful tool to determine how closely the channel was built as proposed. A comparison was made using cross sections that superimposed the proposed KCI design sections with as-built field surveyed sections collected by WK Dickson. Appendix C shows the 15 riffle and 15 pool cross sections that were generated. A detailed inspection of the cross sections was performed for channel topwidths, depths and areas as shown in the following tables:

Table 4: Comparison of Channel Topwidths

Cross Section (Station/Type)	Design Width at Top of Bank (feet)	As-Built Width at Top of Bank (feet)	Difference (feet)
63+30/Pool-Right	27.4	21	-6.4
62+94/Riffle	22.9	22	-0.9
62+10/Riffle	22.9	20	-2.9
60+98/Pool-Right	27.4	20	-7.4
58+24/Pool-Right	27.4	18	-9.4
57+80/ Riffle	22.9	18	-4.9
55+92/Pool-Left	27.4	18	-9.4
55+61/Riffle	22.9	22	-0.9
50+89/Pool-Left	27.4	18	-9.4
48+69/Pool-Left	27.4	19	-8.4
45+26/ Pool-Right	27.4	17	-10.4
44+71/Pool-Left	18.7	17	-1.7
42+32/ Pool-Right	24.5	18	-6.5
40+31/Riffle	18.7	18	-0.7
38+94/ Pool-Right	24.5	24	-0.5
36+57/Riffle	18.7	19	0.3
35+28/Pool-Right	24.5	17	-7.5
34+44/ Riffle	18.7	18	-0.7
30+41/Pool-Left	24.5	17	-7.5
29+79/Riffle	18.7	16	-2.7
26+18/Pool-Right	24.5	16	-8.5
25+83/Riffle	18.7	17	-1.7
23+99/Riffle	18.7	16	-2.7
22+04/Riffle	18.7	16	-2.7
17+93/Pool-Right	24.5	21	-3.5
15+94/Pool-Left	18.7	18	-0.7
13+89/Pool-Right	24.5	19	-5.5
13+62/Riffle	18.7	16	-2.7
12+77/Pool-Right	24.5	16	-8.5
11+64/Riffle	18.7	14	-4.7

As shown in Table 4, on average the as-built channel topwidths are narrower than the proposed topwidths. The following table summarizes the difference in channel widths based on cross section type and reach:

Table 5: Summary of Channel Topwidths Based on Cross Section Type

Reach	Cross Section Type (Riffle/Pool)	Average "As-Built" Width (feet)	Design Width (feet)	% Different
Downstream of Station 48+30	Riffle	20.5	22.9	90
Downstream of Station 48+30	Pool	19	27.4	69.3
Upstream of Station 48+30	Riffle	16.7	18.7	89.1
Upstream of Station 48+30	Pool	18.1	24.5	74.1

A comparison of the channel depths shows that the as-built channel is slightly undersized when compared to the proposed design depths. It is difficult to make a direct comparison to the design depths at pools because it is often preferable in a design to have varying pool depths as this is good for habitat and stream stability. For this reason, the following conclusions about design depths are made at riffles only. As-built depths were consistently less than 0.5 feet different when compared to the proposed conditions. The largest difference in design depths occurred at cross section 62+ 10 which is in a section of channel that is undergoing severe erosion.

Table 6: Comparison of Channel Depths

Cross Section (Station/Type)	Design Max Depth (feet)	As-Built Depth (feet)	Difference (feet)
63+30/Pool-Right	5.8	6.2	0.4
62+94/Riffle	4.0	4.5	0.5
62+10/Riffle	4.0	6.0	2.0
60+98/Pool-Right	5.8	5.8	0.0
58+24/Pool-Right	5.8	5.0	-0.8
57+80/ Riffle	4.0	3.6	-0.4
55+92/Pool-Left	5.8	5.0	-0.8
55+61/Riffle	4.0	3.6	-0.4
50+89/Pool-Left	5.8	5.3	-0.8
48+69/Pool-Left	5.8	4.9	-0.8
45+26/ Pool-Right	4.9	3.9	-1.0
44+71/Pool-Left	4.9	3.5	0.1
42+32/ Pool-Right	4.9	3.7	-1.2
40+31/Riffle	3.4	3.6	0.2
38+94/ Pool-Right	4.9	4.1	-0.8
36+57/Riffle	3.4	3.9	0.5
35+28/Pool-Right	4.9	4.0	-0.9
34+44/ Riffle	3.4	3.5	0.5
30+41/Pool-Left	4.9	4.1	-0.8
29+79/Riffle	3.4	3.0	-0.4
26+18/Pool-Right	4.9	3.9	-1.0
25+83/Riffle	3.4	3.2	-0.2
23+99/Riffle	3.4	3.0	-0.4
22+04/Riffle	3.4	3.2	-0.2
17+93/Pool-Right	4.9	4.9	0.0
15+94/Pool-Left	4.9	4.8	-0.1
13+89/Pool-Right	4.9	3.5	-0.7
13+62/Riffle	3.4	3.5	0.1
12+77/Pool-Right	4.9	4.9	0.0
11+64/Riffle	3.4	3.5	0.1

Table 7: Comparison of Channel Cross Sectional Area

Cross Section (Station/Type)	Design Area (square feet)	As-Built Area (square feet)	% Difference
63+30/Pool-Right	64 to 70	45	-33%
62+94/Riffle	64 to 70	66	-2%
62+10/Riffle	64 to 70	71	6%
60+98/Pool-Right	64 to 70	58	-14%
58+24/Pool-Right	64 to 70	60	-11%
57+80/ Riffle	64 to 70	45	-33%
55+92/Pool-Left	64 to 70	43	-36%
55+61/Riffle	64 to 70	50	-26%
50+89/Pool-Left	64 to 70	51	-24%
48+69/Pool-Left	64 to 70	45	-33%
45+26/ Pool-Right	42 to 50	42	-9%
44+71/Pool-Left	42 to 50	51	11%
42+32/ Pool-Right	42 to 50	30	-35%
40+31/Riffle	42 to 50	28	-39%
38+94/ Pool-Right	42 to 50	38	-17%
36+57/Riffle	42 to 50	37	-20%
35+28/Pool-Right	42 to 50	40	-13%
34+44/ Riffle	42 to 50	32	-30%
30+41/Pool-Left	42 to 50	38	-17%
29+79/Riffle	42 to 50	30	-35%
26+18/Pool-Right	42 to 50	34	-26%
25+83/Riffle	42 to 50	33	-28%
23+99/Riffle	42 to 50	36	-22%
22+04/Riffle	42 to 50	31	-33%
17+93/Pool-Right	42 to 50	31	-33%
15+94/Pool-Left	42 to 50	34	-26%
13+89/Pool-Right	42 to 50	38	-17%
13+62/Riffle	42 to 50	33	-28%
12+77/Pool-Right	42 to 50	48	4%
11+64/Riffle	42 to 50	34	-26%

A review of Table 7 shows that the as-built channel is predominantly 15 percent to 33 percent smaller than the proposed channel. The main reason the channel is smaller is due to the following:

- As-built topwidths are narrower then the proposed topwidths.
- The as-built shape of pools does not match the design cross section. The main difference is that the shape of the as-built cross section is more trapezoidal in shape and does not flatten out where a depositional sand point bar feature would be expected (on the inside of bends). Typically these missing areas on the inside of the bends account for approximately 20 percent to 33 percent of the design cross sectional area.
- 18 of the as-built cross sectional depths were less than the design cross section. Several of these depths were as much as 1.0 foot less. This difference would have

contributed to the smaller cross sectional areas when comparing the as-built to the proposed conditions.

Proposed vs As-Built Rock Structures

A detailed survey of the cross vanes, j-hooks and step pool structures was performed by WK Dickson surveyors and stream designers. This survey included an inventory of all structures including elevations of the header rock and arms (Appendix E). A review of the survey shows the following:

- The proposed cross vane at station 21+ 50 was built as a j-hook in the correct location.
- With the exception of the cross vanes located in the vicinity of station 27+ 00 and 49+ 40 all rock structures were constructed close to the proposed locations. The majority of the rock structures were built less than 5 feet from the proposed location.
- Using a vertical tolerance of 0.2 feet, there were 16 structures that did not meet the required tolerance. There were 22 structures that were within the allowable tolerance.
- The two cross vanes located between stations 10+ 00 to 10+ 35 were not located by WK Dickson staff after wading in stream and using probes. There has been some deposition in the channel so it is possible that these structures are in place and just could not be found.
- The step pool proposed at station 46+00 was not constructed.

As a rule, rock structures were well constructed with arms that had slopes that were not extreme or causing erosion. A more detailed summary of the rock structure construction is provided in Appendix E.

Cut/Fill Calculations

Cut/fill calculations were prepared to determine the volume of cut and fill and net difference for the between the pre-project and as-built conditions. The area of analysis included the left and right overbanks and channel area from stream station 43+ 75 to 62+ 94 (Appendix F). The cut/fill volumes were determined using the following two methods:

- Floodplains Volumes: Land Desktop includes an automated tool to develop and compare surface models. A surface model for the pre-project conditions was compared to the as-built conditions to estimate volumes for cut and fill.
- Channel Volumes: WK Dickson surveyed cross sections were used to estimate cut volumes for the as-built channel. Average riffle and pool sizes were determined using a representative surveyed cross section within the reach of the cut/fill calculations. A review of the plan form showed that in the area of the comparative analysis approximately 60% of the total as-built channel length was considered a pool and approximately 40% was considered a riffle. This weighted pool and riffle lengths along with the representative channel area were used to estimate channel cut/fill volumes (Appendix E).

Average riffle and pool areas used in the calculations were 50 and 51 square feet. The following table summarizes the result of this analysis:

Table 8: Channel and Floodplain Cut/Fill Volume Summary

Floodplain Cut Volume (cubic yards)	Floodplain Fill Volume (cubic yards)	Net Difference (cubic yards)
4033	5908	1875 (fill)

A quality control check was made using hand calculations based on the WK Dickson spot elevations shot at 25-foot spacings and the pre-project conditions topographic mapping. Depths of cut and fill were mapped throughout the floodplain at equal spacings. These depths were averaged and multiplied by the associated areas of cut and fill to provide the check on the Land Desktop results. The following table summarizes results of the cut/fill hand calculations along with a comparison to the Land Desktop results:

Table 9: Quality Control Check on Floodplain Cut/Fill Volumes

Floodplain Cut Volume (cubic yards)	Floodplain Fill Volume (cubic yards)	Net Difference (cubic yards)
3875	5500	1625 (fill)

As shown in Table 9 the results generated using Land Desktop match within 10% of the volumes calculated by hand. The Land Desktop automated software is providing accurate results and therefore will be used for the conclusions found in this report. This report ignores the affects of swelling when calculating the volume of material needed to achieve final in place (compacted) quantities.

Per a February 24, 2009 meeting with NCEEP it was determined that the contractor brought in approximately 1370 cubic yards of material. With consideration given to channel erosion since the end of construction, this number of 1370 cubic yards further validates the estimate of 1875 cubic yards calculated by WK Dickson. Based on the hand calculations prepared by WK Dickson and the volume of material brought in by the contractor, the estimate of 1875 cubic yards of fill material is reasonable.

Conclusions

This report provides a comparison of the proposed and as-built conditions for the McIntyre Creek Stream Restoration Project to determine if the project was built as proposed. This report provides maps, profiles, cross sections and tables that summarize the differences in the proposed and as-built conditions. As documented throughout this report, there were differences in the as-built and proposed design. Numerous items have been compared and differences summarized but the following items should be highlighted as they appear to be the most significant differences:

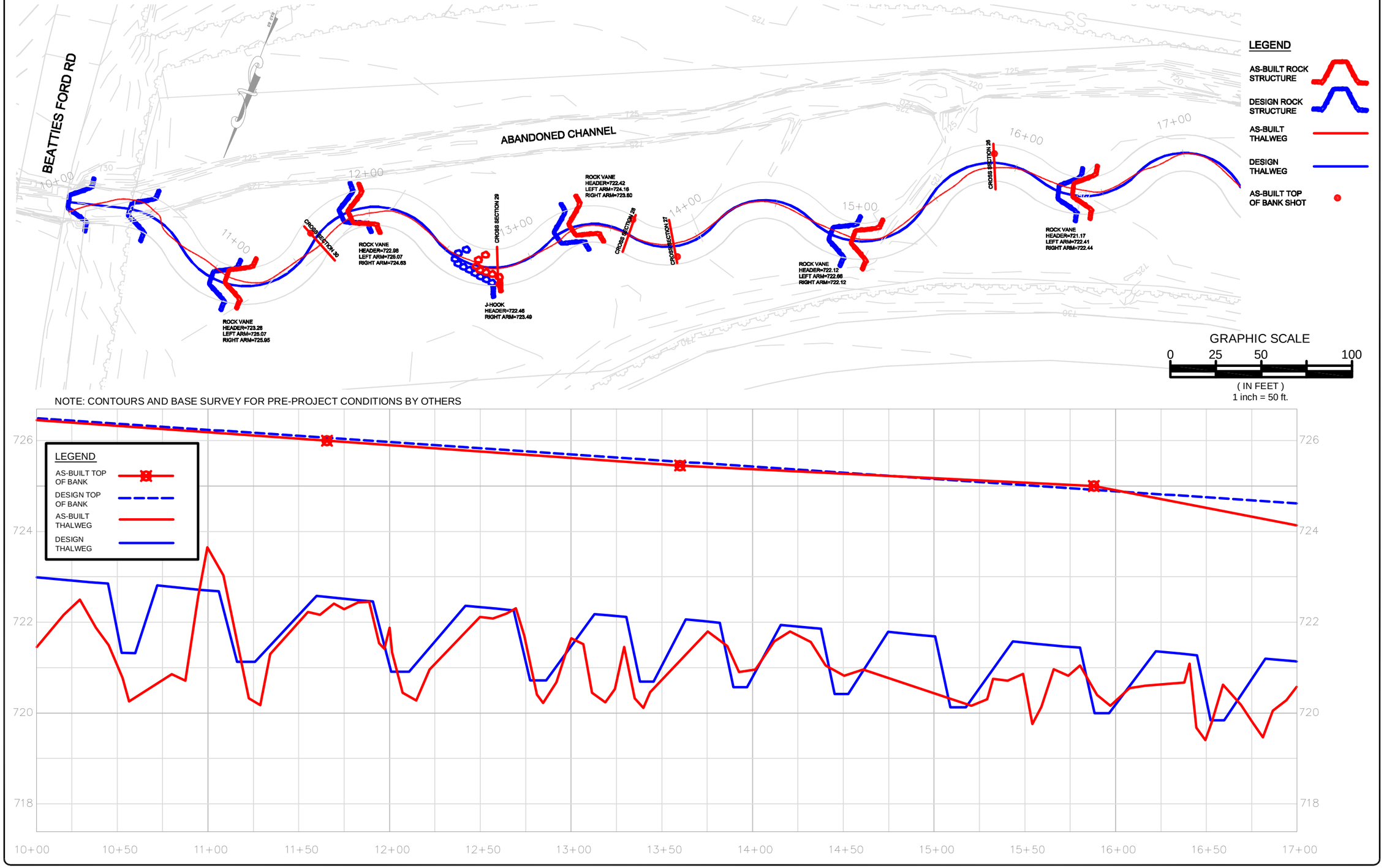
- Channel topwidths at pools are significantly less than the design widths. The upstream average "as-built" width for a pool is 18.1 feet while the design width is 24.5 feet. The downstream average "as-built" width for a pool is 19.0 feet while the design width is 27.4 feet. This is a 22% and 31% different in width.
- The shape of the pools in the as-built conditions is trapezoidal and does not match the design shape. The inside bank on pools was not graded to match design plans and as a result the cross sectional area of the as-built channel is less than the design sections.

- The resultant cut/fill balance shows that the site needed to bring in 1875 cubic yards of material to reach the final design elevations of the floodplain and channel.

If the as-built channel had been shaped as proposed the result would have been an additional cut of approximately 900 cubic yards of material. This would have helped reduce the net difference in the cut/fill volumes from 1875 cubic yards to 975 cubic yards.

Appendix A

Appendix B



NOTE: CONTOURS AND BASE SURVEY FOR PRE-PROJECT CONDITIONS BY OTHERS

REV. NO.	DESCRIPTION	DATE
	REVISIONS	

PROJECT MANAGER: DJK
DRAWN BY: TRS
APPROVED BY: DJK
PLOT NAME: mcintyre_creek
DRAWING SCALE: 1"=50'
PROJECT DATE: 01/2009
PROJECT NUMBER: 200900130RA
PLOT DATE: 02/2009

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CONSTRUCTION	
RECORD DWG.	

McINTYRE CREEK AS-BUILT COMPARISON
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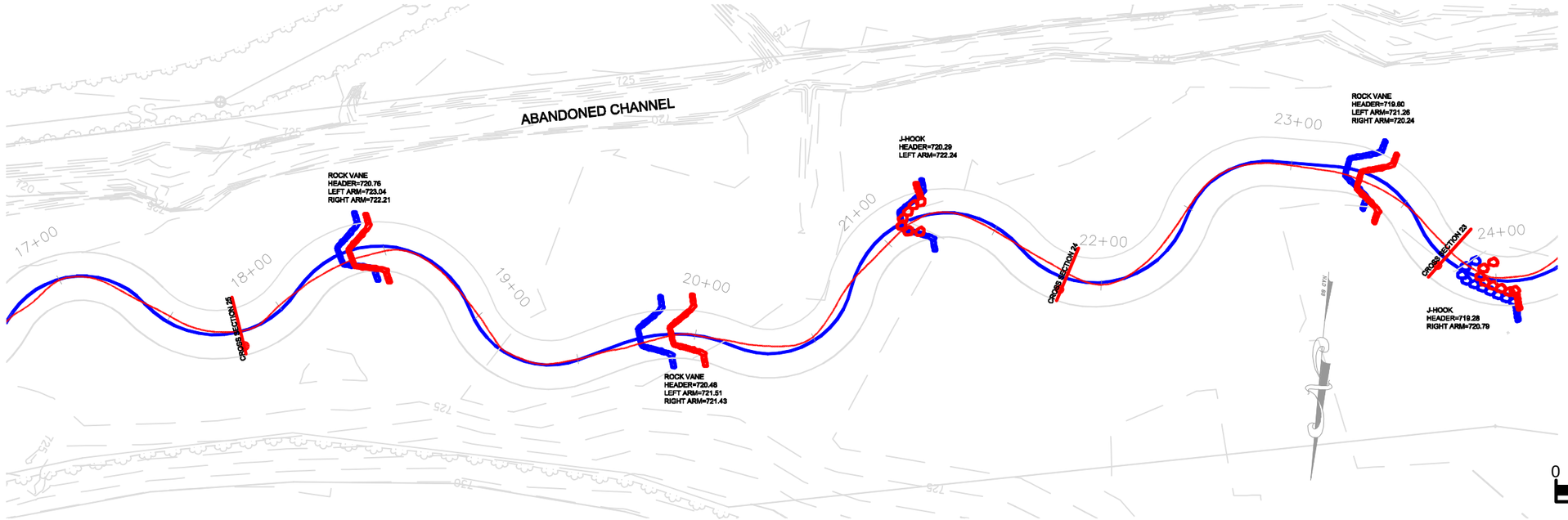
STA. 10+00 - STA. 17+00

1/8



LEGEND

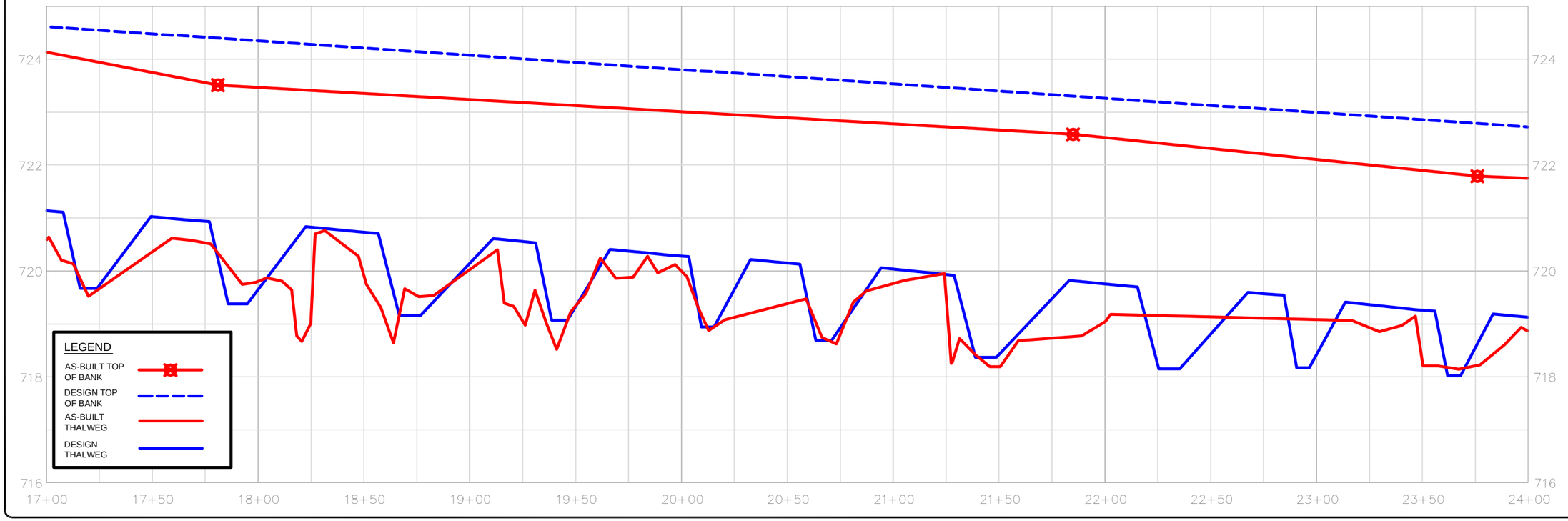
- AS-BUILT ROCK STRUCTURE
- DESIGN ROCK STRUCTURE
- AS-BUILT THALWEG
- DESIGN THALWEG
- AS-BUILT TOP OF BANK SHOT

GRAPHIC SCALE

0 25 50 100

(IN FEET)
1 inch = 50 ft.

NOTE: CONTOURS AND BASE SURVEY FOR PRE-PROJECT CONDITIONS BY OTHERS



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APPROVED BY: DJK
FILE NAME: mcintyre_creek
DRAWING SCALE: 1"=50'
PROJECT DATE: 01/2009
PROJECT NUMBER: 2009001300RA
PLOT DATE: 02/2009

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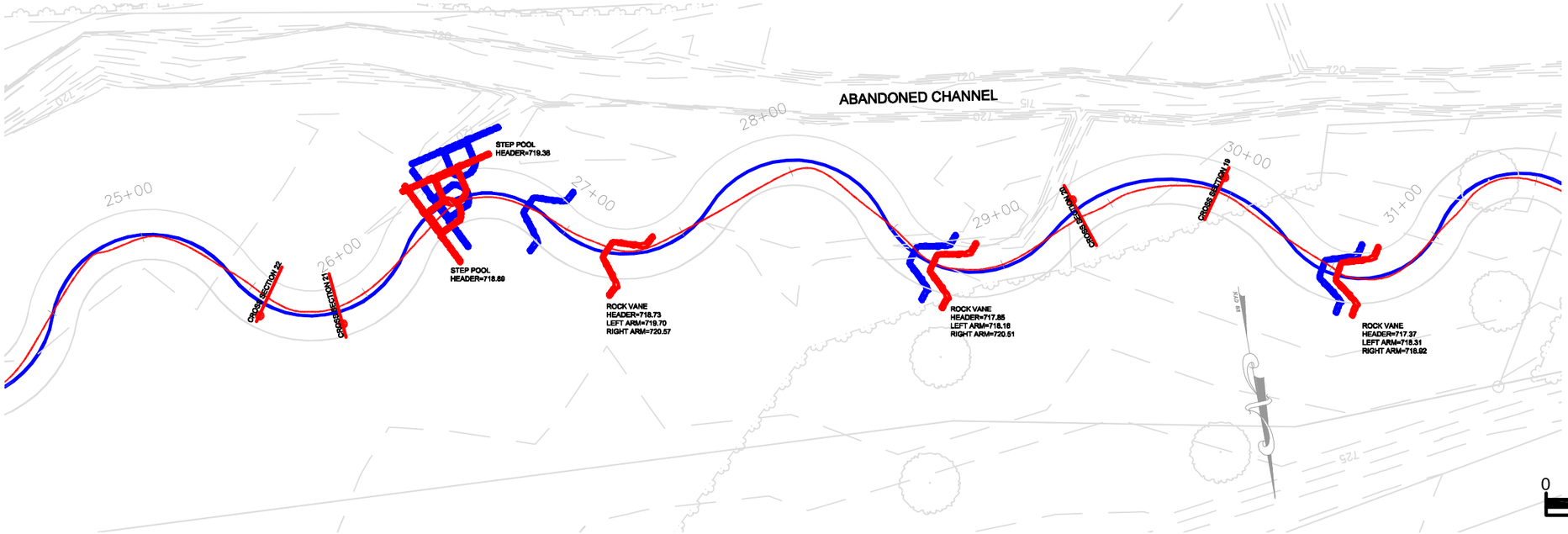
STA. 17+00 - STA. 24+00



LEGEND

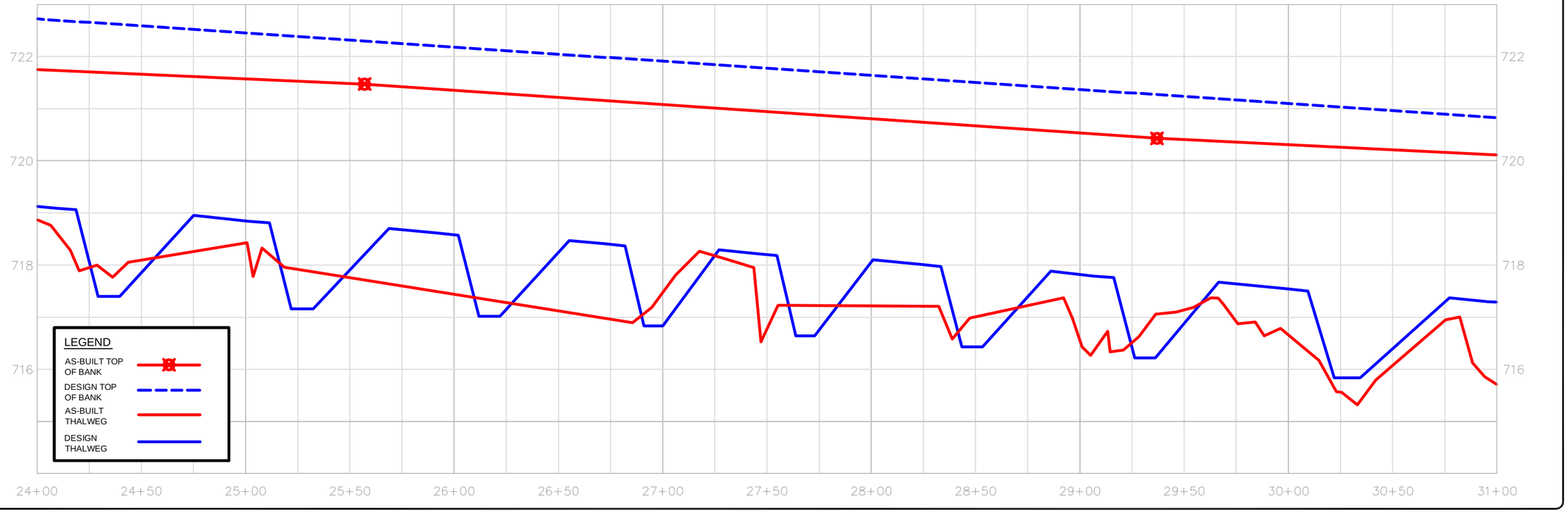
- AS-BUILT ROCK STRUCTURE
- DESIGN ROCK STRUCTURE
- AS-BUILT THALWEG
- DESIGN THALWEG
- AS-BUILT TOP OF BANK SHOT

GRAPHIC SCALE

0 25 50 100

(IN FEET)
1 inch = 50 ft.

NOTE: CONTOURS AND BASE SURVEY FOR PRE-PROJECT CONDITIONS BY OTHERS



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APPROVED BY: DJK
REVISION: mcintyre_creek
DRAWING SCALE: 1"=50'
PROJECT DATE: 01/2009
PROJECT NUMBER: 200900130RA
PLOT DATE: 02/2009

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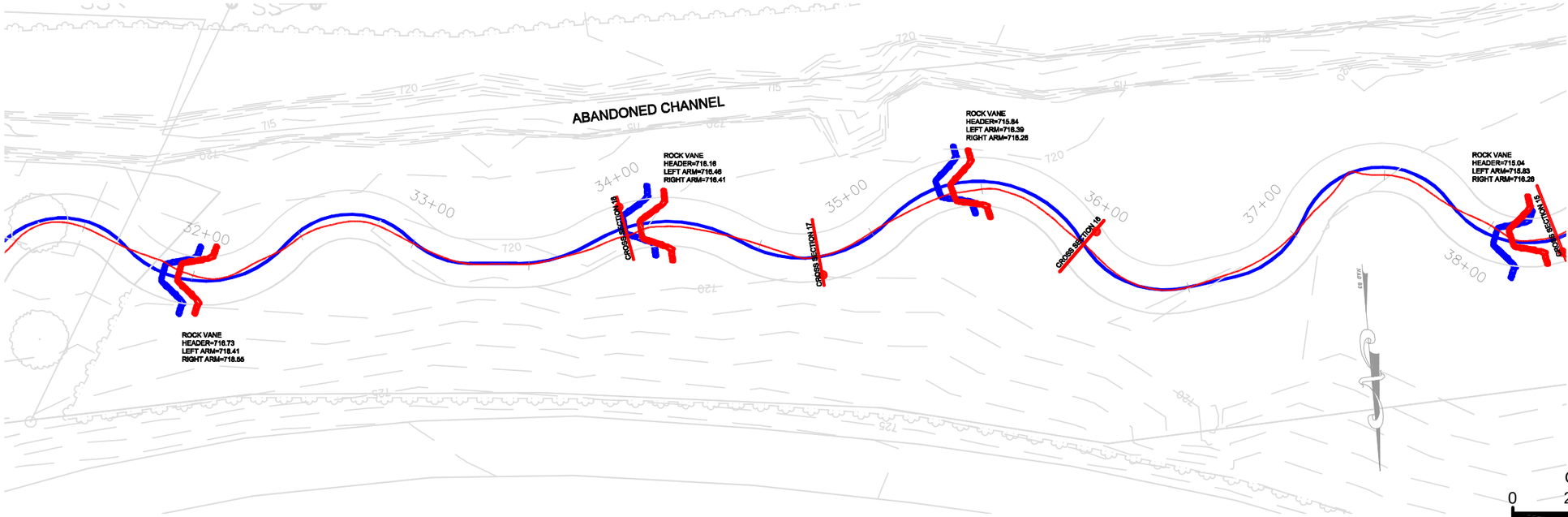
STA. 24+00 - STA. 31+00



NOTE: CONTOURS AND BASE SURVEY FOR PRE-PROJECT CONDITIONS BY OTHERS

GRAPHIC SCALE
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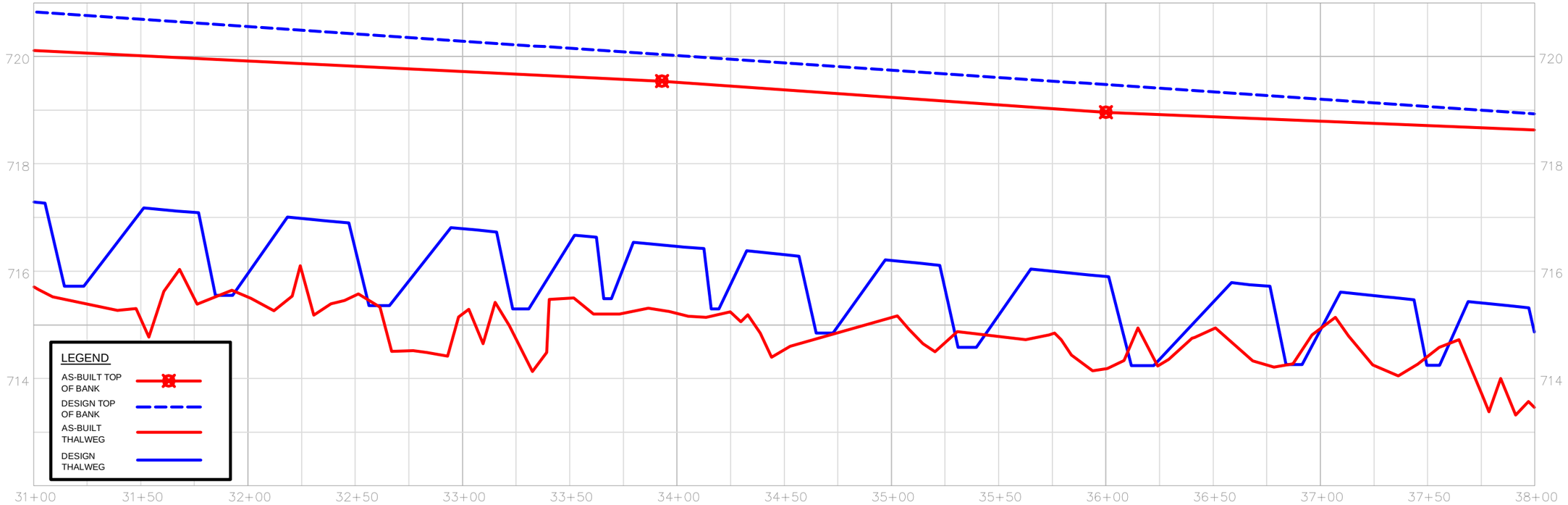
(IN FEET)
1 inch = 50 ft.



REV. NO.	DESCRIPTION	DATE
	REVISIONS	

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APPROVED BY	DJK
PLOT NAME	mcintyre_creek
DRAWING SCALE	1"=50'
PROJECT DATE	01/2009
PROJECT NUMBER	2009001300RA
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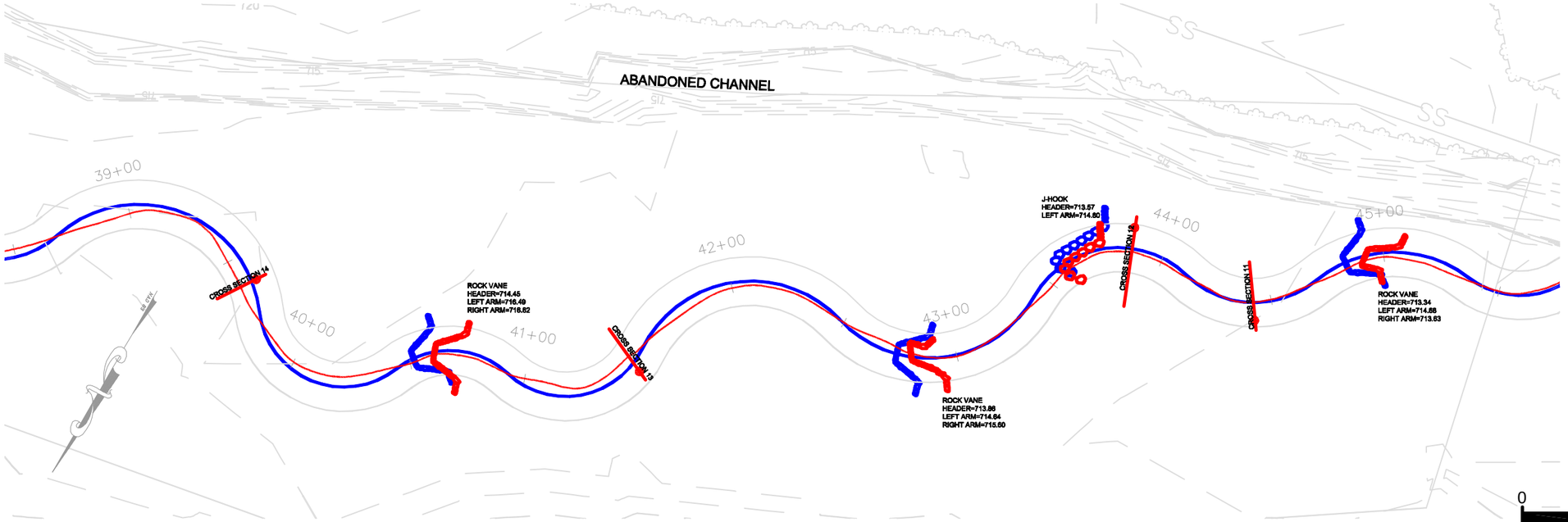
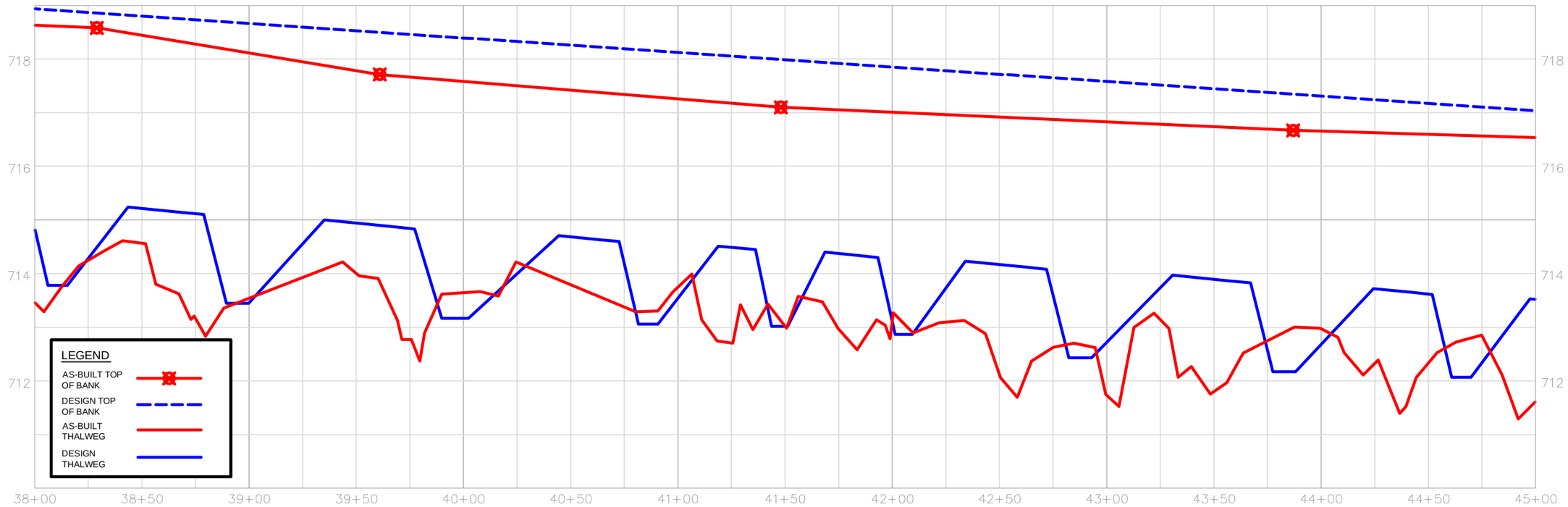
NCDENR ECOSYSTEM ENHANCEMENT PROGRAM

STA. 31+00 - STA. 38+00



NOTE: CONTOURS AND BASE SURVEY FOR PRE-PROJECT CONDITIONS BY OTHERS

GRAPHIC SCALE
0 25 50 100
(IN FEET)
1 inch = 50 ft.



REV. NO.	DESCRIPTION	DATE
	REVISIONS	

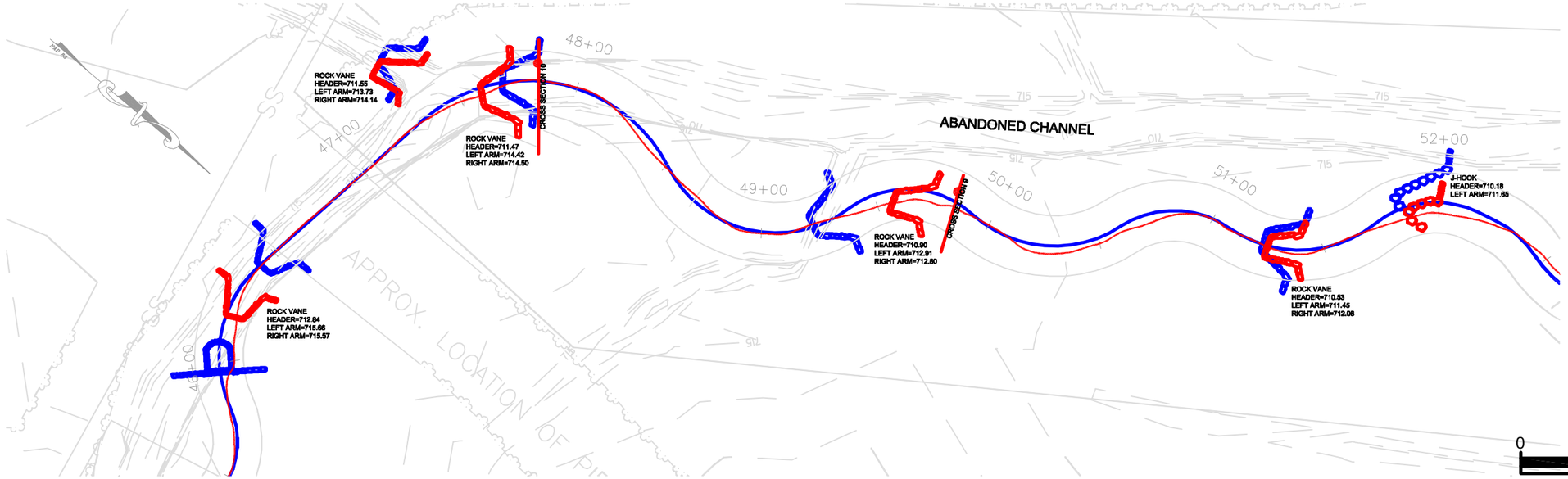
PROJECT MANAGER	DJK
DRAWN BY	TRS
APPROVED BY	DJK
PLOT NAME	mcintyre_creek
DRAWING SCALE	1"=50'
PROJECT DATE	01/2009
PROJECT NUMBER	2009001300RA
PLOT DATE	02/2009

D.K. DICKSON & CO., INC.
community infrastructure consultants
720 CORPORATE CENTER DRIVE
RALEIGH, NC 27607
(919) 782-0495
Office Locations:
North Carolina
South Carolina
Georgia

RELEASED FOR	DATE
APPROVALS	
BIDDING	
CONSTRUCTION	
RECORD DWG.	

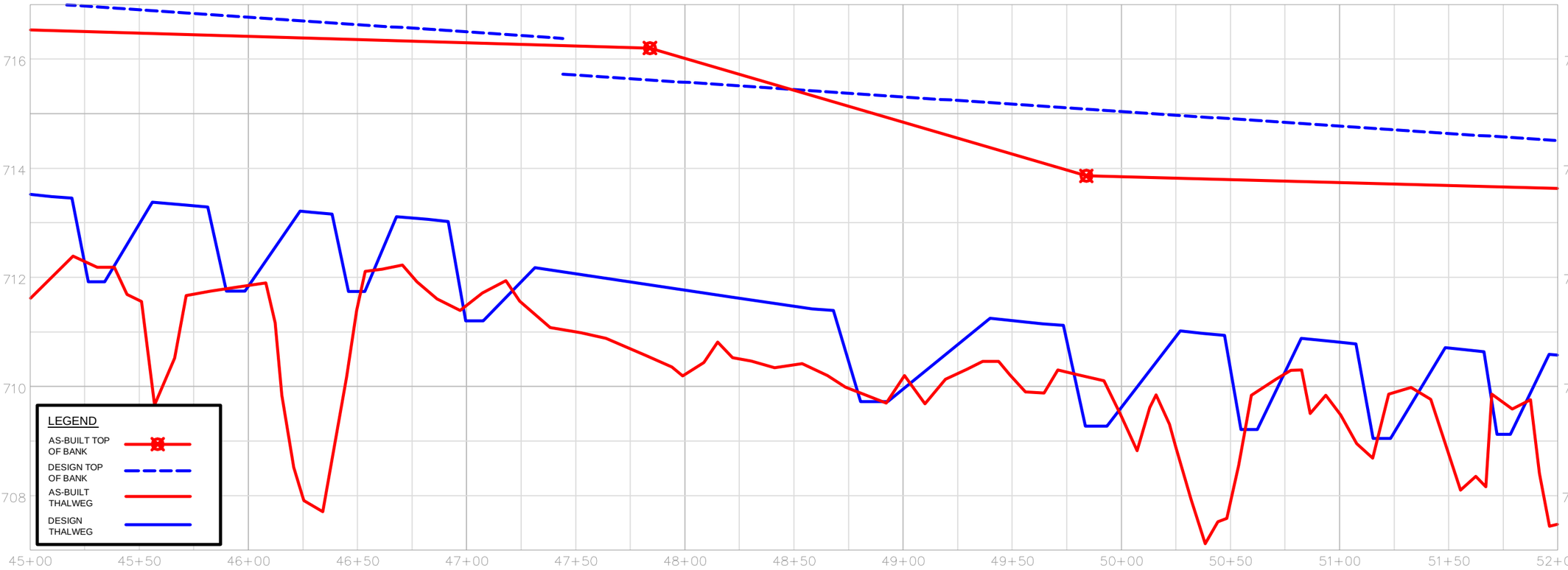
McINTYRE CREEK AS-BUILT COMPARISON
PREPARED FOR
NCDENR ECOSYSTEM ENHANCEMENT PROGRAM

STA. 38+00 - STA. 45+00



GRAPHIC SCALE
0 25 50 100
(IN FEET)
1 inch = 50 ft.

NOTE: CONTOURS AND BASE SURVEY FOR PRE-PROJECT CONDITIONS BY OTHERS



REV. NO.	DESCRIPTION	DATE
	REVISIONS	

PROJECT MANAGER	DJK
DRAWN BY	TRS
APPROVED BY	DJK
PLOT NAME	mcintyre_creek
DRAWING SCALE	1"=50'
PROJECT DATE	01/2009
PROJECT NUMBER	2009001308RA
PLOT DATE	02/2009

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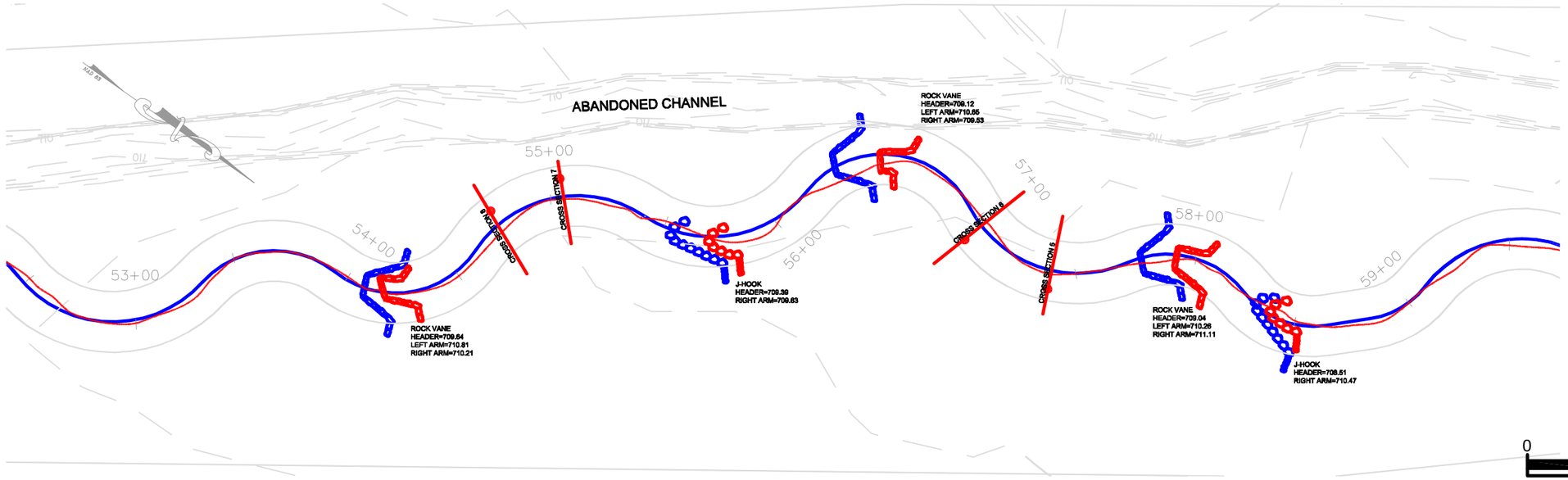
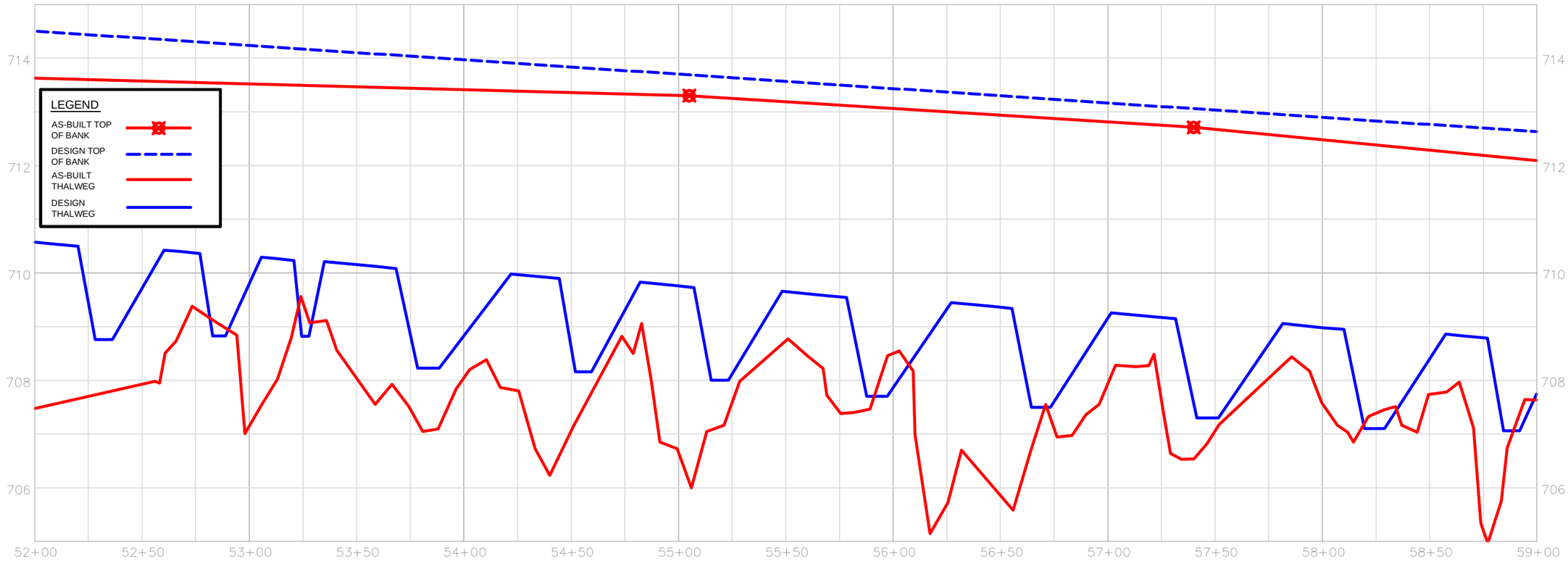
RELEASED FOR	DATE
APPROVALS	
BIDDING	
CONSTRUCTION	
RECORD DWG.	

McINTYRE CREEK AS-BUILT COMPARISON
PREPARED FOR
NCDENR ECOSYSTEM ENHANCEMENT PROGRAM

STA. 45+00 - STA. 52+00



NOTE: CONTOURS AND BASE SURVEY FOR PRE-PROJECT CONDITIONS BY OTHERS



REV. NO.	DESCRIPTION	DATE
	REVISIONS	

PROJECT MANAGER	DJK
DRAWN BY	TRS
APPROVED BY	DJK
PLOT NAME	mcintyre_creek
DRAWING SCALE	1"=50'
PROJECT DATE	01/2009
PROJECT NUMBER	2009001308RA
PLOT DATE	02/2009

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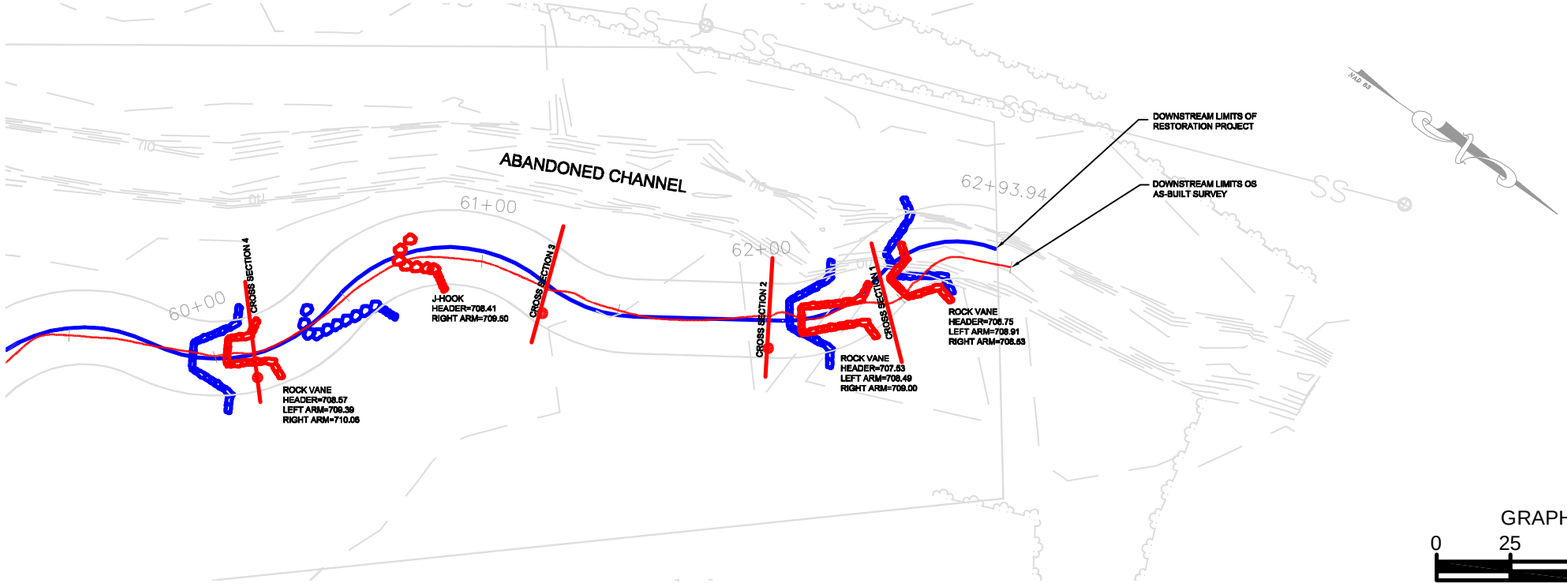
RELEASED FOR	DATE
APPROVALS	
BIDDING	
CONSTRUCTION	
RECORD DWG.	

McINTYRE CREEK AS-BUILT COMPARISON
PREPARED FOR
NCDENR ECOSYSTEM ENHANCEMENT PROGRAM

STA. 52+00 - STA. 59+00



LEGEND

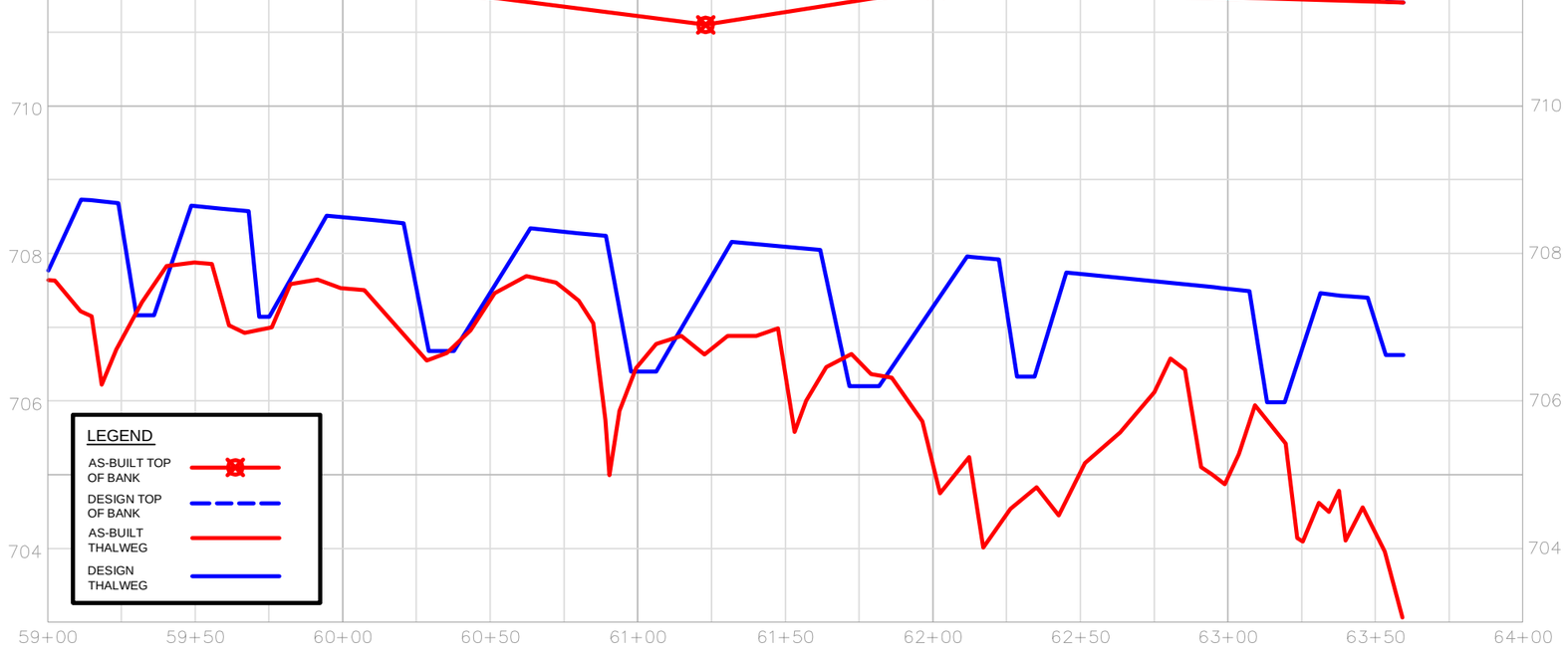
- AS-BUILT ROCK STRUCTURE
- DESIGN ROCK STRUCTURE
- AS-BUILT THALWEG
- DESIGN THALWEG
- AS-BUILT TOP OF BANK SHOT

GRAPHIC SCALE

0 25 50 100

(IN FEET)
1 inch = 50 ft.

NOTE: CONTOURS AND BASE SURVEY FOR PRE-PROJECT CONDITIONS BY OTHERS



REV. NO.	DESCRIPTION	DATE
	REVISIONS	

PROJECT MANAGER: DJK
DRAWN BY: TRS
APPROVED BY: DJK
FILE NAME: mcintyre_creek
DRAWING SCALE: 1"=50'
PROJECT DATE: 01/2009
PROJECT NUMBER: 3003901.300RA
PCSP DATE: 02/2009

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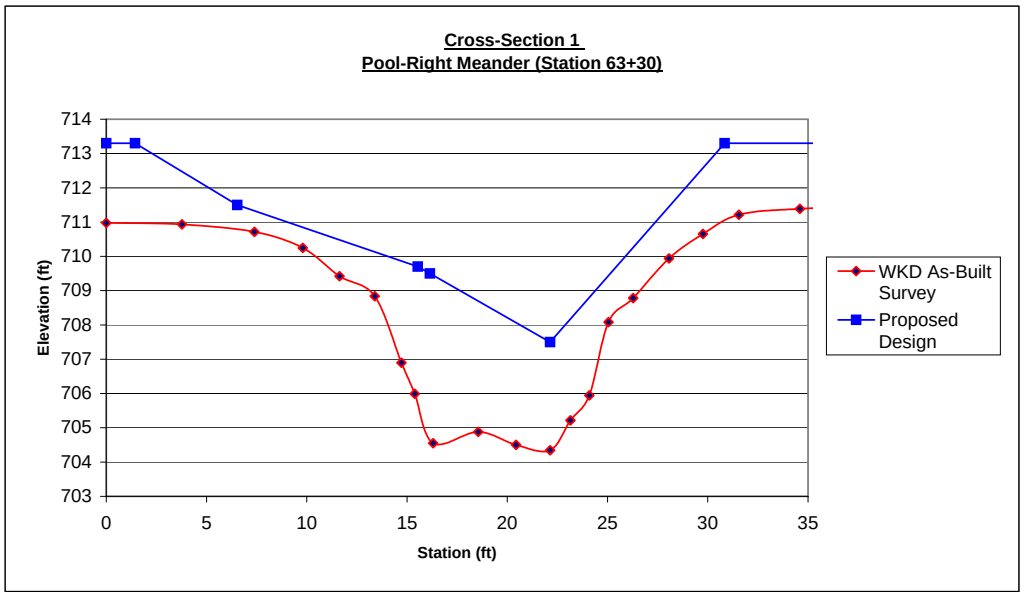
RELEASED FOR	DATE
APPROVALS	
BIDDING	
CONSTRUCTION	
RECORD DWG.	

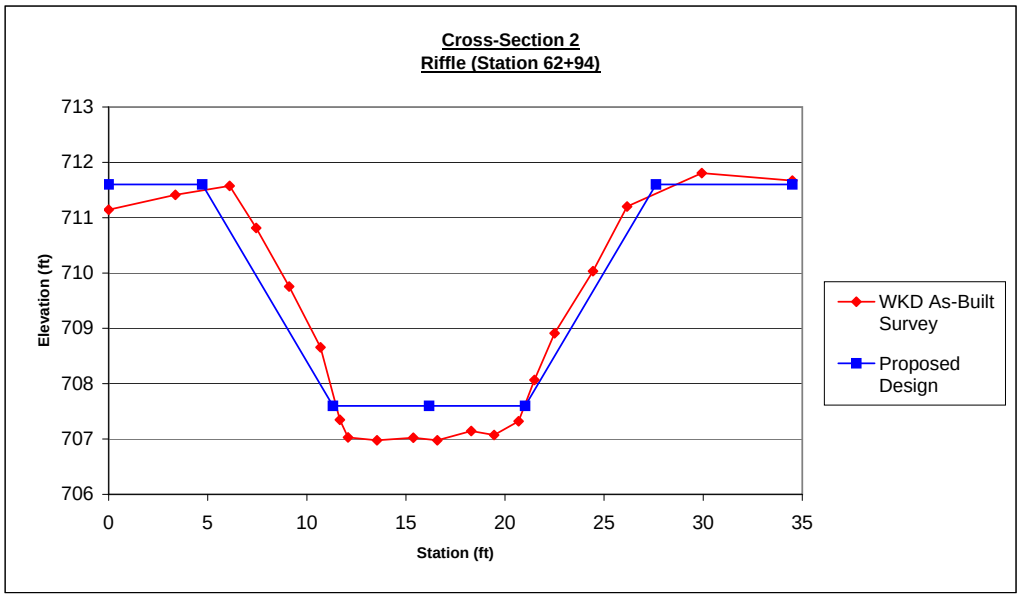
McINTYRE CREEK AS-BUILT COMPARISON
PREPARED FOR
NCDENR ECOSYSTEM ENHANCEMENT PROGRAM

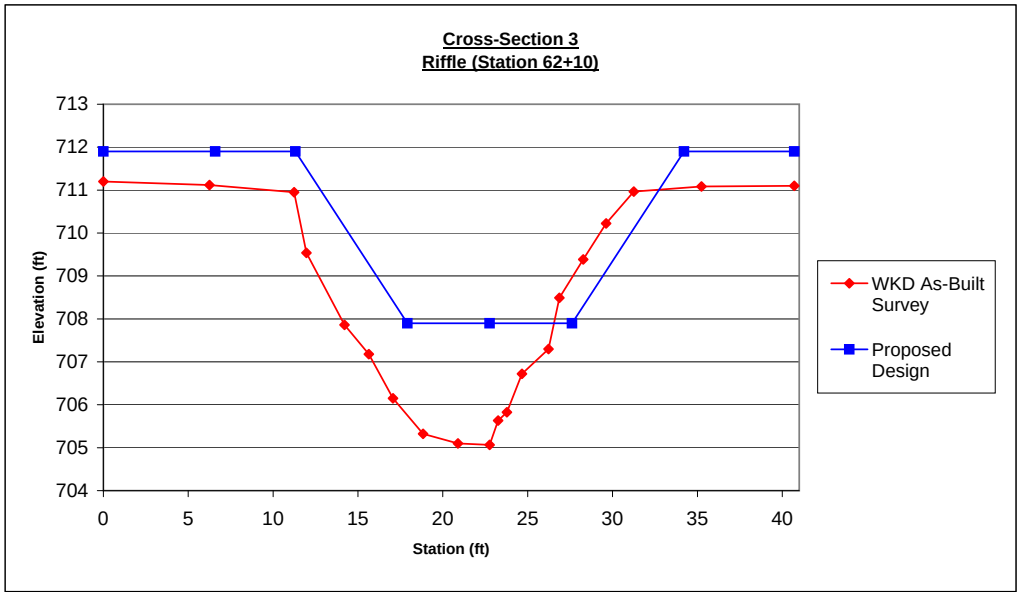
STA. 59+00 - STA. 62+94

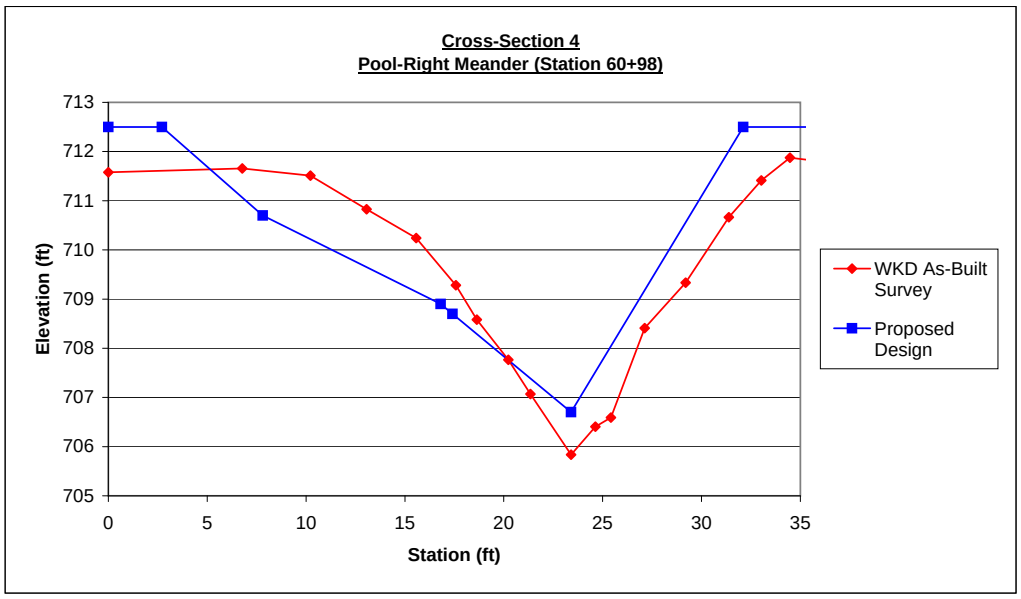
8/8

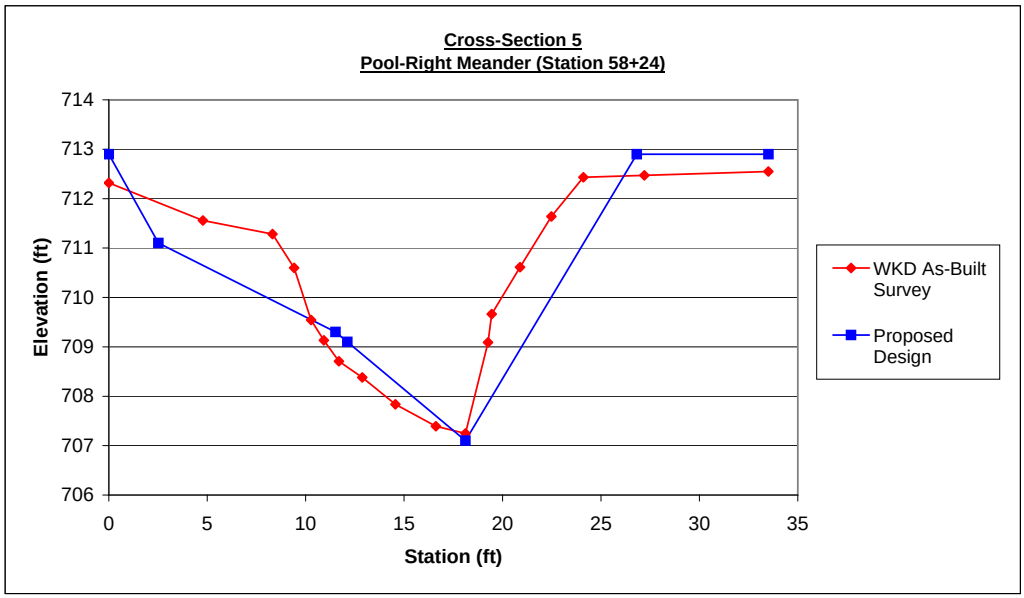
Appendix C

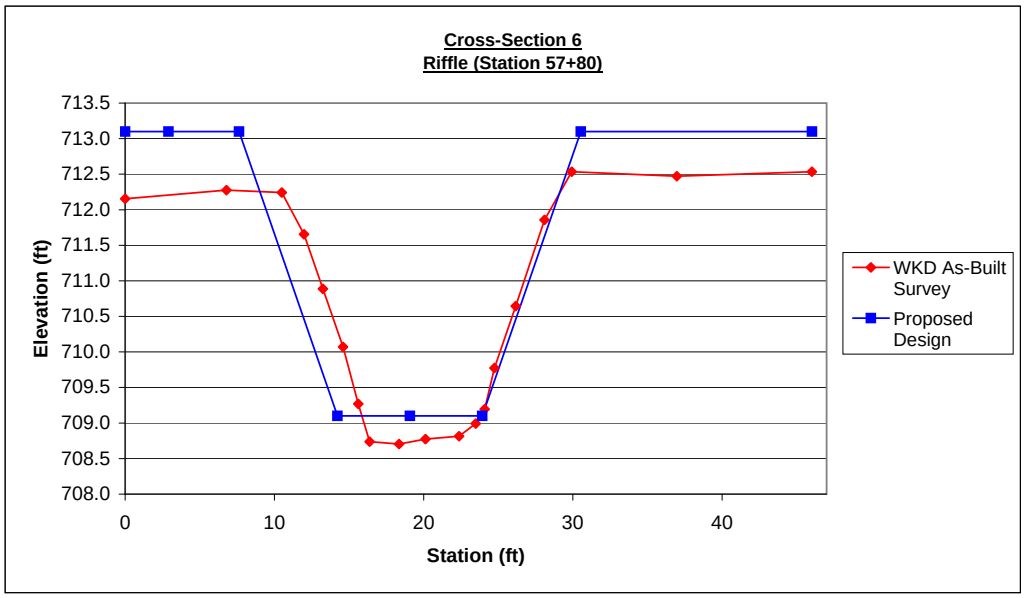

Cross-Section 1
Pool-Right Meander (Station 63+30)
Elevation (ft)
714
713
712
711
710
709
708
707
706
705
704
703
0
5
10
15
20
25
30
35
Station (ft)
WKD As-Built Survey
Proposed Design

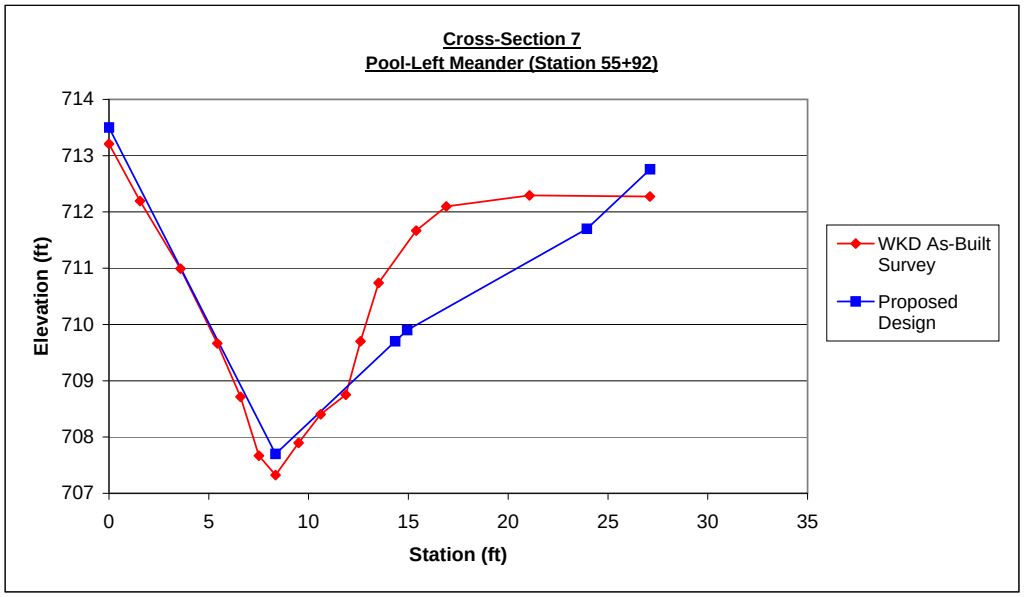

Cross-Section 2
Riffle (Station 62+94)
Elevation (ft)
713
712
711
710
709
708
707
706
0
5
10
15
20
25
30
35
Station (ft)
WKD As-Built Survey
Proposed Design

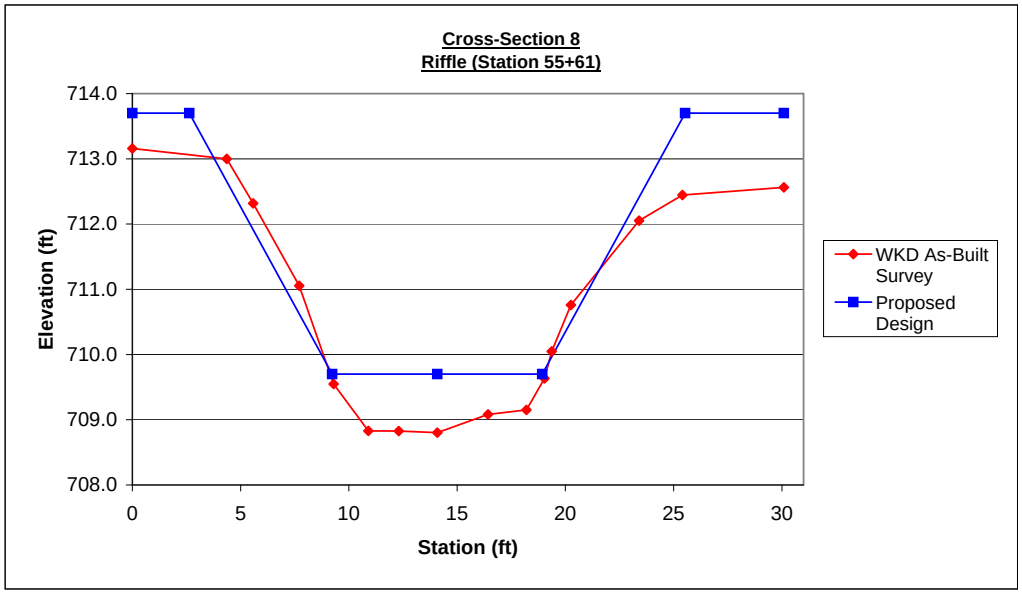

Cross-Section 3
Riffle (Station 62+10)
Elevation (ft)
713
712
711
710
709
708
707
706
705
704
0
5
10
15
20
25
30
35
40
Station (ft)
WKD As-Built Survey
Proposed Design

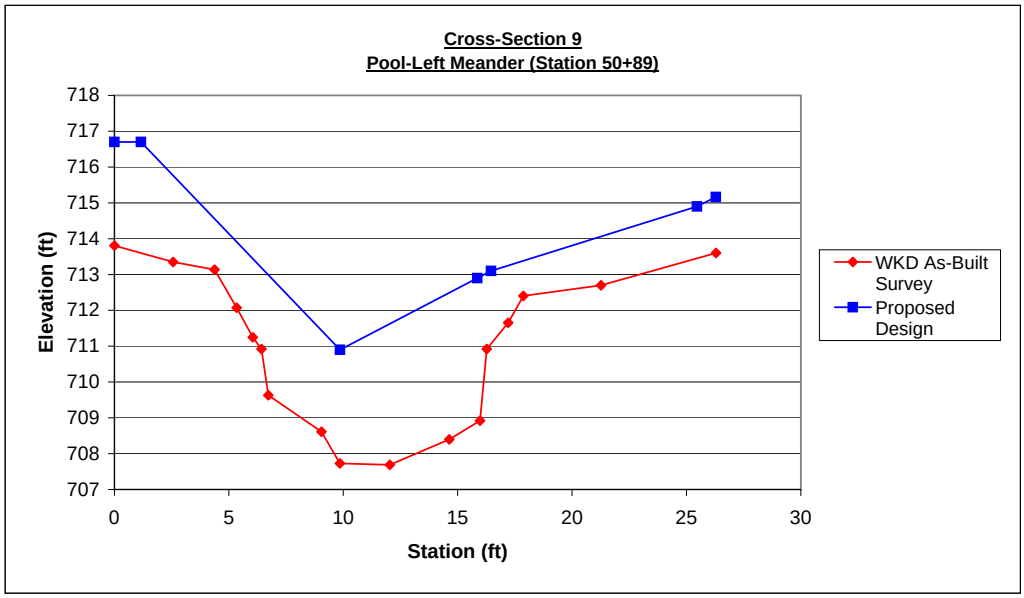

Cross-Section 4
Pool-Right Meander (Station 60+98)
Elevation (ft)
713
712
711
710
709
708
707
706
705
0
5
10
15
20
25
30
35
Station (ft)
WKD As-Built Survey
Proposed Design

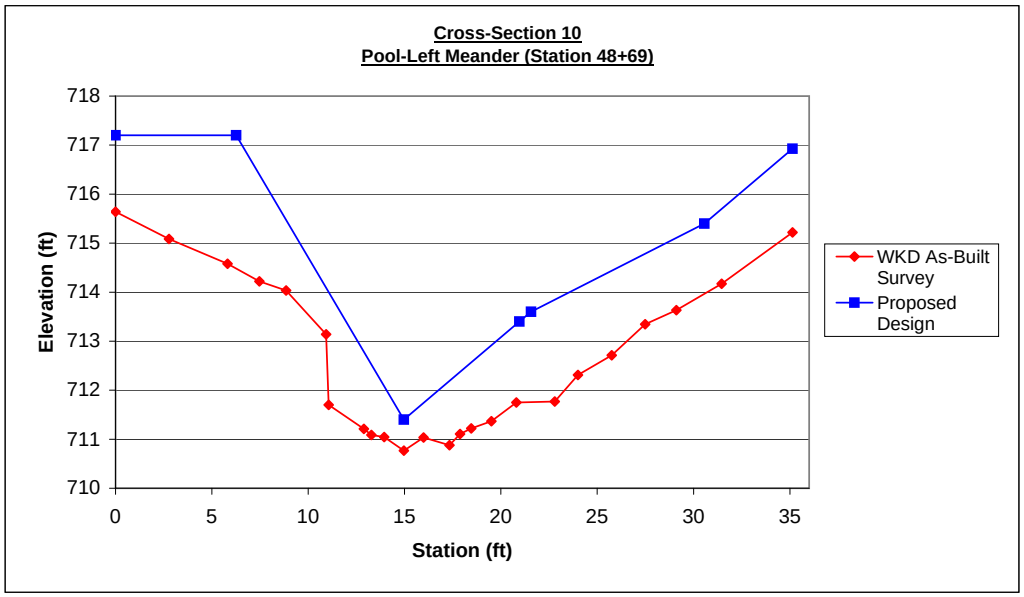

Cross-Section 5
Pool-Right Meander (Station 58+24)
Elevation (ft)
714
713
712
711
710
709
708
707
706
0
5
10
15
20
25
30
35
Station (ft)
WKD As-Built Survey
Proposed Design

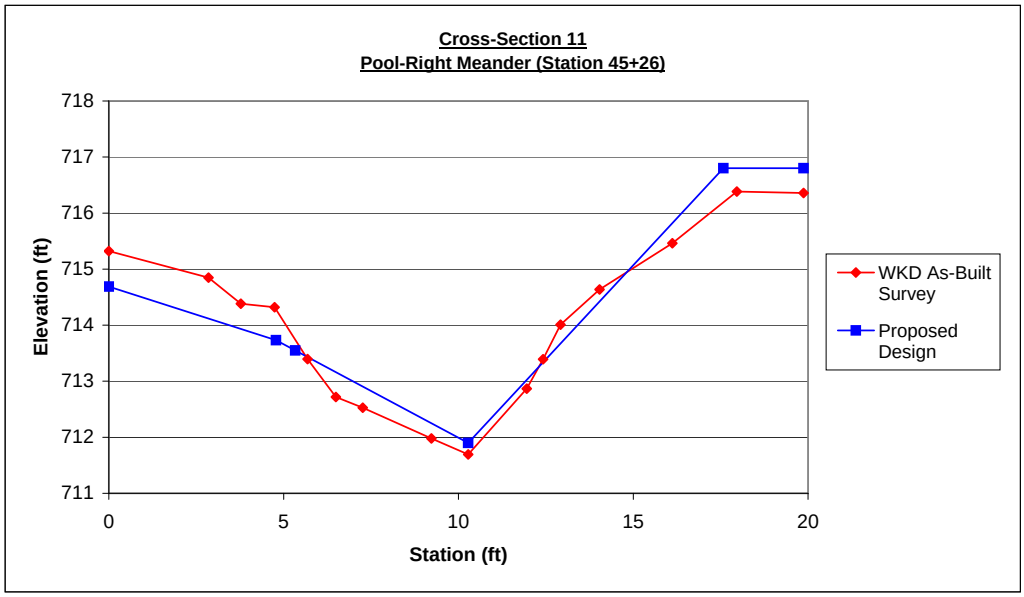

Cross-Section 6
Riffle (Station 57+80)
Elevation (ft)
713.5
713.0
712.5
712.0
711.5
711.0
710.5
710.0
709.5
709.0
708.5
708.0
0
10
20
30
40
Station (ft)
WKD As-Built Survey
Proposed Design

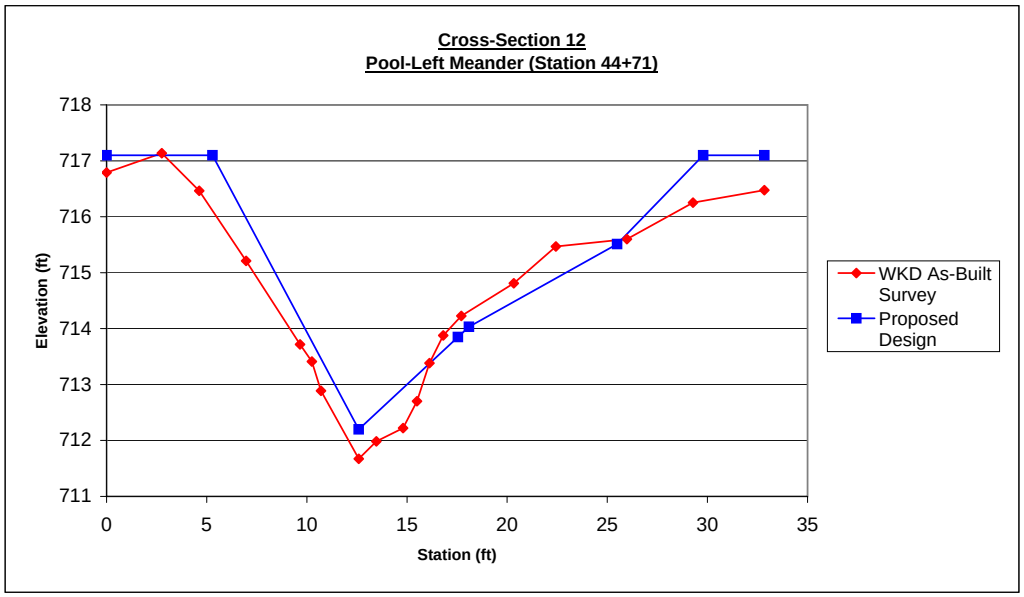

Cross-Section 7
Pool-Left Meander (Station 55+92)
Elevation (ft)
714
713
712
711
710
709
708
707
0
5
10
15
20
25
30
35
Station (ft)
WKD As-Built Survey
Proposed Design

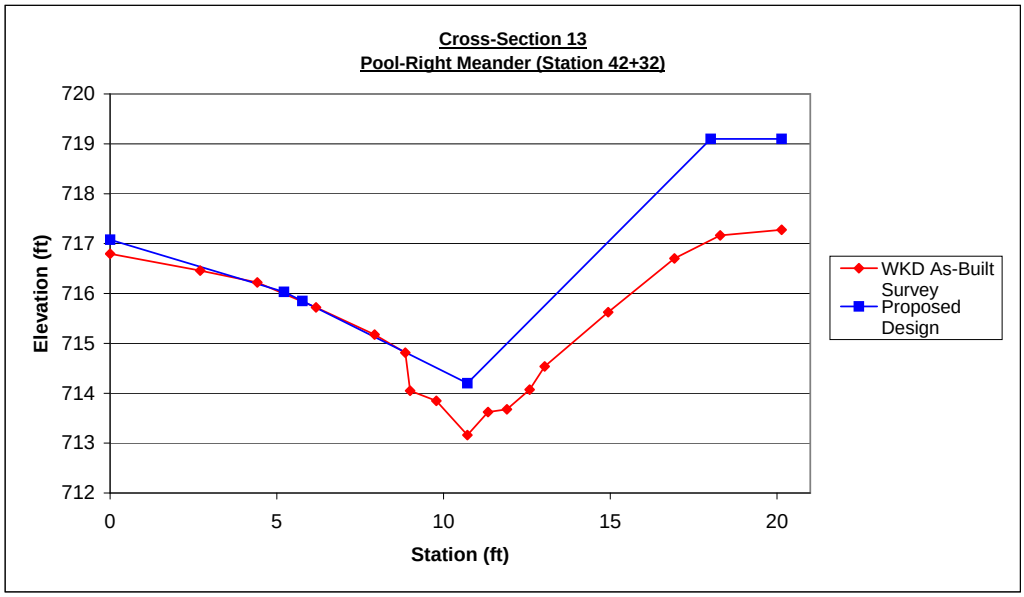

Cross-Section 8
Riffle (Station 55+61)
Elevation (ft)
714.0
713.0
712.0
711.0
710.0
709.0
708.0
0
5
10
15
20
25
30
Station (ft)
WKD As-Built Survey
Proposed Design

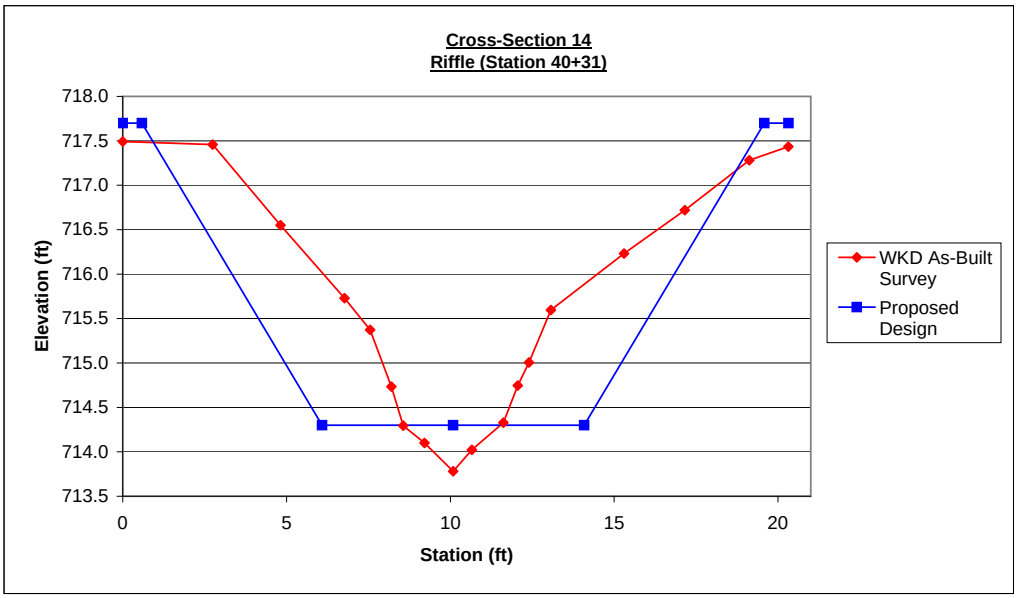

Cross-Section 9
Pool-Left Meander (Station 50+89)
Elevation (ft)
718
717
716
715
714
713
712
711
710
709
708
707
0
5
10
15
20
25
30
Station (ft)
WKD As-Built Survey
Proposed Design

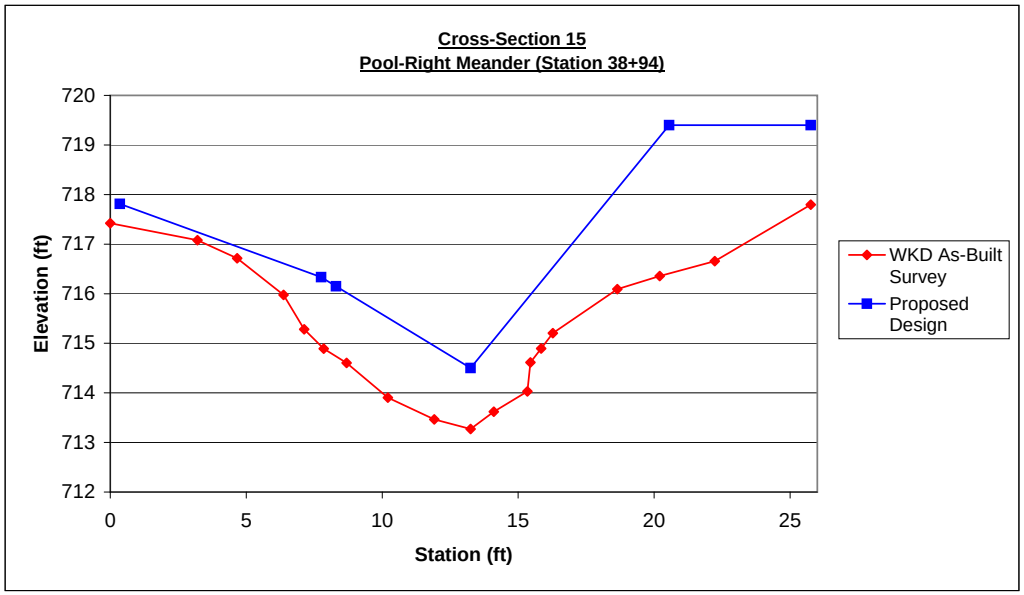

Cross-Section 10
Pool-Left Meander (Station 48+69)
Elevation (ft)
718
717
716
715
714
713
712
711
710
0
5
10
15
20
25
30
35
Station (ft)
WKD As-Built Survey
Proposed Design

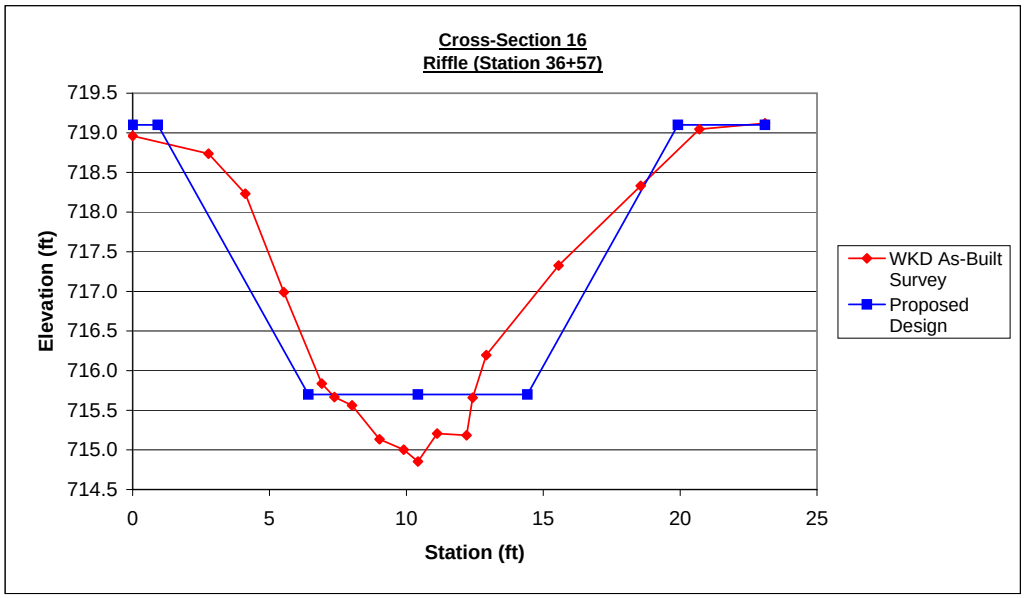

Cross-Section 11
Pool-Right Meander (Station 45+26)
718
717
716
715
714
713
712
711
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design

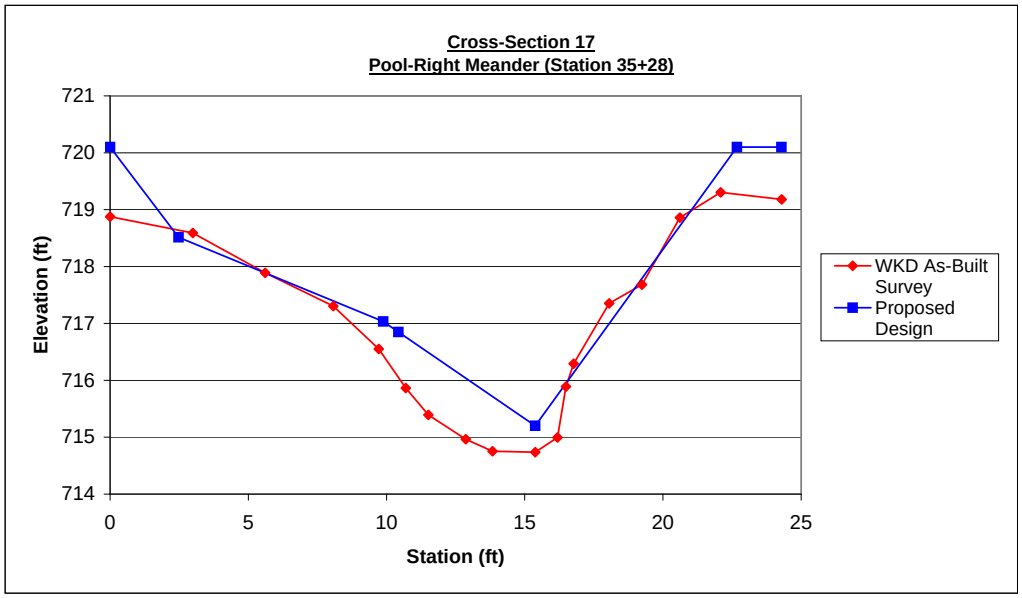

Cross-Section 12
Pool-Left Meander (Station 44+71)
718
717
716
715
714
713
712
711
Elevation (ft)
0
5
10
15
20
25
30
35
Station (ft)
WKD As-Built Survey
Proposed Design

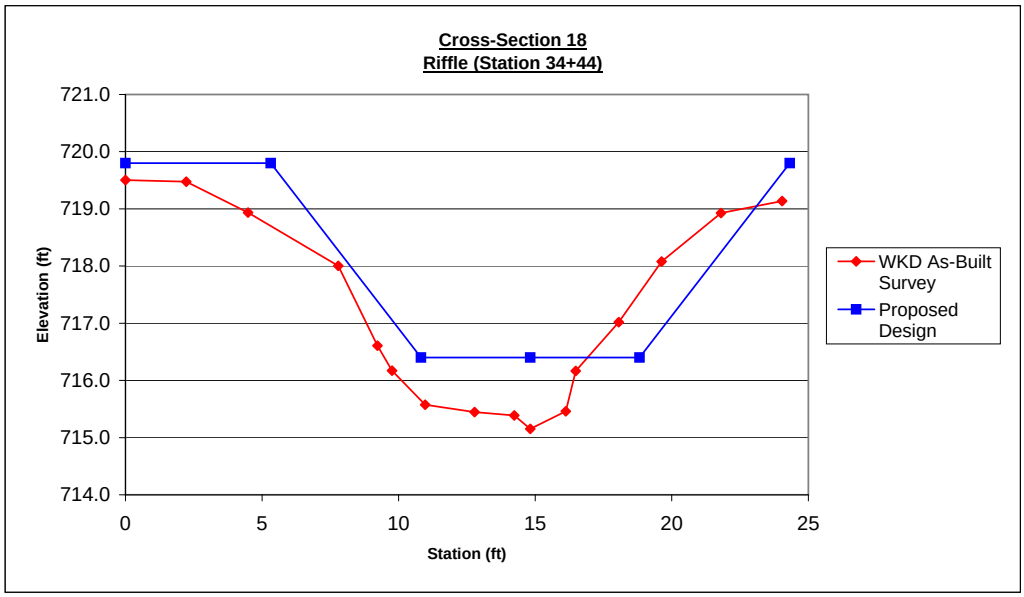

Cross-Section 13
Pool-Right Meander (Station 42+32)
720
719
718
717
716
715
714
713
712
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design

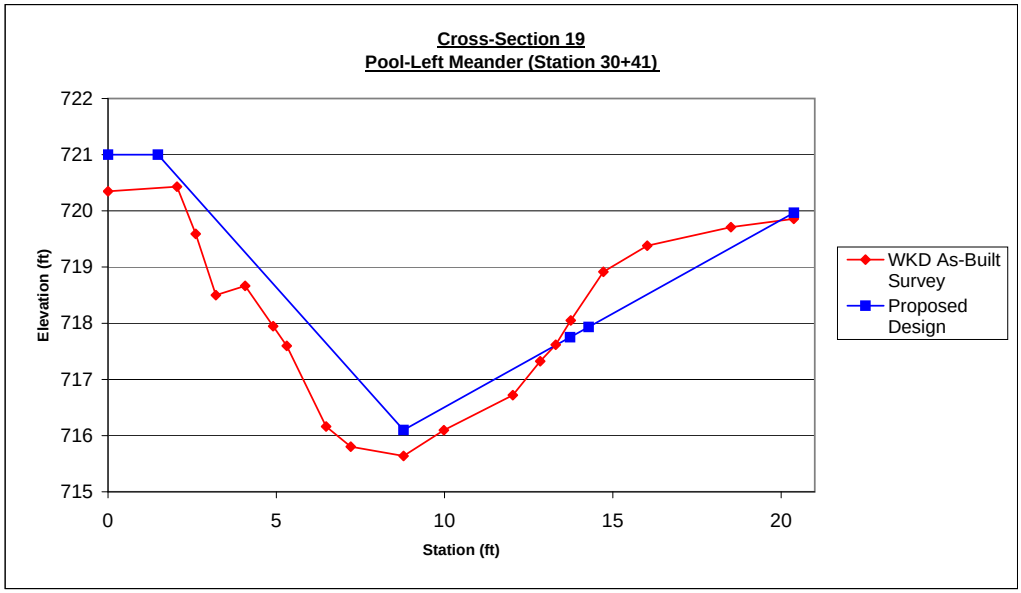

Cross-Section 14
Riffle (Station 40+31)
718.0
717.5
717.0
716.5
716.0
715.5
715.0
714.5
714.0
713.5
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design

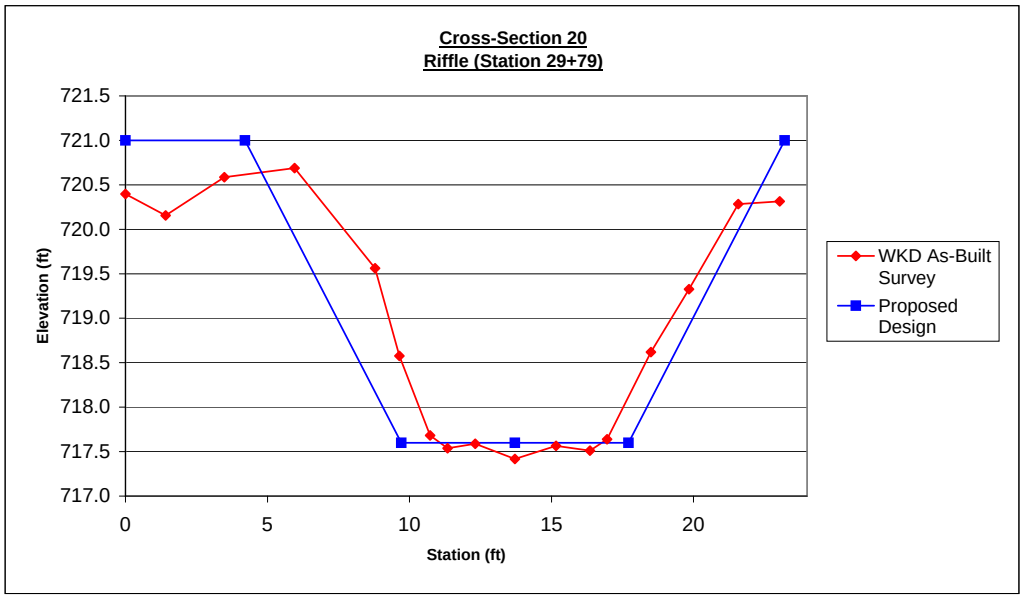

Cross-Section 15
Pool-Right Meander (Station 38+94)
720
719
718
717
716
715
714
713
712
Elevation (ft)
0
5
10
15
20
25
Station (ft)
WKD As-Built Survey
Proposed Design

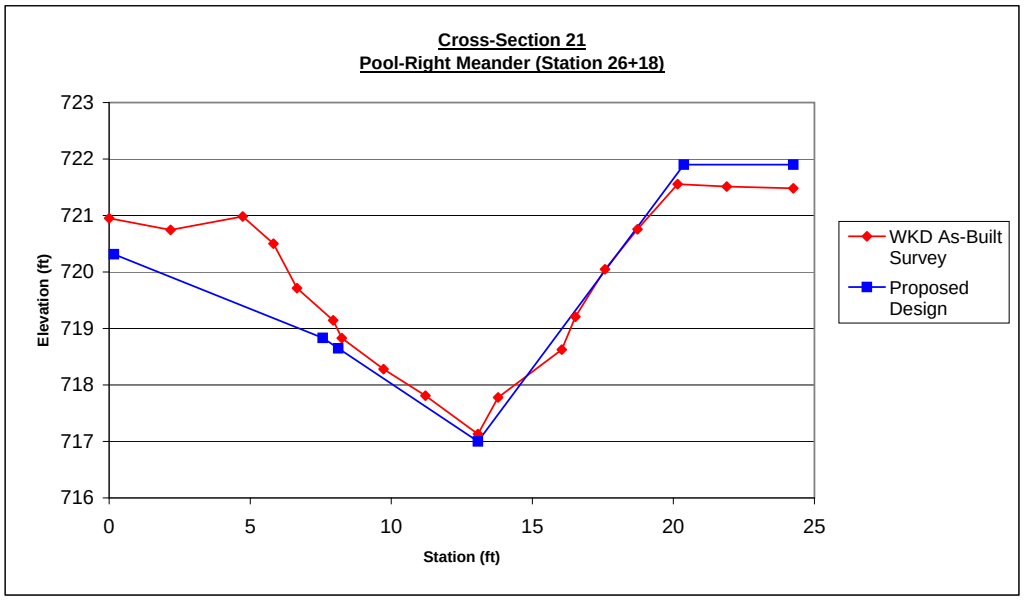

Cross-Section 16
Riffle (Station 36+57)
719.5
719.0
718.5
718.0
717.5
717.0
716.5
716.0
715.5
715.0
714.5
Elevation (ft)
0
5
10
15
20
25
Station (ft)
WKD As-Built Survey
Proposed Design

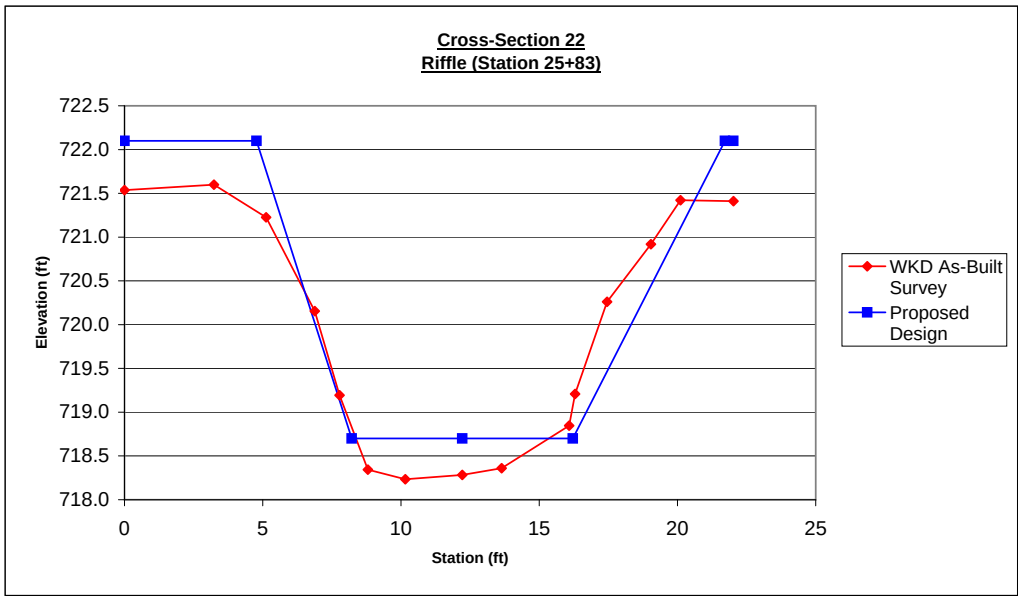

Cross-Section 17
Pool-Right Meander (Station 35+28)
Elevation (ft)
721
720
719
718
717
716
715
714
0
5
10
15
20
25
Station (ft)
WKD As-Built Survey
Proposed Design

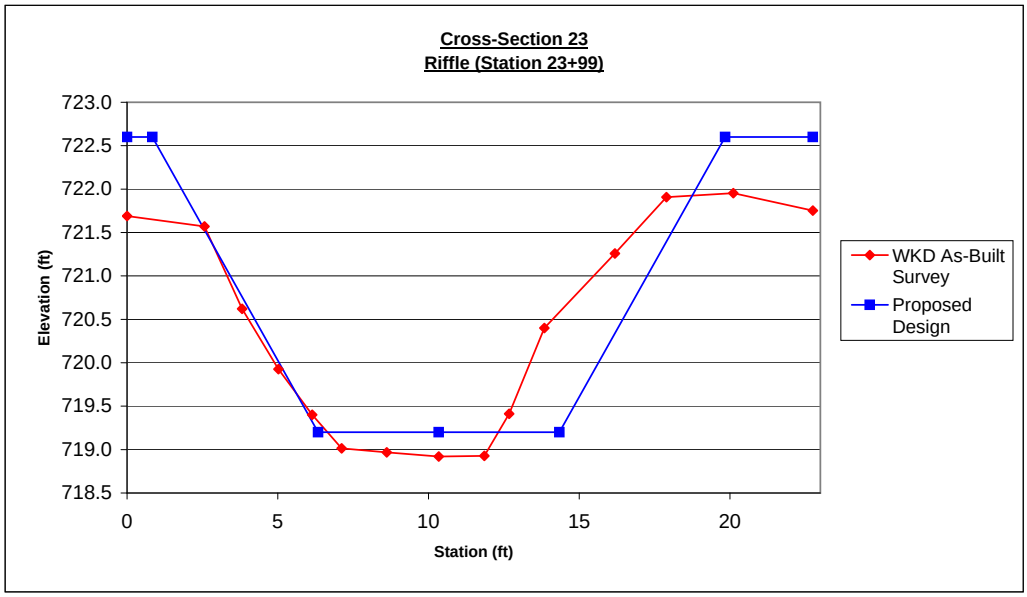

Cross-Section 18
Riffle (Station 34+44)
Elevation (ft)
721.0
720.0
719.0
718.0
717.0
716.0
715.0
714.0
0
5
10
15
20
25
Station (ft)
WKD As-Built Survey
Proposed Design

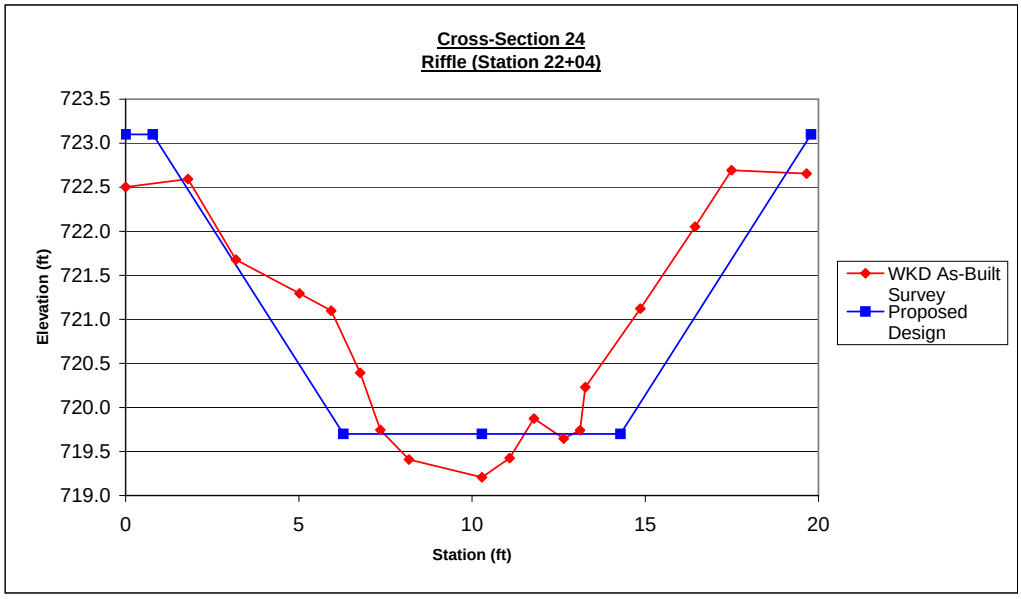

Cross-Section 19
Pool-Left Meander (Station 30+41)
722
721
720
719
718
717
716
715
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design

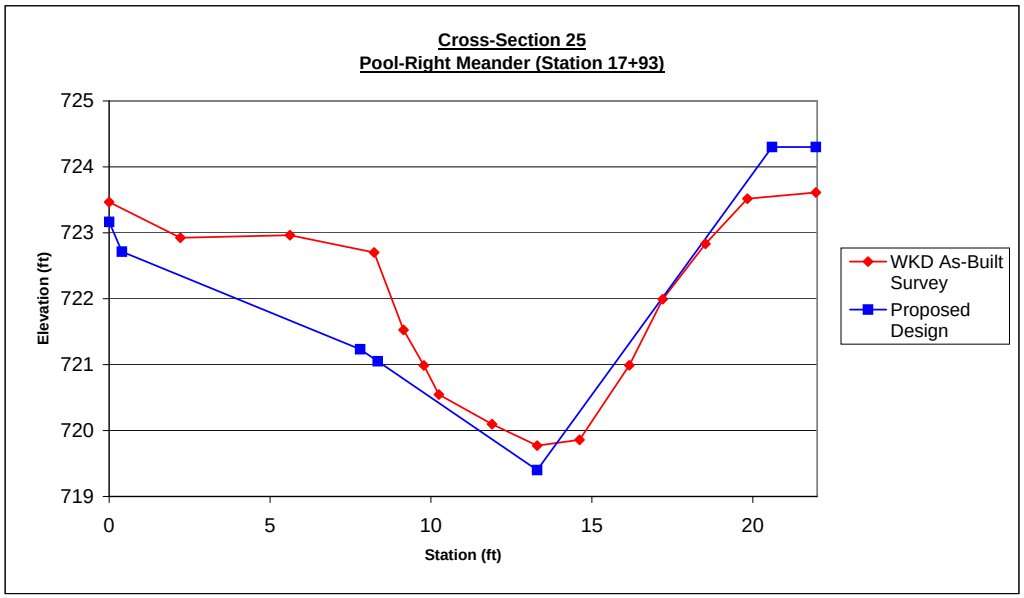

Cross-Section 20
Riffle (Station 29+79)
721.5
721.0
720.5
720.0
719.5
719.0
718.5
718.0
717.5
717.0
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design

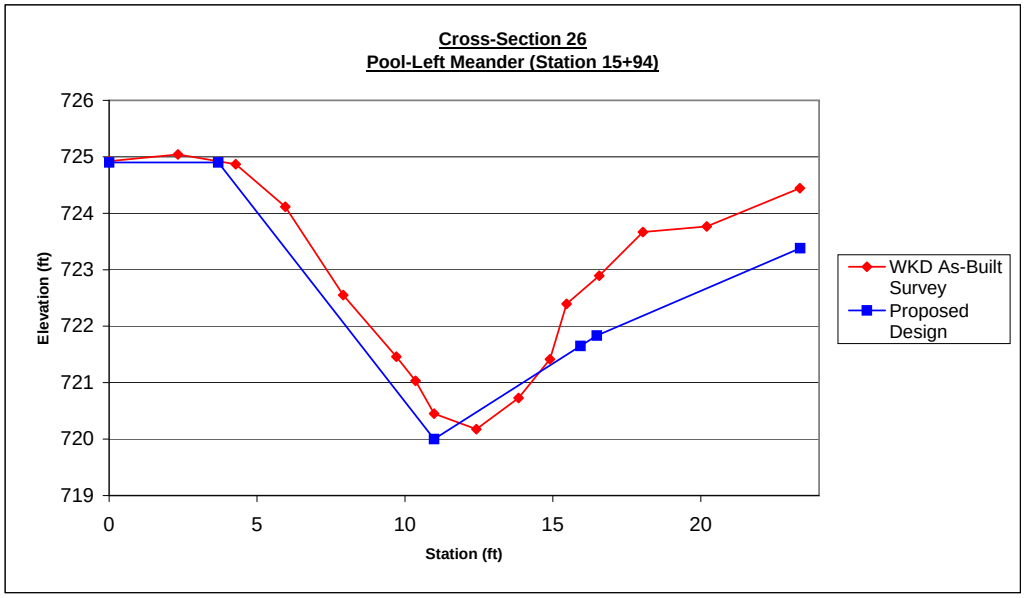

Cross-Section 21
Pool-Right Meander (Station 26+18)
723
722
721
720
719
718
717
716
Elevation (ft)
0
5
10
15
20
25
Station (ft)
WKD As-Built Survey
Proposed Design

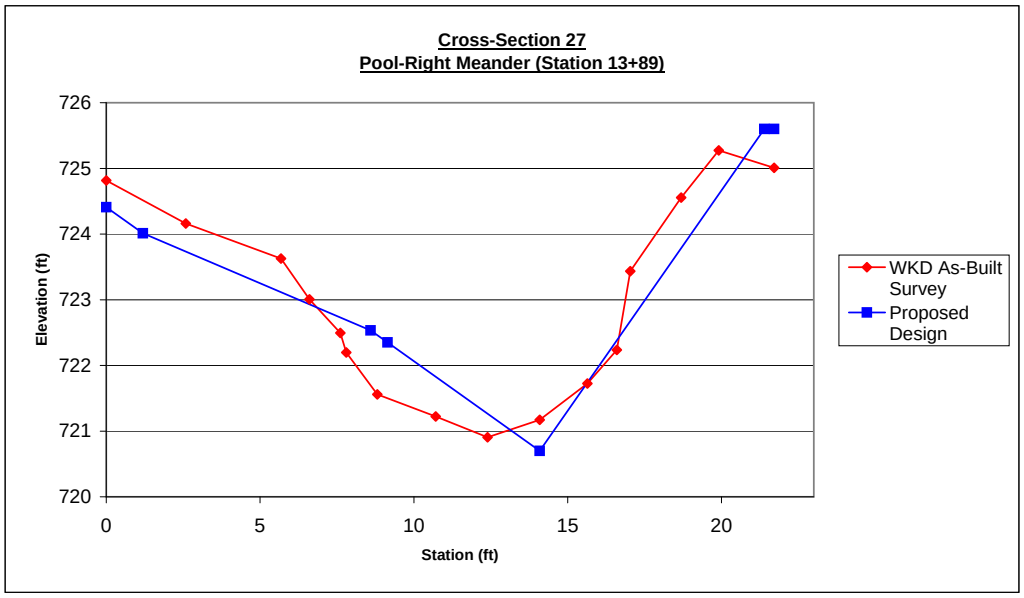

Cross-Section 22
Riffle (Station 25+83)
722.5
722.0
721.5
721.0
720.5
720.0
719.5
719.0
718.5
718.0
Elevation (ft)
0
5
10
15
20
25
Station (ft)
WKD As-Built Survey
Proposed Design

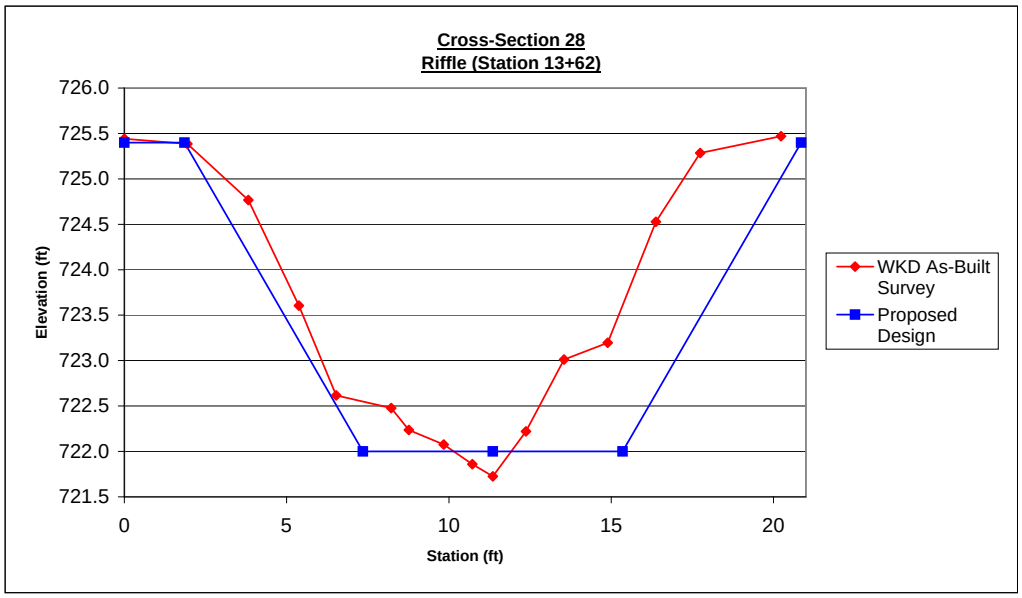

Cross-Section 23
Riffle (Station 23+99)
723.0
722.5
722.0
721.5
721.0
720.5
720.0
719.5
719.0
718.5
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design

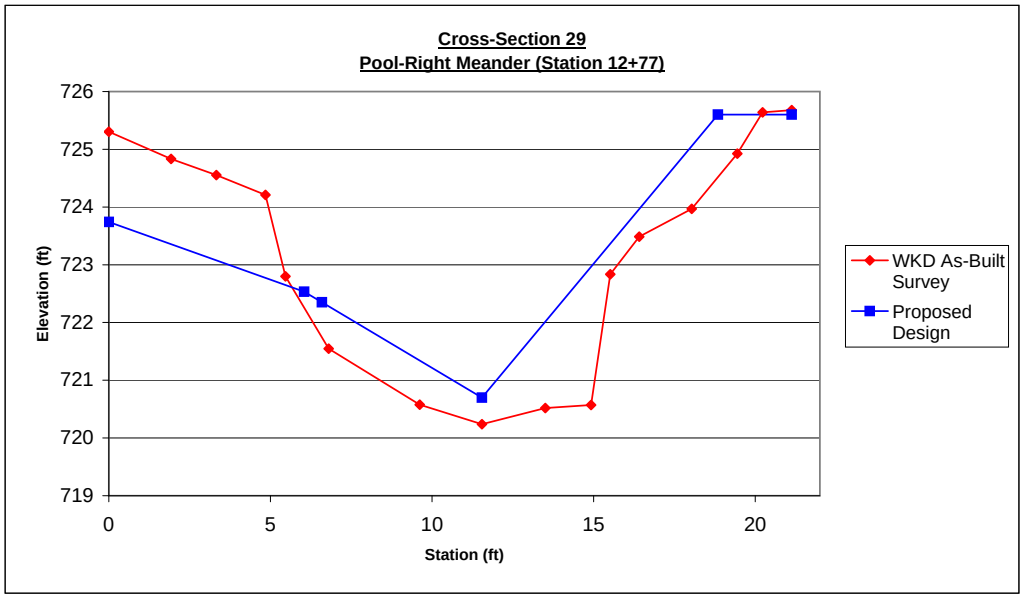

Cross-Section 24
Riffle (Station 22+04)
723.5
723.0
722.5
722.0
721.5
721.0
720.5
720.0
719.5
719.0
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design

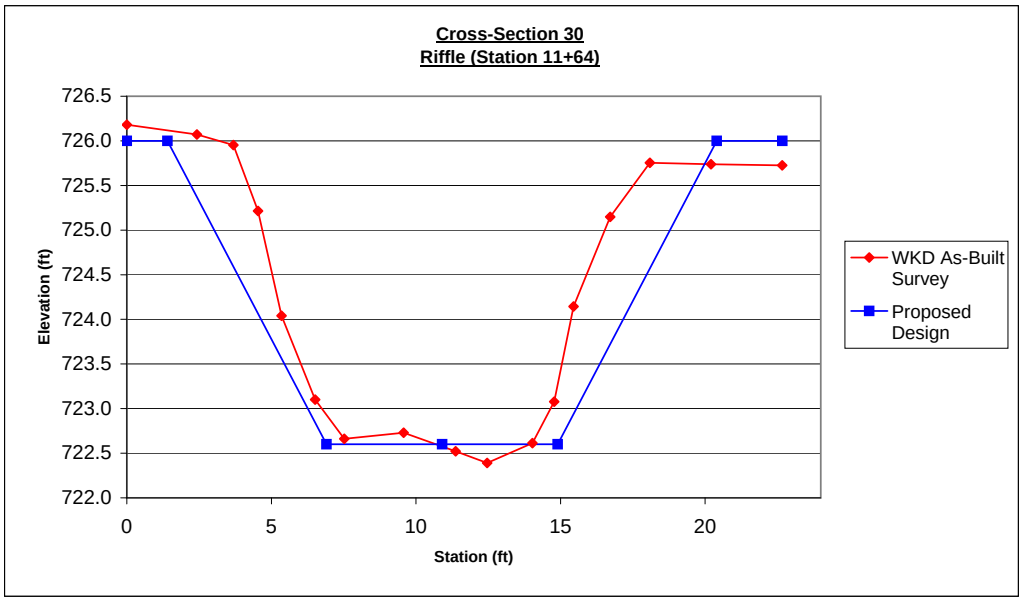

Cross-Section 25
Pool-Right Meander (Station 17+93)
725
724
723
722
721
720
719
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design


Cross-Section 26
Pool-Left Meander (Station 15+94)
726
725
724
723
722
721
720
719
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design


Cross-Section 27
Pool-Right Meander (Station 13+89)
726
725
724
723
722
721
720
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design


Cross-Section 28
Riffle (Station 13+62)
726.0
725.5
725.0
724.5
724.0
723.5
723.0
722.5
722.0
721.5
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design


Cross-Section 29
Pool-Right Meander (Station 12+77)
726
725
724
723
722
721
720
719
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design


Cross-Section 30
Riffle (Station 11+64)
726.5
726.0
725.5
725.0
724.5
724.0
723.5
723.0
722.5
722.0
Elevation (ft)
0
5
10
15
20
Station (ft)
WKD As-Built Survey
Proposed Design

Appendix D

Table 2. Morphological Design Criteria

Variables		Project Site Existing Channel**		Reference Reach	Project Site Restored Reach**	
Stream Type		Modified E5		E5	E5	E5
Drainage Area (mi^2)		1.79	2.55	0.2	1.79	2.5
Bankfull Width (W_{bkf})		17.0'	23-24'	13.1'	18.7'	22.9'
Bankfull Mean Depth (d_{bkf})		2.5'	2.5-2.7'	1.62'	2.3'	2.8'
Bankfull Cross-Sectional Area (A_{bkf}) (ft^2)		40-45	58-68	21.3	42-50	64-70
Width/Depth Ratio (W_{bkf}/d_{bkf})		4-7	8-9	8.1	8.1	8.1
Bankfull Max Depth (d_{mbkf})		3-4'	3.5-4.5'	2.83'	3.3-3.5'	4.0'
Width of Floodprone Area (W_{fpa})		100-300'	100-300'	77'	100-300'	100-300'
Entrenchment Ratio (ER)		6.0-17.5	4.5-12.5	5.9	5.0-16.0	4.0-13.0
Low Bank Height Ratio (LBHR)		1.5-1.9	1.3-1.4	1.0-1.08	1.0	1.0
Channel Materials (D50) (mm)		0.2-0.3	0.2-0.3	0.5	0.3	0.3
Water Surface Slope (S)		0.21%	0.27%	0.44%	0.21-0.25%	
Sinuosity (K)		1.1	1.22*	1.25	1.3-1.5	1.3-1.5
Dimension	Pool Depth (dp)	4.1'	4.1'	1.64'	2.9'	3.4'
	Riffle Depth (dr)	2.5'	2.5-2.7'	1.62'	2.83'	3.37'
	Ratio - Max. Pool Depth: Mean Bkf. Depth	1.64 (=4.1/2.5)		2.0 (=3.25/1.62)	2.0	2.0
	Bankfull mean velocity (u) (ft./sec.)	4.5	4.0	3.87	4.2-4.4	4.0
	Bankfull discharge (Q) (CFS)	180-210	250-280	68-83	180-210	250-280
Pattern	Meander Length (L_m)	96-172'*		60-71'	90-190'	110-230'
	Radius of Curvature (R_c)	60.3-148.1'*		10.3-25.6'	37-56'	45-70'
	Belt Width (W_{blt})	34-58'*		38'	95'	115'
	Meander Width Ratio (MWR)	1.4-2.5*		2.9	5.0	5.0
	Ratio- Rad. of Curv.: Bkf Width (R_c/W_{bkf})	2.6-6.3 *		0.8-2.0	2.0-4.0	2.0-4.0
	Ratio- Meander Length:Bkf Width (L_m/W_{bkf})	4.1-7.3*		4.6-5.4	5.0-10.0	5.0-10.0
Profile	Valley Slope (ft./ft.)	0.33%	0.33%	0.55%	0.33%	0.33%
	Water Surface Slope (ft./ft.)	0.21%	0.27%	0.44%	0.21-0.25%	
	Riffle Slope (ft./ft.)	0.3-0.6%		0.50-1.1%	0.25-0.65%	
	Pool Slope (ft./ft.)	0.1-0.2%		0.00-0.25%	0.00-0.13%	
	Pool to Pool Spacing (ft.)	-	-	11-45'	46-94'	57-115'
	Pool Length (ft.)	-	-	7-18'	12-32'	15-37'
	Ratio - Pool Slope:Water Surface Slope	0.4-1.0	0.4-1.0	0.0-0.57	0.0-0.57	0.0-0.57
	Ratio - Pool to Pool Spacing:Bkf width	-	-	0.8-3.4	2.5 – 5.0	2.5 – 5.0

*The pattern data for the existing channel was measured in the lower portion of the project reach (stabilizing section).

**The morphological parameters/design criteria are separated based on location relative to the confluence of the main thread and the tributary channel (Existing Sta. 43+20). The drainage area below the confluence increases to 2.55 sq. miles.

Appendix E

Project: McIntyre Creek Stream Restoration Project, Charlotte NC
Engineer: DJK
Date: 3-11-09

Stream Location (station number)	Type of Rock Structure	Thalweg Elevation (ft NAVD 1988)	As-Built Header Rock Elevation (ft NAVD 1988)	Proposed Header Rock Elevation (ft NAVD 1988)	Difference in Header Rock Elevation (ft)	Header Rock Within 0.2' Tolerance (Yes/No)	Left End of Arm Elevation (ft NAVD 1988)	Right End of Arm Elevation (ft NAVD 1988)	As-Built Top of Bank (ft NAVD 1988)	2/3 Top of Bank Elevation (ft NAVD 1988)	Arm Constructed to Reasonable Height (Yes/No)
1032	Cross Vane	722.48	n/a	722.88		n/a	724.01	723.73	n/a	n/a	n/a
1054	Cross Vane	723.00	723.28	722.85	0.43	n/a	725.07	725.95	n/a	n/a	n/a
1186	Cross Vane	722.43	722.98	722.49	0.49	No	725.07	724.63	725.70	724.58	Yes
1328	Cross Vane	721.45	722.42	722.12	0.30	No	724.16	723.60	725.28	723.98	Yes
1499	Cross Vane	721.69	722.12	721.69	0.43	No	722.44	722.66	724.47	723.52	Yes
1641	Cross Vane	721.09	721.17	721.31	-0.14	Yes	722.41	722.44	723.60	722.74	Yes
1847	Cross Vane	720.29	720.76	720.74	0.02	Yes	723.04	722.21	723.50	722.41	Yes
2005	Cross Vane	719.91	720.48	720.27	0.21	No	721.51	721.43	723.10	722.02	Yes
2344	Cross Vane	719.18	719.60	719.27	0.33	No	721.26	720.24	721.91	720.98	Yes
2751	Cross Vane	718.00	718.73	718.22	0.51	No	719.70	720.57	720.92	719.93	Yes
2912	Cross Vane	717.04	717.85	717.77	0.08	Yes	718.16	720.51	720.28	719.18	Yes
3099	Cross Vane	717.07	717.37	717.30	0.07	Yes	718.31	718.92	719.30	718.54	Yes
3243	Cross Vane	716.18	716.73	716.90	-0.17	Yes	718.41	718.55	719.10	718.11	Yes
3452	Cross Vane	715.28	716.16	716.28	-0.12	Yes	716.46	716.41	718.93	717.69	Yes
3590	Cross Vane	714.94	715.93	715.84	0.09	Yes	716.39	716.26	719.15	717.72	Yes
3872	Cross Vane	714.66	715.04	715.13	-0.09	Yes	715.83	716.26	716.36	715.78	Yes
4134	Cross Vane	714.10	714.45	714.45	0.00	Yes	716.49	716.62	717.20	716.15	Yes
4362	Cross Vane	713.10	713.86	713.83	0.03	Yes	714.64	715.60	716.34	715.24	Yes
4577	Cross Vane	711.83	713.34	713.32	0.02	Yes	714.68	713.63	716.38	714.83	Yes
4707	Cross Vane	712.36	712.84	712.18	0.66	No	715.66	715.57	714.87	714.01	Yes
4847	Cross Vane	710.97	711.47	711.42	0.05	Yes	714.42	714.50	713.35	712.54	Yes
5048	Cross Vane	710.02	710.90	710.94	-0.04	Yes	712.91	712.80	712.40	711.59	Yes
5212	Cross Vane	709.93	710.53	710.53	0.00	Yes	711.45	712.06	712.48	711.61	Yes
5502	Cross Vane	709.24	709.64	709.73	-0.09	Yes	710.81	710.21	712.45	711.36	Yes
5733	Cross Vane	708.68	709.12	709.15	-0.03	Yes	710.65	709.53	712.43	711.16	Yes
5877	Cross Vane	708.17	709.04	708.79	0.25	No	710.26	711.11	712.40	710.96	Yes
6089	Cross Vane	707.57	708.57	708.24	0.33	No	709.39	710.06	711.87	710.41	Yes
6301	Cross Vane	706.65	707.53	707.49	0.04	Yes	708.49	709.00	711.21	709.66	Yes
6338	Cross Vane	704.40	706.75	707.43	-0.68	No	708.91	708.53	711.20	708.89	Yes

Did not locate structures with probings.

Project: McIntyre Creek Stream Restoration Project, Charlotte NC
Engineer: DJK
Date: 3-11-09

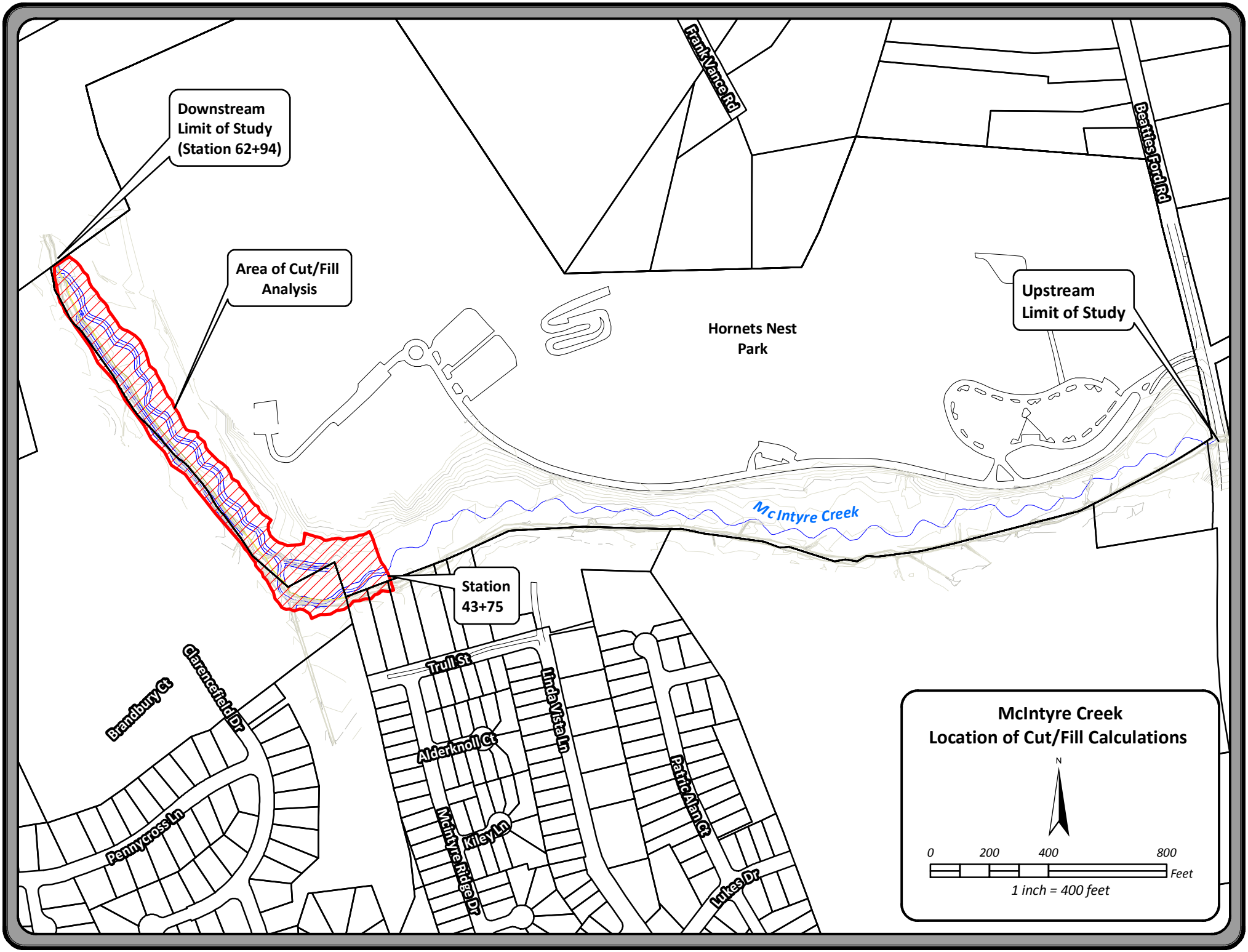
J-Hooks

Stream Location (station number)	Type of Rock Structure	Thalweg Elevation (ft NAVD 1988)	As-Built Header Rock Elevation (ft NAVD 1988)	Proposed Header Rock Elevation (ft NAVD 1988)	Difference in Header Rock Elevation (ft)	Header Rock Within 0.2' Tolerance (Yes/No)	Arm Elevation (ft NAVD 1988)	As-Built Top of Bank (ft NAVD 1988)	2/3 Top of Bank Elevation (ft NAVD 1988)	Arm Constructed to Reasonable Height (Yes/No)
1268	J-Hook	722.29	722.46	722.26	0.20	No	723.49	725.64	724.50	Yes
2126	J-Hook	719.97	720.29	719.96	0.33	No	722.24	722.70	721.77	Yes
2415	J-Hook	719.04	719.28	719.06	0.22	No	720.79	721.91	720.93	Yes
4440	J-Hook	712.94	713.57	713.72	-0.15	Yes	714.80	715.47	714.61	Yes
5274	J-Hook	709.66	710.18	710.36	-0.18	Yes	711.65	712.47	711.51	Yes
5655	J-Hook	708.37	709.39	709.34	0.05	Yes	709.63	712.50	711.10	Yes
5923	J-Hook	707.43	708.51	708.68	-0.17	Yes	710.47	712.10	710.51	Yes
6161	J-Hook	707.20	708.41	708.05	0.36	No	709.50	711.00	709.71	Yes

Step Pools

Stream Location (station number)	Type of Rock Structure	Thalweg Elevation (ft NAVD 1988)	As-Built Header Rock Elevation (ft NAVD 1988)	Proposed Header Rock Elevation (ft NAVD 1988)	Difference in Header Rock Elevation (ft)	Rock Structure Built as Proposed (Yes/No)	Downstream Head Rock Elevation (ft NAVD 1988)	As-Built Top of Bank (ft NAVD 1988)	2/3 Top of Bank Elevation (ft NAVD 1988)	Arm Constructed to Reasonable Height (Yes/No)
2670	Step Pool	718.28	718.89	718.41	0.48	No	719.02	721.00	720.08	Yes
2689	Step Pool	719.05	719.38	718.37	1.01	No	719.02	721.00	720.34	Yes
4682	Step Pool	711.54	713.10	713.06	0.04	Yes	712.84	712.80	712.37	Yes

Appendix F


Downstream
Limit of Study
(Station 62+94)
Area of Cut/Fill
Analysis
Frank Vance Rd
Beattie's Ford Rd
Hornets Nest
Park
Upstream
Limit of Study
McIntyre Creek
Station
43+75
Trull St
Brandbury Ct
Clarencefield Dr
Alderknoll Ct
Linda Vista Ln
McIntyre Ridge Dr
Kiley Ln
Patric Alan Ct
Pennycross Ln
Lukes Dr
McIntyre Creek
Location of Cut/Fill Calculations
N
0
200
400
800
Feet
1 inch = 400 feet

Project: McIntyre Creek Stream Restoration Project, Charlotte NC
Engineer: DJK
Date: 3-2-09

Cut/Fill Calculations from Stream Station 43+80 to 63+00

Land Desktop Calculations

	Volume (Cubic Yards)	
Total Fill Volume	5908	Land Desktop
Floodplain Cut	450	Land Desktop
As-built Channel Cut	3583	Hand Calc
Total Cut	4033	
Net Fill	1875	

Hand Calculations Summary

	Volume (Cubic Yards)	
Total Fill	5500	Hand Calc
Cut w/o Channel	292	Hand Calc
As-built channel Cut	3583	Hand Calc
Total Cut	3875	
Net Fill	1625	

Hand Calculations

Fill Volumes (ft^3)

Floodplain		
Left	Right	Abandoned Channel
3939	67663	76898

Cut Volumes (ft^3)

Floodplain		
Left	Right	As Built Channel
3556	4327	96749

Fill Volumes (yds^3)

Floodplain		
Left	Right	Abandoned Channel
146	2506	2848

Cut Volumes (yds^3)

Floodplain		
Left	Right	As Built Channel
132	160	3583

As-Built Channel Cut Volumes

	Riffle Typical	51	sq feet
	Pool Typical	50	sq feet
	39% Riffles	39%	
	61% Pools	61%	
	Total Channel Length	1920	
	Pool length	1171	
	Riffle Length	749	
	Volume of Cut in Channel	96749	cubic feet
	Volume of Cut in Channel	3583	cubic yds