Blockhouse Creek Mitigation Project

Year 2 Monitoring Report-Final

Polk County, North Carolina

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Table of Contents

Tables

Figures

Appendices

EXECUTIVE SUMMARY

This Annual Report details the monitoring activities during the 2010 growing season (Monitoring Year 2) on the Blockhouse Creek Mitigation Site ("Site"). This Annual Monitoring Report presents data on stream geometry, stem count data from vegetation monitoring stations, and discusses any observed tendencies relating to stream stability and vegetation survival success. The Site is currently on track to meet the hydrologic, vegetative, and stream success criteria specified in the Blockhouse Creek Mitigation Plan.

The Blockhouse Creek Site ("Site") was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). Prior to restoration, stream and riparian functions on the Site were impaired as a result of historic agricultural land use practices as well as culvert installations that took place during the construction of the adjacent equestrian and nature center and Interstate 26. The streams on the Site were channelized and riparian vegetation had been cleared. Blockhouse Creek also exhibited instability as a result of improperly installed culverts. As-built surveys conducted in the Summer of 2008 indicate that 5,875 linear feet of stream were restored on Blockhouse Creek and two unnamed tributaries (UT1 and UT2), to Blockhouse Creek.

A total of ten vegetation monitoring plots 100 square meters (m^2) (10m x 10m) in size were used to predict survivability of the woody vegetation planted on-site. The Year 2 vegetation monitoring indicated an average survivability of 680 stems per acre. The data shows that the Site is on track for meeting the minimum success interim criteria of 320 trees per acre by the end of Year 3 and the final success criteria of 260 trees per acre by the end of Year 5.

With the exception of slight aggradation in isolated reaches, cross-section surveys indicate the stream dimension of Blockhouse Creek and its tributaries remained stable during Year 2. Overall, in-stream structures also remained stable during Year 2. However, the occurrence of two bankfull events in November 2009 and a bankfull event in early Spring 2010 did lead to bank failures in a few isolated meanders along Reaches 2-4 of Blockhouse Creek. In fact, many of the cross-sections surveyed during Year 2 of the monitoring schedule reflect floodplain depositional features associated with the bankfull events that occurred on-site (Appendix B). The lower reach of Blockhouse Creek immediately downstream of Interstate 26 and downstream of the confluence with UT2 also exhibited some aggradation, most likely from sand and gravel coming out of the I-26 box culverts which had been partially plugged with sediment prior to the bankfull events. Bank and channel repair work consisted of installing additional geolifts and grade control, minor grading work, re-seeding or re-livestaking and matting specific areas.

UT1 did not exhibit any significant profile changes. As noted in the previous monitoring report, UT2 did not contain flow during the As-built survey. However, UT2 was flowing during Year 2 monitoring; the longitudinal profile survey reflects generally stable conditions along the channel. A fallen tree near Cross-section 14 contributed to localized aggradation and alteration of the profile. However, the fallen tree has since been removed and the channel profile in this section of UT2 is expected to return to that observed in previous monitoring years. Compared with the as-built survey, UT2 appears to have degraded slightly above and below a wetland complex adjacent to the project area. However, it is likely that the "downcutting" is attributable to the small tributary experiencing periodic flow sufficient to flush the tributary of excess siltation present at the time of the as-built survey. The channel slope on UT2 was designed to be gradual in the vicinity of the wetland as compared to other sections of UT2 to avoid impacts to the hydrology of the site. As a consequence, there is little change in the profile in the vicinity of the wetland when compared to the As-built survey. Visual observations and cross-sections confirm channel overflow in areas, which was also recorded on a crest gauge located on UT2. Based on the overall stability of the channel, no maintenance or repair work of the channel profile is required.

The on-site crest gauges recorded at least three bankfull flow events across the project area during Year 2 of the post construction monitoring period. The site will continue to be periodically monitored for the occurrence of bankfull events which will be included in future monitoring reports.

Table 1 summarizes site conditions before and after restoration as well as what was predicted in the mitigation plan. The stream mitigation units developed on the project exceed the number of units that Baker contracted with the North Carolina Ecosystem Enhancement Program (NCEEP) to provide. The monitoring plan and Year 2 monitoring data are discussed in Sections 2.1 through 2.5 of this report. The 2010 stream cross section data presented in this Report were collected during May and June 2010. Vegetation monitoring plots were assessed in June 2010.

1.0 PROJECT BACKGROUND

The Blockhouse Creek mitigation project involved restoration, enhancement or preservation of 6,305 linear feet (LF) on four on-site streams: Blockhouse Creek and three smaller unnamed tributaries (UTs) identified in the project as UT1, UT2, and UT3. Blockhouse Creek is a "blue-line" stream, as shown on the USGS topographic quadrangle for the site, and is considered to be perennial based on field evaluations using NCDWQ stream assessment protocols. The three tributaries were all identified as perennial during initial project scoping, although UT2 and UT3 have little or no flow during extreme drought conditions as observed during previous summers. A total of 8.6 acres of stream and riparian buffer are protected through a conservation easement.

1.1 Project Goals and Objectives

The goals for the mitigation project are as follows:

- Create geomorphically stable conditions on Blockhouse Creek.
- Restore hydrologic connections between creek and floodplain.
- Improve the water quality of Blockhouse Creek.
- Improve aquatic and terrestrial habitat along the project corridor.

To achieve these goals, design objectives of the project included:

- Restoration or enhancement of channel dimension, pattern and profile;
- Improvements to water quality in the Blockhouse Creek watershed through nutrient removal, sediment removal, improved recreational opportunities, streambank stability, and erosion control;
- Improved water quantity/flood attenuation through water storage and flood control, reduction in downstream flooding due to the reconnection of stream and floodplain, improved ground water recharge, and improved and restored hydrologic connections;
- Enhancement of aquatic and terrestrial habitats through improved substrate and instream cover, addition of woody debris, reduction in water temperature due to shading, restoration of terrestrial habitat, increase of spatial extent of natural area, and improved aesthetics.

1.2 Project Structure

Restoration of site hydrology involved the restoration of natural stream functions to impaired reaches on the site. The streams in their pre-project condition were channelized and, as a result, were highly incised. Because of the extent of the incision, a Rosgen Priority I restoration, which would connect the stream to the abandoned floodplain (terrace), would not have been feasible without extending the project reach several thousand feet upstream and significantly altering the channel profile. However, there was sufficient space in areas within the project boundaries to implement a Rosgen Priority II restoration by excavating the floodplain and creating a new meandering channel. With the exception of a small section of UT2, the restored streams were designed as Rosgen "E" channels with design dimensions based on those of reference parameters. The upper project reach on UT2 was designed as an "E" channel while the lower section of the project reach (approximately 200 feet) was designed as a "B" channel. The preserved reach on UT3 was determined to be a "B" channel that transitions to an "E" channel.

The design for restored sections of the streams involved the construction of new, meandering channels across excavated floodplains. This new channel system was constructed through grassed fields. The

streams through the site were restored to a stable dimension, pattern, and profile. Total stream length across the project was increased from approximately 6,191 LF to 6,305 LF. The design allows stream flows larger than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing streambank stress. Instream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. Rootwad and log vane structures will protect streambanks and promote habitat diversity in pool sections. Constructed riffles were used to promote both hydraulic and habitat heterogeneity to the channel. Where grade control was a design consideration, constructed riffles were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants provided immediate living root mass to increase streambank stability and create shaded holding areas for fish and other aquatic biota. Native vegetation was planted across the site, and the entire mitigation site is protected through a permanent conservation easement. Table 1 summarizes project data for each reach and restoration approaches used.

Table 1. Project Mitigation Components

Blockhouse Creek Mitigation Project-#D06027-A

Project Segment or Reach ID	Existing Feet/ Acres	Type	Approach	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Blockhouse Cr. Reach 1	887 LF	R	P2	1070 LF	1.0	1,070	0+00-10+70	Meandering channel construction; excavation of floodplain
Blockhouse Cr. Reach 2	340 LF	R	P2	340 LF	1.0	340	10+70-14+14	Meandering channel construction; excavation of floodplain
Blockhouse Cr. Reach 3	950 LF	E	I	950 LF	1.5	633	14+34-25+44	Constraints prevented restoration; bankfull benches established, structures installed, pattern stabilized.
Blockhouse Cr. Reach 4	1,821 LF	R	P2	1,780 LF	1.0	1,780	28+37-46+15	Meandering channel construction; floodplain excavation
UT 1	523 LF	R	P2	580 LF	1.0	580	0+00-5+80	Meandering channel construction; floodplain excavation
UT 2	1,240 LF	R	P2	1,155 LF	1.0	1,155	0+00-11+74	Was incised at lower end, upper 1000 LF realigned to a more stable pattern with only minor floodplain grading
UT 3	430 LF	P	-	430 LF	5.0	86	0+00-4+30	No channel alteration (preservation)

Mitigation Unit Summations

Stream (LF)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment
5,644	NA	NA	NA	8.6	

1.3 Project Location

The Blockhouse Creek mitigation site is located on the Foothills Equestrian Nature Center (FENCE) property approximately three miles east of Tryon, in Polk County, North Carolina. From Asheville take I-26 South to South Carolina Exit #1 and turn right toward Landrum, S.C. Go 1.5 miles, and turn right onto Bomar Road (look for the Land Mart on the corner). Go one short block and turn right onto Prince Road. After 1.7 miles, turn left onto Hunting Country Road, just before the I-26 bridge. Go .5 mile to the FENCE entrance on the left or another .1 miles (going under I-26) to the second entrance on the right. The Blockhouse Creek site starts at near the horse stables accessed through the first entrance and below the first culvert under the steeplechase course. Figure 1 illustrates the physical location of the project site.

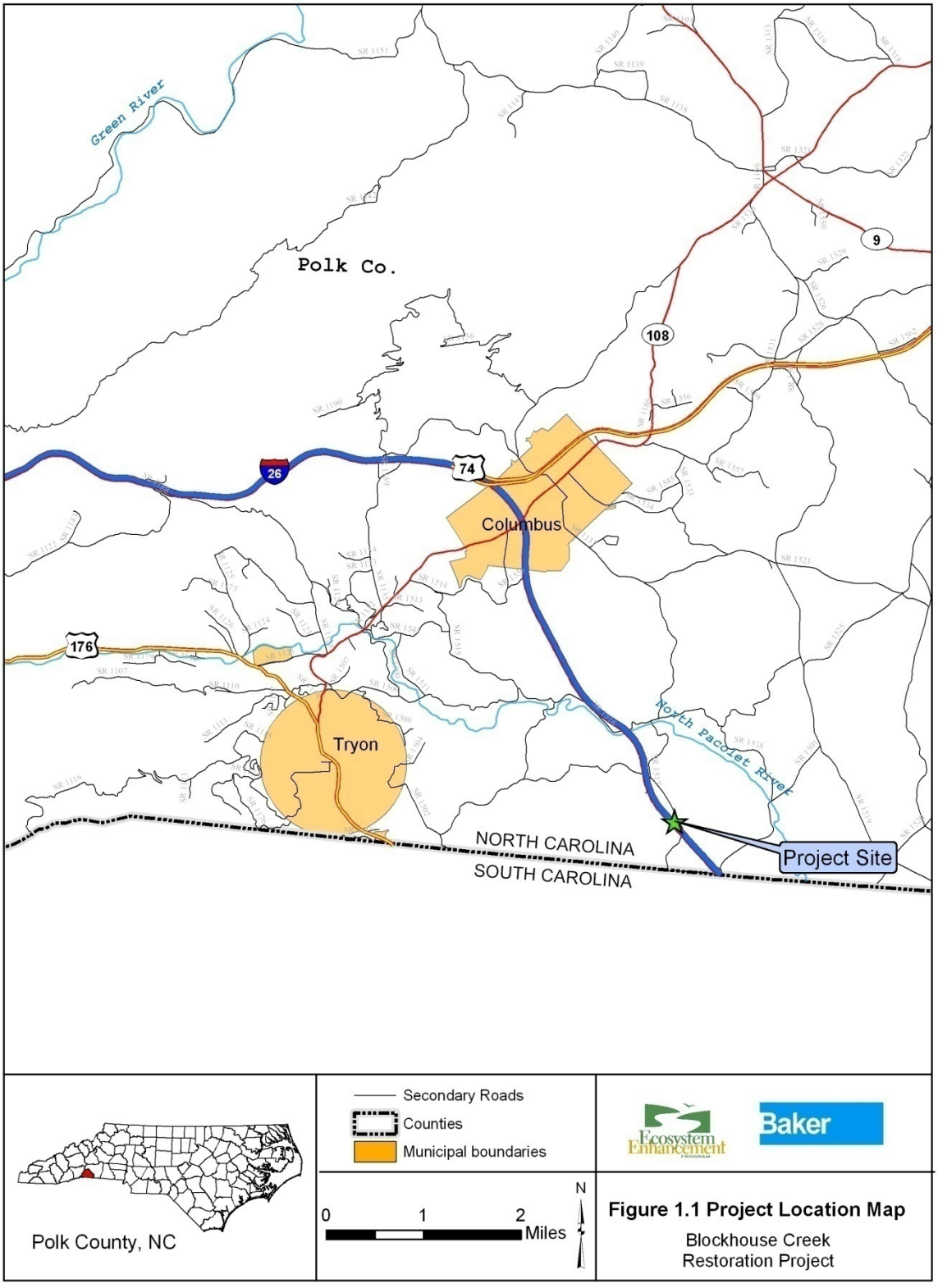


Figure 1.1 Project Location Map

Blockhouse Creek
Restoration Project

1.4 History and Background

The Blockhouse Creek Mitigation Site is located within the Foothills Equestrian Nature Center (FENCE), approximately three miles east of Tryon, in Polk County, North Carolina. The project site is situated in the Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-06 and United States Geologic Survey (USGS) hydrologic unit 03050105150020.

Since the late 1980s, the project area has been used as an equestrian/recreational complex. Surrounding lands are currently used for pasture land, hay production and residential use. Prior to the establishment of an equestrian and nature center, the FENCE property was used for agriculture activities and timber production. At that time, riparian buffers were removed and streams were channelized which was a common practice. There is also evidence on some tributaries of ephemeral gullies which most likely resulted from clear cutting. More recent development in the watershed has resulted in additional changes to Blockhouse Creek and its tributaries. Construction of the equestrian facility, nature trails and Interstate 26 required the installation of bridged and culverted stream crossings that have been detrimental to stream stability. These structures have also impacted the flow pattern and velocity of the project streams, resulting in changes to the cross-sectional area, and often facilitating the deepening of the channel. This deepening of the channel resulted in the streams becoming incised and losing their connection to the adjacent floodplain.

In accordance with the approved mitigation plan for the site, construction activities began in January 2008. Project activity on Blockhouse Creek and UT1 and UT2 consisted of making adjustments to channel dimension, pattern, and profile. A primary design consideration for this project was to allow stream flows larger than bankfull to spread onto a floodplain, dissipating flow energies and reducing streambank stress. The design for most of the restoration reaches involved a priority II approach with the construction of new, meandering channels across a floodplain that was excavated to the bankfull elevation of the creek. The lower part of reach 4 was not incised and did not require this approach. Along this section the overly sinuous channel was realigned in a more stable pattern at the existing elevation. Total stream length across the project increased from approximately 6,191 LF to 6,305 LF.

Rootwads, rock and log vanes and other structures were used to protect streambanks and promote habitat diversity in pool sections. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants provided living root mass quickly to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire mitigation site is protected through a permanent conservation easement.

The chronology of the Blockhouse Creek mitigation project is presented in Table 2. The contact information for designers, contractors and plant material suppliers is presented in Table 3. Relevant project background information is presented in Table 4. The total stream length on restoration and enhancement reaches, surveyed during Year 2 monitoring was 5,875 LF.

Table 2. Project Activity and Reporting History
Blockhouse Creek Mitigation Project-#D06027-A

Activity or Report	Data Collection Complete	Completion or Delivery
Categorical Exclusion Approved	---	January 2007
Conservation Easement Signed	---	September 2007
Mitigation Plan Approved	---	October 2007
Project Permit Approval	---	December 2007/ January 2008
Final Design-90%	---	October 2007
Construction		
`Upstream of Interstate-26	January 2008	March 2008
Downstream of Interstate-26	March 2008	May 2008
Permanent seed mix and riparian vegetation applied to project site		
Upstream of Interstate-26	January 2008	March 2008
Downstream of Interstate-26	March 2008	June 2008
Vegetation Plots , Crest Gauges and Photo Stations Established	July 2008	September 2008
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	July 2008	December 2008
Year 1 Monitoring	June 2009	November 2009
Year 2 Monitoring	June 2010	August 2010
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		

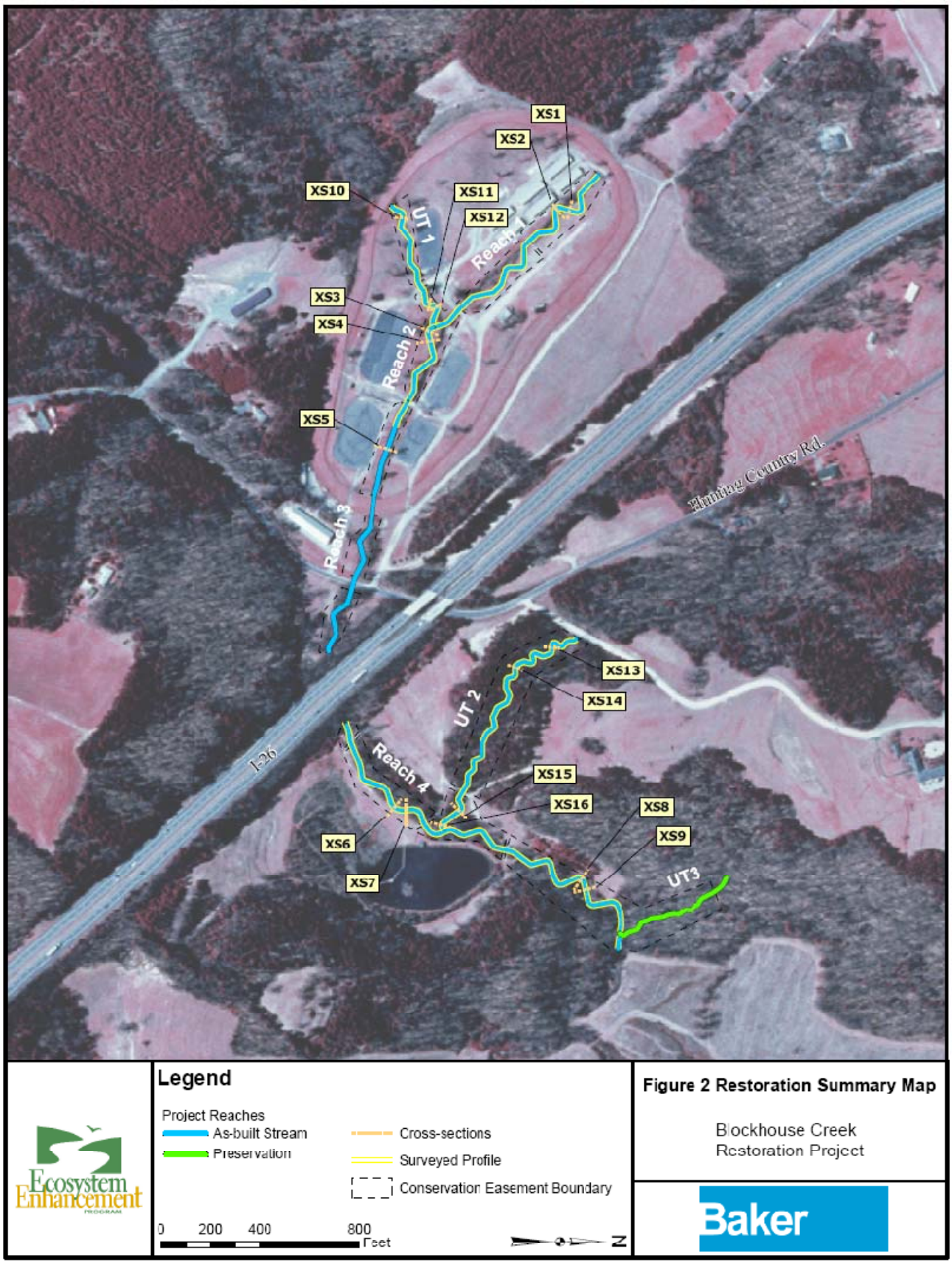
Table 3. Project Contacts Table Blockhouse Creek Mitigation Project-#D06027-A	
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27511 Contact: Will Pedersen, Tel. 919.459.9001
Planting & Seeding Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27511 Contact: George Morris, Tel. 919.459.9001
Seed Mix Sources	Green Resources
Nursery Stock Suppliers	Arborgen and Hillis Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Carmen McIntyre, Tel. 828.350.1408 x2010

Table 4. Project Background Table Blockhouse Creek Mitigation Project-#D06027-A	
Project County	Polk County, NC
Drainage Area (Square Miles or Acres)	
Blockhouse Creek Reach 1	1.63 mi^2
Blockhouse Creek Reach 2	1.97 mi^2
Blockhouse Creek Reach 3	2.21 mi^2
Blockhouse Creek Reach 4	2.44 mi^2
UT 1	211.2 Ac.
UT 2	57.6 Ac.
UT 3	38.4 Ac.
Drainage impervious cover estimate (%)	<1%
Stream Order	Second Order
Physiographic Region	Piedmont Province. Borders Blue Ridge Escarpment
Ecoregion	Southern Inner Piedmont

Table 4. Project Background Table Blockhouse Creek Mitigation Project-#D06027-A	
Rosgen Classification of As-built	
Blockhouse Creek Reach 1	C4
Blockhouse Creek Reach 2	C4
Blockhouse Creek Reach 3	E4/Bc4
Blockhouse Creek Reach 4	E4
UT 1	C4
UT 2	Bc5 (upper)/Cb (lower)
UT 3	B-E (lower)
Cowardin Classification	Riverine
Dominant Soil Types	
Blockhouse Creek Reach 1	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 2	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 3	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 4	Chewacla Loam, Pacolet Sandy Clay Loam, Rion Sandy Loam
UT 1	Chewacla Loam, Pacolet Sandy Clay Loam
UT 2	Pacolet Sandy Clay Loam,
UT 3	Chewacla Loam, Pacolet Sandy Clay Loam
Reference Site ID	Reference reach used for upper portion of project area located 350 LF upstream of project. Big Branch, Surry County was also identified in the NCDOT reference reach database as a suitable reference for design ratios
USGS HUC for Project and Reference Sites	Blockhouse Creek HUC#: 03050105 Big Branch HUC#: 03040101
Any portion of project segment(s) on NC 303d List?	No
Any portion of project upstream of a 303d Listed Segment?	No
Reasons for 303d Listing or Stressor	N/A
% of Project Easement Fenced	0, area demarcated with rope and posts but not a livestock fence.

1.5 Monitoring Plan View

The monitoring plan view for Blockhouse Creek and its tributaries is included in Appendix C. The plan set provides a view of channel pattern as well as the location of structures designed to aid in dimension and profile stability. Other features shown on the plan view include the location of crest gauges, vegetation monitoring plots, cross-sections, reference photo stations, and the location of maintenance and repair work completed. Figure 2 depicts the project streams, easement boundaries and monitoring reference data.


XS1
XS2
XS10
XS11
XS12
UT 1
Reach 1
XS3
XS4
Reach 2
XS5
Reach 3
Fleming Country Rd.
XS13
XS14
UT 2
I-26
Reach 4
XS15
XS16
XS8
XS9
XS6
XS7
UT3
Legend
Project Reaches
As-built Stream
Preservation
Cross-sections
Surveyed Profile
Conservation Easement Boundary
0 200 400 800
Feet
N
Ecosystem Enhancement Program
Figure 2 Restoration Summary Map
Blockhouse Creek
Restoration Project
Baker

2.0 YEAR 2 PROJECT CONDITION AND MONITORING RESULTS

The five-year monitoring plan for the Blockhouse Creek Site includes criteria to evaluate the success of the vegetative and geomorphic components of the project. The specific locations of vegetation plots, permanent cross-sections, and crest gauges are shown on the Year 2 monitoring plan sheets (Appendix C). Photo points, located along the stream mitigation project, are also shown.

2.1 Vegetation Assessment

2.1.1 Description of Vegetative Monitoring

As a final task of construction, the stream margins and riparian area of the Site were planted with bare root trees, live stakes, and an herbaceous seed mixture of temporary and permanent ground cover vegetation. The woody vegetation was planted randomly ten to thirteen feet apart from the top of the stream banks to the outer edge of the project's easement limits. Bare-root trees were planted at a target density of 680 stems per acre and planting was completed in May 2008. Species planted and as-built densities are summarized in Table 5.

The permanent seed mix of herbaceous species applied to the project's riparian area included soft rush (*Juncus effuses),* creeping bentgrass (*Agrostis stolenifera),* virginia wild rye (*Elymus virginicus),* wild bergamot (*Monarda fistulosa),* smartweed (*Polygonum pennsylvanicum),* beggars tick seed (*Bidens frondosa),* indian grass (*Sorgastrum nutans*), fox sedge (*Carex vulpinoidea*), deer tongue (*Dichanthelium clandestinum*), big bluestem *(Andropogon gerardii)* and black eyed susan *(Rudbeckia hirta)*.

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, 10 vegetation monitoring quadrants were installed across the mitigation site to predict the survival rate of the bare-rooted trees. On a designated corner within each of the ten vegetation quadrants, one herbaceous plot was also delineated. Mortality will be determined from the difference between the previous year's living, planted trees and the current year's living, planted trees. The size of individual quadrants is 100 square meters for woody tree species. The herbaceous plots measure 1 square meter in size and are located within the larger vegetation quadrants established. Individual seedlings within each plot were flagged to facilitate locating them during future monitoring events. Each seedling was also marked with aluminum tags to ensure that the correct identification is made during future monitoring of the vegetation plots. The plots were randomly located to represent the different areas within the project. The locations of the ten vegetation plots are presented in Appendix C.

2.1.2 Vegetative Success Criteria

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. Herbaceous cover is photographed annually during the growing season to provide a record of the density of ground cover derived from the riparian seed mix applied. If the measurement of vegetative density proves to be inadequate for assessing plant community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCEEP.

Table 5. Rooted trees, live stakes and seeding planted in the riparian zone of Blockhouse Creek Blockhouse Creek Mitigation Project-#D06027-A		
The species composition for two different areas is shown; with one area being upstream of I-26 and the second area being downstream of I-26.		
Planting Plan		
Scientific name	Common name	Percent Planted by Species
Blockhouse Creek upstream of I-26 and UT1 (40% trees/ 60% shrubs) planted at 680 stems/A		
Trees - Planted 13'x13'		
Acer rubrum	Red maple	13%
Fraxinus pennsylvanica	Green ash	13%
Juglans nigra	Black walnut	13%
Liriodendron tulipfera	Tulip poplar	0.5%
Platanus occidentalis	Sycamore	0.5%
Understory Trees/Shrubs- Planted 10'x10'		
Alnus serrulata	Tag alder	9%
Calicanthus floridus	Sweet shrub	10%
Cornus florida	Flowering dogwood	12%
Cercis Canadensis	Redbud	10%
Carpinus caroliniana	Ironwood	9%
Asimina triloba	Paw paw	9%
Blockhouse Creek downstream of I-26 and UT2 (60% Trees/ 40% shrubs) planted at 680 stems/A		
Trees - Planted 10'x10'		
Acer rubrum	Red maple	4%
Diospyros virginiana	Persimmon	6%
Juglans nigra	Black walnut	12%
Liriodendron tulipfera	Tulip poplar	10%
Platanus occidentalis	Sycamore	10%
Prunus serotina	Black cherry	6%
Quercus phellos	Willow oak	6%
Quercus rubra	Red oak	6%
Understory Trees/Shrubs- Planted 13'x13'		
Alnus serrulata	Tag alder	6%
Calicanthus floridus	Sweet shrub	6%
Cornus florida	Flowering dogwood	9%
Cercis Canadensis	Redbud	8%
Carpinus caroliniana	Ironwood	6%
Asimina triloba	Paw paw	5%
Woody Vegetation for Live Stakes - Planted 3’ x 3’ on center		
Salix sericea	Silky willow	30%
Physocarpus opulifolius	Ninebark	25%
Sambucus Canadensis	Elderberry	15%
Cornus amomum	Silky dogwood	30%
Note: Species selection may change due to availability at the time of planting.		

2.1.3 Vegetation Observations and Results

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has generally provided good ground coverage. Live stake, bare root trees, and live brush in the geolift structures have also flourished and are contributing to streambank stability. Bare-root trees were planted throughout the conservation easement with the exception of the preservation reach. A 30-foot buffer was established along of the majority of the restored stream and the width exceeds this minimum in most places. However at crossings the easement "pinches" in to meet the crossing structure and along one section of Reach 3 the easement on the left bank is less than 30 feet due to existing constraints; however, the total width is greater than 60 feet.

Tables A.1. through A.6. in Appendix A present vegetation metadata, vegetation vigor, vegetation damage and stem count data of the monitoring stations at the end of the Year 2 monitoring period. Data from the Year 2 monitoring event of the ten vegetation plots showed a range of 440 to 1,000 stems per acre. The data showed that the plots had an average of 680 stems per acre. Based on these results, this site is on track to meet the success criteria of 320 stems per acre at the end of monitoring Year 3.

Trees within each monitoring plot are flagged regularly to prevent planted trees from losing their identifying marks due to flag degradation. It is important for trees within the monitoring plots to remain marked to ensure they are all accounted for during the annual stem counts and calculation of tree survival. With the exception of Vegetation Plots #2 and #4, no significant volunteer woody species were observed in the vegetation plots. Volunteer species observed consist of green ash *(Fraxinus pennsylvanica)*, willow (*Salix sericea)*, river birch (*Betula nigra*) and black locust (*Robinia Pseudoacacia*). Vegetation Plot #4 contained the most volunteer species which is likely due to its proximity to an existing wooded buffer along Blockhouse Creek and the additional water it receives from a sprinkler system located nearby. Several trees that were initially planted during 2008 and not previously spotted in Plot #4 have also reached a sufficient height and diameter to be monitored. The tops of these trees initially died; however, they subsequently sprouted from the root and have produced new trunks and are now growing.

2.1.4 Vegetation Problem Areas

Despite flood conditions during the year, no woody vegetation problem areas were identified during Year 2 monitoring. The project area had suffered from a number of drought years at the time planting initially occurred. However, mortality rates for planted woody vegetation appear to be low, though some sections of the project have experienced higher rates of mortality as evidenced by the vegetative plot data listed in Appendix A. Although the density of herbaceous cover varies across the site, conditions observed on-site during the Year 2 monitoring surveys indicate continued improvement in vegetative cover. Drought conditions almost certainly contributed to some of the initial mortality observed among the woody vegetation. However, survival rates of the established plots indicate that plantings across the easement area are of sufficient density to meet regulatory requirements, as well as the site stabilization and habitat enhancement goals originally set forth in the mitigation plan. It is expected that site vegetation will continue to improve given that we continue to experience good weather conditions as the buffer matures during the next several years.

2.1.5 Vegetation Photographs

Photographs are used to visually document vegetation success in sample plots. A total of ten sample sites were established to document tree conditions and herbaceous coverage at each vegetation plot across the Site. Reference photos of tree and herbaceous condition within plots are taken at least once per year. Photos of the plots are included in Appendix A of this report.

2.2 Stream Assessment

2.2.1 Description of Geomorphic Monitoring

Geomorphic monitoring of restored stream reaches is being conducted over a five year period to evaluate the effectiveness of the restoration approach used. Monitored stream parameters include channel dimension (cross-sections), profile (longitudinal survey), bed composition, bank stability, bankfull flows and stability of reference sites documented by photographs. Crest gauges, as well as high flow marks, will be used to document the occurrence of bankfull events. The methods used and any related success criteria are described below for each parameter. The location of permanent cross-sections and crest gauges is shown on the Year 2 monitoring plan sheets in Appendix C.

2.2.2 Morphometric Success Criteria

2.2.2.1 Cross-Sections

Sixteen permanent cross-sections selected for monitoring were located in representative riffle and pool reaches on Blockhouse Creek, UT1 and UT2. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark is used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys includes points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections are classified using the Rosgen Stream Classification System.

There should be little change in the cross-sections between years. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio).

2.2.2.2 Longitudinal Profile

A longitudinal profile was completed for the restored streams to provide a baseline for evaluating changes in channel bed condition over time. A longitudinal profile was conducted for the entire project length of UT1 and UT2. An additional 3,396 linear feet of stream channel was surveyed on Blockhouse Creek, including the upper 1,500 feet above I-26 and the entire length below I-26. Longitudinal profiles will be replicated annually during the five year monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, inner berm, bankfull, and top of low bank, if the features were present. Each of these measurements was taken at the head of each feature (e.g., riffle, or pool) and the maximum pool depth. Elevations of grade control structures will also be included in longitudinal profiles surveyed. All surveys were tied to a permanent benchmark of know elevation. Cross-section and longitudinal profile data are provided in Appendix B.

The longitudinal profiles should show that the bed features are remaining stable and are not aggrading or degrading. The pools should remain deep with flat water surface slopes, and the riffles should remain steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the stream type that the design was based on.

2.2.2.3 Bed Material Analyses

Bed material analyses will include pebble counts taken during each geomorphic survey. Pebble counts will provide data on the particle size distribution of the stream bed. These samples may reveal changes in sediment gradation that can occur over time as the stream adjusts to the constructed channel and to its sediment load. Significant changes in the particle size distribution will be evaluated with respect to stream stability and watershed changes.

2.2.3 Morphometric Results

2.2.3.1 Cross-Sections

As-built cross-section monitoring data for stream stability was collected during May and June 2008. The sixteen permanent cross-sections along the restored channels were re-surveyed to document stream dimension for Monitoring Year 2. Cross-sectional data is presented in Appendix B and the location of cross-sections is shown on the plan sheets in Appendix C.

As noted in the vegetation monitoring section, the Blockhouse Creek mitigation site experienced drought conditions for several years leading up to the construction of the project. However, 2009 was a wetter year; some cross-section and profile data collected reflect bank overflow conditions, the development of low innerberm features as well as deposition on point bar features on the inside bank of meander bends. The cross-sections show that there has been little to no adjustment to stream dimension since construction. Cross-sections 1, 8, and 9 on Blockhouse Creek and Cross-sections 10-12 and 14 and 16 on UT1 and UT2 respectively, exhibited slight signs of aggradation or adjustment of channel dimension via deposition from overbank flow conditions, but are otherwise stable. Cross-section 1 exhibits minor filling in from deposition. In addition to the cross-sections noted, changes at Cross-section 5 between the As-built Monitoring Year and Monitoring Years 1 and 2 may in part be attributable to the fact that the cross-section pin was disturbed and had to be relocated. At Cross-section 5, the original right bank pin could not be located where the cross-section was surveyed on the right bank in 2008. Cross-section 5 data for Monitoring Years 1 and 2 show that little change has occurred at this location within the last year, which would be expected given the stability of the channel and vegetated buffer conditions present at this location on Blockhouse Creek.

Cross-section 8 was surveyed at a pool that was filled in as a result of bank failure on the left bank. Cross-section 9 also exhibits some filling in of the channel, most likely from sediment input as a result of the bankfull events that cleaned out the box culverts under I-26 and subsequent bank failure along isolated meanders downstream of the culverts. These pools should reestablish themselves in the coming years and this should be evident with subsequent monitoring.

All cross-sections (10-12) on UT1 exhibit more narrow bankfull widths and deposition along one or both banks as a result of the bankfull events that occurred on-site since the completion of Year 1 monitoring. A tree was down at Cross-section 14 on UT2, contributing to local aggradation along this subreach of UT2. This tree was removed during Year 2 monitoring and it is expected that the channel profile will return to a dimension similar to that of the As-built survey once aggraded materials trapped by the tree are transported downstream. The last cross-section on UT2, Cross-section 16, shows deposition on the inside of a meander as a result of bankfull conditions experienced at the Site since November 2009. The remaining cross-sections did not indicate any changes in dimension compared to Year 1 monitoring conditions and appeared to be stable with the help of in-stream structures, adequate bank sloping and developing vegetation.

2.2.3.2 Longitudinal Profile

Longitudinal profiles for Year 2 were surveyed during spring 2010 and are compared to the data collected during previous monitoring years. Profiles of the various project reaches are presented in Appendix B.

The longitudinal profile for Blockhouse Creek upstream of Interstate 26 has remained stable over a large percentage of Reaches 1-3 and has not changed significantly since the as-built survey was completed in 2008. The longitudinal profile for Reach 2 of Blockhouse Creek reflects the presence of a sandbag weir at station 14+31which has backed up water within the channel. This was done by the landowner in order to pump water from the creek to wet down equestrian riding rings. Repair work at survey station (Sta.) 11+10 to 11+40 in Reach 2 of Blockhouse Creek was necessary to stabilize a bank that failed during the aforementioned flooding. The unconsolidated nature of the soils present and immature vegetation along the streambank appear to have been susceptible to overbank flows along this, and other meanders that experienced bank failures at the Site. Bank grading, matting, and installation of a geolift downstream of the existing rootwad should provide greater bank stability in the future. The channel profile and habitat diversity in this location should also be improved as the pool feature of this meander was re-established. Repairs in Reach 3 of Blockhouse Creek also consisted of bank stabilization measures as well as the re-establishment of grade control features at Sta. 22+75, Sta. 23+50 and Sta. 25+20, located just upstream of the box-culverts under I-26.

As was the case in Monitoring Year 1, Reach 4 of Blockhouse Creek, located immediately downstream of Interstate 26, exhibited areas of slight aggradation. The most notable source of aggraded material is a triple box-culvert located under I-26 that was partially plugged (two of the three culverts were more than 40% filled) with sediment during Year 1 monitoring. The on-site flooding cleared the sediments that were previously plugging the culverts, moving all of this material into Reach 4. Several isolated meanders were repaired in Reach 4, beginning with Sta. 33+33 as listed in Table 7. However, Blockhouse Creek appears capable of transporting the aggraded material and other particles downstream and the amount of aggraded material present within Reach 4 is not of sufficient volume to significantly diminish the hydraulic properties and habitat diversity of the stream.

Although wrack lines and bank deposition indicate UT1 experienced bankfull flows since Year 1, the tributary does not appear to have undergone any considerable profile changes and is thus relatively stable. UT2 did not contain flow during the As-built survey but at the time of the Year 2 survey had a bold flow. Compared with the as-built survey, UT2 appears to have degraded slightly above and below a wetland complex adjacent to the project area. However, it is likely that the “downcutting” is attributable to the small tributary experiencing periodic flow sufficient to flush the tributary of excess fine bed material. Visual observations and cross-sections confirm channel overflow in areas, and overbank flow was sufficient to be recorded on a crest gauge located on UT2. The channel slope on UT2 was designed to be gradual in the vicinity of the wetland as compared to other sections of UT2 to avoid impacts to the hydrology of the site. As a consequence, there is little change in the profile in this area when compared to the As-built survey.

In-stream structures installed within the restored stream included constructed riffles, log vanes, boulder steps, and root wads. Visual observations of these structures through the second year indicate that most structures have functioned as designed and are holding their elevation and grade. Log vanes placed in meander pool areas have provided scour to keep pools deep and provide cover for fish. Boulder steps maintained step-pool spacing and facilitated transitions in channel slope at the confluence of UT2 to Blockhouse Creek. In addition to providing grade control, the boulder steps also provide bedform diversity, improving in-stream habitat. Rootwads placed on the outside of meander bends have provided bank stability and in-stream cover for fish and other aquatic organisms in many

locations of the project area. Although some of the outer meanders protected by rootwads had to be repaired, the rootwads have generally held up as designed. Where damage occurred this was due to flows that completely spanned the floodway and scour resulted from high flows over and around the rootwad. Additional geolifts have been added to some meanders throughout the project area on Blockhouse Creek to provide further stabilization to banks along outer meanders.

2.2.3.3 Bed Material Analyses

Pebble count data collected in several project reaches indicate Blockhouse Creek and its tributaries continue to transport particles roughly the same size or larger as those found during as-built surveys (Table B2., Appendix B). A pebble count was not performed on UT2 due to the dominance of silt and sand as the bed material in this channel. Visual observation of Blockhouse Creek and its tributaries and a review of pebble count data collected did not yield any signs that sediment transport functions have been hampered by the mitigation project. In fact, the pebble count data indicates that there is a coarsening of the stream bed which is an indication that the stream is moving fines through the system and larger pebbles are making up a greater % of the bed material.

2.2.4 Hydrologic Criteria

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gauges and photographs of high flow lines. Three crest gauges were installed on the floodplain within 10 feet of the restored channels and with the bottom of the gage at approximately bankfull. One crest gauge was placed on UT 2, while 2 gauges were set up on Blockhouse Creek (upstream and downstream of I-26). The first gauge on the main channel was set up on the right bank below the confluence of UT 1 and Blockhouse Creek. The second crest gauge was set up, at the downstream end of the project, just upstream of the confluence of UT3 and Blockhouse Creek on the right bank. The crest gauge on UT2 was placed above the vehicle crossing at the lower end of the tributary. The crest gauges will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during site visits.

Two bankfull flow events must be documented within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring may have to be continued until two bankfull events have been documented in separate years.

2.2.5 Hydrologic Monitoring Results

Three greater-than bankfull events were recorded during the Year 2 monitoring period. Table 6 provides information on the approximate height of the flow events as recorded on dowel rods within each crest gauge. The bottom of the crest gauge is approximately at the bankfull elevation, so flows at bankfull may not register. As we continue to monitor the site, a determination will be made as to whether the crest gauges will be lowered to better detect flows at bankfull.

Table 6. Verification of Bankfull or Greater Than Bankfull Events
Blockhouse Creek Restoration Project-#D06027-A

Date of Data Collection	Date of Event	Method of Data Collection	Gauge Watermark Height (inches)[1]		
			Blockhouse Cr. Reach 2	Blockhouse Cr. Reach 4	UT2
April 2010	Mid Nov. 2009	Gauge measurement. Visual inspection of wrack lines and sediment deposition around gauge.	4.75	2.25	2.81

Table 6. Verification of Bankfull or Greater Than Bankfull Events Blockhouse Creek Restoration Project-#D06027-A					
April 2010	Mid Nov. 2009	Gauge measurement. Visual inspection of wrack lines.	7.38	4.81	6.75
April 2010	March-April 2010	Gauge measurement. Visual inspection of wrack lines.	9.69	10.69	8.94

2.2.6 Stream Problem Areas

A few areas of concern had been noted in the past at the project site, some of which are not related to a specific point on the channel. Overland flow that the site experiences above Interstate 26 continues to be somewhat of a concern. Due to the buildings on this site and the high compaction of the soil from heavy use by horse show participants, the runoff from the land adjoining the stream is high. This has not affected the channel proper but continues to be a source of some minor rutting along terrace slopes leading down to the floodplain. In October 2008, Baker and FENCE submitted a grant funding application to the N.C. Clean Water Management Trust Fund for a project that would address this issue, but the grant was not funded. Although the threat overland flow poses to stream quality will be mitigated as the riparian buffer matures, the implementation of additional measures that may reduce the rate and intensity of stormwater runoff would provide many benefits to FENCE and this project stream.

The second concern previously noted was that two of the three box culverts under Interstate 26 were two thirds full of sediments. As noted in the As-built Report, during high flow events this sand mobilizes into the channel downstream of the interstate. This has caused some pools to fill with aggraded material, causing a loss of pool size and depth. The flooding experienced during the winter of 2009-2010 were of sufficient flow and intensity to clean these culverts out. Some of the aggradation present at the time of the Year 2 monitoring survey is likely a result of the release of this sediment as well as the isolated areas of bank instability.

As previously stated, a series of maintenance and stabilization measures were implemented during the Year 2 monitoring event. Table 7 provides a synopsis of the likely cause for bank instability observed as well as a description of maintenance and repair work completed. Included within the list of work completed was the removal of several beaver dams on Blockhouse Creek. In total, five beaver dams located at stations 12+65, 16+10, 16+90, 35+35 and 37+90 were removed. Beaver activity has been observed elsewhere on Blockhouse Creek prior to restoration and enhancement efforts. Baker will monitor the Site periodically throughout the remainder of the project period to monitor beaver activity. If they continue to be a problem we will develop a plan for addressing their impacts or for their removal.

Table 7. Monitoring Year 2 Project Repairs and Maintenance Work Blockhouse Creek Mitigation Project-#D06027-A		
Station	**Issue: Suspected Cause**	**Repairs/Maintenance Performed**
2+15	Scour-Flood events	Minor hole on floodplain filled
3+80	Scour- Flood events	Bank reshaped and livestaked
5+22	Scour- Flood events	Minor repair of bank at end of geolift
6+40	Scour- Flood events	Large hole on floodplain filled
11+10	Scour- Flood events	Geolift installed to address bank failure
12+65	Beaver habitation in project site	Beaver dam removal

Table 7. Monitoring Year 2 Project Repairs and Maintenance Work Blockhouse Creek Mitigation Project-#D06027-A		
16+10	Beaver habitation in project site	Beaver dam removal
16+90	Beaver habitation in project site	Beaver dam removal
19+65	Bank erosion- Flood events	Additional livestakes added
20+72	Fallen tree	Removal of fallen tree
22+75	Flood events	Reset boulders under tree and in grade control structure
23+45	Flood events	Install grade control structure
25+26	Scour- Flood events	Reset boulders under tree and re-install grade control structure
33+33	Scour- Flood events	Extend geolift to address bank failure
35+35	Beaver habitation in project site	Beaver dam removal
37+90	Beaver habitation in project site	Beaver dam removal
41+00	Bank erosion- Flood events	Sloping, matting and livestaking
41+20	Bank erosion- Flood events	Install geolift to address small bank failure
42+17	Overland flow and bank erosion	Repair area behind rootwad, matting, install more livestakes
42+70	Minor bank erosion- Flood events	Sloping, matting and livestaking
44+40	Minor bank erosion- Flood events	Sloping, matting and livestaking

A small sandbag weir located at Station 14+31 has resulted in an alteration of riffle-pool dimensions and sequencing in Reach 2 of Blockhouse Creek. While no structures have been adversely impacted by the dam, much of Reach 2 is now a pool. If a breach were to occur, it is possible that high flow could damage some of the woody vegetation present on both downstream banks. Although this weir is located within an easement break, Baker has been in communication with the U.S. Army Corps of Engineers regarding the weir. We have submitted a letter to the Director of FENCE requesting that the dam be removed and will continue to monitor the situation. It is possible that we will need to modify a cross-vane just above this location to provide greater convergence and greater pool scour. This will provide the depth needed for the landowner to do their temporary irrigation pumping during horse shows.

Based on the data collected, riffles, pools and other constructed features along the restored channel are stable and are functioning as designed. Structures installed to enhance pool habitat are stable and functioning. However, the full functioning of some structures is being impaired by slight aggradation, particularly downstream of the box culvert under Interstate 26 and areas of UT2 where channel slope modification was limited due to the presence of a nearby wetland. Precipitation events sufficient to transport aggraded materials through the project area will eventually improve pool features that have been impacted by the flushing of sediments from the boxed culverts. Beyond the issues noted above, no areas of concern have been identified during the second year following completion of the project. All identified concerns have been addressed at this point. Overall, the site is on track to achieve the success criteria specified in the Site Mitigation Plan.

2.2.7 Stream Photographs

Photographs are used to document restoration success qualitatively. Reference stations were photographed during the as-built survey and will be monitored for five years following construction. Reference photos are taken once a year, from a height of approximately five to six feet. Permanent markers installed will ensure that the same locations (and view directions) are utilized during each monitoring period. Reference photographs of the project streams are shown in Appendix B.

2.2.7.1 Lateral Reference Photos

Reference photo transects were taken of the right and left banks at each permanent cross-section. For each stream bank photograph, a survey tape was centered in the frame which represents the cross-section line located perpendicular to the channel flow. The water line was located in the lower edge of the frame in order to document bank and riparian conditions. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.2.7.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored stream are included within the photographs taken at reference photo stations. Photographers will make every effort to consistently maintain the same area in each photo over time.

Lateral and structure photographs are used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and effectiveness of erosion control measures. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

Photographs of the restoration project were taken in May and June 2010. The photographs illustrate generally stable conditions across the project site. Vegetative growth along the streambanks and riparian buffers has improved since construction was completed in 2008. Structures are functioning as designed although some structures have been affected in varying degrees by multiple bankfull events and the periodic release of aggraded material from the boxed-culverts under I-26. The location of these structures are referenced in Table 7.

2.2.8 Stream Stability Assessment

To aid the NCEEP in evaluating the risk of erosion from changes in channel and bank stability and subsequent sediment yield from the project area, Baker will assign numeric values to streambank and channel features. This will occur during Year 5 of the monitoring period. These numeric scores will be derived using the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) evaluation methods. The scores will then be used to evaluate channel stability and project sediment export. Results from an annual visual stability assessment are provided in Appendix B.

2.2.9 Quantitative Measures Summary Tables

The quantitative pre-construction, reference reach, and design data used to determine restoration approach, as well as the As-built baseline data used during the project's post-construction monitoring period are summarized in Appendix B.