CLEGHORN CREEK STREAM RESTORATION PROJECT

ANNUAL MONITORING REPORT FOR 2010 (YEAR 5)

Project Number: D-04010

Submitted to:

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EXECUTIVE SUMMARY

This Annual Report details the fifth year monitoring activities on the Cleghorn Creek Stream Restoration Site ("Site"). Construction of the Site, including planting of trees, was initially completed in May 2006. 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. Despite routine repairs over the course of the monitoring period to address impacts related to beaver habitation in the project reaches, vegetative and geomorphic data collected in October 2010 show this Site meets the hydrologic, vegetative, and stream success criteria specified in the Cleghorn Creek Restoration Plan.

The Cleghorn Creek Site was restored through a contract with EBX Neuse-I, LLC (EBX), who is in turn, under contract with the North Carolina Ecosystem Enhancement Program (NCEEP) to develop Stream Mitigation Units from stream restoration efforts conducted on-site. Prior to restoration, stream and riparian functions on the Site were impaired as a result of adjacent agricultural land uses, including livestock grazing. The streams on the Site were channelized and riparian vegetation had been cleared. Cattle were allowed to graze on the banks and had unrestricted access to the channels. As-built surveys conducted in July 2006 after completion of restoration work indicated that 5,196 linear feet of stream were restored on Cleghorn Creek and Charles Creek, a tributary to Cleghorn Creek, producing 5,196 stream mitigation units (SMU).

In order to document project success, five vegetation monitoring plots, eleven permanent cross-sections, two longitudinal profile surveys, and crest gauges were installed and assessed over the last five monitoring periods following the as-built survey.

The five vegetation monitoring plots, 100 square meters (m^2) (10m x 10m) in size, were used to predict survival of the woody vegetation planted on-site. These plots were randomly located to represent the different zones within the project site. Isolated bank stabilization work at the beginning of the 2007 growing season made it necessary to replant some of the site and re-establish the monitoring plots. The Year 5 vegetation monitoring documented an average survivability of 600 stems per acre and a range of 520 to 640 stems per acre. To ensure the survival of planted riparian vegetation, some maintenance in the riparian buffer was conducted in September 2010 to manage Johnsongrass (*Sorghum halepense*) and other invasives that were observed inside the restoration area. The vegetative monitoring data documents that the Site has met the final vegetation survival criteria of 260 stems per acre after the fifth growing season.

Cross-section and longitudinal surveys indicate the stream dimension and profile of Cleghorn Creek and Charles Creek have remained stable. Several pools, most of which are located in meanders on both streams, were noticeably deeper in 2009 as compared to previous monitoring events. These pools (most notably the pool at Cross-Section 4), are now slightly filled in as compared to 2009 and are similar to conditions present prior to Year 4 Monitoring. Some localized aggradation observed in both streams can be attributed to the presence of beaver dams. The site was periodically inspected between Years 4 and 5 of monitoring and multiple beaver dams on Cleghorn Creek and Charles Creek were removed.

In-stream structures have remained stable and riparian vegetation survival is good throughout the project site, despite continued beaver activity in the project area and major flooding during the winter of 2009-2010. At least two intact beaver dams were observed recently on Charles Creek and Cleghorn Creek, while remnants of several other dams were present, primarily on Charles Creek. The longitudinal profiles for Cleghorn Creek and Charles Creek illustrate the location of the two dams and the remnants of additional dams between stations 10+00 and 12+00 on Charles Creek.

Two isolated sections of unstable bank approximately 15- 25 feet in length were recorded on Cleghorn Creek upstream of the bridge crossing at stations 117+00 and 121+50. The source of the bank instability at station 117+00 is attributed to a point bar that has grown over the course of the monitoring period and is now acting as a mid-channel bar, forcing flow into the right bank, causing bank erosion. The source of bank instability along an approximately 15 foot section of the right bank at Station 121+50 is unknown; however, beaver activity is suspected of playing a role in the current condition of the bank. During winter 2010, these bank sections will be stabilized by resloping the banks and planting a series of tag alders or other woody vegetation. Based on the overall stability of both channels, no other maintenance or repair work is required at this time.

Three bankfull events were observed and documented during the As-built and Year 1 monitoring periods. Both Cleghorn Creek and Charles Creek suffered erosion damage during two of these flood events, the first in August 2006 and the second in January 2007. Two rounds of post construction repairs were conducted between November 2006 and April 2007. The third bankfull event occurred on March 2007 while the second round of repairs was in progress. No bankfull events were recorded during 2008. Another round of repairs was completed in the fall of 2008. These repairs included bank grading, bioengineering, matting, seeding, and re-planting at 11 sites on Cleghorn Creek. In May of 2009, the bankfull elevation along the last 100-feet of Charles Creek was lowered to match the bankfull elevation of Cleghorn Creek. Grading work performed should prevent Charles Creek from incising at this location. Riparian vegetation was temporarily moved while the bank elevation was adjusted and re-planted immediately once grading was completed. One or more bankfull events occurred on-site during the first two weeks of November 2009. Streamflow conditions were such that a moderate amount of sediment was deposited at or above bankfull elevations along both Cleghorn Creek and Charles Creek. Debris piles were also a common observance during the Year 4 survey. A minor flood event in 2010 was recorded on the crest gauge on Charles Creek. Streamflow conditions at the time of Year 5 monitoring were normal and there were no indications of recent flooding on-site.

Overall, it appears that the project has achieved the stream stability success criteria specified in the Restoration Plan for the site.

The monitoring plan and Year 5 monitoring data are discussed in Section 2.0 of this report. Vegetation monitoring plots were assessed in October 2010. Stream cross-section and profile data presented in this report were also collected in October 2010.

1.0 PROJECT BACKGROUND

The Cleghorn Creek restoration project involved the restoration or enhancement of 5,167 linear feet (LF) of channelized stream on Cleghorn Creek and Charles Creek, a tributary to Cleghorn Creek. Both Cleghorn Creek and Charles Creek are "blue-line" streams, as shown on the USGS topographic quadrangle for the site, and are considered to be perennial based on field evaluations using NCDWQ stream assessment protocols. A total of 24.33 acres of riparian buffer are protected through a permanent conservation easement.

1.1 Project Goals and Objectives

The goals for the restoration project are as follows:

- Create geomorphically stable conditions on Cleghorn Creek and Charles Creek;
- Restore hydrologic connections between creek and floodplain;
- Improve the water quality of Cleghorn Creek and Charles Creek;
- Improve aquatic and terrestrial habitat along the project corridor; and
- Deliver at least 5,167 LF of stream with restored channel dimension, pattern and profile.

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

- Restoration or enhancement of channel dimension, pattern and profile;
- Improved water quality in the Cleghorn 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 groundwater recharge, and improved and restored hydrologic connections; and
- 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, 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 connects 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. The restored streams were designed as Rosgen "E" channels with design dimensions based on those of reference parameters.

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 agricultural 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 4,641 LF to 5,196 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. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Willow transplants were used to provide immediate living root mass to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement. Table 1 summarizes project data for each reach and restoration approach used.

Table 1. Project Restoration Components
Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)

Project Segment or Reach ID	Existing Feet/ Acres	Type	Approach	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Cleghorn Creek Reach 1	3,055 LF	R	P2	3,424 LF	1.0	3,424	110+00-144+24	Meandering channel construction; excavation of floodplain
Cleghorn Creek Reach 2	346 LF	R	P2	346 LF	1.0	346	144+24 to 147+70	Meandering channel construction; excavation of floodplain
Charles Cr.	1,240 LF	R	P2	1,426 LF	1.0	1,426	110+00-124+50	Meandering channel construction; excavation of floodplain

Mitigation Unit Summations

Stream (LF)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment
5,196	NA	NA	NA	24.33	Project exceeds contracted mitigation units (5,167)

Notes: Stationing corresponds to stationing on plans, not stationing used in longitudinal profile surveys as profile surveyed during monitoring does not begin at upper limit of the project area.

1.3 Project Location

The Cleghorn Creek mitigation site is located in Rutherford County, North Carolina (Figure 1) and lies in the Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-02 and United States Geologic Survey (USGS) hydrologic unit 03050105040090. From Asheville, take I-26 South and merge onto US 74 East towards Columbus. Continue on US 74 East and take the Union Hill Road Exit (Exit 173). Turn right on Union Road (SR1153). At the end of Union Rd., turn left onto Coxe Road. On Coxe Rd. travel northeast and cross under US 74. The Cleghorn Creek site is on the left, across from the Cleghorn Plantation Country Club.

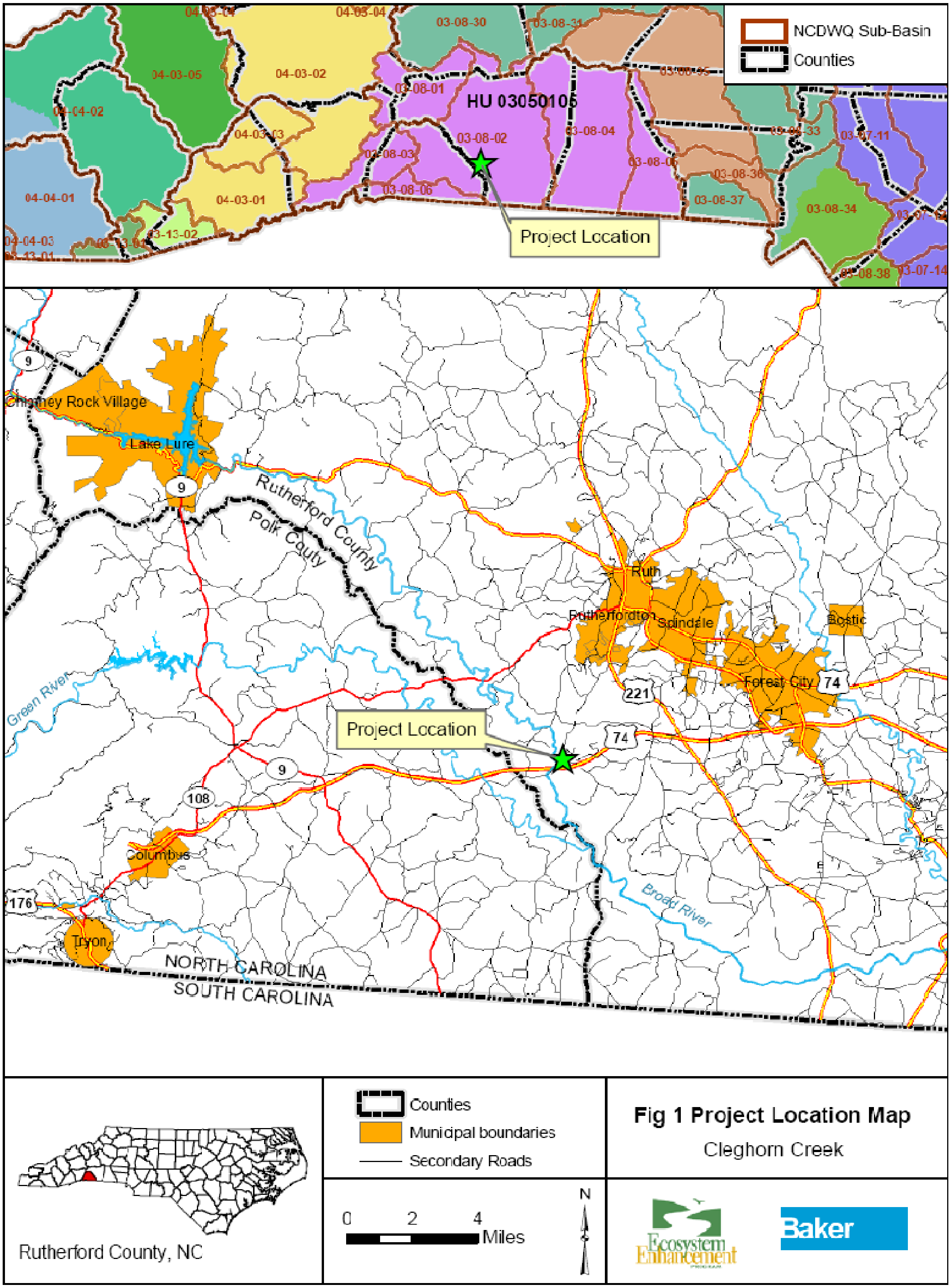

Fig 1 Project Location Map

Cleghorn Creek

1.4 History and Background

The headwaters of Cleghorn Creek are located in the Town of Rutherfordton. Land use within the Town area is predominantly residential and commercial. The remainder of the Cleghorn Creek watershed and the entire Charles Creek watershed are mostly rural, with land uses that include agriculture, timber logging, forested area, residential development and a golf course near the project area. The Site itself has a recent land use history of pasture and general agricultural usage. A small equestrian center is located west of the project area. The streams on- site were historically channelized, and stream and riparian functions had been severely impacted as a result of agricultural land use.

In accordance with the approved restoration plan for the site, construction activities began in July 2005. Project activity on Cleghorn Creek and Charles Creek 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 project design involved a priority II approach with the construction of new, meandering channels across a floodplain that was excavated to the bankfull elevation of the creeks. A modification to channel pattern was made during construction so that the constructed channel would avoid several mature trees and a healthy stand of native river cane. The design intended to avoid the trees, but channel excavation during construction revealed that the design location would damage the root structure of the trees and likely cause them to fall into the creek. The floodplain was not graded around the base of the trees to avoid damage.

An archaeological site was identified by the State Historic Preservation Office (SHPO) on the upstream, left floodplain of Charles Creek. As a result, the original design was modified to avoid impact to the site so that the stream migrates away from the archaeological site rather than along its edge. The vertical alignment was also modified to account for the pattern adjustment. The final as-built stream length for the project is 5,196 LF, producing 5,196 stream mitigation units (SMU).

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 other aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

The chronology of the Cleghorn Creek Restoration Project is presented in Table 2. The contact information for all designers, contractors, and relevant suppliers is presented in Table 3. Relevant project background information is presented in Table 4.

Table 2. Project Activity and Reporting History Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)		
Activity or Report	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan Prepared	N/A	Mar-05
Restoration Plan Amended	N/A	Apr-05
Restoration Plan Approved	N/A	
Final Design – (at least 90% complete)	N/A	Jul-05
Construction Begins	N/A	Aug-05
Temporary S&E mix applied to entire project area	N/A	N/A
Permanent seed mix applied to entire project area	N/A	Apr-06
Planting of live stakes	N/A	Apr-06
Planting of bare root trees	N/A	May-06
End of Construction	N/A	May-06
Survey of As-built conditions (Year 0 Monitoring-baseline)	Jul-06	Jul-06
Repair Work	Apr-07	Apr-07
Year 1 Monitoring	Apr-07	June 2007
Year 2 Monitoring	Dec-07	Dec-07
Repair Work	Nov-08	Nov-08
Year 3 Monitoring	Dec-08	Dec-08
Minor Bank Repair/Grading	May-09	May-09
Year 4 Monitoring	Dec-09	Dec-09
Year 5 Monitoring	Oct-10	Nov-10
Minor Bank Repair/Installation of 1 Vane	Dec-10	Dec-10

Monitoring has occurred each year since the original Mitigation Report (As-built) was submitted in August 2006. Year 1 monitoring was done in the spring of 2007 and evaluated channel changes and vegetation survival since the spring of 2006. Data collection was delayed until spring by repair work that was necessary following flood events that occurred in the summer of 2006 and the beginning of 2007. Year 2 monitoring was also done in 2007 but in the fall of that year after the second growing season. Year 3 monitoring was performed in November and December of 2008. Year 4 monitoring commenced in November and was completed December 2009. Year 5 sampling was conducted in October 2010.

Table 3. Project Contacts	
Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)	
Full Service Delivery Contractor	
EBX-Neuse I, LLC	909 Capability Drive, Suite 3100 Raleigh, NC 27606 Contact: Norton Webster, Tel. 919-829-9909
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Matthew Reid, Tel 828-350-1408
Construction Contractor	
Riverworks, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 Contact: Will Pedersen, Tel. 919-459-9001
Planting and Seeding Contractor	
Riverworks, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27518 Contact: George Morris, Tel. 919-459-9001
Seed Mix Sources	Mellow Marsh Farm, 919-742-1200
Nursery Stock Suppliers	International Paper, 1-888-888-7159
Monitoring	
Stream Monitoring Point of Contact: Michael Baker Engineering, Inc.	Carmen Horne-McIntyre, Tel. 828-350-1408 797 Haywood Rd Suite 201 Asheville, NC 28806
Vegetation Monitoring Point of Contact: Wetland and Natural Resources Consultants, Inc.	Chris Huysman, Tel. 336-406-0906 P.O. Box 882 Canton, NC 28716

Table 4. Project Background Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)	
Project County:	Rutherford County, NC
Drainage Area: Cleghorn Reach 1 Cleghorn Reach 2 Charles Creek	 14.21 mi^2 17.23 mi^2 3.02 mi^2
Stream Order: Cleghorn Reach 1 Cleghorn Reach 2 Charles Creek	 4 4 2
Physiographic Region	Piedmont
Ecoregion	Southern Inner Piedmont
Rosgen Classification of As-Built Cleghorn Reach 1 Cleghorn Reach 2 Charles Creek	 C C C
Cowardin Classification	Riverine, Upper Perennial, Unconsolidated Bottom, Sand
Dominant Soil Types Cleghorn Reach 1 Cleghorn Reach 2 Charles Creek	 ChA, ToA ToA, RnE ToA, GrE
Reference Site ID	Wheat Creek and UT to the Broad River east of the Hwy 74/Union Rd intersection
USGS HUC for Project and Reference Sites	03050105040090
NCDWQ Sub-basin for Project and Reference	03-08-02
NCDWQ classification for Project and Reference	C
Any portion of any project segment 303d listed?	No
Any portion of any project segment upstream of a 303d listed segment?	No
Reasons for 303d listing or stressor?	N/A
% of project easement fenced	100%

1.5 Monitoring Plan View

The monitoring plan view for Cleghorn Creek and Charles Creek is included in Appendix A. 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 and reference photo stations.

2.0 YEAR 5 PROJECT CONDITION AND MONITORING RESULTS

The five-year monitoring plan for the 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 5 monitoring plan sheets (Appendix A). Photo points, located along the stream restoration project, are also shown.

2.1 Vegetation Assessment

2.1.1 Description of Vegetative Monitoring

As a final stage 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. Tree species planted are summarized in Table 5. After grading repairs were completed on the Site, a permanent ground cover seed mixture was broadcast on the Site at a rate of 10 pounds per acre. The seed mix is presented in Table 6.

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, five100 square meter monitoring plots were installed across the restoration site to predict the survival rate of the bare-rooted trees. On a designated corner within each of the five vegetation plots, one - 1 square-meter herbaceous plot was also delineated. Survival was determined from the difference between the previous year's living, planted trees and the current year's living, planted trees. Herbaceous survival was determined by subjectively judging the area of coverage in each herbaceous plot.

Plot construction involved using metal fence posts at each of the four corners to clearly and permanently establish the area that was to be sampled. Then ropes were hung connecting all four corners to help in determining if trees close to the plot boundary were inside or outside of the plot. Trees right on the boundary and trees just outside of the boundary that appear to have greater than 50% of their canopy inside the boundary were counted inside the plot. A piece of white PVC pipe ten feet tall was placed over the metal post on one corner to facilitate visual location of site throughout the five-year monitoring period. All of the planted stems inside the plot were flagged with orange flagging and marked with a 3 foot tall piece of half inch PVC to identify them as the planted stems (vs. any colonizers) and to help in locating them in the future. Each stem was then tagged with a permanent numbered aluminum tag. 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. Plots were stratified in the project site to represent the different areas within the project. These plots, one on Charles Creek (Plot # 5) and the four plots on Cleghorn Creek were re-established in June 2007. The locations of the five vegetation plots are presented in Appendix A.

Live stakes were installed on both stream banks along both reaches of Cleghorn Creek and the upstream half of Charles Creek. The species composition was roughly 40 percent silky dogwood (*Cornus amomum*), 40 percent silky willow (*Salix serecia*), 10 percent elderberry (*Sambucus canadensis*) and 10 percent ninebark (*Physocarpus opuliflia*). These same species were used in brush mattresses and geolifts installed throughout the repair areas on Cleghorn Creek.

Table 5. Tree Species Planted in the Cleghorn Creek Restoration Area Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)			
ID	**Scientific Name**	**Common Name**	**FAC Status**
1	*Nyssa sylvatica*	Blackgum	FAC
2	*Quercus phellos*	Coastal Willow Oak	FACW-
3	*Diospyrus virginiana*	Persimmon	FAC
4	*Fraxinus pennsylvanica*	Green Ash	FACW
5	*Liriodendron tulipifera*	Yellow Poplar	FAC
6	*Platanus occidentalis*	Sycamore	FACW-
7	*Quercus rubra*	Northern Red Oak	FACU
8	*Betula nigra*	River Birch	FACW+
9	*Juglans nigra*	Black Walnut	FACU
10	*Quercus michauxii*	Swamp Chestnut Oak	FACW+

Table 6. Herbaceous Species Planted in the Cleghorn Creek Restoration Area Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)		
Scientific Name	**Common Name**	**Percentage**
Agrostis alba	Redtop Grass	10
Elymus virginicus	Virginia Wildrye	15
Panicum virgatum	Switchgrass	15
Tripsicum dactyloides	Eastern Gamma Grass	5
Polygonum pennsylvanicum	Pennsylvania Smartweed	5
Schizachyrium scoparium	Little Bluestem	5
Juncus effuses	Common Rush	5
Bidens frondosa	Devil's Beggartick	10
Coreopsis lanceolata	Lanceleaf Tickseed	10
Panicum clandestinum	Deertongue	10
Andropogon gerardii	Big Bluestem	5
Sorgastrum nutans	Indian Grass	5

2.1.2 Vegetative Success Criteria

The interim measure of vegetative success for the site was 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 is the survival of 260, 5-year old, planted trees per acre at the end of the fifth monitoring period. Herbaceous cover has been 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.

Up to 20% of the site's species composition may be comprised of volunteers. However, remedial action may be required should volunteer species (i.e. loblolly pine, red maple, sweet gum, etc.) present a problem and exceed 20% composition.

2.1.3 Vegetation Observations and Results

The Site was planted with bottomland hardwood forest species in May 2006. The aforementioned flooding caused damage or destruction of much of the initial planting, and the five vegetation-monitoring plots installed at the Site had to be abandoned to perform grading repairs. The Site was re-planted in April 2007 and vegetation plots were re-established at locations shown on the plans. With the exception of isolated bank repairs performed in 2008 (most of which were the result of beaver activity), permanent seeding applied to streambanks beneath the erosion matting have generally provided good ground coverage. Live stake, bare root trees, and live brush in the geolift structures have flourished and are contributing to streambank stability.

Vegetation monitoring conducted in the fall of 2010 documented a survival rate of 520 stems per acre to 640 stems per acre with an overall average of 600 stems per acre, which is a survival rate of greater than 90% based on the initial planting count of 656 stems per acre. As part of the streambank maintenance performed, some replanting occurred in the repaired areas and equipment access lanes. Despite replanting, these areas appeared comparable to the sections of the project area that have not been repaired.

Earlier vegetative monitoring data documented that this site met the minimum interim success criteria at the end of Year 3 monitoring. Year 5 sampling documented that the Site has met the final success criteria of 260 trees per acre at the end of Year 5.

The following information in Table 7 presents stem counts for each of the plots for Year 5 monitoring. Each planted tree species is identified across the top row, and each plot is identified down the left column. The species code numbers on the top row correlate to the ID column of the previous Table (6). Planted were flagged to indicate there origin at the beginning of site monitoring. Trees are re-flagged in the field on an as needed basis before the old flags degrade. Flagging is utilized, because it will not interfere with the growth of the tree. Volunteer trees are also flagged during this process. Annual variation in stem count data can be attributed to mortality and regeneration from root stock of stems previously assessed to be dead.

Table 7. 2010 Vegetation Monitoring Plot Species Composition
Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)

Plot	Species Code*										Total	Stems/ Per Acre
	1	2	3	4	5	6	7	8	9	10		
1	0	0	0	10	0	0	5	0	0	1	16	640
2	0	1	0	1	1	6	0	6	0	0	15	600
3	0	0	0	0	3	3	4	2	1	0	13	520
4	2	0	1	2	3	3	0	4	0	0	15	600
5	0	1	1	4	4	6	0	0	0	0	16	640

Average Stems/Per Acre: 600
Range of Stems/Per Acre: 520-640
*Species codes relate to identification shown in Table 5.

Volunteer species will also be monitored throughout the five-year monitoring period. Below is a list of the most commonly found woody volunteer species.

Volunteers within the Conservation Easement Area:

Scientific Name	Common Name	FAC Status
Platanus occidentalis	Sycamore	FACW-
Acer negundo	Boxelder	FACW
Acer rubrum	Red Maple	FAC
Alnus serrulata	Tag Alder	FACW+

Volunteer woody species were observed in most all of the vegetation plots. Sycamore (*Platanus occidentalis*), red maple (*Acer rubrum*), and boxelder (*Acer negundo*) are the most common volunteers in plots. Tag alder is more common as a volunteer on the stream banks.

In addition to the volunteer species noted above, there are quite a few weedy species occurring on the site, including aster (*Aster spp.*), goldenrod (*Solidago spp.*), and horseweed (*Conyza spp.*), though they do not appear to be threatening the survival of woody or herbaceous hydrophytic vegetation planted. Johnsongrass (*Sorghum halepense*), multiflora rose (*Rosa multiflora*), and Chinese privet (*Ligustrum sinense)* have been observed inside the restoration area. Maintenance to the riparian buffer was undertaken in September, 2010 to treat invasive vegetation in the easement area.

2.1.4 Vegetation Problem Areas

Besides minor areas of Johnson grass along the right terrace of Charles Creek, no extensive vegetation problem areas were identified. EBX is discussing treatment of the field adjacent to the Charles Creek and Cleghorn Creek with the landowner as the field is heavily infested with Johnsongrass.

2.1.5 Vegetation Photos

Photographs are used to visually document vegetation success in sample plots. Reference photos of tree and herbaceous conditions within the five plots are taken at least once per year. Photos of the plots are included in Appendix C of this report.

2.2 Stream Assessment

2.2.1 Description of Geomorphic Monitoring

Geomorphic monitoring of restored stream reaches was conducted over a five year period to evaluate the effectiveness of the restoration approach. 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, were 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 5 monitoring plan sheets in Appendix B.

2.2.2 Morphometric Success Criteria

2.2.2.1 Cross-sections

Eleven permanent cross-sections were installed in pools and riffles throughout the site, with seven on Cleghorn Creek Reach 1, one on Cleghorn Creek Reach 2, and three on Charles Creek. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark was used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The annual cross-sectional survey included points measured at top of bank, edge of water, water surface, and thalweg, if the features are present. Riffle cross-sections were classified using the Rosgen Stream Classification System.

There should be little change in as-built cross-sections. If changes to the channel cross-section take place, they should be minor changes representing an increase in stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio).

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 1,500-foot longitudinal profile of Cleghorn Creek was surveyed in October as well as the entire project reach along Charles Creek. Longitudinal profiles have been replicated annually during the five year monitoring period for this Site.

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. 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 have included 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 constructed channel and to its sediment load. Significant changes in the particle size distribution was evaluated with respect to stream stability and watershed changes.

2.2.3 Morphometric Results

2.2.3.1 Cross-sections

Cross-section data for stream stability were collected during October 2010. Cross-section (channel dimension) data were collected after construction was completed (as-built condition) and have been collected each subsequent year. Location pins for cross-sections 1, 2, and 3 were disturbed during repair work and were reset nearby, which is why the location of the channel and floodplain features shifted between the As-built and Year 1 monitoring period. Cross-sections 4 through 8 on Cleghorn Creek, and 9 through 11 on Charles Creek have used the same pins since construction was completed.

The eleven permanent cross-sections along the restored channels (six located across riffles and five located across pools) were surveyed in October 2010 to document stream dimension at the end of the monitoring year. Data from each of these cross-sections are summarized in Appendix B. From Year 1 through Year 5, channel dimension has exhibited only small changes in stream bedform and elevation, which could be considered within the range of normal year-to-year variations for a sand-bed channel.

The most notable changes in channel dimension that are shown in the cross-section data actually occurred between the As-built and Year1 surveys. The cross-sections display the effects of the flood damage and subsequent repair work that was done, which had the combined effect of increasing the channel cross-sectional area, and reducing bank slopes, particularly in point bar locations.

To better define changes in channel dimension, measurements of bankfull cross-section geometry were evaluated. These measurements include average depth, width, area, maximum depth, and width/depth ratio. The measurements indicate significant changes between the As-built and Year 1 data, but do not clearly demonstrate a pattern of change in subsequent years. From Year 1 through Year 5, some cross-sections on Cleghorn Creek were either highly variable (getting larger one year then smaller the next) or they did not change appreciably over the course of the monitoring events. Survey data collected in 2010 indicates that the site has remained stable since the last survey was completed in 2009.

Channel dimensions on Charles Creek do not reflect any instability, and instead, seem to reflect normal year-to-year variations. Cross-section 10 has shown minor changes in bankfull width over time due to deposition associated with flood events, but is stable. This channel has often been inundated by a series of beaver dams and some variability is likely associated with the affects of these dams. While conducting Year 5 monitoring, evidence of beaver activity was observed (observations include remnants of dams that have been removed as well as two intact beaver dams that were scheduled to be removed once field surveys were completed).

Eight of the eleven cross-sections surveyed in Year 5 do not appear to deviate from conditions observed in 2009. The pool at Cross-section 4 on Cleghorn Creek was noticeably deeper in 2009 compared to previous years and had decreased in area as sediment has deposited on the point bar and the channel width narrowed. In Year 5, this pool was found to have filled back in to a depth similar to measurements recorded prior to 2009. Pools were also highly variable with regards to width and depth, and only one of the four pool cross-sections on Cleghorn Creek indicated a slight decrease in area as sediment deposits on the point bar and the channel width narrows. Most other pool features appear to have remained relatively similar to what has been observed in previous monitoring events. Most riffle cross-sections surveyed did not change significantly in 2010 and remain stable. Cross-sections 6 and 8 on Cleghorn Creek and Cross-section 11 on Charles Creek had become slightly deeper by Monitoring Year 3. However, these riffle cross-sections have aggraded back to an elevation similar to that of the as-built elevation. Deepening pools, point bar development inside meanders and stable or slightly aggraded riffles reflect a positive trend in channel stability.

Another factor contributing to the stability observed on-site during 2010 was the lack of beaver dams present on Cleghorn Creek as compared to previous years and a thriving riparian buffer. Beaver dams have been built and destroyed several times within the time frame of this project. The beaver dams block the flow of sediment through the system until the dams are removed and the resulting upstream sediment moves downstream. Saturation of banks within the pools created by the dams kills stream bank vegetation and can result in slumping of the banks. Although beaver activity abounds across the site and is suspected to be related to a small section of eroded bank on Cleghorn Creek, bedload transport functions appear to have improved on Cleghorn Creek since 2008. Beaver activity on-site is expected to continue given the proximity of the project area to the confluence of Cleghorn Creek and the Broad River. The two beaver dams that were still intact in October 2010 are not currently causing considerable bank instability problems nor are they expected to since they are scheduled to be removed once field monitoring is complete.

2.2.3.2 Longitudinal Profile

Longitudinal profile data for stream stability were collected at the same time as cross section measurements during October 2010. Longitudinal profile data were collected after construction was completed (as-built condition) and have been collected each subsequent year. The longitudinal profile on Cleghorn Creek begins just downstream of Photo Point 4 and continues 1,500 LF downstream past the bridge crossing. The longitudinal profile for Charles Creek spans the entire length of the project reach on this stream (1,426 LF).

Measurements included top of bank, channel, thalweg, and water surface. Profile plots in Appendix B display 2010 thalweg, water surface, and top-of-bank points as compared to profiles surveyed during previous monitoring events. The Year 1 survey was performed in April 2007 following stream repairs made after the second flood event occurred. The Year 2 longitudinal survey was performed in November 2007 and the Year 3 longitudinal survey was performed in November and December of 2008. The Year 4 longitudinal survey was performed in November and December of 2009. The Year 5 longitudinal survey was performed in October 2010.

The longitudinal profiles should show that the bedform features are remaining stable (not aggrading or degrading). The pools should remain deep with flat water surface slopes and the riffles should remain steeper and shallower than the pools. The profile comparison indicates that overall, both Cleghorn Creek and Charles Creek have maintained their respective as-built slopes and channel depths although some meander pools on Cleghorn Creek have deepened since last year. Although several beaver dams were removed on both Cleghorn Creek and Charles Creek in 2010, the Site does not appear to have suffered significant damage from beaver habitation over the past year in comparison with previous years. During Year 5 Monitoring, at least one intact beaver dam was located on Cleghorn Creek while one of three recent dams built on Charles Creek remained. The other two dams appeared to have been recently removed.

As with the cross sections, the longitudinal profile data show that the greatest adjustments on Cleghorn Creek occurred between the As-built and the Year 1 survey as well as the Year 4 survey which was taken a few weeks after at least two flood events occurred on-site. As discussed in previous monitoring reports, these adjustments were a combination of flooding effects and maintenance adjustments to increase the cross sectional area. When comparisons of the plotted profiles from Monitoring Years 1 through 5 are made, it does not appear that the overall thalweg elevation has increased or decreased significantly.

The most noticeable profile difference on Cleghorn Creek between Years 4 and 5 of monitoring was the filling in of pools that were noticeably deeper in November and December of 2009 as a result of scour associated with recent flood events at the site. However, extreme flooding during the winter of 2010 appears to have moved a significant amount of sand into the project site and contributed to this pool filling. The profile for Year 5 on Cleghorn Creek generally appears to be more in line with what was observed in earlier monitoring years with the exception of sections where beaver dams have been located. As previous monitoring reports note, the thalweg between stations 16+73 and ~20+50 appears to be lower when comparing Year 1 to Year 3, but from station ~20+50 to the end of the profile the elevation is approximately the same. The location of where this change occurs is near the driveway bridge and was the site of a large beaver dam in Year 2 of the monitoring period. At least one more beaver dam was present that year at station 20+17. The impacts of these dams are evident in the Year 2 profile; marked by aggradation upstream of the dams and degradation (plunge pools) below the dams. The lower profile elevation between stations 16+73 and ~20+50 appears to be a result of the large dam at station 16+73 and the down cutting that resulted below the dam. By Year 3 the scour pool below the dam had filled but the overall profile through this dam area had lowered as the fines that aggraded upstream of the dam moved through the system, resulting in a localized lowering of the profile. This lowering of the profile is consistent with what was observed in Year 1 monitoring of the profile. The intact beaver dam located on Cleghorn Creek near station 22+75 as shown on the Year 5 longitudinal profile is characteristic of what has previously been observed: signs of aggradation upstream of the dam followed by a plunge pool on the downstream end of the dam.

Although pool length and pool spacing has decreased since Year 4, the channel appears to be very stable as indicated by a decreasing width-depth ratio, an increasing meander width ratio and generally stable, well vegetated streambanks. This stream has a sand bed that is perpetually scoured by any rock or wood debris in the channel. This process results in the formation of scour holes that may fall between meander bend pools, which is common in these systems and indicates a positive change in bedform diversity. Perhaps the most important determination for stability is how the overall water surface slope and thalweg elevations change year to year and how they change relative to the bankfull elevation. In this case, the reach wide water surface slope and thalweg elevations do not appear to be changing significantly. The water surface slope across the reach has remained at .002 each year and the bank height ratio has not exceeded 1.1.

The profile at Charles Creek is similar to what has been described for Cleghorn; however, the profile has not changed significantly between the As-built monitoring period and subsequent years. Pools have either deepened or have filled slightly, but the overall elevation and water surface slope (.005) have remained relatively the same. In Year 2, the beaver problems experienced on Cleghorn Creek were even more prevalent on Charles Creek. The profile indicates the presence of at least 6 different beaver dams along the project reach and this resulted in most of the reach being inundated by backwater. These dams were either removed or washed out during Year 3 of monitoring. Since that time, the channel had returned to almost the same profile as was seen in the as-built profile, with an additional pool at station 2+50 and the recovery of a pool that had disappeared during Years 1 and 2 near station 6+65. The thalweg elevation in Year 5 is similar to the as-built elevation with the exception of the profile around stations 10+00 to 12+00 and 12+83 to 15+26 where beaver dams have been concentrated and where the channel at the confluence with Cleghorn Creek was scoured in Year 3. A divergence in thalweg elevations occurs in these areas, but recovers near the end of the profile at station 12+83 where the elevation is similar in nature to that of the channel elevation present at the beginning stages of the monitoring period. In 2008, it was discovered that Charles Creek had become incised near its confluence with Cleghorn Creek. There are various ponds upstream of this site and there were a number of high-water events during the fall of 2008. One hypothesis is that a sudden high volume of water was released down this channel resulting in channel bed scour. Subsequently, in May 2009, approximately 100 linear feet of banks were graded at the confluence of Charles Creek and Cleghorn Creek to lower the bankfull elevation and prevent further incision along this subreach of Charles Creek. The increase in channel elevation near station 14+34 can be attributed to the filling in of the previously incised outlet of Charles Creek. Like Cleghorn Creek, Charles Creek appears to be stable as evidenced by healthy bank vegetation, a bank height ratio of 1.0, a low width-depth ratio and stable riffle-pool sequencing.

2.2.3.3 Bed Material Analyses

Year 5 pebble count data collected in the upper and lower subreaches of Cleghorn Creek and Charles Creek indicate these streams are transporting particles roughly the same size or larger as those found during as-built surveys (Table B2, Appendix B). Visual observation of Cleghorn Creek and Charles Creek and a review of pebble count data collected did not yield any signs that sediment transport functions have been hampered by the restoration project. Despite the higher occurrence of beaver dams on Charles Creek as well as the storm event in 2008, the profile of Charles Creek has remained relatively the same as compared to Cleghorn Creek. This is likely in part due to the differences in bedload particle size and the fact that streams like Cleghorn Creek that are sand-bed systems tend to experience more microfeatures and fluxes in riffle-pool features.

2.2.4 Hydrologic Criteria

The occurrence of bankfull events at the Site are documented by the use of crest gauges and photographs. Crest gauges were installed on the floodplain within 10 feet of the restored channels. One crest gauge was placed on Charles Creek, and one was placed on Cleghorn Creek. The crest gauges record the highest watermark between site visits and were checked during site visits to determine if a bankfull event occurred. Photographs were taken to document the occurrence of these bankfull events during the respective years in which they were observed.

The hydrologic monitoring criteria for this project requires the documentation of two bankfull flow events 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

The crest gauge located on Cleghorn Creek approximately 250-feet above the confluence with Charles Creek, documented the occurrence of one bankfull flow event during the first year of the post-construction monitoring period (Table 8). The crest gauge on Charles Creek was damaged during this event; no data was collected from this gauge until April 2010. The Cleghorn gauge was subsequently taken out of service during repair work and re-installed. Inspection of site conditions over the next seven months revealed visual evidence of at least two additional out-of-bank flows. The largest stream flow documented during As-built and Year 1 of monitoring was approximately 2.5 feet above the bankfull stage. The most recent bankfull events likely occurred sometime in late summer/early fall 2010. A small flood event was recorded using the Charles Creek crest gauge. A measurement was not obtained from the crest gauge on Cleghorn Creek due to tampering with the gauge.

Table 8. Verification of Bankfull Events
Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)

Date of Data Collection	Date of Event	Method of Data Collection	Gauge Height (feet)
8/25/2006	8/12/2006	Crest Gauge	2.5
1/3/2007	1/1/2007	Visual Inspection of Wrack Lines	0.1 +/-
3/7/2007	3/2/2007	Visual Inspection of Wrack Lines	2.4 +/-
11/23/09	Early Nov.	Visual Inspection of Wrack Lines and damage to Crest Gauge	2.5+/-
2/17/10	Winter (Jan.- early Feb. 2010)	Visual Inspection of Wrack Lines	>2.5 (nearing terrace elevation)
10/20/10	Unknown	Visual Inspection of Crest Gauge (Charles Creek Gauge)	0.1+/-

Notes: Unless otherwise noted, bankfull and flood events recorded for this project were measured on Cleghorn Creek. A final check of the crest gauge on Cleghorn Creek in October 2010 revealed that a dowel rod used to help measure flood events had been removed from the gauge; therefore a measurement could not be obtained.

2.2.6 Stream Problem Areas

The 2010 monitoring data used to determine stream stability during the project’s post construction monitoring period are summarized in Appendix B. Monitoring of the project site in 2010 resulted in the identification of four minor areas on Cleghorn Creek and Charles Creek that needed maintenance or repair prior to close out of the mitigation project. Maintenance work was limited to beaver dam removal on Charles Creek and Cleghorn Creek and minor bank stabilization along two small sections of Cleghorn Creek above the bridge. Several other dams had already been removed at the time Year 5 monitoring took place. The mid-channel bar present on Cleghorn Creek at Station 116+00 was removed and a small vane was installed to discourage the formation of mid-channel bars in the future. The area of bank erosion on the right bank adjacent to the bar and a small segment of bank erosion downstream at Station 122+00 was repaired using a mini-trackhoe; both banks were replanted in December 2010. Table 9 below summarizes conditions at each site prior to repair and the likely cause for bank instability observed. The location of each site is illustrated on the plans provided in Appendix A.

Table 9. 2010 Stream Repair/Maintenance Sites Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)		
Site	Issue	Suspected Cause
1	Mid-channel bar and eroding bank caused by mid-channel bar (Sta. 116+00)	Channel bar growth (bar has been present throughout monitoring period, but has expanded recently).
2	Minor bank erosion (Sta. 122+00)	Unknown; Beaver habitation in the project site likely a contributing factor.
3	Re-install crossing rope at lower horse crossing on Cleghorn Creek (Station 131+50)	Unknown.
4	Removal of two beaver dams on Cleghorn Creek and Charles Creek (Stations 131+75 and 123+000 respectively). Beaver dams noted on Charles Creek at Stations 120+00 and 122+00 were removed recently enough that they are still obvious in the profile of Charles Creek.	Beaver activity.

2.2.7 Stream Photographs

Photographs are used to document restoration success qualitatively. Reference stations were photographed during the as-built survey and have been documented annually since construction. Reference photos are taken once a year, from a height of approximately five to six feet. Permanent markers were installed to ensure that the same locations (and view directions) are utilized during each monitoring period. Reference photos were taken October 15, 2010 and are shown in Appendix C.

Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation and effectiveness of erosion control measures. Photos should indicate the absence of developing bars within the channel, no excessive bank erosion or increase in channel depth over time, and maturation of riparian vegetation.

Reference photo transects were taken of the right and left banks at each permanent cross-section. Photographs were also taken facing upstream and downstream at the permanent cross-section photo stations. 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. These photos are presented along with the cross-section baseline data in Appendix B.

2.2.8 Stream Stability Assessment

In-stream structures installed within the restored reaches of Cleghorn Creek and Charles Creek include log vanes, geolifts and root wads. Brush mattresses were also installed along the outside of many of the meander bends, but these are not referred to as in-stream structures since they are considered bank treatments. Visual inspection of the log vanes and root wads indicate that they are functioning appropriately and, as of the date of this Report, there are no signs of instability. The geolifts are also performing very well, with healthy growth of the vegetation and a generally stable bank and toe.

Table 10 presents a summary of the visual inspection of in-stream features and structures performed during October 2010. The percentages noted are a general overall field evaluation of how the features were performing and are based solely on the field evaluator’s visual assessment at the time of the site visit.

Table 10. Categorical Stream Feature Visual Stability Assessment Cleghorn Creek Restoration Project-#D0410 (EBX Neuse-I, LLC)						
	Performance Percentage					
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	90%	90%	90%
Pools	100%	90%	80%	90%	100%	100%
Thalweg	100%	100%	100%	90%	90%	100%
Meanders	100%	100%	100%	100%	100%	100%
Bed (General)	100%	95%	85%	90%	100%	100%
Log Vanes	100%	100%	95%	85%	100%	100%
Geolifts	100%	100%	100%	100%	100%	100%
Rootwads	100%	100%	100%	95%	95%	95%

Based on the data collected, riffles, pools and other constructed features along the restored channels are stable and are functioning as designed. Riffles have generally been more stable on Charles Creek as compared to Cleghorn Creek in part because the channel bed of Charles Creek is not in as much flux as the sandbed channel that typifies Cleghorn Creek in the project reach. Transitions aside, riffle-pool sequences on Cleghorn Creek are functioning as needed and are within the acceptable limits of design parameters applied to this project. Structures installed to enhance pool habitat and stabilize streambanks are also stable and functioning well. Beyond the issues noted above, no areas of concern have been identified during the first year following completion of the project. Overall, the site has achieved the stream morphology success criteria specified in the Restoration Plan for the Site.

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.

3.0 WILDLIFE OBSERVATIONS

Observations of deer, coyote, turkey, beaver, and raccoon tracks are common on the Site. Fish have been seen in the both Charles and Cleghorn Creek. Evidence of beaver habitation is prevalent in the project area and includes bank slides, stumps of cut trees and chewed limbs in the channel. Some trees have been visibly damaged by beavers and several dams have been located on the Site. Although several dams have already been removed, at least two were present within the project reach on Charles Creek during the recent surveys. Coyote scat is very common along stream banks throughout the site. Hawks and migratory ducks and geese have also been observed on the Site.

4.0 CONCLUSION

Year 5 data evaluated against monitoring criteria established for this project indicate the site is stable, has a stable channel geometry and has a riparian buffer that is healthy throughout the project reach. No further monitoring is required since monitoring to date indicates that this project, which has experienced numerous flood events and other natural disturbances, meets the success criteria specified in the Restoration Plan.