Cross Creek
Stream Restoration
Cumberland County, North Carolina
Mitigation Report

Ecosystem Enhancement PROGRAM

NCEEP Project Number 105
SCO Number 01-05460-01
EEP Project Manager: Melonie Allen

July 2006

CROSS CREEK STREAM RESTORATION
STREAM MITIGATION REPORT

CONDUCTED FOR THE NORTH CAROLINA DEPARTMENT
OF
ENVIRONMENT AND NATURAL RESOURCES

Table of Contents

LIST OF FIGURES

TABLES

APPENDICIES

I. EXECUTIVE SUMMARY/PROJECT ABSTRACT

The Cross Creek project consists of 2,090 linear feet of stream restoration located within the City of Fayetteville, North Carolina. The site was constructed between March 2004 and January 2005. The following report provides the stream restoration information.

The project consists of portions of two tributaries to the Cape Fear River, Little Cross Creek and Cross Creek. Both are located within the city limits of Fayetteville on public lands south west of Fayetteville State University's Campus in Cumberland County, North Carolina. The watershed area for this project is 25.5 square miles.

The property is located off of the Martin Luther King Freeway (formerly the C.B.D. Loop), between Murchison Road and Bragg Boulevard. Washington Drive and Blue Street, both off of Murchison Road, surround the project site. The site can be accessed from either Washington Drive or Blue Street.

The North Carolina Wetlands Restoration Program (NCWRP), in conjunction with the City of Fayetteville, North Carolina, identified portions of Cross Creek and Little Cross Creek as suitable for stream restoration. Both portions of the identified streams are on property owned by the City of Fayetteville. Both creeks had been impacted from development and had lost ecological functions related to water quality and biological habitat. The main factors in the degradation and impairment of the streams were past straightening of the channels and the filling of their floodplains.

The Priority 2 restoration involved re-establishing the floodplain at a lower elevation, so that it can be accessed during storm events above bankfull. The new stream has essentially the same profile as the existing stream, but with a bank height ratio of one. The natural meander patterns were restored and rock grade control vanes and rootwads were incorporated for aquatic habitat enhancement and bed and bank stability.

Table I. Project Mitigation Structure and Objectives Table
Cross Creek Stream Mitigation Site/Project No. 105

Project Segment/Reach ID	Mitigation Type	Approach	Linear Footage	Stationing	Comment
Cross Creek	Restoration	Priority 2	1376	11+4.00 to 25+16.58	Instream structures and vegetated buffers
Little Cross Creek	Restoration	Priority 2	714	10+00 to 17+13.687	Instream structures and vegetated buffers

2090

Monitoring of the site will consist of evaluating both the morphology and vegetation. Morphological stability will be monitored by establishing monumented cross-sections,

evaluating the longitudinal profile, and conducting pebble counts. Surveys will follow the methodology contained in the USDA Forest Service manual Stream Channel Reference Sites. Vegetation plots will be established to monitor the vegetation. Monitoring will occur after the first rowing season and continually annually for a period of 5 years.

II. PROJECT BACKGROUND

The project consists of portions of two tributaries to the Cape Fear River, Little Cross Creek and Cross Creek. Both are located within the city limits of Fayetteville on public lands south west of Fayetteville State University's Campus in Cumberland County, North Carolina **(Figure 1).**

A. General Description of the Watershed

Cross Creek and its tributary, Little Cross Creek, are located within the Coastal Plain Physiographic Province of the Cape Fear River Basin. Portions of the northwestern areas of the watershed are located within the Sandhills Physiographic Province. The headwaters of Cross Creek originate about 7.5 miles north-northwest of the project area. The headwaters of Little Cross Creek originate 6.0 miles north-northeast of the project area. Both streams enter the site as third-order streams before joining to form a fourth-order stream. Cross Creek (NCDWQ Stream Index Number 18-27-(3)) and Little Cross Creek (18-27-4-(2)) both have a WS-IV classification, which is assigned to water supplies in moderately to highly developed watersheds in North Carolina. Cross Creek and Little Cross Creek account for forty percent of Fayetteville's water supply.

The watershed is approximately 16,300 acres or 25.5 square miles (Figure 2). Approximately 15.5 square miles (9,920 acres) drain into Cross Creek and the remaining 10.0 square miles (6,380 acres) drain into Little Cross Creek. Murchison Road is located along the ridgeline separating the two watersheds.

B. Pre-existing Conditions

The restoration site is located entirely within a highly developed area of Fayetteville. Land immediately adjacent to the restoration site is undeveloped grass covered land slated to be included in the future Martin Luther King Jr. Park expansion. There are both water and sewer utilities within the project limits.

Both Cross Creek and Little Cross Creek have been impacted from development and have lost ecological functions related to water quality and biological habitat. The main factors in the degradation and impairment of the streams are past straightening of the channels and the filling of their floodplains. The both reaches with the project limits were classified as G5-type channels, with a sinuosity of 1, and entrenchment ratios ranging from 1.25 to 1.9.

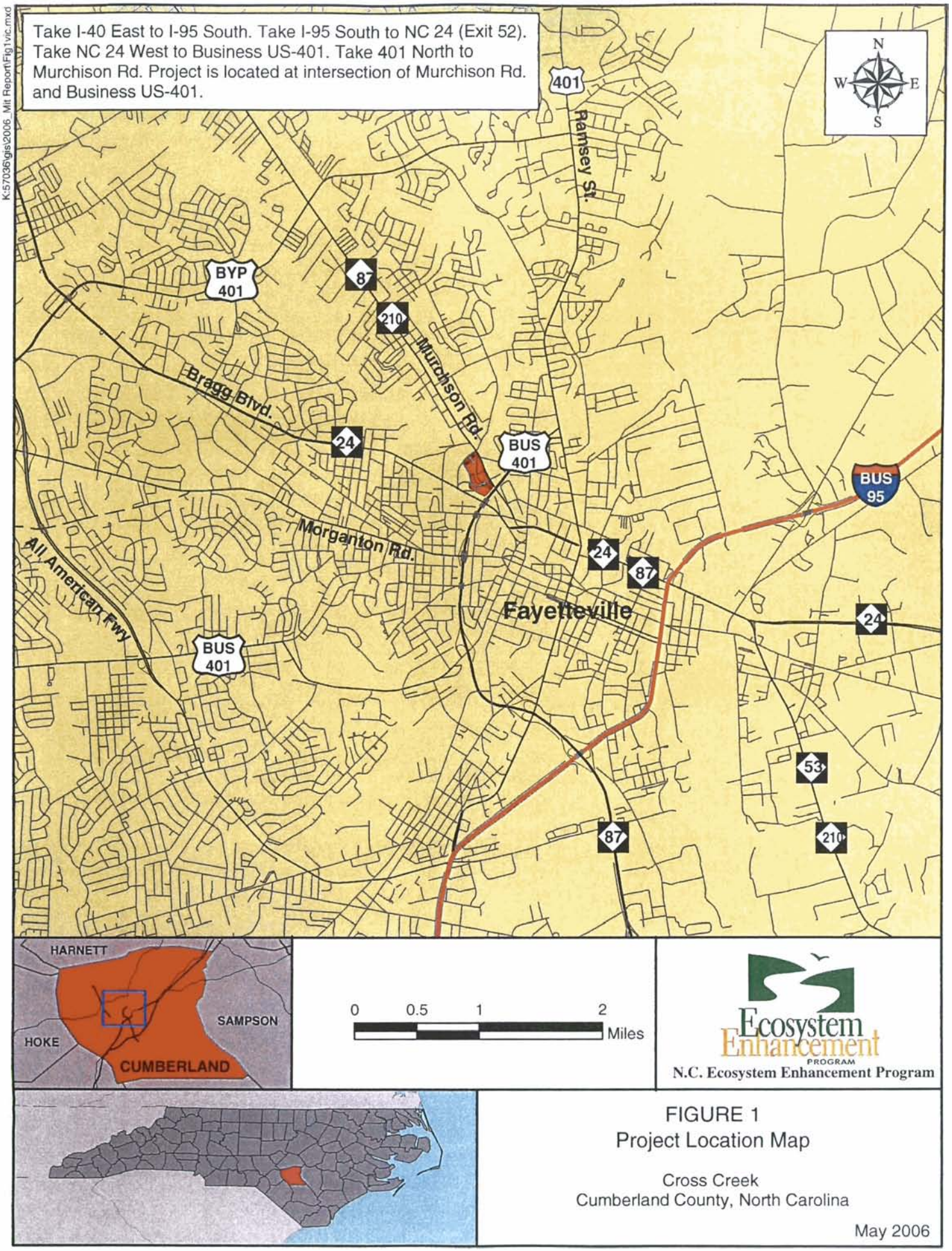


FIGURE 1
Project Location Map

Cross Creek
Cumberland County, North Carolina

May 2006

C. Goals and Objectives

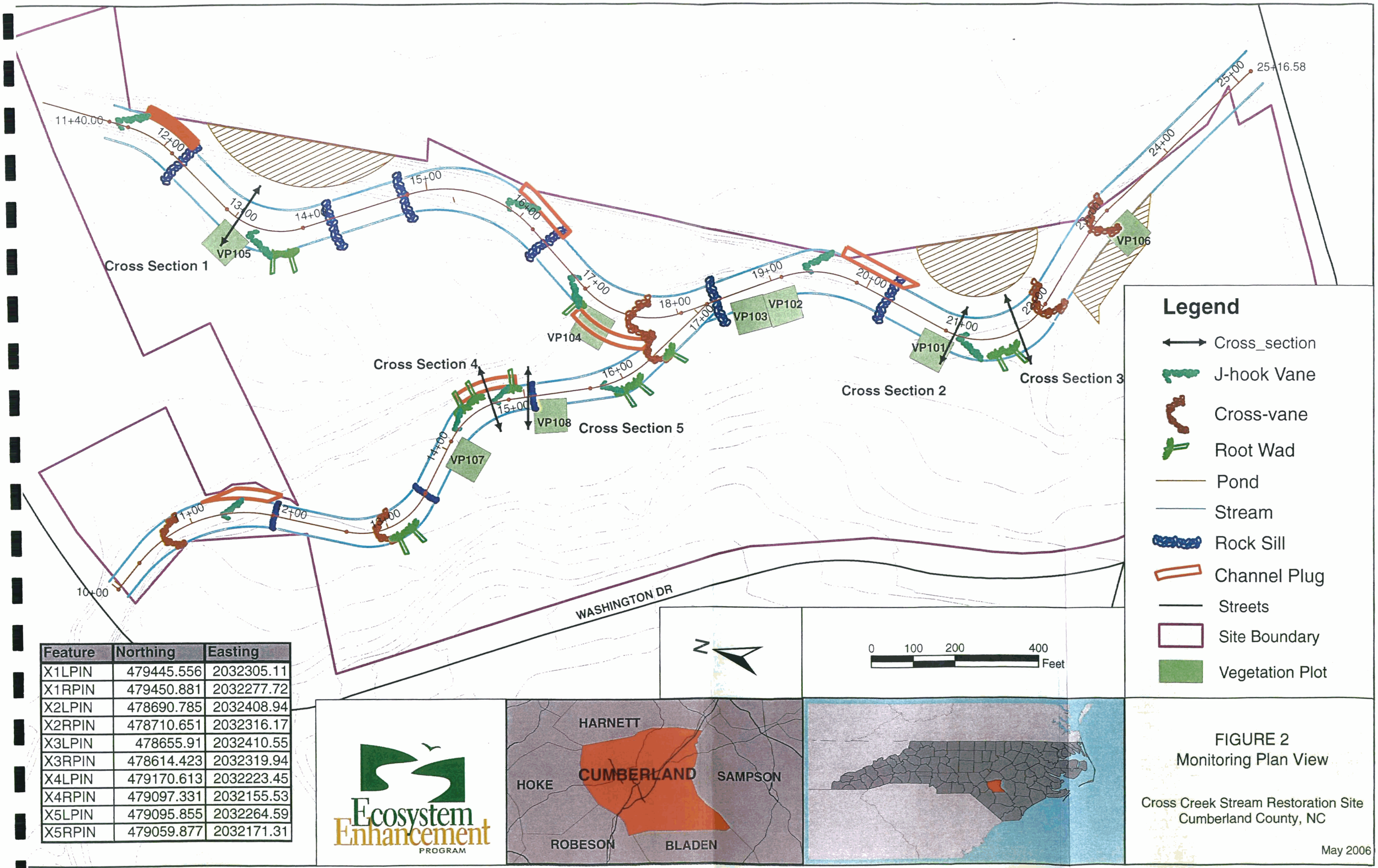
The Priority 2 restoration involved converting the 2,000 ft impaired channel into a sinuous channel that meanders for a total of 2,090 linear feet of stream as measured along the centerline. Rock cross-vanes and rootwads were incorporated for aquatic habitat enhancement and bed and bank stability. A riparian buffer that varies in width from 10 feet to 280 feet was planted with native vegetation and protected by a Conservation Easement.

The project had the following goals and objectives:

1. Provide a stable stream channel that neither aggrades nor degrades while maintaining its dimension, pattern, and profile with the capacity to transport its watershed's water and sediment load.
2. Provide the stream with a floodplain at the stream's current elevation.
3. Improve aquatic habitat with the use of natural material stabilization structures such as root wads, rock vanes, woody debris, and a riparian buffer.
4. Provide wildlife habitat and bank stability through the creation of a riparian zone.

Table II. Project Activity and Reporting History
Cross Creek Stream Mitigation Site/Project No. 105

Activity or Report	Scheduled Completion	Data Collection Complete	Actual Completion Date
Restoration Plan	2002	2002	October 2002
Final Design - 90%	2004	NA	2004
Construction	2004	2004	January 2005
Temporary S&E mix applied to entire project area	2004	2004	2004
Permanent seed mix applied to entire project area	2004	2004	2004
Containerized, B&B, and livestake plantings	January 2005	January 2005	January 2005
Mitigation Plan / As-built (Year 0 Monitoring - baseline)	April 2006	April 2006	July 2006
Year 1 Monitoring	Fall 2006	NA	NA
Year 2 Monitoring	Fall 2007	NA	NA
Year 3 Monitoring	Fall 2008	NA	NA
Year 4 Monitoring	Fall 2009	NA	NA
Year 5 Monitoring	Fall 2010	NA	NA



Feature	Northing	Easting
X1LPIN	479445.556	2032305.11
X1RPIN	479450.881	2032277.72
X2LPIN	478690.785	2032408.94
X2RPIN	478710.651	2032316.17
X3LPIN	478655.91	2032410.55
X3RPIN	478614.423	2032319.94
X4LPIN	479170.613	2032223.45
X4RPIN	479097.331	2032155.53
X5LPIN	479095.855	2032264.59
X5RPIN	479059.877	2032171.31

Ecosystem Enhancement PROGRAM

FIGURE 2
Monitoring Plan View

Cross Creek Stream Restoration Site
Cumberland County, NC

May 2006

Table III. Project Contact Table Cross Creek Stream Restoration Site/Project No. 105	
Designer POC	*Earth Tech* 701 Corporate Center Drive Suite 475 Raleigh, NC 27607 Bill Jenkins PE (919) 854-6200
Construction Contractor POC	*Backwater Environmental* 2312 New Bern Ave. Raleigh, NC 27610 Wes Newell (919) 231-9227
Planting Contractor POC	*Carolina Silvics, Inc.* 908 Indian Trail Road Edenton, North Carolina 27932 Mary-Margaret McKinney (252) 482-8491
Seeding Contractor POC	*Backwater Environmental* 2312 New Bern Ave. Raleigh, NC 27610 Wes Newell (919) 231-9227
Seed Mix Sources	*Ernst Conservation Seeds* 9006 Mercer Pike Meadville, PA 16335 Stacy Charles (814) 336-2404
Nursery Stock Suppliers	*Coastal Plain Conservation Nursery* (container plants) 3067 Conners Drive Edenton, NC 27932 Ellen Colodney (252) 482-5707 *Cure Nursery* (container plants) 880 Buteo Road Pittsboro NC 27312 Jennifer Cure (919)-542-6186 *Taylor's Nursety* 3705 New Bern Avenue Raleigh, NC 27610 Richard Taylor (919) 231-6161 *Internationul Paper* 55594 Hwy 38 S Blenheim, SC 29516 Gary Nelson (1-800-222-1290)
Monitoring Performers	Earth Tech 701 Corporation Center Drive, Suite 475 Raleigh, NC 27607 Ron Johnson (919) 854-6210
Stream Monitoring	Ron Johnson
Vegetation Monitoring	Ron Johnson
Wetland Monitoring	NA

Table IV. Project Background Table Cross Creek/Little Cross Creek Stream Mitigation Site/Project No. 105	
Project County	Cumberland
Drainage Area	
Cross Creek	10.5/25.5 sq mi
Drainage impervious cover estimate (%)	71%
Stream Order	
Cross Creek/Little Cross Creek	2nd/1st
Physiographic Region	Sandhills/Coastal Plain
Ecoregion	Atlantic Southern Loam Plains
Rosgen Classification of As-Built	C
Cowardin Classification	Riverine
Dominant Soil Types	Chewacla loam
	Rion fine sandy loam
Reference site ID	Country Club Branch and Little Rockfish Creek
USGS HUC for Project	03030004
USGS HUC for Reference	03030004
NCDWQ Sub-basin for Project	030615
NCDWQ Sub-basin for Reference	030701
NCDWQ Classification for Project	Cross Creek (C), Little Cross Creek (C)
NCDWQ Classification for Reference	UT Cross Creek (Country Club Branch, C), Little Rockfish Creek C
Any portion of any project segment 303D listed?	Yes
Any portion of any project segment upstream of a 303D listed segment?	Yes
Reasons for 303D listing or stressor	Impaired Biological Activity, fecal coliform
% of project easement fenced	0%

III. PROJECT CONDITION AND MONITORING RESULTS

A. Vegetation Assessment

I. Vegetation Success Criteria

The final vegetative success criteria will be the survival of 260 5-year old planted trees per acre at the end of year 5 of the monitoring period. An interim measure of vegetation planting success will be the survival of at least 320 3-year old planted trees per acre at the end of year 3 of the monitoring period.

2. Soil Data

Table V. Project Soils
Cross Creek/Little Cross Creek Stream Mitigation Site/Project No. 105

Series	Max Depth (in.)	% Clay in Surface Horizon	K	T	OM % (Surface)
Blaney-Urban land *complex-2-8 % slopes*	80	2-10	0.15 to 0.38	5	1 - 4
Faceville Urban Land	72	N/A	0.17 to 0.37	5	0.5 - 1
Ru-Roanoke-Urban land complex -	80	10-18	0.24 to 0.37	4	0.5 - 3

3. Stem Counts

Baseline vegetation plots were established during Year 0 on June *22,* 2005 after vegetative planting was completed in January 2005. Eight (8) 10m X 10m vegetation survival plots were staked out in the floodplain of Cross Creek and Little Cross Creek. Survival of rooted vegetation will be evaluated using the eight plots and will continue for at least 5 years to determine survival. Stems were flagged and counted in each plot.

Tree species planted include ironwood (Carpinus caroliniana), redbud ***(Cercis canadensis),*** persimmon ***(Diospyros virginiana),*** green ash ***(Fraxinus pennsylvanicum),*** black gum ***(Nyssa sylvatica),*** swamp cottonwood ***(Populus heterophylla),*** laurel oak ***(Quercus laurifolia),*** overcup oak ***(Quercus lyrata),*** willow oak ***(Quercus phellos),*** shumard oak ***(Quercus shumardii***), bald cypress ***(Taxodium distichum),*** American elm ***(Ulmus americana).*** Shrubs and livestakes were also planted in the floodplain and concentrated along the tops of the bank. Live stake species include silky dogwood (***Cornus amomum),*** arrowwood ***(Viburnum dentatum***), elderberry ***(Sambucus canadensis),*** and Carolina willow ***(Salix caroliniana).*** Shrubs include red chokeberry ***(Aronia arbutifolia),*** American beautybeny ***(Callicarpa americana),*** sweet pepperbush ***(Clethra alnifolia),*** ti-ti ***(Cyrilla racemiflora***), elderberry ***(Sambucus canadensis),*** witch-alder ***(Fothergilla gardenii),*** gallberry ***(Ilex coriacea),***

inkberry *(Ilex glabra),* **wax myrtle** *(Myrica cerifera),* **winged sumac** *(Rhus copallinurn),* **wither-rod** *(Viburnum nudum),* **and tag-alder** *(Alnus serrulata).*

Table VI. Stem Counts for each species arranged by plot

	Species	Plots								Total
		Main Channel						Trib		
Scientific Name	**Common Name**	**101**	**102**	**103**	**104**	**105**	**106**	**107**	**108**	
Shrubs										
Aronia arbutifolia	Red chokeberry	1	1				2	1		*5*
Callicarpa americana	American beautyberry		2	4	3		1			*10*
Clethra alnifolia	Sweet pepperbush		1				2	1	1	*5*
Sambucus canadensis	Elderberry	1								*1*
Fothergilla gardenii	Witch-alder	2	2				2	1	2	*9*
Ilex decidua	Possumhaw	1	3	4	3	4		2	1	*18*
Ilex glabra	Inkberry		2				2	1		*5*
Myrica cerifera	Wax myrtle		1				2	1	2	*6*
Rhus copallinum	Winged sumac		2				1	2	1	*6*
Viburnum nudum	Wither-rod		2				2	2	1	*7*
	Total Shrubs	***5***	***16***	***8***	***6***	***4***	***14***	***11***	***8***	*72*
Trees										
Carpinus caroliniana	Ironwood				1	3				*4*
Cercis canadensis	Redbud						1		1	*2*
Diospyros virginiana	Persimmon	1	2	3	1		1	2	2	*12*
Fraxinus pennsylvanicum	Green ash	1	3			1	1		1	*7*
Nyssa sylvatica	Black gum	1					2	1		*4*
Populus heterophylla	Swamp cottonwood	2	2	3	3	1	1			*12*
Quercus laurifolia	Laurel oak							2		*2*
Quercus lyrata	Overcup oak				1	8	2	1	4	*16*
Quercus phellos	Willow oak	1	1	3	3	4	1	1	2	*16*
Quercus shumardii	Shumard oak							2		*2*
Taxodium distichum	Bald cypress	5	3	3	3					*14*
Ulmus americana	American elm					1		1		*2*
	Total Trees	***11***	***11***	***12***	***12***	***18***	***9***	***10***	***10***	*93*
TABLE SUMMARY	Total Stems .	16	27	20	18	22	23	21	18	*165*
	Current Density									
	Stems per hectare	1600	2700	2000	1800	2200	2300	2100	1800	*2062.5*
	Stems per acre	648	1093	810	729	891	931	850	729	*835*

The initial baseline revealed an average of 470 trees per acre across the restoration easement area. If shrubs are included in the estimate then the average stem density is increased to 835 stems per acre.

4. Vegetation Plot Photos

Photos of the vegetation plots are located in Appendix A.

B. Stream Assessment

1. Chanel Stability Success Criteria

The restored reach should remain stable or if changes occur the movement should be in the direction of increased stability. There should be insignificant changes in channel cross-section and longitudinal profile from the as-built condition. The pool/riffle spacing should remain constant. Pools should not be filling in or riffles starting to change to pools. Pebble counts should show a coarsening of the bed material. However, it should be noted that Cross Creek is a sand bed stream and significant coarsening will likely not occur.

2. Morphometric Criteria

Cross section and longitudinal surveys were performed on May 10, 2005. Five cross sections and approximately 1,455 linear feet of Cross Creek and 698 feet of Little Cross Creek were surveyed. Photographs were taken at all permanent photo points and a bed material analysis was performed on April 5, 2005. The vegetation is just beginning to become established and the banks are stable with only a few small areas of bare banks or matting exposure.

The assessment included the survey of five cross sections, as well as the longitudinal profile. Cross sections were marked with wooden stakes and rebar. Cross sections are located at the following locations.

Cross Section #1. Cross Creek, Station 11+66.3, midpoint of riffle
Cross Section #2. Cross Creek, Station 20+04.3, midpoint of riffle
Cross Section #3. Cross Creek, Station 20+71.0, midpoint of pool
Cross Section #4. Little Cross Creek, Station 14+75.1, midpoint of pool
Cross Section #5. Little Cross Creek, Station 15+40.4, midpoint of riffle

All of the cross sections appeared stable with little or no active bank erosion. Survey data collected during future monitoring periods may vary depending on actual rod placement and alignment; however, from this point forward this information should remain similar in overall appearance.

2. Hydrologic Criteria

Monitoring requirements state that at least two bankfull events must be documented through the five-year monitoring period. No surface water gauges exist on Cross Creek or its tributaries. A review of known U.S. Geological Survey (USGS) surface water gauges identified three surface water gauges within 20 miles of the mitigation site: one on Rockfish Creek at Raeford (93.1 square miles), one on the Little River near Manchester (348.0 square miles), and one on the Cape Fear River in Fayetteville (4,395.00 square miles). None of the three streams has a drainage area that is comparable to Cross Creek (25.5 square miles). In order to determine future bankfull events for the site it may be necessary to install a stream

gauge onsite since comparison to nearby gauges will not be possible given the large difference in watershed area between existing stream gauges and the project stream.

Table VIII. Verification of Bankfull Events Cross Creek Stream Mitigation Site/Project No. 105			
Date of Data Collection	**Date of Occurrence**	**Method**	**Photo # (if available)**
2005	None	NA	NA

C. Wetland Assessment

There is no wetland restoration associated with this site, therefore this table is not applicable to this project.

Table XI. Baseline Morphology and Hydraulic Summary
Cross Creek Stream Mitigation Site/Project No. 105
(Cross Creek)

Parameter	USGS Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
BF Width (ft)				16.0	52.0	29.4	26.0	30.0	27.4	14.5	27.4				34.2	34.2	49.6	38.6
BF Cross Sectional Area (ft^2)				11.6	115.0	88.6	68.8	77.1	73.2	21.1	49.1				73	67.8	113.6	70.8
BF Mean Depth (ft)				1.3	6.3	2.9	2.5	3.0	2.65	0.8	2.3				2.14	1.8	2.3	2.0
BF Max Depth (ft)							3.3	4.1	3.7	2.1	3.5				3.2	3.2	4.3	3.4
Width/Depth Ratio							8.8	10.3	10.0	8.4	34				16	17.3	21.7	21.0
Entrenchment Ratio							1.25	1.9	1.6	10.5	14.9				2.7			
Wetted Perimeter (ft)																		
Hydraulic radius (ft)																		
Pattern																		
Channel Beltwidth (ft)									27.4	20	36		70	170		28	87	70
Radius of Curvature (ft)									0	7	36		70	120		75	120	93.5
Meander Wavelength									0	32	325		240	479		283	377	354
Meander Width ratio									1.0	0.67	1.8		2.0	5.0		0.82	1.75	1.81
Profile																		
Riffle length (ft)													38	177	92	10.99	60.86	27.84
Riffle slope (ft/ft)													.004	.004	.004	.0019	.0285	.0045
Pool length (ft)													11.0	42.7	30.5	4.34	43.35	16.43
Pool spacing (ft)							77	167	132	19	123		152	228	187	12.65	340.56	80.28
Substrate																		
d50 (mm)																<.062	.5-1.0	
d84 (mm)																.25-.5	2.0-4.0	
Additional Reach Parameters																		
Valley Length (ft)																		1215.3
Channel Length (ft)																		1442
Sinuosity							1.0	1.0	1.0	1.3	1.5				1.10			1.19
Water Surface Slope (ft/ft)							.0022	.0022	0.0022	.0011	.0016				0.0024			0.0030
BF slope (ft/ft)																		0.0021
Rosgen Classification									G5,E5			C5,E5			C5			C
Habitat Index																		
Macrobenthos																		

Table XI. Baseline Morphology and Hydraulic Summary
Cross Creek Stream Mitigation Site/Project No. 105
(Little Cross Creek)

Parameter	USGS Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
BF Width (ft)				14.0	49.0	25.1	17.3	23.0	20.2	14.5	27.4				24.7	23.3	36.4	29.9
BF Cross Sectional Area (ft^2)				11.5	200	66.4	33.5	43.6		21.1	49.1				38	35.5	50.1	42.8
BF Mean Depth (ft)				1.2	5.9	2.6			1.9	0.8	2.3				1.54	1.4	1.5	1.45
BF Max Depth (ft)							2.5	2.9		2.1	3.5				N/A	2.3	3.0	2.65
Width/Depth Ratio							8.9	12.1		8.4	34				16	15.3	26.5	20.9
Entrenchment Ratio									1.6	10.5	14.9				3.3			
Wetted Perimeter (ft)																		
Hydraulic radius (ft)																		
Pattern																		
Channel Beltwidth (ft)									20.2	20	36		50	124		32	90	61
Radius of Curvature (ft)									0	7	36		50	86		71	134	91.5
Meander Wavelength									0	32	325		173	346		210	380	295
Meander Width ratio									1.0	0.67	1.8		2.0	5.0		1.37	2.47	2.04
Profile																		
Riffle length (ft)													58	81	76	12.9	45.4	26.4
Riffle slope (ft/ft)													.006	.006	.006	.0016	.0202	.0029
Pool length (ft)													24.3	37.3	27.7	20.3	128.5	52.2
Pool spacing (ft)							36	131	83	19	123		90	172	118	8.0	43.3	14.2
Substrate																		
d50 (mm)																.5-1.0	1.0-2.0	
d84 (mm)																1.0-2.0	16.0-22.6	
Additional Reach Parameters																		
Valley Length (ft)																		661
Channel Length (ft)																		714
Sinuosity									1.0	1.3	1.5				1.12			1.08
Water Surface Slope (ft/ft)									.0037	.0011	.0016				0.0033			0.0030
BF slope (ft/ft)																		0.0099
Rosgen Classification									G5			C5,E5			C5			C
Habitat Index																		
Macrobenthos																		

Table XII. Morphology and Hydraulic Monitoring Summary
Cross Creek Stream Mitigation Site/Project No. 105
(Cross Creek)

Parameter	Cross Section 1			Cross Section 2			Cross Section 3								
	1+66.3 Riffle			10+04.3 Riffle			10+71.0 Pool								
Dimension	MY0	MY1	MY2	MY0	MY1	MY2	MY0	MY1	MY2	MY0	MY1	MY2	MY0	MY1	MY2
BF Width (ft)	34.2			38.6			49.6								
Floodprone Width (ft) (approx)	>100			>100											
BF Cross Sectional Area (ft^2)	67.8			70.8			113.6								
BF Mean Depth (ft)	2.0			1.8			2.3								
BF Max Depth (ft)	3.2			3.4			4.3								
Width/Depth Ratio	17.3			21.0			21.7								
Entrenchment Ratio	>2.9			>1.8											
Wetted Perimeter (ft)															
Hydraulic radius (ft)															
Substrate															
d50 (mm)	<.062			1.0-2.0			.5-1.0								
d84 (mm)	.25-.5			16.0-22.6			1.0-2.0								

Parameter	MY-01 (2006)			MY-02 (2007)			MY-03 (2008)			MY-04 (2009)			MY-05 (2010)			MY+ (2011)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)																		
Pool length (ft)																		
Pool spacing (ft)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)																		
Sinuosity																		
Water Surface Slope (ft/ft)																		
BF Slope (ft/ft)																		
Rosgen Classification																		
Habitat Index*																		
Macrobenthos*																		

Table XII. Morphology and Hydraulic Monitoring Summary
Cross Creek Stream Mitigation Site/Project No. 105
(Little Cross Creek)

Parameter	Cross Section 1			Cross Section 2											
	1+94 Pool			2+91 Riffle											
Dimension	MY0	MY1	MY2	MY0	MY1	MY2	MY0	MY1	MY2	MY0	MY1	MY2	MY0	MY1	MY2
BF Width (ft)	36.4			23.3											
Floodprone Width (ft) (approx)				90.0											
BF Cross Sectional Area (ft^2)	50.1			35.5											
BF Mean Depth (ft)	1.4			1.5											
BF Max Depth (ft)	3.0			2.3											
Width/Depth Ratio	26.5			15.3											
Entrenchment Ratio				3.9											
Wetted Perimeter (ft)															
Hydraulic radius (ft)															
Substrate															
d50 (mm)	.062-.125			.5-1.0											
d84 (mm)	2.0-4.0			2.0-4.0											

Parameter	MY-01 (2006)			MY-02 (2007)			MY-03 (2008)			MY-04 (2009)			MY-05 (2010)			MY+ (2011)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)																		
Pool length (ft)																		
Pool spacing (ft)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)																		
Sinuosity																		
Water Surface Slope (ft/ft)																		
BF Slope (ft/ft)																		
Rosgen Classification																		
Habitat Index*																		
Macrobenthos*																		

Appendix A

A-1 Vegetation Raw Data

A-2 Vegetation Survey Data Tables

A-3 Vegetation Monitoring Plot Photos

CROSS CREEK AS-BUILT VEGETATION MONITORING		Date 6-22-05 Investigator				
Species		Plots 102 (103)	103 (104)	101 (102)	106 (101)	
	Plots Disturbed?	N				
	Type of Disturbance?	—				
Photo	~~Spacing Distance (ft)~~	510 ✓10	✓11	✓12	✓13	
Trees						
Betula nigra	River birch					
Carpinus caroliniana	Ironwood		①			1
Cercis canadensis	Redbud					
Cornus florida	Flowering dogwood					
Diospyros virginiana	Persimmon	③	①	②	①	7
Fraxinus pennsylvanicum	Green ash			③	①	4
Ilex decidua	Possumhaw					
Nyssa sylvatica	Black gum				①	1
Populus heterophylla	Swamp cottonwood	③	③	②	②	10
Quercus coccinea	Scarlet oak					
Quercus laurifolia	Laurel oak					
Quercus lyrata	Overcup oak		①			1
Quercus phellos	Willow oak	③	③	①	①	8
Quercus shumardii	Shumard oak					
Taxodium distichum	Bald cypress	③	③	③	⑤	14
Ulmus americana	American elm					
Shrubs						
Aronia arbutifolia	Red chokeberry			①	①	2
Callicarpa americana	American beautyberry	④	③	②		9
Clethra alnifolia	Sweet pepperbush			①		1
~~*Cyrilla racemiflora*~~ *Sambucus*	~~Swamp~~ Elderberry				①	1
Fothergilla gardenii	Witch-alder					
Ilex ~~coriacea~~ decidua	Gallberry	④	③	③	①	11
Ilex glabra	Inkberry			②		2
Rhus copallinum	Winged sumac			②		2
Viburnum nudum	Wither-rod			②		2
Exotic Species						
Albizia sp.				②	②	4
Myrica cerifera				①		1

Comments (label by plot):

103 & 102 consec stems plots (20) 103 w/ orange/blue flags (18)

102 - 2 photos??

101 - Pink/Blk stripe flags (22)

(16)

CROSS CREEK AS-BUILT VEGETATION MONITORING		Date 6-22-05 Investigator G CANIFORD				
Species		TRIB 107 (108)	105 (106)	104 (105)	103 (107)	
	Plots Disturbed?	N	N	N		
	Type of Disturbance?	—	—	—		
	Spacing Distance (ft)	≤10				
Trees		Photo #6	Photo #7	Photo #8	Photo #9	
Betula nigra	River birch			①		1
Carpinus caroliniana	Ironwood	BoB	BoB	②		2
Cercis canadensis	Redbud	② ①	② ①			2
Cornus florida	Flowering dogwood					
Diospyros virginiana	Persimmon	②	①		②	5
Fraxinus pennsylvanicum	Green ash	①	①	①		3
~~*Ilex decidua*~~	Possumhaw					
Nyssa sylvatica	Black gum		②		①	3
Populus heterophylla	Swamp cottonwood		①	①		2
Quercus coccinea	Scarlet oak					
Quercus laurifolia	Laurel oak				②	2
Quercus lyrata	Overcup oak	④	②	⑧	①	15
Quercus phellos	Willow oak	②	① BoB	④	①	8
Quercus shumardii	Shumard oak				②	2
Taxodium distichum	Bald cypress					
Ulmus americana	American elm			①	①	2
Shrubs						
Aronia arbutifolia	Red chokeberry		②		①	3
Callicarpa americana	American beautyberry		①			1
Clethra alnifolia	Sweet pepperbush	①	②		①	4
~~*Cyrilla racemosa*~~	Ti-ti					
Fothergilla gardenii	Witch-alder					
~~*Ilex coriacea*~~ *Ilex glabra*	Gallberry	①		④	②	7
Ilex glabra	Inkberry		②		①	3
Rhus copallinum	Winged sumac	①	①		②	4
Viburnum nudum	Wither-rod	①	②		②	5
~~Exotic Species~~						
Alnus ~~Fothergilla~~ serrulata		②	②		①	5
Myrica cerifera		②	②		①	5

Comments (label by plot):

Trib → 107/108 Natural Recruitment - Celtis, ~~Salix~~ (19), (Taxodium ~~2~~ (23) 2 ~ 10 (22) high) 21

Bare soil significant - Annual Grasses dead, weeds invading - overwash w/minor sed

105/106 Mugwort present

104/105 - In the Confluence of channels

Trib → 103/107 Kudzu encroaching from upland

Cross Creek Stream Restoration Site
Mitigation Report
Appendix A-3
Vegetation Monitoring Plot Photos


Vegetation Plot 101


Vegetation Plot 102


Vegetation Plot 103


Vegetation Plot 104


Vegetation Plot 105


Vegetation Plot 106

Vegetation Plot 107

Vegetation Plot 108

APPENDIX B

Cross-Section 1 (Station 11+66.3) Facing US

Cross-Section 1 (Sta. 11+66.3) Facing DS

Cross-Section 2 (Station 20.04.3) Facing US

Not Available

Cross-Section 2 (Station 20+04.3) Facing DS

Cross-Section 3 (Station 20+71.0) Facing US

Cross-Section 3 (Station 20+71.0) Facing DS

Cross-Section 4 (Station 14+75.1) Facing US

Cross-Section 4 (Station 14+75.1) Facing US

Cross-Section 5 (Station 15+40.4) Facing US

Cross-Section 5 (Station 15+40.4) Facing DS

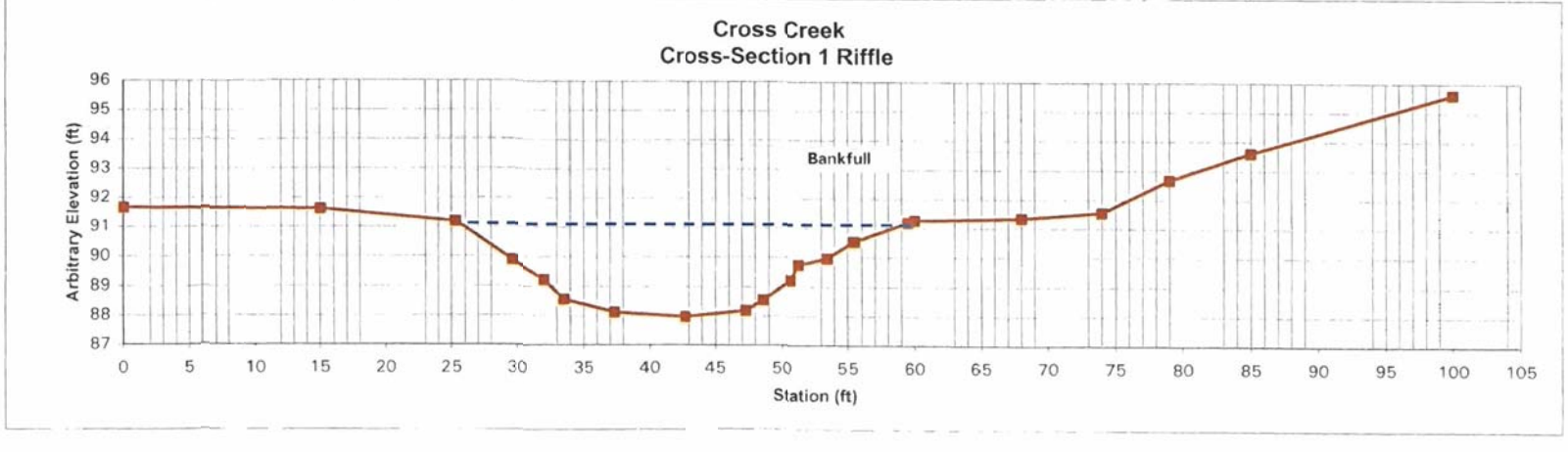
CROSS CREEK AS-BUILT SURVEY

Field Crew:	Amanda Todd, Chad Holland, andWade Patton
River Basin:	Cape Fear
Watershed:	Cross Creek
Stream Reach:	Reach 1
Drainage Area:	15.50
Date:	5/10/2005
Station:	12+38.3
Feature:	riffle

STATION (FEET)	HI (FEET)	FS (FEET)	ELEVATION (FEET)	NOTES	
0+00.0	98.93	7.30	91.63	**REBAR 7.00**	
0+15.0	98.93	7.34	91.59		
0+25.3	98.93	7.76	91.17	TOB.BKF	
0+29.6	98.93	9.05	89.88		
0+32.0	98.93	9.72	89.21		
0+33.5	98.93	10.38	88.55	LEOW	
0+37.3	98.93	10.82	88.11		
0+42.7	98.93	10.98	87.95	TW	
0+47.3	98.93	10.76	88.17		
0+48.6	98.93	10.40	88.53	REOW/WS	
0+50.7	98.93	9.73	89.20		
0+51.3	98.93	9.21	89.72		
0+53.5	98.93	8.98	89.95		
0+55.5	98.93	8.41	90.52		
0+59.5	98.93	7.76	91.17	TOB/BKF lint	
0+60.0	98.93	7.68	91.25		
0+68.0	98.93	7.60	91.33		
0+74.0	98.93	7.39	91.54		
0+79.0	98.93	6.28	92.65		
0+85.0	98.93	5.34	93.59		
1+00.0	98.93	3.35	95.58	rebar 3.00	95.93

BANKFULL/TOB Hydraulic Geometry		
Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
0.0	0.0	0.0
4.3	1.3	2.8
2.4	2.0	3.9
1.5	2.6	3.4
3.8	3.1	10.8
5.4	3.2	17.0
4.6	3.0	14.3
1.3	2.6	3.7
2.1	2.0	4.8
0.6	1.5	1.0
2.2	1.2	2.9
2.0	0.6	1.9
4.0	0.0	1.3
TOTALS 34.2		67.8

SUMMARY DATA (BANKFULL)			
CSA(BKF)	67.8	W(FPA)	>100
W(BKF)	34.2	Slope	0.0030
Max d	3.2	Sinuosity	
Mean d	2.0	Area=	A
W/D	17.3	Width=	W
Entrenchment	>2.9	Depth=	D
Stream Type	C	Bankfull=	BKF
Area from Rural Regional Curve			50.50



CROSS CREEK AS-BUILT SURVEY

Field Crew:	Amanda Todd, Chad Holland, andWade Patton
River Basin:	Cape Fear
Watershed:	Cross Creek
Stream Reach:	Reach 1
Drainage Area:	25.50
Date:	5/10/2005
Station:	20+76.3
Feature:	riffle

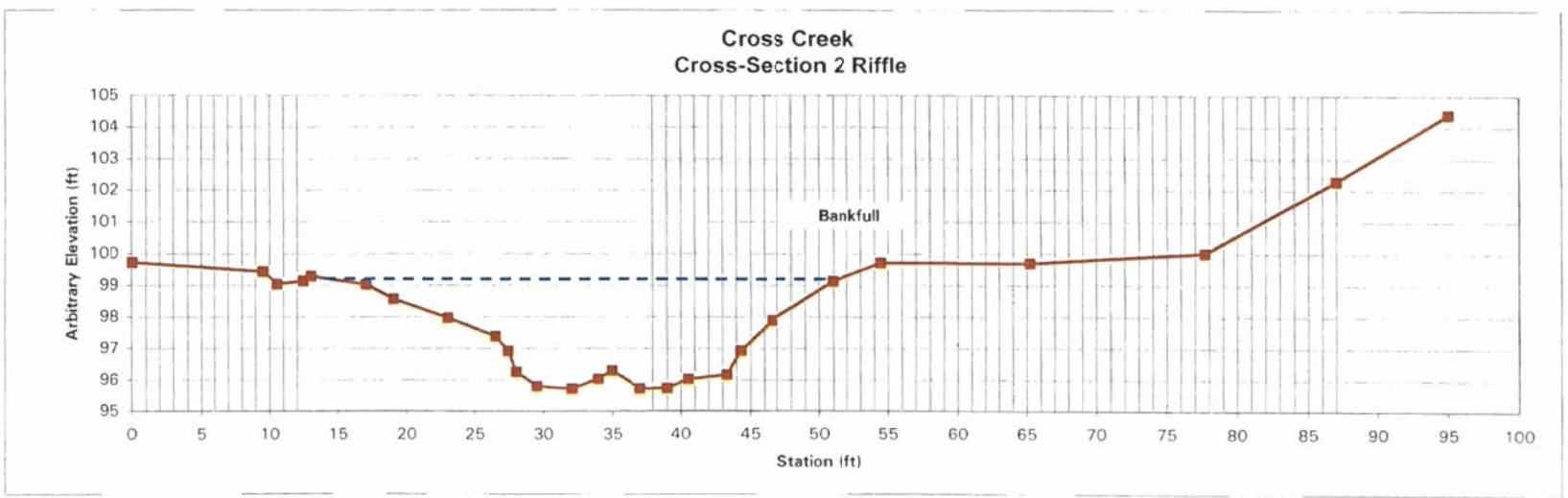
STATION (FEET)	HI (FEET)	FS (FEET)	ELEVATION (FEET)	NOTES
0+00.0	111.57	11.87	99.70	REBAR 11.57
0+09.5	111.57	12.16	99.41	
0+10.5	111.57	12.55	99.02	
0+12.4	111.57	12.45	99.12	BKF
0+13.0	111.57	12.31	99.26	
0+17.0	111.57	12.56	99.01	
0+19.0	111.57	13.02	98.55	
0+23.0	111.57	13.62	97.95	
0+26.5	111.57	14.20	97.37	
0+27.4	111.57	14.67	96.90	LEOW
0+28.0	111.57	15.32	96.25	
0+29.5	111.57	15.79	95.78	
0+32.0	111.57	15.86	95.71	TW
0+33.9	111.57	15.55	96.02	
0+34.9	111.57	15.29	96.28	
0+37.0	111.57	15.86	95.71	TW
0+39.0	111.57	15.85	95.72	
0+40.5	111.57	15.56	96.01	
0+43.3	111.57	15.42	96.15	
0+44.3	111.57	14.66	96.91	REOW/WS
0+46.6	111.57	13.70	97.87	
0+51.0	111.57	12.45	99.12	BKF/TOB
0+54.5	111.57	11.87	99.70	
0+65.2	111.57	11.88	99.69	
0+77.7	111.57	11.57	100.00	
0+87.0	111.57	9.30	102.27	
0+95.0	111.57	7.19	104.38	REBAR 6.79

BANKFULL Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	0.6	-0.1	0.0
	4.0	0.1	-0.1
	2.0	0.6	0.7
	4.0	1.2	3.5
	3.5	1.8	5.1
	0.9	2.2	1.8
	0.6	2.9	1.5
	1.5	3.3	4.7
	2.5	3.4	8.4
	1.9	3.1	6.2
	1.0	2.8	3.0
	2.1	3.4	6.6
	2.0	3.4	6.8
	1.5	3.1	4.9
	2.8	3.0	8.5
	1.0	2.2	2.6
	2.3	1.3	4.0
	4.4	0.0	2.8
TOTALS	38.6		70.8

SUMMARY DATA (BANKFULL)

A(BKF)	70.8	W(FPA)	>100
W(BKF)	38.6	Slope	0.0030
Max d	3.4	Sinuosity	
Mean d	1.8	Area=	A
W/D	21.0	Width=	W
Entrenchment	>1.8	Depth=	D
Stream Type	C	Bankfull=	BKF
Area from Rural Regional Curve			65.20



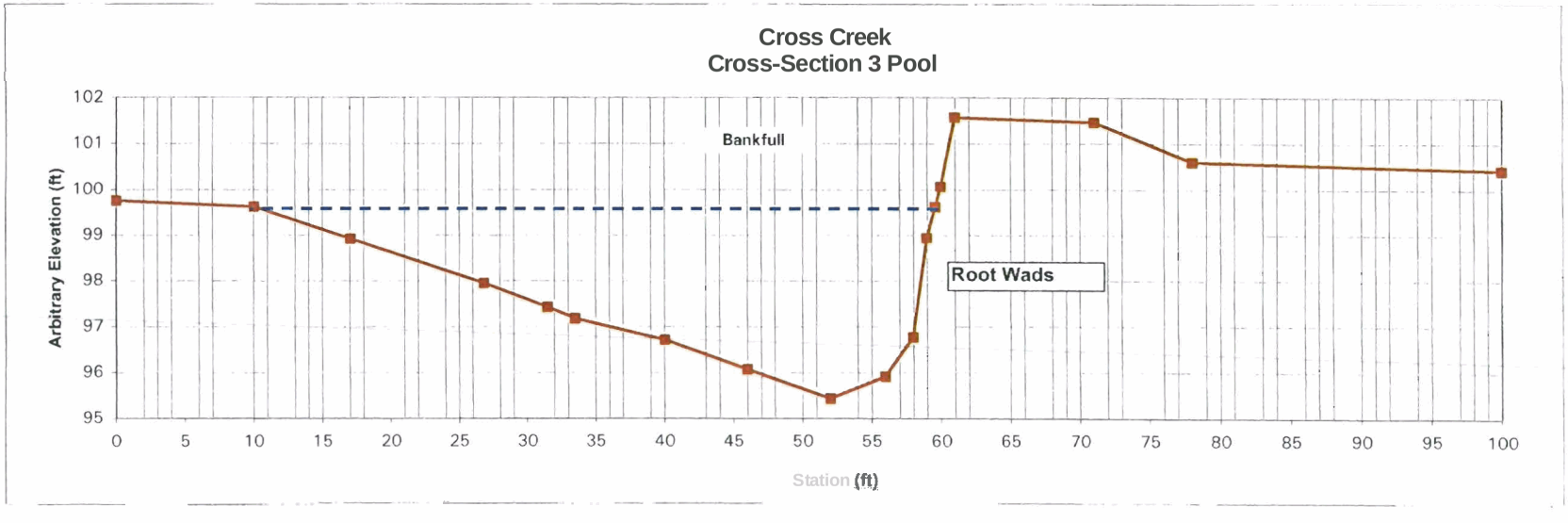
CROSS CREEK AS-BUILT SURVEY

Field Crew:	Amanda Todd, Chad Holland, andWade Patton
River Basin:	Cape Fear
Watershed:	Cross Creek
Stream Reach:	Reach 1
Drainage Area:	25.50
Date:	5/10/2005
Station:	21+43.0
Feature:	pool

STATION (FEET)	HI (FEET)	FS (FEET)	ELEVATION (FEET)	NOTES
0+00.0	111.57	12.11	99.46	REBAR 11.80
0+10.0	111.57	12.24	99.33	BKF
0+17.0	111.57	12.95	98.62	
0+26.8	111.57	13.94	97.63	
0+31.5	111.57	14.46	97.11	
0+33.5	111.57	14.71	96.86	LEOW/WS
0+40.0	111.57	15.18	96.39	
0+46.0	111.57	15.84	95.73	
0+52.0	111.57	16.49	95.08	
0+56.0	111.57	16.00	95.57	TW
0+58.0	111.57	15.13	96.44	REOW
0+59.0	111.57	12.93	98.64	
0+59.6	111.57	12.24	99.33	BKFLINT
0+60.0	111.57	11.79	99.78	
0+61.0	111.57	10.25	101.32	
0+71.0	111.57	10.35	101.22	
0+78.0	111.57	11.24	100.33	
1+00.0	111.57	11.43	100.14	rebar 10.92

BANKFULL/TOB Hydraulic Geometry		
Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
0.0	0.0	0.0
7.0	0.7	2.5
9.8	1.7	11.8
4.7	2.2	9.2
2.0	2.5	4.7
6.5	2.9	17.6
6.0	3.6	19.6
6.0	4.3	23.6
4.0	3.8	16.0
2.0	2.9	6.7
1.0	0.7	1.8
0.6	0.0	0.2
TOTALS 49.6		113.6

SUMMARY DATA (TOB)	
A(BKF)	113.6
W(BKF)	49.6
Max d	4.3
Mean d	2.3
Wm	21.7



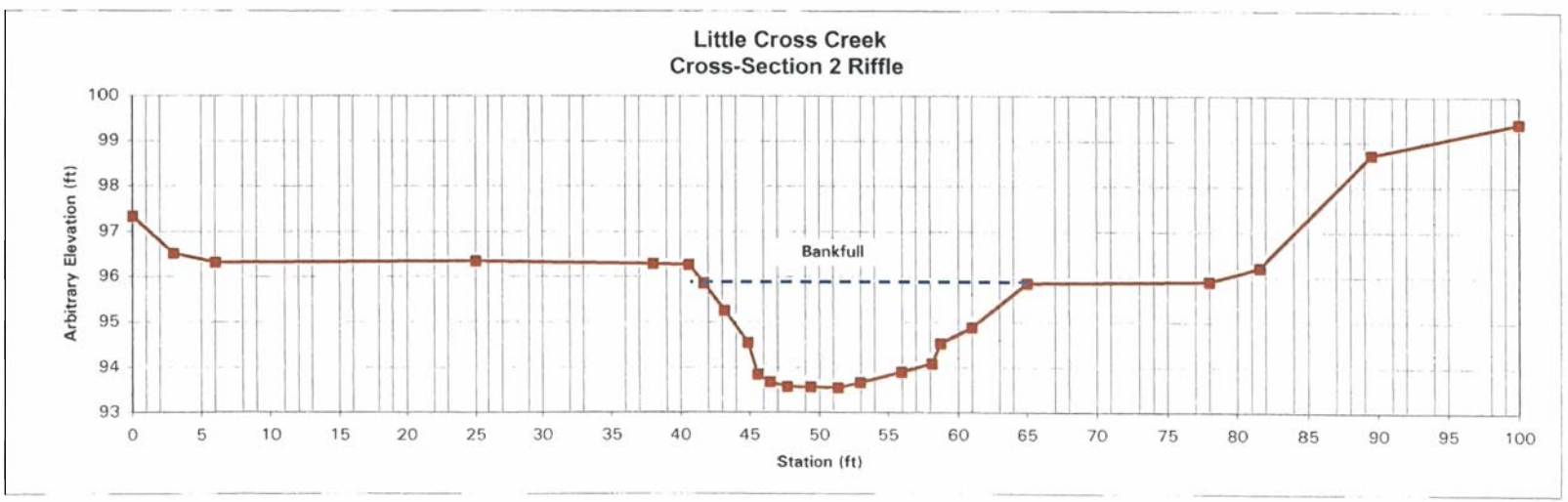
LITTLE CROSS CREEK AS-BUILT SURVEY

Field Crew:	Amanda Todd, Chad Holland, and Wade Patton
River Basin:	Cape Fear
Watershed:	Cross Creek
Stream Reach:	Little Cross Creek
Drainage Area:	10.50
Date:	5/10/2005
Station:	5+40.4
Feature:	riffle

STATION (FEET)	HI (FEET)	FS (FEET)	ELEVATION (FEET)	NOTES
0+00.0	106.53	9.21	97.32	REBAR 8.84
0+03.0	106.53	10.03	96.50	
0+06.0	106.53	10.23	96.30	
0+25.0	106.53	10.19	96.34	
0+38.0	106.53	10.25	96.28	
0+40.6	106.53	10.27	96.26	
0+41.7	106.53	10.68	95.85	BKFLINT
0+43.2	106.53	11.28	95.25	
0+44.9	106.53	11.99	94.54	
0+45.6	106.53	12.68	93.85	LEOW
0+46.5	106.53	12.85	93.68	
0+47.7	106.53	12.95	93.58	
0+49.4	106.53	12.96	93.57	
0+51.4	106.53	12.98	93.55	TW
0+53.0	106.53	12.86	93.67	
0+56.0	106.53	12.63	93.90	REOW/WS
0+58.2	106.53	12.45	94.08	
0+58.8	106.53	12.01	94.52	
0+61.0	106.53	11.65	94.88	
0+65.0	106.53	10.68	95.85	BKF
0+78.0	106.53	10.64	95.89	
0+81.6	106.53	10.33	96.20	
0+89.5	106.53	7.84	98.69	
1+00.0	106.53	7.14	99.39	REBAR 6.85

	BANKFULL/TOB Hydraulic Geometry		
	Width (Feet)	Depth (Feet)	Area (CSA) (Sq. Ft.)
	0.0	0.0	0.0
	1.5	0.6	0.4
	1.7	1.3	1.6
	0.7	2.0	1.2
	0.9	2.2	1.9
	1.2	2.3	2.7
	1.7	2.3	3.9
	2.0	2.3	4.6
	1.6	2.2	3.6
	3.0	1.9	6.2
	2.2	1.8	4.1
	0.6	1.3	0.9
	2.2	1.0	2.5
	4.0	0.0	1.9
TOTALS	23.3		35.5

SUMMARY DATA (BANKFULL)			
CSA(BKF)	35.5	W(FPA)	90.0
W(BKF)	23.3	Slope	0.0030
Max d	2.3	Sinuosity	
Mean d	1.5	Area=	A
W/D	15.3	Width=	W
Entrenchment	3.9	Depth=	D
Stream Type	C	Bankfull=	BKF
Area from Rural Regional Curve			41.34



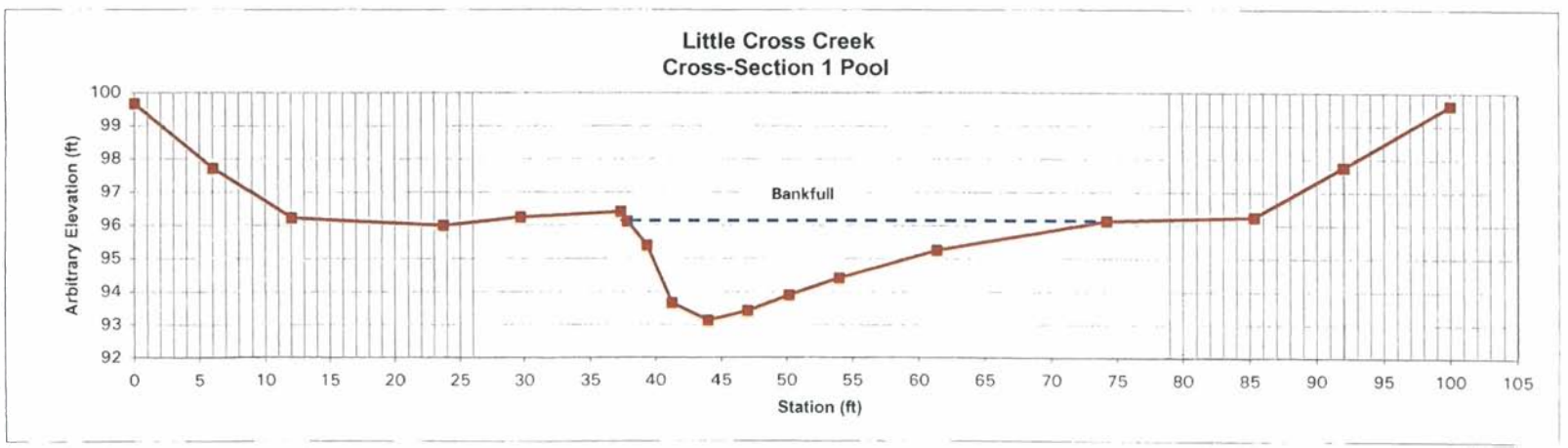
LITTLE CROSS CREEK AS-BUILT SURVEY

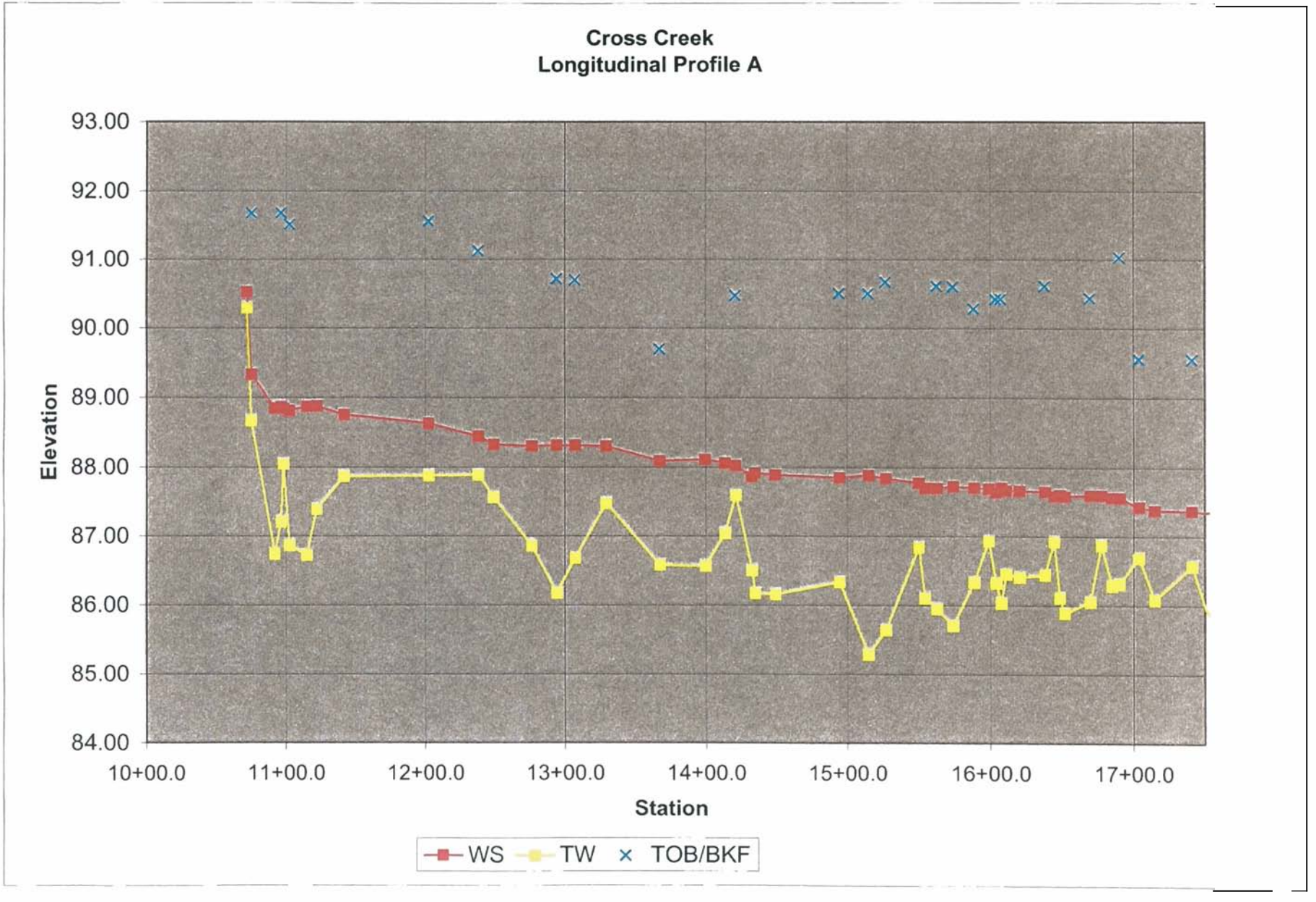
Field Crew:	Amanda Todd, Chad Holland, and Wade Patton
River Basin:	Cape Fear
Watershed:	Cross Creek
Stream Reach:	Little Cross Creek
Drainage Area:	10.50
Date:	5/10/2005
Station:	4+75.1
Feature:	pool

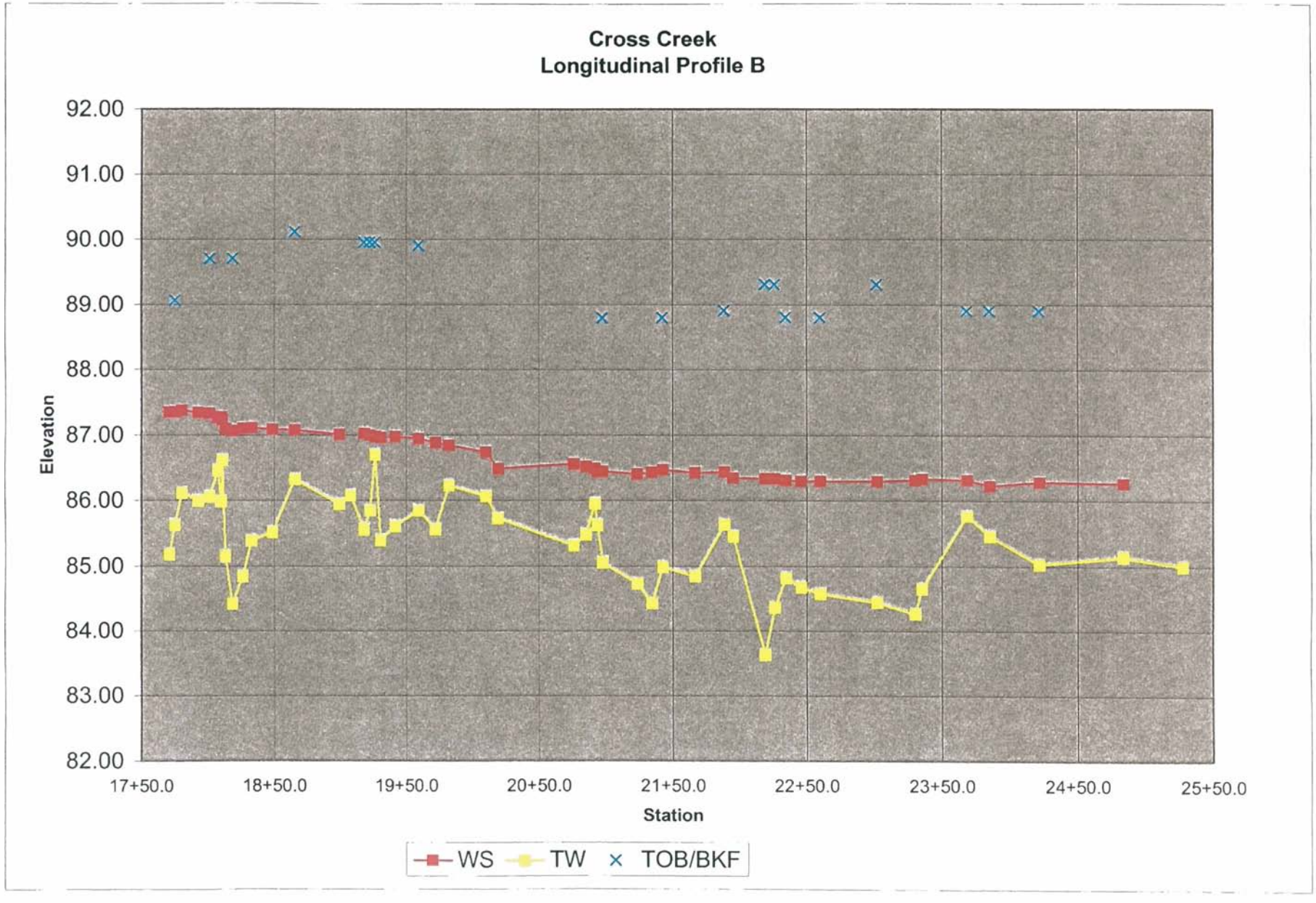
STATION (FEET)	HI (FEET)	FS (FEET)	ELEVATION (FEET)	NOTES
0+00.0	106.53	6.88	99.65	**rebar 6.53**
0+06.0	106.53	8.84	97.69	
0+12.0	106.53	10.32	96.21	
0+23.7	106.53	10.55	95.98	
0+29.7	106.53	10.29	96.24	
0+37.3	106.53	10.13	96.40	
0+37.8	106.53	10.42	96.11	bkfiint
0+39.3	106.53	11.14	95.39	top of root wad
0+41.2	106.53	12.88	93.65	leow
0+44.0	106.53	13.41	93.12	tw
0+47.0	106.53	13.11	93.42	
0+50.2	106.53	12.64	93.89	reow/ws
0+54.0	106.53	12.13	94.40	
0+61.4	106.53	11.29	95.24	
0+74.2	106.53	10.41	96.12	bkf
0+85.3	106.53	10.29	96.24	
0+92.0	106.53	8.79	97.74	
1+00.0	106.53	6.92	99.61	rebar 6.78

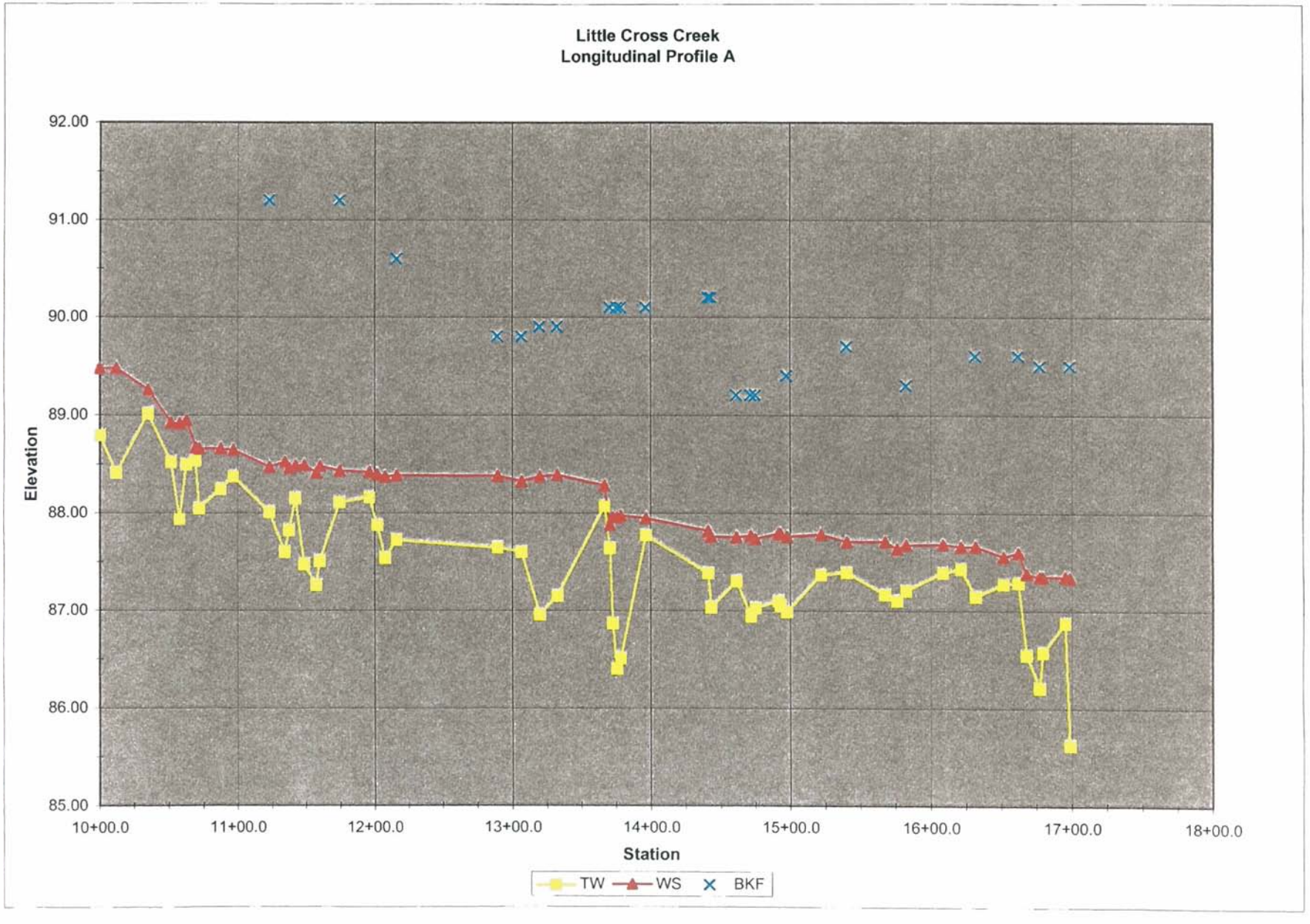
BANKFULL/TOB Hydraulic Geometry		
Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
0.0	0.0	0.0
1.5	0.7	0.5
1.9	2.5	3.0
2.8	3.0	7.6
3.0	2.7	8.5
3.2	2.2	7.9
3.8	1.7	7.5
7.4	0.9	9.5
12.8	0.0	5.5
TOTALS 36.4		50.1

SUMMARY DATA (TOB)	
A(BKF)	50.1
W(BKF)	36.4
Max d	3.0
Mean d	1.4
W/D	26.5




Cross Creek
Longitudinal Profile A
93.00
92.00
91.00
90.00
89.00
88.00
87.00
86.00
85.00
84.00
Elevation
10+00.0
11+00.0
12+00.0
13+00.0
14+00.0
15+00.0
16+00.0
17+00.0
Station
WS
TW
TOB/BKF


Cross Creek
Longitudinal Profile B
92.00
91.00
90.00
89.00
88.00
87.00
86.00
85.00
84.00
83.00
82.00
Elevation
17+50.0
18+50.0
19+50.0
20+50.0
21+50.0
22+50.0
23+50.0
24+50.0
25+50.0
Station
WS
TW
TOB/BKF


Little Cross Creek
Longitudinal Profile A
92.00
91.00
90.00
89.00
88.00
87.00
86.00
85.00
Elevation
10+00.0
11+00.0
12+00.0
13+00.0
14+00.0
15+00.0
16+00.0
17+00.0
18+00.0
Station
TW
WS
BKF

CROSS CREEK AS-BUILT SURVEY

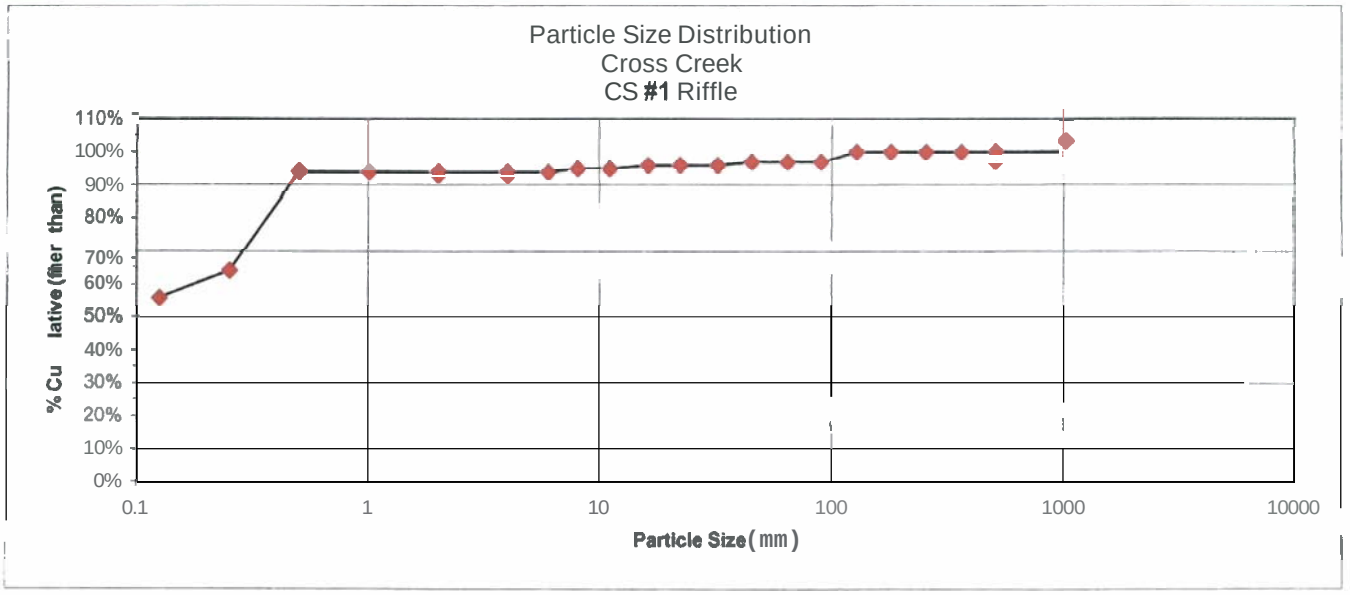
PEBBLE COUNT

Site: Cross Creek | 41512005

Party: Amanda Todd and Russel Barbour | CS#1 Riffle

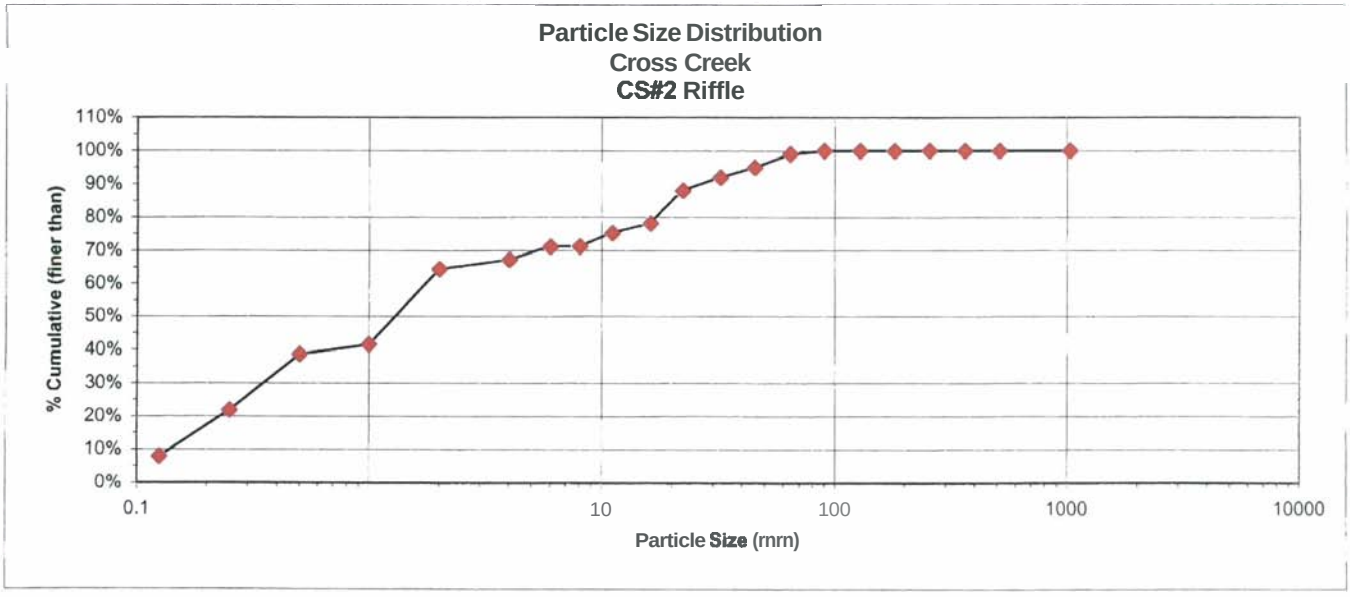
Particle Count

Inches	Particle	Millimeter		Riffle			Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	56			56	56%	56%
	Very Fine	,062 - .125	S	0			0	0%	56%
	Fine	.125 - .25	A	8			8	8%	64%
	Medium	.25 - .50	N	30			30	30%	94%
	Coarse	50 - 1.0	D	0			0	0%	94%
.04 - .08	Very Coarse	1.0 - 2 0	S	0			0	0%	94%
.08 - .16	Very Fine	2.0 - 4.0		0			0	0%	94%
.16 - .22	Fine	4.0 - 5.7	G	0			0	0%	94%
.22 - .31	Fine	7 - 8 0	R	1			1	1%	95%
.31 - .44	Medium	8.0 - 11.3	A	0			0	0%	95%
.44 - .63	Medium	11.3 - 16.0	V	1			1	1%	96%
.63 - .89	Coarse	16.0 - 22.6	E	0			0	0%	96%
.89 - 1.26	Coarse	22.6 - 32.0	L	0			0	0%	96%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	1			1	1%	97%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0			0	0%	97%
2.5 - 3.5	Small	64 - 90	C	0			0	0%	97%
3.5 - 5.0	Small	90 - 128	O	3			3	3%	100%
5.0 - 7.1	Large	128 - 180	B	0			0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0			0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0			0	0%	100%
14.3 - 20	Small	362 - 512	L	0			0	0%	100%
20 - 40	Medium	512 - 1024	D	0			0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0			0	0%	100%
	Bedrock		BDRK	0			0	0%	100%
			Totals	100			100	100%	100%



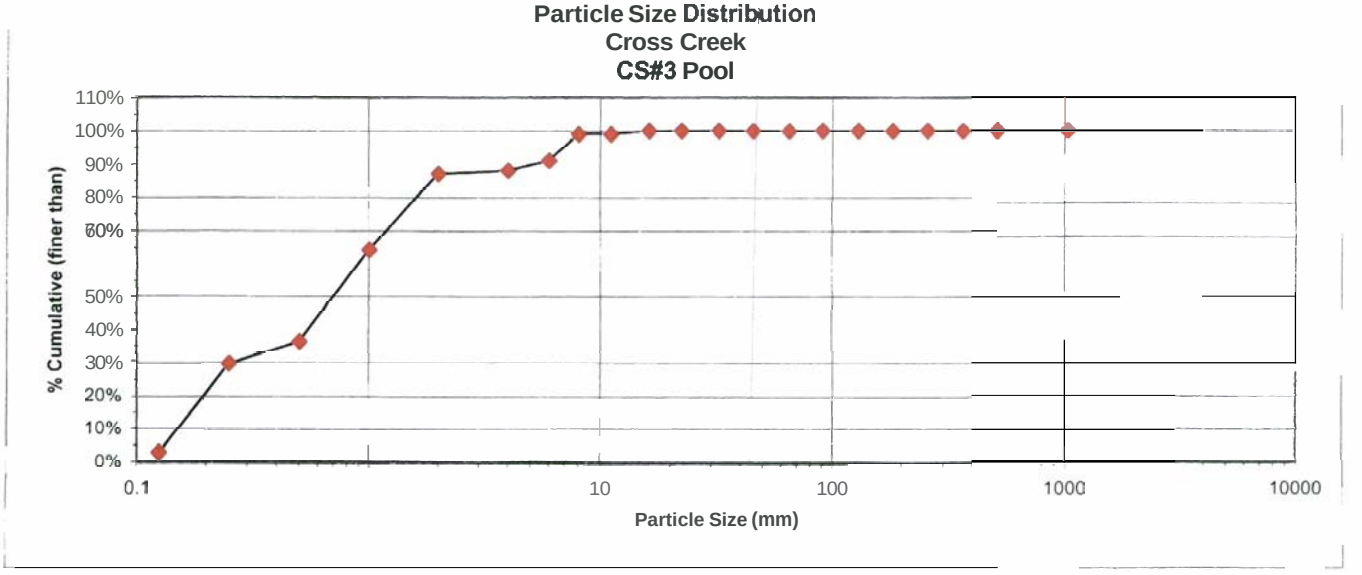
CROSS CREEK AS-BUILT SURVEY

PEBBLE COUNT									
Site: Cross Creek							41512005		
Party: Amanda Todd and Russel Barbour							CS#2 Riffle		
Particle Count									
Inches	Particle	Millimeter		Riffle			Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	4			4	4%	4%
	Very Fine	.062 - .125	S	4			4	4%	8%
	Fine	.125 - .25	A	14			14	14%	22%
	Medium	.25 - .50	N	17			17	17%	39%
	Coarse	.50 - 1.0	D	3			3	3%	42%
.04 -.08	Very Coarse	1 . - 2.0	S	23			23	23%	64%
.08 - .16	Very Fine	2.0 - 4.0		3			3	3%	67%
.16 - .22	Fine	4.0 - 5.7	G	4			4	4%	71%
.22 - .31	Fine	5.7 - 8.0	R	0			0	0%	71%
.31 - .44	Medium	8.0 - 11.3	A	4			4	4%	75%
.44 - .63	Medium	11.3 - 16.0	V	3			3	3%	78%
.63 - .89	Coarse	16.0 - 22.6	E	10			10	10%	88%
.89 - 1.26	Coarse	22.6 - 32.0	L	4			4	4%	92%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	3			3	3%	95%
1.77 - 2.5	Very Coarse	45.0 - 64.0		4			4	4%	99%
2.5 - 3.5	Small	64 - 90	C	1			1	1%	100%
3.5 - 5.0	Small	90 - 128	O	0			0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0			0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0			0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0			0	0%	100%
14.3 - 20	Small	362 - 512	L	0			0	0%	100%
20 - 40	Medium	512 - 1024	D	0			0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0			0	0%	100%
	Bedrock		BDRK	0			0	0%	100%
			Totals	101			101	100%	100%



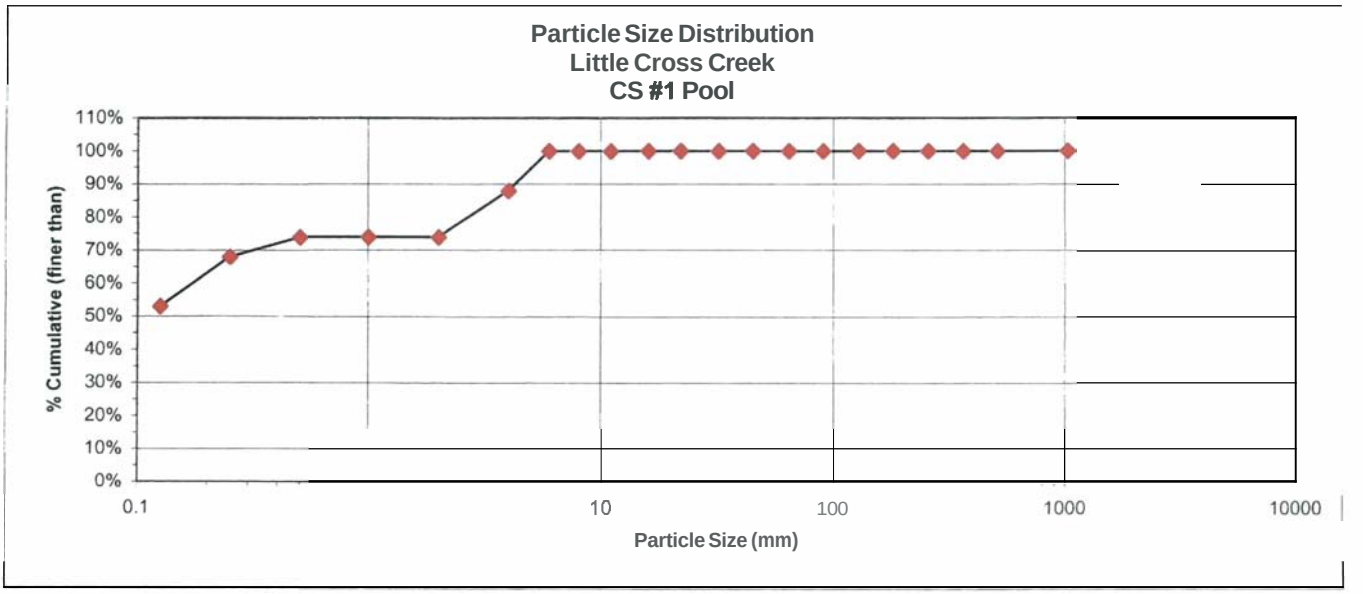
CROSS CREEK AS-BUILT SURVEY

PEBBLE COUNT									
Site: Cross Creek							4/5/2005		
Party: Amanda Todd and Russel Barbour							CS#3 Pool		
Particle Count									
Inches	Particle	Millimeter		Riffle			Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0			0	0%	0%
	Very Fine	.062 - .125	S	3			3	3%	3%
	Fine	.125 - .25	A	27			27	27%	30%
	Medium	.25 - .50	N	7			7	7%	37%
	Coarse	.50 - 1.0	D	28			28	28%	64%
.04 -.08	Very Coarse	1.0 - 2.0	S	23			23	23%	87%
.08 - .16	Very Fine	2.0 - 4.0		1			1	1%	88%
.16 - .22	Fine	4.0 - 5.7	G	3			3	3%	91%
.22 - .31	Fine	5.7 - 8.0	R	8			8	8%	99%
.31 - .44	Medium	8.0 - 11.3	A	0			0	0%	99%
.44 - .63	Medium	11.3 - 16.0	V	1			1	1%	100%
.63 - .89	Coarse	16.0 - 22.6	E	0			0	0%	100%
.89 - 1.26	Coarse	22.6 - 32.0	L	0			0	0%	100%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	0			0	0%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0			0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0			0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0			0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0			0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0			0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0			0	0%	100%
14.3 - 20	Small	362 - 512	L	0			0	0%	100%
20 - 40	Medium	512 - 1024	D	0			0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0			0	0%	100%
	Bedrock		BDRK	0			0	0%	100%
			Totals	**101**			**101**	**100%**	**100%**



LITTLE CROSS CREEK AS-BUILT SURVEY

PEBBLE COUNT									
Site: Little Cross Creek							4/5/2005		
Party: Amanda Todd and Russel Barbour							CS#1 Pool		
				Particle Count					
Inches	Particle	Millimeter		Riffle			Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	9			9	9%	9%
	Very Fine	.062 - .125	S	44			44	44%	53%
	Fine	.125 - .25	A	15			15	15%	68%
	Medium	.25 - .50	N	6			6	6%	74%
	Coarse	.50 - 1.0	D	0			0	0%	74%
.04 -.08	Very Coarse	1.0 - 2.0	S	0			0	0%	74%
.08 - .16	Very Fine	2.0 - 4.0		14			14	14%	88%
.16 - .22	Fine	4.0 - 5.7	G	12			12	12%	100%
.22 - .31	Fine	5.7 - 8.0	R	0			0	0%	100%
.31 - .44	Medium	8.0 - 11.3	A	0			0	0%	100%
.44 - .63	Medium	11.3 - 16.0	V	0			0	0%	100%
.63 - .89	Coarse	16.0 - 22.6	E	0			0	0%	100%
.89 - 1.26	Coarse	22.6 - 32.0	L	0			0	0%	100%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	0			0	0%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0			0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0			0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0			0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0			0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0			0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0			0	0%	100%
14.3 - 20	Small	362 - 512	L	0			0	0%	100%
20 - 40	Medium	512 - 1024	D	0			0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0			0	0%	100%
	Bedrock		BDRK	0			0	0%	100%
			Totals	100			100	100%	100%



LITTLE CROSS CREEK AS-BUILT SURVEY

PEBBLE COUNT									
Site: Little Cross Creek							4/5/2005		
Party: Amanda Todd and Russel Barbour							CS#2 Riffle		
Particle Count									
Inches	Particle	Millimeter		Riffle			Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	13			13	13%	13%
	Very Fine	.062 - .125	S	4			4	4%	17%
	Fine	.125 - .25	A	23			23	23%	40%
	Medium	.25 - .50	N	0			0	0%	40%
	Coarse	.50 - 1.0	D	13			13	13%	53%
.04 -.08	Very Coarse	1.0 - 2.0	S	22			22	22%	75%
.08 - .16	Very Fine	2.0 - 4.0		11			11	11%	86%
.16 - .22	Fine	4.0 - 5.7	G	11			11	11%	97%
.22 - .31	Fine	5.7 - 8.0	R	3			3	3%	100%
.31 - .44	Medium	8.0 - 11.3	A	0			0	0%	100%
.44 - .63	Medium	11.3 - 16.0	V	0			0	0%	100%
.63 - .89	Coarse	16.0 - 22.6	E	0			0	0%	100%
.89 - 1.26	Coarse	22.6 - 32.0	L	0			0	0%	100%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	0			0	0%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0			0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0			0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0			0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0			0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0			0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0			0	0%	100%
14.3 - 20	Small	362 - 512	L	0			0	0%	100%
20 - 40	Medium	512 - 1024	D	0			0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0			0	0%	100%
	Bedrock		BDRK	0			0	0%	100%
			Totals	100			100	100%	100%