Gillespie Golf Course (Mile Run Creek)
Stream Restoration
Greensboro, North Carolina

Annual Monitoring Report

Monitoring Year 2006

Monitoring Year: 2006
Measurement Year 3
As-Built Date: 2004
NCEEP Project Number 144

January 2007

GILLESPIE GOLF COURSE (MILE RUN CREEK) STREAM RESTORATION
2006 MONITIORING REPORT

Table of Contents

LIST OF FIGURES

TABLES

APPENDICES

I. EXECUTIVE SUMMARY/PROJECT ABSTRACT

The Gillespie Golf Course Stream Restoration Site includes 2,634 linear feet of Mile Run Creek and 3,436 linear feet of a tributary within the City of Greensboro, Guilford County, North Carolina. The site was constructed between February and March 2004. The following report provides the Year 3, 2006 Monitoring information.

Overall, the project is doing well with a few minor areas of erosion and several sections where coir fiber matting has pulled away from the bank. Previously, there had been a beaver dam constructed on Mile Run Creek but it has since been eliminated and is no longer creating a problem along the restoration reach. The problem areas should be watched and remediation options developed if they get worse.

The vegetation monitoring of the site revealed an average tree density of 296 trees per acre. This average is below the minimum criteria of at least 320 stems per acre after 3 years. The low density can be attributed to mowing of portions of the vegetation plots by golf course personnel. Seedlings from natural recruitment are very low. Additional plantings are needed to restore the density to at least 320 stems per acre to meet mitigation requirements.

II. PROJECT BACKGROUND

A. Location and Setting

The Gillespie Golf Course Stream Restoration Site includes 2,634 linear feet of Mile Run Creek and 3,436 linear feet of an unnamed tributary. The site is located in the City of Greensboro near the intersection of Interstate 85 and North Carolina Highway 22 (NC-22) in Guilford County, North Carolina (See Figure 1).

B. Structure and Objectives

Mile Run Creek and its unnamed tributary are located on Gillespie Golf Course, a community golf course in the City of Greensboro. The stream channel has low sinuosity and varying levels of incision due to historic channelization. The alternative of creating a stable meandering stream with bankfull stage corresponding to the existing floodplain elevation was evaluated. However, topographic and development restrictions did not allow for a new channel pattern to be established. The existing incised channels were enhanced by excavating new floodplain benches at the design bankfull stage and installing structures to improve bed features and control channel grade.

The mitigation plan consisted of a Priority 3 restoration of Mile Run Creek and 936 linear feet of the unnamed tributary. Stream bank stabilization was also performed on 2,225 linear feet of the unnamed tributary. In-stream structures including root wads, double wing deflectors, and rock vanes were used to stabilize eroding streambanks and improve the channel profile and bedform of Mile Run Creek. Seven rock cross vanes were constructed to stabilize the channel of the unnamed tributary and forested buffers of varying widths were planted to stabilize the stream banks. Additional details regarding the structure and objectives of the project are provided in Table 1.

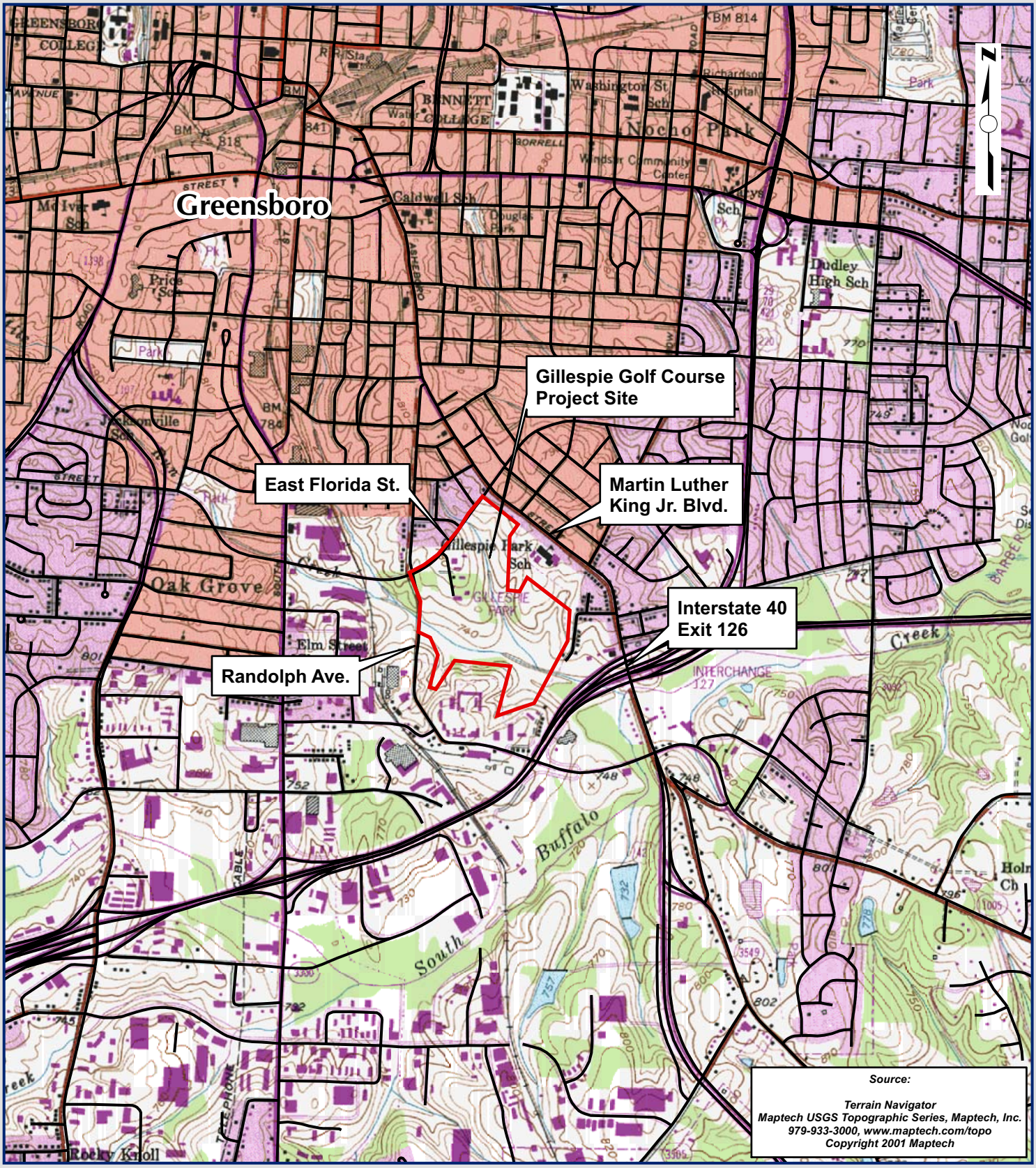
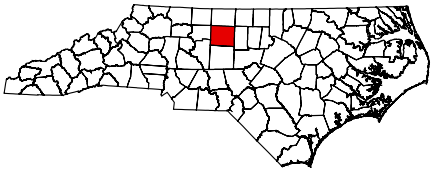


Figure 1.
Gillespie Golf Course
Stream Restoration Site
Vicinity Map
Guilford County, NC



Feet
0 1,000 2,000 4,000

Ecosystem Enhancement PROGRAM

Table I. Project Mitigation Structure and Objectives Table							
Gillespie Golf Course Stream Mitigation/Project No. 144							
Project Segment or Reach ID	**Mitigation Type**	**Approach**	**Linear Footage**	**Mitigation Ratio**	**Mitigation Units**	**Stationing**	**Comment**
Mile Run Crk., Reach 1	Enhancement	Priority 3	484	1:1.5	323	0+00 to 26+34.26	In-stream Structures and Buffers
UT Reach GR2	Enhancement	Priority 3	250	1:1.5	167	17+00 of Mile Run	In-stream Structures and Buffers
UT Reach GR3a	Stabilization	Bank Stabilization	461	1:1.0	461	NA	In-stream Structures and Buffers
UT Reach GR3b	Enhancement	Priority 3	225	1:1.0	225	NA	In-stream Structures and Buffers
UT Reach GR4	Stabilization	Bank Stabilization	1,425	1:1.0	1,425	NA	20 to 50 foot buffer
UT Reach GR5	Stabilization	Bank Stabilization	800	1:1.0	800	NA	20 to 50 foot buffer
Mitigation Unit Summary							
Stream (lf)	**Riparian Wetland (ac)**	**Nonriparian Wetland (ac)**		**Total Wetland (ac)**		**Buffer (ac)**	**Comment**
3,401	0.0	0.0		0.0		0.0	

NA* - No stationing was provided for these reaches

C. Project History and Background

The construction of Mile Run Creek was completed in early 2004 with the As-Built survey occurring in February 2005. Year 1 monitoring took place in April 2005 with Year 2 monitoring occurring in October 2005. Additional details regarding the timeline of the project are provided in Table 2 below.

Table II. Project Activity and Reporting History Gillespie Golf Course Stream Restoration/Project No. 144			
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan	NA	NA	February 2005
Final Design-90%	NA	NA	NA
Construction	NA	NA	March 15, 2004
Temporary S&E mix applied to entire project area	NA	NA	NA
Permanent seed mix applied to reach/segments 1&2	NA	NA	NA
Containerized and B&B plantings for reach/segments 1&2	NA	NA	March 15, 2004
Mitigation Plan /As-Built (Year 0 Monitoring-baseline)	NA	NA	February 2005
Year 1 Monitoring	NA	April 2005	April 2005
Year 2 Monitoring	NA	October 2005	December 2005
Year 3 Monitoring	Fall 2006	October 2006	December 2006
Year 4 Monitoring	Fall 2007		
Year 5 Monitoring	Fall 2008		

NA-Historical project documents necessary to provide these data were unavailable at the time of this report submission

The project was designed by Buck Engineering. Construction was performed by LJ, Incorporated. Monitoring activities for Year 3 were performed by WK Dickson and Co., Inc. Additional information regarding contractors is shown in Table III.

Table III. Project Contact Table **Gillespie Golf Course Stream Restoration/Project No. 144**	
Designer POC	Buck Engineering Mr. Mike Rooney 8000 Regency Parkway, Suite 200 Cary, NC 27511 (919) 463-5490
Construction Contractor POC	LJ, Incorporated Mr. Arden Reiser PO Box 3188 Mooresville, North Carolina 28117 (704) 799-2670
Planting Contractor POC	NA
Seeding Contractor POC	NA
Seed Mix Sources	NA
Nursery Stock Suppliers	NA
Monitoring POC	WK Dickson and Co., Inc. Mr. Daniel Ingram 3101 John Humphries Wynd Raleigh, NC 27612 (919) 782-0495

NA-Historical project documents necessary to provide these data were unavailable at the time of this report submission

The project is located within Guilford County, located within the Southern Outer Piedmont of the Piedmont physiographic province of North Carolina. The site is located within a highly urbanized area. Additional information regarding this stream is included in Table IV.

Table IV. Project Background Table **Gillespie Golf Course Stream Restoration/Project No. 144**	
Project County	Guilford
Drainage Area	
Mile Run Creek	2.2 sq. mi.
Tributary GR2	0.002 sq. mi.
Tributary GR3	0.04 sq. mi.
Tributary GR4	0.13 sq. mi.
Tributary GR5	0.04 sq. mi.
Drainage impervious cover estimate (%)	>20%
Stream Order	
Mile Run Creek	2nd order
Tributary GR2	1st order
Tributary GR3	1st order
Tributary GR4	1st order/2nd order
Tributary GR5	1st order
Physiographic Region	Piedmont
Ecoregion	Southern Outer Piedmont
Rosgen Classification of As-Built	C5
Cowardian Classification	N/A
Dominant Soil Types	Chewacla sandy loam, Enon fine sandy loam
Reference Site ID	E5, Ut Lake Jeanette (Guilford), McClintock 1 & 2 (Mecklenburg); B4c, DuHart (Gaston), Silas (Forsyth), Morgan (Orange)
USGS HUC for Project	03030002 (Cape Fear)
USGS HUC for Reference	Ut Lake Jeanette 03030002, McClintock 03050103, DuHart 03050102, Silas 03040101, Morgan 03030002
NCDWQ Sub-basin for Project	030602
NCDWQ Sub-basin for Reference	Ut Lake Jeanette 030602, McClintock 030834, DuHart 030836, Silas 030704, Morgan 030606
NCDWQ Classification for Project	C, NSW
NCDWQ Classification for Reference	Ut Lake Jeanette-WSIII, NSW; McClintock-C, DuHart-WS-V, Silas-C, Morgan-WS-II, HQW, NSW, CA
Any Portion of any project segment 303d listed?	No
Any portion of any project segment upstream of a 303d listed segment?	Yes, Mile Run Creek is upstream of South Buffalo Creek
Reasons for 303d listing or stressor	Impaired biological stressor, stressor not identified, Urban runoff-storm sewers
% of project easement fenced	None

D. Monitoring Plan View

A series of monitoring devices have been installed on site. A total of six (6) individual cross-sections were located. Cross-sections were plotted from left to right facing downstream. Each cross-section is also a designated photographic point that is photographed annually. There are thirty-four (34) permanent photo points located at various points along the length of the channel. Four (4) vegetation-monitoring plots were randomly located within the riparian buffer of the Gillespie Golf Course Stream Restoration project. The locations of all monitoring installations are shown on figures 2a and 2b (Monitoring Plan View).

LEGEND

- STREAM TOP OF BANK
- STREAM CENTERLINE
- VEG PLOT
- SINGLE-ARM DEFLECTOR
- OUTLET BASIN
- DROP CROSS-VANE
- CONSTRUCTED RIFFLE
- DOUBLE-WING DEFLECTOR
- J-HOOK
- BOULDER CLUSTER
- BEDROCK
- PHOTO POINT

NAD 83

REACH 1A STATION 0+00
BEGIN CONSTRUCTION

FAIRWAY 9 & 18 REACH 1A

FAIRWAY

SECTION 1

SECTION 2

SECTION 3

SECTION 4

SECTION 5

REACH 1B FAIRWAY

REACH 1C

BRIDGE #1

BRIDGE #2

INV=727.52

INV=725.20

INV=723.62

INV=722.37

INV=721.89

18" RCP

36"

12" RCP

48" RCP

X = 1768240.76
Y = 836721.24
Z = 731.59

X = 1768574.45
Y = 836547.47
Z = 727.32

X = 1768866.66
Y = 836273.66
Z = 727.00

X = 1769164.71
Y = 836336.85
Z = 723.87

X=1768119.70957
Y=836566.85407
EL=728.57750

X = 1768438.90
Y = 836455.53
Z = 726.22

X = 1768627.20
Y = 836376.42
Z = 726.94

X=1768687.87
Y=836374.10
Z=727.44

X= 1768736.17
Y= 836349.01
Z= 725.92

X = 1768847.73
Y = 836108.92
Z = 724.75

X = 1769152.92
Y = 836155.73
Z = 725.46

PHOTO POINT #1
PHOTO POINT #2
PHOTO POINT #3
PHOTO POINT #4
PHOTO POINT #5
PHOTO POINT #6
PHOTO POINT #7
PHOTO POINT #8
PHOTO POINT #9
PHOTO POINT #10

VEG PLOT #1
25'x 100'

VEG PLOT #2
25'x 100'

RANDOLPH AVE

FAIRWAY 9 & 18

CART PATH

INV=729.00

FO

1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00 13+00

Gillespie
Figure 2a

100 50 0 100 200
SCALE (FT)

PROJECT MANAGER	DRAWING SCALE
DPI	1"=100'
DRAWN BY	SURVEY DATE
TRS	
APPROVED BY	MAP DATE
PROJECT NUMBER	
5045700RA	

WK DICKSON
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Landscape Architects

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Office Locations:
North Carolina Georgia
South Carolina Florida

Ecosystem Enhancement Program

PREPARED FOR:

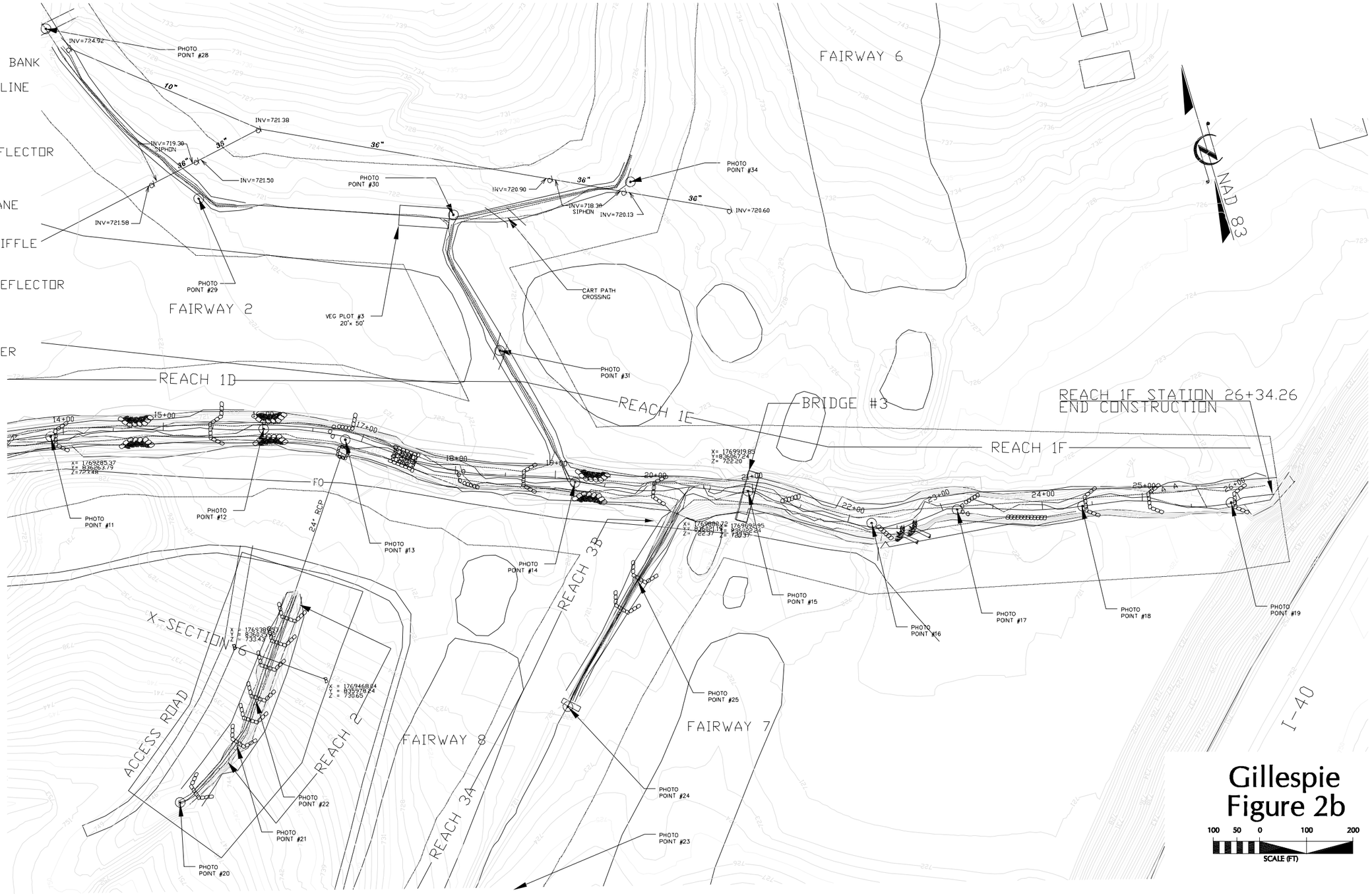
NORTH CAROLINA
ECOSYSTEM ENHANCEMENT PROGRAM

TITLE:

YEAR 3 MONITORING PLAN VIEW
GILLESPIE GOLF COURSE
GREENSBORO
NORTH CAROLINA

LEGEND

- STREAM TOP OF BANK
- STREAM CENTERLINE
- VEG PLOT
- SINGLE-ARM DEFLECTOR
- OUTLET BASIN
- DROP CROSS-VANE
- CONSTRUCTED RIFFLE
- DOUBLE-WING DEFLECTOR
- J-HOOK
- BOULDER CLUSTER
- BEDROCK
- PHOTO POINT



Gillespie
Figure 2b

100 50 0 100 200
SCALE (FT)

PROJECT MANAGER	DRAWING SCALE
DPI	1"=100'
DRAWN BY	SURVEY DATE
TRS	
APPROVED BY	MAP DATE
PROJECT NUMBER	
5045700RA	

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GILLESPIE GOLF COURSE
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III. PROJECT CONDITION AND MONITORING RESULTS

Monitoring results are discussed below. An initial visual survey was conducted on March 10, 2006 with a more detailed monitoring survey (evaluation of vegetation plots) conducted in October 2006.

A. Vegetation Assessment

Planted zones related to the stream restoration consist of the riparian buffer zone and the stream banks. The riparian buffer zone initiates at the top of the bank and continues out perpendicular to the immediate channel following the general pattern of the meandering channel. The planted stream bank initiates at the normal base flow elevation and extends to the top of bank or interface with the floodplain.

1. Soil Data

Soils present in the riparian areas adjacent to Mile Run Creek are characteristic of those found in alluvial landforms in the Southern Outer Piedmont. However, extensive grading and dredging has likely modified much of the naturally occurring soils on site.

Chewacla soils (*Fluvaquentic Dystrudepts*) are the prevalent map unit along the channel. Formed in recent alluvial sediments, they are very deep, moderately well and somewhat poorly drained soils with moderate permeability.

Other soil series found along the stream corridor are Enon soils. Enon soils (*Ultic Hapludalfs*) are very deep, well drained, slowly permeable soils found on ridgetops and side slopes in the Piedmont.

2. Vegetative Problem Areas

Several areas with minimum vegetation were observed in August 2006 and five exotic and invasive species were observed within the plots during the vegetation sampling. These include thorny olive (*Elaeagnus punguns*), common wormwood (*Artemisia vulgaris*), mimosa (*Albizia julibrissin*), multiflora rose (*Rosa multiflora*), and Chinese privet (*Ligustrum sinense*). Areas with extensive populations of invasive exotic vegetation are depicted in Appendix A-4 Vegetation Problem Areas Plan View.

Mowing has been a problem at all vegetation plots since the implementation of the restoration project. Plot 4 was reported as completely mowed in the April 2005 Year 1 Monitoring Report. This plot had apparently recovered as of the Year 2 vegetation monitoring site visit and was back to its original state in Year 3 monitoring. Annual weeds of about 8' tall or higher were observed on the right bank. Many shrubs were multi-stemmed and coral berry appears to be spreading throughout plot 4. Mowing did not seem to be a problem for plots 1 and 2, but was apparent at plot 3. Although plot 3 was not mowed completely as previously stated in the Year 2 monitoring report, there was a narrow buffer present and the fairway was mowed beyond the plot boundary. Vegetation problem areas table and plan view are located in Appendix A. The problem areas table lists the vegetation problem areas, the approximate stationing of the problem area, and the probable cause of the problem.

3. Stem Counts

The complexity of the planting plan required the establishment of four vegetation survival plots that were designed to monitor varying vegetation planting types.

- Plot 1 monitors bare root trees and live stakes.
- Plot 2 monitors shrubs, live stakes, and perennial plantings.
- Plot 3 monitors live stakes and perennial plantings.
- Plot 4 monitors shrubs on both sides of the channel.

Plots 1 and 2 are 100 feet in length and 25 feet in width along the right bank of the channel. The vegetation monitored in these plots includes planted bare root trees and live stake plantings. The remaining two plots span both channel banks. Plot 4, a shrub plot, is 50 feet in length and 50 feet in width and Plot 3 is 50 feet in length and 25 feet in width. All plots are adjacent to the fairways and greenways of the golf course.

The plots were originally marked with wooden stakes. The original corner stakes were often missing or found lying within the buffer. It appears that some corners are now within the maintained fairway by approximately two feet with the upper portion if the plot away from the stream having been mowed.

- Plot 1 has not changed since Year 2 and is still approximately the same dimension as previously observed. The unmowed portion of the vegetation plot is still 23 feet x 100 feet.
- Plot 2 has not changed since Year 2 and is still approximately the same dimension as previously observed. The unmowed portion of the vegetation plot is still 23 feet x 100 feet.
- Plot 3 has a narrow buffer and had been mowed beyond the plot boundary but because of topography, the lower portion of some stems remained. WK Dickson was able to count stems in an area of about 15 feet x 50 feet.
- Plot 4 had been previously mowed but for the Year 3 monitoring season live stems were present with several species beginning to thrive throughout the plot.

In addition to percentage of survival of planted stems, an estimate of total stems per acre is provided. The number of stems per acre is based upon extrapolating the number of stems per plot to stems per acre. This allows a useful assessment of the current conditions and will help decide if further action is necessary.

Of the original 223 live stakes, 70 were counted for Year 3, resulting in a 31% survival rate. Plot 3 was heavily mowed but the stems have since come back. The issue of mowing beyond the vegetation plot boundary needs to be addressed. Of the original 162 shrubs that were planted only 29 remain which is 18% of the original number. This large decrease of shrubs necessitates additional plantings in order to restore the density to a level that meets mitigation requirements. In general, the mortality of greater than 25% of the original planting of live stakes and shrubs necessitates additional plantings according to the guidelines set forth in the mitigation plan of February 2005.

The vegetation monitoring of the site revealed an average tree density of 296 trees per acre in Plot 1. The total number of trees stems per acre has dropped below the required 320 stems/acre after 3 years needed to meet mitigation requirements. Natural recruitment of seedlings is also very low.

Additional plantings are needed to restore the density to at least 320 stems per acre to meet mitigation requirements according to success criteria set forth in the mitigation plan of February 2005.

The total number of shrubs has also been reduced to 18% of the original number planted. It appears that aggressive mowing soon after planting has been the main contributor to the low survival of shrubs. The number of shrub stems per acre is 105 in Plot 2 and 401 in Plot 4.

Volunteer species are prevalent in all plots. There is an abundance of volunteer species found in Plots 1 and 2. Common volunteer species found in Plot 1 are box elder (*Acer negundo*), silver maple (*Acer saccharinum*), sweet gum (*Liquidambar styraciflua*), and sycamore saplings. Common volunteer species found in Plot 2 are silver maple, sycamore saplings, smooth sumac (*Rhus glabra*), caltalpa (*Catalpa speciosa*), Bradford pear (*Pyrus calleryana*), and hickory (*Carya sp.*). Common volunteer species found in Plot 3 are tear thumb (*Polygonum arifolium*) and bamboo grass (*Sasa veitchii*). Common volunteer species found in Plot 4 are Bradford pear, giant ragweed (*Ambrosia trifida*), black cherry (*Prurius serotina*), and smooth aster (*Aster laevis*).

On September 21, 2006, WK Dickson conducted vegetation counts within each established plot as described above. The results of this survey are shown in Appendix A.

4. Vegetation Plot Photos

Photos of the vegetation plots are located in Section A-3 of Appendix A.

B. Stream Assessment

WK Dickson and Co., Inc personnel performed an initial site visit at Gillespie Golf Course on August 15th, 2006. During the field visit qualitative observations were recorded regarding the condition of the stream restoration project. Cross section and longitudinal surveys were also performed at the time of this visit. Six cross sections and approximately 3,000 linear feet of stream profiles were surveyed. Photographs were taken at all permanent photo points. A pebble count was performed for Year 3, but no data are available for comparison from earlier monitoring periods. The photographs show that vegetation is generally growing well and is a good combination of woody and herbaceous growth although aggressive mowing has continued in the vicinity of Plot 3 and reduced the height and diversity by killing some of the trees and shrubs and narrowing the buffer. Overall, the project is doing well with a few minor areas of erosion or areas of minimal vegetation. A beaver dam that was previously located at station 10+90 was no longer there and flow has returned to normal in this section. At this time, no repairs are recommended. The problem areas should be monitored over time; if the problems worsen then solutions should be discussed to assess the reason for the problem and potential options to fix the areas. Vegetative problem areas are described in Appendix A, Table 6 and stream problem areas are described in Appendix B, Table B.1.

Hydrologic Assessment

No crest gauges are installed at this site to document bankfull flow events. The following USGS stream gauge had been used in past reports to verify bankfull events. If this proximal gauge is the only alternative, there is no recourse except to make assumptions about out-of-bank events based on the gauge record. However, there are multiple reasons why this is not a good practice. First, the gauge represents the hydrology at one point in the watershed and not anywhere upstream or downstream with any certainty. There are multiple tributaries entering the stream between the gauge and the project site. Second, there are likely differences in cross-sectional geometry and

slope between the two sites- especially given that the project site was rebuilt. Even if the discharge could be accurately determined with this method, we still don't know for sure that there were not more or less out-of-bank events at the project reach than at the gauge reach. In short, gauge-height is not transferable. The accepted USGS procedure would be to transfer the discharge to the project reach from the gauge site, and then run a step-backwater or other flow model to predict slope and water surface elevation. Given the substantial short comings in this method, our recommendation is that a crest gage be installed at the project site.

Figure 3. USGS Stream Gauge Discharge Data for South Buffalo Creek at US 220.

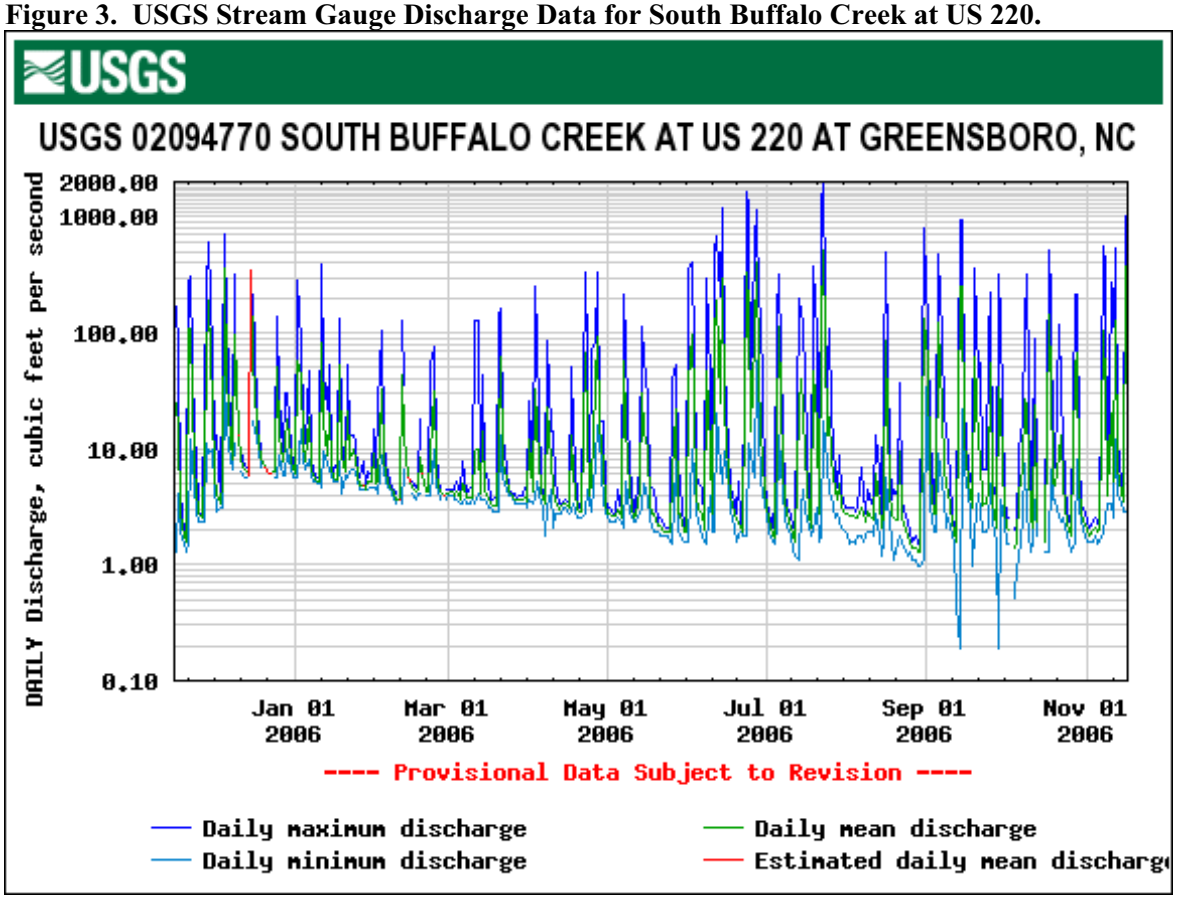

Table V lists bankfull events and high flows as they occurred in 2006.

Table V. Verification of High Flows/Bankfull Events
Gillespie Golf Course Stream Restoration/Project No. 144

Date of Data Collection	Date of Occurrence	Method	Photo # (if available)
NA	NA	NA	NA

Bank Erodibility Hazard Index (BEHI)

The entire reach that was monitored was separated into separate reaches that could then be categorized based on BEHI parameters such as bank height/bankfull height, root depth/bank height, root density percentage, bank angle, and surface protection percentage.

Methodology
The Bank Erodibility Hazard Index (BEHI) is a method of assessing stream bank erosion potential (Rosgen, 1996). The method used for finding BEHI for Gillespie was that a representative group of segments for each stream were chosen based upon the vegetation and the characteristics of the banks. Segments were chosen such that a range of disturbance was represented. For each designated segment, approximately the same footage of channel was characterized on both sides. At the beginning of the segment, a stretch of stream with relatively consistent characteristics (i.e eroded banks adjacent to a well maintained area) was assessed for bankfull height, bank height, root depth and density, surface protection, and bank angle. Bank materials and soil types were also observed. Bankfull height and bank height were measure with a survey rod while root density, root depth and surface protection were assesses based on judgement and general knowledge of the vegetation on the banks. Each stretch of stream was delineated and measured according to its characteristics. Occasionally, the left and right side of the stream did not coincide where each segment began and ended. In such a case, the length of the segment along one side may correspond with two or more segments totaling the same distance on the other side of the stream.

Results
The BEHI rating for most of the stream was High to Very High. The vegetation appears to be the driving characteristic that created such high ratings. The vegetation along the stream has very low root density and low root depths. Most of the trees along the banks are small saplings with short root depths and this coupled with a high bank creates a large ratio when comparing root depth to bank height. In most cases the bank height and bankfull height were not the same height, but the bank angle was steeper along some segments as compared with others. These conditions created values that created a rating of High to Very High.

1. Problem Areas Plan View

An assessment of the stability of the channel was preformed on August 16 and 17, 2006, by WK Dickson and Co., Inc. Several areas of concern were observed and documented including localized bank scour, aggradation, and failure occurring with the engineered structures. These problem areas are shown in Appendix B, Section B-1.

2. Problem Areas Table Summary

The Stream Problem Areas Summary Table can be found in Appendix B as Table B.1.

3. Representative Stream Problem Area Photos

Representative photos of each category of stream problem area were taken and are shown in Appendix B, Section B-3.

4. Fixed Photo Station Photos

Photos from established photo stations were collected on August 16 and 17, 2006 during the stream survey. These photos are included in Appendix B, Section B-4.

5. Stability Assessment

A visual qualitative assessment was performed to inspect channel facets, meanders, bed, banks, and installed structures. This visual assessment was confirmed and enhanced with a quantitative assessment of the physical stream survey. The goal of this assessment is to provide a percentage of the features listed in Table VI that are in a state of stability.

Table VI. Categorical Stream Feature Visual Stability Assessment
Gillespie Golf Course Stream Restoration/Project No. 144
Reach GR1/ (2,634 feet)

Feature	Initial	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles	100%	98%	96.20%	82%		
B. Pools	100%	95%	NA	90%		
C. Thalweg	100%	100%	NA	NA		
D. Meanders	100%	100%	NA	NA		
E. Bed General	100%	100%	NA	98%		
F. Bank Condition	NA	NA	NA	96.2%		
G. Vanes/J-Hooks etc.	100%	100%	95.80%	96%		
H. Wads and Boulders	100%	100%	100%	86%		

Note: Year 1 estimates are based upon review of text within the Buck Engineering Year 1 Monitoring Report.

6. Quantitative Morphology

The following tables (Table VII and Table VIII) summarize the quantitative data collected from the cross-sectional and longitudinal stream survey. These data were analyzed and summarized, and then compared with baseline data (i.e. as-built and previous year's data) available for this project. The SRI urban Piedmont curve was used to determine an average bankfull cross-sectional area, and bankfull was placed at the elevation that would yield this area (for 2006 cross-sections). When the elevations chosen for bankfull were plotted on the longitudinal profile, the points formed a reasonably uniform slope that was consistent with the water surface slope. The baseline that has been chosen for 2006 is consistent with the regional curve and will provide accurate illustrations of departure if bankfull is located in the same manner for future years of monitoring. The results of analysis of the data show that there are some disparities between the 2006 data and previous year's data. This can be explained by the fact that bankfull elevation for previous years was chosen at a different elevation than the 2006 bankfull elevation. The bankfull elevation for 2006 was assumed to be top of bank which is typical for a newly restored stream. This was not the case for baseline or the previous year's analysis. Plots for previous years assumed a lower bankfull elevation than top of bank which would be nearly impossible to locate because of the lack of natural indicators on a newly restored stream. The Quantitative Morphology Tables illustrate the degree of departure, if any, of the current channel from the baseline data. Tables VII and VIII were compiled from the cross-section and profile raw data and plots located in Appendix B of this report.

Table VII. Baseline Morphology and Hydraulic Summary
Gillespie Golf Course Stream Restoration/Project No. 144
Reach GR1 (2,634 feet)

Parameter	USGS Gage 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)				27	35.9	31.6	27.2	44.4	29.2	9.1	12.6	10.6	*	*	27	24	28.5	26.3
BF Cross Sectional Area (ft2)				96	106	101	61.5	112.8	88	14.2	21.8	20.5	*	*	74	49.9	85.5	52.3
BF Mean Depth (ft)				2.7	3.6	3.1	1.9	3.9	2.9	1.6	2	1.6	*	*	2.7	1.9	3.4	2.2
BF Max Depth (ft)							3.8	5.4	4.7	*	*	*	*	*	3.4	2.9	5.7	3.4
Width/Depth Ratio							7.2	19.3	9.9	5	8	6	*	*	10	7.3	13.9	11.15
Entrenchment Ratio							>2.5	>3.9	>3.1	*	*	*	3	3.6	*	2.1	9.4	3.75
Bank Height Ratio (BHR)							*	*	*	*	*	*	*	*	1.0	*	*	1.0
Wetted Perimeter (ft)							34.6	49	35	*	*	*	*	*	*	28.4	34.3	30.7
Hydraulic Radius (ft)							1.72	3.05	2.42	*	*	*	*	*	*	1.66	2.7	1.83
Pattern																		
Channel Beltwidth (ft)							*	*	*	32	45	*	*	*	*	*	*	*
Radius of Curvature (ft)							*	*	*	18	30	*	*	*	*	*	*	*
Meander Wavelength (ft)							*	*	*	35	69	*	*	*	*	*	*	*
Meander Width Ratio							*	*	*	2.7	5.7	*	*	*	*	*	*	*
Profile																		
Riffle Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Riffle Slope (ft)							*	*	*	0.0066	0.011	*	*	*	*	*	*	*
Pool Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool –to-Pool Spacing (ft)							*	*	*	*	*	*	54	108	*	*	*	*
Substrate																		
d50 (mm)							*	*	1	0.28	0.5	0.4	*	*	*	*	*	*
d84 (mm)							*	*	20	2.5	10	3.5	*	*	*	*	*	*
Additional Reach Parameters																		
Valley Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Channel Length (ft)							*	*	2877	*	*	*	*	*	1867	*	*	*
Sinuosity							*	*	1.1	1.3	2.4	*	*	*	1.1	*	*	*
Water Surface Slope (ft/ft)							*	*	0.0028	*	*	*	*	*	0.0028	*	*	*
BF Slope (ft/ft)							*	*	*	*	*	*	*	*	0.0025	*	*	*
Rosgen Classification							*	*	E5/C5	E5	E5	E5	*	*	E5	*	*	*
*Habitat Index							*	*	*	*	*	*	*	*	*	*	*	*
*Macrobenthos							*	*	*	*	*	*	*	*	*	*	*	*

*Historical documents necessary to provide this information were unavailable at the time of the report submission

Table VII Continued. Baseline Morphology and Hydraulic Summary
Gillespie Golf Course Stream Restoration/Project No. 144
Reach GR2 (250 feet)

Parameter	USGS Gage 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)							*	*	*	*	*	*	*	*	*	7.2	7.2	7.2
BF Cross Sectional Area (ft2)							*	*	*	*	*	*	*	*	*	4.6	4.6	4.6
BF Mean Depth (ft)							*	*	*	*	*	*	*	*	*	0.6	0.6	0.6
BF Max Depth (ft)							*	*	*	*	*	*	*	*	*	0.8	0.8	0.8
Width/Depth Ratio							*	*	*	*	*	*	*	*	*	11.2	11.2	11.2
Entrenchment Ratio							*	*	*	*	*	*	*	*	*	3.1	3.1	3.1
Bank Height Ratio (BHR)							*	*	*	*	*	*	*	*	*	*	*	1.0
Wetted Perimeter (ft)							*	*	*	*	*	*	*	*	*	8.4	8.4	8.4
Hydraulic Radius (ft)							*	*	*	*	*	*	*	*	*	0.55	0.55	0.55
Pattern																		
Channel Beltwidth (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Radius of Curvature (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Wavelength (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Meander Width Ratio							*	*	*	*	*	*	*	*	*	*	*	*
Profile																		
Riffle Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Riffle Slope (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Pool -to-Pool Spacing (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Substrate																		
d50 (mm)							*	*	*	*	*	*	*	*	*	*	*	*
d84 (mm)							*	*	*	*	*	*	*	*	*	*	*	*
Additional Reach Parameters																		
Valley Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Channel Length (ft)							*	*	*	*	*	*	*	*	*	*	*	*
Sinuosity							*	*	*	*	*	*	*	*	*	*	*	*
Water Surface Slope (ft/ft)							*	*	*	*	*	*	*	*	*	*	*	*
BF Slope (ft/ft)							*	*	*	*	*	*	*	*	*	*	*	*
Rosgen Classification							*	*	*	*	*	*	*	*	*	E5b	E5b	E5b
*Habitat Index							*	*	*	*	*	*	*	*	*	*	*	*
*Macrobenthos							*	*	*	*	*	*	*	*	*	*	*	*

*Historical documents necessary to provide this information were unavailable at the time of the report submission

Table VIII. Morphology and Hydraulic Monitoring Summary
Gillespie Golf Course Stream Restoration/Project No. 144
Reach GR1 CS 1-5 (2,634 feet), Tributary CS 6 (250 feet)

Parameter	Cross-Section 1 2+09 Pool				Cross-Section 2 5+86 Riffle				Cross-Section 3 7+31 Riffle				Cross-Section 4 9+65 Pool				Cross-Section 5 12+76 Riffle				Cross-Section 6 Trib 2 Riffle			
Dimension	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3	MY0	MY1	MY2	MY3
BF Width (ft)	24.9	25.4	25.9	34.3	26.7	26.3	24.2	25.9	24	26.8	36.9	26.1	28.5	30.1	29.8	26.1	26.3	27.1	25	25.2	7.2	7.4	7.3	6.9
Floodprone Width (ft)	235	235	235	**	56	66	>60	>90	52	63	>90	>80	262	262	262	**	115	115	>185	>185	22	22	18.2	22
BF Cross Sectional Area (ft2)	85.5	91	87.3	87.5	52.3	61.4	46.3	45.7	51.9	79.6	87.1	58.7	82.6	79.7	99	84.2	49.9	51.6	55	58.8	4.6	2.8	3.3	3.4
BF Mean Depth (ft)	3.4	3.6	3.4	2.6	2	2.3	1.9	1.8	2.2	3	2.4	2.2	2.9	2.7	3.3	3.2	1.9	1.9	2.2	2.3	0.6	0.4	0.5	0.5
BF Max Depth (ft)	5.7	5.3	5.2	5.2	3.1	3.8	3.4	3.4	3.4	4.6	4.3	4.2	4.4	4	5.4	4.8	2.9	3.1	5.1	5.4	1	0.8	0.9	1
Width/Depth Ratio	7.3	7.1	7.6	13.4	13.6	11.3	12.7	14.6	11.1	9	15.6	11.6	9.8	11.3	9	8.1	13.9	14.2	11.4	10.8	12	18.5	14.6	14.3
Entrenchment Ratio	9.4	9.2	9.1	**	2.1	2.5	>2.5	>2.5	2.2	2.4	>2.4	3.1	9.2	8.7	8.8	**	4.4	4.2	>7.4	7.3	3.1	3	2.5	3.2
Bank Height Ratio (BHR)	1.0	1.0	*	1.0	1.0	1.0	*	1.0	1.0	1.0	*	1.0	1.0	1.0	*	0.9	1.0	1.0	*	1.0	1.0	1.0	*	0.9
Wetted Perimeter (ft)	31.7	36	32.64	38.0	30.7	30.9	28.05	27.1	28.4	32.8	41.64	28.1	34.3	35.5	36.45	28.7	30.1	30.9	29.4	28.8	8.4	8.2	8.19	7.4
Hydraulic Radius (ft)	2.7	2.53	2.67	2.3	1.7	1.99	1.91	1.7	1.83	2.43	2.09	2.1	2.41	2.25	2.72	2.9	1.66	1.67	1.87	2	0.55	0.34	0.41	0.5
Substrate																								
d50 (mm)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
d84 (mm)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Parameter	MY-01 (2005)			MY-02 (2005)			MY-03 (2006)			MY-04 (2007)			MY-05 (2008)			MY+ (2009)			
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	
Channel Beltwidth (ft)	*	*	*	*	*	*	8	34	25										
Radius of Curvature (ft)	*	*	*	*	*	*	2	17	8										
Meander Wavelength (ft)	*	*	*	*	*	*	8	45	30										
Meander Width Ratio	*	*	*	*	*	*	0.33	1.41	1.04										
Profile																			
Riffle Length (ft)	*	*	*	5	79	24	15	65	37										
Riffle Slope (ft)	*	*	*	0	0.066	0.0025	0	0.041	0.023										
Pool Length (ft)	*	*	*	19.41	98.53	33.76	36.2	146.1	74.14										
Pool -to-Pool Spacing (ft)	*	*	*	19.41	292.7	100.18	38.7	203.5	107.4										
Additional Reach Parameters																			
Valley Length (ft)	2648			2648			2648												
Channel Length (ft)	2642			2642			2642												
Sinuosity	0.99			0.99			0.99												
Water Surface Slope (ft/ft)	0.00267			0.00296			0.00275												
BF Slope (ft/ft)	NA			0.002835			0.0029												
Rosgen Classification	E/C			E/C			E/C												
*Habitat Index	NA			NA			NA												
*Macrobenthos	NA			NA			NA												

*Historical documents necessary to provide this information were unavailable at the time of the report submission

**Typically a flood prone width and entrenchment ratio are not calculated for a pool cross section.

C. Wetland Assessment

There is no wetland restoration associated with this site. Table IX is not applicable to this project.

IV. RECOMMENDATIONS

It is highly recommended that crest gauges be installed at Gillespie Golf Course in order to measure bankfull flows if they occur onsite.

References:

USACOE (2003) *Stream Mitigation Guidelines*. USACOE, USEPA, NCWRC, NCDENR-DWQ

USACOE (1987) *Corps of Engineers Wetlands Delineation Manual*. Tech report Y-87-1. AD/A176.

Rosgen, D.L. (1996) *Applied River Morphology*. Wildland Hydrology Books, Pagosa Springs, Co.

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Appendix A

Appendix B