ROCKY BRANCH STREAM RESTORATION PLAN

YADKIN COUNTY, NORTH CAROLINA

NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

Ecosystem Enhancement PROGRAM

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Prepared For:

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1.0 Introduction

1.1 Project Description

The Rocky Branch Stream Restoration Site (RBSRS) is situated in the southwest corner of Yadkin County, North Carolina. Specifically, it is located on the east side of I-77 between SR 1120 and SR 1122, approximately three miles east of Hamptonville and two miles south of the US 421/I-77 interchange (Figure 1).

This segment of Rocky Branch was selected for the excellent opportunity it presented to restore natural stream functions, to establish effective riparian buffers and to restore healthy floodplain stability. Much of the land within RBSRS is dominated by open pasture without fencing. Since cattle have had relatively unrestricted access to the creek channel for watering, the channels at the RBSRS have been severely impacted. Stream restoration will be implemented on the Rocky Branch channel and one of its two unnamed tributaries (Tributary 1). These efforts will primarily utilize Priority I, II, and IV stream restoration principles to reestablish approximately 4,363 linear feet of the streams' channels within their historical floodplain. A pond will be created in place of the other unnamed tributary (Tributary 2), which is fed by a natural spring. Approximately 24 acres of conservation easement will provide large riparian and upland buffers to protect the restored stream channels. The project will also provide a shade house and watering structures for approximately 75 beef cattle, which are anticipated to use the remaining pasturelands following the completion of the project. In addition, the project will provide assistance in decommissioning a dairy waste storage pond. The entire conservation easement will be fenced to restrict access to the restored areas and the I-77 right-of-way. A permanent crossing will be established within the conservation easement. Access to the site will be limited to gated entry points.

2.0 Goals and Objectives

The goals and objectives of this stream restoration plan will result in:

- Providing a stable system of stream channels that neither aggrades nor degrades while maintaining their dimension, pattern, and profile with the capacity to transport the watershed's water and sediment load
- Improving the overall water quality and aquatic habitat by reducing sediment and waste inputs into the stream caused by bank erosion, mass-wasting, and livestock influences.
- Providing protection for the restored stream channels and associated riparian and upland buffers through a fenced conservation easement
- Providing watering structures and a shade house for livestock that will facilitate approximately seventy-five beef cattle
- Extracting waste from the dairy waste storage pond through a decommissioning process, whereby eliminating future risks to the Rocky Branch channel

3.0 General Watershed Information

Rocky Branch and its two unnamed tributaries are situated within the Yadkin-Pee Dee River Basin. The site is specifically within the US Geological Survey (USGS) hydrological unit code

(HUC) 03040102 and the NC Division of Water Quality (NCDWQ) sub-basin 03-07-06. This sub-basin is known as the South Yadkin River Watershed and covers 907 square miles (580,480 acres). Forests and agricultural operations account for approximately 95% of the land use within the sub-basin.

Rocky Branch arises near the Town of Marler, north of US 421, and flows east, crossing portions of the US 421/I-77 interchange, before turning south. The stream passes through the project area en route to its ultimate confluence with Hunting Creek, located approximately 1,600 feet south of the RBSRS. The stream flows predominately southward once it exits the US 421/I-77 right of way except for a 3,000^{+}-foot section within the RBSRS, which flows east before turning south toward its terminus at Hunting Creek. The drainage area associated with the Rocky Branch watershed is approximately 3.1 square miles (1,984 acres) (Figure 2).

Rocky Branch collects its surface hydrology from four unnamed tributaries prior to entering the RBSRS. Within the site, Rocky Branch receives hydrologic inputs from Tributary 1, which contains a drainage area of approximately 0.2 square miles (128 acres) and Tributary 2 (natural spring), originating immediately outside of the project area. Hydrological inputs to Rocky Branch, south of Deacon's Hill Road (SR 1120) are limited to flows from drainage ditches, small seeps and sheet flows across the landscape.

The dominant land use within the Rocky Branch watershed is primarily agriculture, which occupies approximately 75 percent of all land area within the watershed. Rural residences and their yardscapes are included within the agricultural land use category, where they comprise a small subset of the agricultural land use. Agriculture in this area is primarily field crops and livestock production. Corn and small grains are the chief agricultural crops grown in the area. Other agricultural land areas are used as pastures for dairy and beef cattle. Forest lands within the watershed are limited to small, narrow areas that account for approximately 20 percent of the land use. Impervious surfaces and intensely maintained areas lying adjacent to these areas account for the remaining 5 percent of the land area. This large area of impervious surface can be attributed to the close proximity of two major multi-lane highways (US 421 and I-77), as well as the presence of three secondary roadways in the immediate watershed area.

It is reasonable to predict that future land use trends in the watershed area may gradually shift from pure agriculture to rural homesites and small businesses. Agricultural demands in the area will remain high; however, the secondary effects of the growth and expansion of nearby urban areas will ultimately result in shifts in land-use patterns.

According to the North Carolina Department of Environment and Natural Resources (NCDENR), no water quality sampling sites are located along the Rocky Branch stream channel (NCDENR, 2002). Rocky Branch is currently classified as WS-III (Water Supply – Moderately Developed) waters according to a 1992 assessment (NCDENR, 2004). Rocky Branch is not currently listed as a 303(d) impaired stream within the 03-07-06 sub-basin according to the latest report issued by the NCDENR (2004a).

Currently, there are 29 National Pollutant Discharge Elimination System (NPDES) dischargers within the 03-07-06 sub-basin, which includes all of Iredell and portions of five other counties. During 2001, the NCDOT I-77 Rest Area received a permit violation for excessive chlorination of effluent, which ultimately was discharged into Rocky Branch. As a result of this violation, the NCDOT is in the process of installing a new chlorination system.

The closest sampling location for water quality was North Little Hunting Creek. This sampling area is located approximately six miles south of the project in Iredell County at SR 1829. North Little Hunting Creek exhibited a North Carolina Index of Biotic Integrity (NCIBI) rating of "Good" in 2001. The NCIBI is a method use for determining the biological integrity of streams by examining the structure and health of its fish community (NCDENR, 2002). A rating of "Good" indicates that the waterbody is fully supporting aquatic life and its intended use.

3.1 Current Property Ownership

The Rocky Branch project site will be held in perpetuity under the strictures of a conservation easement. The entire 24.095 acre tract of land will not be subject to development and traditional uses are substantially curtailed, or limited. Three individual landowners currently make up the land contained within this conservation easement. The acreage within the easement is divided amongst Mr. Bill Allen (13.469 acres), Mr. Joe Allen (6.985 acres), and Mrs. Texie Owens (3.641 acres). The NCDOT conservation easement plat is currently being recorded at the Yadkin County Register of Deeds office in Yadkinville, NC.

4.0 Existing Conditions

4.1 Existing Topography

The project site is characterized by a medium sized floodplain of variable widths. Rocky Branch is bordered by moderate slopes of 15 to 20 percent along the northern and southern portions of the project. These slopes are mainly used for pastures and contain a variety of grasses with a few scattered trees. Slopes along the western portion of the project, which form the I-77 roadway corridor, are steeper with slopes that range from 30 to 40 percent. Large trees and shrubs are found along these slopes, which are contained almost entirely within the NCDOT right-of-way. This vegetation serves to stabilize the roadway fill slopes, and filter out some of the pollutants that flow across the roadway during rainfall events. Elevations within the project area range from a high of 975 feet above mean sea level at the northwestern site boundary to approximately 900 feet above mean sea level at the end of the conservation easement boundary downstream of Deacon's Hill Road (SR 1120).

4.2 Existing Natural Features

4.2.1 Geology

The Rocky Branch Site is within the Piedmont physiographic province; specifically, the Northern Inner Piedmont Ecoregion (Griffith et al., 2002). It is underlain by the Inner Piedmont Belt, a region consisting of intrusive, metamorphosed granitic rock, which formed during the Cambrian and Ordovician Periods (455 to 540 million years ago) (NCDLR, 1985).

4.2.2 Soils

Soils found at the Rocky Branch project site lie within the Felsic Crystalline System of the western Piedmont (Daniels et al., 1999). According to the Yadkin County Soil Survey, Chewacla soils are the most common soils underlying the project and are mapped within the Madison Association (Figure 3). Soil borings associated with wetland determinations conducted at the site are also shown on soils figure. The Chewacla soils are deep, somewhat poorly drained soils which have formed from recent alluvium on nearly level floodplains along streams that drain from the Mountains and Piedmont physiographic provinces. The upland areas surrounding the project are mapped as the Cecil-Appling association. This association is characterized by its deep, well-drained soils that have formed in residuum from weathered granite, gneiss, and schist (Curle, 1962). These soils cover broad, gently rolling ridges within Yadkin County.

Based on the Soil Survey of Yadkin County, Chewacla soils comprise the floodplain portion of the site, while the adjacent uplands consist mainly of Cecil, Appling, and Wilkes soils. Chewacla soils are classified by the Natural Resources Conservation Service (NRCS) as fine-loamy, mixed, active, thermic Fluvaquentic Dystrudepts. Chewacla soils are classified as Hydric B soils because their map unit is not entirely hydric, but retain a Hydric status due to inclusions of Hydric A soils. Wehadkee soils are the most common Hydric A inclusions found within the Chewacla map unit in Yadkin County.

4.3 Existing Hydrologic Features

Mulkey surveyed the existing conditions at the project site by using total station survey equipment with GPS survey grade receivers. Topographic data from the NCDOT were merged with the survey data collected by Mulkey. Existing condition surveys included longitudinal profiles, cross sections, pebble counts, and bar samples to determine the current state of the stream channels. Existing longitudinal profiles were conducted by identifying each stream feature (riffle, run, pool, or glide) and surveying specific points at those features (Figure 4). These specific locations included top of bank, bankfull, waters edge or surface, and thalweg). In addition, 14 cross sections were identified at representative stream features throughout the project to fully characterize the dimension of the existing channels associated with Rocky Branch and Tributary 1 (Figure 5 and Appendix A). Following the completion of the existing channel surveys, pebble counts were conducted at specific cross section locations as well as a bar sample analysis. Data pertaining to each stream channel are discussed in the following sections.

4.3.1 Jurisdictional Streams

According to the North Carolina Administrative Code, Rocky Branch, Tributary 1, and Tributary 2 meet the jurisdictional definitions for perennial streams. Perennial streams have water flowing in a well-defined channel for a majority of the year (greater than 90 percent of the time) (NCAC, 1999). Tributary 2 is best described as a natural spring which contains a significant flow throughout the entire year (Allen, 2004), but does not have defined stream channel due to degradation from livestock.

4.3.1.1 Rocky Branch

The current location of the Rocky Branch stream channel (along the east toe of the I-77 roadway fill) is a product of the I-77 roadway construction completed in 1967. Prior to the construction of I-77 a segment of the stream channel, which presently flows through the RBSRS, originally flowed southwesterly at the present location of the I-77 corridor, before looping back into the present RBSRS. This channel reach was relocated to the base of the I-77 fill slope to avoid the need for two culverts. Over the last three decades, this realignment of the Rocky Branch channel has given rise to areas of erosion along the base of the fill slope, which, if ignored, may eventually compromise the integrity of the roadway. Rocky Branch is currently being impacted by cattle grazing. This damage includes stream bank erosion, mass wasting of banks, and reduction in the riparian vegetation. Grazing of cattle without adequate fencing has resulted in significant damage to the Rocky Branch channel and its water quality. The lack of vegetation and the steep topography surrounding Rocky Branch has also caused additional degradation due to the increased overland flow.

The existing Rocky Branch channel totals approximately 5,000 linear feet within the limits of the RBSRS area. The existing channel slope ranges from 0.0155 ft/ft in its upper reaches and maintains an average slope of 0.0044 ft/ft throughout the remainder of the project area Existing profile information for Rocky Branch can be found in Appendix B. Rocky Branch is classified as a B4/1c channel in the upper portions of the project according to the Rosgen stream classification system (Rosgen, 1994). As the slope of the channel changes, the channel morphs initially into a degraded C4 channel and then to a degraded E4 channel before reaching the bridge at SR 1120. Below the SR 1120 bridge the channel slope begins to increase, resulting in a B4/1c channel again. A summary of the cross section data used to determine these classifications can be found in Table 1 and existing cross section views are presented in Appendix B. Additional information including existing pattern data for Rocky Branch can be found with all the morphological data in Appendix C.

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The composition of the stream bed and banks is an important facet of stream character, influencing channel form and hydraulics, erosion rates and sediment supply. The stream bed along Rocky Branch was characterized using two protocols, the modified Wolman Pebble Count (Rosgen, 1993) and the bar sample analysis. The bar sample analysis provides data for both comparison purposes and sediment transport validations.

According to the modified Wolman Pebble Count procedure, the average d_{50} (50% of the sampled population is equal to or finer than the representative particle diameter) is approximately 11.0 mm for Rocky Branch, which falls into the medium gravel size category.
Pebble counts were taken at 8 locations along Rocky Branch. The locations included 7 riffles and 1 pool cross section. To obtain a more detailed picture of the pebble counts, counts were taken within specific areas within the stream channel. Samples taken between bankfull elevations were categorized as "Classification" samples and those taken below the water surface were used as the "Wetted Perimeter" samples. The classification samples determine the stream's material size as it relates to bankfull events and its overall stream material classification. The wetted perimeter samples are used to describe the movement of sediment within the active bed. The particle size distribution data which includes the classification, wetted perimeter, and bar sample are presented in Appendix D.

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The stability rating of the existing Rocky Branch channel was determined by using the Pfankuch Channel Stability and Bank Erosion Hazard Index (BEHI) Forms. The Rocky Branch channel was surveyed on sections which predominantly classify as a C4 Rosgen stream type for these two evaluations. The Pfankuch rating for the Rocky Branch channel was estimated to be 115, which ranks as "Poor" according to the rating system established for a C4 Rosgen stream type. The BEHI rating ranged from "Very High" for the upper and middle reaches to "High" for the lower reach. These stream channel stability evaluations can be found in Appendix E.

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Table 1. Summary of Existing Cross Sections – Rocky Branch and Tributary 1

Cross Section	Station No.	Morph. Feature	Bankfull Area (ft²)	Ent. Ratio *	W/D Ratio*	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Stream Class.*
1	2+33	Pool	35.7	1.9	10.9	23.4	1.5	--
2	4+45	Riffle	27.5	1.5	13.2	21.9	1.3	B4/1c
3	6+00	Run	34.4	1.6	11.8	23.5	1.5	--
4	7+43	Pool	37.4	4.4	7.43	21.0	1.8	--
5	8+83	Glide	34.6	1.5	17.3	27.3	1.3	--
6	11+37	Riffle	35.7	2.3	17.7	27.9	1.3	C4
7	16+97	Riffle	35.0	3.7	18.9	28.5	1.2	C4
8	23+12	Run	40.5	1.8	11.8	25.6	1.6	--
9	26+30	Pool	45.1	>5	13.1	28.0	1.6	--
10	26+43	Glide	35.1	1.7	12.2	24.1	1.5	--
11[A]	28+09	Riffle	45.2	>5	11.1	23.9	1.9	E4
12	35+39	Riffle	43.5	>5	11.8	26.5	1.6	E4
13	44+30	Riffle	27.3	1.8	25.6	28.6	0.9	B4/1c
Trib. 1	3+84	Riffle	3.1	1.6	33.6	10.8	0.3	C5

*Notes: Ent. Ratio is "Entrenchment Ratio"
W/D Ratio is "Width/Depth Ratio"
Stream classification is only viable along riffle sections.
[A] Bar Sample Location

4.3.1.2 Tributary 1

Tributary 1 contains approximately 595 linear feet of existing channel within the project area and is classified as a degraded C5 stream. The average slope of this channel is 0.0135 ft/ft. The stream channel and banks associated with this tributary have been principally altered through channelization, which is evident from its linear characteristics shown on Figure 4. Tributary 1 was likely channelized to increase the size of the pasture areas.

According to the modified Wolman Pebble Count procedure, the average d_{50} for the stream classification was approximately 1.3 mm, which falls into the very coarse sand size category (Appendix D). The d_{50} for the wetted perimeter was approximately 1.5 mm. The wetted perimeter data were utilized for entrainment and velocity calculations, since no bar sample was taken for Tributary 1. The Pfankuch Channel Stability rating for Tributary 1 was estimated to be 59, which is considered "Good" for a C5 Rosgen stream type. The BEHI evaluation conducted on Tributary 1 determined that the channel has "Moderate" bank erosion potential.

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4.3.1.3 Tributary 2

Tributary 2 emanates from a natural spring and totals approximately 250 linear feet before emptying into the Rocky Branch channel. No stream morphology classification was assigned to this channel due to its degraded condition and its ultimate fate as a pond. The channel area associated with Tributary 2 has been modified for use as a watering area for cattle. As a result, the stream banks and channel have been heavily damaged from cattle use. This tributary currently contributes a large quantity of sediment to the Rocky Branch channel when cattle are actively watering. No Pfankuch Channel Stability or BEHI evaluations were conducted for Tributary 2.

4.3.2 Jurisdictional Wetlands

Jurisdictional wetland determinations were performed using the three-parameter approach as prescribed in the 1987 *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987). Three jurisdictional wetlands (Wetlands A, B, and C) exist, mostly within the boundaries of the RBSRS. These wetland areas total approximately 1.98 acres; however, only 1.44 acres are completely contained within the permanent conservation easement (Figure 4). Wetland A and C are contained within the conservation easement, but Wetland B extends beyond the easement boundaries. Wetland determination forms for the Rocky Branch site are presented in Appendix F. Photographs of wetlands found in this section can be found in Appendix A. These wetlands will be protected on a temporary basis by erosion control measures (silt fence) and on a permanent basis through fencing of the entire periphery of the conservation easement.

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Wetland A comprises 0.35 acre and is characterized as a narrow, linear swale in which seepage from the adjacent landscape provides its hydrology. The wetland is dominated by herbaceous species which have been heavily damaged by foraging cattle. The wetland provides only modest habitat, very limited water storage capacity, and based on low opportunity, plays a minor role in improving water quality at the site. This wetland is likely to be impacted by the relocation of the Rocky Branch channel. However, the remaining portions of the wetland will be enhanced through native wetland plantings.

Wetland B is the largest wetland (1.49 acres) and is best characterized as a Piedmont Bottomland Forest by Schafale and Weakley (1990). However, only 0.95 acres of the total wetland acreage is completely contained within the conservation easement. The vegetative community has been altered by logging activities, resulting in a patchwork of early to mid-successional vegetation and surface drainage patterns reflect repeated disturbances at the site. Original portions of this wetland forest may have been eliminated over the years to provide more pasture for livestock.

Wetland C is the smallest wetland present at the project site with a total acreage of 0.14 acre. This wetland is characterized as an emergent wetland that has formed due to the presence of a natural seepage. The plant species found in this wetland are primarily herbaceous with several tree species on its perimeter. This wetland area is located immediately adjacent to Tributary 1, where it drains into the channel.

4.4 Existing Plant Communities

The vegetative communities found within the project area can be characterized by three major groupings. These groupings include Pastureland, Piedmont Bottomland Forest, and Dry Oak—Hickory Forest (Figure 6). Each plant community with its distinct assemblage of plants arose in response to diverse topography and the influences of changing land uses over time. Scientific names are presented along with the common names the first time the species is cited, but subsequent textual references to the same species will be limited only to its common name.

4.4.1 Pastureland

The pastureland is the most dominant vegetative community, where it accounts for approximately 80% of the total land area within the RBSRS. The pasture areas consist mainly of grasses such as fescue (*Festuca* spp.). A large number of weed species were identified including white clover (*Trifolium repens*), dog fennel (*Eupatorium capillifolium*), horsenettle (*Solanum carolinense*), bittercress (*Cardamine hirsuta*), roundleaf plantain (*Plantago rugelii*), pokeweed (*Phytolacca americana*), chickweed (*Stellaria media*), henbit (*Lamium purpureum*), and broadleaf dock (*Rumex obtusifolius*). Most of the pasture is located within the Rocky Branch floodplain, with small portions located along the side slopes of the project area. Intensive browsing by cattle and the constant exposure of disturbed soil by cattle hooves, particularly during wet weather, has resulted in a dynamic influx of weedy species, where seeds of varied species are indiscriminately dispersed to the disturbed soils in the pasture. This results in a constantly changing pattern of succession in the pasture.

4.4.2 Piedmont Bottomland Forest

Vegetation found in this community is consistent with the Schafale and Weakley's (1990) Piedmont Bottomland Forest classification. This vegetative community exists along the wooded portion of the project site currently owned by Mrs. Texie Owens. Dominant species found within this vegetative community include red maple (*Acer rubrum*), river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), tulip poplar (*Liriodendron tulipifera*), American holly (*Ilex opaca*) and Chinese privet (*Ligustrum sinense*). Piedmont Bottomland Forests are generally situated on floodplain ridges and terraces other than active levees adjacent to the stream channel. They are underlain by various alluvial soils, including the Chewacla and Congaree series. These communities are flooded; however, they are seldom disturbed by flowing water. Bottomland forests are believed to form a stable climax forest, having an un-even aged canopy with primarily gap phase regeneration, although the possibility of unusually deep and prolonged flooding may make widespread mortality more likely than in uplands (Schafale and Weakley, 1990).

4.4.3 Dry Oak—Hickory Forest

This vegetative community contains species and characteristics commonly associated with the Dry Oak—Hickory Forest described by Schafale and Weakley (1990). The community occupies an upland area of the project site where the highest elevations are found. The dominant species found at the site include red maple, mockernut hickory (*Carya tomentosa*), white oak (*Quercus alba*), scarlet oak (*Quercus coccinea*), tulip poplar, American holly, post oak (*Quercus stellata*), Southern red oak (*Quercus falcata*), black cherry (*Prunus serotina*), and American beech (*Fagus grandifolia).* Other less dominant species found within this vegetative community were Virginia pine (*Pinus virginiana),* Eastern red cedar (*Juniperus virginiana),* sourwood (*Oxydendrum* *arboreum*), black walnut (*Juglans nigra*), and white pine (*Pinus strobus*). Species found on the fringe of this community include mountain laurel (*Kalmia latifolia*), blackberry (*Rubus* spp.), and Chinese privet.

4.5 Invasive Plant Species

Invasive, or non-native species, were most prevalent in the Piedmont Bottomland. Extensive quantities of Chinese privet, Japanese honeysuckle (*Lonicera japonica*), and multiflora rose (*Rosa multiflora*) were observed along the stream banks, floodplain, and along the fringe of the pasture areas.

4.6 Threatened and Endangered Species

According to the US Fish and Wildlife Service (USFWS), neither threatened nor endangered species are known to occur in Yadkin County. However, two federal species of concern, the Robust redhorse (a fish) and the Brook floater (a mussel) have been documented for Yadkin County. Due to the severely deteriorated conditions of the stream channels at the RBSRS, it is reasonable to conclude that suitable habitat is not available for mussel species. Information regarding these federally listed species of concern can be found in Table 2.

Table 2. Federally Listed Species

Common Name	Scientific Name	Federal Status	State Status	Habitat Requirements	Suitable Habitat	Biological Conclusion
Brook floater	*Alasmidonta varicosa*	FSC	E	Piedmont systems and along the Blue Ridge escarpment of the Catawba River system	None	Not Applicable
Robust Redhorse	*Moxostoma robustum*	FSC	SR(PE) [1]	Pee Dee River	None	Not Applicable

[1] SR (PE)—Significantly Rare and Is Proposed for Endangered Status

4.7 Environmental Issues

During preliminary site assessments, the EcoScience Corporation obtained data from Environmental Data Resources, Inc. (EDR) regarding the potential for on-site or nearby sources of contamination. EDR maintains an updated database of current and historical sources of contamination. This database identifies all storage tanks, whether above-ground or underground, as well as superfund sites, landfills, hazardous waste sites, and other potential hazards. No sites exist on their database within a one-mile radius of the site. This report is on file.

The Mulkey team conducted a visual reconnaissance for any Recognized Environmental Concerns (RECs) throughout the site. The REC is the presence or likely presence of any hazardous substances or petroleum products on a property under conditions that indicate an existing release, a past release, or a material threat of a release of any hazardous substances or petroleum products into structures on the property or into the ground, groundwater, or surface water of the property (ASTM E1527-00). None were observed. No buildings, sheds, or other structures were noted within the Rocky Branch project area. The only REC exists outside of the stream restoration project area as an inactive dairy waste storage pond. The waste storage pond is located approximately 250 feet upslope from the Rocky Branch channel and will be decommissioned as part of this project.

4.8 Cultural Resources

Currently, an investigation is underway to document a stone dam located within the Rocky Branch stream channel below the SR 1120 bridge. The stone dam is currently located behind Mr. Joe Allen's home, where it is causing heavy sedimentation and debris jams. The status of the dam is currently "Unresolved" pending an eligibility determination for the National Register of Historic Places and consultations with the North Carolina State Historic Preservation Office (NCSHPO).

5.0 Natural Channel Design

5.1 Reference Reach Analyses

Due to the existing unstable nature of many second, third and fourth order streams in the Piedmont physiographic province; only one reference reach (Spencer Creek) has been identified to date. Spencer Creek is situated in Montgomery County, approximately 8 miles from Troy and on the west side of SR 1134 (Figure 7). Spencer Creek is characterized as a second order stream and it is classified as a rural E4/C4 stream type. Specific morphological data for this reference reach are given within the morphological table found in Appendix C. Its watershed is approximately 0.54 square mile (348 acres) and encompasses large tracts of undeveloped woodland within the Uwharrie National Forest. The riparian corridor associated with this stream consists of native, woody vegetation. Dominant species include American holly, red maple , sweetgum, mountain laurel, flowering dogwood (*Cornus florida*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), sourwood (*Oxydendrum arboreum*), and giant cane (*Arundinaria gigantea*). This stream was chosen due to its stable nature and relatively low bank-height ratios.

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5.2 Sediment Transport Analyses

Sediment plays a major role in the influence of channel stability and morphology (Rosgen, 1996). A stable stream has the capacity to move its sediment load without aggrading or degrading. Sediment analyses are generally divided into measurements of bedload and suspended sediment (washload), changes in sediment storage, size distributions and source areas. Washload is normally composed of fine sands, silts and clay transported in suspension at a rate that is determined by availability and not hydraulically controlled. Bedload is transported by rolling, sliding, or hopping (saltating) along the bed. At higher discharges, some portion of the bedload can be suspended, especially if there is a sand component in the bedload. Bed material transport rates are essentially controlled by the size and nature of the bed material and hydraulic conditions (Hey and Rosgen, 1997).

Two measures are used to calculate sediment loads for natural channel design projects: (1) sediment transport competency and (2) sediment transport capacity. Competency is a stream's ability to move particles of a given size. It is expressed as a measure of force (lbs/ft^2). Capacity is a stream's ability to move a quantity of sediment and is a measurement of stream power, expressed in units of lbs/ft•sec. These analyses are conducted to ensure that the designed stream beds including Rocky Branch and its tributary do not aggrade or degrade during bankfull conditions. Brief descriptions of these two analyses are presented in the following sub-sections. Entrainment and velocity calculation sheets used for these analyses are presented in Appendix G and H, respectively.

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5.2.1 Sediment Competency Analysis

The critical dimensionless shear stress (τ^*_{ci}) is the measure of force required to initiate general movement of particles in a bed of a given composition. This calculation is part of several calculations used to determine aggradation/degradation along the stream channel. For shear stresses exceeding this critical value, essentially all grain sizes are transported at rates in proportion to their presence in the bed (Wohl, 2000). For gravel-bed streams, the critical dimensionless shear stress is generally calculated using surface and subsurface particle samples from representative riffle sections. The critical dimensionless shear stress calculation is presented below.

$$\tau^*_{ci} = 0.0834\,(d_i/d_{50})^{-0.872}$$

where,

- τ^*_{ci} = critical dimensionless shear stress (lbs/ft^2)
- d_i = median particle size of riffle bed surface (mm)
- d_{50} = median particle size of subsurface sample (mm)

Note that d_i and d_{50} values were empirically determined by *in situ* measurements. Based on the d_i of 48 mm and the d_{50} of 6.3 mm, the critical dimensionless shear stress was calculated to be approximately 0.0141 lbs/ft^2 utilizing the calculation above. This critical dimensionless shear stress is used as part of the aggradation analysis presented in the following section.

The shear stress placed on the sediment particles is the force that entrains and moves the particles. The critical shear for the proposed channel has to be sufficient to move the D_{84} of the bed material. The critical shear stress was calculated and plotted on the Modified Shield's curve to determine the approximate size of particles that will be moved (Rosgen, 2001).

Based on the Modified Shield's curve, particles ranging from 50 mm to 140 mm could be moved within the Rocky Branch channel, with an average moveable size of 95 mm. The largest particle found on depositional bars was 63 mm. The D_{84} and D_{100} of Rocky Branch are 85 mm and 130 mm, respectively. Therefore, the proposed design has sufficient shear stress to move the bedload associated with both streams. Based on Shield's curve, the unnamed tributary can move particles ranging from 5 mm to 15 mm. The D_{84} and D_{100} of the first unnamed tributary are 4.0 and 12 mm, respectively.

5.2.2 Sediment Transport Capacity

Stream power was calculated for both the existing and design channel conditions to determine the effect of the restoration on sediment transport capacity. A stream's capacity is defined as the maximum load a stream can transport at a given time. The capacity of a stream to move sediment is directly related to velocity and stream power. The existing channel exhibited an excess of stream power as noted by the mass wasting of banks and excessive bank height ratios. By adjusting width-to-depth ratios and providing a floodplain at the bankfull stage, the proposed design reduces both stream power and velocity; thereby, reducing capacity to only that needed to move the sediment supplied by the watershed.

5.2.3 Aggradation/Degradation Analysis

New channel construction associated with natural channel design projects generally includes the design and layout of a channel with increased length and sinuosity and reduced slope as compared with the existing channel. However, there are some situations where the existing channel exhibits excessive and unstable patterns. The new channel design in these cases will result in an increase in slope and a decrease in channel length. The data associated with these channels must prove that the adjusted channel slope will not cause the stream to aggrade or degrade. The proposed design for the upper portion of Rocky Branch will result in a new and longer channel with more meanders and with slightly less slope (0.0109 ft/ft) than the existing channel (0.0155 ft/ft). The middle portion of Rocky Branch follows the second model; consequently the new channel will have a greater slope, but will be somewhat shorter. The proposed design for this segment of stream will result in an increase in slope (0.0069 ft/ft) versus the existing (0.0053 ft/ft). The lower portion of Rocky Branch maintains a relatively stable profile; therefore the proposed design will not alter the channel's slope (0.0036 ft/ft), only its dimension and pattern. The proposed width/depth ratios were adjusted in conjunction with the slope to ensure that the proposed stream will transport its sediment over time without aggrading or degrading.

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Calculations of critical depth are required. These calculations represent the need to transport large sediment particles, usually defined as the largest particle of the riffle sub-pavement sample. As a result, critical depth can be compared with the design mean riffle depth in order to verify that the design stream has sufficient competency to move large particles without causing the thalweg to aggrade or degrade. The calculation for critical water depth is shown below.

$$d_{cr} = \frac{1.65\,(\tau^*_{ci})D_i}{S}$$

where,

d_{cr}	= critical water depth (ft)
τ^*_{ci}	= critical dimensionless shear stress (lbs/ft^2)
D_i	= largest particle of bar or sub-pavement sample (ft)
S	= average channel slope (ft/ft)

5.2.4 Sediment Transport Summary

Based on the calculations for competency, aggradation, degradation and capacity, bankfull conditions in the design channel will entrain particles ranging from 50 to 140 mm. The D_{100} of Rocky Branch is 130 mm. The design channel is predicted to remain stable over time based on the establishment of proper dimension, pattern and profile and an active floodplain. The addition of riparian vegetation will further enhance the long term stability of the entire system.

5.3 Proposed Design

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Design methodologies are based on natural channel design concepts outlined by Rosgen (1994, 1996, 1998). These methodologies include existing and reference reach channel surveys, data interpretations and geomorphological comparisons of all channel features. Based on field observations and preliminary ideas, the project will attempt to implement Priority I and II Restoration and Priority IV Stabilization. The restoration of Rocky Branch will follow Priority Level I, II, and IV protocols. The Priority Level I Restoration will result in a new stream channel adjacent to the existing channel that exhibits a bank height ratio (ratio of the top of bank elevation divided by the bankfull elevation) of 1.0 to 1.3. The Priority Level II Restoration involves construction of a new channel with a floodplain bench at the bankfull elevation. The Priority Level IV Stabilization will involve the placement of structures to alter the dimension of the channel, without constructing a new channel. A summary of the existing and proposed streams at RBSRS is outlined in Table 3. A Conceptual Design for Rocky Branch can be found in the Attachments section.

Table 3. Rocky Branch Stream Restoration Summary

Streams				
Stream	**Priority Level**	**Type**	**Existing Length of Channel (lf)**	**Proposed Length of Channel (lf)**
Rocky Branch	I	Restoration	4,171	3,444
	II	Restoration		320
	IV	Enhancement		407
Tributary #1	I	Restoration	593	192
Tributary #2	N/A	Pond	280	0
		Total	5,044	4,363

5.3.1 Rocky Branch

It is anticipated that Priority Level II Restoration design measures will be applied to approximately 320 linear feet of Rocky Branch (Station 0+00 to 3+20) (Appendix I). This upper reach area will serve as a transition from the existing channel to the newly constructed channel. The slope in the upper reach averages 0.0109 ft/ft, which is the steepest portion of the entire project. Cross vanes will be the primary structures used in this section in order to provide stability and grade control for this area of transition. Bankfull cross sectional areas found in this portion of the project average 30.0 square feet for riffles and 38.5 square feet for pools and are also found in Appendix I). The upper reach stream channel will contain floodplain benches, which will help reduce stream velocities and provide a transitional tool to link the Priority I stream restoration area starting at Station 3+20.

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The middle reach of the proposed channel is the beginning of Priority I restoration activities. The middle reach which contains a slope of 0.0069 ft/ft, will provide a gradual transition between the upper and the lower reaches. Bankfull cross sectional areas associated with the middle reach average 35.0 square feet for riffles to 46.0 square feet for pools. Bankfull associated with the middle reach will lie at or very close to the top of bank. By positioning the bankfull elevation at the top of bank, the stream channel with be able to fully utilize its floodplain. This utilization of the floodplain should significantly reduce bank erosion. Structures used in this section will include cross vanes, j-hook vanes, and single arm rock vanes.

Rootwads will be installed at specific areas to relieve stress from outside bends and to provide natural habitat for aquatic life.

The lower reach of Rocky Branch begins at Station 11+80, where it continues to follow Priority I stream restoration methods. This section contains slopes averaging 0.0034 ft/ft, which are the lowest throughout the project. Bankfull cross sectional areas associated with the lower reach average 45.0 square feet for riffles and 52.5 square feet for pools. This reach will also utilize cross vanes, j-hooks, single arm vanes, and rootwads structures. Any existing drainage tiles within the conservation easement will be removed or destroyed during the channel construction. A 25 foot-wide permanent ford crossing will be established within proposed Rocky Branch channel between Stations 14+99 and 15+24.

Beginning at Station 37+10, where the new channel connects back to the existing channel, stream restoration methods will follow Priority IV stabilization methods. This section will use a minimal number of cross vane structures to achieve the appropriate channel dimensions. Stream banks will be sloped and tapered into the floodplain, which will reduce the current bank erosion induced by cattle grazing. Following the removal of the boulder dam, areas previously impacted should return to a bedrock controlled stream bed.

5.3.2 Tributary 1

Stream restoration associated with Tributary 1 will be exclusively Priority Level I Restoration. The proposed restoration will reduce the linear footage of the stream channel, but provide a more natural configuration and alignment with the Rocky Branch channel. Bankfull cross sectional areas proposed for this stream channel are 4.5 square feet for riffles and 5.25 square feet for pools. Cross vanes will be installed to provide grade control within this newly constructed channel. Spoil material removed from the newly excavated channel will be placed in the abandoned channel of Tributary 1 following the placement of clay plug at the new connection point.

5.3.3 Tributary 2

As a result of conservation easement agreements, no stream restoration activities will take place on the Tributary 2 stream channel. The current stream channel, which arises from a natural spring, will be converted to a small pond. The construction of this pond will significantly reduce sediment inputs and should improve the quality of the water flowing into Rocky Branch. The outflow of the pond will eventually drain back into the Rocky Branch channel.

5.4 Proposed Construction Sequence

Construction of the project will be carried out in three phases to ensure adequate implementation of sedimentation controls, channel stability, and maximum vegetation survival. During the first phase, primary construction access roads, spoil areas, and staging areas will be established. Following the completion of these construction zones, the boulder dam will be removed. During the second phase, the Rocky Branch stream channels, the pond, and the secondary access roads will be constructed. Filling of the abandoned channels will also be completed during the second phase. The final phase will involve minor grading, site preparation (sub-soiling), removal of temporary access roads and staging areas, and the creation of depressions (vernal pools).

Initially, the primary construction access roads, spoil areas, and the staging areas will be established throughout the entire RBSRS. Once these areas have been established, the boulder dam will be removed and the boulders stockpiled. Removal of the dam at this stage of construction will allow the on-site engineer to monitor this area, while continuing to proceed with other phases of the project. Removal of the dam should allow accumulated sediments to exit the impounded area, returning the channel to its original bed material, which is comprised of bedrock. Since the conservation easement does not include any area downstream of the SR 1120 bridge, boulders removed from the dam will be stored and used for in-stream structures on Mr. Joe Allen's portion of the conservation easement.

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The second phase of the project will involve construction of new channels and placement of structures for Rocky Branch and Tributary 1. The proposed pond will be constructed at the current location of Tributary 2. These structures will provide stability and habitat for the stream channel and will include cross vanes, j-hook vanes, single-arm rock vanes, and rootwads. Construction of the new channel must be staged to ensure the most economical use of equipment and materials, and to ensure that sedimentation controls and channel stability efforts are maximized.

The new Rocky Branch channel will be constructed from Station 0+50 (50 feet downstream of project's northern limit) to Station 20+00. Dewatering structures will be built near Stations 7+00 and 12+00 to filter out residual sediment. These dewatering structures will drain into the depression area on the east side of the field to further filter the water. A third structure will be installed at Station 20+00, and it will drain into the existing channel. This phase of construction will be built in segments that will cease at stations where the dewatering structures are planned. This will further ensure superior sediment control since groundwater difficulties are anticipated. A small portion of the channel between Stations 19+80 to 20+00 will remain in place to prevent movement of groundwater past the dewatering structures. This will be excavated and vegetated prior turning the water into the new channel. Spoil generated from excavation of the new channel will eventually be used to fill the existing stream channel. Consequently, the majority of the excavation spoil from upstream of Station 20+00 will be stockpiled on the west side of the newly constructed channel as detailed on the erosion control plans, to reduce material-handling time and to minimize compaction of the substrate.

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Between Stations 20+00 and 30+00, the distance between the existing and proposed channel locations prevent spoil stockpiling. In order to continue construction of the new channel, two 24-inch corrugated plastic pipes will be placed in the stream and serve as a conveyance for the water near Station 20+00. An impervious rock dyke (rock silt screen) will be installed around the pipe inlet to concentrate water into the pipes and not disturb the flow of the stream. Fill will then be placed over the pipes in the existing channel. Silt fence should be installed as shown on the erosion control plan on either side of the pipe outlet to protect against any erosion upstream. Pipes will be laid in 20 to 50-foot segments, as needed on a day by day basis. At least 2 rock silt screens will be installed downstream of the pipe inlets to prevent the pipes from floating or moving, and a fourth will be established at the pipe outlets. A rip-rap energy dissipater will be constructed at Station 30+00. A rock check will be installed just upstream of the pipe inlet to trap heavy sediment and fines, protecting the pipe from clogging. The use of corrugated plastic pipes and the proximity of the existing and proposed channel locations will permit concurrent filling of the existing channel during construction of the new channel. This system should significantly reduce material handling and equipment movement which in turn minimizes impacts to the soil substrate. Dewatering structures will be established near Station 30+00 to handle groundwater seepage between Stations 20+00 and 30+00.

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The final leg of main channel construction is between Stations 30+00 and 37+00. Dewatering structures will be installed at Station 37+00 to account for filtration of groundwater. Stockpile areas will be located on either side of the new channel as outlined in the erosion control plans. When construction is complete on the main channel, the new channel work on Tributary 1 can be then be started.

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The new Tributary 1 channel will be constructed from Station 0+20 to the new Rocky Branch channel and allowed to vegetate prior to any diversion of water. Prior to diverting water into the new Rocky Branch channel, a secondary access road will be built to allow the contractor access to the area between Stations 0+00 to 0+50. Following the construction of the secondary access road, the Rocky Branch channel will be connected with its new channel by excavating an opening between Stations 0+00 to 0+50 and installing a clay plug in the old channel. In the interim, backfilling of the abandoned Rocky Branch channel will begin, which should allow adequate time for the newly constructed Tributary 1 channel to vegetate. Once the new Tributary 1 channel is considered adequately vegetated, water can then be diverted into the channel by excavating between Stations 0+00 to 0+20 and placing a clay plug in its old channel. Following the completion of the new Tributary 1 channel, the construction of the pond will begin.

The final phase of the construction process will involve minor grading and sub-soiling of the site, removal and amelioration of temporary access roads, and the creation of depressions commonly known as vernal pools. The sub-soiling will be done to mitigate soil compaction of by heavy equipment and cattle and to create micro-topographic features adjacent to the stream channel. Removal of temporary access roads and staging areas will start at the beginning of the project and proceed downstream. This will allow the removal of all temporary materials and the renovation of areas as well as constructing vernal pools. The vernal pools were strategically located near or in staging and stockpile areas to eliminate compaction areas on the site and to reduce the construction costs. Following the final grading activities, native trees and shrubs will be planted at the site during the dormant season.

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6.0 Flood Analyses

Portions of the Rocky Branch Site, including the channel of Rocky Branch and its immediate floodplain are located within the Federal Emergency Management Association's (FEMA) approximate 100-year flood boundary, as depicted on Figure 8 (FEMA, 1991). These areas are inundated by the 100-year flood where Base Flood Elevations (BFE) have not been determined. Currently Yadkin County does not participate in the National Flood Insurance Program; therefore, no formal study is required according to FEMA's 44 CFR 60.3(b).

Approximate limits of flooding for the existing and proposed channels were determined using HEC-RAS software from the US Army Corps of Engineers Hydrologic Engineering Center. Water surface profiles for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year storm events were computed. Data from the 50-year and 100-year storm events are included in Table 4.

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Table 4. Flood Analyses for the 50-Year and 100-Year Storm Events.

Rocky Branch Profile: 50 yr

Station (proposed)	Q Total (cfs)	Water Surface Elevation Existing (ft)	Proposed (ft)	Difference (ft)
19.60	1200	882.91	882.91	0.00
240.51	1200	889.49	889.49	0.00
642.82	1200	897.39	897.39	0.00
947.94	1200	902.43	902.43	0.00
1284.23	1200	908.77	911.68	2.91
1544.40	1200	911.07	913.59	2.52
1597.98	1200	911.93	913.45	1.52
1620	Bridge			
1635.84	1200	914.33	914.98	0.65
1689.69	1200	914.71	915.78	1.07
1771.64	1200	914.78	915.80	1.02
2046.16	1100	915.21	916.10	0.89
2457.83	1100	917.37	917.17	-0.20
3074.68	1100	919.47	919.20	-0.27
3572.24	1100	920.70	920.21	-0.49
4327.59	1100	923.12	923.01	-0.11
4903.24	1100	925.34	926.29	0.95
5593.52	1100	929.01	931.06	2.05
6339.76	1100	941.99	941.99	0.00

Rocky Branch Profile: 100 yr

Station (proposed)	Q Total (cfs)	Water Surface Elevation Existing (ft)	Proposed (ft)	Difference (ft)
19.60	1500	883.40	883.40	0.00
240.51	1500	889.92	889.92	0.00
642.82	1500	897.83	897.83	0.00
947.94	1500	903.04	903.03	-0.01
1284.23	1500	909.33	912.15	2.82
1544.40	1500	911.56	914.16	2.60
1597.98	1500	912.58	913.91	1.33
1620	Bridge			
1635.84	1500	915.42	916.01	0.59
1689.69	1500	915.85	916.90	1.05
1771.64	1500	915.94	916.92	0.98
2046.16	1400	916.07	917.09	1.02
2457.83	1400	917.69	617.94	0.25
3047.68	1400	919.97	919.70	-0.27
3572.24	1400	921.26	920.70	-0.56
4327.59	1400	823.25	823.57	0.32
4903.24	1400	925.94	926.74	0.80
5593.52	1400	929.71	931.74	2.03
6339.76	1400	942.50	942.50	0.00

7.0 Typical Drawings

Four different structure types made of natural materials will be installed in the stream channels. These structures include single-arm rock vanes, j-hook rock vanes, cross vanes and rootwads. These will be composed of natural materials from the boulder dam and off-site sources. Details for these structures can be found in Appendix J.

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7.1 Single-Arm Rock Vane

These structures are designed to dissipate the secondary circulation cells which cause stress in the near bank region. They also force the thalweg away from the bank and towards the middle of the channel. These structures are placed on the outsides of meander bends. Footer rocks are placed on one side of the channel bottom for stability. More rocks are then placed at an angle to the stream bank, gradually inclining in elevation until they are located at the proposed bankfull elevation. At the point at which the structure reaches the bankfull elevation, rocks are placed perpendicular to the rock vane arm and embedded into the bank. These additional rocks provide a linkage to the existing stream bank as well as providing added protection during heavy flows.

7.2 J-Hook Rock Vanes

These structures are also designed to dissipate the secondary circulation cells which cause stress in the near bank region. They also force the thalweg away from the bank and towards the middle of the channel. Similar in design to single-arm rock vanes, these structures are placed on the outsides of meander bends. Footer rocks are placed on one side of the channel bottom for stability. More rocks are then placed at an angle to the stream bank, gradually inclining in elevation until they are located above the bankfull surface directly adjacent to the stream bank. Additional rocks are placed in the channel to give the structure a "J" shape. These extra rocks are added to maintain the pool and provide additional fish habitat.

7.3 Cross Vanes

These structures serve to maintain the integrity and composition of the riffle while promoting scour along the center of the channel, away from the adjacent banks. The design shape is roughly that of the letter "U" with the apex situated on the upstream side in the riffle section. Footer rocks are placed in the channel bottom for stability. Rocks are then placed on the top of these footer rocks in the middle of the channel at approximately the same elevation as the designed stream bed. Rocks are then placed at an angle to the stream bank on either side of the channel. These rocks gradually incline to the bankfull elevation. Water flowing downstream is forced over these rocks towards the middle of the channel on either side of the structure, effectively scouring a pool immediately downstream. Cross vanes are used primarily for stabilization and grade control, but the structures also provide habitat.

7.4 Root Wads

The objectives of these structures are to: provide in-stream and overhead cover for aquatic organisms, including fish; provide shade, detritus and terrestrial insect habitat; and provide minimal protection of the stream bank from erosion. Generally, a footer log and boulder are placed on the channel bottom and abut the stream bank along the outside of the meander bend. This provides support for the rootwad and stability (minimal) to the stream bank. A large tree rootwad (or root-ball) is then placed on the stream bank with additional boulders and rocks on either side for stability. Flowing water is deflected away from the bank and towards the center of the channel.

8.0 Stream Riparian Planting Plan

The planting plan for the riparian and upland buffers of the Rocky Branch site will provide post-construction erosion control and riparian habitat enhancement. The planting plan will also attempt to blend existing vegetative communities into recently restored areas. Plantings in the buffer areas will include native species appropriate for the Piedmont physiographic province and the RBSRS. Plants within the floodplain will be flood tolerant species, which can accommodate periodic flooding events throughout the year. A variety of trees and shrubs will be planted to provide cover and habitat for wildlife as well as soil stabilization.

Tree and shrub species will be planted in specific planting zones. These planting zones will accommodate plant species which have specific requirements for growth. Hydrology and topography are main factors that dictate a plant's ability to survive and to thrive following planting. These planting zones will be created around these requirements and will include the following zones: Zone 1 (Stream Banks), Zone 2 (Riparian Buffer), Zone 3 (Wetlands), Zone 4 (Vernal Pools), and Zone 5 (Upland Buffers. A list of species in each Zone can be found in Table 5.

Table 5. Recommended Plant Species and Planting Zones.

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Planting Zone	Zone Description	Recommended Plant Species [A]	
		Scientific Name	**Common Name**
1	Stream Banks	*Alnus serrulata* *Betula nigra* *Cephalanthus occidentalis* *Cornus amomum* *Hibiscus mosheutos* *Lindera benzoin* *Salix nigra* *Salix sericea* *Sambucus canadensis*	Tag alder River birch Buttonbush Silky dogwood Marsh mallow Spicebush Black willow Silky willow Elderberry
2	Riparian Buffer	*Betula nigra* *Fraxinus pennsylvanica* *Lindera benzoin* *Plantanus occidentalis* *Quercus nigra* *Quercus phellos* *Sambucus canadensis*	River birch Green ash Spicebush Sycamore Water oak Willow oak Elderberry
3	Wetlands	*Alnus serrulata* *Cephalanthus occidentalis* *Cornus amomum* *Fraxinus pennsylvanica* *Hibiscus mosheutos* *Salix nigra* *Salix sericea*	Tag alder Buttonbush Silky dogwood Green ash Marsh mallow Black willow Silky willow
4	Vernal Pools	*Boehmeria cylindrica* *Carex lurida* *Carex intumescens* *Cyperus strigosus* *Eleocharis obtusa* *Eupatorium fistulosum* *Juncus coriaceus* *Juncus effuses* *Saururus cernuus*	False nettle Lurid sedge Bladder sedge Umbrella sedge Blunt spike-rush Joe-pye weed Leathery rush Soft rush Lizard's tail
5	Upland Buffer	*Carya tomentosa* *Cornus florida* *Diospryos virginiana* *Ilex opaca* *Juniperus virginiana* *Pinus echinata* *Pinus strobus* *Pinus virginiana* *Prunus serotina* *Quercus alba* *Quercus falcata*	Mockernut hickory Flowering dogwood Persimmon American holly Eastern red cedar Shortleaf pine White pine Virginia pine Black cherry White oak Southern red oak

[A] List is alphabetized by scientific name within each planting zone.

Shrubs and trees with extensive, deep rooting systems will assist in stabilizing the banks in the long term. Native grasses, transplants, and live stakes will be utilized at the site for immediate stabilization as well as erosion control matting along the newly created stream banks. Vegetation will be planted in a random fashion in an effort to mimic natural plant communities. Colonization of local herbaceous vegetation will inevitably occur, which will provide additional soil stability. Tree species will be planted as bare root stock on random eight-foot centers at a frequency of 680 stems per acre. Shrub species will be dispersed among these tree species also on random eight-foot centers. Larger plant stock will be established in areas immediately adjacent to channel structures. These areas will also receive much denser plantings in order to expedite the stabilization of the soil through greater rooting mass. Planting stock will be culled to remove inferior specimens, so only healthy, viable stock will be planted at the RBSRS. Planting of species will utilize dormant plant stock and will be performed to the extent practicable between December 1st and March 15th.

9.0 Stream Monitoring Plan

Monitoring will determine the degree of success the mitigation project has achieved in meeting the objectives of providing proper channel functions and increased habitat quality. This monitoring data will provide the Ecosystem Enhancement Program (EEP) and resource agencies with evidence that the goals of the Rocky Branch project have been met. Monitoring of the site will include an assessment of geomorphology and riparian vegetation at least once each year for a total of five years. Monitoring reports will be submitted annually to the EEP by December of each year. The monitoring reports will include detailed analysis of the new stream and floodplain, plant survivability, photos, and photo location points as well as a description of any problems and recommendations for remedial measures. Photo point locations are shown on Figure 5 and pre-construction photos of these areas can be found in Appendix A. In the event that success criteria are not met, remedial measures will be installed to achieve success, as directed by the EEP.

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Upon completion of the project, an as-built channel survey will be conducted. The survey will document the dimension, pattern, and profile of the restored channel. Permanent cross sections will be established at an approximate frequency determined by the EEP. The locations will be selected to represent approximately 50% riffle and 50% pool areas. The as-built survey will include photo documentation at all cross sections, a plan view diagram, a longitudinal profile, vegetation information and pebble counts. The as-built plan will serve as a reference for demonstrating and quantifying the magnitude and frequency of problem events.

9.1 Stream Channel Assessment

During the first-year Mulkey will evaluate the restored portion of Rocky Branch and Tributary 1 in regard to overall channel stability. Since streams are considered as “active” or “dynamic” systems, restoration is achieved by allowing the channel to develop a stable dimension, pattern, and profile such that, over time, the stream features (riffle, run, pool, and glide) are maintained and the channel does not aggrade or degrade. Minor morphologic adjustments from the design stream are anticipated based on the correlation of reference reach data, excessive sediment deposition from upstream sources, and on-going changes in land use within the watershed in addition to the effects of extraordinary meteorological events.

9.2 Vegetation Success

Vegetation requirements state that 260 stems/acre must be viable for success after the five year monitoring period. Should the performance criteria outlined above not be met during the monitoring period, Mulkey will provide the EEP with a remediation proposal, detailing corrective actions and/or maintenance actions proposed, and an implementation schedule. Upon review and approval/modification of proposed corrective measures by the EEP and the regulatory agencies, Mulkey will implement the necessary corrective measures.

9.3 Monitoring Data

Monitoring data for each monitoring year will consist of the following:

1. Stream Channel Assessment
   Channel stability

2. Vegetation Data
   Number of stems/acre of woody species
   Percent of survival of planted woody species
   Species composition, including non-dominants
   Quantitative measure of noxious species
   Overall condition of the planted species
   Photo reference locations of each plot

9.4 Reporting

The first-year monitoring reports will be submitted to the EEP's designated representative for coordination with the appropriate regulatory agencies on an annual basis. The first-year of monitoring will have two submittals, one being the As-Built drawings and the second being the First Year Annual Monitoring Report. It is understood that the EEP will coordinate any necessary monitoring report submittals with the regulatory agencies. If monitoring reports indicate any deficiencies in achieving the success criteria on schedule, a remedial action plan will be included in the annual monitoring reports. Mulkey will be available to coordinate any agency site visits, both before and after restoration activities have been completed. Vegetative monitoring will be conducted during the summer months of each monitoring year.

9.5 Exotic/Invasive Species

Invasive species will be identified and controlled so that none become dominant species or alter the desired community structure of the site. Specific areas have already been identified to contain invasive plants. Invasive species within these areas will be controlled using the most appropriate means that is suitable to EEP.

All vegetation removal from the site shall be done by mechanical means only unless the EEP has first authorized the use of herbicides or algaecides for the control of plants in or immediately adjacent to the site.

10.0 Stream Performance Criteria

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Based on the Classification Key for Natural Rivers (Rosgen, 1996), restoration activities will ultimately result in the classification of a C-stream type for Rocky Branch and Tributary 1. These stream types are slightly entrenched, meandering, gravel dominated, riffle-pool channels with well developed floodplains. Pool to pool spacing for this stream type averages five-toseven bankfull channel widths in length. The stream banks are generally composed of sand and gravel material, with stream beds exhibiting little difference in pavement and sub-pavement material composition. Rates of lateral migration are influenced by the presence and condition of riparian vegetation. The C-stream type, is best characterized by the presence of point bars and other depositional features, it is very susceptible to shifts in both lateral and vertical stability caused by direct channel disturbance and changes in the flow and sediment regimes of the contributing watershed. As a result, stream success criteria will be based on overall stability. It is expected that channel adjustment will occur throughout the restored reaches; however, excessive adjustment and potential stream instability will be judged to be occurring if the width/depth ratio is measured to be greater than 18, the bank height ratio is greater than 1.4; radius of curvature ratio is less than 1.5, or the development of head cuts occur.

11.0 Wetland Performance Criteria

Baseline wetlands determinations were performed to quantify the existing wetlands at the RBSRS. Currently, a total of 1.44 acres of wetlands are located within the conservation easement. Wetland creation, restoration, and enhancement activities presented in the following sections only represent approximate wetland acreages, which are anticipated at the end of monitoring year-five (Table 6). An actual acreage of these wetlands will be determined during the fifth-year of monitoring by a new jurisdictional determination. Each wetland category (creation, restoration, enhancement, and preservation) will be determined at the time of the jurisdictional determinations. Wetlands derived as a result of the project will be determined by subtracting the existing wetland acreage from the total wetland acreage found at the site at the end of monitoring year five.

Table 6. Rocky Branch Wetland Restoration Summary

<table>
<tr><th colspan="4">Wetlands</th></tr>
<tr><th>Name</th><th>Type</th><th>Existing (Acres) [A]</th><th>Proposed (Acres) [A]</th></tr>
<tr><td rowspan="4">Non-Riparian</td><td>Creation</td><td rowspan="4">0.35 [B]</td><td>--</td></tr>
<tr><td>Restoration</td><td>--</td></tr>
<tr><td>Enhancement</td><td>--</td></tr>
<tr><td>Preservation</td><td>--</td></tr>
<tr><td></td><td>Total</td><td>0.35 [C]</td><td>0.00</td></tr>
<tr><td rowspan="4">Riparian</td><td>Creation</td><td rowspan="4">1.09</td><td>1.50</td></tr>
<tr><td>Restoration</td><td>0.72</td></tr>
<tr><td>Enhancement</td><td>0.24</td></tr>
<tr><td>Preservation</td><td>1.09</td></tr>
<tr><td></td><td>Total</td><td>1.09</td><td>3.55</td></tr>
<tr><td></td><td>Grand Total</td><td>1.44</td><td>3.55</td></tr>
</table>

[A] Represents acreage completely contained within the conservation easement.
[B] Wetland acreage represents "Wetland A".
[C] Existing non-riparian wetland acreage reverts to riparian enhancement acreage following channel relocation.

11.1 Wetland Creation

Wetlands created as a result of the stream restoration activities will be located within the abandoned stream channel of Rocky Branch and throughout the floodplain as vernal pools (Attachments). Soil material removed from new channel excavations will be used to partially fill the abandoned stream channel. The specific location of each created wetland was purposely selected to provide water storage for overland flow due to the steep topography surrounding the project and stormwater drainage from the I-77 roadway. These created wetlands will be planted with wetland species native to this region. Creation of these wetlands will provide habitat for amphibians, waterfowl, and other plant and animal species in the area. Approximately 1.50 acres of wetland creation is anticipated within the conservation easement.

11.2 Wetland Enhancement

Wetland enhancement activities will be focused on reestablishing vegetation within Wetland A. Due to the relocation of the Rocky Branch channel, some portions of the original wetland may be altered or eliminated. As a result of these activities, the remaining portions of Wetland A (0.24 acres) will be enhanced through riparian plantings. The vegetation currently found within the wetland is comprised herbaceous species that have been significantly impacted due to cattle grazing. Very few woody species are present except for several American hollies and a black willow. Planting appropriate native, wetland vegetation within this area should significantly improve the quality of this wetland area.

11.3 Wetland Preservation

The preservation of existing wetlands will include the portions of Wetland B and Wetland C (1.09 acres) found within the established conservation easement. Wetland B is characterized as a Piedmont Bottomland Forest and Wetland C is an emergent wetland. The elimination of cattle within these areas through fencing, should only improve the quality of these wetlands. The relocation of the Rocky Branch channel and the removal of drainage tiles in adjacent fields will also help enhance the value of these areas.

11.4 Wetland Restoration

Wetland restoration is anticipated in areas adjacent to the Piedmont Bottomland Forest and the abandoned channel of Tributary 1 (Attachments). Soils found in these areas are conducive to wetland restoration because of their existing redoximorphic features, their proximity to existing wetlands, and the presence of drainage mechanisms within these areas. Vegetation in these areas has been maintained through mowing and livestock grazing. Following the relocation of the stream channel and the installation of fencing around the project, more typical successional patterns should result in the return of wetland vegetation and hydrology to these areas. The current conceptual design proposes the restoration of 0.72 acres of wetlands. The current base mapping will serve as baseline for determining the actual quantities of wetland creation or restoration following the completion of the project.

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Wetland restoration is anticipated in areas adjacent to the Piedmont Bottomland Forest and the abandoned channel of Tributary 1 (Attachments). Soils found in these areas are conducive to wetland restoration because of their existing redoximorphic features, their proximity to existing wetlands, and the presence of drainage mechanisms within these areas. Vegetation in these areas has been maintained through mowing and livestock grazing. Following the relocation of the stream channel and the installation of fencing around the project, more typical successional patterns should result in the return of wetland vegetation and hydrology to these areas. The current conceptual design proposes the restoration of 0.72 acres of wetlands. The current base mapping will serve as baseline for determining the actual quantities of wetland creation or restoration following the completion of the project.¶
¶
<#>Wetland Enhancement¶
¶
Wetland enhancement activities will be focused on reestablishing vegetation within Wetland A. Due to the relocation of the Rocky Branch channel, some portions of the original wetland may be altered or eliminated. As a result of these activities, the remaining portions of Wetland A (0.24 acres) will be enhanced through riparian plantings. The vegetation currently found within the wetland is comprised herbaceous species that have been significantly impacted due to cattle grazing. Very few woody species are present except for several American hollies and a black willow. Planting appropriate native, wetland vegetation within this area should significantly improve the quality of this wetland area.

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12.0 Farm Management

This section includes the management of activities that fall outside of the stream restoration tasks, but are directly linked to the overall quality of the project. The tasks are a direct result of the stream restoration project or a part of the conservation easement agreement agreed upon by the current property owners. EEP and Mulkey will provide administrative assistance during the planning and implementation phases of these farm management tasks. These tasks will include installation of watering structures and piping, the drilling of wells, the construction a shade house for cattle, and the decommissioning of a waste storage pond. Contractors will be selected to implement these tasks through an informal bid process.

12.1 Livestock

As a result of stream restoration activities, which includes a provision for fencing out cattle, livestock currently utilizing the Rocky Branch channels for water will no longer have access to shade or watering areas along the stream and immediate riparian and non-riparian buffer areas. Therefore, as a condition of the future conservation easement five drinking stations, two wells, one shade house, and fencing will be installed at designated locations outside of the conservation easement (Figure 9). EEP and Mulkey will only provide administrative assistance with these farm management tasks.

In order to provide water for approximately seventy-five head of beef cattle, four drinking stations and a well will be installed on Mr. Joe Allen's property within the conservation easement An existing well will be connected to two of the drinking stations, while the remaining two stations will be connected via the newly drilled well. All water connections and pumps will be installed to provide the most effective watering stations. Due to the lack of vegetation in the remaining pastures, a shade house will also be installed on Mr. Joe Allen's property to provide artificial shade for the livestock. According to Weaver (2004), each cow requires approximately 64 square feet of floor space to adequately coexist within the shade house. A structure should be built to provide a minimum 5,000 square feet of floor space for 75 head of beef cattle. It is recommended that horizontal structural beams be used to reduce the number of internal supports and that the floor of the structure be made of concrete. The use of structural beams and concrete flooring will expedite daily maintenance processes and provide a higher level of sanitation within the shade house. In addition, one well and one drinker will be established on Mr. Bill Allen's property as part of the conservation easement agreement.

12.2 Waste Storage Pond

An inactive dairy waste storage pond currently occupies approximately 0.5 acre of land found on Mr. Bill Allen's property, which is upslope of proposed stream restoration activities (Figure 9 and Appendix A). To reduce future risks to stream water quality in the Rocky Branch channel, elimination of the waste storage pond through a decommissioning process, is an integral part of this stream restoration project.

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The State of North Carolina requires a waste storage pond closure plan to be written by the local NRCS before any waste can be removed or land applied. As a part of the waste storage closure plan, sludge and liquid waste samples were taken to determine their current nutrient content. Soil samples from adjacent farmland were also taken to determine their current nutrient levels and respective soil properties. These samples were taken to the North Carolina Department of Agriculture (NCDA) laboratory in Raleigh, NC for analyses.

Following the completion of a waste storage pond closure plan, a contractor will be hired to follow the specifications contained within the plan. Solid and liquid waste will be removed and land applied to Mr. Bill Allen's farmland directly across SR 1120, currently being leased by Myers Farms, Inc. The land application fields recommended by the NRCS are shown on Figure 9. Each year a waste management plan is prepared for their farming operation and the decommissioning of the dairy waste storage pond will be incorporated into their 2005 waste management plan. All land application activities will be coordinated with Myers Farms to ensure that an active crop will be growing or will be planted within 30 days of application of the waste. Once the waste has been completely removed from the storage pond and the excavated site passes a required inspection, the pit will be filled with suitable earthen material. Copies of the Waste Storage Pond Closure Plan are on file with the Ecosystem Enhancement Program and the Yadkin County NRCS office.

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