Northgate Park (Ellerbe Creek)
Stream Restoration Monitoring and Baseline Report
EEP Project # 272
Monitoring Years – 00 and 01
2009

Submitted to:

Ecosystem Enhancement PROGRAM

NCDENR-EEP, 1652 Mail Service Center, Raleigh, NC 27699-1652

April 2010

Monitoring Firm

Landmark Center II, Suite 220
4601 Six Forks Road
Raleigh, NC 27609
Phone: (919) 278-2514
Fax: (919) 783-9266

Project Contact: Adam Spiller
Email: adam.spiller@kci.com
KCI Project No: 12071067B_EC

Design Firm

URS

URS Corporation – North Carolina
1600 Perimeter Park Drive
Suite 400
Morrisville, North Carolina 27560
(919) 461-1100
Fax (919) 461-1415

TABLE OF CONTENTS

APPENDIX A – GENERAL FIGURES AND PLAN VIEW

APPENDIX B – GENERAL PROJECT TABLES

APPENDIX C – VEGETATION ASSESSMENT DATA

APPENDIX D – STREAM ASSESSMENT DATA

1.0 EXECUTIVE SUMMARY / PROJECT ABSTRACT

In 2008, the North Carolina Ecosystem Enhancement Program (EEP) restored and enhanced a reach of Ellerbe Creek, an Unnamed Tributary to Ellerbe Creek (UT 3), and stream buffer within Northgate Park in Durham County, NC. The project also included the creation of two stormwater wetlands with outfalls to the project streams. The 5.9 mi^2 project watershed is located in US Geological Survey Hydrologic Unit 03020201-05-0010 (NC Division of Water Quality Sub-basin 03-04-01) of the Neuse River Basin. This Hydrologic Unit is within EEP's *Ellerbe Creek Local Watershed Plan* (2003) area and is also listed as a Targeted Local Watershed (TLW) in EEP's *Neuse River Basin Priorities Plan* (2010).This project is within the Falls Lake watershed, a drinking supply reservoir for the City of Raleigh. The drainage area for the site is urban residential land. The State has a permanent conservation easement of 7.5 acres and the project is located entirely within Northgate Park, which is a City of Durham public park. The project stream begins at the pedestrian bridge near the baseball diamond and flows 2,284 linear feet to the culvert under Acadia Street. The project goals and objectives are listed below.

Project Goals

- Improving water quality.
- Enhancing flood attenuation.
- Restoring aquatic and riparian habitat.

Project Objectives

- Restoring the Project Reach to a stable urban stream channel that will retain its dimension, pattern, and profile over time, and that is capable of transporting watershed flows and sediment load efficiently.
- Using Priority II restoration to change Ellerbe Creek from a G5c type stream channel to a E type channel.
- Enhancing the capacity of the site to mitigate flood flows by improving the connection of the stream to its floodplain.
- Improving aquatic habitat by establishing a heterogeneous bed morphology with riffle-pool sequences supported by in-stream structures.
- Restoring the riparian buffer from park grasses and herbaceous vegetation to Piedmont Bottomland Forest to provide filtration of nutrients and organic matter inputs into the stream, to improve wildlife habitat, and to provide shade for the stream channel.
- Reducing sediment inputs from localized streambank erosion by re-establishing stream geometry and by stabilizing and revegetating the stream banks.
- Installing three stormwater wetland best management practices (BMPs) to reduce stormwater pollutants (namely nitrogen and phosphorus) and improve water quality prior to discharging into the stream.

Ellerbe Creek is a perennial, third-order stream. Three unnamed tributaries and four stormwater outfalls enter Ellerbe Creek within the project site. The park setting has scattered large trees, recreational grasses, and patches of upland forest. The restoration and enhancement designs followed a Priority 2 approach. There are three distinct reaches: Reaches 1 and 2 on Ellerbe Creek and UT 3. Reach 1 (Station 10+00 to 25+80) is the Enhancement I portion of Ellerbe Creek and Reach 2 (Station 25+80 to 32+69) is Restoration. UT 3 (Station 100+00 to 101+17) covers all of UT 3, which is restoration. Two stormwater wetlands were also built as a part of this project. One is upstream of UT 3 and the second is on the stormwater outfall immediately downstream of UT 3 (Outfall 3).

Construction was completed at the site in December 2008. In March 2009, live stakes were planted along the stream and the stormwater wetlands were planted. The planting of the riparian buffer was delayed until November 2009 when the rest of the site was planted with tublings and containerized plants. After planting, six vegetation plots were installed following the CVS-EEP vegetation monitoring procedure,

five in buffer restoration areas and one in the planted stream riparian zone. This report documents the baseline vegetation monitoring conditions. The vegetation monitoring success criterion for the planted stream riparian zone is a density of 320 stems/acre after the third year of monitoring and an allowance for 10% mortality in the fourth and fifth years with a final density of 260 stems/acre. The vegetation monitoring success criterion for the buffer restoration zone is a density of 320 stems/acre after the fifth year of monitoring. The site's average baseline density was 600 stems/acre. All six of the plots had greater than 404 stems/acre. The first-year vegetation monitoring will be based on the Level 2 CVS-EEP vegetation monitoring protocol to ensure that all of the volunteers are counted. That monitoring will occur in 2010. The easement includes a few isolated areas of managed herbaceous zones (as shown in Figure 2) for public safety sight line considerations and pedestrian trail access. These areas are shown in Figure 2. Invasive vegetation was present onsite prior to restoration. These invasive species were treated/removed during construction, but some return is likely and will be monitored/addressed as necessary.

The project as-built survey was conducted in January 2009 and KCI conducted the first-year monitoring survey in January 2010. The longitudinal profile in Appendix D includes the longitudinal profile data from both of these surveys. The as-built profile data are limited in that the survey measurements taken were not annotated in the field and water surface measurements were not taken. As a result, the survey is not detailed enough to generate profile morphology data. The five detailed cross-sections were installed after the as-built survey, so there are no baseline dimensional data, but there are first-year dimensional data. Any changes in these cross-sections will be evident when comparing the monitoring data from year to year. The first year of monitoring found most of Reach 1 to be stable and functioning as designed. The portion of Reach 1 upstream of the Lavender St. culvert does not have any areas of significant bank erosion or bed degradation. After the Lavender St. culvert, the stream does have areas of bank erosion and bed degradation. All but two of the project's in-stream structures are functioning without any problems. These areas have been called out in the Current Condition Plan View (CCPV). As a part of the stream success criterion, the stream must experience at least two bankfull events, each in separate monitoring years. The site has experienced multiple bankfull events since construction.

Summary information/data related to the occurrence of items such as beaver or encroachment and statistics related to performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Narrative background and supporting information formerly found in these reports can be found in the mitigation and restoration plan documents available on the EEPs website. All raw data supporting the tables and figures in the appendices are available upon request.

2.0 SUCCESS CRITERIA

2.1 Dimension

The dimensional data from the yearly cross-sectional survey should show minimal change over the course of the monitoring period. However, some change is natural and expected, indicating that the site is becoming more stable. Changes that may indicate destabilizing conditions include significant widening or deepening of the riffle section or a consistent trend of change over the course of the monitoring. For a pool cross-section, deepening is frequently a positive change while consistent filling of the pool may indicate destabilization.

2.2 Pattern and Profile

For the profile, the reach under assessment should not demonstrate any trends in thalweg aggradation or degradation over any significant continuous portion of its length. The profile should also demonstrate contrasting bedform diversity against the pre-existing condition. Bedform distribution, riffle/pool lengths, and slopes will vary, but should do so around design distributions. The majority of pools should be maintained at greater depths with lower water surface slopes while riffles should be shallow with steeper water surface slopes. Pattern features should show little adjustment over the monitoring period.

2.3 Substrate

Substrate measurements should indicate the progression towards, or the maintenance of, the known distributions from the design phase. While stream projects are designed to transport bedload in equilibrium and carry overall sediment loads at bankfull, fines can be transported even at low discharges and upstream instability beyond design projections can also lead to deposition as storm events recede in areas of energy dissipation such as restoration reaches. This can have the effect of obscuring bedform and fining of riffles especially in the first few years after the implementation of a stream project. In many cases subsequent narrowing and reduction of width-to-depth ratios as a project develops/stabilizes can then increase transport efficiency and return bedform to intended distributions, but some fining can persist due to upstream disturbance.

2.4 Sediment Transport

Maintenance of sediment transport will be evident by the monitored cross-sections and profile. These two indicators should show no evidence of any significant trend in aggradation or degradation throughout the channel.

2.5 Vegetation

Vegetation success is based on the criteria established in the USACE Stream Mitigation Guidelines (2003) and the requirements for Neuse buffer restoration (2000). For the planted stream riparian zone that is not part of the Neuse buffer credit the vegetation monitoring results should have the following planted stem density minimums in the corresponding monitoring years: 320 stems/acre through Year Three, 288 stems/acre in Year Four, and 260 stems/acre in Year Five. For the vegetation plots in the Neuse Buffer restoration areas, the stem density must average 320 stems/acre in Year Five. If the plots in the Neuse Buffer restoration areas attain densities of between 260 and 320 stems/acre in Year Five, they may be considered successful for the stream restoration, but the site may not be creditable for Neuse Buffer restoration.

2.6 Hydrology

A minimum of two bankfull events, occurring in separate years, must be documented within the monitoring period.

3.0 MONITORING PLAN

3.1 Dimension

Five permanent monitoring cross-sections have been established on the site. One pool cross-section and two riffle cross-sections were established on Reach 1, and there are two riffle cross-sections on Reach 2. Permanent monuments of rebar in concrete have been established at each end of these cross-sections. These cross-sections will be surveyed each year, with measurements occurring at bankfull, top of bank, edge of water, and other significant breaks in slope.

3.2 Profile

The entire profile of the restored stream will be surveyed each monitoring year. The profile will be surveyed in detail, documenting the elevations of the thalweg, water surface, and bankfull. Pool and riffle features will be called out to calculate feature slopes and lengths.

3.3 Pattern

Pattern measurements have been taken for the as-built condition and are documented in this report. Future pattern measurements will not be taken unless there is evidence that significant geomorphological adjustments have occurred.

3.4 Visual Assessment

A visual assessment of the stream, easement boundary, and site vegetation will be completed each year to document any problem areas and to provide an overview of the entire site, as required for the EEP monitoring report.

3.5 Vegetation

Six vegetation plots were set up and assessed for the baseline vegetation monitoring. Vegetation data collection must follow the CVS-EEP Protocol for Recording Vegetation (Lee et al. 2006, http://cvs.bio.unc.edu/methods.htm). The baseline vegetation monitoring was conducted as a Level 1: Inventory of Planted Stems. Beginning in Year One and continuing throughout the rest of the monitoring period, the site will be monitored using the Level 2 protocol.

3.6 Digital Photos

Ten permanent photo stations have been established as part of the baseline monitoring. Starting in the second monitoring year, these photos will be taken in late October / early November, so that vegetative conditions are similar at the site between monitoring years.

4.0 MAINTENANCE AND CONTINGENCY PLANS

Problem areas at the site will be dealt with based on the severity of the problem and at the discretion of the EEP. Site maintenance may include reinstallation of coir matting, removal of debris from the channel, stabilization of bank erosion with protective structures, or adjustments to in-stream structures. All maintenance activities will be documented in the annual monitoring reports.

5.0 METHODOLOGY

The survey data were collected with a total station instrument, using control coordinates supplied by URS and the as-built surveyor, Level Cross.
The stationing for the longitudinal profile is based on the thalweg stationing.
The CVS-EEP Level 1 Protocol (http://cvs.bio.unc.edu/methods.htm) was used to collect vegetation data from Ellerbe Creek this year.

6.0 REFERENCES

DWQ, 2000. Neuse Riparian Buffer Mitigation Rules. **15A NCAC 2B .0242** (http://ncrules.state.nc.us/ncac/title%2015a%20-%20environment%20and%20natural%20resources/chapter%2002%20-%20environmental%20management/subchapter%20b/15a%20ncac%2002b%20.0242.html)

EEP. 2003. Ellerbe Creek Local Watershed Plan. (http://www.nceep.net/services/lwps/Upper_Neuse/Ellerbe_Creek_Local_Watershed_Plan.pdf)

EEP. 2010. Neuse River Basin Restoration Priorities. (soon available: http://www.nceep.net/services/lwps/pull_down/by_basin/Neuse_RB.html)

Lee, M. T., R. K. Peet, S. D. Roberts, and T. R. Wentworth. 2006. CVS-EEP Protocol for Recording Vegetation, Version 4.0 (http://cvs.bio.unc.edu/methods.htm).

USACE. 2003. Stream Mitigation Guidelines. (http://www.saw.usace.army.mil/wetlands/Mitigation/Documents/Stream/).

Weakley, A. S. 2006. Flora of the Carolinas, Virginia, Georgia, and Surrounding Areas. (http://www.herbarium.unc.edu/FloraArchives/WeakleyFlora_2006-Jan.pdf).

Appendix A

General Figures and Plan Views

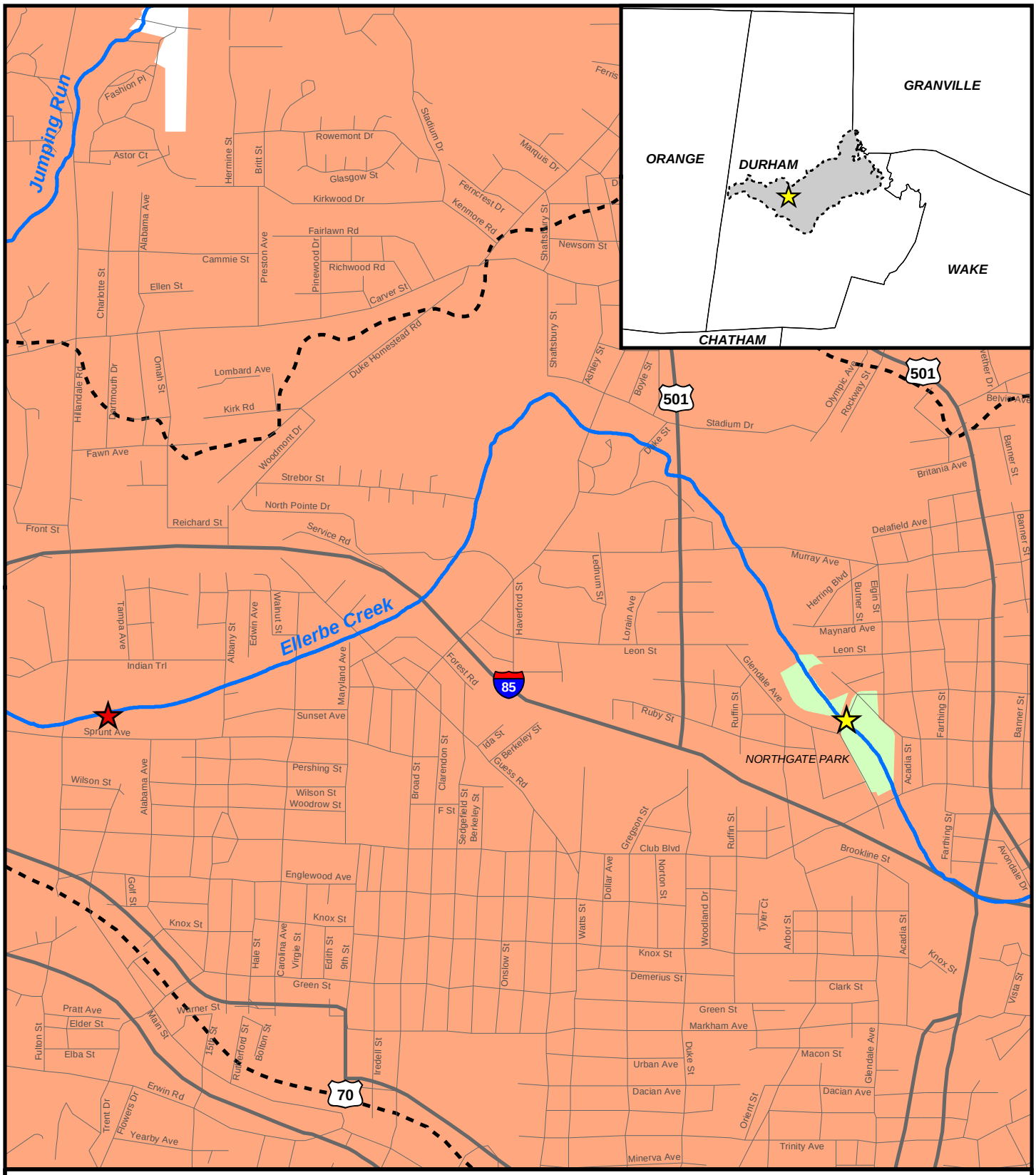


Figure 1. Vicinity Map

KCI

- Roads
- Counties
- Municipalities
- Northgate Park
- Local Watershed Plan Boundary
- Major Streams
- Project Location
- Hillandale Golf Course Project #127

N W E S

1:24,000
1 inch = 2,000 feet

0 500 1,000 2,000
Feet

Ecosystem Enhancement Program

Figure 2. Site Map

KCI

Reach 1
Reach 2
UT 3
Other Streams
Pre-Restoration Alignment

Conservation Easement
Buffer Enhancement (0.2 ac)
Buffer Restoration (3.6 ac)
Managed Lawn
Pedestrian Bridge Entrance
Stormwater Wetlands

N
W E
S

1:3,000
1 inch = 250 feet

250 125 0 250
Feet

Ecosystem Enhancement Program

Image Source: Durham County Orthoimagery, 2005.

LEGEND

- EASEMENT BOUNDARY
- AS-BUILT STATIONED
- CENTERLINE AND TOP OF BANK
- PHOTO POINT
- CROSS-SECTION
- BMP
- OLD STREAM CHANNEL

PROJECT CONDITION

- STREAM BED DEGRADATION
- BANK EROSION
- UNDERCUT BANK
- MASS WASTING OF BANK
- VEG PLOT ACHIEVING DENSITY CRITERION
- VEG PLOT BELOW DENSITY CRITERION

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

Ecosystem Enhancement Program

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

NORTHGATE PARK (ELLERBE CREEK) PROJECT #272 - MONITORING YEAR 01

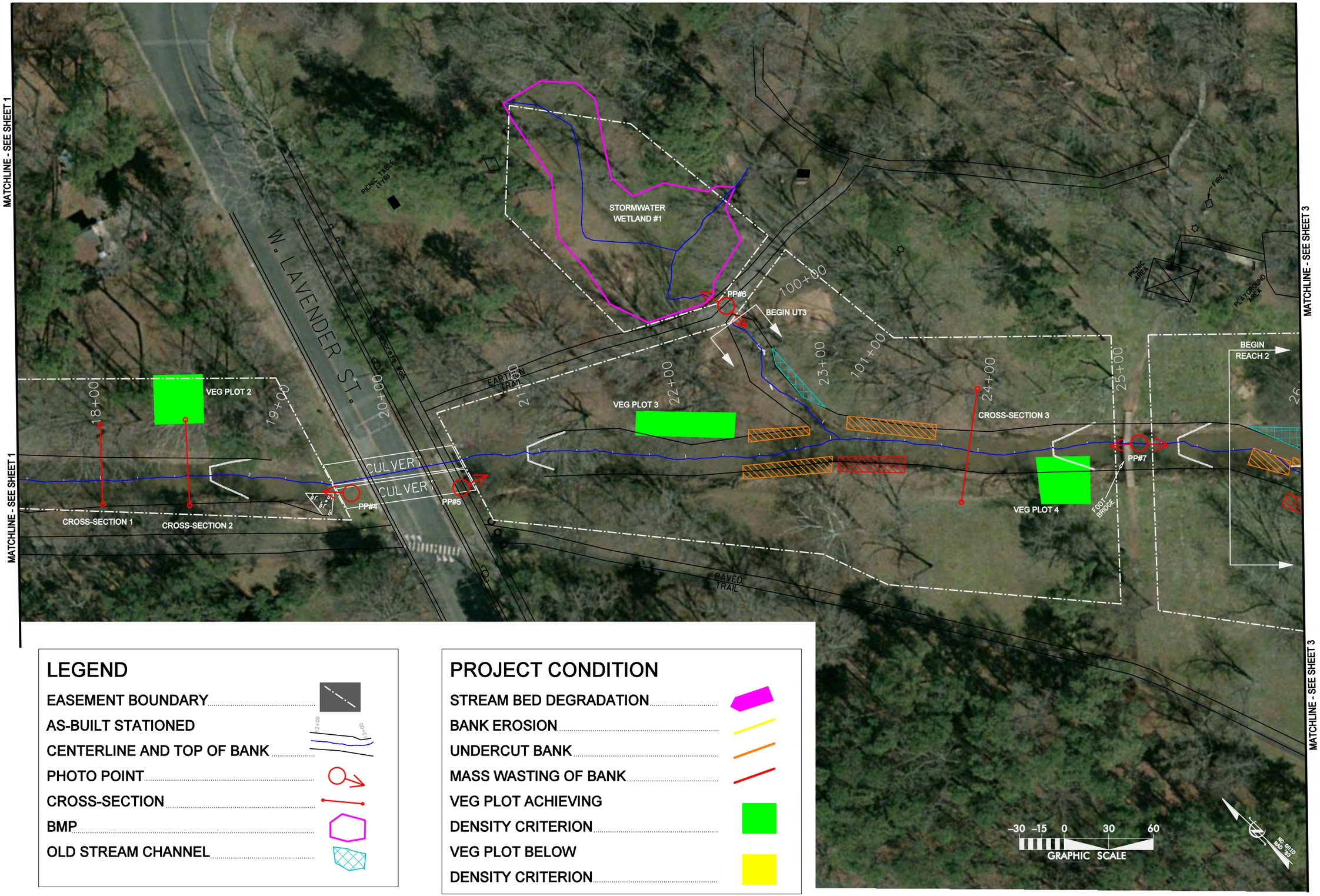
DURHAM, DURHAM COUNTY, NORTH CAROLINA

ELLERBE CREEK: STATION 10+00 TO STATION 17+40

DATE: JAN 2010
SCALE: 1" = 60'

CURRENT CONDITION PLAN VIEW

SHEET 1 OF 3



LEGEND

- EASEMENT BOUNDARY
- AS-BUILT STATIONED
- CENTERLINE AND TOP OF BANK
- PHOTO POINT
- CROSS-SECTION
- BMP
- OLD STREAM CHANNEL

PROJECT CONDITION

- STREAM BED DEGRADATION
- BANK EROSION
- UNDERCUT BANK
- MASS WASTING OF BANK
- VEG PLOT ACHIEVING DENSITY CRITERION
- VEG PLOT BELOW DENSITY CRITERION

REVISIONS			
SYM.	DESCRIPTION	DATE	APPROVED

Ecosystem Enhancement Program

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

NORTHGATE PARK (ELLERBE CREEK) PROJECT #272 - MONITORING YEAR 01

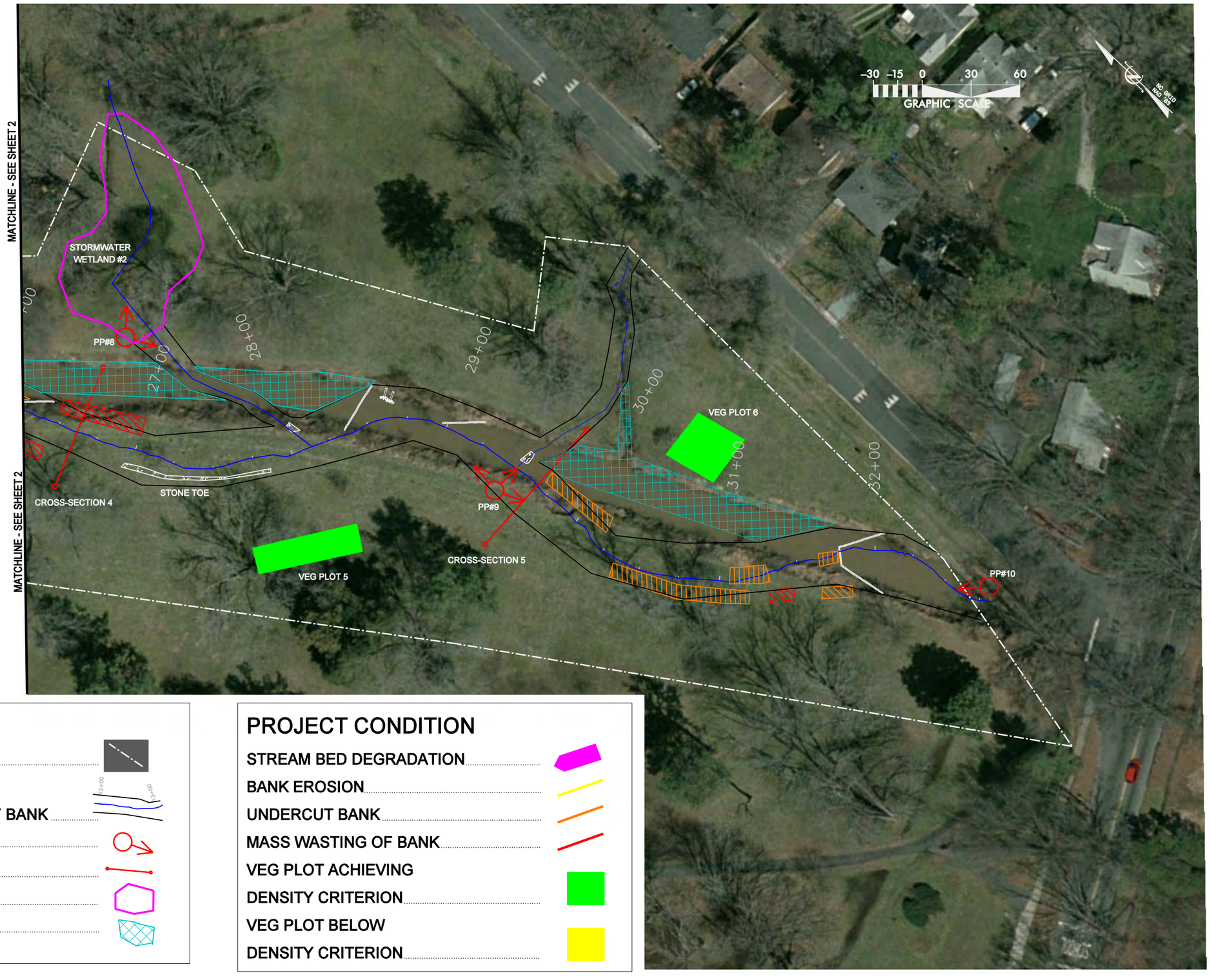
DURHAM, DURHAM COUNTY, NORTH CAROLINA

ELLERBE CREEK: STATION 17+40 TO STATION 26+25

DATE: JAN 2010
SCALE: 1" = 60'

CURRENT CONDITION PLAN VIEW

SHEET 2 OF 3



LEGEND

- EASEMENT BOUNDARY
- AS-BUILT STATIONED
- CENTERLINE AND TOP OF BANK
- PHOTO POINT
- CROSS-SECTION
- BMP
- OLD STREAM CHANNEL

PROJECT CONDITION

- STREAM BED DEGRADATION
- BANK EROSION
- UNDERCUT BANK
- MASS WASTING OF BANK
- VEG PLOT ACHIEVING DENSITY CRITERION
- VEG PLOT BELOW DENSITY CRITERION

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

Ecosystem Enhancement Program

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

NORTHGATE PARK (ELLERBE CREEK) PROJECT #272 - MONITORING YEAR 01

DURHAM, DURHAM COUNTY, NORTH CAROLINA

ELLERBE CREEK: STATION 28+25 TO STATION 32+70

DATE: JAN 2010
SCALE: 1" = 60'

CURRENT CONDITION PLAN VIEW

SHEET 3 OF 3

Appendix B

General Project Tables

Table 1. Project Restoration Components
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)

Segment/ Reach ID	Existing Linear Feet	Type	Approach	Linear Feet / Square Feet	Stationing	Mitigation Ratio	Mitigation Units	BMP Elements	Comment
Reach 1	1,580	EI	P2	1,466*	10+00 - 25+80	1.5:1	977		Reach was regraded to create a bankfull channel with a new profile and a bankfull bench, and instream structures were installed along the existing planform. Two tributaries enter Reach 1.
Reach 2	646	R	P2	690	25+80 - 32+70	1:1	690	SW	Reach was regraded to create a bankfull channel with a new profile and a bankfull bench, and instream structures were installed along a new planform. One stormwater wetland captures runoff prior to discharge in Reach 2.
UT 3	104	R	P2	117	100+00 - 101+17	1:1	117	SW	Reach was regraded to create a bankfull channel with a new profile and a bankfull bench, and instream structures were installed along a new planform. UT 3 is a perennial stream with a stormwater wetland immediately upstream.
Buffer		R		158,172		1:1	158,172		The existing buffer had fewer than 100 stems/acre and was planted with native vegetation.
Buffer		E		10,000		3:1	3,333		The existing buffer had greater than 100, but fewer than 200 stems/acre and was planted with native vegetation.

R = Restoration P2 = Priority 2
EI = Enhancement I SW = Stormwater Wetland
E = Enhancement

* The stream length through easement exceptions at a road crossing and a pedestrian bridge crossing are not included in these lengths.

Table 2. Project Activity and Reporting History
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)

Activity or Report	Data Collection Complete	Actual Completion or Delivery
Concept Plan		Jan 06
Restoration Plan		Jun 06
Final Design - 90%		May 07
Construction		Dec 08
As-Built Survey		Jan 09
Live Stake Planting		Mar 09
Riparian Buffer Planting		Nov 09
Baseline Vegetetation & Year 1 Stream Monitoring	Nov 09 - Jan 10	May 10

Table 3. Project Contacts Table Project Number and Name: 272 - Northgate Park (Ellerbe Creek)	
Design Firm	URS 1600 Perimeter Park Drive, Suite 400 Morrisville, North Carolina 27560 Contact: Ms. Kathleen McKeithan Phone: (919) 461-1597
Construction Contractor	Environmental Quality Resources, LLC 1405 Benson Court, Suite C Arbutus, MD 21227 Contact: Mr. John Talley Phone: (443) 304-3310 ext.110 Fax: (443) 304-3315
Planting Contractor	HARP 301 McCullough Drive, 4th Floor Charlotte, North Carolina 28262 Contact: Mr. Alan Peoples Phone: (704) 841-2841
Monitoring Performers	
MY-00, 01	KCI Associates of NC Landmark Center II, Suite 220 4601 Six Forks Rd. Raleigh, NC 27609 Contact: Mr. Adam Spiller Phone: (919) 278-2514 Fax: (919) 783-9266

Table 4. Project Attribute Table Project Number and Name: 272 - Northgate Park (Ellerbe Creek)			
Project County	Durham County		
Physiographic Region	Piedmont		
Ecoregion	Triassic Basin		
Project River Basin	Neuse		
USGS HUC for Project (14 digit)	03020201050010		
NCDWQ Sub-basin for Project	03-04-01		
Within extent of EEP Watershed Plan?	Yes - Ellerbe Creek LWP		
WRC Class (Warm, Cool, Cold)	Warm		
% of project easement demarcated	100%		
Beaver activity observed during design phase?	No		
Restoration Component Attribute Table			
	Reach 1	Reach 2	UT 3
Drainage Area	5.9 sq.mi.	5.9 sq.mi.	-
Stream Order	Third	Third	First
Restored length (feet)	1,466	690	117
Perennial or Intermittent	Perennial	Perennial	Intermittent
Watershed Type (Rural, Urban, Developing, etc.)	Urban		
Watershed LULC Distribution			
Urban	38%		
Ag-Row Crop	0%		
Ag-Livestock	0%		
Forested	62%		
Water/Wetlands	<1%		
Watershed impervious cover (%)	-		
NCDWQ AU/Index Number	27-5-(0.7)		
NCDWQ Classification	WS-IV; NSW		
303d listed?	Yes		
Upstream of a 303d listed segment?	Yes		
Reasons for 303d Listing or Stressor	impaired biological integrity		
Total acreage of easement	7.5 Acres		
Total vegetated acreage within the easement	1.0 Acre		
Total planted acreage as part of the restoration	6.4 Acres		
Rosgen Classification of pre-existing	G5c	G5c	-
Rosgen Classification of As-built	C5	C5	-
Valley Type	U	U	U
Valley Slope	0.0006	0.0005	U
Valley side slope range (e.g. 2-3%)	U	U	U
Valley toe slope range (e.g. 2-3%)	U	U	U
Trout waters designation	No		
Species of concern, endangered etc.? (Y/N)	No		
Dominant soil series and characteristics			
Series	Chewacla and Wehadkee		
Depth Clay%	-	-	-
K	-	-	-
T	-	-	-

"N/A" is for items that do not apply.

"-" is for items that are unavailable.

"U" is for items that are unknown.

Appendix C

Vegetation Assessment Data

Table 5. Planted Vegetation Project Number and Name: 272 - Northgate Park (Ellerbe Creek)				
Planting Zone	**Species**	**Common Name**	**Size**	**Quantity**
Woody Trees and Shrubs				
Terrace	Acer saccharum	Southern Sugar Maple	tubling	106
Terrace	Aronia arbutifolia	Red-chokeberry	tubling	127
Terrace	Asimina triloba	Pawpaw	tubling	40
Terrace	Cercis canadensis	Redbud	tubling	100
Terrace	Corylus americana	Hazelnut	tubling	20
Terrace	Diospyros virginiana	Persimmon	tubling	127
Terrace	Juniperus virginiana	Eastern Red Cedar	tubling	113
Terrace	Liriodendron tulipifera	Tulip Poplar	tubling	63
Terrace	Oxydendrom arboretum	Sourwood	tubling	85
Terrace	Quercus michauxii	Swamp Chestnut Oak	tubling	127
Terrace	Quercus pagoda	Cherrybark Oak	tubling	40
Terrace	Symphoricarpos orbiculatus	Coralberry	tubling	77
Terrace & Bench	Quercus phellos	Willow Oak	tubling	177
Terrace & Bench	Spiraea tomentosa	Steeplebush	tubling	141
Bench	Alnus serrulata	Tag Alder	tubling	55
Bench	Betula nigra	River Birch	one gallon	88
Bench	Carpinus caroliniana	Hornbeam	tubling	105
Bench	Celtis laevigata	Sugarberry	one gallon	88
Bench	Fraxinus pennsylvanica	Green Ash	tubling	77
Bench	Ilex decidua	Deciduous Holly	tubling	61
Bench	Ilex verticilata	Winterberry	tubling	60
Bench	Lindera benzoin	Spicebush	tubling	50
Bench	Platanus occidentalis	American Sycamore	tubling	104
Bench	Viburnum nudum	Possumhaw	tubling	88
Bench & SW Wetland	Cephalanthus occidentalis	Buttonbush	tubling	50
Bench & SW Wetland	Itea virginica	Virginia Sweetspire	tubling	88
SW Wetland	Morella cerifiera	Wax Myrtle	one gallon	20
Streamside	Cornus amomum	Silky Dogwood	live stake	900
Streamside	Salix sericea	Silky Willow	live stake	450
Streamside	Sambucus canadensis	Elderberry	live stake	450
Streamside	Physocarpus opulifolius	Ninebark	live stake	450
Herbaceous Plants / Native Grasses Seed Mix				
Terrace	Andropogon gerardii	Big Blue Stem	seed	N/A
Terrace	Sorghastrum nutans	Indian Grass	seed	N/A
Terrace, Bench & Streamside	Panicum virgatum	Switchgrass	seed	N/A
Terrace, Bench & Streamside	Eupatorium fistulosus	Joe-Pye-Weed	seed	N/A
Terrace, Bench & Streamside	Vernonia noveboracensis	Ironweed	seed	N/A
Bench & Streamside	Carex vulpinoidea	Fox Sedge	seed	N/A
Bench & Streamside	Scirpus polyphyllus	Leafy Bullrush	seed	N/A

Table 5. Planted Vegetation continued Project Number and Name: 272 - Northgate Park (Ellerbe Creek)				
Planting Zone	**Species**	**Common Name**	**Size**	**Quantity**
Herbaceous Plants / Native Grasses Seed Mix				
Bench & Streamside	Helenium autumnale	Sneezeweed	seed	N/A
Bench & Streamside	Bidens aristosa	Showy Tickseed Flower	seed	N/A
Bench & Streamside	Rosa palustris	Swamp Rose	seed	N/A
Bench & Streamside	Panicum clandestinum	Deertongue	seed	N/A
Bench & Streamside	Andropogon glomeratus	Bushy Beard Grass	seed	N/A
Bench & Streamside	Asclepias incarnate	Swamp Milkweed	seed	N/A
Bench, Streamside, & SW Wetland	Helianthus angustifolius	Swamp Sunflower	seed	N/A
Bench, Streamside, & SW Wetland	Juncus effusus	Soft Rush	seed	N/A
Streamside	Alnus serrulata	Tag Alder	seed	N/A
SW Wetland	Iris virginica	Blue Flag Iris	seed	N/A
SW Wetland	Scirpus cyperinus	Woolgrass	seed	N/A
SW Wetland	Hibiscus moscheutos	Swamp Mallow	seed	N/A
SW Wetland	Eupatorium perfoliatum	Boneset	seed	N/A
SW Wetland	Alisma subcordatum	Common Water Plantain	seed	N/A

Table 6. Vegetation Plot Mitigation Success Summary Table Project Number and Name: 272 - Northgate Park (Ellerbe Creek)		
Vegetation Plot ID	**Monitoring Year 01 Planted Stem Density (stems/acre)**	**Vegetation Survival Threshold Met?**
1	769	Yes
2	567	Yes
3	769	Yes
4	607	Yes
5	486	Yes
6	405	Yes

Table 7. Vegetation Metadata Table
Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

Report Prepared By	Brian Roberts
Date Prepared	1/19/2010 9:51
Database Name	KCI-2010_EC.mdb
Database Location	C:\Users\broberts\Desktop\KCI_2008-entrytool-v2.2.7

PROJECT SUMMARY----------

Project Code	Project Name	Description	Length (ft)	Stream-to-Edge Width (ft)	Area (sq m)	Required Plots (calculated)	Sampled Plots
272	Ellerbe Creek	Stream restoration site in Durham, NC.	2,200	40	16,349	6	6

Table 8. Stem Count Total and Planted by Plot and Species
Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

			Current Plot Data (MY00 2009)																		Annual Means		
			272-A-0001			272-A-0002			272-A-0003			272-A-0004			272-A-0005			272-A-0006			MY0 (2009)		
Scientific Name	**Common Name**	**Species Type**	**P-LS**	**P-all**	**T**	**P-LS**	**P-all**	**T**	**P-LS**	**P-all**	**T**	**P-LS**	**P-all**	**T**	**P-LS**	**P-all**	**T**	**P-LS**	**P-all**	**T**	**P-LS**	**P-all**	**T**
Alnus serrulata	hazel alder	Shrub Tree											1	1					2	2		3	3
Aronia arbutifolia	Red Chokeberry	Shrub														1	1					1	1
Celtis laevigata	sugarberry	Shrub Tree		9	9																	9	9
Cornus amomum	silky dogwood	Shrub							1	3	3										1	3	3
Diospyros virginiana	common persimmon	Tree					2	2														2	2
Fraxinus pennsylvanica	green ash	Tree								1	1											1	1
Oxydendrum arboreum	sourwood	Shrub Tree														1	1					1	1
Quercus coccinea	scarlet oak	Tree					2	2					2	2								4	4
Quercus lyrata	overcup oak	Tree																	1	1		1	1
Quercus michauxii	swamp chestnut oak	Tree		8	8											1	1		3	3		12	12
Quercus phellos	willow oak	Tree								2	2		1	1								3	3
Salix nigra	black willow	Tree										2	2	2							2	2	2
Sambucus canadensis	Common Elderberry	Shrub Tree								1	1											1	1
Symphoricarpos orbiculatus	coralberry	Shrub														1	1					1	1
Cornus	dogwood	Shrub Tree								3	3											3	3
Juniperus virginiana	eastern redcedar	Tree		2	2											3	3					5	5
Liriodendron tulipifera	tuliptree	Tree					2	2					1	1					2	2		5	5
Platanus occidentalis	American sycamore	Tree								1	1											1	1
Physocarpus	ninebark								1	1	1										1	1	1
Spiraea	spirea									3	3		8	8								11	11
Acer	maple						5	5														5	5
Unknown		unknown					3	3		4	4					5	5		2	2		14	14
		Stem count	0	19	19	0	14	14	2	19	19	2	15	15	0	12	12	0	10	10	4	89	89
		size (ares)	1			1			1			1			1			1			6		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02			0.15		
		Species count	0	3	3	0	5	5	2	9	9	1	6	6	0	6	6	0	5	5	3	22	22
		Stems per ACRE	0	768.9	768.9	0	566.56	566.56	80.937	768.9	768.9	80.937	607.03	607.03	0	485.62	485.62	0	404.69	404.69	26.979	600.28	600.28

P-LS – Planted Live Stakes P-all – Planted Stems Total (with Live Stakes) T – Total (Planted Including Live Stakes and Volunteers)

Vegetation Monitoring Plot Photos

Plot 1 Photo – Taken looking southeast from the plot origin. 11/13/09 - MY 00

Plot 2 Photo – Taken looking south from the plot origin. 11/13/09 - MY 00

Plot 3 Photo – Taken looking east from the plot origin. 11/13/09 - MY 00

Plot 4 Photo – Taken looking south from the plot origin. 11/13/09 - MY 00

Plot 5 Photo – Taken looking east from the plot origin. 11/13/09 - MY 00

Plot 6 Photo – Taken looking south from the plot origin. 11/13/09 - MY 00

Appendix D

Stream Assessment Data

Stream Station Photos

PP#1 – MY01 – 1/19/10

PP#2A – MY01 – 1/19/10

PP#2B – MY01 – 1/19/10

PP#3A – MY01 – 1/19/10

PP#3B – MY01 – 1/19/10

PP#4 – MY01 – 1/19/10

PP#5 – MY01 – 1/19/10

PP#6A – MY01 – 1/19/10

PP#6B – MY01 – 1/19/10

PP#7A – MY01 – 1/19/10

PP#7B – MY01 – 1/19/10

PP#8A – MY01 – 1/19/10

PP#8B – MY01 – 1/19/10

PP#9A – MY01 – 1/19/10

PP#9B – MY01 – 1/19/10

PP#9C – MY01 – 1/19/10

PP#10 – MY01 – 1/19/10

Table 9a. Baseline Stream Data Summary Table

Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

Segment Reach: Reach 1 (1,580 ft.)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)							30.8			13.5			30.0					
Floodprone Width (ft)							60			300								
Bankfull Cross-Sectional Area (ft^2)							118.6			30.8			54.6					
Bankfull Mean Depth (ft)							3.9			2.3			1.8					
Bankfull Maximum Depth (ft)							4.6			3.8			2.5					
Width/Depth Ratio							8.0			5.9			16.7					
Entrenchment Ratio							1.9			22.2								
Bank Height Ratio							1.7			0.9			1.0					
Pattern																		
Channel Beltwidth (ft)							50	100		50	125		40	60				
Radius of Curvature (ft)							150	180		16	30		165	180				
Meander Wavelength (ft)							700	1000		115	200		700	1000				
Meander Width Ratio							1.6	3.2		3.7	9.3		1.3	2.0				
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)							0.014			0.005			0.002					
Pool Length (ft)																		
Pool Spacing (ft)							45	521		45	93		83	172				
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)							1,466						1,466					
Sinuosity							1.02			1.33			1.01					
Water Surface Slope (ft/ft)							0.0009			0.0019			0.0006					
BF Slope (ft/ft)																		
Rosgen Classification							G5c			E5			C5					

Note: The Pre-Existing Condition and Project Reference Stream Data are the same for both reaches and are from the Restoration Plan document. The Design data are also from the Restoration Plan, except for the Dimension Parameter, which is from the Construction Plans. As-Built data were not taken due to project delays.

Table 9b. Baseline Stream Data Summary Table

Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

Segment Reach: Reach 2 (690 ft.)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)							30.8			13.5			40.0					
Floodprone Width (ft)							60			300								
Bankfull Cross-Sectional Area (ft^2)							118.6			30.8			75.6					
Bankfull Mean Depth (ft)							3.9			2.3			1.9					
Bankfull Maximum Depth (ft)							4.6			3.8			2.8					
Width/Depth Ratio							8.0			5.9			21.1					
Entrenchment Ratio							1.9			22.2								
Bank Height Ratio							1.7			0.9			1.0					
Pattern																		
Channel Beltwidth (ft)							50	100		50	125		80	100				
Radius of Curvature (ft)							150	180		16	30		63	100				
Meander Wavelength (ft)							700	1000		115	200		260	300				
Meander Width Ratio							1.6	3.2		3.7	9.3		3.2	4.0				
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)							0.014			0.005			0.001					
Pool Length (ft)																		
Pool Spacing (ft)							45	521		45	93		83	172				
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)							1,466						690					
Sinuosity							1.02			1.33			1.02					
Water Surface Slope (ft/ft)							0.0009			0.0019			0.0005					
BF Slope (ft/ft)																		
Rosgen Classification							G5c			E5			C5					

Note: The Pre-Existing Condition and Project Reference Stream Data are the same for both reaches and are from the Restoration Plan document. The Design data are also from the Restoration Plan, except for the Dimension Parameter, which is from the Construction Plans. As-Built data were not taken due to project delays.

Table 9c. Baseline Stream Data Summary Table

Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

Segment Reach: UT 3 (117 ft.)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)										13.5			3.2					
Floodprone Width (ft)										300								
Bankfull Cross-Sectional Area (ft^2)										30.8			1.5					
Bankfull Mean Depth (ft)										2.3			0.5					
Bankfull Maximum Depth (ft)										3.8			0.7					
Width/Depth Ratio										5.9			6.4					
Entrenchment Ratio										22.2								
Bank Height Ratio										0.9			1.0					
Pattern																		
Channel Beltwidth (ft)										50	125							
Radius of Curvature (ft)										16	30							
Meander Wavelength (ft)										115	200							
Meander Width Ratio										3.7	9.3							
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)										0.005								
Pool Length (ft)																		
Pool Spacing (ft)										45	93							
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)													117					
Sinuosity										1.33								
Water Surface Slope (ft/ft)										0.0019								
BF Slope (ft/ft)																		
Rosgen Classification										E5			E5					

Note: The Project Reference Stream Data are from the Restoration Plan document. The Design data are from the Construction Plans. There were no Pattern or Profile data for UT3 in the Restoration Plan.

Table 10. Morphology and Hydraulic Summary (Cross-Section Parameters)

Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

Segment Reach: Reach 1 (1,580 ft.) and Reach 2 (690 ft.)

Parameter	Cross-Section 1						Cross-Section 2						Cross-Section 3					
	Riffle - Reach 1						Pool - Reach 1						Riffle - Reach 1					
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5
Bankfull Width (ft)		24.0						28.5						25.0				
Floodprone Width (ft)		42						-						62				
Bankfull Cross-Sectional Area (ft^2)		45.0						82.4						53.4				
Bankfull Mean Depth (ft)		1.9						2.9						2.1				
Bankfull Maximum Depth (ft)		2.8						5.8						3.4				
Width/Depth Ratio		12.8						-						11.7				
Entrenchment Ratio		1.8						-						2.5				
Bank Height Ratio		1.0						-						1.0				
Wetted Perimeter (ft)		25.1						32.1						27.3				
Hydraulic Radius (ft)		1.8						2.6						2.0				
Substrate																		
d50 (mm)		1.2						0.08						0.06				
d84 (mm)		51						0.17						19				

Parameter	Cross-Section 4						Cross-Section 5					
	Riffle - Reach 2						Riffle - Reach 2					
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5
Bankfull Width (ft)		25.2						36.1				
Floodprone Width (ft)		>75						>90				
Bankfull Cross-Sectional Area (ft^2)		80.2						82.0				
Bankfull Mean Depth (ft)		3.2						2.3				
Bankfull Maximum Depth (ft)		4.5						4.0				
Width/Depth Ratio		7.9						15.9				
Entrenchment Ratio		>3.0						>2.5				
Bank Height Ratio		1.0						1.0				
Wetted Perimeter (ft)		27.9						38.9				
Hydraulic Radius (ft)		2.9						2.1				
Substrate												
d50 (mm)		0.06						0.06				
d84 (mm)		2.3						2.7				

Table 11a. Morphology and Hydraulic Monitoring Summary (Reach Parameters)

Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

Segment Reach: Reach 1 (1,580 ft.)

Parameter	MY - 01 (2009)			MY - 02 (2010)			MY - 03 (2011)			MY - 04 (2012)			MY - 05 (2013)		
Pattern	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)	24	85	35												
Riffle Slope (ft/ft)	0.0000	0.0010	0.0006												
Pool Length (ft)	10	53	37												
Pool Spacing (ft)	29	211	89												
Additional Reach Parameters															
Valley Length (ft)	1,518														
Channel Length (ft)	1,580														
Sinuosity	1.04														
Water Surface Slope (ft/ft)	0.0014														
Rosgen Classification	C5														

*Reach 1 was enhanced, and is not a meandering channel

Table 11b. Morphology and Hydraulic Monitoring Summary (Reach Parameters)

Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

Segment Reach: Reach 2 (690 ft.)

Parameter	MY - 01 (2009)			MY - 02 (2010)			MY - 03 (2011)			MY - 04 (2012)			MY - 05 (2013)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	59	94	74												
Radius of Curvature (ft)	51	107	68												
Meander Wavelength (ft)	237	303	276												
Meander Width Ratio*	2.1	3.4	2.7												
Profile															
Riffle Length (ft)	9	29	16												
Riffle Slope (ft/ft)	>3.0	0.0026	0.0014												
Pool Length (ft)	18	91	67												
Pool Spacing (ft)	68	184	157												
Additional Reach Parameters															
Valley Length (ft)	658														
Channel Length (ft)	710.00														
Sinuosity	1.08														
Water Surface Slope (ft/ft)	0.00017														
Rosgen Classification	C5														

*Taken from average of all riffle cross-section bankfull widths.

Table 12a. Visual Morphological Stability Assessment
Project Number and Name: 272 – Northgate Park (Ellerbe Creek)
Segment/Reach: Reach 1 (1,580 ft.)

Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total Number per As-built *	Total Number / feet in unstable state	% Perform. in Stable Condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	5	8		63%	
	2. Armor stable (e.g. no displacement)?	5	8		63%	
	3. Facet grade appears stable?	5	8		63%	
	4. Minimal evidence of embedding/fining?	5	8		63%	
	5. Length appropriate?	5	8		63%	**63%**
B. Pools**	1. Present? (e.g. no severe aggradation)	15	13		115%	
	2. Sufficiently deep (Dmax pool:Mean Bkf > 1.6?)	15	13		115%	
	3. Length appropriate?	15	13		115%	**115%****
C. Thalweg #	1. Upstream of meander bend centering?					
	2. Downstream of meander centering?					
D. Meanders #	1. Outer bend in state of limited/controlled erosion?					
	formation?					
	3. Apparent Rc within spec?					
	4. Sufficient floodplain access and relief?					
E. Bed General	1.General channel bed aggradation areas (bar formation)			0/0	100%	
	2. Channel bed degradation - areas of increasing down cutting or head cutting?			0/0	100%	**100%**
F. Bank	1. Actively eroding, wasting, or slumping bank			4/190	94%	**94%**
G. Vanes	1. Free of back or arm scour?	7	7		100%	
	2. Height appropriate?	7	7		100%	
	3. Angle and geometry appear appropriate?	7	7		100%	
	4. Free of piping or other structural failures?	7	7		100%	**100%**

*Total number of features per as-built estimated from designed profile.

** The total number of features for Monitoring Year 1 is greater than the number of features in the plan sheets.

Reach 1 is not a meandering channel.

Table 12b. Qualitative Visual Stability Assessment
Project Number and Name: 29 – Northgate Park (Ellerbe Creek)
Segment/Reach: Reach 2 (690 ft.)

Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total Number per As-built *	Total Number / feet in unstable state	% Perform. in Stable Condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	3	5		60%	
	2. Armor stable (e.g. no displacement)?	3	5		60%	
	3. Facet grade appears stable?	3	5		60%	
	4. Minimal evidence of embedding/fining?	3	5		60%	
	5. Length appropriate?	3	5		60%	**60%**
B. Pools**	1. Present? (e.g. no severe aggradation)	5	4		125%	
	2. Sufficiently deep (Dmax pool:Mean Bkf > 1.6?)	5	4		125%	
	3. Length appropriate?	5	4		125%	**125%**
C. Thalweg	1. Upstream of meander bend centering?	5	5		100%	
	2. Downstream of meander centering?	5	5		100%	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	4	5		80%	
	2. Of those eroding, # w/ concomitant point bar formation?	1	1		100%	
	3. Apparent Rc within spec?	5	5		100%	
	4. Sufficient floodplain access and relief?	5	5		100%	**95%**
E. Bed General	1.General channel bed aggradation areas (bar formation)			0/0	100%	
	2. Channel bed degradation - areas of increasing down cutting or head cutting?			3/55	92%	**96%**
F. Bank	1. Actively eroding, wasting, or slumping bank			7/260	81%	**81%**
G. Vanes	1. Free of back or arm scour?	2	3		66%	
	2. Height appropriate?	3	3		100%	
	3. Angle and geometry appear appropriate?	3	3		100%	
	4. Free of piping or other structural failures?	1	3		33%	**75%**

*Total number of features per as-built estimated from designed profile.

** The total number of features for Monitoring Year 1 is greater than the number of features in the plan sheets.

Table 13. Verification of Bankfull Events
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)

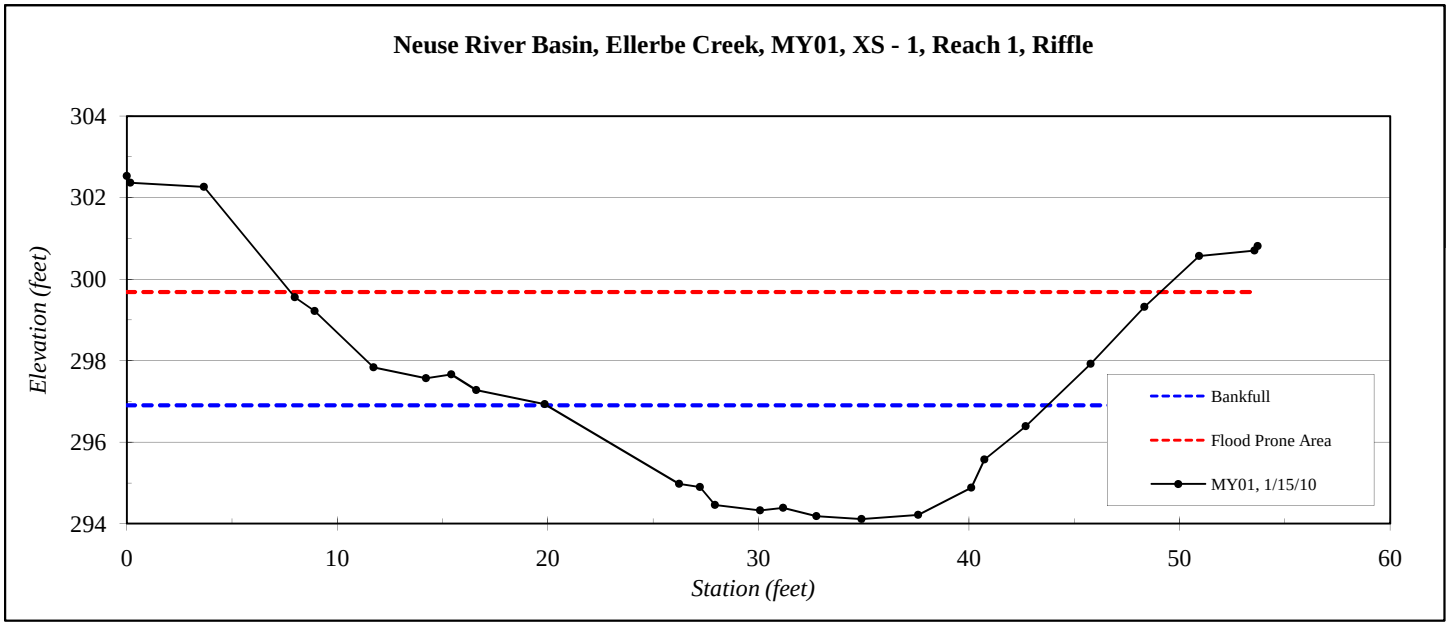
Date of Data Collection	Date of Occurrence	Method	Photo Number
6/14/2009	6/11/2009	Site visit to evaluate indicators of stage after storm event	N/A
11/11/2009	11/11/2009	Site visit to evaluate indicators of stage after storm event	N/A
12/25/2009	12/25/2009	Eye-witness account	N/A
1/25/2010	1/25/2010	Site visit to evaluate indicators of stage after storm event	N/A

Cross-Section Plots

River Basin:	Neuse
Watershed:	Ellerbe Creek, MY01
XS ID	XS - 1, Reach 1, Riffle
Drainage Area (sq mi):	5.9
Date:	1/15/2010
Field Crew:	B. Roberts, A. Spiller

Station	Elevation
0.0	302.53
0.2	302.37
3.7	302.26
8.0	299.55
8.9	299.22
11.7	297.84
14.2	297.57
15.4	297.67
16.6	297.28
19.8	296.94
26.2	294.98
27.2	294.90
27.9	294.46
30.1	294.33
31.2	294.39
32.8	294.18
34.9	294.12
37.6	294.22
40.1	294.88
40.7	295.57
42.7	296.39
45.8	297.92
48.3	299.32
50.9	300.57
53.6	300.71
53.7	300.81

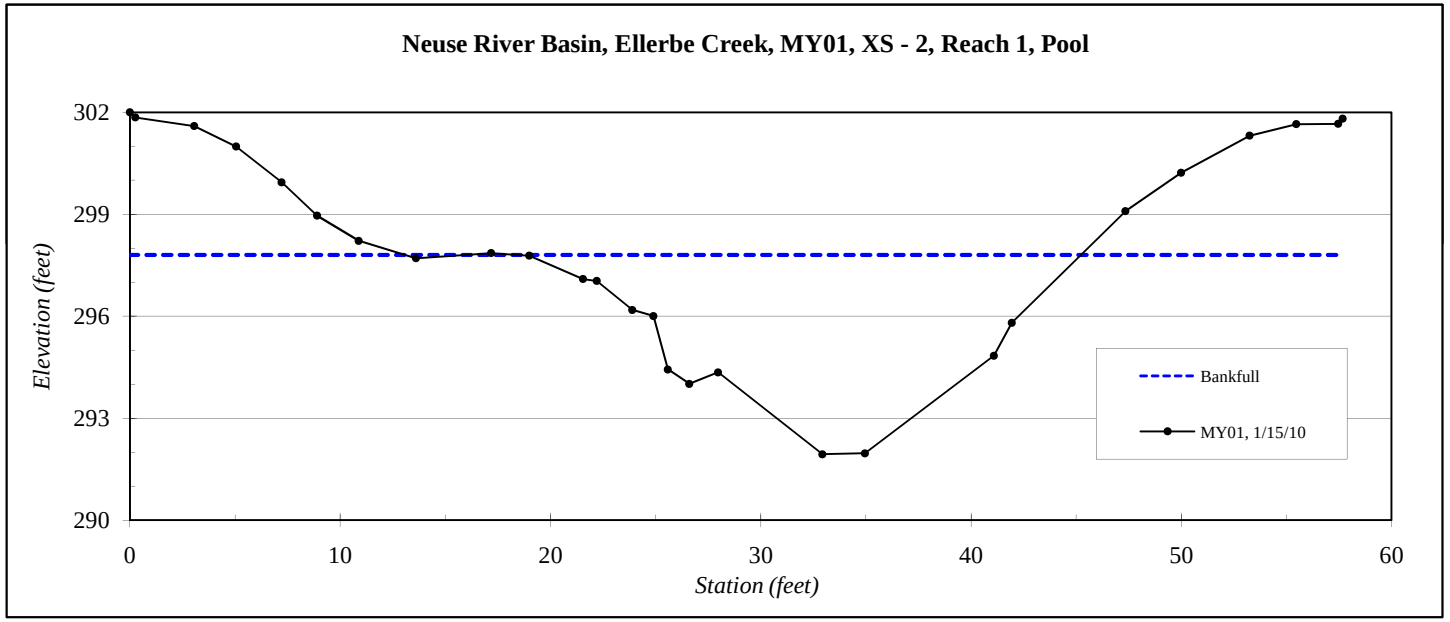
SUMMARY DATA	
Bankfull Elevation:	296.9
Bankfull Cross-Sectional Area:	45.0
Bankfull Width:	24.0
Flood Prone Area Elevation:	299.7
Flood Prone Width:	42
Max Depth at Bankfull:	2.8
Mean Depth at Bankfull:	1.9
W / D Ratio:	12.8
Entrenchment Ratio:	1.8
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Ellerbe Creek, MY01
XS ID	XS - 2, Reach 1, Pool
Drainage Area (sq mi):	5.9
Date:	1/15/2010
Field Crew:	B. Roberts, A. Spiller

Station	Elevation
0.0	302.00
0.3	301.85
3.1	301.60
5.1	300.99
7.2	299.94
8.9	298.96
10.9	298.22
13.6	297.71
17.2	297.86
19.0	297.78
21.5	297.10
22.2	297.04
23.9	296.18
24.9	296.01
25.6	294.44
26.6	294.01
28.0	294.35
32.9	291.94
35.0	291.96
41.1	294.84
41.9	295.81
47.4	299.09
50.0	300.22
53.2	301.32
55.5	301.66
57.5	301.66
57.7	301.82

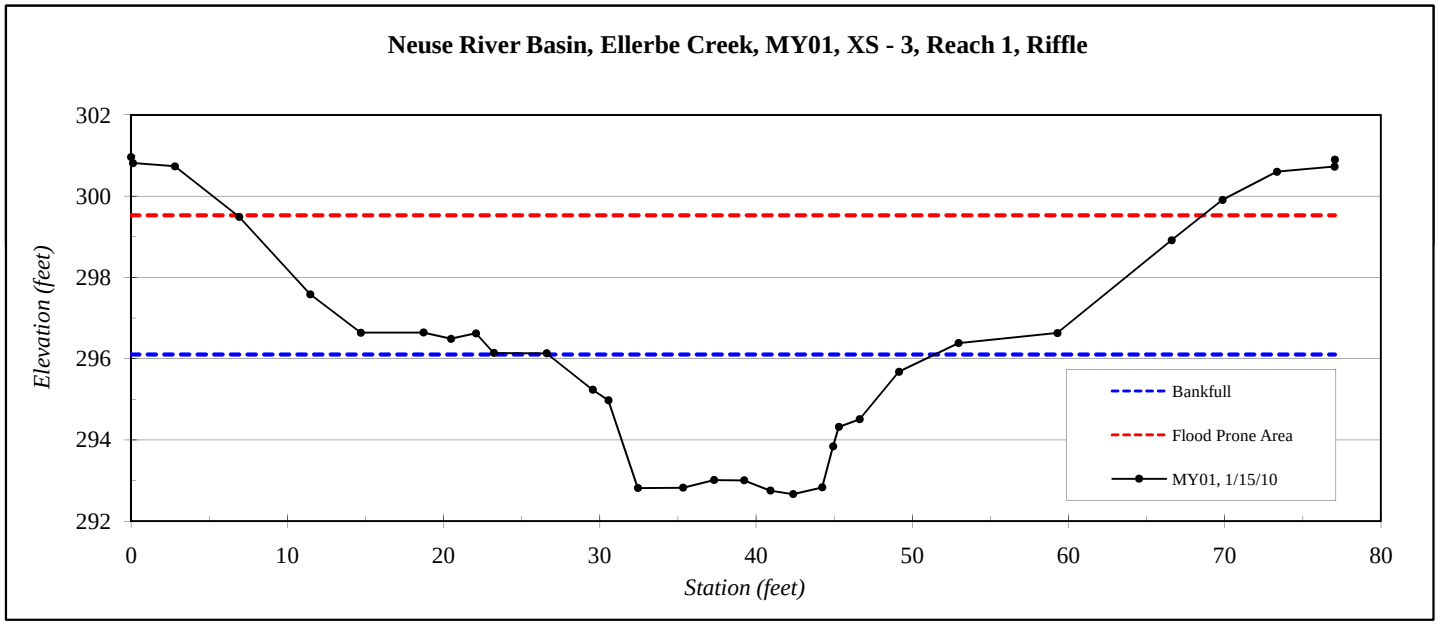
SUMMARY DATA	
Bankfull Elevation:	297.8
Bankfull Cross-Sectional Area:	82.4
Bankfull Width:	28.5
Flood Prone Area Elevation:	-
Flood Prone Width:	-
Max Depth at Bankfull:	5.9
Mean Depth at Bankfull:	2.9
W / D Ratio:	-
Entrenchment Ratio:	-
Bank Height Ratio:	-



River Basin:	Neuse
Watershed:	Ellerbe Creek, MY01
XS ID	XS - 3, Reach 1, Riffle
Drainage Area (sq mi):	5.9
Date:	1/15/2010
Field Crew:	B. Roberts, A. Spiller

Station	Elevation
0.0	300.96
0.1	300.81
2.8	300.74
6.9	299.49
11.5	297.58
14.7	296.64
18.7	296.64
20.5	296.49
22.1	296.63
23.2	296.14
26.6	296.13
29.5	295.24
30.6	294.97
32.4	292.82
35.3	292.82
37.3	293.01
39.3	293.01
40.9	292.75
42.4	292.67
44.3	292.83
44.9	293.84
45.3	294.32
46.6	294.51
49.2	295.68
53.0	296.38
59.3	296.63
66.6	298.92
69.9	299.91
73.4	300.60
77.0	300.72
77.1	300.90

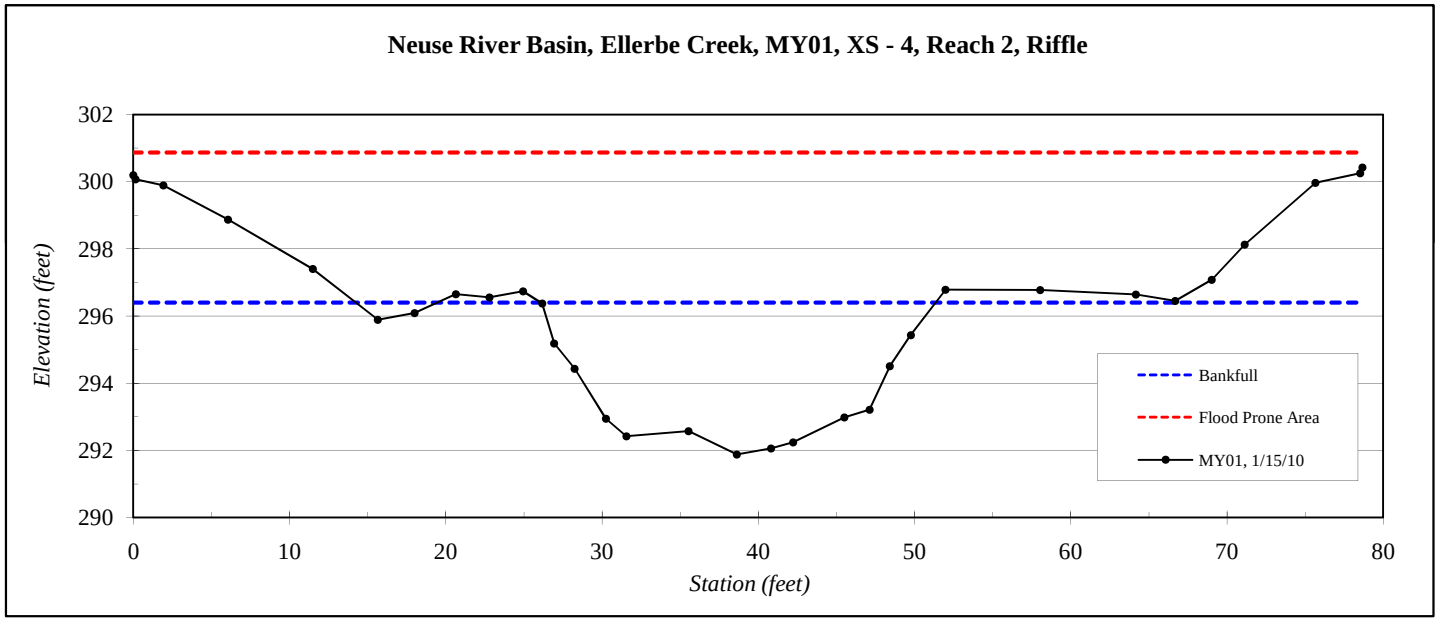
SUMMARY DATA	
Bankfull Elevation:	296.1
Bankfull Cross-Sectional Area:	53.4
Bankfull Width:	25.0
Flood Prone Area Elevation:	299.5
Flood Prone Width:	62
Max Depth at Bankfull:	3.4
Mean Depth at Bankfull:	2.1
W / D Ratio:	11.7
Entrenchment Ratio:	2.5
Bank Height Ratio:	1.0



River Basin:	Neuse
Watershed:	Ellerbe Creek, MY01
XS ID	XS - 4, Reach 2, Riffle
Drainage Area (sq mi):	5.9
Date:	1/15/2010
Field Crew:	B. Roberts, A. Spiller

Station	Elevation
0.0	300.19
0.1	300.07
1.9	299.89
6.1	298.87
11.5	297.40
15.7	295.89
18.0	296.09
20.6	296.65
22.8	296.55
24.9	296.73
26.2	296.38
26.9	295.18
28.3	294.43
30.3	292.95
31.6	292.42
35.6	292.58
38.6	291.88
40.8	292.06
42.2	292.23
45.5	292.98
47.1	293.21
48.4	294.50
49.8	295.43
52.0	296.78
58.0	296.77
64.2	296.64
66.7	296.45
69.0	297.08
71.1	298.12
75.7	299.97
78.5	300.25
78.7	300.42

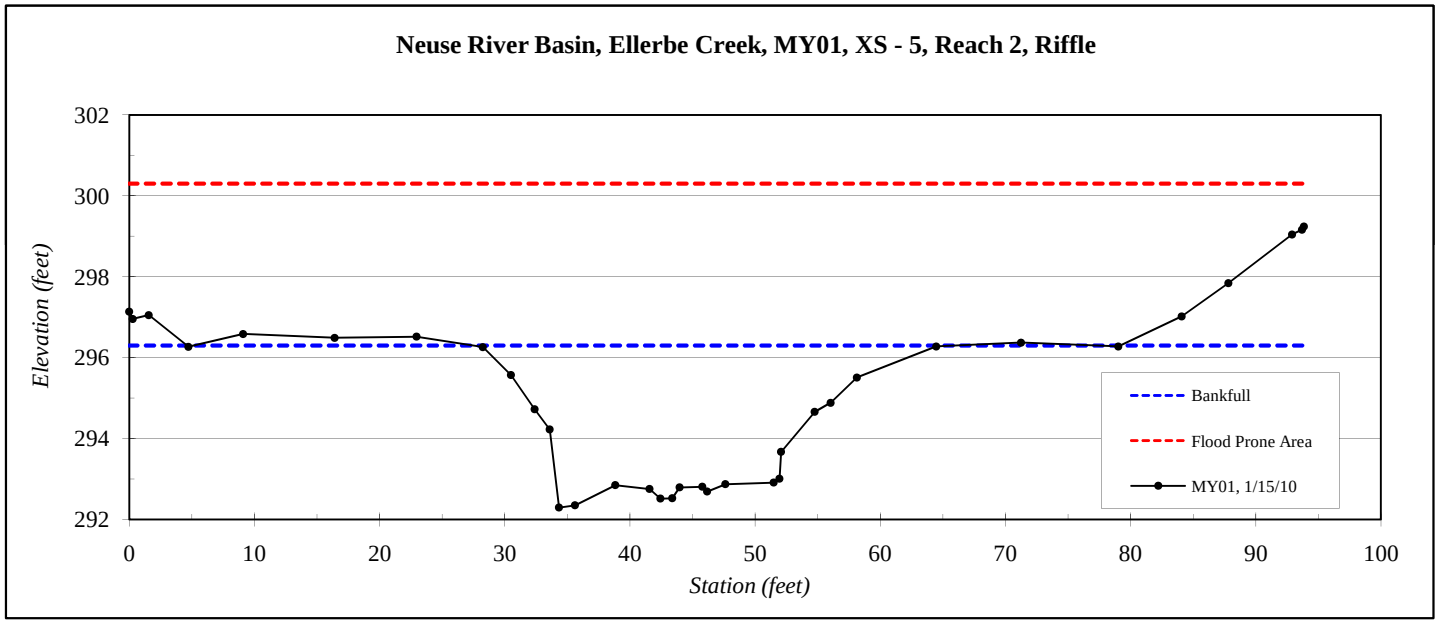
SUMMARY DATA	
Bankfull Elevation:	296.4
Bankfull Cross-Sectional Area:	80.2
Bankfull Width:	25.2
Flood Prone Area Elevation:	300.9
Flood Prone Width:	>75
Max Depth at Bankfull:	4.5
Mean Depth at Bankfull:	3.2
W / D Ratio:	7.9
Entrenchment Ratio:	>3.0
Bank Height Ratio:	1.0



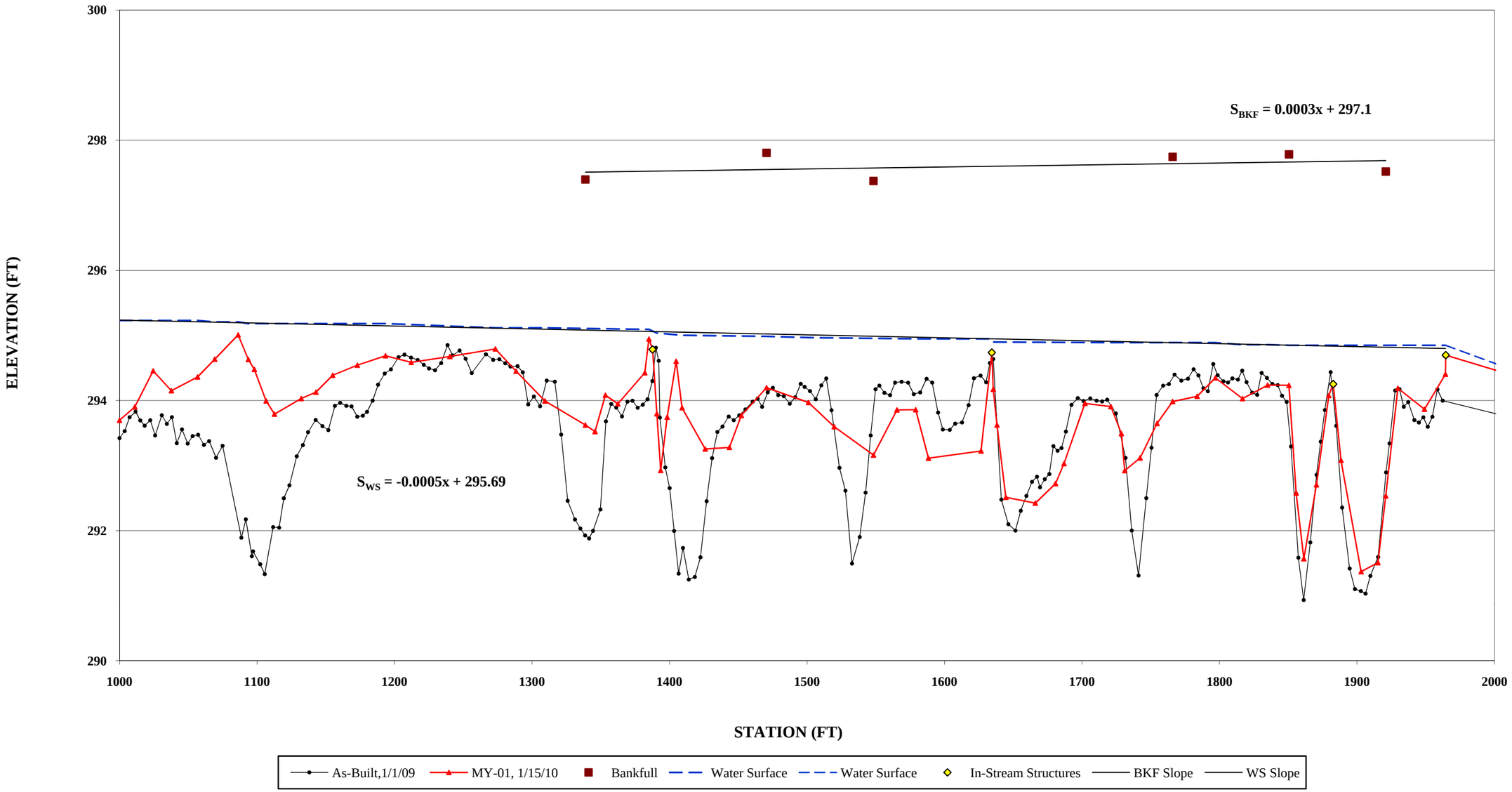
River Basin:	Neuse
Watershed:	Ellerbe Creek, MY01
XS ID	XS - 5, Reach 2, Riffle
Drainage Area (sq mi):	5.9
Date:	1/15/2010
Field Crew:	B. Roberts, A. Spiller

Station	Elevation
0.0	297.14
0.3	296.96
1.6	297.06
4.7	296.27
9.1	296.59
16.4	296.49
22.9	296.52
28.2	296.26
30.5	295.57
32.4	294.73
33.6	294.23
34.3	292.30
35.6	292.36
38.8	292.85
41.6	292.75
42.4	292.52
43.4	292.53
44.0	292.79
45.8	292.81
46.2	292.69
47.6	292.87
51.5	292.91
51.9	293.01
52.1	293.67
54.8	294.66
56.0	294.89
58.1	295.51
64.5	296.28
71.2	296.38
79.0	296.28
84.1	297.02
87.8	297.84
92.9	299.05
93.7	299.17
93.9	299.24

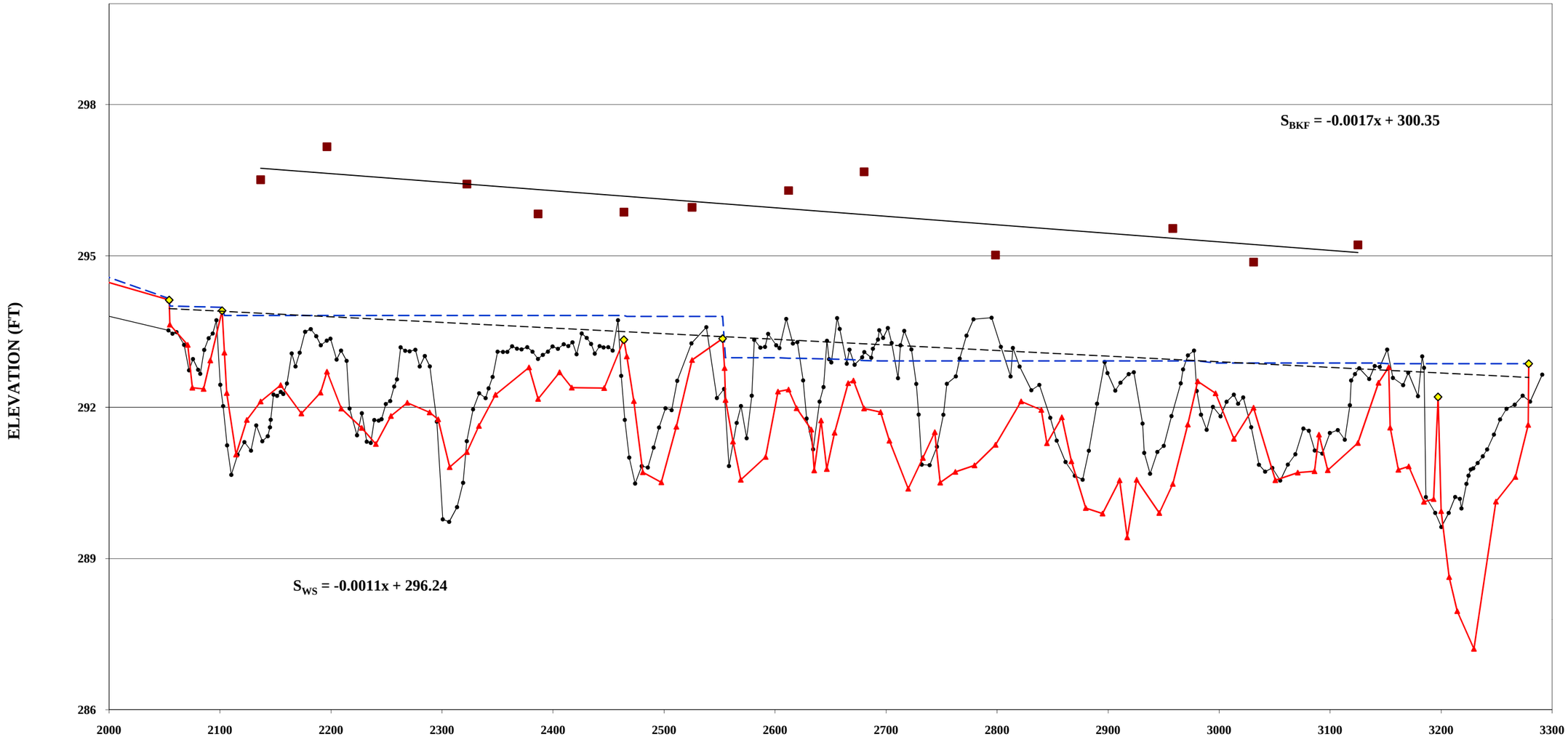
SUMMARY DATA	
Bankfull Elevation:	296.3
Bankfull Cross-Sectional Area:	82.0
Bankfull Width:	36.1
Flood Prone Area Elevation:	300.3
Flood Prone Width:	>90
Max Depth at Bankfull:	4.0
Mean Depth at Bankfull:	2.3
W / D Ratio:	15.9
Entrenchment Ratio:	>2.5
Bank Height Ratio:	1.0



Longitudinal Profile
Ellerbe Creek
EEP Project Number 272- MY01
Stations 10+00 - 20+00



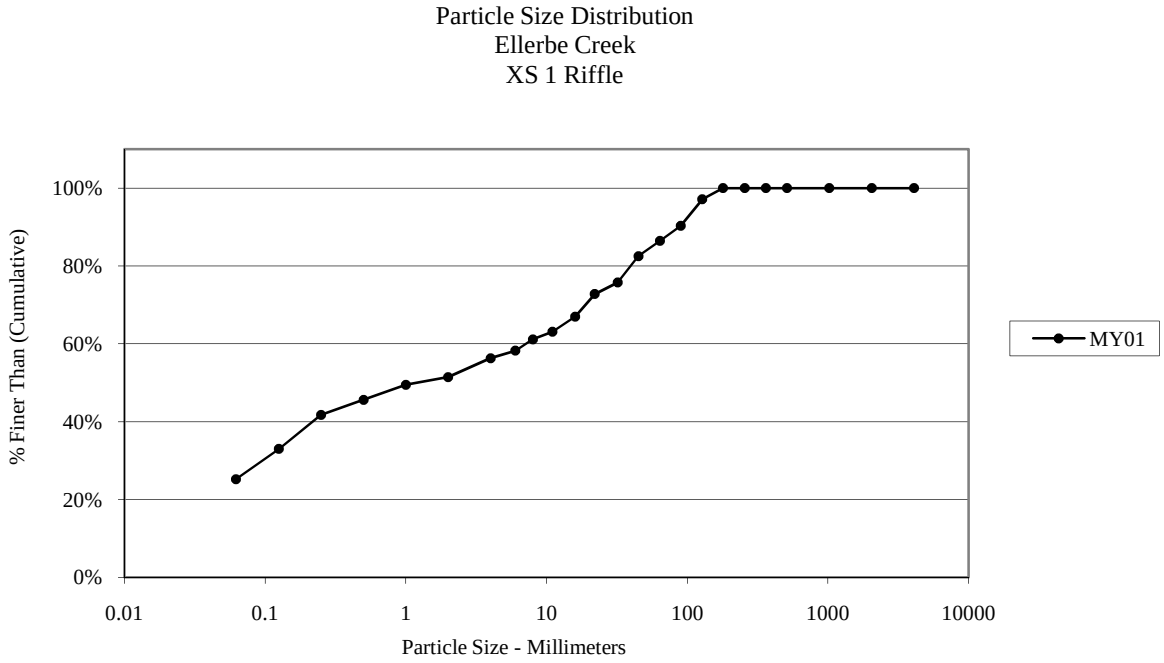
Longitudinal Profile
Ellerbe Creek
EEP Project Number 272- MY01
Stations 20+00 - 33+00



Pebble Count Plots

Cross-Section 1 Riffle - MY01			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	26
Very Fine	.062 - .125	S	8
Fine	.125 - .25	A	9
Medium	.25 - .50	N	4
Coarse	.50 - 1	D	4
Very Coarse	1 - 2	S	2
Very Fine	2 - 4		5
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	3
Medium	8 - 11.3	A	2
Medium	11.3 - 16	V	4
Coarse	16 - 22.6	E	6
Coarse	22.6 - 32	L	3
Very Coarse	32 - 45	S	7
Very Coarse	45 - 64		4
Small	64 - 90	C	4
Small	90 - 128	O	7
Large	128 - 180	B	3
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	103

Note:



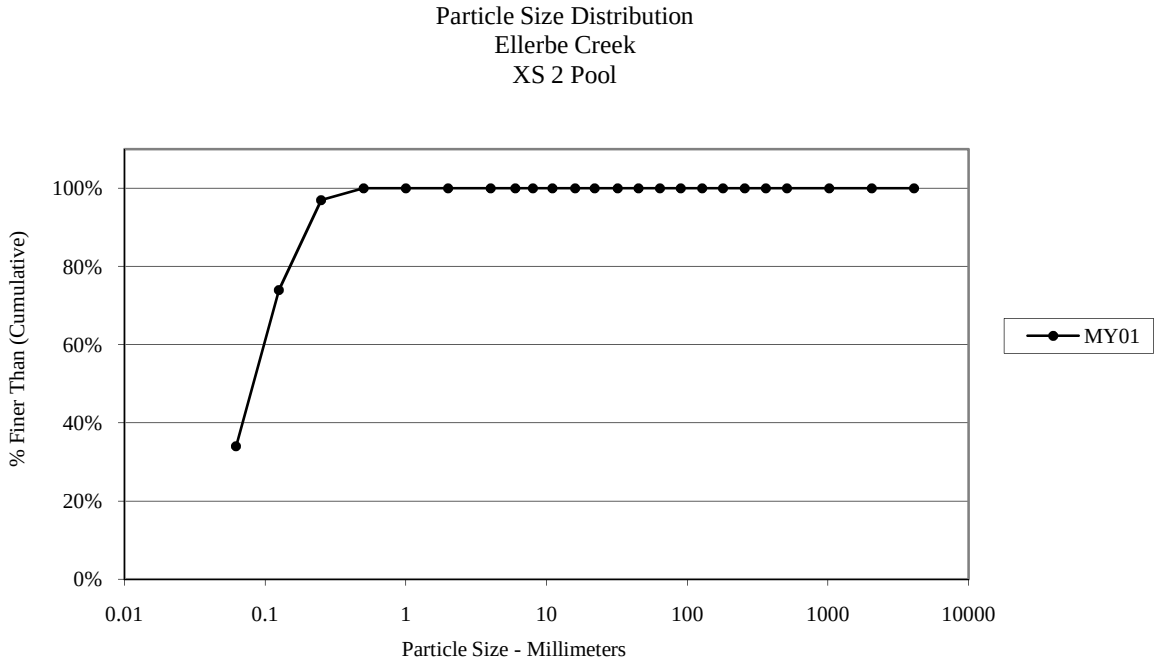
Size (mm)	
D16	0.062
D35	0.15
D50	1.2
D65	13
D84	51
D95	110

Size Distribution	
mean	1.8
dispersion	30.9
skewness	0.10

Type	
silt/clay	25%
sand	26%
gravel	35%
cobble	14%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 2 Pool - MY01			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	34
Very Fine	.062 - .125	S	40
Fine	.125 - .25	A	23
Medium	.25 - .50	N	3
Coarse	.50 - 1	D	
Very Coarse	1 - 2	S	
Very Fine	2 - 4		
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	
Coarse	22.6 - 32	L	
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:



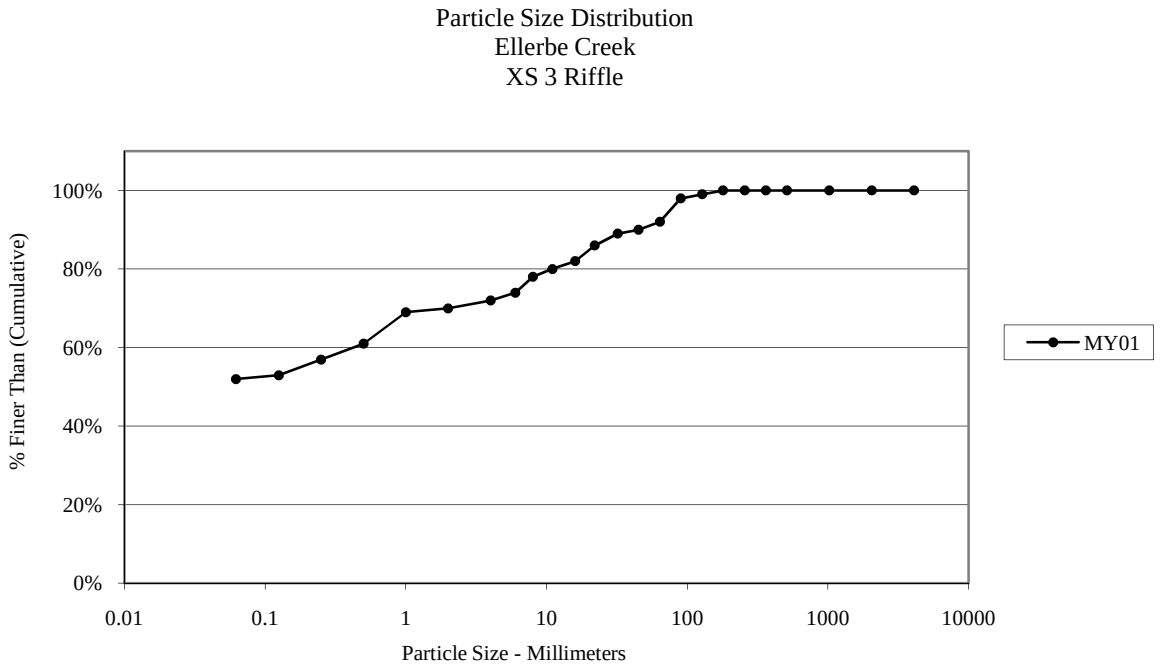
Size (mm)	
D16	0.062
D35	0.063
D50	0.082
D65	0.11
D84	0.17
D95	0.24

Size Distribution	
mean	0.1
dispersion	1.7
skewness	0.15

Type	
silt/clay	34%
sand	66%
gravel	0%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 3 Riffle - MY01			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	52
Very Fine	.062 - .125	S	1
Fine	.125 - .25	A	4
Medium	.25 - .50	N	4
Coarse	.50 - 1	D	8
Very Coarse	1 - 2	S	1
Very Fine	2 - 4		2
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	4
Medium	8 - 11.3	A	2
Medium	11.3 - 16	V	2
Coarse	16 - 22.6	E	4
Coarse	22.6 - 32	L	3
Very Coarse	32 - 45	S	1
Very Coarse	45 - 64		2
Small	64 - 90	C	6
Small	90 - 128	O	1
Large	128 - 180	B	1
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:



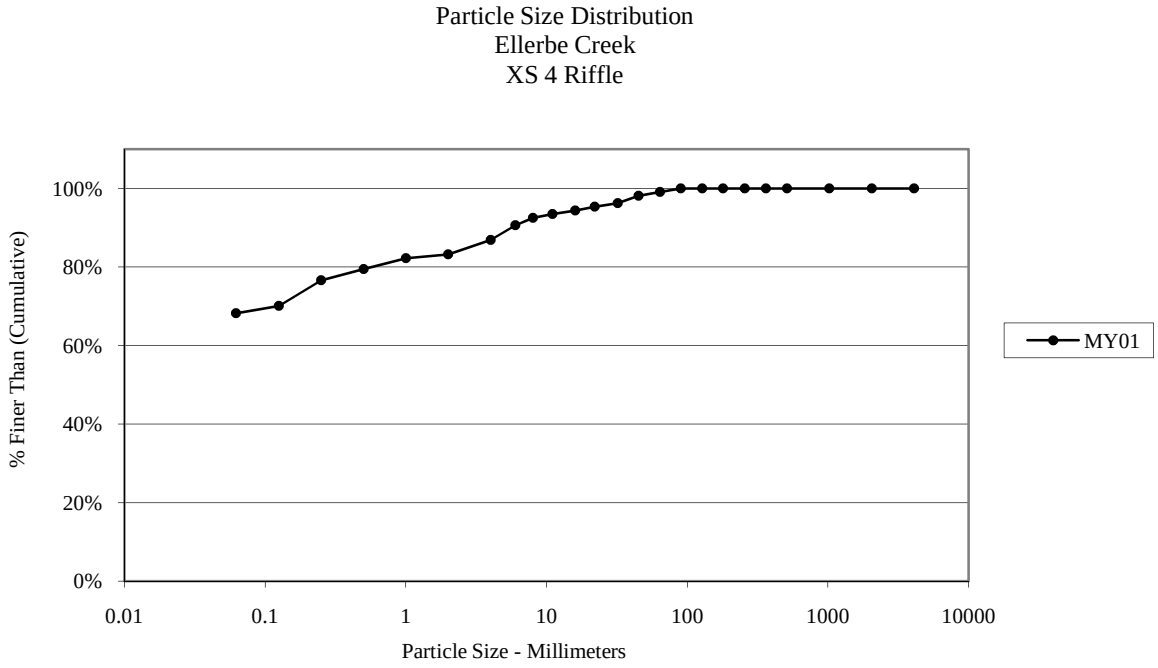
Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	0.71
D84	19
D95	76

Size Distribution	
mean	1.1
dispersion	153.7
skewness	0.79

Type	
silt/clay	52%
sand	18%
gravel	22%
cobble	8%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 4 Riffle - MY01			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	73
Very Fine	.062 - .125	S	2
Fine	.125 - .25	A	7
Medium	.25 - .50	N	3
Coarse	.50 - 1	D	3
Very Coarse	1 - 2	S	1
Very Fine	2 - 4		4
Fine	4 - 5.7	G	4
Fine	5.7 - 8	R	2
Medium	8 - 11.3	A	1
Medium	11.3 - 16	V	1
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	1
Very Coarse	32 - 45	S	2
Very Coarse	45 - 64		1
Small	64 - 90	C	1
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	107

Note:



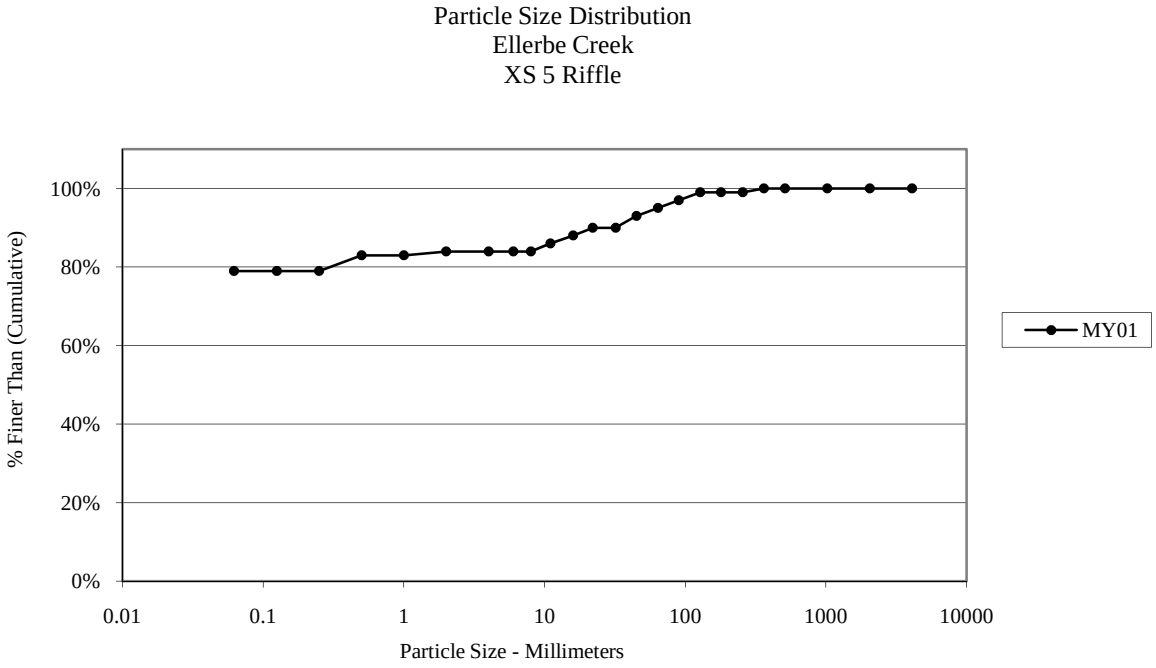
Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	0.062
D84	2.3
D95	20

Size Distribution	
mean	0.4
dispersion	19.0
skewness	0.63

Type	
silt/clay	68%
sand	15%
gravel	16%
cobble	1%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 5 Riffle - MY01			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	79
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	4
Coarse	.50 - 1	D	
Very Coarse	1 - 2	S	1
Very Fine	2 - 4		
Fine	4 - 5.7	G	
Fine	5.7 - 8	R	
Medium	8 - 11.3	A	2
Medium	11.3 - 16	V	2
Coarse	16 - 22.6	E	2
Coarse	22.6 - 32	L	
Very Coarse	32 - 45	S	3
Very Coarse	45 - 64		2
Small	64 - 90	C	2
Small	90 - 128	O	2
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	1
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:



Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	0.062
D84	2.7
D95	64

Size Distribution	
mean	0.4
dispersion	6.6
skewness	0.63

Type	
silt/clay	79%
sand	5%
gravel	11%
cobble	4%
boulder	1%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%