RESTORATION PLAN

UT TO BEAR CREEK STREAM RESTORATION PROJECT

Chatham County, North Carolina
Project ID No. 060684901

Prepared for:

NCDENR-Ecosystem Enhancement Program
2728 Capital Boulevard, Suite 1H 103
Raleigh, North Carolina 27604

July 27, 2007

Prepared by:

KO & ASSOCIATES, P.C.
Consulting Engineers

Ko & Associates, P.C.
1011 Schaub Drive, Suite 202
Raleigh, North Carolina 27606

919.851.6066
919.851.6846 (fax)

R. Kevin Williams, PE, PLS, CPESC, CPSWQ
Project Engineer/Manager

TABLE OF CONTENTS

List of Tables

Appendices

EXECUTIVE SUMMARY

The North Carolina Ecosystem Enhancement Program (EEP) is currently developing stream restoration plans for the UT to Bear Creek Stream Restoration Project (Project) located on the southeast side of Highway 902 between the town of Bear Creek and Johnsons Crossings. The Project is located in United States Geological Survey (USGS) Hydrologic Unit (HU) 03030003070050 (North Carolina Division of Water Quality [NCDWQ] Subbasin 03-06-12) of the Cape Fear River Basin and will service the USGS 8-digit HU 03030003. The Project is not located within a Targeted Local Watershed.

This document details planned stream restoration activities on the Project. An approximately 32-acre conservation easement will be placed on the Project to incorporate all restoration activities. The Project contains Bear Creek, two unnamed tributaries (UT) to Bear Creek (Northern and Southern UTs), riparian buffer, floodplain, and upland slopes. The Project watersheds are characterized primarily by agriculture and forest land with scattered residential and business development. Site land uses, including the removal of riparian vegetation, grazing by livestock, and a lack of exclusionary fence for livestock adjacent to the Northern and Southern UTs have resulted in degraded water quality and unstable channel characteristics (stream incision, erosion, and bank collapse).

The primary goals of the Project focus on improving water quality by reducing nutrient loading from the on-site cattle operation, reducing excess sedimentation input from channel banks, increasing the attenuation of floodwater flows, and restoring and enhancing aquatic and riparian habitat. These goals will be accomplished through the following objectives:

- Reduce point and non-point source pollution associated with an on-site cattle operation by fencing out cattle from the stream and riparian buffer, and by providing a vegetative buffer on stream banks and floodplain to treat surface runoff. Virtually all research shows vegetated riparian buffers substantially decrease pollutants such as nitrate-nitrogen, phosphorous, chloride, ammonium, and sedimentation prior to entering the waterway.
- Stabilize on-site streams by restoring a stable dimension, pattern, and profile so they will transport watershed flows and sediment loads without aggrading or degrading.
- Improve aquatic habitat by enhancing stream bed variability, providing shading/cover areas within the stream channel, and introducing woody debris in the form of rootwads, log vanes, and log sills.
- Enhance wildlife habitat by vegetating the existing fescue dominated riparian buffers with native trees, shrubs, herbs and grasses. Forest vegetation species were selected by studying a Reference Forest Ecosystem located immediately upstream of the Project and reviewing Piedmont/Low Mountain Alluvial Forest species listed in *Classification of the Natural Communities of North Carolina: Third Approximation* (Schafale and Weakley 1990).

- Create wildlife corridors through agricultural lands which have significantly dissected the landscape. The corridors will provide connectivity to a diversity of habitats including mature forest, early successional forest, stream-side forest, riparian wetlands, and uplands.

The proposed restoration plan, depicted on Sheets 2 through 2C, is expected to produce a restored length of 3,132 linear feet of the Northern UT and 1,745 linear feet of the Southern UT. Additionally, 0.39 acres of riparian wetlands will be enhanced by supplemental vegetation plantings, 15 acres of buffers along the Northern and Southern UTs will be planted with native species, 3.23 acres of buffers along Bear Creek will be planted with native species, and 12.15 acres of buffers along Bear Creek will be preserved.

This document represents a detailed restoration plan summarizing activities proposed within the Project limits. The plan includes: 1) descriptions of existing conditions; 2) reference stream and forest studies; 3) restoration plans; and 4) Project monitoring and success criteria. Upon approval of this plan by EEP, engineering construction plans will be prepared and activities implemented as outlined. Proposed restoration activities may be modified during the civil design stage due to constraints such as access issues, sediment-erosion control measures, drainage needs (floodway constraints), or other design considerations.

1.0 **PROJET SITE LOCATION**: The UT to Bear Creek Stream Restoration Project (Project) is located south of Siler City, in Chatham County, North Carolina. The Project is located immediately east of SR 1009 (Bear Creek Church Road) and southeast of NC Highway 902 between the town of Bear Creek and Johnsons Crossroads (Figure 1). The Project includes Bear Creek and two unnamed tributaries (UTs) to Bear Creek (Northern and Southern UTs). The Latitude and Longitude (WGS 84 datum) of the mid-point for the restoration channels are 35.609497101°N and 79.387817088°W for the Northern UT and 35.609497101°N and 79.394411255°W for the Southern UT.

Approximately 4,877 linear feet of stream are to be restored. Table 1 describes the Project restoration structures and objectives.

Table 1. Project Restoration Structures and Objectives
Project ID No. 060684901 (UT to Bear Creek Restoration Project)

Restoration Segment/ Reach ID	Station Range	Restoration Type	Priority Approach	Existing Linear Footage/ Acreage	Designed Linear Footage/ Acreage	Comment
Bear Creek	--	Buffer Preservation	--	--	12.15 ac	
Bear Creek	--	Buffer Enhancement	--	--	3.23 ac	Vegetative plantings to pasture areas within 50' of Bear Creek
Northern UT to Bear Creek	10 + 00 – 15+50	Restoration	PI	2,832 lf	550 lf	Restore channel on new location
	15+50 – 16+75		PII		125 lf	
	16+75 – 19+00		PI		225 lf	
	19+00 – 23+00		PII		400 lf	
	23+00 – 39+75		PI		1,675 lf	
	39+75 – 41+32		PII		157 lf	
Southern UT to Bear Creek	10 + 00 – 23+50	Restoration	PI	1,635 lf	1,350 lf	Restore channel on new location
	23+50 – 27 + 45		PII		395 lf	
Riparian Wetlands	--	Enhancement	--	0.49 ac	0.39 ac	Supplemental plantings to existing wetlands

1.1 **Directions to Project Site**: From Siler City, North Carolina take US Highway 421 South for approximately 8 miles. Turn right on NC Highway 902 West and proceed approximately 2 miles. The Project is located on the southeast side of NC Highway 902 between Bear Creek and Johnsons Crossing across from Central Chatham High School.

1.2 **USGS Hydrologic Unit Code and NCDWQ River Basin Designation**: The Project is located in Chatham County, North Carolina within United States Geological Survey (USGS) Hydrologic Unit (HU) 03030003070050 (North

Carolina Division of Water Quality [NCDWQ] Subbasin 03-06-12) of the Cape Fear River Basin and will service the USGS 8-digit HU 03030003 (USGS 1974). The Project is not located within a Targeted Local Watershed (NCWRP 2001). NCDWQ Subbasin 03-06-12 of the Cape Fear River Basin includes the Rocky River, Loves Creek, Tick Creek, and Bear Creek. This subbasin is located in the Carolina Slate Belt and is characterized by seasonally low flowing streams (NCDWQ 2005).

1.3 **Project Vicinity Map**: The Project vicinity is depicted on Figure 1.

2.0 WATERSHED CHARACTERIZATION

2.1 Drainage Area: Table 2 depicts drainage areas of Project streams (Figure 2). Onsite elevations range from a high of 440 feet National Geodetic Vertical Datum (NGVD) at the upstream extent of the Project to a low of approximately 410 feet NGVD at the downstream extent of the Project.

Table 2. Drainage Areas
Project ID No. 060684901 (UT to Bear Creek Restoration Project)

Reach	Stream Order	Drainage Area	
		Acres	Square Mile(s)
Bear Creek (at South UT to Bear Creek)	4th	14020	21.9
Bear Creek (at North UT to Bear Creek)	4th	16034	25.0
North UT to Bear Creek (at NC 902)	2nd	1385	2.16
North UT to Bear Creek (at Bear Creek)	2nd	1510	2.36
South UT to Bear Creek (at NC 902)	1st	175	0.27
South UT to Bear Creek (at Bear Creek)	1st	215	0.34

2.2 Surface Water Classification/Water Quality: Bear Creek has been assigned Stream Index Number 17-43-16, a Best Usage Classification of **C**, and is not rated for its intended uses (NCDWQ 2005, NCDWQ 2007). Class C waters are suitable for aquatic life propagation and survival, fishing, wildlife, secondary recreation, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner.

Bear Creek is not listed on the draft 2006 or final 2004 303d lists (NCDWQ 2006a, 2006b)

2.3 Physiography, Geology, and Soils: The Project is located within the Piedmont of North Carolina in the Carolina Slate Belt ecoregion. The Carolina Slate Belt is characterized by dissected, irregular plains, some hills, linear ridges, isolated monadnocks, and low to moderate gradient streams with mostly boulder or cobble substrates (Griffith 2002).

Soils that occur within the Project limits, according to the *Soil Survey of Chatham County, North Carolina* are depicted in Figure 3 and described in Table 3 (USDA 2006).

Table 3. USDA Soils Mapped within the Project
Project ID No. 060684901 (UT to Bear Creek Restoration Project)

Soil Series	Hydric Status*	Family	Description
Badin	Nonhydric	*Typic Hapludults*	This series consists of moderately deep, well-drained, moderately permeable soils on ridges and side slopes. Depth to the seasonal high water table is greater than 6 feet.
Chewacla	Class B	*Fluvaquentic Dystrudepts*	This series consists of very deep, somewhat poorly drained, moderately permeable soils on floodplains. Depth to the seasonal high water table occurs at 0.5 to 1.5 feet.
Cid	Nonhydric	*Aquic Hapludults*	This series consists of moderately deep, somewhat poorly to moderately well-drained, slowly permeable soils on interstream divides, broad ridges, drainageways, and heads of drainageways. Depth to the seasonal high water table is 1.5 to 2.5 feet.
Georgeville	Nonhydric	*Typic Kanhapludults*	This series consists of very deep, well-drained, moderately permeable soils on ridges and side slopes. Depth to the seasonal high water table is greater than 6 feet.
Lignum	Class B	*Aquic Hapludults*	This series consists of deep, somewhat poorly to moderately well-drained, very slowly permeable soils on interstream divides, broad ridges, drainageways, and heads of drainageways. Depth to the seasonal high water table is 1.0 to 2.5 feet.
Nanford	Nonhydric	*Typic Kanhapludults*	This series consists of deep, well-drained, moderately permeable soils on ridges and side slopes. Depth to the seasonal high water table is greater than 6 feet.
Riverview	Class B	*Fluventic Dystrudepts*	This series consists of very deep, well-drained, moderately permeable soils on floodplains. Depth to the seasonal high water table occurs at 3 to 5 feet.
State	Nonhydric	*Typic Hapludult*	This series consists of very deep, well-drained, moderately permeable soils on stream terraces. Depth to the seasonal high water table occurs at 4 to 6 feet.
Wehadkee	Class A	*Fluvaquentic Endoaquepts*	This series consists of very deep, poorly drained, moderately permeable soils on floodplains. Depth to the seasonal high water table occurs at the surface to 1 foot.

* Class A = hydric soils; Class B = nonhydric soils, which may contain hydric soil inclusions

2.4 **Historical Land Use and Development Trends**: Land use within the Project watershed is characterized primarily by agriculture, forest, impervious surfaces, and sparse residential/commercial development (Table 4 and Figure 2). The adjacent US Highway 64 corridor is developing between Siler City and Pittsboro and is expected to continue expanding into this subbasin (03-06-12) (NCDWQ 2005).

Table 4. Land Use of Watershed
Project ID No. 060684901 (UT to Bear Creek Restoration Project)

Land Use	Acreage	Percentage
Developed Land	300	2
Agricultural Land	6250	40
Forest Land	9210	58
TOTAL	**15760**	**100**

2.5 **Threatened and Endangered Species:** Species with a Federal classification of Endangered or Threatened are protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). The term "Endangered species" is defined as "any species which is in danger of extinction throughout all or a significant portion of its range," and the term "Threatened species" is defined as "any species which is likely to become an Endangered species within the foreseeable future throughout all or a significant portion of its range" (16 U.S.C. 1532).

Based on the most recently updated county-by-county database of federally listed species in North Carolina as posted by the United States Fish and Wildlife Service (USFWS) at http://nc-es.fws.gov/es/countyfr.html, four federally protected species are listed for Chatham County. Table 5 lists the federally protected species for Chatham County and indicates if potential habitat exists within the Project for each.

Table 5. Federally Protected Species for Chatham County
Project ID No. 060684901 (UT to Bear Creek Restoration Project)

Common Name	Scientific Name	Status*	Habitat Present Within Project	Biological Conclusion
Vertebrates				
Bald eagle	*Haliaeetus leucocephalus*	Threatened	No	No Effect
Cape Fear shiner	*Notropis mekistocholas*	Endangered	No	No Effect
Red-cockaded woodpecker	*Picoides borealis*	Endangered	No	No Effect
Vascular Plants				
Harperella	*Ptilimnium nodosum*	Endangered	No	No Effect

*Endangered = a taxon "in danger of extinction throughout all or a significant portion of its range"; Threatened = a taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range".

No potential habitat is located in the Project for bald eagle, Cape Fear shiner, red-cockaded woodpecker, or harperella. In addition, no known occurrences for the species are documented by NCNHP within 3 miles of the Project; therefore, this Project will have no effect on these species.

Critical habitat for the Cape Fear shiner has been designated on Bear Creek in Chatham County, the Rocky River in Chatham County, the Deep River in Chatham and Lee Counties, Fork Creek in Randolph County, and the Deep River in Randolph and Moore Counties. No designated critical habitat occurs within the Project reach of Bear Creek. The closest reach of designated critical habitat is greater than 11 miles downstream from the Project.

2.6 **Cultural Resources:** Pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for compliance with Section 106 (36 CFR Part 800) concurrence will be received for the Project from the North Carolina State Historic Preservation Office (NCSHPO) prior to initiating Project implementation.

No known archaeological sites or structures of historical or architectural importance were identified during field investigations.

2.7 **Potential Constraints:** The presence of conditions or characteristics that have the potential to hinder restoration activities at the Project were evaluated. The evaluation focused primarily on the presence of hazardous materials, utilities and restrictive easements, rare/threatened/endangered species or critical habitats, and the potential for hydrologic trespass. Existing information regarding constraints was acquired and reviewed. In addition, any Project conditions that have the potential to restrict the restoration design and implementation were documented during the field investigation.

Environmental screening of the Project was conducted during field investigations to evaluate the presence of potentially harmful environmental hazards. Environmental concerns under review include past or present storage of hazardous or regulated materials and/or waste, illicit dumping of solids or hazardous waste, and degradation of surface waters that may have a negative impact on the environment. Visual screening for objects such as storage tanks, debris, hazardous materials, and evidence of waste burial was conducted through field reconnaissance. No evidence of storage tanks or illicit dumps was identified during field investigations. In addition, no point source discharges were identified. Based on field reviews, hazardous materials will not be a hindrance to proposed project activities.

2.7.1 Property Ownership and Boundary

The Project is contained in a parcel owned by Mr. James R. Weaver. The permanent conservation easement will total approximately 32 acres.

2.7.2 Project Access

Numerous potential access points have been located along the property boundary of NC Highway 902, including existing dirt roads. There are no significant constraints because the Project is in a rural area.

2.7.3 Utilities

No existing utilities or easements will be disturbed/impacted by this Project.

2.7.4 FEMA/Hydrologic Trespass

The HEC-RAS analysis indicates that the restoration design will result in a no-rise in the 100-year floodplain water surface elevations outside of the Project area. The results of this analysis affirm that hydrologic trespass to adjacent properties will not occur. The HEC-RAS mod is discussed in more detail in Section 6.3 (HEC-RAS Analysis).

3.0 **PROJECT SITE STREAMS (EXISTING CONDITIONS)**: There are two streams (Northern UT and Southern UT) in the Project that were studied for restoration potential. Existing conditions have resulted in degraded water quality, loss of aquatic and terrestrial habitat, reduced nutrient and sediment retention, unstable channel characteristics (mass wasting of channel banks, sediment loading, and the loss of bed form diversity), and channel banks and floodplain that have been denuded of native trees and shrubs at the Project (Figure 4 and Sheets 1 through 1A).

3.1 **Channel Classification:** Stream geometry and substrate data have been evaluated to classify existing stream conditions, utilizing fluvial geomorphic principles (Rosgen 1996). Appendix D provides a summary of measured stream geometry attributes for the Northern and Southern UTs under existing conditions (considered to be unstable), in addition to stable stream attributes (reference and proposed).

Data collected during a Rosgen Level II survey were used to classify the Northern and Southern UTs as an unstable E4-type channels that are both transitioning towards a G4-type channel. G-type channels typically display low entrenchment and width-to-depth ratios, and a low sinuosity. This can lead to higher shear stresses on channel banks and bed, and an over abundance of stream power, which leads to channel degradation. Evidence of channel degradation can be seen in the existing conditions photographs (Appendix C). The primary causes of degradation in both channels stems from cattle access and the denudation of vegetation along the channel banks from cattle grazing. The second descriptor, 4, indicates that channel materials are dominated by gravel.

It should be noted that the dominant channel type is an E-4 type channel transitioning towards a G4-type channel, however there are significant portions of each channel (approximately one third to one half) that are over widened and could be classified as an F4 type channel. F4 type channels display high width-to-depth ratios (greater than 12) and are entrenched. F4 type channels typically loose their capacity to transport sediment loads because shear stress drops dramatically. This condition is apparent in numerous sections of the Northern UT and Southern UT where the channel has over widened due to cattle access or because the landowner has dug out the channel for watering purposes. These areas are where the channel has begun to aggrade because the channel's shear stress is not high enough to transport the contributing sediment load.

3.2 **Discharge:** The Northern and Southern UTs have a bankfull discharge of 100 cubic feet per second (cfs) and 22 cfs, respectively.

3.3 **Channel Morphology:** Channel cross-sections were measured on the existing streams. The Morphological Stream Characteristics table (Appendix D) includes a summary of dimension, profile, and pattern data for the stream.

3.4 **Channel Stability Assessment:** A visual assessment accompanied by a morphological assessment using data collected during a Rosgen Level II survey was used to determine channel stability. These data, which can be found in Appendix D (Morphological Stream Characteristics), Appendix C (Existing Conditions Site Photographs), and Appendix F (Restoration Site NCDWQ Stream Classification Forms), confirmed the channel attributes do not fall within acceptable ranges for a stable channel as evidenced by: 1) mass wasting of channel banks; 2) incision of the bankfull elevation below the rooting depth of existing vegetation on the channel banks; 3) undermining of existing trees along the channel bank; 4) over widening of the channels in select spaces by the landowner to provide watering holes for cattle; 5) sections of braided and over widened channel in both the Northern and Southern UTs where cattle have eroded channel banks and side slopes; and 6) a lack of riparian vegetation on many sections of banks.

Data collected during field surveys of the Northern UT indicate that: 1) approximately 80% of the channel length displays signs of instability; 2) the Bank Erosion Hazard Index (BEHI) of 39 is considered High; 3) the bedform is comprised of sand and gravel; 4) the channel profile 30% riffles with 70% pools; 5) a Band Height Ratio (BHR) of 1.35; 6) approximately 80% of the channel contains a baseflow depth that is below the rooting depth of vegetation along the banks.

Data collected during field surveys of the Southern UT indicate that: 1) approximately 90% of the channel length displays signs of instability; 2) the BEHI of 48 is considered Very High; 3) the bedform is comprised of sand and gravel; 4) the channel profile 40% riffles with 60% pools; 5) a Band Height Ratio (BHR) of 1.39; 6) approximately 90% of the channel contains a baseflow depth that is below the rooting depth of vegetation along the banks.

An existing conditions entrainment analysis was completed for the Northern and Southern UTs (Section 6.2 and Appendix H). The analysis confirms that the existing slope and dimension for both channels provides an overabundance of shear stress during bankfull flows. Evidence of an overabundance of shear stress can be seen in eroding meander bends, and the fact that both channels have incised into the landscape and down cut to bedrock.

The landowner has not placed a fence around either the Northern or Southern UT. As a result cattle grazing in the adjacent pastures are accessing both channels as a

watering and cooling source. Massive amounts of algal blooms were noted during all site inspections. The algal blooms are likely a direct result of nutrient loading from cattle defecating directly into the stream channels.

Primary vegetation along the Northern UT is Chinese privet (*Ligustrum sinense*). This invasive species should be eradicated and controlled. If this species is removed from the Project, it would enhance the ability of native flora to populate the site however, it would cause significant physical disturbance to the soils on the channel banks and floodplain. So, although the existing privet is not a physical hindrance to channel stability, it likely would become a hindrance following its eradication because of soil disturbance.

3.5 **Bankfull Verification:** Bankfull indicators were identified along the Northern and Southern UTs during field inspections. Existing conditions surveys were conducted which included surveying representative riffle cross-sections, representative hydraulic (bankfull) slope, and determining an existing Manning's n coefficient for the surveyed reaches. The surveyed data and calculated Manning's n were correlated with identified bankfull indicators to estimate bankfull cross-sectional area and velocity, and consequently bankfull discharge. The estimated bankfull cross-sectional area and discharge were compared with a calculated bankfull cross-sectional area and discharge using the *Bankfull Hydraulic Geometry Relationships for North Carolina Streams* (Harman, W. H. et al., 1999) (Piedmont regional curve). Data obtained from on-site falls within a level of confidence of the data obtained from the Piedmont regional curve.

3.6 **Vegetation:** Two plant communities are currently present within the Project limits: 1) pasture and 2) disturbed riparian fringe.

Pasture land contains fields that are grazed by livestock and/or used for hay production. The fields are vegetated by a mixture of cultivated grasses, as well as clover (*Trifolium* sp.), buttercup (*Ranunculus* sp.), poison ivy (*Toxicodendron radicans*), jewelweed (*Impatiens capensis*), and nightshade (*Solanum* sp.).

The disturbed riparian fringe is characterized by a thin, disturbed strip of vegetation located adjacent to existing Project streams. The canopy layer consists of sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), hackberry (*Celtis laevigata*), shagbark hickory (*Carya ovata*), slippery elm (*Ulmus rubra*), mockernut hickory (*Carya tomentosa/alba*), box elder (*Acer negundo*), willow oak (*Quercus phellos*), white ash (*Fraxinus americana*), black walnut (*Juglans nigra*), southern red oak (*Quercus falcata*), loblolly pine (*Pinus taeda*), and sycamore (*Platanus occidentalis*). The subcanopy consists of ironwood (*Carpinus caroliniana*), winged elm (*Ulmus alata*), deciduous holly (*Ilex decidua*), flowering dogwood (*Cornus florida*), and eastern red cedar

(*Juniperus virginiana*). The understory consists of species listed above, as well as pokeweed (*Phytolacca americana*), red bud (*Cercis canadensis*), greenbrier (*Smilax rotundifolia*), greenbrier (*Smilax bona-nox*), jewelweed, blackberry (*Rubus argutus*), and poison ivy.

In addition, several invasive species are present within the disturbed buffer including tree-of-heaven (*Ailanthus altissima*), Chinese privet (*Ligustrum sinense*), Japanese honeysuckle (*Lonicera japonica*), and China-berry (*Melia azedarach*).

4.0 **REFERENCE STREAMS:** One stream, Landrum Creek, was surveyed and used as a reference reach for the design of the Northern and Southern UTs. Distinct bankfull variables were identifiable in Landrum Creek and pattern/profile characteristics appear to have not been degraded, allowing for assistance with proposed design characteristics. The Landrum Creek reference site vicinity, watershed, and soils are depicted in Figures 5 through 7. Photographs for the reference reach can be found in Appendix I.

Landrum Creek was specifically used as a reference stream because it is a stable stream that depicts a similar valley type and substrate as streams on-site.

4.1 **Watershed Characterization**: Land use within Landrum Creek's watershed can be characterized as rural in nature with the majority of lands historically being mature forest and utilized for agriculture. Many areas of mature forests have recently been clear cut and can now be classified as early succesional communities. The watershed is approximately 60 percent wooded, 35 percent agriculture, and five percent residential.

4.2 **Channel Classification:** Landrum Creek is characterized as a C4-type stream, with a moderate sinuosity (1.12), gravel-dominated substrate (Appendix D), and a bank height ratio of 1.02. C-type streams are characterized as slightly entrenched (entrenchment ratios higher than 2.2) streams with high width-to-depth ratios (typically 12 (+/- 2) and higher) that display riffle-pool complexes.

4.3 **Discharge:** The UT to Ledge Creek reference reach has a drainage area of 2.53 square miles and a bankfull discharge of 173.7 cfs.

4.4 **Channel Morphology:** Channel cross-sections (dimension), channel profiles, and plan form variables were measured along Landrum Creek to obtain morphological data. Additionally, bed material was evaluated, and a vegetation assessment in the buffer was completed. The reaches are transporting their sediment supply while maintaining dimension, pattern, and profile. The table of Morphological Stream Characteristics (Appendix D) includes a summary of dimension, profile, and plan form data of Landrum Creek.

4.5 **Channel Stability Assessment:** Major components for stability include determining if the channel is conveying its discharge and sediment load without aggrading or degrading. Evidence that a channel does not fit these criteria includes: bank degradation, channel incision, channel widening, channel aggradation, massive amounts of sediment loading within and/or outside of the channel banks, channel armoring, and no sparse vegetation on the channel's banks.

A visual assessment accompanied by a morphological assessment using data collected during a Rosgen Level II survey was used to determine channel stability. These data, which can be found in Appendix D (Morphological Stream Characteristics), Appendix I (Reference Site Photographs), and J (Reference Site NCDWQ Stream Classification Form), confirmed the channels fell within acceptable ranges for a stable reference channel. Landrum Creek was determined to be a stable channel suitable as a reference reach.

4.6 **Bankfull Verification:** Bankfull indicators were identified along Landrum Creek during field inspections. Surveys were conducted which included surveying representative riffle cross-sections, representative hydraulic (bankfull) slope, and determining an existing Manning's n coefficient for the surveyed reach. The surveyed data and calculated Manning's n were correlated with identified bankfull indicators to estimate bankfull cross-sectional area and velocity, and consequently bankfull discharge. The estimated on-site bankfull cross-sectional area (28.2 square feet) and discharge (173.7 cfs) were compared with a calculated bankfull cross-sectional area and discharge using the *Bankfull Hydraulic Geometry Relationships for North Carolina Streams* (Harman, W. H. et al., 1999) (Piedmont regional curve). Data obtained from on-site falls within a level of confidence of the data obtained from the Piedmont regional curve.

4.7 **Reference Forest Ecosystem**: According to Mitigation Site Classification (MiST) guidelines (USEPA 1990), a Reference Forest Ecosystem (RFE) must be established for restoration sites. RFEs are forested areas on which to model restoration efforts of the restoration site in relation to soils and vegetation. RFEs should be ecologically stable climax communities and should represent believed historical (predisturbance) conditions of the restoration site. Data describing plant community composition and structure are collected at the RFEs and subsequently applied as reference data for design of the restoration Project planting scheme.

The RFE is located immediately upstream of the Project within a small area (approximately 2 acres) of mature Piedmont Alluvial Forest. Tree and shrub species identified within the reference forest are identified in Table 6 and Figure 8 and will be used, in addition to other relevant species within the Project and Schafale and Weakley (1990) to supplement community descriptions.

Table 6. Reference Forest Ecosystem
Project ID No. 060684901 (UT to Bear Creek Restoration Project)

Piedmont Alluvial Forest	
Canopy Species	**Understory Species**
Carya tomentosa/alba	*Acer negundo*
Carya ovata	*Acer rubrum*
Liquidambar styraciflua	*Carpinus caroliniana*
Liriodendron tulipifera	*Cercis canadensis*
Quercus alba	*Cornus florida*
Quercus phellos	*Ulmus rubra*
Pinus taeda	

5.0 PROJECT SITE WETLANDS (EXISTING CONDITIONS):

5.1 Jurisdictional Wetlands: A jurisdictional wetland delineation occurred within the Project limits in May 2007. The Project was evaluated using the three-parameter approach (hydric soils, hydrophytic vegetation, and hydrology) as outlined in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

Four jurisdictional wetlands were delineated within the boundaries of the Project (Sheets 1 through 1A, and 2 through 2C), totaling 0.49 acres. The delineation has yet to be verified by the United States Army Corps of Engineers. Routine Wetland Determination Data Forms can be found in Appendix E.

5.2 Hydrological Characteristics: All four (4) jurisdictional Project wetlands are riparian wetlands. Riparian wetlands within the Project receive hydrological inputs from periodic overbank flooding of the Northern UT, groundwater migration into the Project, upland/stormwater runoff, and direct precipitation.

Three of the four wetlands are located in abandoned sections of the Northern UT (meander scrolls) that receive and retain floodwater flows from the Northern UT. One wetland's hydrology is fed primarily by overland flow from the Northern UT and from groundwater seeps from an adjacent hill slope.

5.3 Soil Characteristics: Soils within the Project consist primarily of the Chewacla and Wehadkee mapping units (Figure 3). Chewacla soils are classified as fine-loamy, mixed, thermic Fluvaquentic Dystrochrepts. A typical soil profile obtained on-site from a wetland is as follows.

0 -5" 10 YR 4/2 silt loam
Mottles 10 YR 4/4 few/faint

5 – 10" 2.5 Y 5/3 Silty clay loam
Mottles 10 YR 3/6 common/distinct

10 -16" 2.5 Y 5/2 Silty clay loam
Mottles 10 YR 3/6 common/distinct

5.4 **Plant Community Characterization**: Project wetlands can be classified as disturbed pasture wetlands dominated by *Juncus effuses* and *Carex* spp. The wetlands are located within pasture lands, which are used for cattle grazing. The following primary vegetated species were identified within the Project wetlands:

- Common rush (*Juncus effuses*)
- Sedge (*Carex* spp.)
- Black willow (*Salix nigra*)
- Sweetgum
- Smartweed (*Polygonum* sp.)
- Green ash (*Fraxinus pennsylvanica*)
- Lizard's tail (*Saururus cernuus*)

6.0 PROJECT SITE RESTORATION PLAN

6.1 Restoration Project Goals and Objectives: The primary goals of this Project focus on improving water quality by reducing nutrient loading from the on-site cattle operation, reducing excess sedimentation input from channel banks, increasing the attenuation of floodwater flows, and restoring and enhancing aquatic and riparian habitat. These goals will be accomplished through the following objectives:

- Reduce point and non-point source pollution associated with an on-site cattle operation by fencing out cattle from the stream and riparian buffer, and by providing a vegetative buffer adjacent to streams to treat surface runoff.
- Stabilize on-site streams by restoring a stable dimension, pattern, and profile so they will transport watershed flows and sediment loads without aggrading or degrading.
- Improve aquatic habitat by enhancing stream bed variability, providing shading/cover areas within the stream channel, and introducing woody debris in the form of rootwads, log vanes, and log sills.
- Enhance wildlife habitat by vegetating the existing fescue dominated riparian buffers with native trees, shrubs, herbs and grasses.
- Create wildlife corridors through agricultural lands which have significantly dissected the landscape. The corridors will provide connectivity to a diversity of habitats including mature forest, early successional forest, stream-side forest, riparian wetlands, and uplands.

The proposed restoration plan, depicted on Sheets 2 through 2C, is expected to produce a restored length of 3,132 linear feet of the Northern UT and 1,745 linear feet of the Southern UT. Additionally, 0.39 acres of riparian wetlands will be enhanced by supplemental vegetation plantings, 15 acres of buffers along the Northern and Southern UTs will be planted with native species, 3.2 acres of buffers along Bear Creek will be planted with native species, and 12.15 acres of buffers along Bear Creek will be preserved. All activities within the Project limits will be protected in perpetuity by a 32 acre permanent conservation easement.

6.1.1 Designed Channel Classification

Both streams on-site were designed using Natural Channel Design principals. Appendix D (Morphological Stream Characteristics) details channel classification and variables used to classify the design channels. Both the Northern and Southern UTs are designed as C4 type stream channels with moderately low width-to-depth ratios (12). The Northern UT will be constructed as a Priority I and Priority II restoration (Sheets 3 through 3A). Priority I restorations reconnect the bankfull discharge to the historic floodplain (existing ground). A floodplain

bench is cut at the bankfull elevation for a Priority II restoration. The Northern UT will begin as a Priority II restoration at the beginning of the Project. The channel invert will be raised as the channel falls through the valley so that the bankfull elevation eventually mirrors existing ground.

The Southern UT will be constructed as a Priority I and Priority II restoration (Sheets 3 through 3A). Like the Northern UT, the Southern UT will begin as a Priority II restoration and eventually become a Priority I restoration as the channel falls through the valley.

6.1.2 Stream Restoration Activities

The stream will be constructed partially on new location and partially in place. The existing channel will be abandoned and filled. Primary activities that will take place during channel restoration include: 1) the placement of permanent fencing around all restored, enhanced, and preserved areas within the Project limits; 2) channel and floodplain bench excavation; 3) installation of channel plugs; 4) backfilling of the abandoned channel; and 5) installation of in-stream structures.

An erosion control plan and construction/transportation plan are expected to be developed during the next phase of this Project. Erosion control will be performed locally throughout the Project and incorporated into construction sequencing. Exposed surficial soils at the Project are unconsolidated, alluvial sediments, which do not revegetate rapidly after disturbance. Therefore, seeding with appropriate grasses and immediate planting with disturbance-adapted shrubs will be employed following the earth-moving process.

A transportation plan, including the location of access routes and staging areas will be designed to minimize Project disturbance to the maximum extent feasible. The number of transportation access points into the floodplain will be maximized to avoid traversing long distances through the Project interior.

Fencing and Ford Crossings
A permanent fence will be placed along the entire easement boundary that the EEP is acquiring. The fence will protect the easement from cattle accessing the streams or vegetation within the easement.

Three ford crossings are proposed for the Project. Two crossings are proposed for the Northern UT and one crossing is proposed for the Southern UT. A permanent fence will be placed along the fords to block cattle from accessing the up and down stream portions of the Project. Additionally, a gate will be placed at both ends of the crossings to restrict cattle from accessing the streams during normal grazing times.

Design Channel Location
The objective to placing the channel in a new location was threefold. First, the design channel was required to stay within the proposed easement boundary that the EEP and landowner have agreed upon.

Second, the design channel was placed back into the low point of its respective valley. One-foot topographical data and data obtained from a site survey of existing meander scrolls (using a sub foot accurate GPS) were used to determine where the low points of the valley are. Where possible the design channel was placed into meander scrolls that have not completely filled in.

Third, the design channel was strategically placed near existing trees. A survey of existing trees eight inches or greater (diameter at breast height) was conducted prior to design. All of these trees were taken into consideration during the design process. The existing trees will provide root stabilization to the disturbed soils in the floodplain and on channel banks. Shading from the trees will help regulate water temperatures, and woody materials such as leaves and branches will provide biomass to the stream for foraging and cover.

Channel and Floodplain Bench Grading
The channel and corresponding floodplain will be excavated along the alignment as shown in Sheets 2 through 2C. Material excavated during grading of the channel and floodplain will be stockpiled immediately adjacent to channel segments to be abandoned and backfilled. These segments will be backfilled after the design channel has been constructed. Preliminary earthwork estimates indicate the Project will excavate approximately 7,800 cubic yards and fill approximately 7,362 cubic yards of soil.

Spoil material may be placed to stabilize temporary access roads and to minimize compaction of the underlying floodplain. However, all spoil will be removed from floodplain surfaces upon completion of construction activities.

Channel Plugs
Impermeable plugs will be installed along abandoned channel segments. Due to landowner constraints, the conservation easement is rather confined, which dictated the need to meander the proposed alignment back and forth across the existing channel. Impermeable plugs are installed along the downstream side of the proposed channel banks where the proposed channel crosses the existing channel. The will prevent the channel flow from accessing the abandoned channel segment. The plugs will consist of low-permeability materials designed to be of sufficient strength to withstand the erosive energy of surface flow events across the Project. Dense clays may be imported from off-site or existing material, compacted within the channel, may be suitable for plug construction. The plug will be of sufficient width and depth to form an imbedded overlap in the existing banks and channel bed.

Channel Backfilling
After impermeable plugs are installed, the abandoned channel will be backfilled. Backfilling will be performed primarily by pushing stockpiled materials into the channel. The channel will be filled to the extent that onsite material is available and compacted to maximize microtopographic variability, including ruts, ephemeral pools, and hummocks in the vicinity of the backfilled channel.

Wetland Impacts
The proposed alignment of the Northern UT is expected to impact 0.10 acres of existing riparian wetlands onsite. It is expected that enhancing 0.39 acres of riparian wetlands will make up for the 0.1 acres of wetland impact.

Justification for Wetland Impacts
Project restoration activities will provide a functional uplift from existing conditions. Current conditions have resulted in degraded water quality, a loss of aquatic habitat, reduced nutrient and sediment retention, and unstable channel characteristics (mass wasting of channel banks, channel incision and aggradation, sediment loading, and the loss of bed form diversity) at the Project. Restoration of the channel will restore stable riffle-pool morphology, aid in energy dissipation, and increase aquatic habitat. Wetlands occurring within the project limits are considered low quality wetlands. The wetlands are located in and around areas where abandoned channel scrolls and meanders were observed. The proposed channel alignment took into account the constrained easement, existing low quality wetlands, and the existing mature trees. Minimizing impact to the wetlands and the loss of existing mature trees played an important role in determining the location of the proposed alignment

6.1.3 In-stream Structures

Stream restoration using Natural Channel Design techniques, typically involves the use of in-stream structures for bank stabilization, grade control, and habitat improvement. Primary structures used to achieve these objectives may include the installation of log and rock vanes, log sills, log and rock cross-vanes, root wads, and other log type structures.

6.1.4 Target Buffer Communities

Restoration of floodplain forest and stream-side habitat allows for development and expansion of characteristic species across the landscape. Community associations that will be utilized to develop primary plant community associations include: 1) Piedmont Alluvial Forest, 2) stream-side assemblage, and 3) riparian wetland. This is discussed in more detail in Section 6.5 (Natural Plant Community Restoration).

6.2 **Sediment Transport Analysis**: One of the primary goals of this Project is to construct a stable channel that will transport its sediment and flow such that, over time, the stream system neither aggrades nor degrades. This stability is achieved when the sediment input to the design reach equals the sediment output.

It is common practice in gravel bed streams to study the competency of the stream's ability to entrain the largest sized particle during bankfull flows for stability analysis. The primary factor studied is shear stress of the bankfull channel. The bankfull mean depth and slope are the two primary variables used to determine if the channel has the competency to entrain its largest particle size under bankfull flows. Entrainment calculations for both existing and proposed conditions on the Northern and Southern UTs are included as Appendix H.

In summary, the Northern UT has an excess amount of shear stress (0.53 lb/ft^2) as evidenced by an average slope that is too steep (0.62 percent) and mean depth that is too deep (1.37 ft). The proposed design substantially lowers the shear stress to 0.22 lb/ft^2, by lowering the bankfull slope to 0.31 percent, and slightly lowering the mean depth to 1.33 ft.

The Southern UT has an excess amount of shear stress (0.76 lb/ft^2) as evidenced by an average slope that is too steep (1.5 percent) and mean depth that is too deep (1.05 ft). The proposed design substantially lowers the shear stress to 0.16 lb/ft^2, by lowering the bankfull slope to 0.41 percent, and lowering the mean depth to 0.71 ft.

The designed channel slopes and dimensions for the Northern and Southern UTs will produce a stable channel which will transport its sediment load without aggrading or degrading.

6.3 **HEC-RAS Analysis**: Given that the Project involves modifications to a stream channel, it is important to analyze the effect of these changes on flood elevations. Floodwater elevations were analyzed using HEC-RAS. HEC-RAS is a software package designed to perform one-dimensional, steady flow, analysis of water surface profiles for a network of natural and constructed channels.

HEC-RAS uses two equations, energy and/or momentum, depending upon the water surface profile. The model is based on the energy equation. The energy losses are evaluated by friction (Manning's equation) and contraction/expansion (coefficient multiplied by the change in velocity head). The momentum equation is used in situations where the water surface profile rapidly varies, such as hydraulic jumps and stream junctions.

Backwater analysis was performed for the existing and proposed conditions for both bankfull and 100-year discharges. In addition to steady flow data, geometric data is also required to run HEC-RAS. Geometric data consists of establishing the connectivity of the river system, which includes cross-section data, reach lengths, energy loss coefficients (friction losses, contraction, and expansion losses), and stream junction information.

6.3.1 Bankfull Discharge Analysis

Bankfull indicators were identified along both the Northern and Southern UTs during field inspections. Existing conditions surveys were conducted which included surveying representative riffle cross-sections, representative hydraulic (bankfull) slope, and determining an existing Manning's n coefficient for the surveyed reaches. The surveyed data and calculated Manning's n were correlated with identified bankfull indicators to estimate bankfull cross-sectional area and velocity, and consequently bankfull discharge. The estimated on-site bankfull cross-sectional area and discharge were compared with a calculated bankfull cross-sectional area and discharge using the *Bankfull Hydraulic Geometry Relationships for North Carolina Streams* (Harman, W. H. et al., 1999) (Piedmont regional curve). Data obtained from on-site falls within a level of confidence of the data obtained from the Piedmont regional curve.

The Northern and Southern UTs have a bankfull discharge of 100 cfs and 22 cfs, respectively. Hydrologic Engineering Center's River Analysis System (HEC-RAS Version 3.0.1, see Section 6.3.2 [No-Rise]) was used to evaluate how the discharge flows within the proposed channel geometry. This evaluation verifies that the proposed plan, dimension, and profile would adequately convey the discharge at the bankfull stage; the point where water begins to overflow onto the floodplain.

6.3.2 No-Rise

A HEC-RAS analysis has been prepared and completed on existing and proposed conditions of the Project channel(s). The resulting data output has been analyzed to determine if the design channel is adequately conveying its bankfull discharge, and to determine if a rise, fall, or no-rise in water surface elevations during the 100-year flood event has occurred.

The analysis indicates the proposed channel geometry will not increase the 100-year flood elevations within or upstream of the Project area. Results are located within the HEC-RAS Summary Table in Appendix K.

6.3.3 Hydrologic Trespass

Hydrologic trespass includes any issue which may affect hydrology outside of the property boundaries on which the project is located. These issues were reviewed for this Project. All onsite modifications will not affect offsite hydrology.

6.4 Soil Restoration

Soil grading will occur during Project stream restoration activities. Topsoils will be stockpiled during construction activities and spread on the soil surface once grading activities have been completed. The replaced topsoil will serve as a viable growing medium for community restoration to provide nutrients and aid in the survival of planted species.

6.4.1 Floodplain Soil Scarification

Microtopography and differential drainage rates within localized floodplain areas represent important components of floodplain functions. Reference forests in the region exhibit complex surface microtopography. Efforts to advance the development of characteristic surface microtopography will be implemented. In areas where soil surfaces have been compacted, ripping or scarification will be performed. After construction, the soil surface is expected to exhibit complex microtopography ranging to 1 foot in vertical asymmetry. Subsequently, plant community restoration will be initiated.

6.5 Natural Plant Community Restoration: Restoration of floodplain forest and stream-side habitat allows for development and expansion of characteristic species across the landscape. Ecotonal changes between community types contribute to diversity and provide secondary benefits, such as enhanced feeding and nesting opportunities for mammals, birds, amphibians, and other wildlife.

Reference Forest Ecosystem (RFE) data, onsite observations, and community descriptions from *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990) were used to develop the primary plant community

associations that will be promoted during community restoration activities. Community associations that will be utilized to develop primary plant community associations include: 1) Piedmont Alluvial Forest, 2) stream-side assemblage, and 3) riparian wetland (Sheet 4). Planting elements are listed below.

Piedmont Alluvial Forest

1. River birch (*Betula nigra*)
2. Slippery elm (*Ulmus rubra*)
3. Winged elm (*Ulmus alata*)
4. Bitternut hickory (*Carya cordiformis*)
5. Shagbark hickory (*Carya ovata*)
6. Black walnut (*Juglans nigra*)
7. Willow oak (*Quercus phellos*)
8. Green ash (*Fraxinus pennsylvanica*)
9. Ironwood (*Carpinus caroliniana*)
10. Box elder (*Acer negundo*)
11. Painted buckeye (*Aesculus sylvatica*)

Stream-Side Assemblage

1. Black willow (*Salix nigra*)
2. Silky dogwood (*Cornus amomum*)
3. Buttonbush (*Cephalanthus occidentalis*)
4. Elderberry (*Sambucus canadensis*)
5. Tag alder (*Alnus serrulata*)
6. Painted buckeye (*Aesculus sylvatica*)
7. Spicebush (*Lindera benzoin*)

Riparian Wetland

1. Green Ash
2. Slippery elm
3. Swamp Chestnut Oak (*Quercus michauxii*)
4. Black willow
5. Silky dogwood
6. Buttonbush
7. Elderberry

Stream-side trees and shrubs include species with high value for sediment stabilization, rapid growth rate, and the ability to withstand hydraulic forces associated with bankfull flow and overbank flood events. Stream-side trees and shrubs will be planted on all channel side slopes, concentrated along outer bends. Piedmont Alluvial Forest is targeted for the remainder of the riparian buffer, with the exception of existing riparian wetlands. Riparian wetland plantings include

tree and shrub species that are adapted for wetter conditions. The following planting plan is the blueprint for community restoration.

6.5.1 Planting Plan

Species selected for planting will be dependent upon availability of local seedling sources. Bare-root seedlings of tree species will be planted within specified areas at a density of approximately 680 stems per acre on 8-foot centers. Shrub species in the stream-side assemblage will be planted at a density of 2720 stems per acre on 4-foot centers.

Table 7 depicts the total number of stems and species distribution within each vegetation association. Planting will be performed between December 1 and March 15 to allow plants to stabilize during the dormant period and set root during the spring season.

Table 7. Planting Plan
Project ID No. 060684901 (UT to Bear Creek Restoration Project)

Vegetation Association	Piedmont Alluvial Forest	Stream-side Assemblage	Riparian Wetland	Piedmont Alluvial Forest (Bear Creek Buffer Planting)	TOTAL
Area (acres)	**14.62 Acres**	**1.03 Acres**	**0.39 Acres**	**3.23 Acres**	**19.3 Acres**
Species	**Number planted* (% of total)**	**Number planted** (% of total)**	**Number planted* (% of total)**	**Number planted* (% of total)**	**Number planted**
Betula nigra	994 (10)			220 (10)	1,214
Ulmus rubra	497 (5)			113 (5)	610
Ulmus alata	495 (5)			110 (5)	605
Carya cordiformis	994 (10)			220 (10)	1,214
Carya ovata	994 (10)			220 (10)	1,214
Juglans nigra	994 (10)			220 (10)	1,214
Quercus phellos	994 (10)			220 (10)	1,214
Fraxinus pennsylvanica	994 (10)		40 (15)	220 (10)	1,254
Carpinus caroliniana	994 (10)			220 (10)	1,214
Acer negundo	994 (10)			220 (10)	1,214
Aesculus sylvatica	994 (10)	280 (10)		220 (10)	1,494
Salix nigra		420 (15)	27 (10)		447
Cornus amomum		420 (15)	40 (15)		460
Cephalanthus occidentalis		420 (15)	40 (15)		460
Sambucus canadensis		420 (15)	40 (15)		460
Alnus serrulata		420 (15)			420
Lindera benzoin		420 (15)			420
Ulmus americana			40 (15)		40
Quercus michauxii			40 (15)		40
					0
TOTAL	**9,940 (100)**	**2,802 (100)**	**265 (100)**	**2,200 (100)**	**15,206**

* Planted at a density of 680 stems/acre.
**Planted at a density of 2720 stems/acres

6.5.2 Invasive Species Management

Several invasive species were observed at the Project within the existing disturbed riparian fringe including tree-of-heaven, Chinese privet, Japanese honeysuckle, and China-berry. These species will be controlled so none become dominant or alter the desired community structure of the Project. It is likely that manual removal (by cutting and grubbing); in addition to chemical herbicide treatments may be required.

During the five-year monitoring period, where necessary, undesirable plant or animal species will be removed, treated, or otherwise managed by means of physical removal, use of herbicides, live trapping, confining wires, or nets.

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

7.0 PERFORMANCE CRITERIA: Monitoring of Project restoration efforts will be performed until success criteria are fulfilled. Monitoring is proposed for the stream channel, stormwater management devices, wetlands, and vegetation. In general, the restoration success criteria, and required remediation actions, are based on Appendix II of the *Stream Mitigation Guidelines* (USACE et al. 2003).

7.1 Streams: The restored stream reaches are proposed to be monitored for geometric activity. Annual fall monitoring will include development of channel cross-sections on riffles and pools and a water surface profile of the channel. The data will be presented in graphic and tabular format. Data to be presented will include: 1) cross-sectional area; 2) bankfull width; 3) average depth; 4) maximum depth; 5) width-to-depth ratio; 6) meander wavelength; 7) belt-width; 8) water surface slope; and 9) sinuosity. The stream will subsequently be classified according to stream geometry and substrate (Rosgen 1996). Significant changes in channel morphology will be tracked and reported by comparing data in each successive monitoring year. A photographic record that will include preconstruction and post construction pictures has been initiated (Appendix C).

7.1.1 Stream Success Criteria

Success criteria for stream restoration will include: 1) successful classification of the reach as a functioning stream system (Rosgen 1996), and 2) channel variables indicative of a stable stream system.

The channel configuration will be measured on an annual basis in order to track changes in channel geometry, profile, or substrate. These data will be utilized to determine the success in restoring stream channel stability. Specifically, the width-to-depth ratio should characterize an C-type or borderline E-/C-type channel, bank-height ratios indicative of a stable or moderately unstable channel, and minimal changes in cross-sectional area, channel width, and/or bank erosion along the monitoring reach. In addition, channel abandonment and/or shoot cutoffs must not occur and sinuosity values must remain at approximately the same design sinuosity (thalweg distance/straight-line distance). The field indicator of bankfull will be described in each monitoring year and indicated on a representative channel cross-section figure. If the stream channel is down-cutting or the channel width is enlarging due to bank erosion, additional bank or slope stabilization methods will be employed.

Visual assessment of in-stream structures will be conducted to determine if failure has occurred. Failure of a structure may be indicated by collapse of the structure, undermining of the structure, abandonment of the channel around the structure, and/or stream flow beneath the structure.

7.1.2 Stream Contingency

In the event that stream success criteria are not fulfilled, a mechanism for contingency will be implemented. Stream contingency may include, but may not be limited to: 1) structure repair and/or installation, 2) repair of dimension, pattern, and/or profile variables, and 3) bank stabilization. The method of contingency is expected to be dependent upon stream variables that are not in compliance with success criteria.

7.2 **Vegetation:** Restoration monitoring procedures for vegetation will monitor plant survival and species diversity. After planting has been completed in winter or early spring, an initial evaluation will be performed to verify planting methods and to determine initial species composition and density. Supplemental planting and additional modifications will be implemented, if necessary. A photographic record of plant growth will be included in each annual monitoring report.

During the first year, vegetation will receive a cursory, visual evaluation on a periodic basis to ascertain the degree of overtopping of planted elements by nuisance species. Subsequently, quantitative sampling of vegetation will be performed between June 1 and September 30, after each growing season, until the vegetation success criteria are achieved.

During quantitative vegetation sampling in early fall of the first year, up to 17 sample plots (10 meters by 10 meters) will be randomly placed within the Project however, best professional judgment may be necessary to establish vegetative monitoring plots upon completion of construction activities. In each sample plot, vegetation parameters to be monitored include species composition and density.

7.2.1 Vegetation Success Criteria

Success criteria have been established to verify that the vegetation component supports community elements necessary for forest development. Success criteria are dependent upon the density and growth of characteristic forest species. Additional success criteria are dependent upon density and growth of "Character Tree Species." Character Tree Species include planted species along with species identified through visual inventory of an approved reference (relatively undisturbed) forest community used to orient the Project design. All canopy tree species planted and identified in the reference forest will be utilized to define "Character Tree Species" as termed in the success criteria.

An average density of 320 stems per acre of Character Tree Species must be surviving in the first three monitoring years. Subsequently, 290 Character Tree Species per acre must be surviving in year four (4) and 260 Character Tree Species per acre in year five (5).

7.2.2 Vegetation Contingency

If vegetation success criteria are not achieved based on average density calculations from combined plots over the entire restoration area, supplemental planting may be performed with tree species approved by regulatory agencies. Supplemental planting will be performed as needed until achievement of vegetation success criteria.

.

7.3 Scheduling and Reporting: A tentative phasing schedule for the proposed Project is presented below. Certain tasks may be dependant on seasonal conditions.

Table 8. Project Scheduling and Reporting
Project ID No. 060684901 (UT to Bear Creek Restoration Project)

Task Description	Date of Scheduled Completion
Restoration Plan Finalized	June 29, 2007
Submission of Final Design	October 26, 2007
Permitting Initiated	November 30, 2007
Advertise for Bidders	February 29, 2008
Bid Opening	March 28, 2008
Begin Construction	August 22, 2008
End Construction	December 2008
Prepare As-built Mitigation Plan and Mitigation Plan	December 2008
First Year Monitoring Report	December 2009
Second Year Monitoring Report	December 2010
Third Year Monitoring Report	December 2011
Fourth Year Monitoring Report	December 2012
Fifth Year Monitoring Report	December 2013

8.0 REFERENCES

Cowardin, L.M., V. Carter, F.C. Goblet, and E.T. Laroe. 1979. Classification of Wetland and Deepwater Habitats of the United States. United States Department of the Interior, Fish and Wildlife Service.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. United States Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Griffith, G.E. 2002. Ecoregions of North and South Carolina. Reston Virginia. United States Geological Society (map scale 1:1,500,000).

Harman, W. H. et al. 1999. Bankfull Hydraulic Geometry Relationships for North Carolina Streams. AWRA Wildland Hydrology Symposium Proceedings. Edited by: D. S. Olsen and J. P. Potyondy. AWRA Summer Symposium. Bozeman, MT.

Manning, R. 1891. On the Flow of Water in Open Channels and Pipes. Transactions of the Institution of Civil Engineers of Ireland. 20, 161-20.

North Carolina Division of Water Quality (NCDWQ). 2005. Cape Fear River Basinwide Water Quality Plan (online). Available: http://h2o.enr.state.nc.us/basinwide/draftCPFApril2005.htm [May 23, 2007]. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

North Carolina Division of Water Quality (NCDWQ). 2006a. Final North Carolina Water Quality Assessment and Impaired Waters List (2004 Integrated 305(b) and 303(d) Report) (online). Available: http://h2o.enr.state.nc.us/tmdl/documents/2004IRCategories4-7.PDF [May 24, 2007]. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

North Carolina Division of Water Quality (NCDWQ). 2006b. Draft North Carolina Water Quality Assessment and Impaired Waters List (2006 Integrated 305(b) and 303(d) Report). Public Review (online). Available: http://h2o.enr.state.nc.us/tmdl/documents/2006303dListPublicReviewDraft.pdf [May 24, 2007]. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

North Carolina Division of Water Quality (NCDWQ). 2007. North Carolina Waterbodies by Subbasin (online). Available: http://h2o.enr.state.nc.us/bims/reports/basinsandwaterbodies/03-06-12.pdf [May 24, 2007]. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

North Carolina Wetlands Restoration Program (NCWRP). 2001. Watershed Restoration Plan for the Cape Fear River Basin (online). Available: http://www.nceep.net/services/restplans/cape_fear_2001.pdf [May 23, 2007]. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina

North Carolina Division of Water Quality (NCDWQ). 2006c. Final North Carolina Water Quality Assessment and Impaired Waters List (2004 Integrated 305(b) and 303(d) Report) (online). Available: http://h2o.enr.state.nc.us/tmdl/documents/2004IRCategories4-7.PDF [February 26, 2007]. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

North Carolina Division of Water Quality (NCDWQ). 2006d. Draft North Carolina Water Quality Assessment and Impaired Waters List (2006 Integrated 305(b) and 303(d) Report). Public Review (online). Available: http://h2o.enr.state.nc.us/tmdl/documents/2006303dListPublicReviewDraft.pdf [February 26, 2007]. North Carolina Department of Environment and Natural Resources, Raleigh, North Carolina.

Rosgen D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado.

Schafale, M.P. and A.S. Weakley. 1990. Classification of the Natural Communities of North Carolina: Third Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation, North Carolina Department of Environment, Health, and Natural Resources. Raleigh, North Carolina.

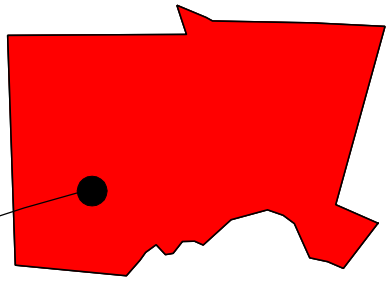
United States Army Corps of Engineers (USACE), United States Environmental Protection Agency (USEPA), North Carolina Wildlife Resources Commission (NCWRC), Natural Resources Conservation Service (NRCS), and North Carolina Division of Water Quality (NCDWQ). 2003. Stream Mitigation Guidelines. State of North Carolina.

United States Department of Agriculture (USDA). 2006. Soil Survey of Chatham County, North Carolina. United State Department of Agriculture, Natural Resources Conservation Service.

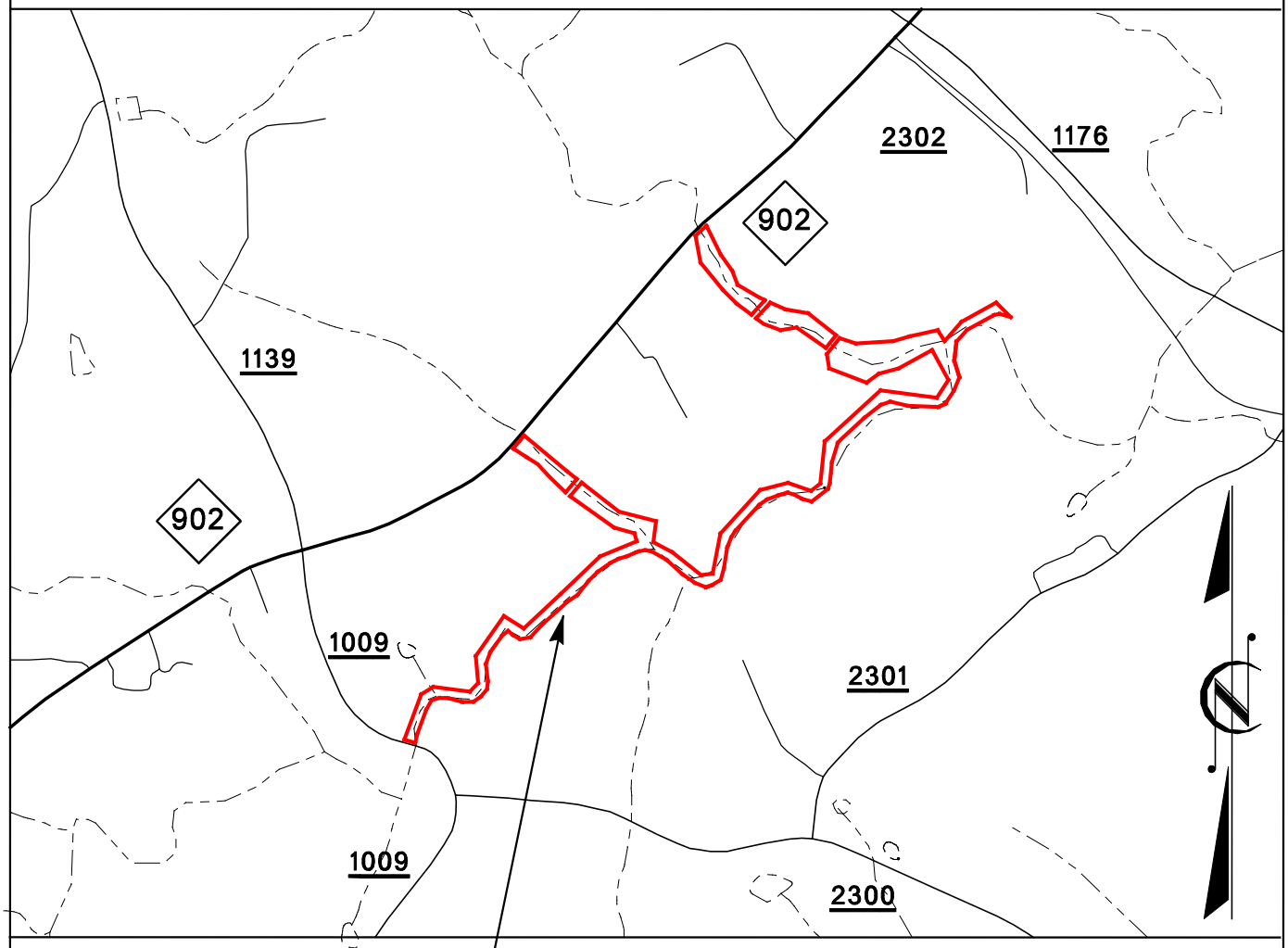
United States Geological Survey (USGS). 1974. Hydrologic Unit Map. Reston, Virginia. United States Geological Society (map scale 1: 500,000).

APPENDIX A
FIGURES

Chatham County
North Carolina



PROJECT AREA



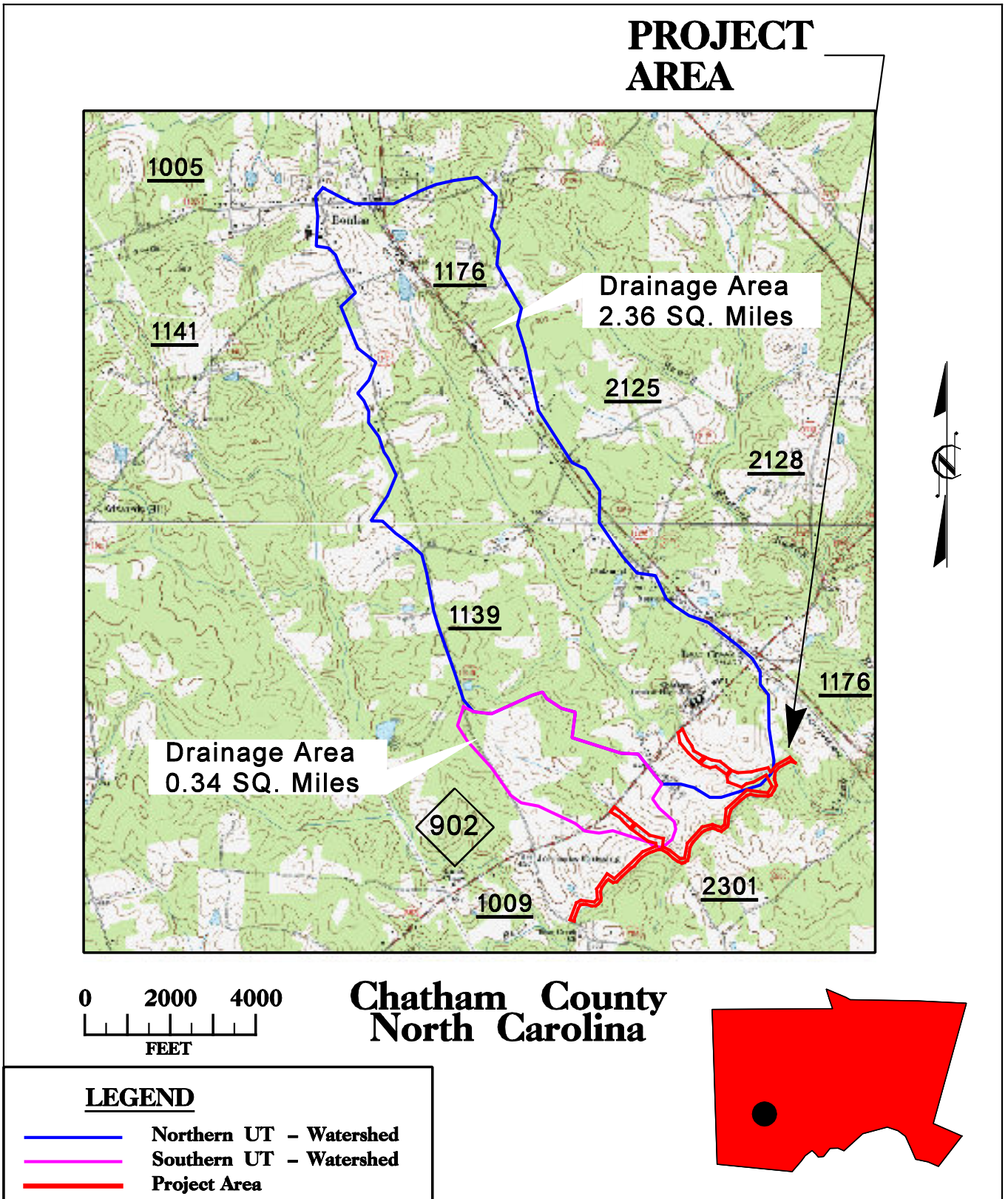
Ecosystem Enhancement Program

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Vicinity Map

Restoration Plan
UT to Bear Creek
Chatham County, North Carolina

Date: 5/31/07	Figure: 1



Watershed Topo Map

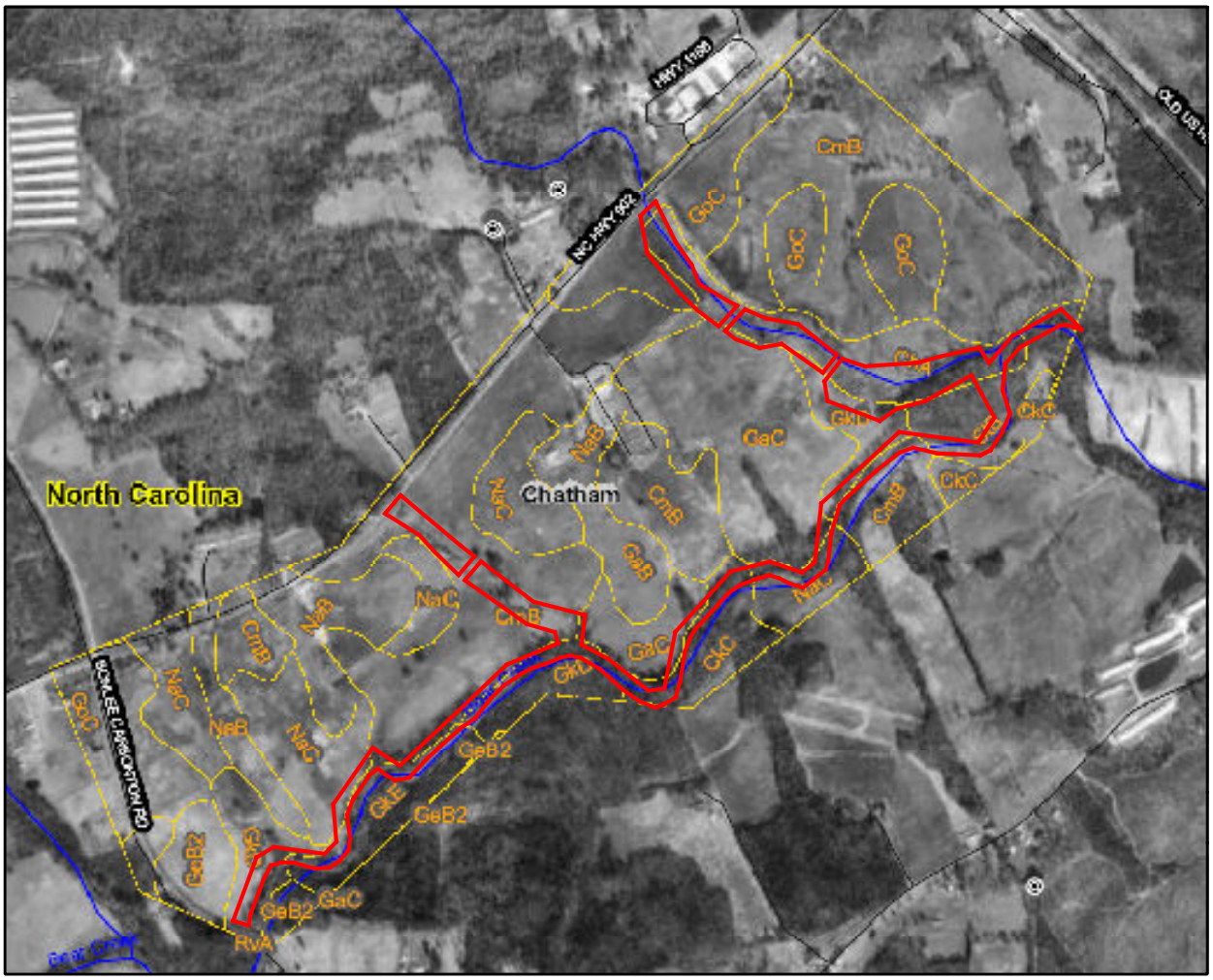
Restoration Plans
UT to Bear Creek
Chatham County, North Carolina

Ecosystem Enhancement Program

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Date: 5/31/07

Figure: 2



LEGEND

Symbol	Name	Symbol	Name
ChA	Chewacla and Wehadkee	GkE	Georgeville-Badin Complex
CkC	Cid Silt Loam	GoC	Goldston-Badin Complex
CmB	Cid-Lignum Complex	NaB	Nanford-Badin Complex
GaB	Georgeville Silt Loam	NaC	Nadford-Badin Complex
GaC	Georgeville Silt Loam	RvA	Riverview Silt Loam
GeB2	Georgeville Silty Clay Loam	StB	State Sandy Loam
GkD	Georgeville-Badin Complex		Project Area

0 1000 2000

FEET

Ecosystem Enhancement PROGRAM

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Soil Survey Map

Restoration Plans
UT to Bear Creek
Chatham County, North Carolina

Date: 5/31/07

Figure: 3

PROJECT AREA

0 1000 2000

FEET

Hydrological Features Map

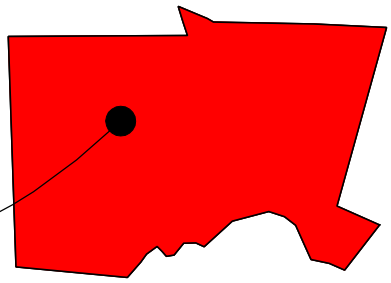
Restoration Plan
UT to Bear Creek
Chatham County, North Carolina

Ecosystem Enhancement Program

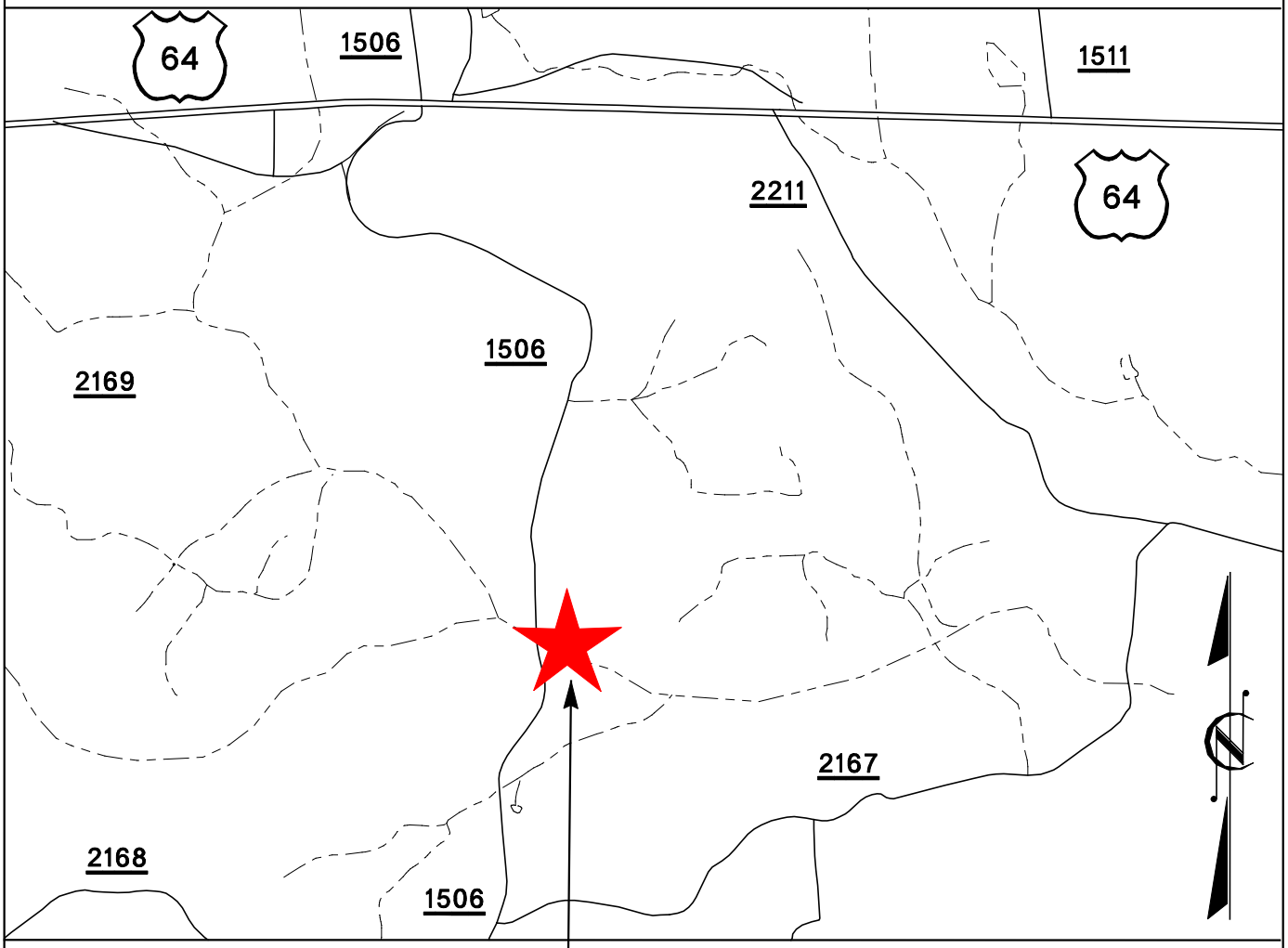
KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Date: 5/31/07	Figure: 4

Chatham County North Carolina



PROJECT AREA



Ecosystem Enhancement Program

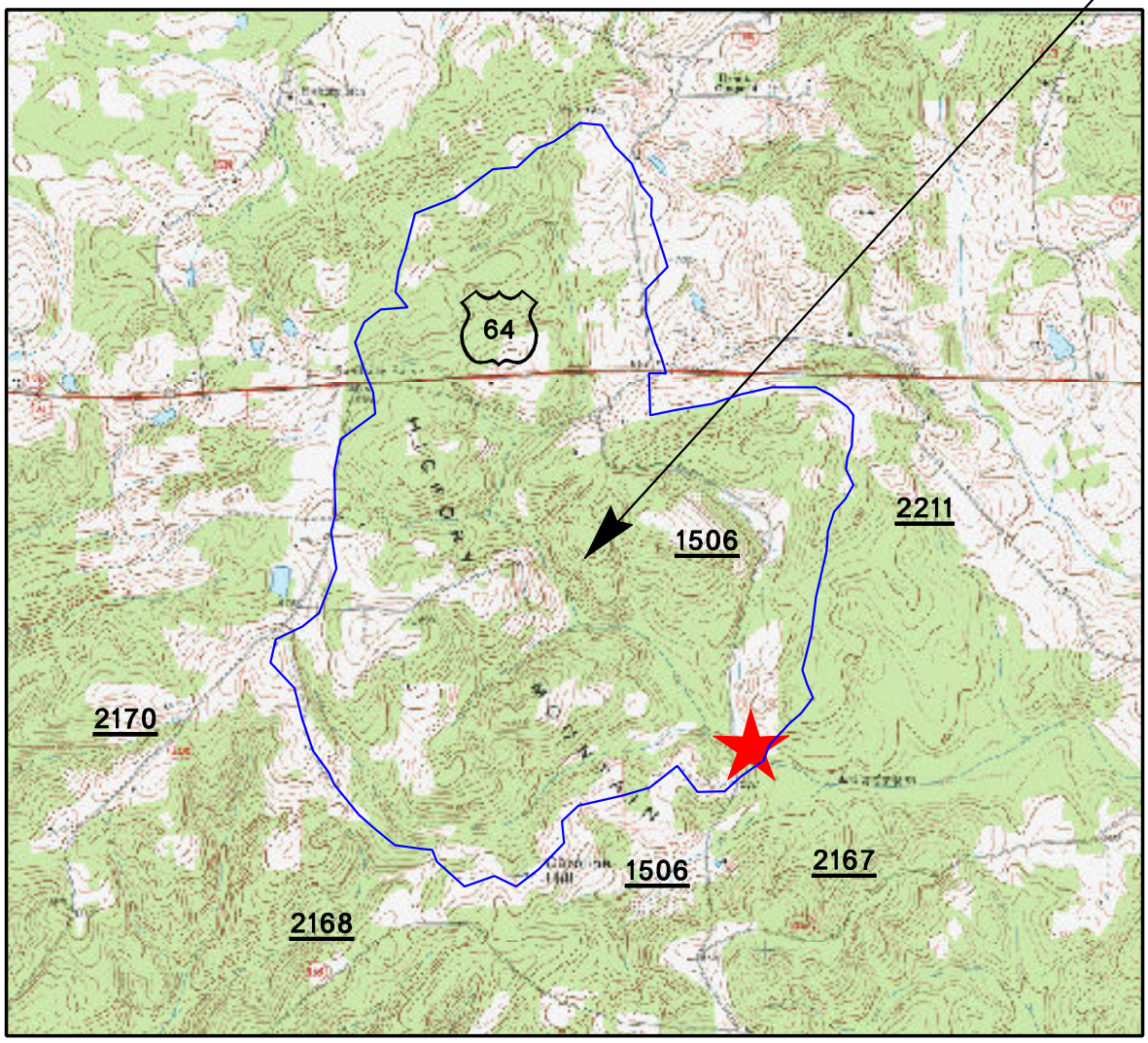
KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Landrum Creek Vicinity Map

Restoration Plan
UT to Bear Creek
Chatham County, North Carolina

Date: 6/01/07

Figure: 5

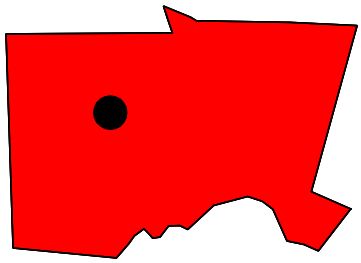


0 1000 2000
FEET

LEGEND

Watershed

Chatham County North Carolina



Ecosystem Enhancement Program

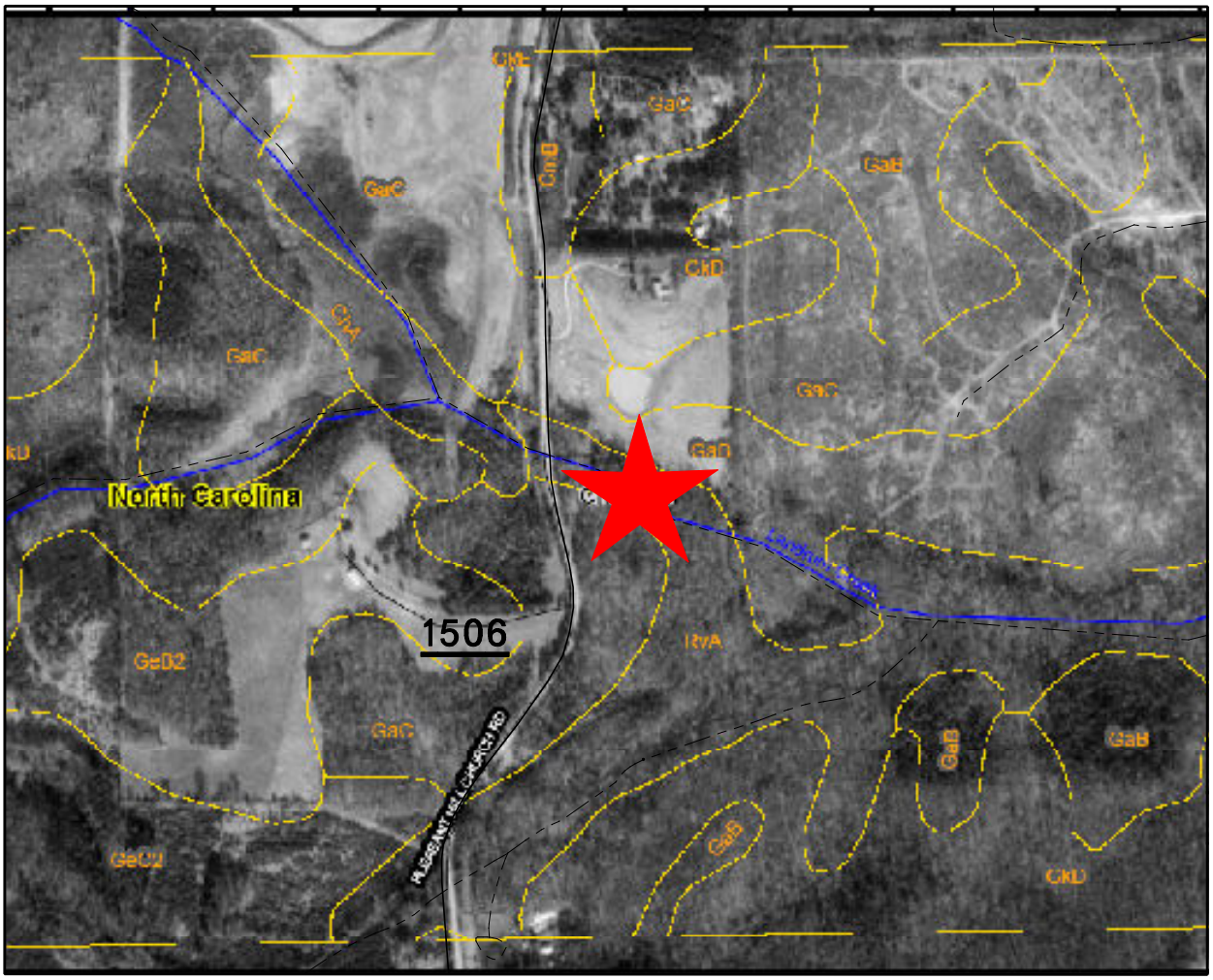
KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Landrum Creek Watershed Map

Restoration Plans
UT to Bear Creek
Chatham County, North Carolina

Date: 6/1/07

Figure: 6



LEGEND

Symbol	Name
GaB	- Georgeville Silt Loam (6/10% Slope)
GaC	- Georgeville Silt Loam (2-6% Slope)
RvA	- Riverview Silt Loam
★	- Project Area

N

0 500 1000
FEET

Ecosystem Enhancement Program

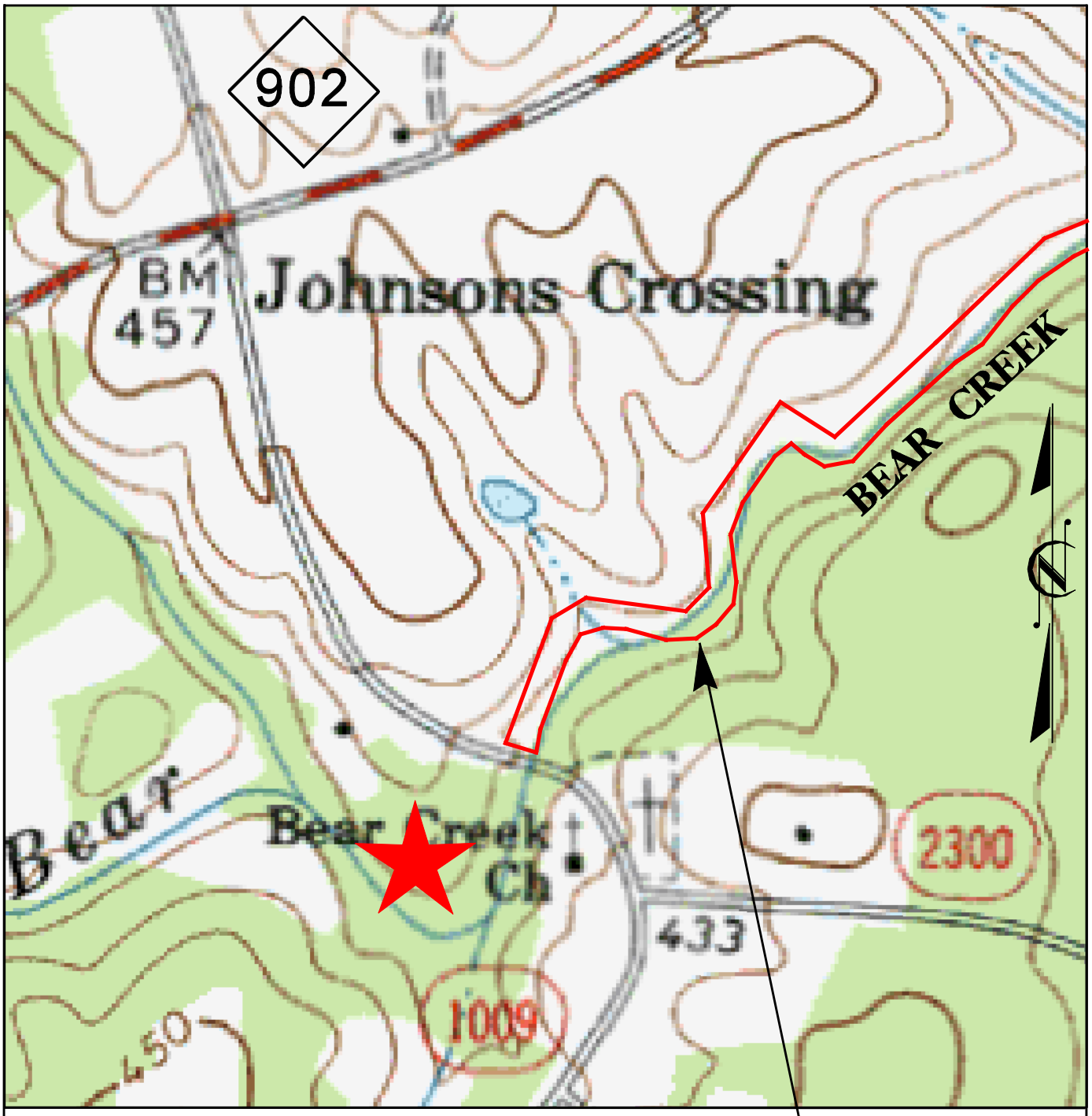
KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Landrum Creek Soil Survey

Restoration Plan
UT to Bear Creek
Chatham County, North Carolina

Date: 6/01/07

Figure: 7



LEGEND

Vegetative Communities Location

Project Area

0 500 1000

FEET

PROJECT AREA

Reference Site Vegetative Communities Map

Restoration Plan
UT to Bear Creek
Chatham County, North Carolina

Ecosystem Enhancement PROGRAM

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Date: 5/31/07

Figure: 8

APPENDIX B
SHEETS

EXISTING CONDITIONS
NORTHERN UT BEAR CREEK

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606
(919) 851-6066

100 0 200
SCALE

PROJECT REFERENCE NO.	SHEET NO.
UT TO BEAR CREEK	Sheet 1
PROJECT ENGINEER	

LEGEND

- EXISTING PROPERTY LINE AND CORNER
- TB — EXISTING TOP OF BANK
- EXISTING FENCE LINE
- WOODS
- TREE
- WLB — EXISTING WETLAND BOUNDARY

JAMES R. WEAVER
DEED BOOK 876, PAGE 893
PLAT SLIDE 99-436

EXISTING WETLANDS

EXISTING WETLANDS

NORTHERN UT

EXISTING WETLANDS

BEAR CREEK

NC HIGHWAY 902

FLOW DIRECTION

WOODS

FENCE

ROCK BED

ROCKS

GRASS ISLAND

DITCH

POOLING

EXISTING 60' R/W

60'

JAMES R. WEAVER
DEED BOOK 876, PAGE 893
PLAT SLIDE 99-436

LOCATION:
RESTORATION PLAN
UT TO BEAR CREEK

COUNTY: CHATHAM

DESIGNED BY: RVS/RKW

CHECKED BY: RKW/RVS DATE: 7/25/07

8/6/2007
H:\stream\Proj\Restoration_Plans\bear_creek_psh_1.dgn
KO & Associates, P.C.

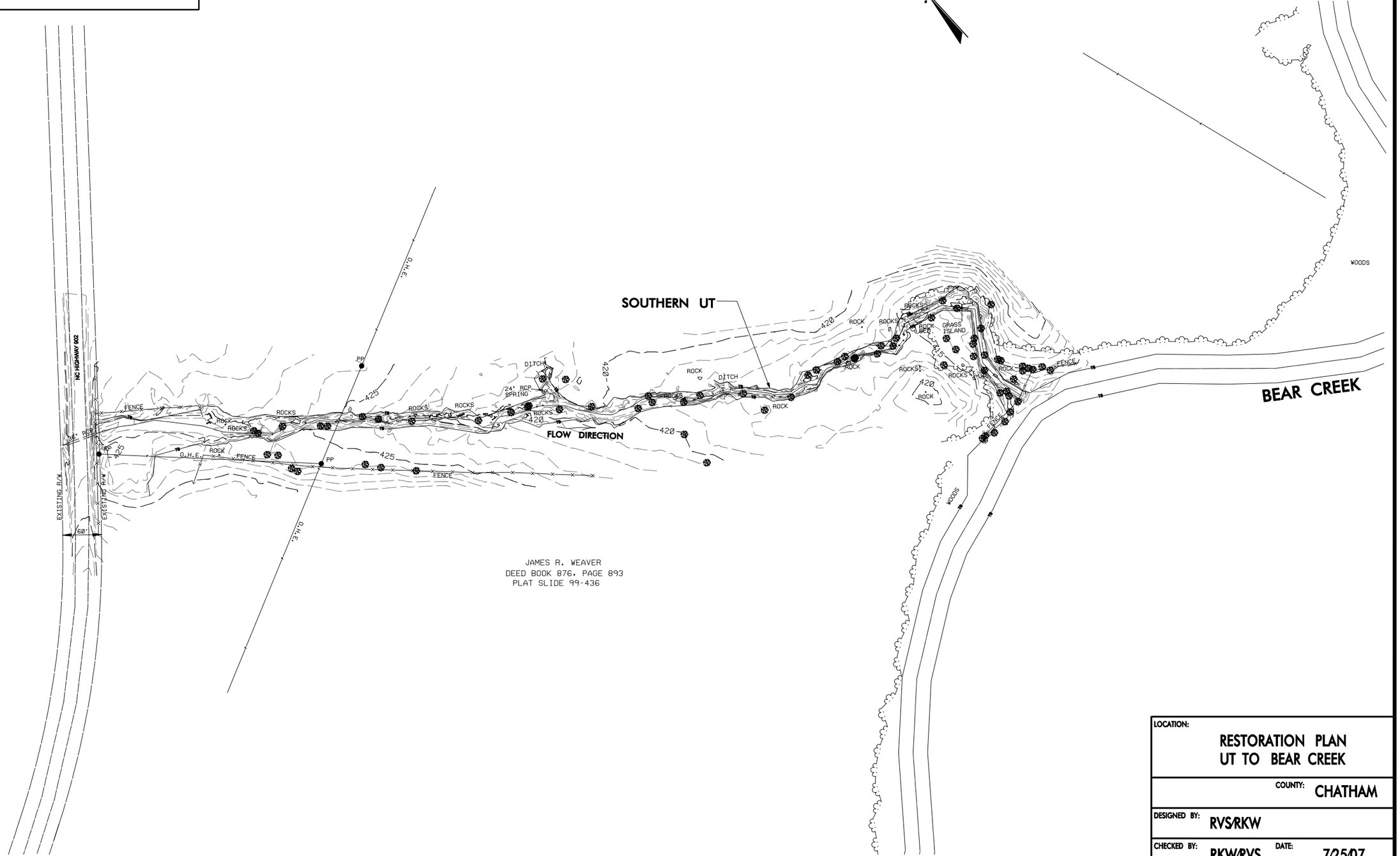
EXISTING CONDITIONS
SOUTHERN UT BEAR CREEK

KO & ASSOCIATES, P.C. Consulting Engineers	PROJECT REFERENCE NO.	SHEET NO.
1011 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606 (919) 851-6066	UT TO BEAR CREEK	Sheet 1A
	PROJECT ENGINEER	

75 0 150
SCALE

LEGEND

- TB — EXISTING TOP OF BANK
- EXISTING FENCE LINE
- WOODS
- TREE



LOCATION:	RESTORATION PLAN UT TO BEAR CREEK
COUNTY:	CHATHAM
DESIGNED BY:	RVS/RKW
CHECKED BY:	RKW/RVS
DATE:	7/25/07

8/6/2007
H:\stream\Proj\Restoration_Plans\bear_creek_psh_1a.dgn
Ko & Associates, P.C.

PROPOSED CONDITIONS
NORTHERN UT BEAR CREEK

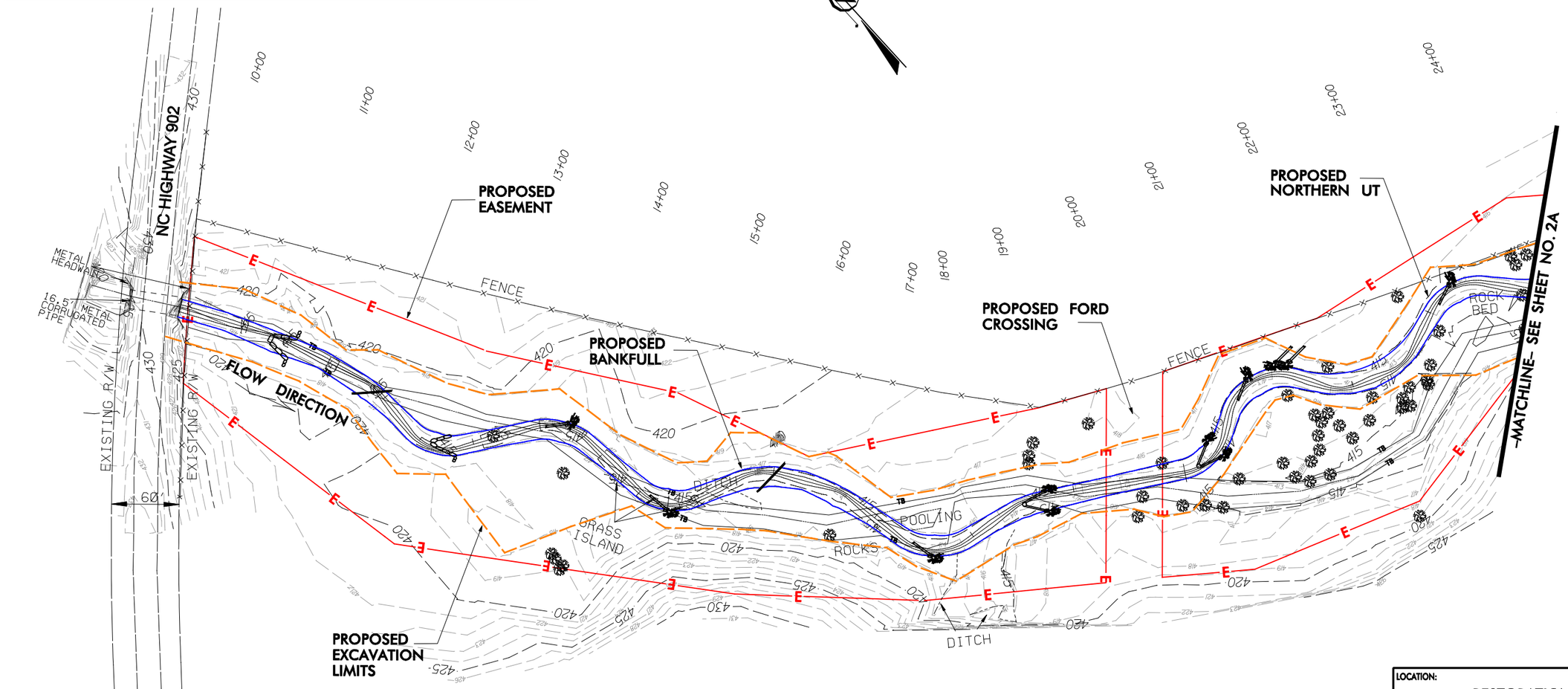
KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606
(919) 851-6066

50 0 100
SCALE

PROJECT REFERENCE NO.	SHEET NO.
UT TO BEAR CREEK	Sheet 2
PROJECT ENGINEER	

LEGEND

- EXISTING PROPERTY LINE AND CORNER
- EXISTING TOP OF BANK (TB)
- EXISTING FENCE LINE
- WOODS
- TREE
- ROCK STEP STRUCTURE
- LOG STEP SEQUENCE
- LOG VANE / ROOT WAD
- L-VANE
- ROCK CROSS VANE
- LOG SILL
- LOG CROSS VANE



NOTE:
EXISTING FEATURES ARE SHOWN WITH THIN LINES AND SMALL TEXT.

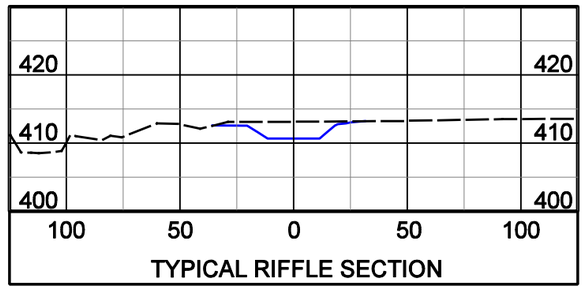
LOCATION:	RESTORATION PLAN UT TO BEAR CREEK
COUNTY:	CHATHAM
DESIGNED BY:	RVS/RKW
CHECKED BY:	RKW/RVS
DATE:	7/25/07

8/6/2007
H:\stream\Proj\Restoration_Plans\bear_creek_psh_2.dgn
ko & associates, p.c.

KO & ASSOCIATES, P.C. Consulting Engineers 1011 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606 (919) 851-6066	PROJECT REFERENCE NO.	SHEET NO.
	UT TO BEAR CREEK	Sheet 2A
	PROJECT ENGINEER	

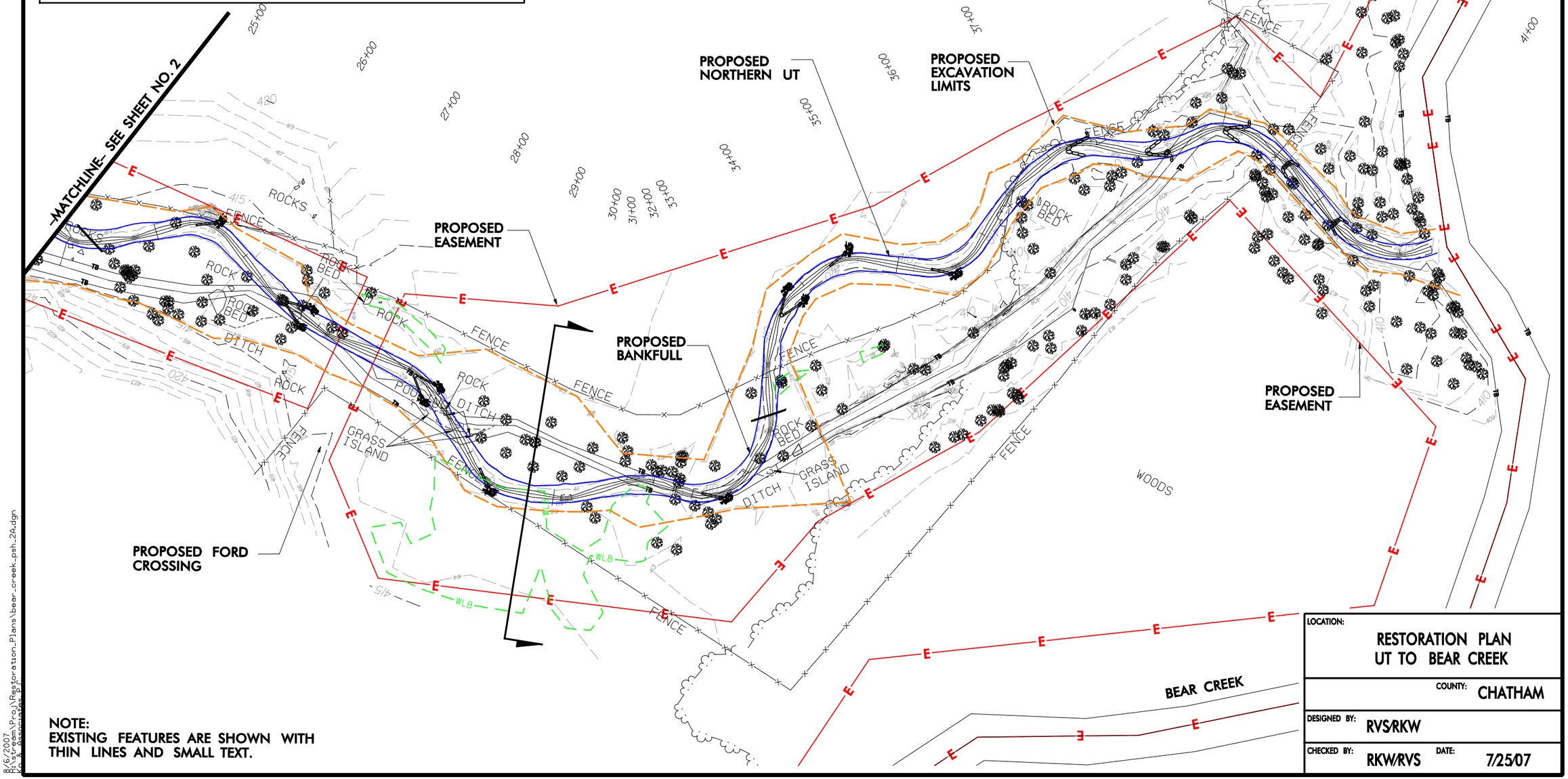
50 0 100
SCALE

PROPOSED CONDITIONS
NORTHERN UT BEAR CREEK



LEGEND

- EXISTING PROPERTY LINE AND CORNER
- TB — EXISTING TOP OF BANK
- EXISTING FENCE LINE
- WOODS
- TREE
- WLB — EXISTING WETLAND BOUNDARY
- ROCK STEP STRUCTURE
- LOG STEP SEQUENCE
- LOG VANE / ROOT WAD
- L-VANE
- ROCK CROSS VANE
- LOG SILL
- LOG CROSS VANE



NOTE:
EXISTING FEATURES ARE SHOWN WITH THIN LINES AND SMALL TEXT.

LOCATION: RESTORATION PLAN UT TO BEAR CREEK	
	COUNTY: CHATHAM
DESIGNED BY: RVS/RKW	
CHECKED BY: RKW/RVS	DATE: 7/25/07

8/6/2007
P:\stream\Proj\Restoration_Plans\bear_creek_psh_2A.dgn
K.S. Associates, P.

KO & ASSOCIATES, P.C.
Consulting Engineers
1021 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606
(919) 851-0066

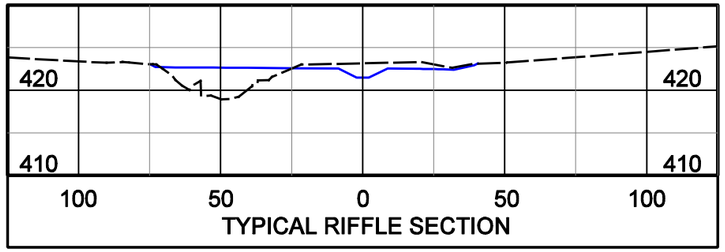
PROJECT REFERENCE NO.	SHEET NO.
UT TO BEAR CREEK	Sheet 2B
PROJECT ENGINEER	

30 0 60
SCALE

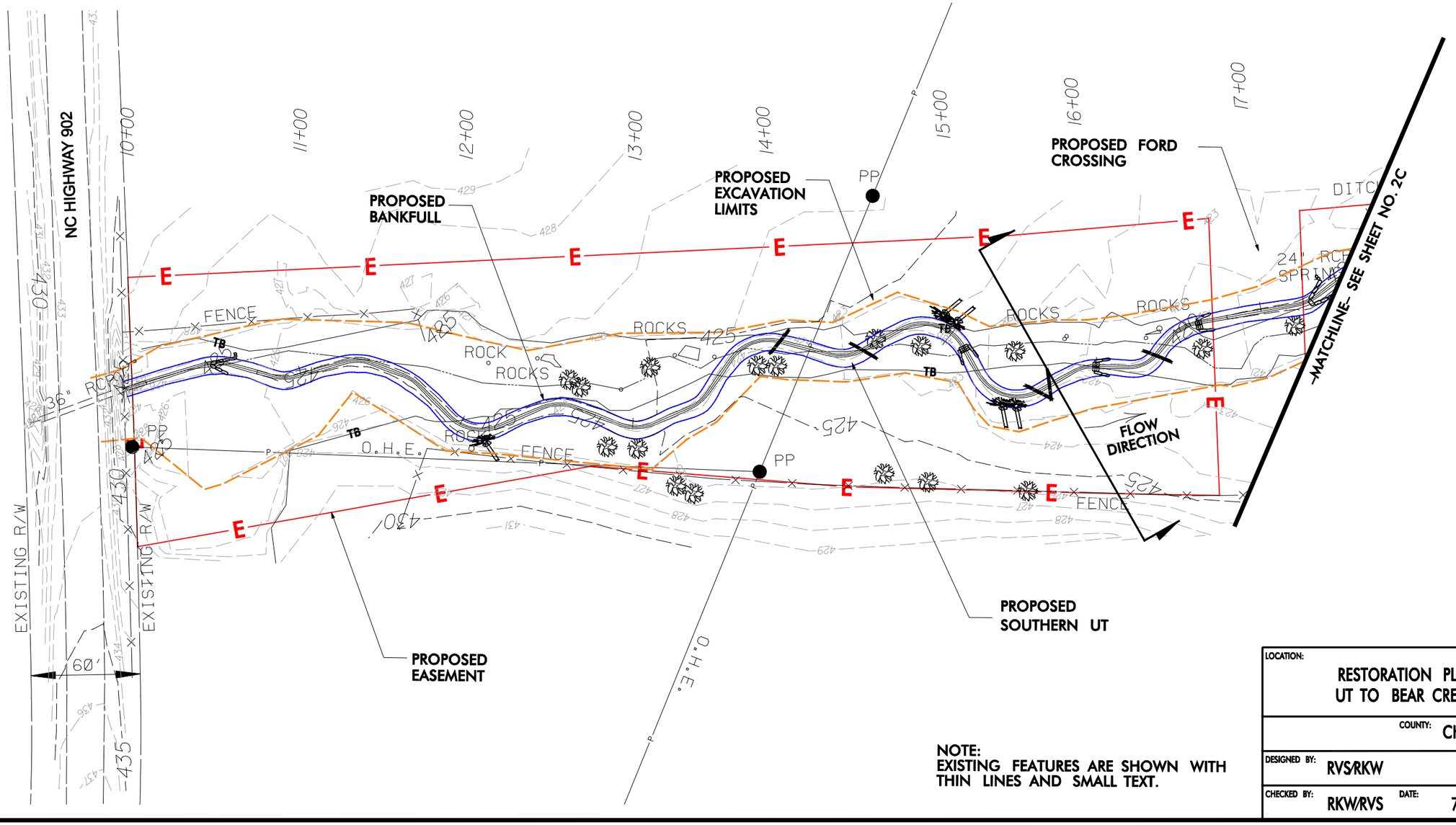
LEGEND

- EXISTING PROPERTY LINE AND CORNER
- EXISTING TOP OF BANK (TB)
- EXISTING FENCE LINE
- WOODS
- TREE
- ROCK STEP STRUCTURE
- LOG STEP SEQUENCE
- LOG VANE / ROOT WAD
- L-VANE
- ROCK CROSS VANE
- LOG SILL
- LOG CROSS VANE

PROPOSED CONDITIONS
SOUTHERN UT BEAR CREEK



TYPICAL RIFFLE SECTION



NOTE:
EXISTING FEATURES ARE SHOWN WITH THIN LINES AND SMALL TEXT.

LOCATION:	RESTORATION PLAN UT TO BEAR CREEK
COUNTY:	CHATHAM
DESIGNED BY:	RVS/RKW
CHECKED BY:	RKW/RVS
DATE:	7/25/07

8/6/2007
H:\stream\Proj\Restoration_Plans\bear_creek_psh_2B.dgn

PROPOSED CONDITIONS
SOUTHERN UT BEAR CREEK

KO & ASSOCIATES, P.C.
Consulting Engineers
1021 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606
(919) 851-0066

30 0 60
SCALE

PROJECT REFERENCE NO.	SHEET NO.
UT TO BEAR CREEK	Sheet 2C
PROJECT ENGINEER	

LEGEND

- EXISTING PROPERTY LINE AND CORNER
- EXISTING TOP OF BANK (TB)
- EXISTING FENCE LINE
- WOODS
- TREE
- ROCK STEP STRUCTURE
- LOG STEP SEQUENCE
- LOG VANE / ROOT WAD
- L-VANE
- ROCK CROSS VANE
- LOG SILL
- LOG CROSS VANE

PROPOSED EXCAVATION LIMITS

PROPOSED BANKFULL

PROPOSED SOUTHERN UT

PROPOSED EASEMENT

PROPOSED FOR CROSSING

FLOW DIRECTION

-MATCHLINE- SEE SHEET NO. 2B

NOTE:
EXISTING FEATURES ARE SHOWN WITH THIN LINES AND SMALL TEXT.

LOCATION:	RESTORATION PLAN UT TO BEAR CREEK
COUNTY:	CHATHAM
DESIGNED BY:	RVS/RKW
CHECKED BY:	RKW/RVS
DATE:	7/25/07

8/6/2007
H:\stream\Proj\Restoration_Plans\bear_creek_psh_2C.dgn

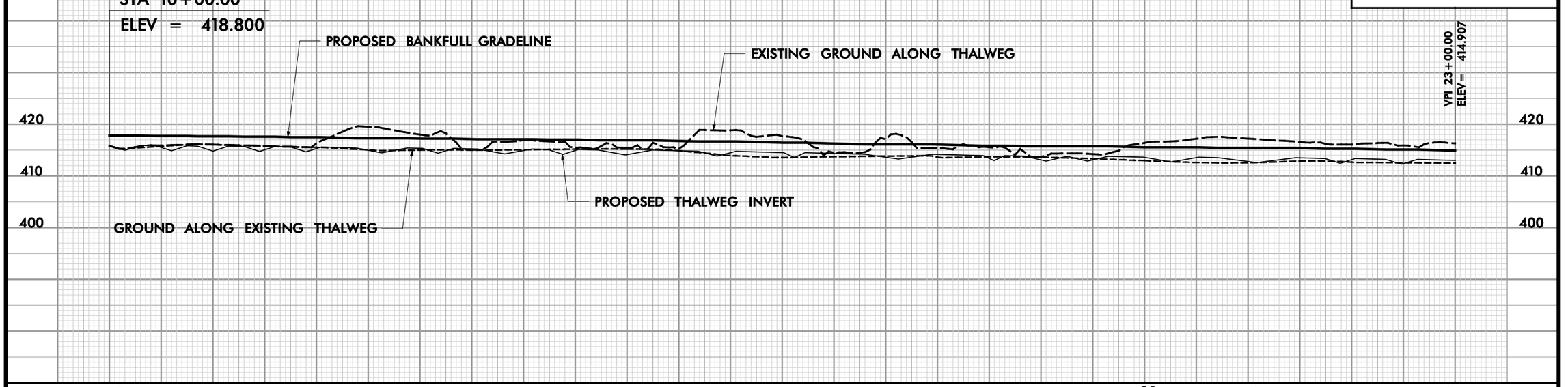
5/28/99

LONGITUDINAL PROFILE

NORTHERN UT

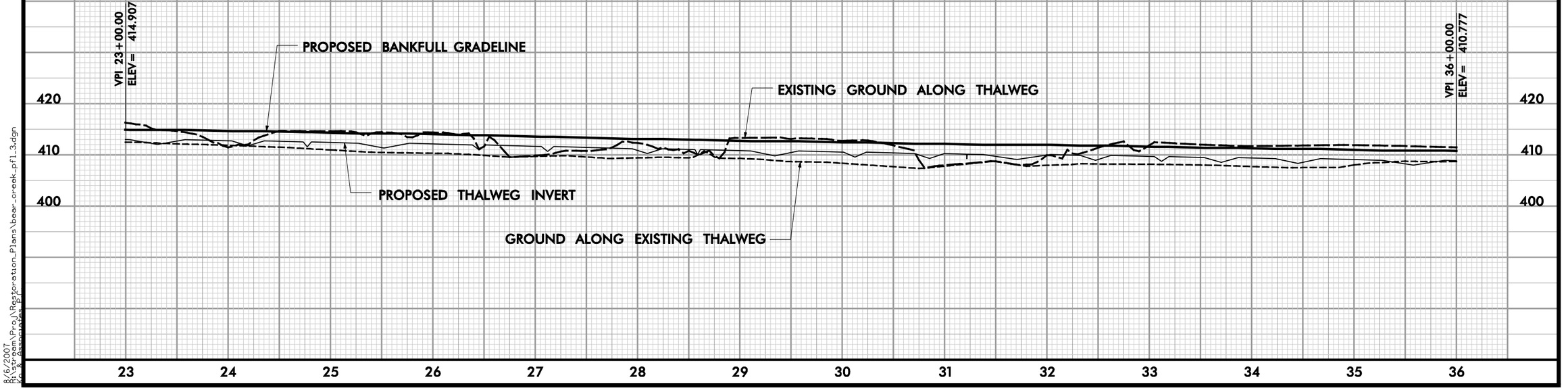
KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606
(919) 851-6066

PROJECT REFERENCE NO.	SHEET NO.
BEAR CREEK	Sheet 3
PROJECT ENGINEER	



LONGITUDINAL PROFILE

NORTHERN UT

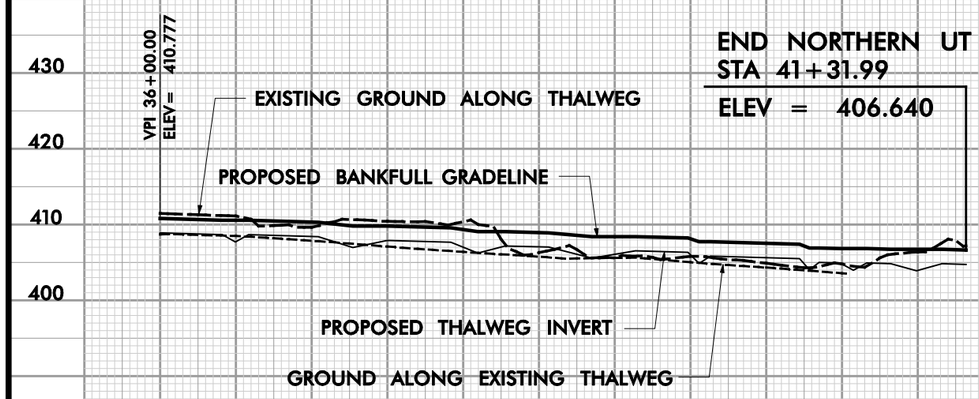


8/6/2007
P:\stream\Proj\Restoration_Plans\bear_creek_pf1_3.dgn
KO & Associates, P.C.

5/28/99

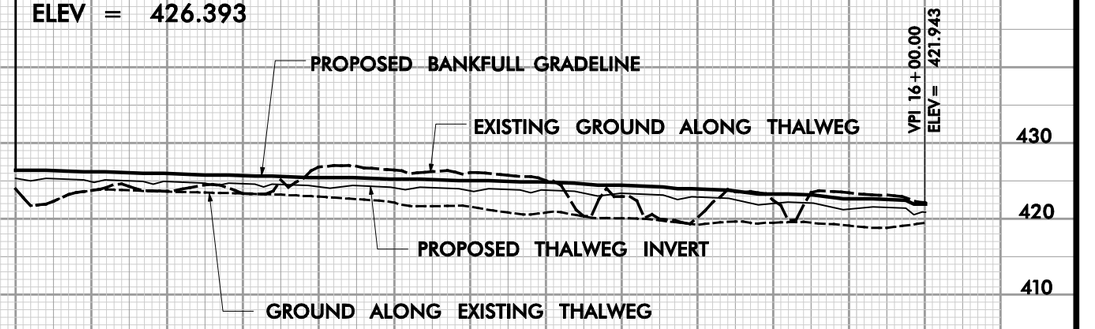
LONGITUDINAL PROFILE

NORTHERN UT



LONGITUDINAL PROFILE

SOUTHERN UT



KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606
(919) 851-6066

PROJECT REFERENCE NO.	SHEET NO.
BEAR CREEK	Sheet 3A
PROJECT ENGINEER	

LONGITUDINAL PROFILE

SOUTHERN UT

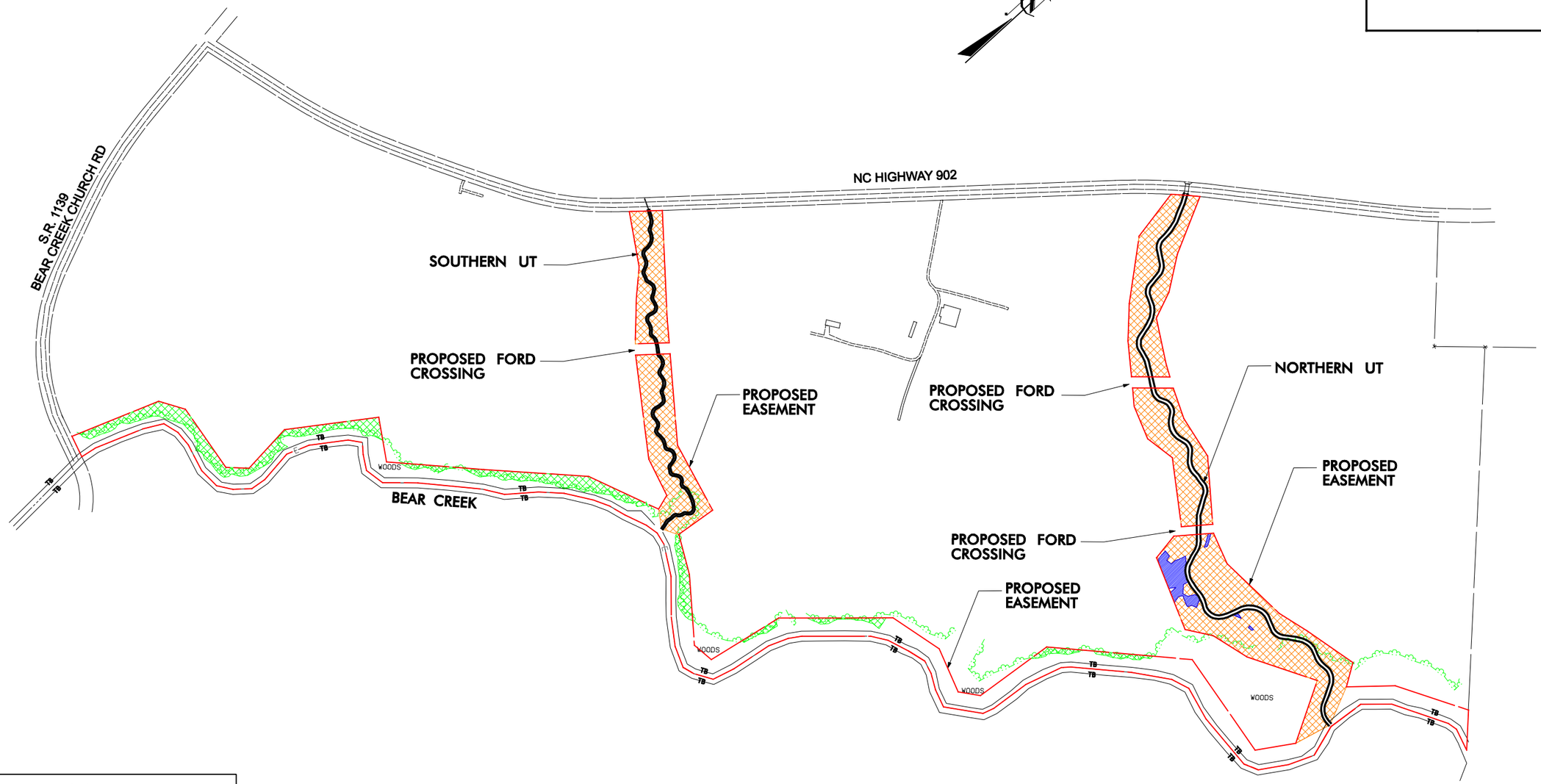
8/6/2007
P:\stream\Proj\Restoration_Plans\bear_creek_pf1_3a.dgn
KO & Associates, P.C.

PLANTING PLAN

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE 202 RALEIGH, N.C. 27606
(919) 851-6966

250 0 500
SCALE

PROJECT REFERENCE NO.	SHEET NO.
UT TO BEAR CREEK	Sheet 4
PROJECT ENGINEER	



LEGEND

- WOODS
- STREAM-SIDE – (1.03 Ac) ASSEMBLAGE
- PIEDMONT ALLUVIAL – (14.62 Ac) FOREST
- PIEDMONT ALLUVIAL – (3.23 Ac) FOREST (BEAR CREEK BUFFER PLANTING)
- RIPARIAN WETLAND – (0.39 Ac)

LOCATION:
RESTORATION PLAN
UT TO BEAR CREEK

COUNTY: CHATHAM

DESIGNED BY: RVS/RKW

CHECKED BY: RVS/RKW DATE: 7/25/07

8/6/2007
H:\stream\Proj\Restoration_Plans\bear_creek_psh_4b.dgn
K & Associates, P.

APPENDIX C
EXISTING CONDITIONS
SITE PHOTOGRAPHS

Northern UT looking downstream at cattle access point, and channel over widening. Notice aggradation where channel has over widened.

Northern UT where channel is incising and mass wasting of the banks are occurring.

Northern UT where mass wasting of the banks is occurring because of the loss of vegetation and incision of the channel.

Northern UT Cattle access point where the cattle are using the channel for a watering hole and cooling area.

Northern UT where the channel has incised to bedrock and high shear stress is being placed on banks.

Northern UT where channel has incised to bedrock and is undercutting the trees that are left on the channel banks.

Southern UT: notice slumpage of channel and the deep incision of bankfull (bankfull depth should be just over one foot from channel

Southern UT where channel has braided because of cattle access.

Southern UT has incised to the point that it is undercutting existing vegetation on the banks.

Southern UT: banks are experiencing mass wasting because channel is trying to increase belt width and because of the loss of vegetation.

Southern UT has incised and ruts in banks due to cattle access are causing bank slumpage into the middle of channel.

Southern UT: the loss of bank vegetation and cattle access has increased shear stress on banks causing mass wasting and slumpage.

APPENDIX D
MORPHOLOGICAL STREAM CHARACTERISTICS

Morphological Characteristics of Northern UT

Restoration Plan: **UT Bear Creek Stream Restoration**
County: **Chatham County, NC**
Design by: **RVS/RKW**
Checked by: **RKW**

ITEM	Existing Conditions	Proposed Conditions	Reference Reach
LOCATION	Northern UT to Bear Creek - Weaver Property	Northern UT Bear Creek	Landrum Creek
STREAM TYPE	Degraded E4	C4	C4
DRAINAGE AREA, Ac - Sq Mi	1508 Ac - 2.36 Sq Mi	1508 Ac - 2.36 Sq Mi	1619 Ac - 2.53 Sq Mi
BANKFULL WIDTH (W_{bkf}), ft	15.2 ft	19.0 ft	20.2 ft
BANKFULL MEAN DEPTH (d_{bkf}), ft	1.37 ft	1.36 ft	1.39 ft
WIDTH/DEPTH RATIO (W_{bkf}/d_{bkf})	11.0	14.0	14.5
BANKFULL X-SECTION AREA (A_{bkf}), ft^2	20.8 ft^2	25.8 ft^2	28.2 ft^2
BANKFULL MEAN VELOCITY, fps	4.8 fps	3.5 fps	6.2 fps
BANKFULL DISCHARGE, cfs	100.0 cfs	100.0 cfs	173.7 cfs
BANKFULL MAX DEPTH (d_{max}), ft	1.72 ft	1.90 ft	1.87 ft
BANK HEIGHT RATIO	1.35	1.00	1.02
WIDTH Flood-Prone Area (W_{fpa}), ft	40.0 ft	100.00 ft	140.0 ft
ENTRENCHMENT RATIO (ER)	2.6	5.3	6.9
MEANDER LENGTH (Lm), ft	125 - 250 ft	95.0 - 228.0 ft	94.0 - 100.0 ft
RATIO OF Lm TO W_{bkf}	8.2 - 16.5	5.0 - 12.0	4.6 - 4.9
RADIUS OF CURVATURE, ft	21 - 75 ft	38.0 - 76.0 ft	10.2 - 13.3 ft
RATIO OF Rc TO W_{bkf}	1.4 - 4.9	2.0 - 4.0	0.5 - 0.7
BELT WIDTH, ft	41.00 - 116.00 ft	38.0 - 114.0 ft	20.0 - 77.0 ft
MEANDER WIDTH RATIO	2.70 - 7.65 ft	2.0 - 6.0	1.0 - 3.8
SINUOSITY (K)	1.05	1.13	1.12
VALLEY SLOPE, ft/ft	0.0066 ft/ft	0.0040 ft/ft	0.0080 ft/ft
AVERAGE SLOPE (S), ft/ft	0.0062 ft/ft	0.0028 ft/ft	0.0077 ft/ft
POOL SLOPE, ft/ft	0.0003 ft/ft	0.0011 ft/ft	0.0000 ft/ft
RATIO OF POOL SLOPE TO AVERAGE SLOPE	0.0	0.4	0.0
MAX POOL DEPTH, ft	2.03 ft	2.71 ft	2.71 ft
RATIO OF POOL DEPTH TO AVERAGE BANKFULL DEPTH	1.5	2.0	1.9
POOL WIDTH, ft	13.7 ft	21.85 ft	22.08 ft
RATIO OF POOL WIDTH TO BANKFULL WIDTH	0.9	1.15	1.09
POOL TO POOL SPACING, ft	25.50 - 127.00 ft	22.8 - 114.0 ft	25.0 - 104.0 ft
RATIO OF POOL TO POOL SPACING TO BANKFULL WIDTH	1.68 - 8.38 ft	1.2 - 6.0	1.2 - 5.1

** Existing Conditions data was taken along a *reach* of stream. Data, such as stream and valley slopes, may not corrospond to the entire length of channel inside of the Project Area.

Morphological Characteristics of Southern UT

Restoration Plan: **UT Bear Creek Stream Restoration**
County: **Chatham County, NC**
Design by: **RVS/RKW**
Checked by: **RKW**

ITEM	Existing Conditions	Proposed Conditions	Reference Reach
LOCATION	Southern UT to Bear Creek - Weaver Property	Southern UT Bear Creek	Landrum Creek
STREAM TYPE	Degraded E4	C4	C4
DRAINAGE AREA, Ac - Sq Mi	212 Ac - 0.33 Sq Mi	212 Ac - 0.33 Sq Mi	1619 Ac - 2.53 Sq Mi
BANKFULL WIDTH (W_{bkf}), ft	5.0 ft	8.5 ft	20.2 ft
BANKFULL MEAN DEPTH (d_{bkf}), ft	1.05 ft	0.71 ft	1.39 ft
WIDTH/DEPTH RATIO (W_{bkf}/d_{bkf})	4.7	12.0	14.5
BANKFULL X-SECTION AREA (A_{bkf}), ft^2	5.2 ft^2	6.0 ft^2	28.2 ft^2
BANKFULL MEAN VELOCITY, fps	4.2 fps	3.9 fps	6.2 fps
BANKFULL DISCHARGE, cfs	22.0 cfs	22.0 cfs	173.7 cfs
BANKFULL MAX DEPTH (d_{max}), ft	1.31 ft	1.06 ft	1.87 ft
BANK HEIGHT RATIO	1.39	1.00	1.02
WIDTH Flood-Prone Area (W_{fpa}), ft	14.3 ft	50.00 ft	140.0 ft
ENTRENCHMENT RATIO (ER)	2.9	5.9	6.9
MEANDER LENGTH (Lm), ft	40 - 53 ft	42.5 - 102.0 ft	94.0 - 100.0 ft
RATIO OF Lm TO W_{bkf}	8.1 - 10.7	5.0 - 12.0	4.6 - 4.9
RADIUS OF CURVATURE, ft	5 - 30 ft	17.0 - 34.0 ft	10.2 - 13.3 ft
RATIO OF Rc TO W_{bkf}	1.0 - 6.1	2.0 - 4.0	0.5 - 0.7
BELT WIDTH, ft	25.00 - 36.00 ft	34.0 - 51.0 ft	20.0 - 77.0 ft
MEANDER WIDTH RATIO	5.04 - 7.26 ft	4.0 - 6.0	1.0 - 3.8
SINUOSITY (K)	1.06	1.14	1.12
VALLEY SLOPE, ft/ft	0.0150 ft/ft	0.0110 ft/ft	0.0087 ft/ft
AVERAGE SLOPE (S), ft/ft	0.0145 ft/ft	0.0041 ft/ft	0.0077 ft/ft
POOL SLOPE, ft/ft	0.0022 ft/ft	0.0016 ft/ft	0.0000 ft/ft
RATIO OF POOL SLOPE TO AVERAGE SLOPE	0.2	0.4	0.0 - 0.0
MAX POOL DEPTH, ft	1.73 ft	1.42 ft	2.71 ft
RATIO OF POOL DEPTH TO AVERAGE BANKFULL DEPTH	1.6	2.0	1.9
POOL WIDTH, ft	6.8 ft	9.78 ft	22.08 ft
RATIO OF POOL WIDTH TO BANKFULL WIDTH	1.4	1.15	1.09
POOL TO POOL SPACING, ft	6.80 - 21.50 ft	10.2 - 51.0 ft	25.0 - 104.0 ft
RATIO OF POOL TO POOL SPACING TO BANKFULL WIDTH	1.37 - 4.34 ft	1.2 - 6.0	1.2 - 5.1

** Existing Conditions data was taken along a *reach* of stream. Data, such as stream and valley slopes, may not corrospond to the entire length of channel inside of the Project Area.

APPENDIX E
RESTORATION SITE USACE ROUTINE WETLAND DETERMINATION DATA FORMS

DATA FORM

ROUTINE WETLAND DETERMINATION
(1987 COE Wetlands Delineation Manual)

Project/Site: UT to Bear Creek			Date: 5-23-07
Applicant / Owner: EEP			County: Chatham
Investigator: RVS			State: NC
Do Normal Circumstances exist on the site?	YES	NO	Community ID:
Is the site significantly disturbed (Atypical Situation)?	YES	NO	Transect ID:
Is the area a potential Problem Area? (If needed, explain on reverse)	YES	NO	Plot ID: Wetlands 1, 2, 3 and 4

VEGETATION

Dominant Plant Species	Stratum	Indicator	Dominant Plant Species	Stratum	Indicator
1)soft rush	Herb	FACW+	9)		
2) sedge (*Carex* spp.)	Herb	FAC	10).		
3) smartweed (*Polygonum* sp.)	Herb	FAC	11)		
4) American elm	Sap	FACW	12)		
5) green ash	Sap	FACW	13)		
6) lizard's tail	herb	OBL			
7)					
8)					
Percent of Dominant Species that are OBL, FACW, or FAC (excluding FAC-): 100%					
Remarks:					

HYDROLOGY

[ ] Recorded Data (Describe in Remarks)
[ ] Stream, Lake, or Tide Guage
[ ] Aerial Photographs
[ ] Other

[X] No Recorded Data Available

FIELD OBSERVATIONS		
Depth of Surface Water	--	(in)
Depth of Free Water in Pit	--	(in)
Depth to Saturated Soil	10"	(in)

WETLAND HYDROLOGY INDICATORS

Primary Indicators:
[ ] Inundated
[x] Saturated in Upper 12 Inches
[ ] Water Marks
[ ] Drift Lines
[ ] Sediment Deposits
[ ] Drainage Patterns in Wetlands

Secondary Indicators (2 or more Required)
[ ] Oxidized Root Channels in Upper 12 inches
[ ] Water-stained Leaves
[ ] Local Soil Survey Data
[ ] FAC-Neutral Test
[ ] Other (Explain in Remarks)

SOILS

Map Unit Name (Series and Phase): Chewacla sandy loam	Drainage Class: somewhat poorly
Taxonomy (Subgroup): Fluvaquentic Dystrochrepts	Field Observations Confirm Mapped Type? YES NO

PROFILE DESCRIPTION

Depth (inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle Abundance/Contrast	Texture, Concretions, Structure, etc.
0-5"		10 YR 4/2	10 YR 4/4	few/faint	silt loam
5-10"		2.5 Y 5/3	10 YR 3/6	common/distinct	clay loam
10-16"		2.5 Y 5/2	10 YR 3/6	common/distinct	clay loam

HYDRIC SOIL INDICATORS:

[ ] Histosol	[ ] Concretions
[ ] Histic Epipedon	[ ] High Organic Content in Surface Layer in Sandy Soils
[ ] Sulfidic Odor	[ ] Organic Streaking in Sandy Soils
[ ] Aquic Moisture Regime	[ ] Listed on Local Hydric Soils List
[ ] Reducing Conditions	[ ] Listed on National Hydric Soils List
[x] Gleyed or Low-Chroma Colors	[ ] Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	YES	NO	Is this Sampling Point Within a Wetland? YES NO
Wetland Hydrology Present?	YES	NO	
Hydric Soil Present?	YES	NO	

Remarks:

Conditions were extremely dry upon site visit. Was very difficult to get augur past first 6" of soil because there was no moisture in the upper horizons of the majority of soils on-site.

APPENDIX F
RESTORATION SITE NCDWQ STREAM CLASSIFICATION FORM

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date: 11-30-2006	Project: UT to Bear Creek	Latitude: 35° 36' 34.87" N	
Evaluator: RVS	Site: Northern UT	Longitude: 79° 23' 18.34" W	
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 45.5	County: Chatham	Other *e.g. Quad Name:* Bear Creek	

A. Geomorphology (Subtotal = 27)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	(3)
2. Sinuosity	0	1	(2)	3
3. In-channel structure: riffle-pool sequence	0	1	2	(3)
4. Soil texture or stream substrate sorting	0	1	2	(3)
5. Active/relic floodplain	0	1	2	(3)
6. Depositional bars or benches	0	1	2	(3)
7. Braided channel	0	(1)	2	3
8. Recent alluvial deposits	0	1	2	(3)
9[a] Natural levees	0	(1)	2	3
10. Headcuts	0	1	(2)	3
11. Grade controls	0	0.5	1	(1.5)
12. Natural valley or drainageway	0	0.5	1	(1.5)
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		(Yes = 3)	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 11.5)				
14. Groundwater flow/discharge	0	1	2	(3)
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	(3)
16. Leaflitter	(1.5)	1	0.5	0
17. Sediment on plants or debris	0	0.5	(1)	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	(1.5)
19. Hydric soils (redoximorphic features) present?	No = 0		(Yes = 1.5)	

C. Biology (Subtotal = 7)				
20[b]. Fibrous roots in channel	3	(2)	1	0
21[b]. Rooted plants in channel	3	(2)	1	0
22. Crayfish	0	0.5	(1)	1.5
23. Bivalves	(0)	1	2	3
24. Fish	0	0.5	(1)	1.5
25. Amphibians	0	0.5	(1)	1.5
26. Macrobenthos (note diversity and abundance)	(0)	0.5	1	1.5
27. Filamentous algae; periphyton	(0)	1	2	3
28. Iron oxidizing bacteria/fungus.	(0)	0.5	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; (Other = 0)			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch:

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date: 11-30-2006	Project: UT to Bear Creek	Latitude: 35° 36' 18.99"N	
Evaluator: RVS	Site: Southern UT	Longitude: 79° 23' 38.81"W	
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 42	County: Chatham	Other *e.g. Quad Name:* Bear Creek USGS Topo	

A. Geomorphology (Subtotal = 24)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	(3)
2. Sinuosity	0	1	(2)	3
3. In-channel structure: riffle-pool sequence	0	1	(2)	3
4. Soil texture or stream substrate sorting	0	1	2	(3)
5. Active/relic floodplain	0	1	(2)	3
6. Depositional bars or benches	0	1	(2)	3
7. Braided channel	0	1	(2)	3
8. Recent alluvial deposits	0	1	(2)	3
9[a] Natural levees	0	(1)	2	3
10. Headcuts	0	1	(2)	3
11. Grade controls	0	0.5	1	(1.5)
12. Natural valley or drainageway	0	0.5	1	(1.5)
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	(No = 0)		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 9.5)				
14. Groundwater flow/discharge	0	1	2	(3)
15. Water in channel and > 48 hrs since rain, **or** Water in channel -- dry or growing season	0	1	2	(3)
16. Leaflitter	1.5	1	0.5	(0)
17. Sediment on plants or debris	0	0.5	(1)	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	(1)	1.5
19. Hydric soils (redoximorphic features) present?	No = 0		(Yes = 1.5)	

C. Biology (Subtotal = 8.5)				
20[b]. Fibrous roots in channel	(3)	2	1	
21[b]. Rooted plants in channel	(3)	2	1	0
22. Crayfish	(0)	0.5	1	1.5
23. Bivalves	(0)	1	2	3
24. Fish	0	0.5	(1)	1.5
25. Amphibians	0	0.5	(1)	1.5
26. Macrobenthos (note diversity and abundance)	(0)	0.5	1	1.5
27. Filamentous algae; periphyton	(0)	1	2	3
28. Iron oxidizing bacteria/fungus.	0	(0.5)	1	1.5
29[b]. Wetland plants in streambed	FAC = 0.5; FACW = 0.75; OBL = 1.5 SAV = 2.0; (Other = 0)			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Sketch:

APPENDIX G
RESTORATION SITE CONCURRENCE LETTERS
1. US Fish and Wildlife Letter
2. NCSHPO Letter

North Carolina Wildlife Resources Commission

Richard B. Hamilton, Executive Director

11 June 2007

Mr. W. Grant Lewis
Axiom Environmental, Inc.
2126 Rowland Pond Drive
Willow Springs, NC 27592

Subject: Bear Creek Stream Restoration, Chatham County, North Carolina.

Dear Mr. Lewis:

Biologists with the North Carolina Wildlife Resources Commission have reviewed the subject document. Our comments are provided in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-667d) and North Carolina General Statutes (G.S. 113-131 et seq.).

The North Carolina Ecosystem Enhancement Program has identified Bear Creek and an unnamed tributary to Bear Creek in the Cape Fear River basin as stream restoration sites. Approximately 4,800 linear feet of Bear Creek and two unnamed tributaries will be restored. The site is located in a pasture heavily grazed by livestock. Primary restoration activities include: construct a stable, riffle-pool stream channel, reconnect the stream with its historic floodplain, remove livestock from the stream corridor, eliminate invasive plant species, minimize disturbance to mature vegetation, create a natural vegetated buffer along the streams, and establish a conservation easement.

There are records for the federal and state endangered Cape Fear shiner (*Notropis mekistocholas*), the federal species of concern and state endangered brook floater (*Alasmidonta varicosa*), the federal species of concern and state special concern Carolina darter (*Etheostoma collis*), the state threatened creeper (*Strophitus undulatus*), and the state special concern notched rainbow (*Villosa constricta*) in Bear Creek.

We offer the following recommendations to minimize impacts to aquatic and terrestrial wildlife species and in particular to Cape Fear shiner.

1. An in-water work moratorium take place during 1 March to 31 July to minimize impacts to spawning fish and to the survivability of young fish.

Mailing Address: Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721
Telephone: (919) 707-0220 • **Fax:** (919) 707-0028

2. Sediment and erosion control measures that meet the design standards for sensitive watersheds should be used. Further, any excavated materials should not be stockpiled where sediment will erode to surface waters.

3. Avoid impacts to any large mature trees along each stream and establish native, forested buffers in riparian areas to improve terrestrial wildlife habitat and provide a travel corridor for wildlife species.

Thank you for the opportunity to review this project. If you require further assistance, please contact our office at (336) 449-7625.

Sincerely,

Shari L. Bryant
Piedmont Region Coordinator
Habitat Conservation Program

ec: Ryan Heise, WRC
David Rabon, USFWS

CONCURENCE LETTER FROM NCSHPO HAS NOT BEEN RECEIVED AT THIS POINT.

APPENDIX H
SEDIMENT TRANSPORT ANALYSIS

EXISTING ENTRAINMENT CALCULATION FORM					
Stream:	UT to Bear Creek	Reach:	Northern UT		
Team:	RKW, RVS	Date:	5/23/2007		
Information Input Area					
17.0	D_{50}	Riffle bed material D50 (mm)			
7.8	D^*_{50}	Bar sample D50 (mm)			
30.00	D_l	Largest particle from bar sample (mm)	0.10	(feet)	304.8 mm/foot
0.0062	S_e	Existing bankfull water surface slope (ft/ft)			
1.37	d_e	Existing bankfull mean depth (ft)			
1.37	R	Hydraulic Radius of Riffle Cross Section (ft)			
1.65	γ_s	Submerged specific weight of sediment			
Calculation of Critical Dimensionless Shear Stress					
2.18	D_{50}/D^*_{50}	If value is between 3-7 **Equation 1** will be used: $\tau^*_{ci} = 0.0834(D_{50}/D^*_{50})^{-0.872}$			
1.76	D_l/D_{50}	If value is between 1.3-3.0 **Equation 2** will be used: $\tau^*_{ci} = 0.0384(D_l/D_{50})^{-0.887}$			
0.0232	τ^*_{ci}	Critical Dimensionless Shear Stress	**Equation used:**		2
Calculation of Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample					
0.61	d_r	Required bankfull mean depth (ft/ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_l}{S_e}$			
1.37	d_e	Existing bankfull mean depth (ft)			
2.25	d_e/d_r	**Existing Stream Condition:**			**Degrading**
Calculation of BKF Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample					
0.0027	S_r	Required bankfull water surface slope (ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_l}{d_e}$			
0.0062	S_e	Existing bankfull water surface slope (ft)			
2.25	S_e/S_r	**Existing Stream Condition:**			**Degrading**
Sediment Transport Validation					
0.53	Bankfull Shear Stress $\tau_c = \gamma RS$ (lb/ft2) γ = Specific Weight of water = 62.4 lbs/ft^3				
37 - 145 mm	Moveable particle size (mm) at bankfull shear stress (predicted by the Revised Shields Diagram by Rosgen, 2002, and Shields Diagram)				
0.13 - 0.4 lbs/sf	Predicted shear stress required to initiate movement of D_l (mm) (see Revised Shields Diagram, Rosgen, 2002, and Shields Diagram)				
	Note: If available bankfull shear stress exceeds D100 of bed, degradation potential exists.				

PROPOSED CONDITIONS ENTRAINMENT CALCULATION FORM					
Stream:	UT to Bear Creek		Reach:	Northern UT	
Designer:	RKW, RVS		Date:	5/23/2007	
Information Input Area					
17.00	D_{50}	Riffle bed material D50 (mm)			
7.80	D^*_{50}	Bar sample D50 (mm)			
30.00	D_l	Largest particle from bar sample (mm)	0.10	(feet)	304.8 mm/foot
0.0031	S_e	Proposed bankfull water surface slope (ft/ft)			
1.33	d_e	Proposed bankfull mean depth (ft)			
1.15	R	Proposed Hydraulic Radius of Riffle Cross Section (ft)			
1.65	γ_s	Submerged specific weight of sediment			
Calculation of Critical Dimensionless Shear Stress					
2.18	D_{50}/D^*_{50}	If value is between 3-7 **Equation 1** will be used: $\tau^*_{ci} = 0.0834(D_{50}/D^*_{50})^{-0.872}$			
1.76	D/D_{50}	If value is between 1.3-3.0 **Equation 2** will be used: $\tau^*_{ci} = 0.0384(D/D_{50})^{-0.887}$			
0.0232	τ^*_{ci}	Critical Dimensionless Shear Stress	**Equation used:**		2
Calculation of Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample					
1.22	d_r	Required bankfull mean depth (ft/ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_l}{S_e}$			
1.33	d_e	Proposed bankfull mean depth (ft)			
1.09	d_e/d_r	**Existing Stream Condition:**	**Stable**		
Calculation of BKF Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample					
0.0028	S_r	Required bankfull water surface slope (ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_l}{d_e}$			
0.0031	S_e	Existing bankfull water surface slope (ft)			
1.09	S_e/S_r	**Existing Stream Condition:**	**Stable**		
Sediment Transport Validation					
0.221	Bankfull Shear Stress $\tau_c = \gamma RS$ (lb/ft2) γ = Specific Weight of water = 62.4 lbs/ft^3				
17 - 50 mm	Moveable particle size (mm) at bankfull shear stress (predicted by the Revised Shields Diagram by Rosgen, 2002)				
0.13 - 0.4 lbs/sf	Predicted shear stress required to initiate movement of D (mm) (see Revised Shields Diagram, Rosgen, 2002)				
	Note: If available bankfull shear stress exceeds D100 of bed, degradation potential exists				

EXISTING ENTRAINMENT CALCULATION FORM					
Stream:	UT to Bear Creek	Reach:	Southern UT		
Team:	RKW, RVS	Date:	5/23/2007		
Information Input Area					
12.0	D_{50}	Riffle bed material D50 (mm)			
5.5	D^*_{50}	Bar sample D50 (mm)			
30.00	D_l	Largest particle from bar sample (mm)	0.10	(feet)	304.8 mm/foot
0.0145	S_e	Existing bankfull water surface slope (ft/ft)			
1.05	d_e	Existing bankfull mean depth (ft)			
0.85	R	Hydraulic Radius of Riffle Cross Section (ft)			
1.65	γ_s	Submerged specific weight of sediment			
Calculation of Critical Dimensionless Shear Stress					
2.18	D_{50}/D^*_{50}	If value is between 3-7 **Equation 1** will be used: $\tau^*_{ci} = 0.0834(D_{50}/D^*_{50})^{-0.872}$			
2.50	D_l/D_{50}	If value is between 1.3-3.0 **Equation 2** will be used: $\tau^*_{ci} = 0.0384(D_l/D_{50})^{-0.887}$			
0.0170	τ^*_{ci}	Critical Dimensionless Shear Stress	**Equation used:**		2
Calculation of Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample					
0.19	d_r	Required bankfull mean depth (ft/ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_l}{S_e}$			
1.05	d_e	Existing bankfull mean depth (ft)			
5.48	d_e/d_r	**Existing Stream Condition:**			**Degrading**
Calculation of BKF Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample					
0.0026	S_r	Required bankfull water surface slope (ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_l}{d_e}$			
0.0145	S_e	Existing bankfull water surface slope (ft)			
5.48	S_e/S_r	**Existing Stream Condition:**			**Degrading**
Sediment Transport Validation					
0.76	Bankfull Shear Stress $\tau_c = \gamma RS$ (lb/ft2) γ = Specific Weight of water = 62.4 lbs/ft^3				
60 - 185 mm	Moveable particle size (mm) at bankfull shear stress (predicted by the Revised Shields Diagram by Rosgen, 2002)				
0.13 - 0.4 lbs/sf	Predicted shear stress required to initiate movement of D_l (mm) (see Revised Shields Diagram, Rosgen, 2002)				
	Note: If available bankfull shear stress exceeds D100 of bed, degradation potential exists.				

PROPOSED CONDITIONS ENTRAINMENT CALCULATION FORM					
Stream:	UT to Bear Creek		Reach:	Southern UT	
Designer:	RKW, RVS		Date:	5/23/2007	
Information Input Area					
12.00	D_{50}	Riffle bed material D50 (mm)			
5.50	D^*_{50}	Bar sample D50 (mm)			
30.00	D_l	Largest particle from bar sample (mm)	0.10	(feet)	304.8 mm/foot
0.0041	S_e	Proposed bankfull water surface slope (ft/ft)			
0.71	d_e	Proposed bankfull mean depth (ft)			
0.64	R	Proposed Hydraulic Radius of Riffle Cross Section (ft)			
1.65	γ_s	Submerged specific weight of sediment			
Calculation of Critical Dimensionless Shear Stress					
2.18	D_{50}/D^*_{50}	If value is between 3-7 **Equation 1** will be used: $\tau^*_{ci} = 0.0834(D_{50}/D^*_{50})^{-0.872}$			
2.50	D_l/D_{50}	If value is between 1.3-3.0 **Equation 2** will be used: $\tau^*_{ci} = 0.0384(D_l/D_{50})^{-0.887}$			
0.0170	τ^*_{ci}	Critical Dimensionless Shear Stress	**Equation used:**		2
Calculation of Bankfull Mean Depth Required for Entrainment of Largest Particle in Bar Sample					
0.68	d_r	Required bankfull mean depth (ft/ft) $d_r = \frac{\tau^*_{ci}\gamma_s D_l}{S_e}$			
0.71	d_e	Proposed bankfull mean depth (ft)			
1.04	d_e/d_r	**Existing Stream Condition:**			**Stable**
Calculation of BKF Water Surface Slope Required for Entrainment of Largest Particle in Bar Sample					
0.0039	S_r	Required bankfull water surface slope (ft) $S_r = \frac{\tau^*_{ci}\gamma_s D_l}{d_e}$			
0.0041	S_e	Existing bankfull water surface slope (ft)			
1.04	S_e/S_r	**Existing Stream Condition:**			**Stable**
Sediment Transport Validation					
0.161	Bankfull Shear Stress $\tau_c = \gamma RS$ (lb/ft2) γ = Specific Weight of water = 62.4 lbs/ft^3				
13 - 36 mm	Moveable particle size (mm) at bankfull shear stress (predicted by the Revised Shields Diagram by Rosgen, 2002)				
0.13 - 0.4 lbs/sf	Predicted shear stress required to initiate movement of D (mm) (see Revised Shields Diagram, Rosgen, 2002)				
Note: If available bankfull shear stress exceeds D100 of bed, degradation potential exists.					

APPENDIX I
REFERENCE SITE PHOTOGRAPHS

Landrum Creek looking downstream from start of profile.

Landrum Creek looking upstream.

APPENDIX J
REFERENCE SITE NCDWQ STREAM CLASSIFICATION FORM

NCDWQ Stream Classification Form

Project Name: Landrum Creek Reference Reach River Basin: Cape Fear County: Chatham Evaluator: PBC

DWQ Project Number: N/A Nearest Named Stream: Landrum Creek Latitude: 35°43' Signature:
Date: 9/30/02 USGS QUAD: Siler City NE Longitude: 79°21'
Location/Direction: Pleasant Hill Church Rd.

PLEASE NOTE:** ***If evaluator and landowner agree that the feature is a man-made ditch, then use of this form is not necessary. Also, if in the best professional judgement of the evaluator, the feature is a man-made ditch and not a modified natural stream—this rating system should not be used*

Primary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Riffle-Pool Sequence?	0	1	2	3
2) Is The USDA Texture In Streambed Different From Surrounding Terrain?	0	1	2	3
3) Are Natural Levees Present?	0	1	2	3
4) Is The Channel Sinuous?	0	1	2	3
5) Is There An Active (Or Relic) Floodplain Present?	0	1	2	3
6) Is The Channel Braided?	0	1	2	3
7) Are Recent Alluvial Deposits Present?	0	1	2	3
8) Is There A Bankfull Bench Present?	0	1	2	3
9) Is A Continuous Bed & Bank Present?	0	1	2	3
("NOTE: If Bed & Bank Caused By Ditching And WITHOUT Sinuosity Then Score=0")				
10) Is A 2nd Order Or Greater Channel (As Indicated On Topo Map *And/Or* In Field) Present?	*Yes*=3		*No*=0	

PRIMARY GEOMORPHOLOGY INDICATOR POINTS: 22

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is There A Groundwater Flow/Discharge Present?	0	1	2	3

PRIMARY HYDROLOGY INDICATOR POINTS: 1

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fibrous Roots Present In Streambed?	3	2	1	0
2) Are Rooted Plants Present In Streambed?	3	2	1	0
3) Is Periphyton Present?	0	1	2	3
4) Are Bivalves Present?	0	1	2	3

PRIMARY BIOLOGY INDICATOR POINTS: 7

Secondary Field Indicators: *(Circle One Number Per Line)*

I. Geomorphology	Absent	Weak	Moderate	Strong
1) Is There A Head Cut Present In Channel?	0	.5	1	1.5
2) Is There A Grade Control Point In Channel?	0	.5	1	1.5
3) Does Topography Indicate A Natural Drainage Way?	0	.5	1	1.5

SECONDARY GEOMORPHOLOGY INDICATOR POINTS: 2

II. Hydrology	Absent	Weak	Moderate	Strong
1) Is This Year's (Or Last's) Leaf litter Present In Streambed?	1.5	1	.5	0
2) Is Sediment On Plants (Or Debris) Present?	0	.5	1	1.5
3) Are Wrack Lines Present?	0	.5	1	1.5
4) Is Water In Channel *And* >48 Hrs. Since Last *Known* Rain? *(*NOTE: If Ditch Indicated In #9 Above Skip This Step And #5 Below*)*	0	.5	1	1.5
5) Is There Water In Channel During Dry Conditions *Or* In Growing Season)?	0	.5	1	1.5
6) Are Hydric Soils Present In Sides Of Channel (Or In Headcut)?		*Yes*=1.5		*No*=0

SECONDARY HYDROLOGY INDICATOR POINTS: 7

III. Biology	Absent	Weak	Moderate	Strong
1) Are Fish Present?	0	.5	1	1.5
2) Are Amphibians Present?	0	.5	1	1.5
3) Are AquaticTurtles Present?	0	.5	1	1.5
4) Are Crayfish Present?	0	.5	1	1.5
5) Are Macrobenthos Present?	0	.5	1	1.5
6) Are Iron Oxidizing Bacteria/Fungus Present?	0	.5	1	1.5
7) Is Filamentous Algae Present?	0	.5	1	1.5

8) Are Wetland Plants In Streambed? N/A	SAV	Mostly OBL	Mostly FACW	Mostly FAC	Mostly FACU	Mostly UPL
(NOTE: If Total Absence Of All Plants In Streambed As Noted Above Skip This Step UNLESS SAV Present*).*	2	1	.75	.5	0	0

SECONDARY BIOLOGY INDICATOR POINTS: 3

TOTAL POINTS (Primary + Secondary)= 42 *(If Greater Than Or Equal To 19 Points The Stream Is At Least Intermittent)*

APPENDIX K
HEC-RAS ANALYSIS

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
Upstream End of Project					
3908	Bankfull	100	418.89	418.38	-0.51
3908	100 Year	1300	426.12	425.92	-0.20
3808	Bankfull	100	418.54	418.23	-0.31
3808	100 Year	1300	424.99	425.00	0.01
3784		Culvert			0.00
3775.29	Bankfull	100	418.46	418.07	-0.39
3775.29	100 Year	1300	421.70	421.87	0.17
3760.25	Bankfull	100		418.11	
3760.25	100 Year	1300		422.13	
3745.21	Bankfull	100		418.01	
3745.21	100 Year	1300		421.94	
3730.18	Bankfull	100		417.99	
3730.18	100 Year	1300		422.17	
3715.14	Bankfull	100		418.03	
3715.14	100 Year	1300		422.29	
3700.1	Bankfull	100		417.91	
3700.1	100 Year	1300		422.31	
3690.07	Bankfull	100		417.85	
3690.07	100 Year	1300		422.32	
3674.15	Bankfull	100	418.34	417.90	-0.44
3674.15	100 Year	1300	422.26	422.32	0.06
3658.66	Bankfull	100		417.82	
3658.66	100 Year	1300		422.04	
3643.27	Bankfull	100		417.78	
3643.27	100 Year	1300		421.82	
3628.34	Bankfull	100	418.24	417.82	-0.42
3628.34	100 Year	1300	422.09	421.89	-0.20
3613.47	Bankfull	100		417.72	
3613.47	100 Year	1300		421.80	
3598.55	Bankfull	100		417.64	
3598.55	100 Year	1300		421.85	

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
3580.85	Bankfull	100		417.68	
3580.85	100 Year	1300		421.92	
3566.36	Bankfull	100	418.08	417.59	-0.49
3566.36	100 Year	1300	421.91	421.89	-0.02
3535.63	Bankfull	100		417.54	
3535.63	100 Year	1300		421.92	
3520.7	Bankfull	100		417.52	
3520.7	100 Year	1300		421.86	
3506.68	Bankfull	100		417.43	
3506.68	100 Year	1300		421.87	
3493.45	Bankfull	100		417.41	
3493.45	100 Year	1300		421.87	
3480.25	Bankfull	100		417.44	
3480.25	100 Year	1300		421.88	
3467.32	Bankfull	100		417.33	
3467.32	100 Year	1300		421.91	
3447.64	Bankfull	100	417.77	417.30	-0.47
3447.64	100 Year	1300	421.70	421.93	0.23
3417.59	Bankfull	100		417.28	
3417.59	100 Year	1300		421.93	
3386.22	Bankfull	100		417.17	
3386.22	100 Year	1300		421.85	
3372.06	Bankfull	100		417.14	
3372.06	100 Year	1300		421.76	
3357.89	Bankfull	100		417.17	
3357.89	100 Year	1300		421.64	
3343.5	Bankfull	100		417.06	
3343.5	100 Year	1300		421.51	
3329.81	Bankfull	100		417.02	
3329.81	100 Year	1300		421.35	
3316.58	Bankfull	100	417.02	416.99	-0.03
3316.58	100 Year	1300	421.20	421.00	-0.20

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
3305.51	Bankfull	100		416.87	
3305.51	100 Year	1300		420.53	
3272.38	Bankfull	100		416.76	
3272.38	100 Year	1300		420.60	
3252.62	Bankfull	100	416.72	416.75	0.03
3252.62	100 Year	1300	420.83	420.60	-0.23
3231.66	Bankfull	100		416.65	
3231.66	100 Year	1300		420.53	
3190.27	Bankfull	100	416.62	416.52	-0.10
3190.27	100 Year	1300	420.51	420.21	-0.30
3180.47	Bankfull	100		416.53	
3180.47	100 Year	1300		420.25	
3171.14	Bankfull	100		416.40	
3171.14	100 Year	1300		419.97	
3131.86	Bankfull	100		416.31	
3131.86	100 Year	1300		419.67	
3110.59	Bankfull	100		416.28	
3110.59	100 Year	1300		419.93	
3085.33	Bankfull	100		416.18	
3085.33	100 Year	1300		420.06	
3024.44	Bankfull	100	416.40	416.08	-0.32
3024.44	100 Year	1300	420.44	419.99	-0.45
3010.79	Bankfull	100		416.09	
3010.79	100 Year	1300		419.97	
2998.25	Bankfull	100		415.99	
2998.25	100 Year	1300		419.94	
2978.22	Bankfull	100		415.97	
2978.22	100 Year	1300		419.72	
2958.19	Bankfull	100	416.19	416.00	-0.19
2958.19	100 Year	1300	420.19	419.64	-0.55
2938.16	Bankfull	100		415.90	
2938.16	100 Year	1300		419.30	

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
2918.13	Bankfull	100		415.92	
2918.13	100 Year	1300		419.06	
2898.1	Bankfull	100	416.01	415.82	-0.19
2898.1	100 Year	1300	419.71	419.02	-0.69
2863.98	Bankfull	100	415.97	415.74	-0.23
2863.98	100 Year	1300	419.60	418.97	-0.63
2845.01	Bankfull	100		415.73	
2845.01	100 Year	1300		419.17	
2810.18	Bankfull	100		415.63	
2810.18	100 Year	1300		419.16	
2798.59	Bankfull	100		415.59	
2798.59	100 Year	1300		419.12	
2776.98	Bankfull	100	415.83	415.55	-0.28
2776.98	100 Year	1300	419.26	418.99	-0.27
2753.71	Bankfull	100		415.40	
2753.71	100 Year	1300		418.70	
2728.99	Bankfull	100		415.34	
2728.99	100 Year	1300		418.72	
2711.96	Bankfull	100		415.34	
2711.96	100 Year	1300		418.71	
2694.1	Bankfull	100	415.56	415.25	-0.31
2694.1	100 Year	1300	418.93	418.72	-0.21
2664.76	Bankfull	100		415.18	
2664.76	100 Year	1300		418.69	
2646.47	Bankfull	100		415.17	
2646.47	100 Year	1300		418.61	
2629.72	Bankfull	100		415.07	
2629.72	100 Year	1300		418.57	
2597.38	Bankfull	100		414.98	
2597.38	100 Year	1300		418.26	
2581.94	Bankfull	100	413.87	414.95	1.08
2581.94	100 Year	1300	417.40	418.14	0.74

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
2566.09	Bankfull	100		414.82	
2566.09	100 Year	1300		417.88	
2523.4	Bankfull	100	413.87	414.70	0.83
2523.4	100 Year	1300	417.51	417.81	0.30
2504.13	Bankfull	100	413.85	414.70	0.85
2504.13	100 Year	1300	417.45	417.72	0.27
2484.27	Bankfull	100		414.60	
2484.27	100 Year	1300		417.63	
2447.48	Bankfull	100		414.44	
2447.48	100 Year	1300		417.53	
2443	Bankfull	100		414.45	
2443	100 Year	1300		417.54	
2438.34	Bankfull	100	413.67	414.36	0.69
2438.34	100 Year	1300	417.19	417.53	0.34
2395.15	Bankfull	100		414.29	
2395.15	100 Year	1300		417.48	
2386.61	Bankfull	100		414.26	
2386.61	100 Year	1300		417.45	
2378.3	Bankfull	100		414.13	
2378.3	100 Year	1300		417.38	
2334.3	Bankfull	100	412.89	413.93	1.04
2334.3	100 Year	1300	416.51	417.04	0.53
2326.68	Bankfull	100		413.96	
2326.68	100 Year	1300		416.98	
2319.12	Bankfull	100		413.81	
2319.12	100 Year	1300		416.82	
2265.43	Bankfull	100		413.59	
2265.43	100 Year	1300		416.17	
2258.02	Bankfull	100		413.63	
2258.02	100 Year	1300		416.25	
2250.65	Bankfull	100	412.52	413.45	0.93
2250.65	100 Year	1300	415.80	416.05	0.25

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
2172.93	Bankfull	100	412.38	413.19	0.81
2172.93	100 Year	1300	415.57	415.36	-0.21
2163.32	Bankfull	100		413.21	
2163.32	100 Year	1300		415.36	
2153.67	Bankfull	100		413.13	
2153.67	100 Year	1300		415.35	
2123.48	Bankfull	100		412.93	
2123.48	100 Year	1300		415.27	
2120.58	Bankfull	100		412.94	
2120.58	100 Year	1300		415.27	
2117.36	Bankfull	100		412.84	
2117.36	100 Year	1300		415.26	
2070.67	Bankfull	100	412.10	412.76	0.66
2070.67	100 Year	1300	415.20	415.19	-0.01
2057.74	Bankfull	100		412.73	
2057.74	100 Year	1300		415.08	
2044.14	Bankfull	100		412.62	
2044.14	100 Year	1300		414.90	
2000.47	Bankfull	100	411.90	412.49	0.59
2000.47	100 Year	1300	414.89	414.71	-0.18
1993.46	Bankfull	100		412.50	
1993.46	100 Year	1300		414.63	
1986.21	Bankfull	100		412.38	
1986.21	100 Year	1300		414.56	
1937.38	Bankfull	100		412.27	
1937.38	100 Year	1300		414.54	
1919.41	Bankfull	100		412.27	
1919.41	100 Year	1300		414.51	
1904.23	Bankfull	100		412.18	
1904.23	100 Year	1300		414.51	
1881.96	Bankfull	100		412.09	
1881.96	100 Year	1300		414.47	

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
1866.6	Bankfull	100		412.08	
1866.6	100 Year	1300		414.42	
1835.03	Bankfull	100	411.04	412.04	1.00
1835.03	100 Year	1300	414.32	414.37	0.05
1811.31	Bankfull	100		411.88	
1811.31	100 Year	1300		414.32	
1779.59	Bankfull	100	410.83	411.82	0.99
1779.59	100 Year	1300	414.21	414.28	0.07
1761.25	Bankfull	100		411.80	
1761.25	100 Year	1300		414.26	
1748.7	Bankfull	100		411.78	
1748.7	100 Year	1300		414.26	
1721.89	Bankfull	100		411.57	
1721.89	100 Year	1300		414.24	
1719.07	Bankfull	100		411.59	
1719.07	100 Year	1300		414.22	
1716.28	Bankfull	100	410.59	411.48	0.89
1716.28	100 Year	1300	414.11	414.22	0.11
1691.35	Bankfull	100		411.41	
1691.35	100 Year	1300		414.17	
1680.95	Bankfull	100		411.39	
1680.95	100 Year	1300		414.15	
1671.46	Bankfull	100		411.28	
1671.46	100 Year	1300		414.14	
1635.27	Bankfull	100	410.43	411.20	0.77
1635.27	100 Year	1300	413.96	414.08	0.12
1621.55	Bankfull	100		411.17	
1621.55	100 Year	1300		414.01	
1608.38	Bankfull	100		411.01	
1608.38	100 Year	1300		414.00	
1561.73	Bankfull	100		410.84	
1561.73	100 Year	1300		413.91	

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
1528.72	Bankfull	100	410.24	410.78	0.54
1528.72	100 Year	1300	413.72	413.87	0.15
1492.58	Bankfull	100		410.57	
1492.58	100 Year	1300		413.83	
1442.26	Bankfull	100		410.59	
1442.26	100 Year	1300		413.75	
1436.66	Bankfull	100		410.58	
1436.66	100 Year	1300		413.73	
1431.56	Bankfull	100		410.26	
1431.56	100 Year	1300		413.72	
1391.9	Bankfull	100	409.55	409.62	0.07
1391.9	100 Year	1300	413.34	413.67	0.33
1380.12	Bankfull	100		409.71	
1380.12	100 Year	1300		413.66	
1367.97	Bankfull	100		409.52	
1367.97	100 Year	1300		413.65	
1333.06	Bankfull	100		408.90	
1333.06	100 Year	1300		413.60	
1311.49	Bankfull	100		408.91	
1311.49	100 Year	1300		413.54	
1287.83	Bankfull	100		408.70	
1287.83	100 Year	1300		413.51	
1258.39	Bankfull	100	408.35	408.27	-0.08
1258.39	100 Year	1300	413.01	413.48	0.47
1230.44	Bankfull	100		408.38	
1230.44	100 Year	1300		413.48	
1200.7	Bankfull	100	408.04	408.19	0.15
1200.7	100 Year	1300	412.24	412.46	0.22
1165.94	Bankfull	100		407.75	
1165.94	100 Year	1300		411.68	
1157.98	Bankfull	100		407.89	
1157.98	100 Year	1300		412.28	

UT BEAR CREEK
NORTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
1149.4	Bankfull	100	407.67	407.79	0.12
1149.4	100 Year	1300	411.81	412.20	0.39
1099.17	Bankfull	100	406.91	407.03	0.12
1099.17	100 Year	1300	411.37	412.41	1.04
1095.59	Bankfull	100		406.58	
1095.59	100 Year	1300		412.39	
1091.76	Bankfull	100		406.44	
1091.76	100 Year	1300		412.39	
1079.12	Bankfull	100	406.77	406.42	-0.35
1079.12	100 Year	1300	411.26	410.59	-0.67
Downstream End of Project					

UT BEAR CREEK
SOUTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
Upstream End of Project					
2701	Bankfull	22	428.34	428.34	0.00
2701	100 Year	250	433.42	433.39	-0.03
2601	Bankfull	22	428.33	428.33	0.00
2601	100 Year	250	433.41	433.39	-0.02
2576		Culvert			0.00
2552.08	Bankfull	22	424.75	426.73	1.98
2552.08	100 Year	250	426.96	428.63	1.67
2541.69	Bankfull	22		426.66	
2541.69	100 Year	250		427.97	
2531.3	Bankfull	22	424.78	426.46	1.68
2531.3	100 Year	250	427.03	428.25	1.22
2505.97	Bankfull	22		426.39	
2505.97	100 Year	250		428.18	
2502.22	Bankfull	22	424.73	426.38	1.65
2502.22	100 Year	250	426.91	428.17	1.26
2497.89	Bankfull	22		426.33	
2497.89	100 Year	250		428.16	
2465.54	Bankfull	22		426.24	
2465.54	100 Year	250		428.09	
2460.95	Bankfull	22		426.22	
2460.95	100 Year	250		428.00	
2456.15	Bankfull	22		426.16	
2456.15	100 Year	250		427.99	
2428.42	Bankfull	22	424.39	426.04	1.65
2428.42	100 Year	250	426.55	427.82	1.27
2418.36	Bankfull	22		426.03	
2418.36	100 Year	250		427.76	
2407.86	Bankfull	22		425.95	
2407.86	100 Year	250		427.62	
2391.4	Bankfull	22		425.87	
2391.4	100 Year	250		427.50	

UT BEAR CREEK
SOUTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
2384.84	Bankfull	22		425.86	
2384.84	100 Year	250		427.52	
2379.14	Bankfull	22		425.82	
2379.14	100 Year	250		427.48	
2362.93	Bankfull	22		425.72	
2362.93	100 Year	250		427.43	
2354.87	Bankfull	22		425.70	
2354.87	100 Year	250		427.29	
2344.85	Bankfull	22	423.89	425.58	1.69
2344.85	100 Year	250	425.86	427.25	1.39
2320.34	Bankfull	22		425.48	
2320.34	100 Year	250		427.10	
2306.98	Bankfull	22		425.45	
2306.98	100 Year	250		427.02	
2293.94	Bankfull	22		425.38	
2293.94	100 Year	250		426.98	
2270.67	Bankfull	22	423.15	425.30	2.15
2270.67	100 Year	250	425.42	426.89	1.47
2264.54	Bankfull	22		425.27	
2264.54	100 Year	250		426.81	
2258.75	Bankfull	22		425.18	
2258.75	100 Year	250		426.74	
2238.81	Bankfull	22		425.09	
2238.81	100 Year	250		426.57	
2234.57	Bankfull	22		425.08	
2234.57	100 Year	250		426.53	
2231.43	Bankfull	22		425.01	
2231.43	100 Year	250		426.50	
2204.52	Bankfull	22		424.71	
2204.52	100 Year	250		426.32	
2194.94	Bankfull	22		424.73	
2194.94	100 Year	250		426.17	

UT BEAR CREEK
SOUTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
2186.46	Bankfull	22		424.61	
2186.46	100 Year	250		426.10	
2157.99	Bankfull	22	421.90	424.14	2.24
2157.99	100 Year	250	424.38	425.86	1.48
2147.25	Bankfull	22		424.22	
2147.25	100 Year	250		425.64	
2135.88	Bankfull	22		424.14	
2135.88	100 Year	250		425.46	
2111.61	Bankfull	22		423.65	
2111.61	100 Year	250		425.18	
2100.79	Bankfull	22		423.53	
2100.79	100 Year	250		424.85	
2092.02	Bankfull	22		423.36	
2092.02	100 Year	250		424.65	
2067.78	Bankfull	22		423.09	
2067.78	100 Year	250		424.48	
2059.08	Bankfull	22		422.90	
2059.08	100 Year	250		424.24	
2046.52	Bankfull	22		422.74	
2046.52	100 Year	250		424.03	
2026.71	Bankfull	22		422.34	
2026.71	100 Year	250		423.83	
2019.31	Bankfull	22		422.18	
2019.31	100 Year	250		423.82	
2011.69	Bankfull	22		422.12	
2011.69	100 Year	250		423.78	
1992.6	Bankfull	22		421.68	
1992.6	100 Year	250		423.30	
1987.43	Bankfull	22		421.78	
1987.43	100 Year	250		422.85	
1983.43	Bankfull	22		421.69	
1983.43	100 Year	250		422.69	

UT BEAR CREEK
SOUTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
1969.91	Bankfull	22		421.38	
1969.91	100 Year	250		422.90	
1960.23	Bankfull	22		421.48	
1960.23	100 Year	250		422.93	
1953.4	Bankfull	22	420.07	421.42	1.35
1953.4	100 Year	250	421.69	422.95	1.26
1898.25	Bankfull	22		420.64	
1898.25	100 Year	250		422.18	
1888.51	Bankfull	22		420.73	
1888.51	100 Year	250		422.18	
1880.15	Bankfull	22		420.65	
1880.15	100 Year	250		422.17	
1867.48	Bankfull	22		420.41	
1867.48	100 Year	250		422.17	
1856.93	Bankfull	22	418.37	420.44	2.07
1856.93	100 Year	250	421.01	422.15	1.14
1846.46	Bankfull	22		420.31	
1846.46	100 Year	250		422.14	
1826.43	Bankfull	22		419.87	
1826.43	100 Year	250		421.70	
1811	Bankfull	22		419.95	
1811	100 Year	250		421.63	
1795.59	Bankfull	22		419.86	
1795.59	100 Year	250		421.63	
1777.36	Bankfull	22		419.52	
1777.36	100 Year	250		421.28	
1765.25	Bankfull	22	417.30	419.52	2.22
1765.25	100 Year	250	420.39	420.97	0.58
1753.12	Bankfull	22		419.36	
1753.12	100 Year	250		420.71	
1738.2	Bankfull	22		419.12	
1738.2	100 Year	250		420.68	

UT BEAR CREEK
SOUTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
1727.85	Bankfull	22		419.12	
1727.85	100 Year	250		420.58	
1718.41	Bankfull	22		419.06	
1718.41	100 Year	250		420.51	
1689.41	Bankfull	22	416.36	418.63	2.27
1689.41	100 Year	250	419.50	420.20	0.70
1683.99	Bankfull	22		418.69	
1683.99	100 Year	250		420.00	
1674.69	Bankfull	22		418.60	
1674.69	100 Year	250		419.95	
1646.58	Bankfull	22		418.51	
1646.58	100 Year	250		419.91	
1634.1	Bankfull	22		418.46	
1634.1	100 Year	250		419.80	
1617.4	Bankfull	22		418.29	
1617.4	100 Year	250		419.66	
1596.68	Bankfull	22		418.19	
1596.68	100 Year	250		419.53	
1580.47	Bankfull	22	415.72	418.18	2.46
1580.47	100 Year	250	418.88	419.47	0.59
1564.57	Bankfull	22		418.09	
1564.57	100 Year	250		419.37	
1558.46	Bankfull	22		417.81	
1558.46	100 Year	250		419.18	
1551.8	Bankfull	22		417.88	
1551.8	100 Year	250		419.05	
1544.99	Bankfull	22		417.79	
1544.99	100 Year	250		419.03	
1518.67	Bankfull	22		417.28	
1518.67	100 Year	250		418.82	
1510.87	Bankfull	22		417.36	
1510.87	100 Year	250		418.78	

UT BEAR CREEK
SOUTHERN TRIBUTARY
HEC-RAS ANALYSIS

River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
1503.66	Bankfull	22	415.34	417.29	1.95
1503.66	100 Year	250	417.77	418.75	0.98
1481.04	Bankfull	22		417.20	
1481.04	100 Year	250		418.63	
1468.76	Bankfull	22		417.16	
1468.76	100 Year	250		418.50	
1453.68	Bankfull	22		417.07	
1453.68	100 Year	250		418.23	
1445.62	Bankfull	22		416.83	
1445.62	100 Year	250		418.15	
1440.97	Bankfull	22		416.81	
1440.97	100 Year	250		418.12	
1436.23	Bankfull	22		416.69	
1436.23	100 Year	250		418.09	
1422.19	Bankfull	22	414.90	416.48	1.58
1422.19	100 Year	250	417.28	417.64	0.36
1418.93	Bankfull	22		416.45	
1418.93	100 Year	250		417.70	
1415.97	Bankfull	22		416.39	
1415.97	100 Year	250		417.57	
1385.24	Bankfull	22		415.88	
1385.24	100 Year	250		417.22	
1382.32	Bankfull	22		415.73	
1382.32	100 Year	250		417.25	
1377.9	Bankfull	22		415.65	
1377.9	100 Year	250		417.27	
1364.76	Bankfull	22	414.64	415.27	0.63
1364.76	100 Year	250	416.96	417.05	0.09
1358.17	Bankfull	22		415.14	
1358.17	100 Year	250		417.09	
1353.19	Bankfull	22		415.06	
1353.19	100 Year	250		416.90	

UT BEAR CREEK
SOUTHERN TRIBUTARY
HEC-RAS ANALYSIS

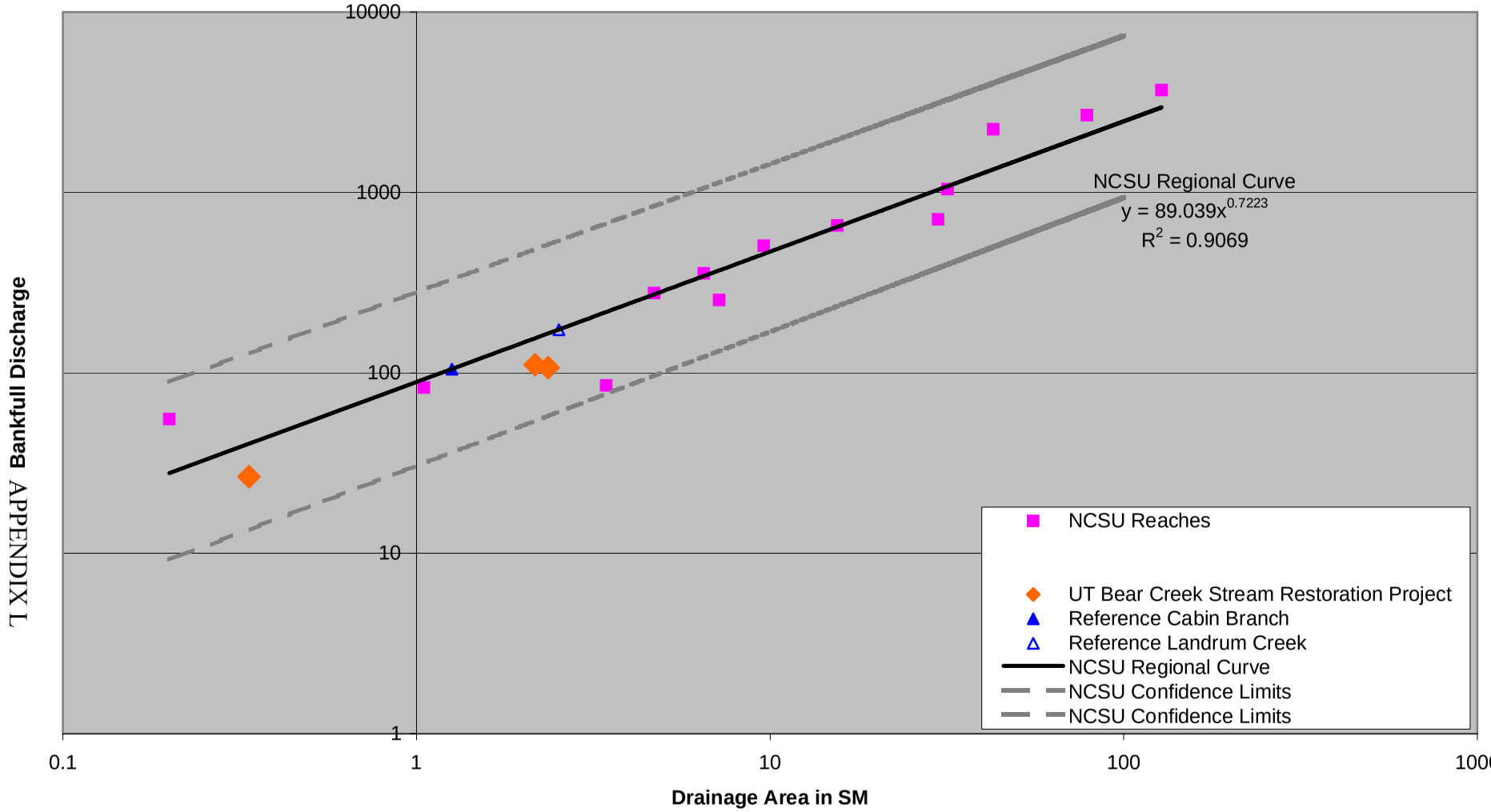
River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
1337.62	Bankfull	22		414.60	
1337.62	100 Year	250		416.24	
1320.35	Bankfull	22		414.47	
1320.35	100 Year	250		415.98	
1305.76	Bankfull	22	414.38	414.31	-0.07
1305.76	100 Year	250	416.67	415.64	-1.03
1293.97	Bankfull	22		414.05	
1293.97	100 Year	250		415.63	
1286.89	Bankfull	22		413.88	
1286.89	100 Year	250		415.78	
1281.35	Bankfull	22		413.73	
1281.35	100 Year	250		415.56	
1271.19	Bankfull	22		413.44	
1271.19	100 Year	250		415.53	
1263.54	Bankfull	22		413.54	
1263.54	100 Year	250		415.53	
1257.49	Bankfull	22	413.29	413.47	0.18
1257.49	100 Year	250	415.62	415.43	-0.19
1242.47	Bankfull	22		413.08	
1242.47	100 Year	250		415.09	
1234.45	Bankfull	22		413.18	
1234.45	100 Year	250		414.96	
1226.44	Bankfull	22	412.06	413.07	1.01
1226.44	100 Year	250	414.17	414.88	0.71
1204.54	Bankfull	22		412.62	
1204.54	100 Year	250		414.77	
1203.25	Bankfull	22		412.72	
1203.25	100 Year	250		414.77	
1201.95	Bankfull	22		412.66	
1201.95	100 Year	250		414.45	
1195.4	Bankfull	22	410.72	412.36	1.64
1195.4	100 Year	250	413.04	414.27	1.23

UT BEAR CREEK
SOUTHERN TRIBUTARY
HEC-RAS ANALYSIS

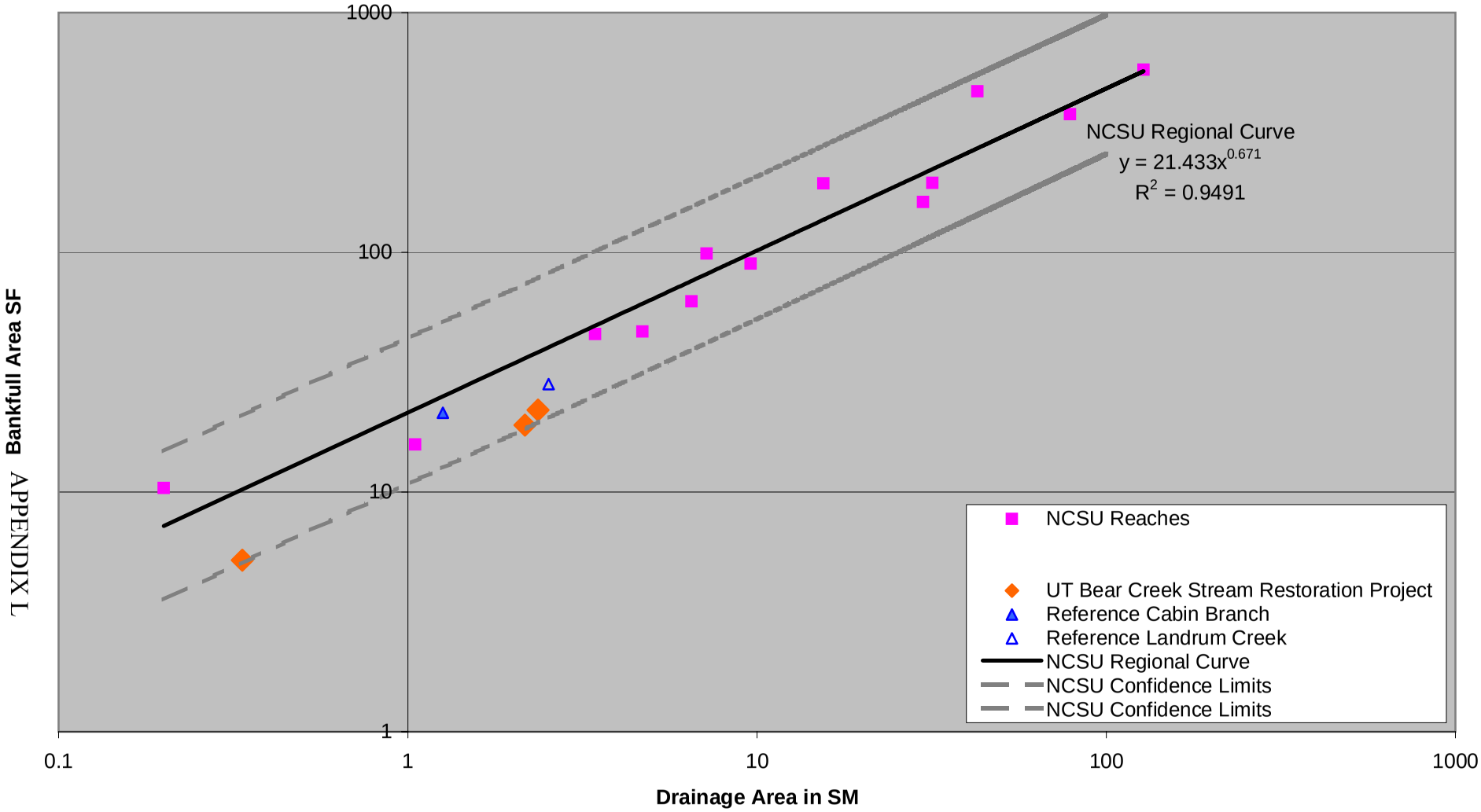
River Station	Storm Event	Discharge (cfs)	Existing WSEL (ft)	Proposed WSEL (ft)	Backwater (ft)
1188.77	Bankfull	22		412.44	
1188.77	100 Year	250		414.32	
1177.85	Bankfull	22		412.32	
1177.85	100 Year	250		414.32	
1165.71	Bankfull	22	409.88	412.04	2.16
1165.71	100 Year	250	413.11	414.23	1.12
1154.74	Bankfull	22	409.82	411.95	2.13
1154.74	100 Year	250	412.88	414.14	1.26
1147.11	Bankfull	22		411.78	
1147.11	100 Year	250		414.12	
1140.99	Bankfull	22		411.39	
1140.99	100 Year	250		413.54	
1135.6	Bankfull	22		411.24	
1135.6	100 Year	250		413.48	
1126.58	Bankfull	22		411.12	
1126.58	100 Year	250		413.41	
1120.45	Bankfull	22		410.86	
1120.45	100 Year	250		413.48	
1118.47	Bankfull	22		410.96	
1118.47	100 Year	250		413.45	
1116.63	Bankfull	22		410.83	
1116.63	100 Year	250		413.33	
1111.82	Bankfull	22		410.63	
1111.82	100 Year	250		413.12	
1104.04	Bankfull	22		410.69	
1104.04	100 Year	250		413.13	
1091.67	Bankfull	22	409.24	410.60	1.36
1091.67	100 Year	250	412.08	412.95	0.87
1057.57	Bankfull	22		410.02	
1057.57	100 Year	250		412.50	
1054.1	Bankfull	22		410.09	
1054.1	100 Year	250		412.60	
1051	Bankfull	22	408.96	410.04	1.08
1051	100 Year	250	411.80	412.44	0.64
Downstream End of Project					

APPENDIX L
REGIONAL CURVE PLOTS

Rural Regional
Bankfull Discharge Curve

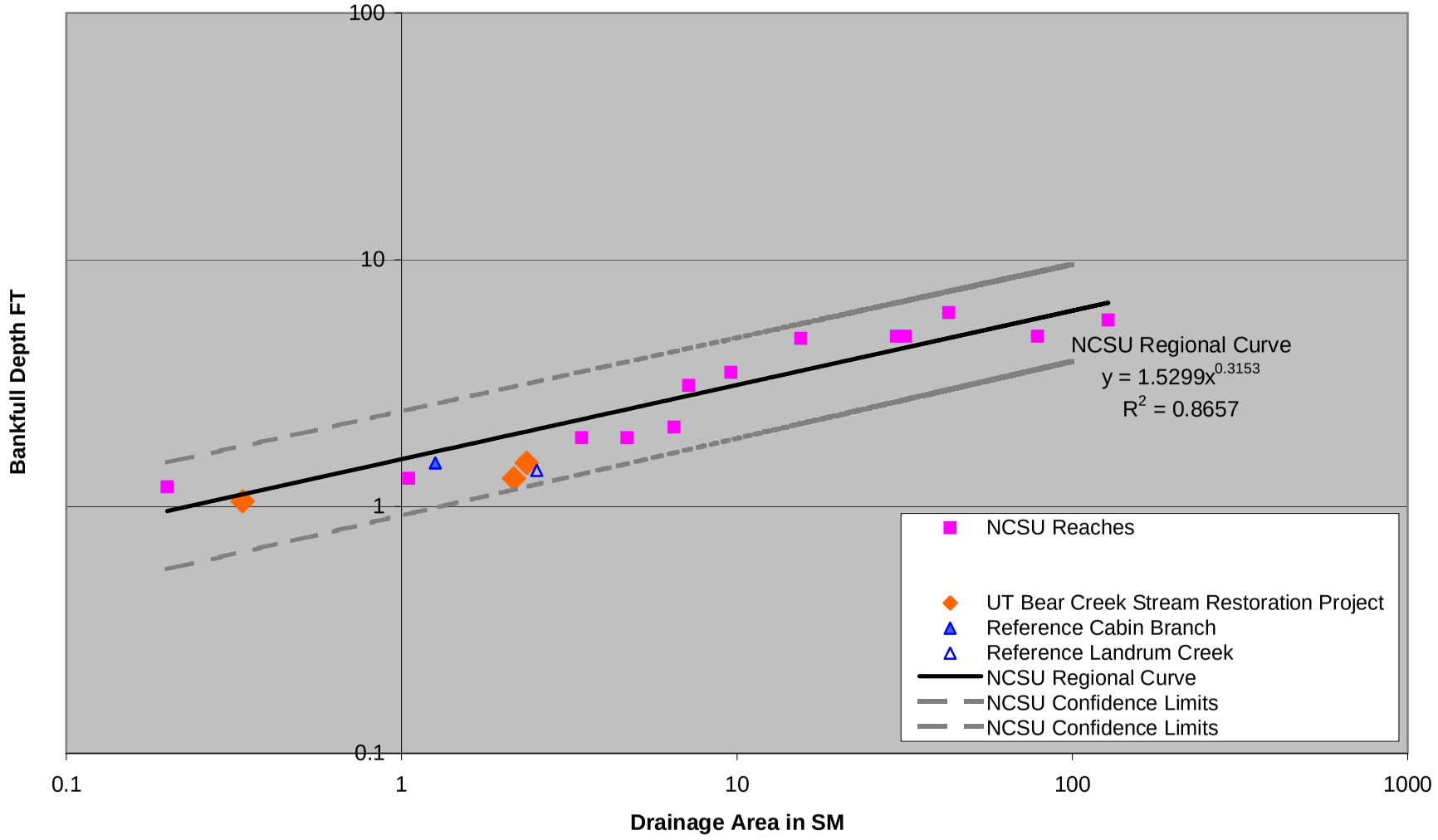


Rural Regional Bankfull Area Curve

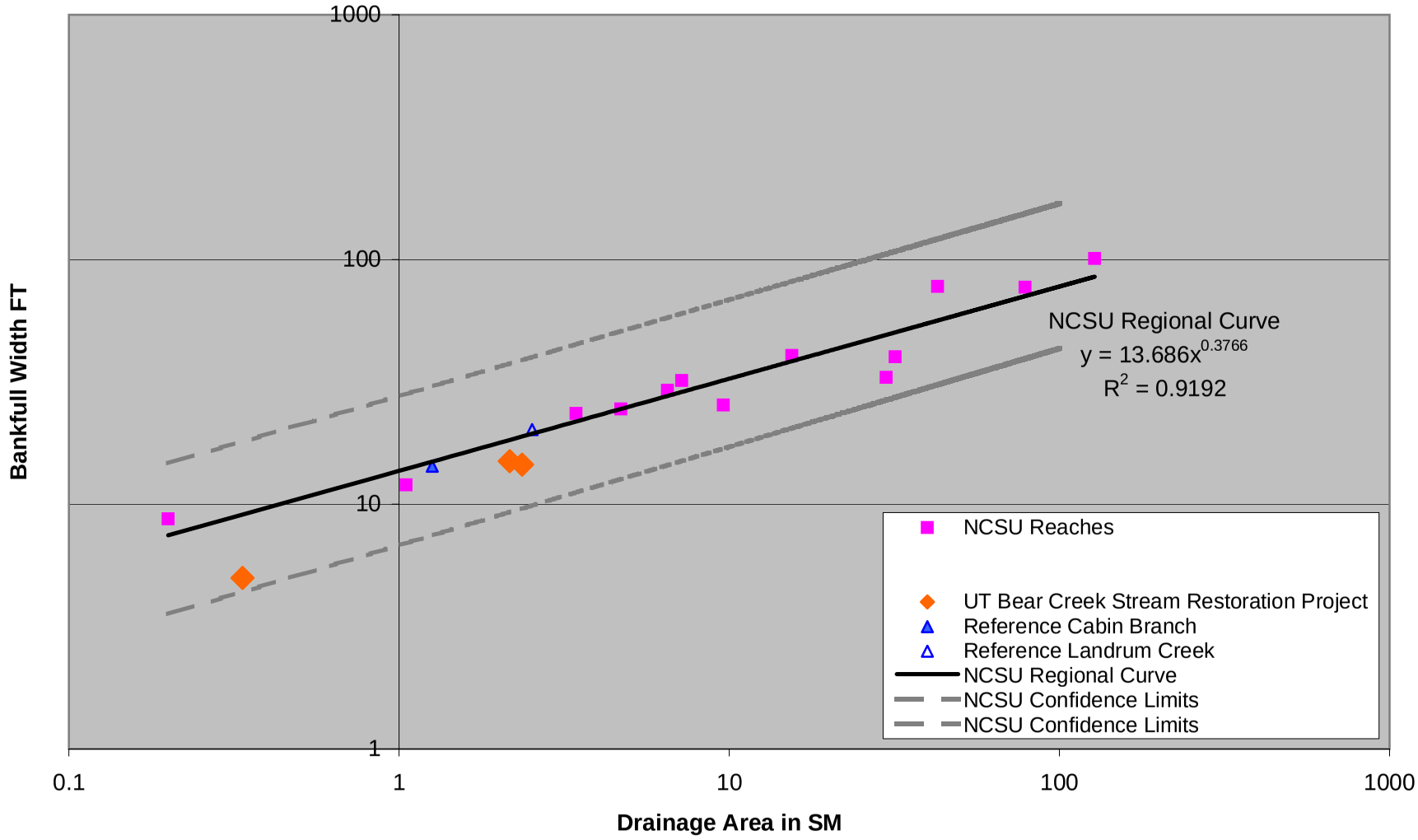


APPENDIX L

Rural Regional
Bankfull Mean Depth Curve



Rural Regional Bankfull Width Curve



APPENDIX M
CE DOCUMENTATION

~~Appendix A~~

Categorical Exclusion Form for Ecosystem Enhancement Program Projects
Version 1.4

Note: Only Appendix A should to be submitted (along with any supporting documentation) as the environmental document.

Part 1: General Project Information	
Project Name:	UT Bear Creek Stream Restoration
County Name:	Chatham County
EEP Number:	060684910
Project Sponsor:	KO & Associates, P.C.
Project Contact Name:	Kevin Williams
Project Contact Address:	1100 Schaub Drive, Suite 202, Raleigh, NC 27606
Project Contact E-mail:	kwilliams@koassociates.com
EEP Project Manager:	Melonie Allen

Project Description

The UT Bear Creek Stream Restoration Site is encompassed within a 275 acre tract that is cleared for livestock pasture. Three tributaries (Bear Creek and two unnamed tributaries) have been impacted by vegetative clearing, hoof shear, incision, and lateral erosion. The primary restoration objectives for the Site include 1) construction of a stable, riffle-pool stream channel, 2) reconnect Site streams with the historic floodplain, 3) removal of livestock from the stream corridor, 4) eliminate invasive vegetative species, 5) minimize disturbance to existing mature vegetation, 6) creation of a natural vegetation buffer along Site streams, and 7) establishment of a conservation easement. The restoration concept is expected to restore approximately 4800 linear feet of stream.

For Official Use Only

Reviewed By:

Date — **EEP Project Manager**

Conditional Approved By:

Date — **For Division Administrator FHWA**

☐ **Check this box if there are outstanding issues**

Final Approval By:

Date — **For Division Administrator FHWA**

Part 2: All Projects Regulation/Question	Response
Coastal Zone Management Act (CZMA)	
1. Is the project located in a CAMA county?	☐ Yes ☑ No
2. Does the project involve ground-disturbing activities within a CAMA Area of Environmental Concern (AEC)?	☐ Yes ☐ No ☑ N/A
3. Has a CAMA permit been secured?	☐ Yes ☐ No ☑ N/A
4. Has NCDCM agreed that the project is consistent with the NC Coastal Management Program?	☐ Yes ☐ No ☑ N/A
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)	
1. Is this a "full-delivery" project?	☐ Yes ☑ No
2. Has the zoning/land use of the subject property and adjacent properties ever been designated as commercial or industrial?	☐ Yes ☐ No ☑ N/A
3. As a result of a limited Phase I Site Assessment, are there known or potential hazardous waste sites within or adjacent to the project area?	☐ Yes ☐ No ☑ N/A
4. As a result of a Phase I Site Assessment, are there known or potential hazardous waste sites within or adjacent to the project area?	☐ Yes ☐ No ☑ N/A
5. As a result of a Phase II Site Assessment, are there known or potential hazardous waste sites within the project area?	☐ Yes ☐ No ☑ N/A
6. Is there an approved hazardous mitigation plan?	☐ Yes ☐ No ☑ N/A
National Historic Preservation Act (Section 106)	
1. Are there properties listed on, or eligible for listing on, the National Register of Historic Places in the project area?	☐ Yes ☐ No
2. Does the project affect such properties and does the SHPO/THPO concur? *A concurrence letter has been sent to SHPO (attached) and no reply has been received at this time.*	☐ Yes ☐ No ☐ N/A
3. If the effects are adverse, have they been resolved?	☐ Yes ☐ No ☑ N/A
Uniform Relocation Assistance and Real Property Acquisition Policies Act (Uniform Act)	
1. Is this a "full-delivery" project?	☐ Yes ☑ No
2. Does the project require the acquisition of real estate?	☐ Yes ☐ No ☑ N/A
3. Was the property acquisition completed prior to the intent to use federal funds?	☐ Yes ☐ No ☑ N/A
4. Has the owner of the property been informed: * prior to making an offer that the agency does not have condemnation authority; and * what the fair market value is believed to be?	☐ Yes ☐ No ☑ N/A

Part 3: Ground-Disturbing Activities Regulation/Question	Response
American Indian Religious Freedom Act (AIRFA)	
1. Is the project located in a county claimed as "territory" by the Eastern Band of Cherokee Indians?	☐ Yes ☑ No
2. Is the site of religious importance to American Indians?	☐ Yes ☐ No ☑ N/A
3. Is the project listed on, or eligible for listing on, the National Register of Historic Places?	☐ Yes ☐ No ☑ N/A
4. Have the effects of the project on this site been considered?	☐ Yes ☐ No ☑ N/A
Antiquities Act (AA)	
1. Is the project located on Federal lands?	☐ Yes ☑ No
2. Will there be loss or destruction of historic or prehistoric ruins, monuments or objects of antiquity?	☐ Yes ☐ No ☑ N/A
3. Will a permit from the appropriate Federal agency be required?	☐ Yes ☐ No ☑ N/A
4. Has a permit been obtained?	☐ Yes ☐ No ☑ N/A
Archaeological Resources Protection Act (ARPA)	
1. Is the project located on federal or Indian lands (reservation)?	☐ Yes ☑ No
2. Will there be a loss or destruction of archaeological resources?	☐ Yes ☐ No ☑ N/A
3. Will a permit from the appropriate Federal agency be required?	☐ Yes ☐ No ☑ N/A
4. Has a permit been obtained?	☐ Yes ☐ No ☑ N/A
Endangered Species Act (ESA)	
1. Are federal Threatened and Endangered species and/or Designated Critical Habitat listed for the county?	☑ Yes ☐ No
2. Is Designated Critical Habitat or suitable habitat present for listed species? *Designated Critical Habitat for Cape Fear Shiner is located in Chatham County in the Deep River, Rocky River, and Bear Creek. The nearest Critical Habitat is 11 miles downstream from the Site; therefore, this project will not effect Critical Habitat. No suitable habitat is present within the Site for federally protected species.*	☐ Yes ☑ No ☐ N/A
3. Are T&E species present or is the project being conducted in Designated Critical Habitat?	☐ Yes ☐ No ☑ N/A
4. Is the project "likely to adversely affect" the species and/or "likely to adversely modify" Designated Critical Habitat?	☐ Yes ☐ No ☑ N/A
5. Does the USFWS/NOAA-Fisheries concur in the effects determination?	☐ Yes ☐ No ☑ N/A
6. Has the USFWS/NOAA-Fisheries rendered a "jeopardy" determination?	☐ Yes ☐ No ☑ N/A

Executive Order 13007 (Indian Sacred Sites)	
1. Is the project located on Federal lands that are within a county claimed as "territory" by the EBCI?	☐ Yes ☑ No
2. Has the EBCI indicated that Indian sacred sites may be impacted by the proposed project?	☐ Yes ☐ No ☑ N/A
3. Have accommodations been made for access to and ceremonial use of Indian sacred sites?	☐ Yes ☐ No ☑ N/A
Farmland Protection Policy Act (FPPA)	
1. Will real estate be acquired?	☑ Yes ☐ No
2. Has NRCS determined that the project contains prime, unique, statewide or locally important farmland?	☑ Yes ☐ No ☐ N/A
3. Has the completed Form AD-1006 been submitted to NRCS? *Form AD-1006 has been sent to NRCS (attached).*	☑ Yes ☐ No ☐ N/A
Fish and Wildlife Coordination Act (FWCA)	
1. Will the project impound, divert, channel deepen, or otherwise control/modify any water body?	☑ Yes ☐ No
2. Have the USFWS and the NCWRC been consulted? *A concurrence letter has been sent to USFWS and NCWRC (attached) and no reply has been received at this time.*	☑ Yes ☐ No ☐ N/A
Land and Water Conservation Fund Act (Section 6(f))	
1. Will the project require the conversion of such property to a use other than public, outdoor recreation?	☐ Yes ☑ No
2. Has the NPS approved of the conversion?	☐ Yes ☐ No ☑ N/A
Magnuson-Stevens Fishery Conservation and Management Act (Essential Fish Habitat)	
1. Is the project located in an estuarine system?	☐ Yes ☑ No
2. Is suitable habitat present for EFH-protected species?	☐ Yes ☐ No ☑ N/A
3. Is sufficient design information available to make a determination of the effect of the project on EFH?	☐ Yes ☐ No ☑ N/A
4. Will the project adversely affect EFH?	☐ Yes ☐ No ☑ N/A
5. Has consultation with NOAA-Fisheries occurred?	☐ Yes ☐ No ☑ N/A
Migratory Bird Treaty Act (MBTA)	
1. Does the USFWS have any recommendations with the project relative to the MBTA? *A concurrence letter has been sent to USFWS, no reply has been received at this time.*	☐ Yes ☐ No
2. Have the USFWS recommendations been incorporated?	☐ Yes ☐ No ☐ N/A
Wilderness Act	
1. Is the project in a Wilderness area?	☐ Yes ☑ No
2. Has a special use permit and/or easement been obtained from the maintaining federal agency?	☐ Yes ☐ No ☑ N/A

Axiom Environmental, Inc.

2126 Rowland Pond Drive Willow Spring Raleigh, North Carolina 27592 919-215-1693

May 21, 2007

Renee Gledhill-Earley
Environmental Review Coordinator
North Carolina State Historic Preservation Office
4617 Mail Service Center
Raleigh, NC 27699-4617

Subject: UT Bear Creek Stream Restoration Project, Chatham County **07-006**

Dear Ms. Gledhill-Earley,

The purpose of this letter is to request a concurrence letter for historic architectural and archaeological surveys and resources within the UT Bear Creek Restoration Site, a potential stream restoration project depicted on the attached Site Location Map.

The UT Bear Creek Restoration Site includes approximately 4,800 linear feet of Bear Creek and two unnamed tributaries to Bear Creek located in southern Chatham County (see attached figures). The site is located in pasture land that is heavily grazed by livestock, resulting in erosion and degraded stream function. The primary restoration activities at the Site include 1) construction of a stable, riffle-pool stream channel, 2) reconnect Site streams with the historic floodplain, 3) removal of livestock from the stream corridor, 4) eliminate invasive vegetative species, 5) minimize disturbance to existing mature vegetation, 6) creation of a natural vegetation buffer along Site streams, and 7) establishment of a conservation easement. The restoration concept is expected to restore approximately 4800 linear feet of stream.

Please note that no structures, including buildings, bridges, or monuments are to be affected by the project. The nearest building to the project is greater than 100 feet from the construction limits and all impacts are to be contained within 70 feet of the existing stream channel.

We thank you in advance for your timely response concerning historic architectural and archaeological issues from your office. I would appreciate receiving such letter for this project at your earliest convenience. Please feel free to contact us with any questions or concerns that you may have concerning the project.

Sincerely,

Mr. W. Grant Lewis
Axiom Environmental, Inc.

Attachments: Figures 1 -4

cc: Mr. Kevin Williams, Project Manager

Axiom Environmental, Inc.

Axiom Environmental, Inc.

2126 Rowland Pond Drive Willow Spring Raleigh, North Carolina 27592 919-215-1693

May 22, 2007

Alan Walters
United States Department of Agriculture
Natural Resources Conservation Service
600 West Innes Street
Salisbury, North Carolina 28144

Subject: UT Bear Creek Stream Restoration Project, Chatham County **07-006**

Dear Mr. Walters,

The purpose of this letter is to request completion of Form AD-1006 (Farmland Conversion Rating Form) for prime, unique, statewide, or local important farmland. Form AD-1006 is required for our project to ensure compliance with respect to the Farmland Protection Policy Act (FPPA) from the proposed UT Bear Creek stream restoration project (Weaver Property). The project is depicted on the four attached maps.

The UT Bear Creek Restoration Site includes approximately 4,800 linear feet of Bear Creek and two unnamed tributaries to Bear Creek located in southern Chatham County (see attached figures). The site is located in pasture land that is heavily grazed by livestock, resulting in erosion and degraded stream function. The primary restoration activities at the Site include 1) construction of a stable, riffle-pool stream channel, 2) reconnect Site streams with the historic floodplain, 3) removal of livestock from the stream corridor, 4) eliminate invasive vegetative species, 5) minimize disturbance to existing mature vegetation, 6) creation of a natural vegetation buffer along Site streams, and 7) establishment of a conservation easement. The restoration concept is expected to restore approximately 4800 linear feet of stream.

We thank you in advance for your timely response concerning a Form AD-1006 (Farmland Conversion Rating Form). Please feel free to contact us with any questions or concerns that you may have concerning the project.

Sincerely,

Mr. W. Grant Lewis
Axiom Environmental, Inc.

Attachments: Figures 1 -4
Form AD-1006

cc: Mr. Kevin Williams, Project Manager

Axiom Environmental, Inc.

Axiom Environmental, Inc.

2126 Rowland Pond Drive Willow Spring Raleigh, North Carolina 27592 919-215-1693

May 24, 2007

Alan Walters
United States Department of Agriculture
Natural Resources Conservation Service
600 West Innes Street
Salisbury, North Carolina 28144

Subject: UT Bear Creek Stream Restoration Project, Chatham County **07-006**

Dear Mr. Walters,

Please find attached the completed Form AD-1006 Farmland Conversion Impact Rating form. I appreciate your quick turn around with regards to completing the form. Please feel free to contact us with any questions or concerns that you may have concerning the project.

Sincerely,

Mr. W. Grant Lewis
Axiom Environmental, Inc.

Attachments: Completed Form AD-1006

cc: Mr. Kevin Williams, Project Manager

U.S. DEPARTMENT OF AGRICULTURE — Form AD-1006

FARMLAND CONVERSION IMPACT RATING

PART I (To be completed by Federal Agency)	1. Date of Land Evaluation Request: May 21, 2007	2. Sheet 1 of 1
3. Name of Project: UT Bear Creek Restoration	4. Federal Agency Involved / 4a. State, Local or other agency involved: Federal Highway Administration	
5. Proposed Land Use: Stream Restoration	6. County and State: Chatham Co., NC	7. Type of Project: Corridor ☐ Other ☑
PART II (To be completed by NRCS)	1. Date Request Received by NRCS: 5/23/2007	2. Person Completing the NRCS parts of this form: Alan Mathews
3. Does the site or corridor contain prime, unique, statewide or local important farmland? Yes ☒ No ☐ (If no, the FPPA does not apply - Do not complete additional parts of this form)	4. Acres Irrigated: C	5. Average Farm Size: 105 Ac
6. Major Crop(s): CORN	7. Farmable Land in Government Jurisdiction: Acres: 393160 % 86.7	8. Amount of Farmland As Defined in FPPA: Acres: 8[illegible]86[illegible] % 60.5[illegible]
9. Name of Land Evaluation System Used: CHATHAM CO LE	10. Name of Local Site Assessment System: N/A	11. Date Land Evaluation Returned by NRCS: 5/25/2007

PART III (To be completed by Federal Agency)	Alternative Site Rating			
	Site A	Site B	Site C	Site D
A. Total Acres To Be Affected Directly	32			
B. Total Acres To Be Affected Indirectly	NA			
C. Total Acres in Site	32			
PART IV (To be completed by NRCS) Land Evaluation Information				
A. Total Acres Prime and Unique Farmland	0			
B. Total Acres Statewide and Local Important Farmland	6.72			
C. Percentage of Farmland in County or Local Govt. Unit to be Converted	0.001			
D. Percentage of Farmland in Govt. Jurisdiction with Same or Higher Relative Value	65.8			
PART V (To be completed by NRCS) Land Evaluation Criterion Relative Value of Site to be Converted (Scale of 0 - 100 Points)	69			
PART VI (To be completed by Federal Agency) Corridor or Site Assessment Criteria (These criteria are explained in 7 CFR 658.5(b & c))	Max. Points Corridor / Other			
1. Area in Nonurban Use	15 / 15	0			
2. Perimeter in Nonurban Use	10 / 10	9			
3. Percent of Site Being Farmed	20 / 20	18			
4. Protection Provided by State and Local Government	20 / 20	0			
5. Distance from Urban Built-up area (not for use in corridors)	0 / 15	5			
6. Distance to Urban Support Services (not for use in corridors)	0 / 15	10			
7. Size of Present Farm Unit Compared to Average	10 / 10	10			
8. Creation of Non-Farmable Farmland	25 / 10	~~25~~ 10			
9. Availability of Farm Support Services	5 / 5	5			
10. On-Farm Investments	20 / 20	10			
11. Effects of Conversion on Farm Support Services	25 / 10	0			
12. Compatibility with Existing Agricultural Use	10 / 10	0			
TOTAL CORRIDOR OR SITE ASSESSMENT POINTS	160	77			
PART VII (To be completed by Federal Agency)				
Relative Value of Farmland (from Part V above)	100	69			
Total Corridor or Site Assessment (From Part VI above or a local site assessment)	160	77			
TOTAL POINTS (Total of above 2 lines)	260	146			

(To be completed by Federal Agency after final decision)

1. Corridor or Site Selected:	2. Date of Selection:	3. Was A Local Site Assessment Used? Yes ☐ No ☐

4. Reason For Selection:

Form parts I, III and VI completed by:
(print name, address, telephone #) William Grant Lewis 2126 Rowland Pond Drive Willow Spring, NC 27592 (919) 215-1693
Signature: William Grant Lewis Date: 5/24/07
Return a copy to NRCS after completion of Part VIII

Axiom Environmental, Inc.

2126 Rowland Pond Drive Willow Spring Raleigh, North Carolina 27592 919-215-1693

May 21, 2007

Shannon Deaton
NC Wildlife Resources Commission
Division of Inland Fisheries
1751 Varsity Drive
NCSU Centennial Campus
Raleigh, NC 27606

Subject: UT Bear Creek Stream Restoration Project, Chatham County **07-006**

Dear Ms. Deaton,

The purpose of this letter is to request comment on any possible issues that might emerge with respect to the Fish and Wildlife Coordination Act (FWCA) from the proposed UT Bear Creek Restoration project. The project is depicted on the four attached maps.

The UT Bear Creek Restoration Site includes approximately 4,800 linear feet of Bear Creek and two unnamed tributaries to Bear Creek located in southern Chatham County (see attached figures). The site is located in pasture land that is heavily grazed by livestock, resulting in erosion and degraded stream function. The primary restoration activities at the Site include 1) construction of a stable, riffle-pool stream channel, 2) reconnect Site streams with the historic floodplain, 3) removal of livestock from the stream corridor, 4) eliminate invasive vegetative species, 5) minimize disturbance to existing mature vegetation, 6) creation of a natural vegetation buffer along Site streams, and 7) establishment of a conservation easement. The restoration concept is expected to restore approximately 4800 linear feet of stream.

We thank you in advance for your timely response concerning a letter of concurrence from your office for the FWCA. I would appreciate receiving such letter for this project at your earliest convenience. Please feel free to contact us with any questions or concerns that you may have concerning the project.

Sincerely,

Mr. W. Grant Lewis
Axiom Environmental, Inc.

Attachments: Figures 1 -4

cc: Mr. Kevin Williams, Project Manager

North Carolina Wildlife Resources Commission

Richard B. Hamilton, Executive Director

11 June 2007

Mr. W. Grant Lewis
Axiom Environmental, Inc.
2126 Rowland Pond Drive
Willow Springs, NC 27592

Subject: Bear Creek Stream Restoration, Chatham County, North Carolina.

Dear Mr. Lewis:

Biologists with the North Carolina Wildlife Resources Commission have reviewed the subject document. Our comments are provided in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-667d) and North Carolina General Statutes (G.S. 113-131 et seq.).

The North Carolina Ecosystem Enhancement Program has identified Bear Creek and an unnamed tributary to Bear Creek in the Cape Fear River basin as stream restoration sites. Approximately 4,800 linear feet of Bear Creek and two unnamed tributaries will be restored. The site is located in a pasture heavily grazed by livestock. Primary restoration activities include: construct a stable, riffle-pool stream channel, reconnect the stream with its historic floodplain, remove livestock from the stream corridor, eliminate invasive plant species, minimize disturbance to mature vegetation, create a natural vegetated buffer along the streams, and establish a conservation easement.

There are records for the federal and state endangered Cape Fear shiner (*Notropis mekistocholas*), the federal species of concern and state endangered brook floater (*Alasmidonta varicosa*), the federal species of concern and state special concern Carolina darter (*Etheostoma collis*), the state threatened creeper (*Strophitus undulatus*), and the state special concern notched rainbow (*Villosa constricta*) in Bear Creek.

We offer the following recommendations to minimize impacts to aquatic and terrestrial wildlife species and in particular to Cape Fear shiner.

1. An in-water work moratorium take place during 1 March to 31 July to minimize impacts to spawning fish and to the survivability of young fish.

Mailing Address: Division of Inland Fisheries • 1721 Mail Service Center • Raleigh, NC 27699-1721
Telephone: (919) 707-0220 • **Fax:** (919) 707-0028

2. Sediment and erosion control measures that meet the design standards for sensitive watersheds should be used. Further, any excavated materials should not be stockpiled where sediment will erode to surface waters.

3. Avoid impacts to any large mature trees along each stream and establish native, forested buffers in riparian areas to improve terrestrial wildlife habitat and provide a travel corridor for wildlife species.

Thank you for the opportunity to review this project. If you require further assistance, please contact our office at (336) 449-7625.

Sincerely,

Shari L. Bryant
Piedmont Region Coordinator
Habitat Conservation Program

ec: Ryan Heise, WRC
David Rabon, USFWS

Axiom Environmental, Inc.

Axiom Environmental, Inc.

2126 Rowland Pond Drive Willow Spring Raleigh, North Carolina 27592 919-215-1693

May 22, 2007

Dale Suiter
US Fish and Wildlife Service
Raleigh Field Office
P.O. Box 33726
Raleigh, NC 27636

Subject: UT Bear Creek Stream Restoration Project, Chatham County **07-006**

Dear Mr. Suiter,

The purpose of this letter is to request comment on any possible issues that might emerge with respect to the Migratory Bird Treaty Act (MBTA), the Fish and Wildlife Coordination Act (FWCA), and the Endangered Species Act (ESA) from the UT Bear Creek stream restoration project. The project is depicted on the four attached maps.

Site Description and Proposed Activities

The UT Bear Creek Restoration Site includes approximately 4,800 linear feet of Bear Creek and two unnamed tributaries to Bear Creek located in southern Chatham County (see attached figures). The site is located in pasture land that is heavily grazed by livestock, resulting in erosion and degraded stream function. The primary restoration activities at the Site include 1) construction of a stable, riffle-pool stream channel, 2) reconnect Site streams with the historic floodplain, 3) removal of livestock from the stream corridor, 4) eliminate invasive vegetative species, 5) minimize disturbance to existing mature vegetation, 6) creation of a natural vegetation buffer along Site streams, and 7) establishment of a conservation easement. The restoration concept is expected to restore approximately 4800 linear feet of stream.

Federally Protected Species

Based on the May 10, 2007 United States Fish and Wildlife Service (USFWS) list, 4 federally protected species are listed for Chatham County. The following table lists the federally protected species for Chatam County, indicates if potential habitat exists within the Site, and gives a biological conclusion for each species.

North Carolina Natural Heritage Program (NCNHP) records were reviewed on May 21, 2007 and no known federally protected species are documented within or in the vicinity of the Site. The nearest documentation of a federally protected species (Cape Fear shiner) is located approximately 6 miles south of the Site in the Deep River.

The Site is characterized by agricultural fields and is grazed by livestock. Site streams are devoid of vegetation, or have a narrow riparian fringe of disturbance adapted hardwood species including tulip poplar (*Liroidendron tulipifera*), sweetgum (*Liquidambar styraciflua*), and red maple (*Acer rubrum*). Streams are characterized by stagnant flow with substrate characterized by silt and sand, resulting from livestock hoof shear and bank erosion.

Federally Protected Species for Chatham County

Common Name	Scientific Name	Status*	Habitat Present Within Site	Biological Conclusion
Vertebrates				
Bald eagle	*Haliaeetus leucocephalus*	Threatened (proposed for delisting)	No	No Effect
Cape Fear shiner	*Notropis mekistocholas*	Endangered	No	No Effect
Red-cockaded woodpecker	*Picoides borealis*	Endangered	No	No Effect
Vascular Plants				
Harperella	*Ptilimnium nodosum*	Endangered	No	No Effect

*Endangered = a taxon "in danger of extinction throughout all or a significant portion of its range"; Threatened = a taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range".

Haliaeetus leucocephalus (bald eagle) Threatened

Adult bald eagles are identified by their large white head, short white tail, and dark-brown to chocolate- brown body plumage. Immature eagles lack the white head plumage and have brown to black body plumage. In flight bald eagles can be identified by their flat wing soar. Adults average about 3.0 feet from head to tail, weigh approximately 10.0 to 12.0 pounds, and have a wingspan that can reach up to 7.0 feet. Fish are the major food source for bald eagles although bald eagles also consume a variety of birds, mammals, and turtles when fish are not readily available.

Eagle nests are generally found in close proximity to water (within 0.5 miles) where the eagle has a clear flight path to the water. They generally nest in the largest living tree with an open view of the surrounding land. Human disturbance may cause an eagle to abandon otherwise suitable habitat.

Biological Conclusion:

NO EFFECT

Potential habitat for the bald eagle does not occur within or adjacent to the Site. The nearest open water which may serve as habitat for the bald eagle is 4.5 miles to the south in the Deep River. The Site may serve as a fly over corridor for the bald eagle; however, proposed project will have no effect on the bald eagle.

Notropis mekistocholas (Cape Fear Shiner) Endangered

The Cape Fear shiner is a small (to 2 inches), moderately stocky minnow. It is pale silvery yellow with a black band along the sides and the moderate-sized eyes are located on the sides of the head. This species is distinguished from all other Notropis by having a coiled alimentary tract that is visible through the wall of the belly. Plant material forms the primary part of the shiner's diet.

Habitat elements include clean streams with gravel, cobble, and boulder substrates with pools, riffles, shallow runs and slackwater areas with large rock outcrops and side channels and pools with water of good quality with relatively low silt loads. Little is known about the Cape Fear shiner's life history.

Biological Conclusion:

NO EFFECT

Site streams are characterized by stagnant flow over a sand and silt substrate. Disturbance from vegetation clearing and livestock hoof shear has eliminated Cape Fear Shiner habitat within, and adjacent to, the Site; therefore, this project will have no effect on the Cape Fear Shiner

Picoides borealis (red-cockaded woodpecker) Endangered

The adult red-cockaded woodpecker (RCW) has black and white plumage; male RCWs have small red streaks on the sides of the nape. The RCW is identifiable by horizontal stripes of black and white on the back, white with streaked flanks on the breast and underside, and a large white cheek patch.

The RCW uses open old growth stands of southern pines, particularly longleaf pine (*Pinus palustris*), for foraging and nesting habitat. RCWs require forested stands that contain at least 50 percent pine, lack a thick understory, and are contiguous with other pine stands. These birds nest exclusively in trees greater than 60 years old that are contiguous with pine stands at least 30 years of age. The foraging range of the RCW is up to 500 acres and must be contiguous with suitable nesting sites.

RCWs nest exclusively in living pine trees, generally those trees infected with red-heart disease. The cavities can be identified by a large incrustation of running sap surrounding the tree. The incrustation of sap is believed to be a defense mechanism of the RCW against possible predators.

Biological Conclusion:

NO EFFECT

The Site is almost entirely composed of livestock pasture, with a narrow, disturbed, hardwood fringe adjacent to Site streams and contains no open stands of pine suitable for red-cockaded woodpecker foraging (30 years or older) or roosting/nesting (60 years or older) habitat. Therefore, no habitat for red-cockaded woodpecker occurs within the Site and the proposed project will have no effect on red-cockaded woodpecker.

Ptilimnium nodosum (Harperella) Endangered

Harperella is a slender, annual herb which grows to 6 to 36 inches in height. The leaves are reduced to hollow, quill-like structures which are green, ribbed, and purplish-tinged near the base. Flowers occur as umbels consisting of five regular parts and are bisexual or unisexual, each umbel containing both perfect and male florets. Flowering begins in May in populations occurring in ponds, while riverine populations may flower much later, beginning in late June or July and continuing until frost.

Harperella typically occurs in two habitat types: (1) rocky or gravel shoals and margins of clear, swift-flowing stream sections; and (2) edges of intermittent pineland ponds in the coastal plain. Harperella is known from 12 extant populations, rangewide. One population occurs in each of two North Carolina counties: Granville and Chatham. This plant is a relatively prolific annual, and large numbers may occur within each population, especially along rivers. This plant tolerates and may actually require a very specific and unusual water regime, which includes moderately intensive spring floods, which may reduce or eliminate competing vegetation. Harperella is readily eliminated from its habitat by alterations of the water regime which result from impoundments, water withdrawal, and drainage or deepening of ponds. Other factors such as siltation, pollution, and shoreline development also threaten Harperella populations.

Biological Conclusion:

NO EFFECT

Site streams are characterized by stagnant flow over a sand and silt substrate. Disturbance from vegetation clearing and livestock hoof shear has eliminated Harperella habitat within, and adjacent to, the Site; therefore, this project will have no effect on Harperella

Designated Critical Habitat

The N.C. Wildlife Resources Commission has designated Critical Habitat for this species in Bear Creek in Chatham County, the Rocky River in Chatham County, the Deep River in Chatham and Lee Counties, Fork Creek in Randolph County, and the Deep River in Randolph and Moore Counties. Total numbers are unknown, but all populations appear to be small. No designated critical habitat occurs within the onsite reach of Bear Creek and the nearest reach of designated critical habitat is greater than 11 miles downstream from the Site..

We thank you in advance for your timely response concerning letter(s) of concurrence from your office for the MBTA, FWCA, and ESA. I would appreciate receiving such letter(s) for this project at your earliest convenience. Please feel free to contact us with any questions or concerns that you may have concerning the project.

Sincerely,

Mr. W. Grant Lewis
Axiom Environmental, Inc.

Attachments: Figures 1 -4

cc: Mr. Kevin Williams, Project Manager

Axiom Environmental, Inc.

Axiom Environmental, Inc.

2126 Rowland Pond Drive Willow Spring Raleigh, North Carolina 27592 919-215-1693

May 24, 2007

Alan Walters
United States Department of Agriculture
Natural Resources Conservation Service
600 West Innes Street
Salisbury, North Carolina 28144

Subject: UT Bear Creek Stream Restoration Project, Chatham County **07-006**

Dear Mr. Walters,

Please find attached the completed Form AD-1006 Farmland Conversion Impact Rating form. I appreciate your quick turn around with regards to completing the form. Please feel free to contact us with any questions or concerns that you may have concerning the project.

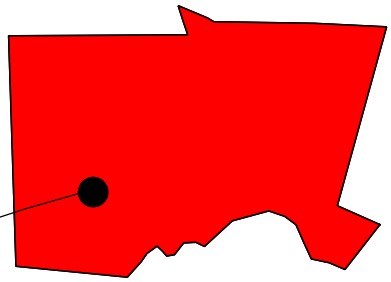
Sincerely,

Mr. W. Grant Lewis
Axiom Environmental, Inc.

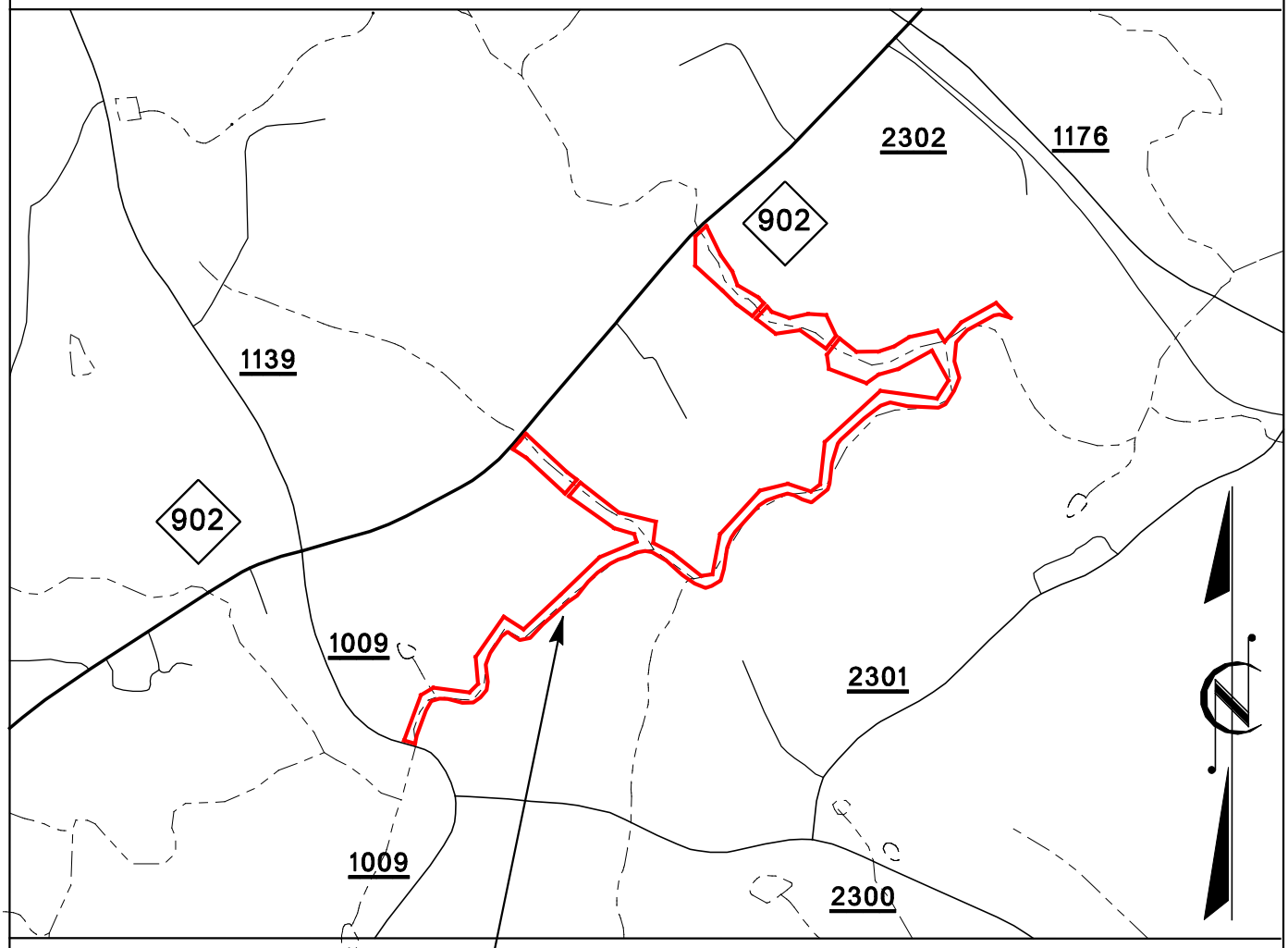
Attachments: Completed Form AD-1006

cc: Mr. Kevin Williams, Project Manager

Chatham County
North Carolina



PROJECT AREA



PROJECT AREA

0 1000 2000
FEET

Ecosystem Enhancement Program

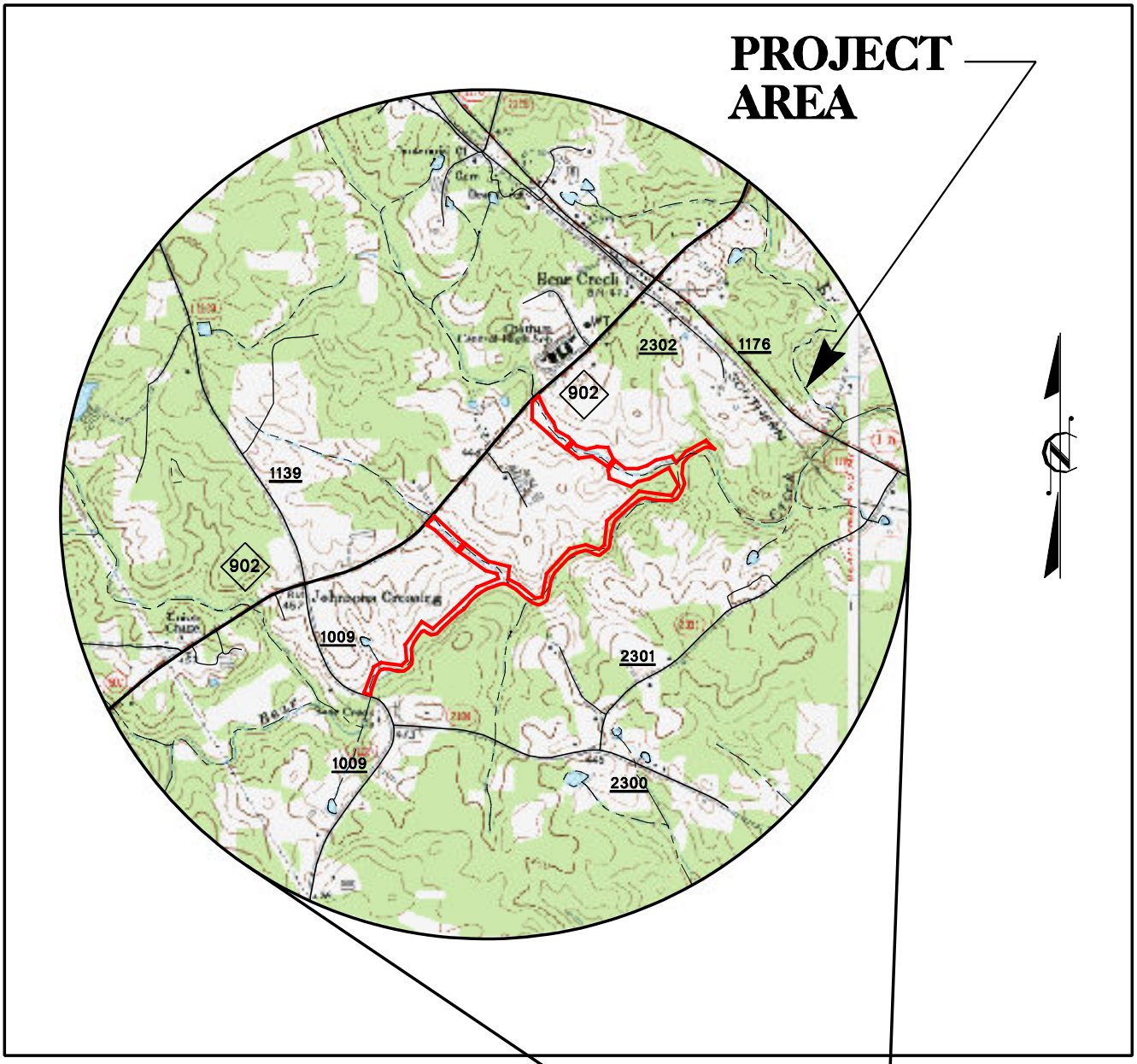
KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

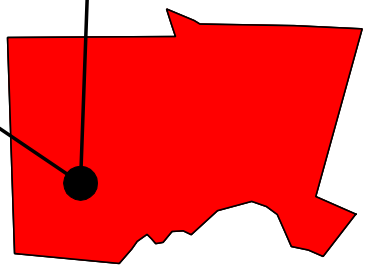
Vicinity Map

Restoration Plan
Bear Creek
Chatham County, North Carolina

Date: 4/30/07

Figure: 1





LEGEND

Watershed

Project Area

Chatham County North Carolina

Watershed Topo Map

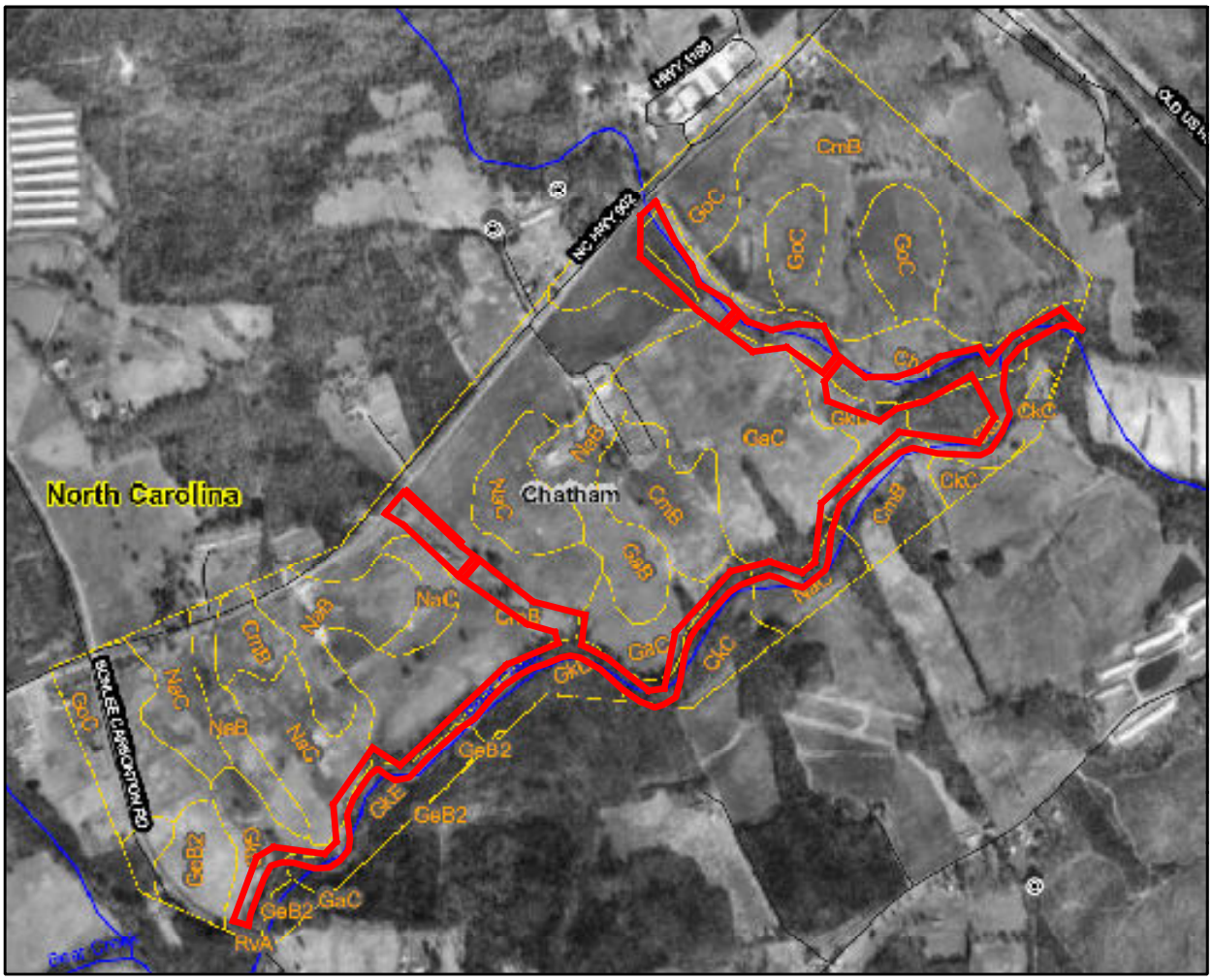
Restoration Plans
Bear Creek
Chatham County, North Carolina

Ecosystem Enhancement PROGRAM

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Date: 4/3007

Figure: 2



LEGEND

Symbol	Name	Symbol	Name
ChA	Chewacla and Wehadkee	GkE	Georgeville-Badin Complex
CkC	Cid Silt Loam	GoC	Goldston-Badin Complex
CmB	Cid-Lignum Complex	NaB	Nanford-Badin Complex
GaB	Georgeville Silt Loam	NaC	Nadford-Badin Complex
GaC	Georgeville Silt Loam	RvA	Riverview Silt Loam
GeB2	Georgeville Silty Clay Loam	StB	State Sandy Loam
GkD	Georgeville-Badin Complex		Project Area

0 1000 2000

FEET

Ecosystem Enhancement PROGRAM

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Soil Survey Map

Restoration Plans
Bear Creek
Chatham County, North Carolina

Date: 4/30/07

Figure: 3

Hydrological Features Map

BEAR CREEK

Restoration Plan
Bear Creek
Chatham County, North Carolina

Ecosystem Enhancement Program

KO & ASSOCIATES, P.C.
Consulting Engineers
1011 SCHAUB DR., SUITE #202 RALEIGH, N.C. 27606
(919) 851-6066

Date: 4/30/07

Figure: 4