ELK SHOALS STREAM RESTORATION SITE

ANNUAL MONITORING REPORT FOR 2009 (YEAR 5)
CONTRACT NUMBER AW03003-B

Prepared For:

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December 2009

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ANNUAL REPORT FOR 2009 (YEAR 5)
Elk Shoals Stream Restoration Site

1.0 SUMMARY

This Year 5 Annual Report describes the monitoring activities during the 2009 growing season at the Elk Shoals Stream Restoration Site (Site) and summarizes data and activities during the five-year monitoring period (2005-2009). Construction of the Site, including planting of trees, was completed in April 2005. The 2009 data represent results from the fifth year of stream and vegetation monitoring.

The design for the Elk Shoals project involved the restoration of channel dimension, pattern, and profile on Elk Shoals Creek and two of its unnamed tributaries (UTs). After construction was complete, 5,376 linear feet (LF) of stream had been restored and enhanced on the Site.

This Annual Report presents the data from 3 vegetation monitoring stations, 21 photo point stations, 1 crest gauge and 10 cross-sections. The cross-sections are of Elk Shoals Creek and two UTs, as described in the approved Restoration Plan for the Site. Photos were taken of cross-sections and at in-stream structures.

Year 5 vegetation monitoring indicated a range of survivability between 421 and 596 stems per acre. Following Year 5 of monitoring the vegetation plots showed an average survivability of 514 stems per acre. Seeded herbaceous vegetation has also thrived onsite during each year of monitoring and has provided adequate ground cover during all growing seasons. It is concluded that all three vegetation plots on the Site have met the final success criteria of 260 stems per acre after Year 5.

Part of the monitoring effort for this project includes observation of the project's response to local climatic conditions. Weather data from the Statesville Weather Station (UCAN: 14362, COOP: 318292) were used to document precipitation. Historical average rainfall totals were compared to the 2009 observed rainfall totals. For 2009, total rainfall observed at the weather station between the months of April and October was 39.68 inches, compared to the long-term average of 38.96 inches for the same period. Monthly precipitation values were close to normal averages for April, August, and October and varied from above average to below average values for the other months of the growing season, with the total growing season rainfall being 0.72 inches above normal.

The on-site crest gauge documented the occurrence of at least one bankfull flow event during the Year 5 monitoring period. It is noted that the onsite crest gauge recorded bankfull flow events during every year of monitoring. The highest onsite crest gauge recordings observed are as follows: Year 1 (0.80 feet), Year 2 (0.94 feet), Year 3 (1.8 feet), Year 4 (>4.0 feet) and Year 5 (1.64 feet). Therefore, it is concluded that the onsite crest gauge has met the final success criteria of two bankfull flow events in separate years.

Year 5 cross-section monitoring data and longitudinal monitoring data for stream stability were collected during November 2009. The riffle and pool cross-sections show that there has been some adjustment to stream dimension since construction. The longitudinal profiles show that there have been adjustments and fluctuations to the restored stream channel since as-built conditions.

Visual observations of all structures for the Year 5 monitoring season revealed that structures and stream features are functioning as designed. However, two repairs were completed during Year 5 and following re-construction, the repairs were functioning properly.

During Year 5, approximately ½ acre of kudzu (*Pueraria montana.*) was treated at the Site. This was a follow-up to treatment of the same area made in 2007 and 2008.

Table 1. Background Information.

Project Name	Elk Shoals Stream Restoration Site
Primary Contractor	Restoration Systems, LLC 1001 Haynes Street, Suite 203, Raleigh, NC 27604 (919) 755-9490
Designer	Michael Baker Engineering, Inc. 8000 Regency Parkway, Suite 200, Cary, NC, 27518 (919) 463-5488
Construction Contractor	River Works, Inc. 8000 Regency Parkway, Suite 200, Cary, NC, 27518 (919) 459-9001
Project County	Alexander County
Directions to Project Site	From Raleigh, follow I-40 west to exit 144 (Old Mountain Rd.). Head north on Old Mountain Rd to Old Concord Church Rd. Turn left on Old Concord Church Rd., Site entrance is on the right after crossing Elk Shoals Creek.
Drainage Area	Elk Shoals Creek = 4.6 square miles UT1 = 0.38 square miles UT2 = 0.5 square miles
USGS Cataloging Unit	03050101
NCDWQ Sub-basin	03-08-32
Project Length	5,376 LF (Restoration and Enhancement Level I)
Restoration Approach	Restore and enhance channel dimension, pattern and profile to three separate stream reaches (As-built stream restoration units = 5,188)
Date of Completion	April 2005
Monitoring Dates	2005-2009

2.0 INTRODUCTION

2.1 Project Description

The Site is located near the town of Stony Point in Alexander County within the Piedmont physiographic province of North Carolina (Figure 1). The Site lies in US Geological Survey (USGS) Cataloging Unit 03050101 and North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-32 of the Catawba River Basin. Environmental components monitored in this project are those that allow an evaluation of channel stability and survivability of riparian vegetation. The design for the restored streams involved the construction of stable meandering channels for the purpose of improving water quality and wildlife habitat.

The stream systems that historically flowed through the Site were degraded by past land management practices including land clearing, straightening and ditching of streams, row crop production (corn and soybeans), and livestock production. The streams on the Site were channelized, and riparian vegetation was cleared in most locations to increase arable acreage and improve drainage for agricultural purposes. Stream and riparian functions on the Site had been severely impacted as a result of agricultural conversion.

The project involved the restoration and enhancement of 5,376 LF of channelized stream on Elk Shoals Creek and 2 UTs. Table 2 shows the as-built lengths and restoration type per reach. The as-built plans presented in Figure 2 illustrate the construction and planting that were completed for this project in April 2005.

Table 2. Summary of As-built Lengths and Restoration Approaches.

Reach Name	As-built Length (LF)	Mitigation Units	Restoration Approach
Elk Shoals Creek	563	375	Enhancement Level I
Elk Shoals Creek	3,531	3,531	Restoration
UT1	613	613	Restoration
UT2	669	669	Restoration
Total	**5,376**	5,188	

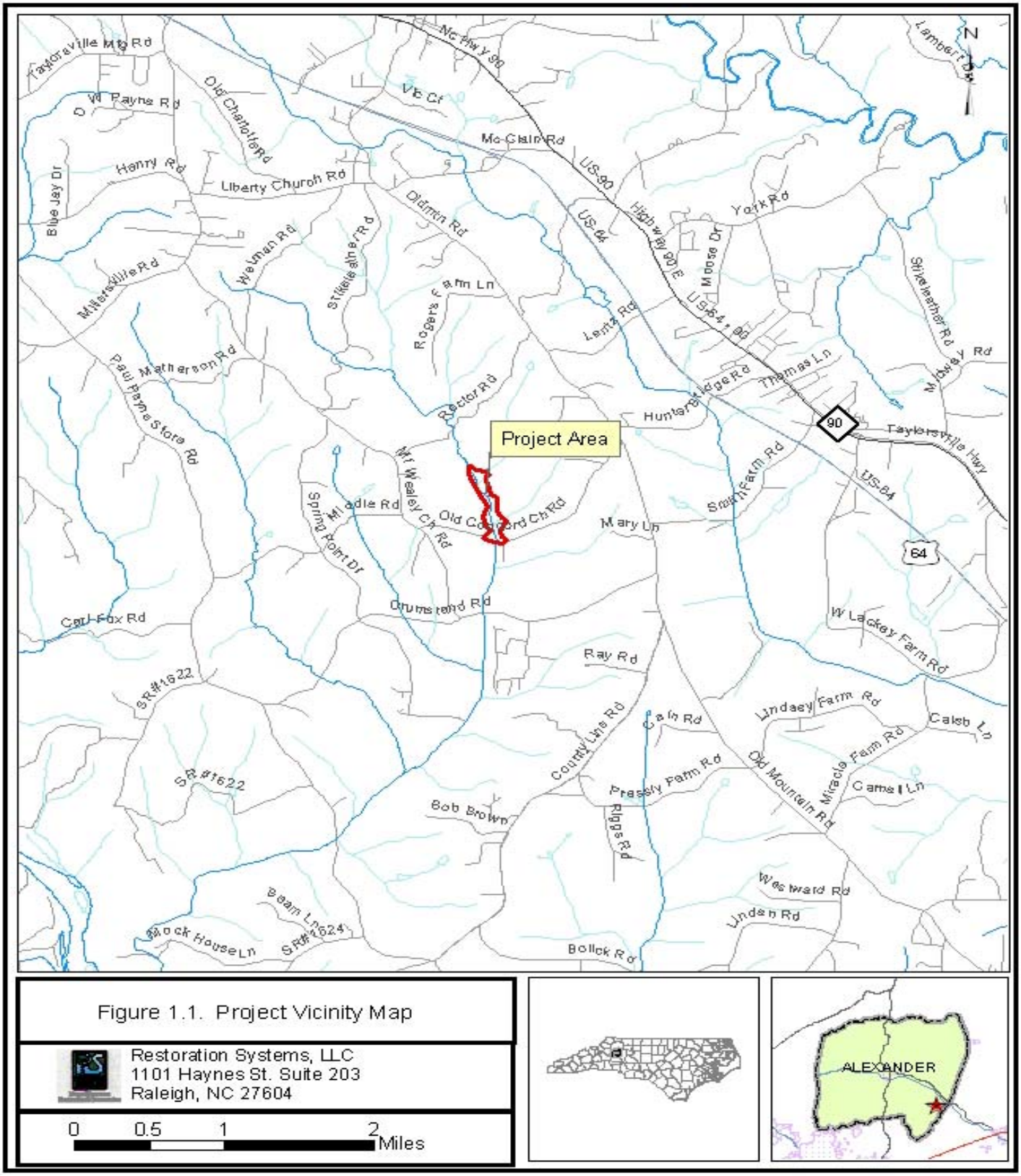
2.2 Purpose

Monitoring of the Elk Shoals Site is required to demonstrate successful stream restoration based on the criteria described in the approved Restoration Plan for this Site. Vegetation and stream stability monitoring were conducted on an annual basis. Success criteria for this site must be met for five consecutive years. This Annual Report details the results of the monitoring efforts performed during 2009 (Year 5) at the Elk Shoals Site.

2.3 Project History

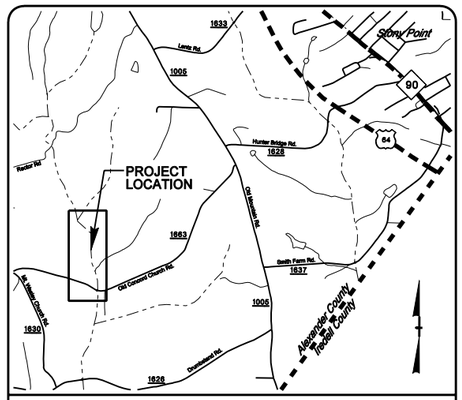
October 2004	Approved Mitigation Plan
April 2005	Construction Completed
April 2005	Planting Completed
December 2005	1st Annual Monitoring Report
March 2006	Supplemental Planting
June 2006	Channel Repair Work
December 2006	2nd Annual Monitoring Report
November 2007	3rd Annual Monitoring Report
November 2008	4th Annual Monitoring Report
December 2009	5th Annual Monitoring Report

Figure 1. Location of Elk Shoals Stream Restoration Site.



ELK SHOALS

PROJECT: 0173R



VICINITY MAP

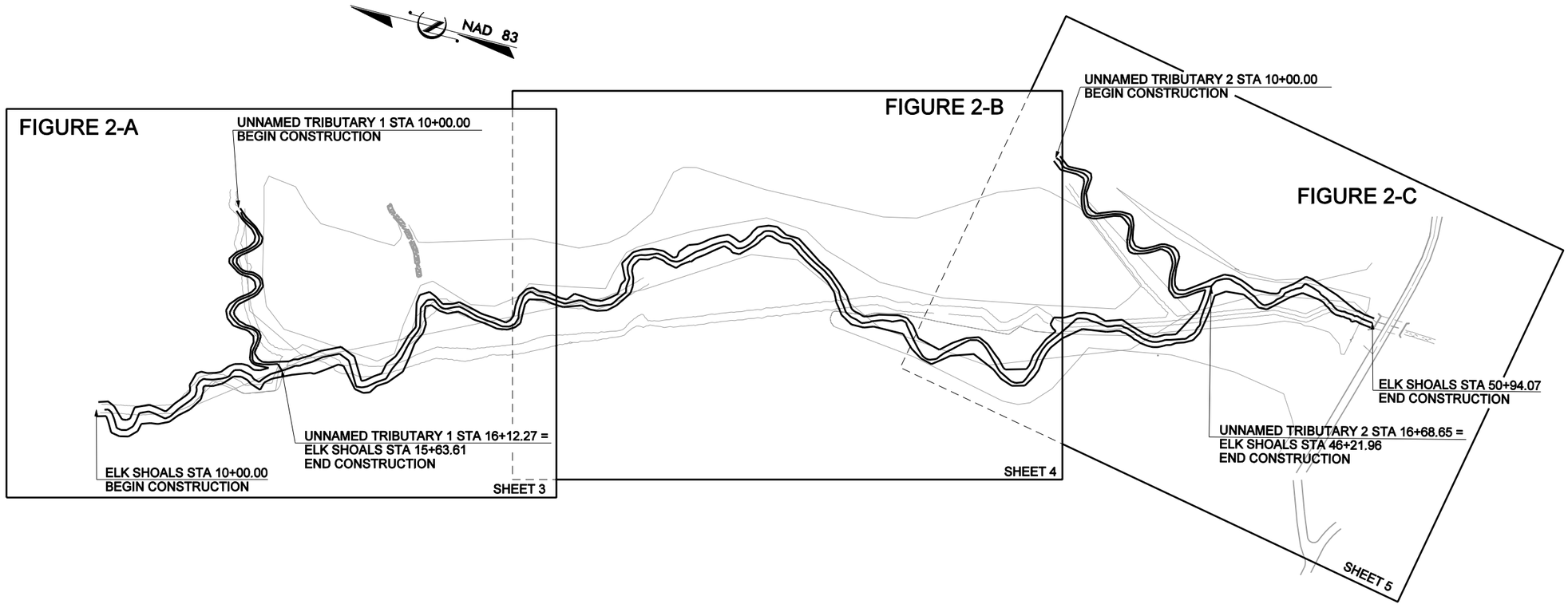
SINK PROPERTY STREAM RESTORATION SITE
ELK SHOALS CREEK

ALEXANDER COUNTY

LOCATION: OFF SR 1663 OLD CONCORD CHURCH ROAD

FIGURE 2
TYPE OF WORK: AS–BUILT

STATE	BUCK PROJECT REFERENCE NO.		SHEET NO.	TOTAL SHEETS
NC	173		1	8
NO.	DATE	CHECKED BY	APPROVED BY	
1	4/27	HW	WH	



GRAPHIC SCALES

50 25 0 50 100
PLANS

PROJECT SUMMARY

		ELK SHOALS	UT1	UT2	
DESIGN STREAM TYPE	=	C4	C4	C4	TOTAL
DRAINAGE AREA	=	4.6	0.38	0.5	SQ. MI.
AS-BUILT REACH LENGTH	=	4094	613	669	5376 - FEET
EXISTING REACH LENGTH	=	3342	412	493	4247 - FEET

PREPARED FOR THE OFFICE OF:
RESTORATION SYSTEMS, LLC

RESTORATION SYSTEMS, LLC
Natural Resources Restoration & Conservation

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APRIL, 2005
CONSTRUCTION COMPLETE:

C. HEATH WADSWORTH, P.E.
PROJECT ENGINEER

PROJECT ENGINEER

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28421

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P.E.
SIGNATURE:

2/26/03

FIGURE 2-A

PROJECT REFERENCE NO.	SHEET NO.
173	3

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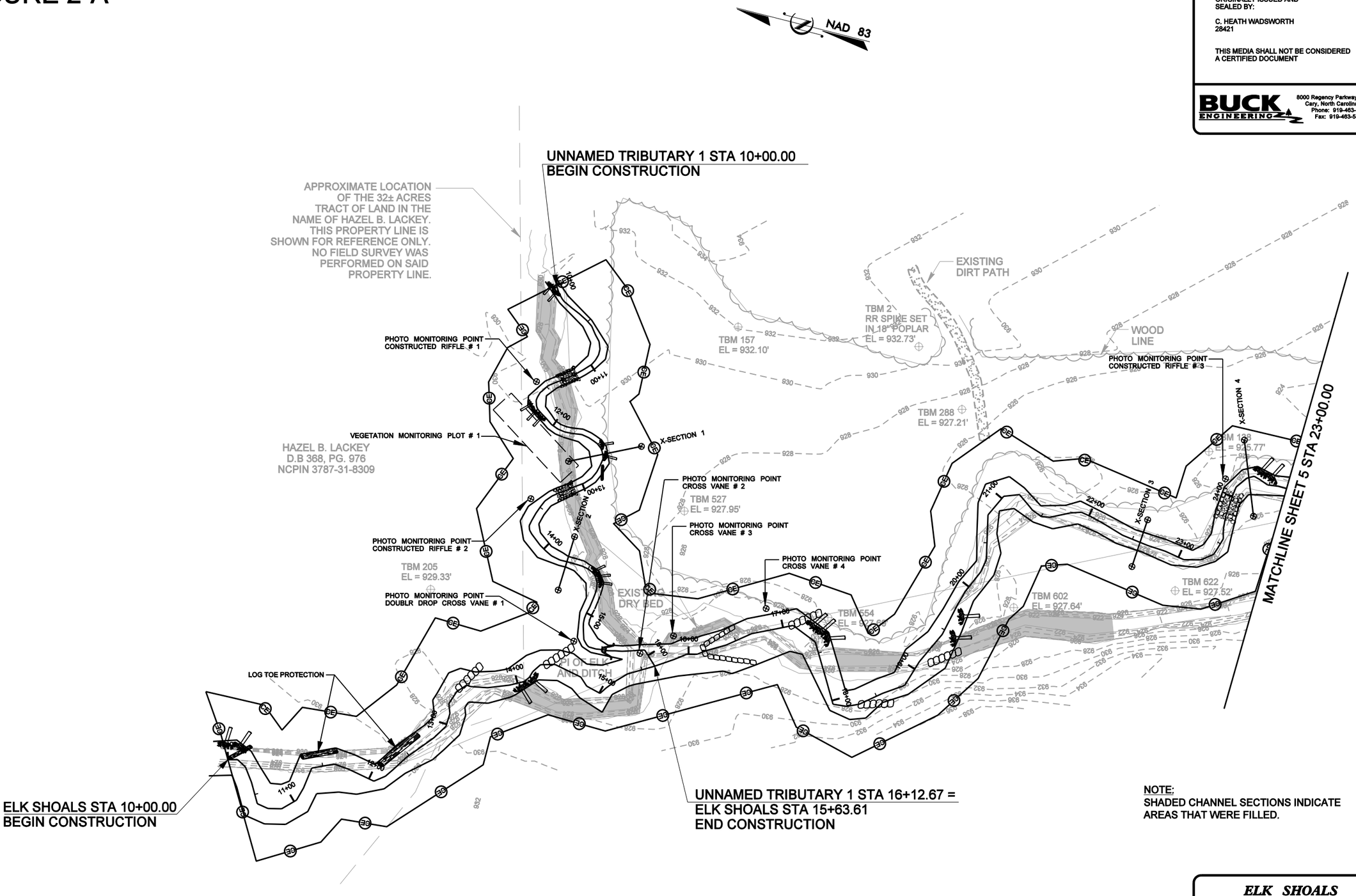

NOTE:
SHADED CHANNEL SECTIONS INDICATE AREAS THAT WERE FILLED.

ELK SHOALS AS–BUILT

50 25 0 50 100
SCALE (FT)

1/20/2006
I:\2003\03-0173\Design\Plans\0173_RS_psh_AB_03.dgn

FIGURE 2-B

PROJECT REFERENCE NO.	SHEET NO.
173	4

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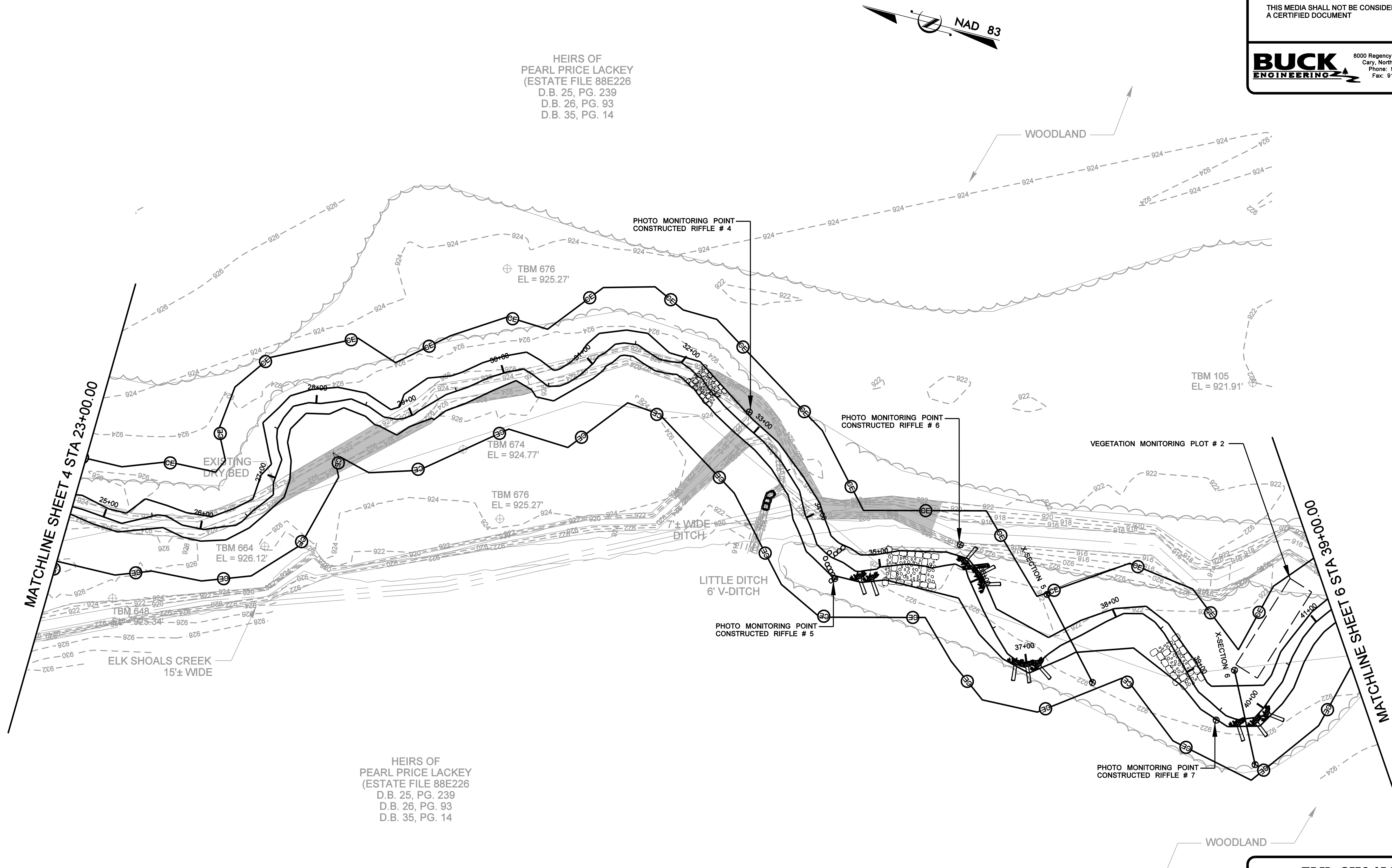

NOTE:
SHADED CHANNEL SECTIONS INDICATE AREAS THAT WERE FILLED.

ELK SHOALS AS–BUILT

SCALE (FT): 50 25 0 50 100

2/26/03
1/23/2006
r:\0173R\Design\Plans\0173_RS_psh_AB_04.dgn

2/26/03

FIGURE 2-C

PROJECT REFERENCE NO.	SHEET NO.
173	5

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NAD 83

UNNAMED TRIBUTARY 2 STA 10+00.00
BEGIN CONSTRUCTION

PHOTO MONITORING POINT CONSTRUCTED RIFFLE # 9
PHOTO MONITORING POINT CONSTRUCTED RIFFLE # 10
PHOTO MONITORING POINT CROSS VANE # 6
PHOTO MONITORING POINT CROSS VANE # 7
CREST GAGE
PHOTO MONITORING POINT CROSS VANE # 8
X-SECTION 7
X-SECTION 9
X-SECTION 10
X-SECTION 8
10+00
11+00
12+00
13+00
14+00
15+00
16+00
47+00
48+00
50+00
PHOTO MONITORING POINT CROSS VANE # 5
PHOTO MONITORING POINT CROSS VANE # 9
PHOTO MONITORING POINT CROSS VANE # 9
PHOTO MONITORING POINT CONSTRUCTED RIFFLE # 11
VEGETATION MONITORING PLOT # 3
PERMANENT STREAM CROSSING
45+00
43+00
44+00
42+00
TBM 46
EL = 919.51
PHOTO MONITORING POINT CONSTRUCTED RIFFLE # 8
MATCHLINE SHEET 5 STA 39+00.00

2 - 16'(W) x 10'(H) RCBC
w/ CONCRETE HEADWALLS

TBM 1
CHISELED "X" ON
TOP OF HEAD WALL
EL = 922.58'

ELK SHOALS STA 50+94.07
END CONSTRUCTION

UNNAMED TRIBUTARY 2 STA 16+68.65 =
ELK SHOALS STA 46+21.96
END CONSTRUCTION

RW
EOP
EOP
RW

N.C.S.R. 1663 -
OLD CONCORD CH. RD
(60' R/W PAVED PUBLIC)

R/W
EOP
EOP
R/W
"A"
R/W
EOP
EOP
R/W

N.C.S.R. 1630 -
MT. WESLEY CH. RD.
(60' R/W PAVED PUBLIC)

NOTE:
SHADED CHANNEL SECTIONS INDICATE AREAS THAT WERE FILLED.

ELK SHOALS AS-BUILT

50 25 0 50 100
SCALE (FT)

1/20/2006
I:\2003\03-173\Design\Plans\0173_RS_psh_AB_05.dgn

3.0 STREAM MONITORING

3.1 Description of Stream Monitoring

To document the stated success criteria, the following monitoring program was instituted following construction completion on the Elk Shoals Creek Restoration Site:

Bankfull Events: A crest gauge was installed on the Site to document bankfull events. The gauge is checked during yearly site visits, and records the highest out-of-bank flow event that occurs during the year. The gauge is located at stream station 47+00, near permanent cross-section 10 (see Figure 2-C).

Cross-Sections: As per the design criteria, 2 permanent cross-sections were installed per 2,000 LF of stream restoration work, with 1 of the locations being a riffle cross-section and 1 location being a pool cross-section. A total of 10 permanent cross-sections were established on the Site, 6 on Elk Shoals Creek, 2 on UT1, and 2 on UT2. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. Permanent cross-section pins were surveyed and located relative to a common benchmark to facilitate easy comparison of year-to-year data. The annual cross-section surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg. Riffle cross-sections are classified using the Rosgen stream classification system.

Longitudinal Profiles: A complete longitudinal profile was surveyed following construction completion to record as-built conditions. For monitoring years 1, 3, and 5 the longitudinal profile will be surveyed for at least 1,000 LF of the restored channel on Elk Shoals Creek, which shall include a 500-foot reach of the restored channel near the upstream section of the project and another 500-foot reach measured downstream. Measurements will include thalweg, water surface, bankfull, and top of low bank. Each of these measurements will be taken at the head of each feature (e.g., riffle, pool, and glide). In addition, maximum pool depth will be recorded. All surveys will be tied to a single permanent benchmark.

Photo Reference Stations: Photographs are used to visually document restoration success. A total of 21 photo reference stations were established to document conditions at the constructed grade control structures across the Elk Shoals Creek Site, and additional photo stations were established at each of the 10 permanent cross-sections. The GPS coordinates of each photo station have been noted as additional references to ensure the same photo location is used throughout the monitoring period. Reference photos are taken at least once per year.

Both stream banks are photographed at each permanent cross-section photo station. For each stream bank photo, the photograph is framed so that the survey tape is centered in the photo (appears as a vertical line at the center of the photograph), keeping the channel water surface line horizontal and near the lower edge of the frame, to include as much of the photographed bank as possible in the photo. A photo log of structures and photographs taken at the permanent cross-sections at the Elk Shoals Creek Site is included in Appendix A of this report.

3.2 Stream Restoration Success Criteria

The approved Restoration Plan requires the following criteria be met to achieve stream restoration success:

- *Bankfull Events*: Two bankfull flow events must be documented within the five-year monitoring period. The two bankfull events must occur in separate years.
- *Cross-Sections:* There should be little change in the as-built cross-sections. If cross-section changes are observed, they should be minor changes representing an increase in stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections shall be classified using the Rosgen stream classification method and all monitored cross-sections should fall within the quantitative parameters defined for "C4/E4" type channels.
- *Longitudinal Profiles:* The longitudinal profiles should show that the bedform features are remaining stable (not aggrading or degrading). The pools should remain deep with flat water surface slopes and the riffles should remain steeper and shallower than the pools. Bedforms observed should be consistent with those observed in "C" or "E" type channels.
- *Photo Reference Stations*: Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Photos should indicate the absence of developing bars within the channel, no excessive bank erosion or increase in channel depth over time, and maturation of riparian vegetation.

3.3 Results of Stream Monitoring

The on-site crest gauge documented the occurrence of at least two bankfull flow events during the Year 5 monitoring period. An inspection of site conditions during the April and September visits revealed visual evidence of out-of-bank flow, such as debris and wrack lines, confirming the crest gauge readings. The largest on-site bankfull flow documented by the crest gauge during Year 5 of monitoring was in April 2009, and was 1.64 feet above the bankfull stage. Photos of the April bankfull evidence are located in Appendix A.

The onsite crest gauge recorded bankfull flow events during every year of monitoring. The highest onsite crest gauge recordings observed are as follows: Year 1 (0.80 feet), Year 2 (0.94 feet), Year 3 (1.8 feet), Year 4 (>4.0 feet) and Year 5 (1.64 feet).

The longitudinal profile survey was also collected during Year 5 of monitoring and was completed in November 2009. For this report the Year 5 longitudinal survey data for all reaches were compared to the longitudinal profiles from the as-built survey and Years 1 and 3 of monitoring. Longitudinal profile data are included in Appendix B of this report.

The profile for UT1 shows that meander bend pools have decreased in depth while the pools at cross vanes have deepened. According to the survey data, the riffles on UT1 have remained relatively stable. The UT2 Year 5 longitudinal profile demonstrates that the pools within the meander bends have fluctuated slightly throughout the monitoring period. The pools at the two cross-vanes on UT2 have also changed overtime, showing a tendency to fill during low rainfall periods and to scour back out during higher rainfall periods. . The riffles on UT2 have remained relatively stable and are within the quantitative parameters defined for the restored stream type.

The Year 5 monitoring data for the Elk Shoals Creek profile show that the riffles and pools are stable upstream of the cross vane at station 16+20. According to the survey data, the thalweg downstream of the cross vane at station 16+20 has aggraded since as-built conditions. This aggradation has occurred in the section of remnant channel that was restored, upstream of the

connection with the new section of restored channel that was constructed across the floodplain. This remnant channel section was lower in elevation than the design, but the design approach was to allow this section to aggrade over time to reach equilibrium. The in-stream structures in this section were placed to center the thalweg flows while this process was occurring; therefore, aggradation around the structures was planned. The thalweg stabilizes back to the as-built elevation at approximate station 19+75. From stations 45+25 to station 50+93 it was observed that the channel deepened in some locations due to scour downstream of structures; however, the channel bed elevation has changed little since the Year 3 data were collected and it appears that the channel has equilibrated.

Year 5 cross-section monitoring data for stream stability were collected during November 2009 and compared to baseline stream data collected in May 2005 (as-built conditions), Year 1 data collected in November 2005, Year 2 data collected in September 2006, Year 3 data collected in August 2007 and Year 4 data collected in August 2008. The ten, permanent cross-sections along the restored channels (five located across riffles and five located across pools) were re-surveyed to document stream dimension at the end of monitoring Year 5. Data from each permanent cross-section are included in Appendix B of this report.

The riffle and pool cross-sections for all monitoring years show that there has been some adjustment to stream dimension since construction. Cross-sections 1, 4, 6, 7, and 9 are located in pools found at the apex of meander bends. Cross-sections 2, 3, 5, 8 and 10 are located in riffles before and after pools.

Cross-sections 1 and 2 are located on UT1 between stations 12+00 and 15+00. The dimensions of pool cross-section 1 have changed significantly throughout the monitoring period. Cross-section 1 was originally constructed with a bankfull area of 13.4 feet. During Year 5 the cross-sectional area of the channel has decreased to approximately 2.4 square feet and is now functioning as a riffle. Riffle cross-section 2 on UT1 after Year 5 has remained very stable since as-built conditions. Given that the pool cross-sectional area has decreased and the riffle cross-section has remained stable, it appears that after Year 5 of monitoring UT1 is reaching a state of equilibrium.

UT2 pool and riffle cross sections 7 and 8 respectively, were also compared to the earlier monitoring survey data. The dimension of pool cross-section 7 changed throughout the monitoring period to decrease the cross-sectional area. During as-built conditions cross-section 7 showed a bankfull area of 13.7 feet, after Year 5 it was determined to have a channel area of 6.9 feet. Riffle cross-section 8 remained relatively stable throughout the monitoring period; the apparent shift in the cross-section seen in the Year 5 data was caused by the survey crew needing to shift around growing woody vegetation along the bank. Since the pool bankfull area has decreased and the riffle bankfull has remained stable, it appears that after Year 5 of monitoring, UT2 is also reaching a natural equilibrium. The cross-section data show that UT1 and UT2 are experiencing similar year-to-year variability.

Six cross-sections, 3, 4, 5, 6, 9 and 10 on Elk Shoals Creek were also re-surveyed in November 2009 and compared to the earlier years of survey data. According to the survey data, for all years of monitoring, the pool cross-sections (4, 6, and 9) have deepened since as-built conditions while developing point bar features. Riffle cross-sections 3 and 5 on Elk Shoals Creek have deepened since as-built conditions, while cross-section 10 has remained relatively stable.

Survey data from all pool cross-sections indicate the continued development of point bar features on the inside bank of the meander bends. All monitored cross-sections fell within the quantitative parameters defined for "C" or "E" type channels.

Flow through a meander bend possesses higher conveyance velocity along the outer bank of the bend, and lower flow velocity along the bend's inner bank. As flow velocity decreases, sediment transport capacity also declines, causing transported sediment to fall out and settle on the bottom as it slows down. Point bar formation along the inside of a meander bend indicates flow velocity vectors occurring as designed, and is therefore expected.

In-stream structures installed within the restored stream included constructed riffles, rock cross vanes, rock j-hooks and vanes, log bank toe protection, and root wads. A constructed riffle and three rock cross vanes were installed on the lower end of the project to step down the elevation of the restored stream bed to match the existing channel invert at the outlet of the project. Two cross vanes were repaired in June 2006 after minor piping or head cuts were noted upstream.

Visual observations of all structures during Year 4 and 5 of monitoring revealed that the cross vane at station 49+50 exhibited minor piping occurring on the left bank. The cross-vane piping has remained stable since Year 4. The ephemeral step pool sequence located just upstream of Old Concord Church Road along the N.C. Department of Transportation (DOT) right-of-way experienced erosion on the left bank and a large headcut had formed in this area. These two areas were repaired during Year 5 of monitoring. Details of these and other repairs are presented in Section 5.3

Rock vanes and J-hooks placed in meander pool areas have provided scour to keep pools deep and provide cover for fish. Cross vanes placed in riffle areas have maintained riffle elevations and provided a downstream scour hole that provides habitat. Root wads and brush layers placed on the outside of meander bends have provided bank stability and in-stream cover for fish and other aquatic organisms.

Photographs of the channel were taken during the Year 5 monitoring season to document the evolution of the restored stream geometry (see Appendix A and B).

4.0 VEGETATION MONITORING

4.1 Description of Vegetation Monitoring

At the completion of construction activities, stream margins and riparian areas of the Site were planted with bare root trees, live stakes, and a permanent herbaceous seed mixture. The woody vegetation was planted randomly six to eight feet apart from the top of the stream banks to the outer edge of the project's re-vegetation limits at a density of 680 stems per acre. The tree species planted at the Site are shown in Table 3. The seed mix of herbaceous species applied to the project's riparian area included Soft rush (*Juncus effusus*), Joe-pie-weed (*Eupatorium maculatum*), Wool grass (*Scirupus cyperinus)*, Fringe sedge (*Carex crinata*), River Oats (*Uniola latifolia*), and Cardinal flower (*Lobelia cardinalis*). This seed mixture was broadcast on the Site at a rate of 21 pounds per acre. All planting was completed in April 2005.

Table 3. Tree Species Planted in the Elk Shoals Restoration Area.

ID Number	Scientific Name	Common Name	FAC Status
1	*Platanus occidentalis*	Sycamore	FACW-
2	*Quercus phellos*	Willow Oak	FACW-
3	*Quercus rubra*	Northern Red Oak	FACU
4	*Quercus alba*	White Oak	FACU
5	*Betula nigra*	River Birch	FACW
6	*Diospyros virginiana*	Persimmon	FAC
7	*Hamamelis virginiana*	Witch Hazel	FACU
8	*Fraxinus pennsylvanica*	Green Ash	FACW
9	*Liriodendron tulipifera*	Tulip Poplar	FAC
10	*Quercus falcata*	Southern Red Oak	FACU-
***11**	*Quercus michauxii*	Swamp Chestnut	FACW
***12**	*Quercus virginiana*	Live Oak	FACU
***13**	*Quercus shumardii*	Shumard Oak	FAC

*September 2006 after supplemental planting conducted by River Works, Inc *

At the time of planting, three vegetation plots, labeled M1, M2, and M3, were established on-site to monitor survival of the planted woody vegetation. Each vegetation plot is 0.057 acre in size or 25 feet x 100 feet dimensionally. Plot delineation involved using metal fence posts at each of the four corners to clearly and permanently establish the area that was to be sampled. Then ropes were hung connecting all four corners to help in determining if trees close to the plot boundary were inside or outside of the plot. Trees on the boundary and trees just outside of the boundary that appear to have greater than 50 percent of their canopy inside the boundary were counted inside the plot. All of the planted stems inside the plot were flagged to distinguish them from any colonizing individuals and to facilitate locating them in the future.

4.2 Vegetation Success Criteria

To determine vegetation success criteria objectively, specific goals for woody vegetation density have been defined. Data from vegetation monitoring plots should display a surviving tree density of at least 320 trees per acre at the end of Year 3 monitoring, and a surviving tree density of at least 260 trees per acre at the end of the 5-year monitoring period. Although the selected native canopy species planted throughout the Site are the target woody vegetation cover, up to 20 percent of the Site's established woody vegetation at the end of the monitoring period may be comprised of volunteer species.

4.3 Results of Vegetative Monitoring

Table 4 presents stem counts of surviving individuals found at each of the monitoring stations at the end of Year 5. Each planted tree species is identified across the top row, and each plot is identified down the left column. The numbers on the top row correlate to the ID column of Table 3. Trees within each monitoring plot are flagged regularly to prevent the occurrence of unmarked trees due to flag degradation. It is important for trees within the monitoring plots to remain marked to ensure they are all accounted for during the annual stem counts and calculation of tree survivability. Volunteer individuals found within the plots are also flagged during this process. Flags are used to tag trees because they do not interfere with the growth of the tree.

Table 4. 2009 (Year 5) Vegetation Monitoring Plot Species Composition.

	Tree Species ID Number														
Plot	1	2	3	4	5	6	7	8	9	10	*11	*12	*13	Total	Stems/acre
M1	8	3						17	2					30	526
M2	3	2						18	2		2	2	5	34	596
M3	4	1	3					9		1	1		5	24	421
														Average Stems/acre	514

*September 2006 after supplemental planting conducted by River Works, Inc *

4.4 Vegetation Observations

All of the herbaceous species seeded throughout the Site after construction (see Section 4.1 of this report) were found on-site at the end of the Year 5 monitoring period. In addition, Switch grass (*Panicum virgatum*) and Deer tongue (*Panicum clandestinum*) were observed throughout the Site. Microstegium (*Microstegium vimineum*), a non-native grass, was also noted within the riparian area.

Two invasive species plants were present on the Site following Year 5 monitoring. The plant kudzu (*Pueraria montana.*) was noted on the Site within the conservation easement at the permanent stream crossing and within vegetation plot M2. The kudzu within vegetation plot M2 has started to take over several five-year old planted stems within the plot boundaries. Chinese privet plants (*Ligustrum sinense*) were noted within vegetation plot M1 following Year 5 monitoring.

4.5 Vegetative Conclusions

The survival of woody vegetation at all 3 vegetation monitoring plots was notably low at the end of 2005. This low survival rate of planted trees was attributed to late planting (April 2005) combined with drier than average conditions throughout the growing season.

The initial low survivability of woody vegetation suggested the Site may not meet the minimum success criteria established as goal at the end of Year 3 monitoring. To increase the density of successfully established trees at the Site, supplemental planting of woody vegetation took place during March 2006. The entire Site was planted with 50 percent of the original plantings, or 2,200 additional trees.

At the end of Year 5 monitoring, the density of the 3 vegetation plots ranged from 421 to 596 stems/acre and had an average survivability of 514 stems/acre, as shown in Table 4. Following Year 5 vegetation monitoring, it was determined that the Site has met the final success criteria of 260 stems per acre after Year 5. Photographs of the vegetation plots are presented in Appendix B.

4.5.1 Climatic Data

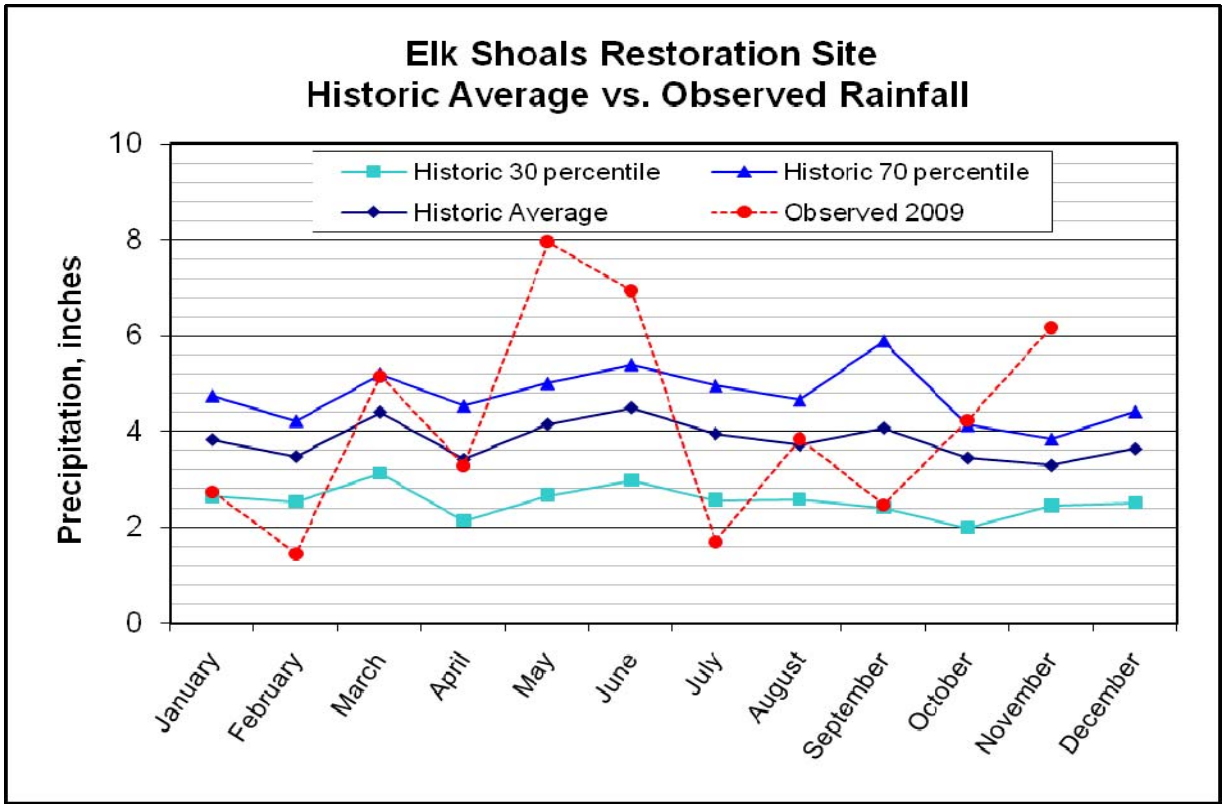
Table 5 and Figure 3 show a comparison of the 2009 monthly rainfall to historical precipitation (WETS table for Iredell County, collected between 1971 and 2000) for the project area. Historic climate information for Alexander County is not readily available; therefore, data from Iredell County were used due to its proximity to the Site. Weather data from the Statesville Weather Station (UCAN: 14362, COOP: 318292) were used to document precipitation for the monitoring year. Historical average rainfall totals were compared to the 2009 observed rainfall totals. For 2009, total rainfall observed at the weather station between the months of January and November was 46.01 inches, compared to the long-term average of 42.26 inches for the same period. Monthly precipitation values were close to normal averages for April, August, and October and varied from above average to below average values for the other months of the growing season, with the total growing season rainfall being 3.75 inches above historic average.

Table 5. Comparison of Historic Average Rainfall to 2009 Observed Rainfall (Inches).

Month	Average	30%	70%	Observed Precipitation, P (in)	
				Month	P
January	3.83	2.65	4.74	**January 2009**	2.75
February	3.48	2.53	4.22	**February 2009**	1.46
March	4.4	3.13	5.19	**March 2009**	5.16
April	3.42	2.13	4.53	**April 2009**	3.30
May	4.15	2.67	5.00	**May 2009**	7.96
June	4.49	2.99	5.39	**June 2009**	6.94
July	3.95	2.57	4.95	**July 2009**	1.70
August	3.72	2.59	4.65	**August 2009**	3.85
September	4.07	2.41	5.88	**September 2009**	2.47
October	3.45	1.99	4.13	**October 2009**	4.24
November	3.3	2.45	3.84	**November 2009**	6.18
December	3.64	2.51	4.41	**December 2009**	*

Notes:
* Data not available for Statesville Weather Station before submittal date of this report

Figure 3. Comparison of Historic Average Rainfall to 2009 Observed Rainfall



5.0 PROJECT MAINTENANCE

5.1 Kudzu Control

During Year 5, approximately ½ acre of kudzu (*Pueraria montana.*) was treated at the Site. This was a follow-up to treatments of the same area made in 2007 and 2008. The area treated in 2009 is located between Stations 42+00 and 44+00 on the western portion of the restored stream channel. Treatment was made with Milestone VM herbicide at a rate of 7 oz. per acre. The area has been a concern since as-built conditions and has been closely observed and/or treated during each year of monitoring.

5.2 Beaver Activity

During Years 1 – 4 the Site experienced numerous beaver problems. Throughout this period, many beaver were trapped and the dams were subsequently removed. During Year 5 monitoring, beaver activity was not a concern on the Site.

5.3 Stream Maintenance

During Year 5 stream repairs were completed on the Site. The first repair is located at the road side swale along Concord Church Road. Storm flows in the swale had created a large headcut above the right top of bank. This repair was completed by adding class B stone to the affected area, thus, creating a riprap swale above and below the headcut to stabilize the area. The second repair was located at the upstream area of the project between stations 13+00 and 14+00. The repairs in this area included bank stabilization and installation of transplants. A toe log held in place with boulders provided bank stabilization. Transplants were used to provide extra reinforcement within the repair. Before and after photos of the repaired swale are included in Appendix A.

6.0 OVERALL SUMMARY AND CONCLUSIONS

Stream Monitoring. The total length of stream channel restored or enhanced on the Site was 5,376 LF, resulting in 5,188 stream mitigation units. This entire length was inspected during Year 5 of the monitoring period to assess stream performance.

The on-site crest gauge documented the occurrence of at least two bankfull flow events during the Year 5 monitoring period. The largest on-site bankfull flow documented by the crest gauge during Year 5 of monitoring was in April 2009, and was 1.64 feet above the bankfull stage. After Year 5 of monitoring, it was noted that the onsite crest gauge recorded bankfull flow events during every year of monitoring. The highest onsite crest gauge recordings during each year of monitoring are as follows: Year 1 (0.80 feet), Year 2 (0.94 feet), Year 3 (1.8 feet), Year 4 (>4.0 feet) and Year 5 (1.64 feet).

It is concluded that the Site has met the final success criteria of two bankfull flow events in separate years.

The longitudinal profile and cross-sections for Year 5 monitoring were compared to previous monitoring years during 2009. It was found that the pools and riffles within the project area have reached a relatively stable condition on all reaches. During the monitoring period, various minor repairs were made to different areas or structures when there was concern that the stability of the channel might be compromised. The repaired areas were closely observed throughout the monitoring period. These repairs are currently functioning properly and will continue to be monitored until closeout of the project. Two repairs were completed during Year 5 and following re-construction, the repairs were functioning properly.

It is concluded that the Site has met the final success criteria for bankfull events, cross-section variability was within expected parameters, and the geomorphic assessment indicated that the restored reaches were retaining the characteristics of “C” and “E” type streams, based on the Rosgen Classification system.

Vegetation Monitoring. During Year 5, vegetation monitoring indicated a range of survivability between 421 and 596 stems per acre. Following Year 5 monitoring the vegetation plots showed an average survivability of 514 stems per acre. Seeded herbaceous vegetation has also thrived onsite during each year of monitoring, providing adequate ground cover during the all growing seasons.

Monthly precipitation values were close to normal averages for April, August, and October and varied from above average to below average values for the other months of the growing season, with the total growing season rainfall being 0.72 inches above normal. The average rainfall observed during the Year 5 growing season has maintained and assisted the survivability and success of the vegetation plots.

It is concluded that the all vegetation and stream success criteria were met at the Elk Shoals Site throughout the five-year monitoring period on the Site have met the final success criteria of 260 stems per acre after Year 5.

APPENDIX A

PHOTO LOG

Constructed Riffle 1

Constructed Riffle 2

Constructed Riffle 3

Constructed Riffle 4

Constructed Riffle 5

Constructed Riffle 6

Constructed Riffle 7

Constructed Riffle 8

Constructed Riffle 9

Constructed Riffle 10

Constructed Riffle 11

Cross Vane 1

Cross Vane 2

Cross Vane 3

Cross Vane 4

Cross Vane 5

Cross Vane 6

Cross Vane 7

Cross Vane 8

Cross Vane 9

Cross Vane 10

Vegetation Plot M1

Vegetation Plot M2

Vegetation Plot M3

Bankfull evidence – Wrack lines with direction of flow, photo taken 4/1/2009

Bankfull evidence – Debris at base of crest gauge, photo taken 4/1/2009

Bankfull reading – 1.64 feet, photo taken 4/1/2009

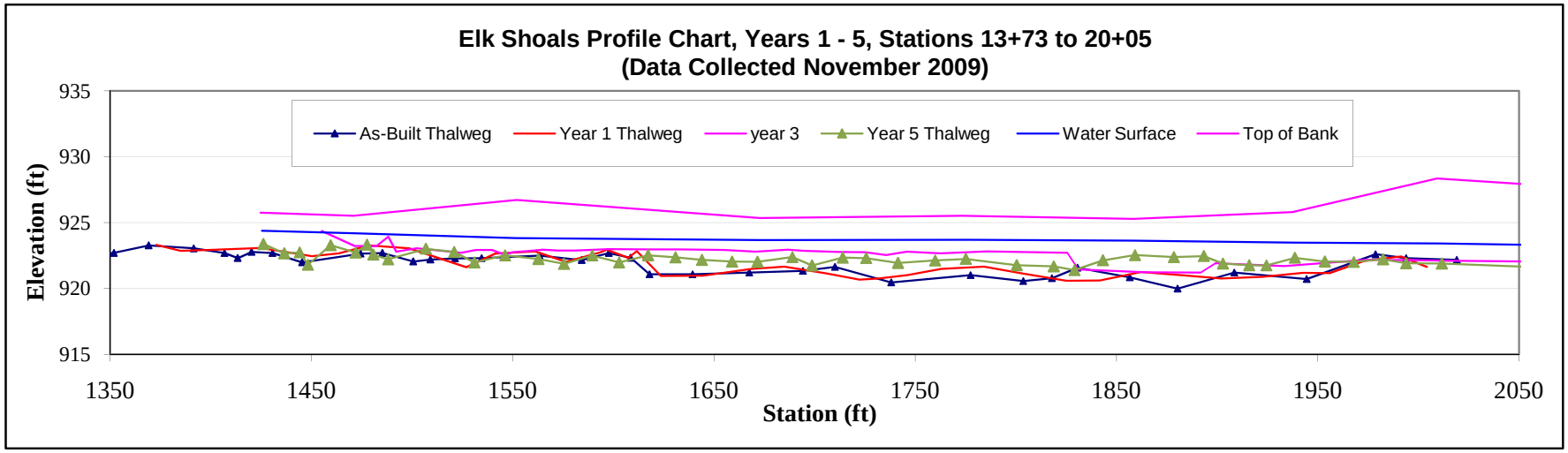
Bankfull reading – 1.54 feet, photo taken 9/15/2009

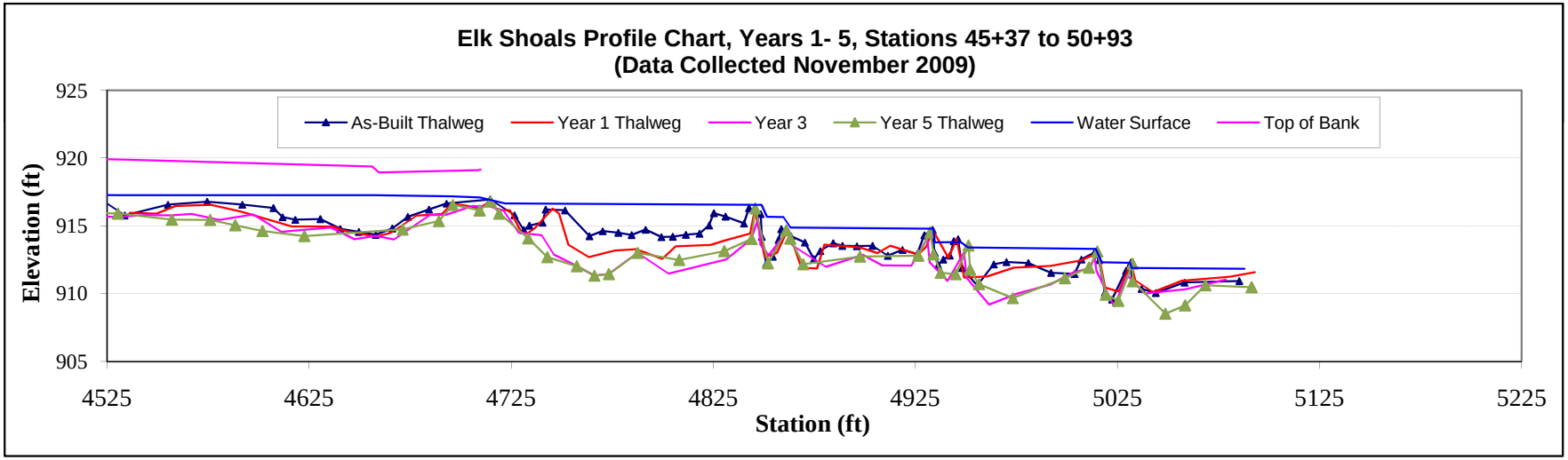
Headcut at Concord Church Road roadside swale – before repair

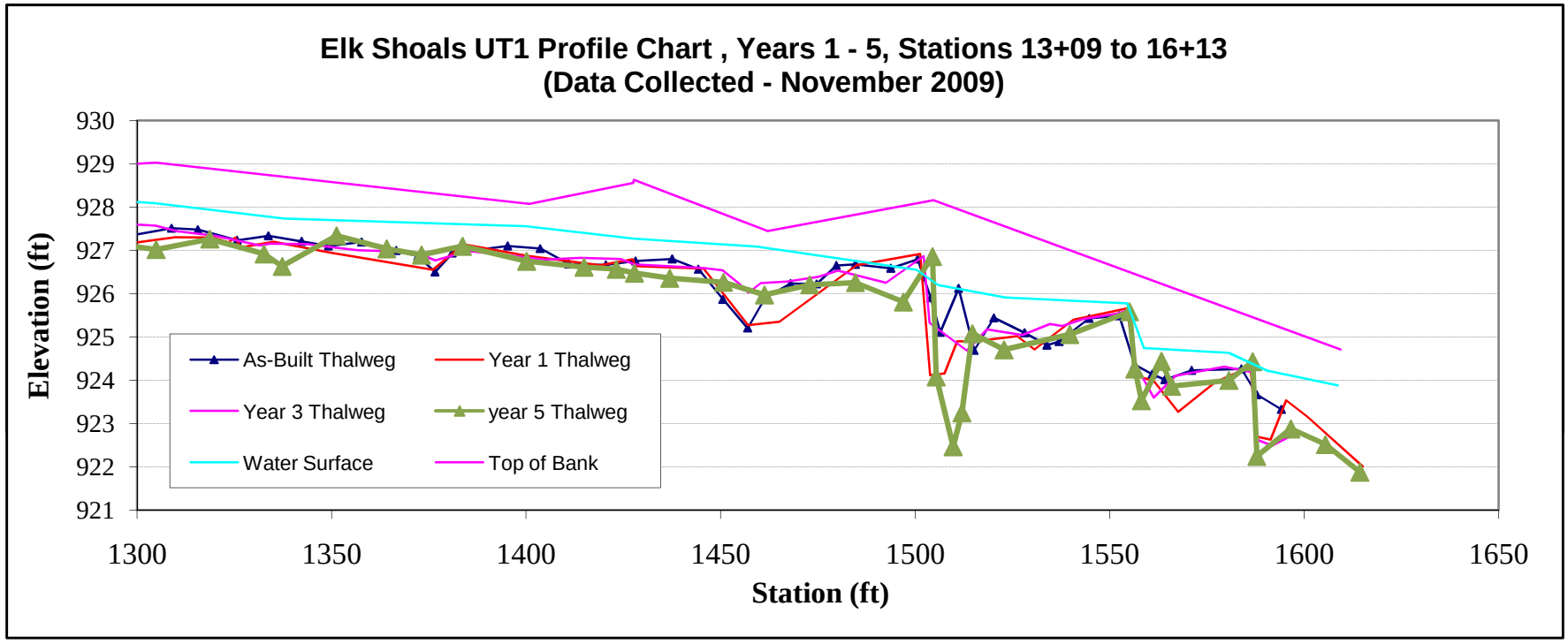
August 2009 - Repaired roadside swale using Class B stone, installed above and below the headcut

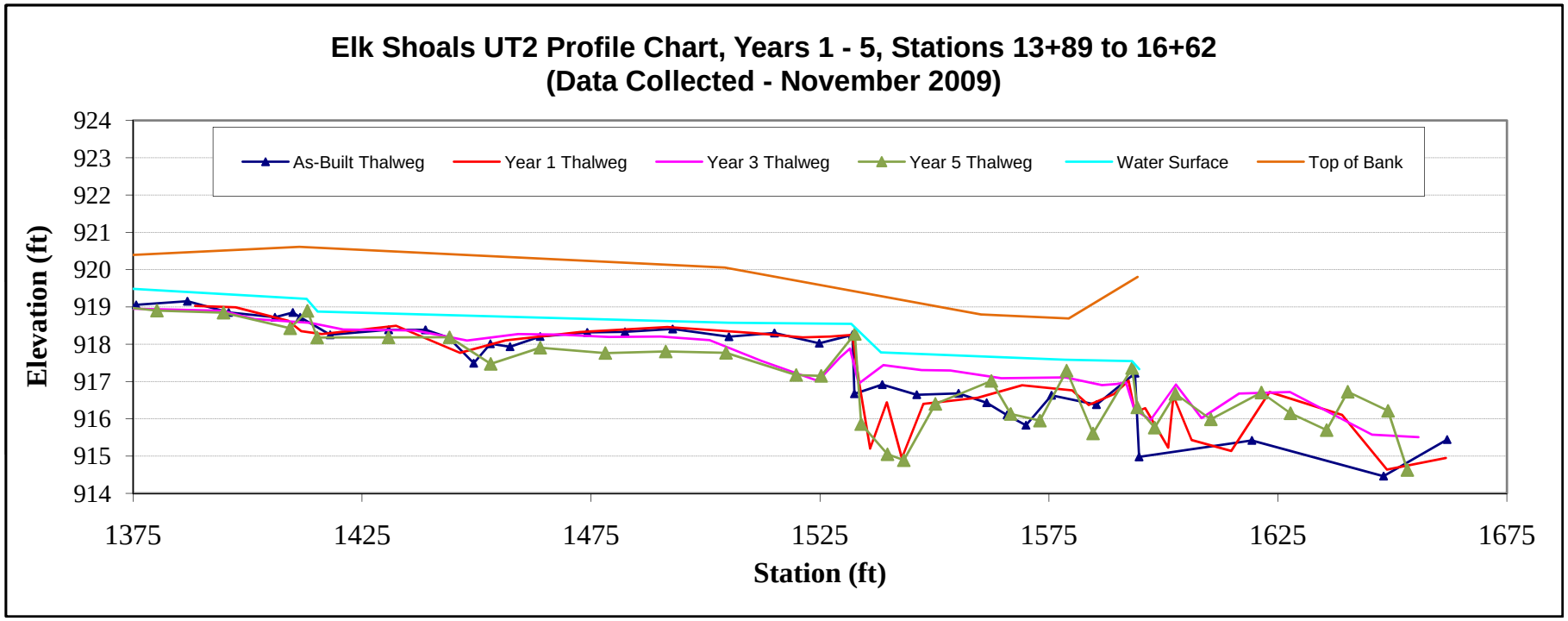
APPENDIX B

STREAM MONITORING DATA


Elk Shoals Profile Chart, Years 1 - 5, Stations 13+73 to 20+05
(Data Collected November 2009)
As-Built Thalweg
Year 1 Thalweg
year 3
Year 5 Thalweg
Water Surface
Top of Bank
Elevation (ft)
935
930
925
920
915
1350
1450
1550
1650
1750
1850
1950
2050
Station (ft)


Elk Shoals Profile Chart, Years 1- 5, Stations 45+37 to 50+93
(Data Collected November 2009)
As-Built Thalweg
Year 1 Thalweg
Year 3
Year 5 Thalweg
Water Surface
Top of Bank
Elevation (ft)
925
920
915
910
905
4525
4625
4725
4825
4925
5025
5125
5225
Station (ft)


Elk Shoals UT1 Profile Chart , Years 1 - 5, Stations 13+09 to 16+13
(Data Collected - November 2009)
Elevation (ft)
930
929
928
927
926
925
924
923
922
921
1300
1350
1400
1450
1500
1550
1600
1650
Station (ft)
As-Built Thalweg
Year 1 Thalweg
Year 3 Thalweg
year 5 Thalweg
Water Surface
Top of Bank


Elk Shoals UT2 Profile Chart, Years 1 - 5, Stations 13+89 to 16+62
(Data Collected - November 2009)
As-Built Thalweg
Year 1 Thalweg
Year 3 Thalweg
Year 5 Thalweg
Water Surface
Top of Bank
Elevation (ft)
924
923
922
921
920
919
918
917
916
915
914
1375
1425
1475
1525
1575
1625
1675
Station (ft)

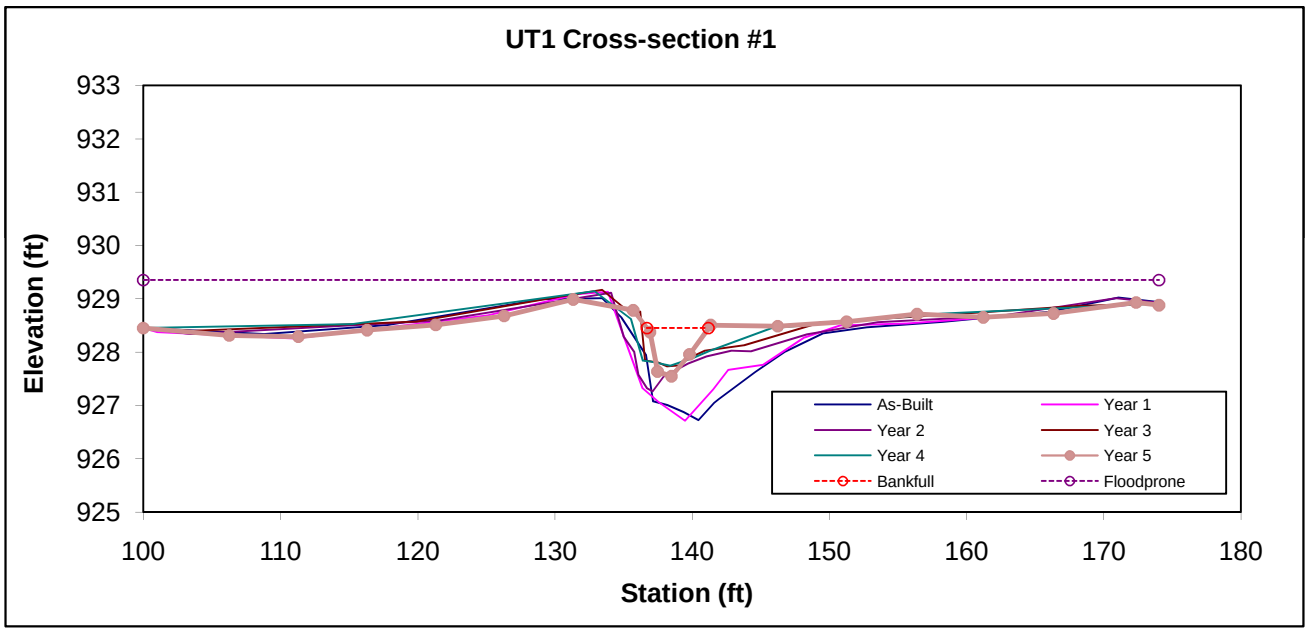
UT1 Permanent Cross-section #1

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev	W-fpa
Pool		2.4	4.49	0.53	0.9	8.45	1.1	16.5	928.45	928.51	



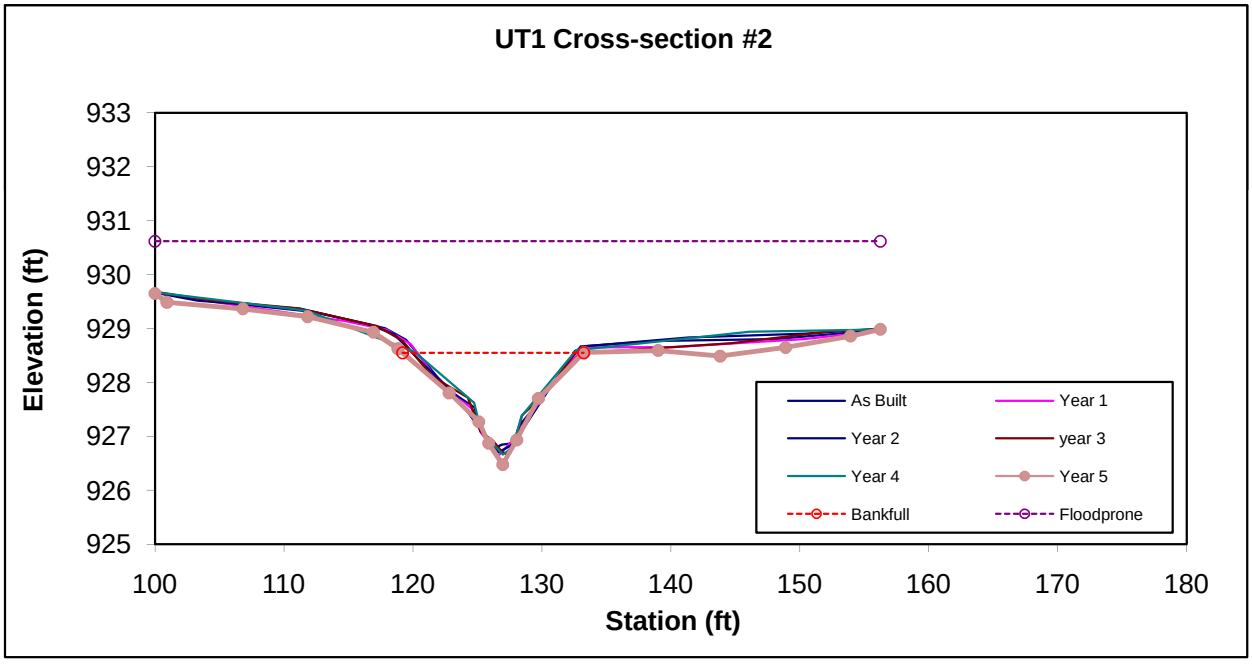
UT1 Permanent Cross-section #2

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	12.4	14.03	0.89	2.07	15.85	1	4	928.55	928.56



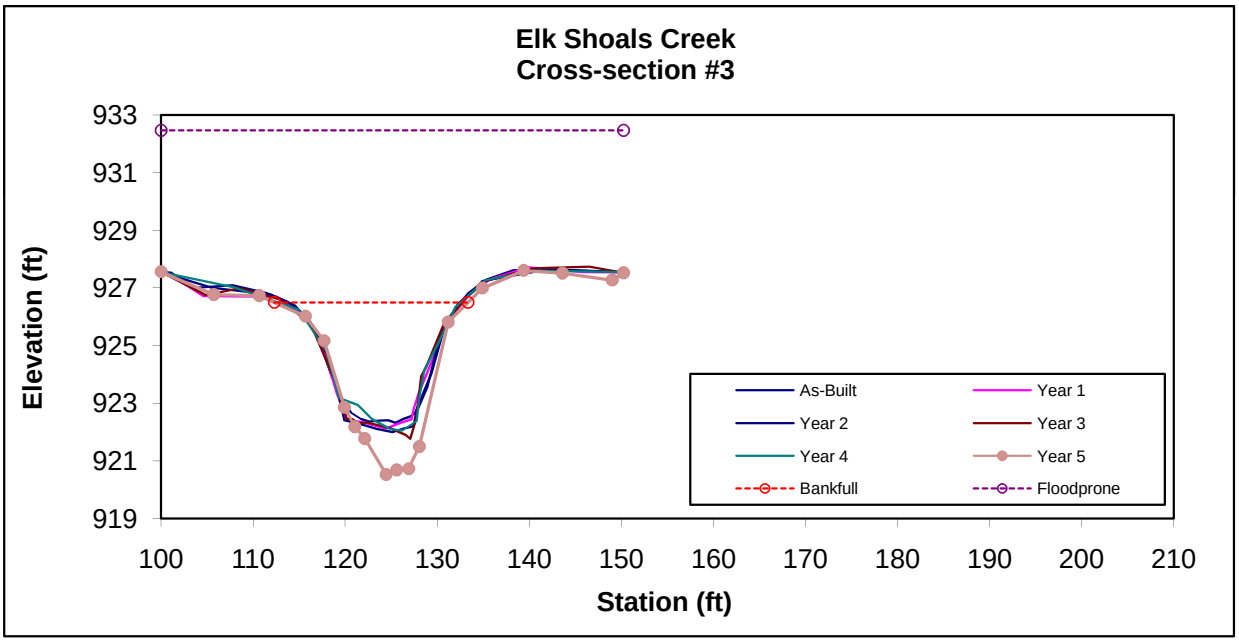
Permanent Cross-section #3

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	60.1	21.01	2.86	5.97	7.35	1	2.4	926.5	926.74



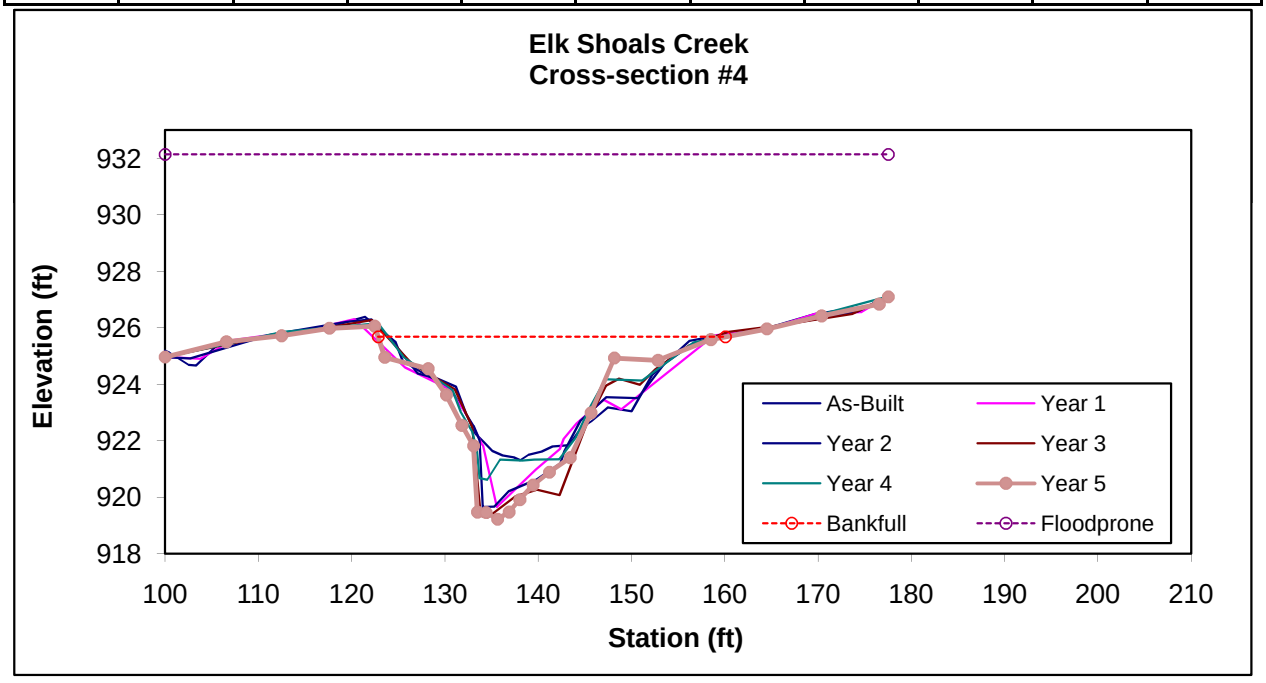
Permanent Cross-section #4

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		92	37.23	2.47	6.46	15.06	1	2.1	925.68	925.58



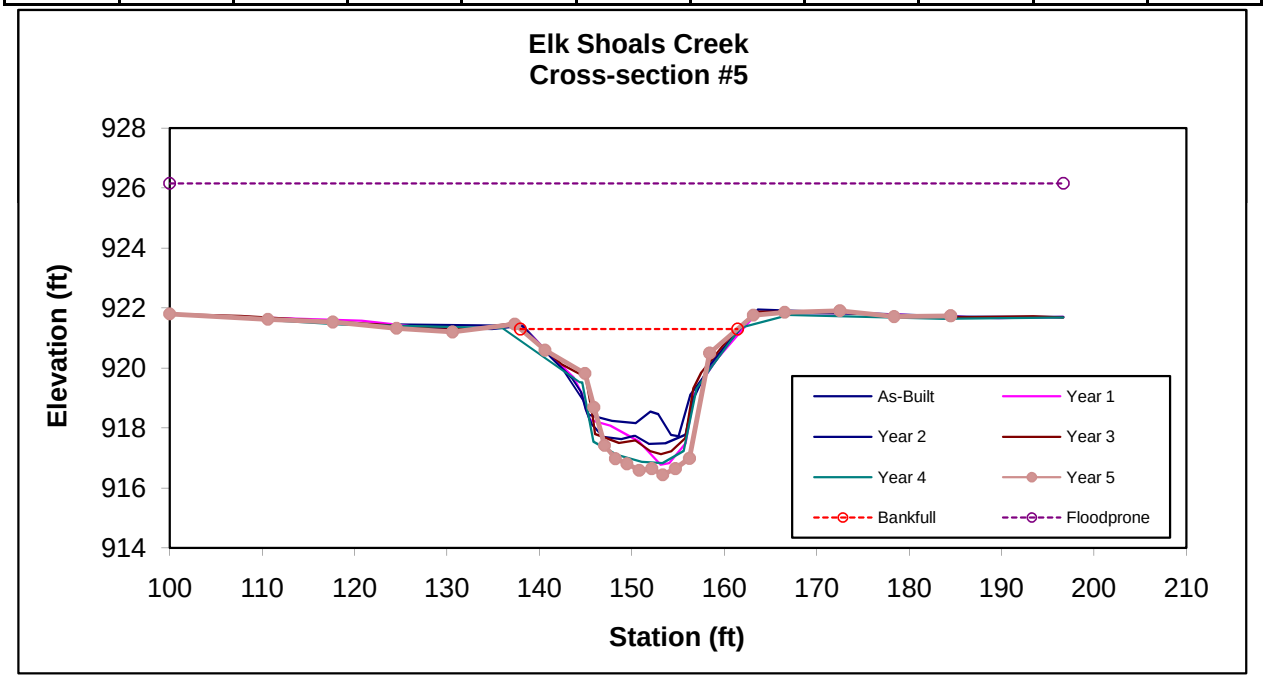
Permanent Cross-section #5

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	59.9	23.49	2.55	4.86	9.21	1	4.1	921.3	921.46



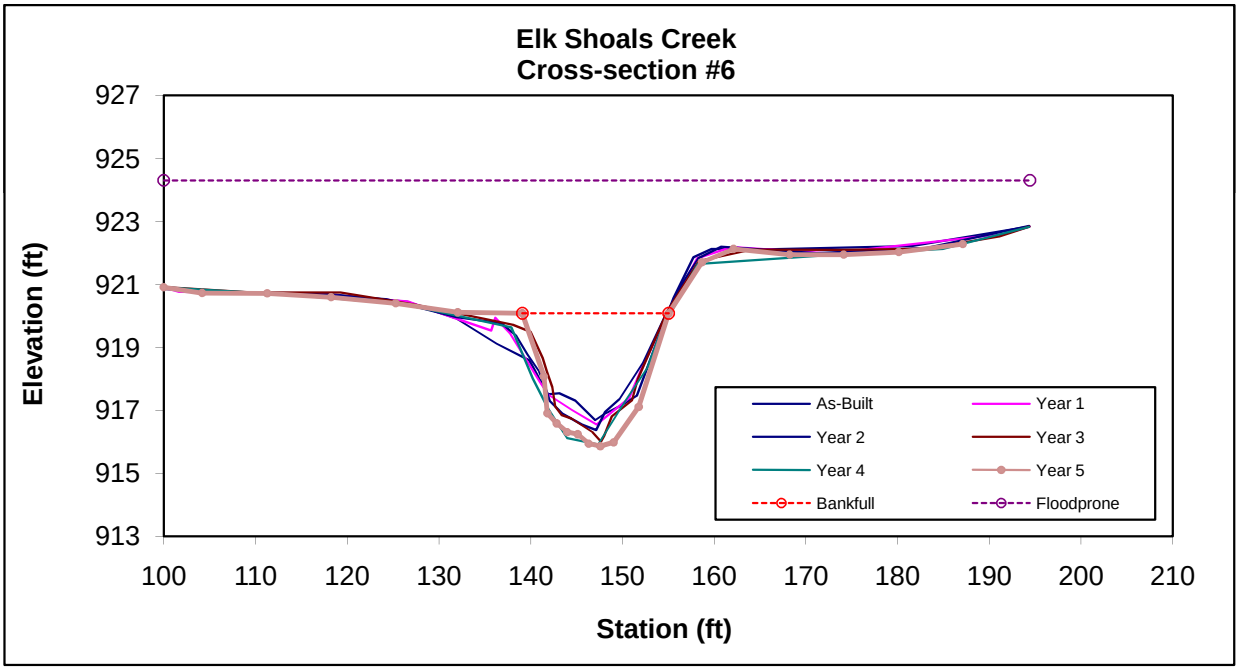
Permanent Cross-section #6

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		45.8	15.95	2.87	4.22	5.55	1	5.9	920.08	920.09



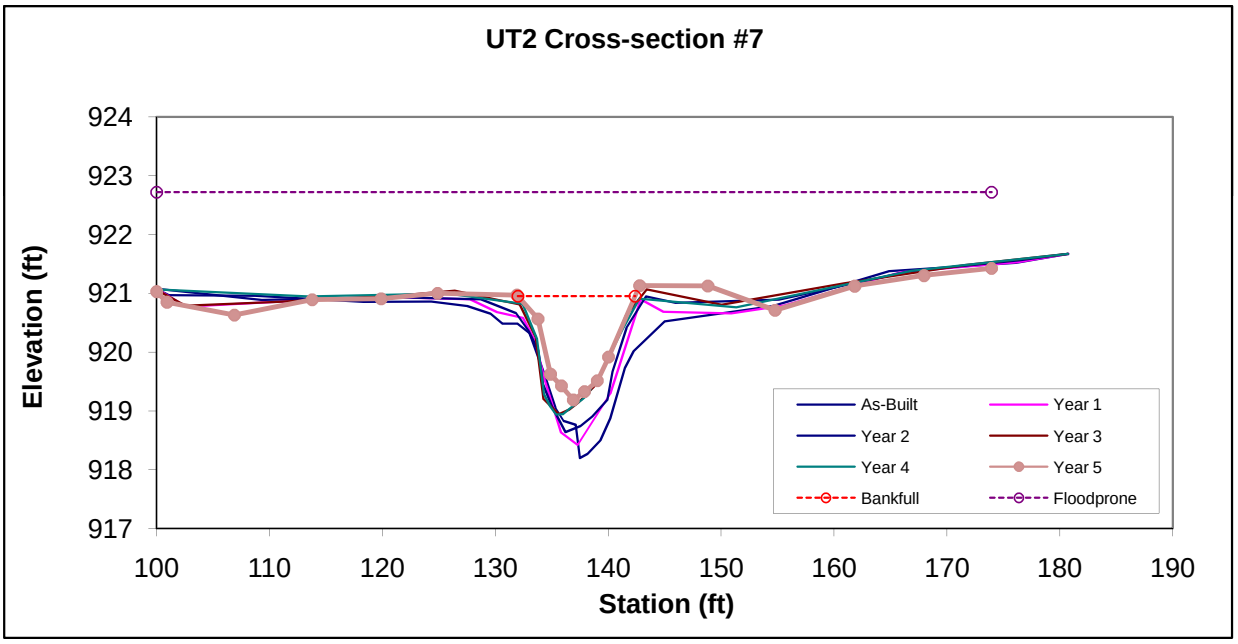
UT2 Permanent Cross-section #7

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		10.3	10.37	0.99	1.77	10.47	1	7.1	920.95	920.97



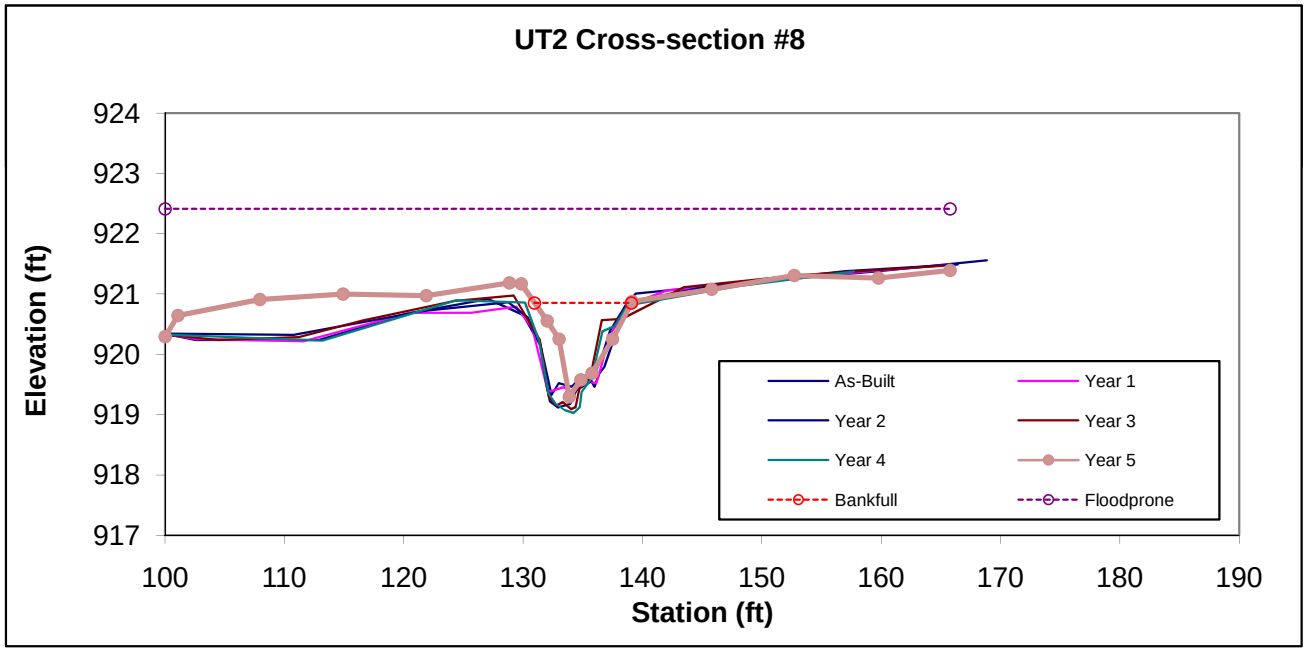
UT2 Permanent Cross-section #8

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	6	8.13	0.74	1.56	10.93	1	8.1	920.85	920.87



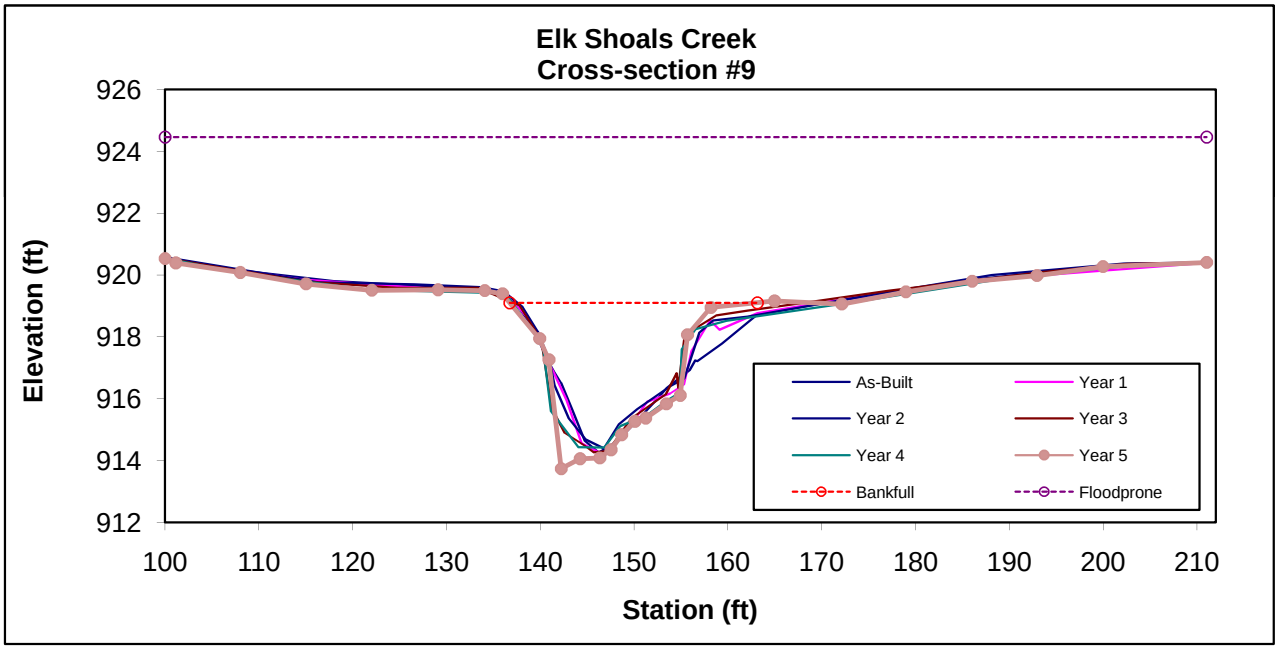
Permanent Cross-section #9

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		65.9	26.39	2.5	5.36	10.57	1	4.2	919.1	918.95



Permanent Cross-section #10

(Year 5 Data - Collected November 2009)

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	38.8	24.31	1.59	3.24	15.24	1	3.6	919.11	919.11