Elk Branch Restoration Plan-Final
Mitchell County, North Carolina

EEP Project Number D06125-B

Prepared For

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Elk Branch Restoration Plan
Mitchell County, North Carolina

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EXECUTIVE SUMMARY

Michael Baker Engineering, Inc. (Baker) proposes the restoration or enhancement of 2,192 linear feet (LF) of stream channel along Elk Branch as well as 898 LF of restoration along two unnamed perennial tributaries (UT 1 and UT 2) to Elk Branch in Mitchell County, NC. These low order streams have been impacted by agriculture for many decades and have been moved, altered, and otherwise degraded by grazing, lack of buffers, livestock access to the creek, and other impacts. Elk Branch flows into Cane Creek approximately 4,000 feet below the project site. The nearest town, Bakersville, is one mile southwest of the Elk Branch Project area (Figure 1.1). The site lies in the French Broad River Basin within the North Carolina Division of Water Quality (NCDWQ) sub-basin 04-03-06 and local watershed unit 06010108040010. This project is not located within a targeted local watershed.

The goals for the restoration project are as follows:

The restoration and enhancement of headwater tributaries to Cane Creek and the French Broad Basin;
The reduction of sediment and nutrient loading through restoration of riparian areas and streambanks;
To improve and restore hydrologic connections between the creek and floodplain;
To create geomorphically stable conditions on the Elk Branch project site; and
To improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, we recommend the following:

Restore the existing trampled, straightened and relocated streams by creating stable channels with adequate grade control and access to the floodplain;
Improve water quality by establishing buffers for nutrient removal from runoff and by stabilizing streambanks to reduce bank erosion.
Improve in-stream habitat by reducing fine sediment loading from the watershed, providing a more diverse bedform with riffles and pools, creating deeper pools and areas of water aeration, and providing woody debris for habitat and the reduction of bank erosion;
Improve terrestrial habitat by planting riparian areas with native vegetation and protecting these areas with a permanent conservation easement so that the riparian area will increase storm water runoff filtering capacity, improve bank stability, provide shading to decrease water temperature, and improve wildlife habitat.

Table ES.1 Elk Branch Restoration Plan Overview
Elk Branch Restoration Plan- EEP Project # D06125-B

Project Feature	Existing Condition (LF)	Design Condition (LF)	Approach
Elk Branch Reach 1	2,020	1,913	Restoration (Priority I)
Elk Branch Reach 2	279	279	Enhancement I
UT 1	685	654	Restoration (Priority I)
UT 2	185*	244	Restoration (Priority I)
Total Stream Work	**3,169**	**3,090**	**Variable**

Notes: Design condition excludes breaks in conservation easement, existing condition does not
* buried portion not included in existing length

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

List of Appendices

1.0 PROJECT SITE IDENTIFICATION AND LOCATION

1.1 Project Description and Directions to Project Site

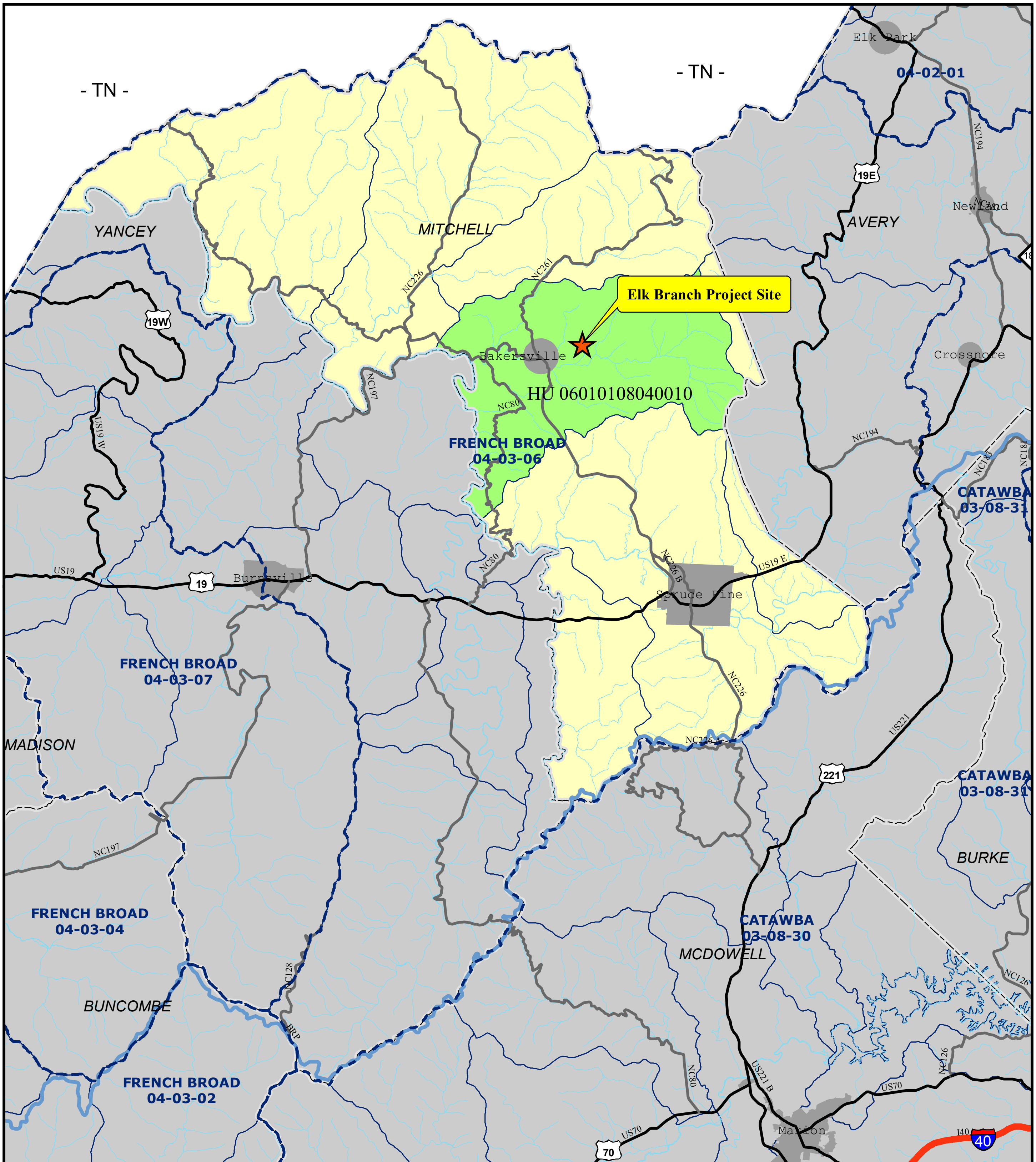
Baker proposes to restore or enhance 2,192 LF of Elk Branch and complete 898 LF of channel restoration along two unnamed tributaries (UT and UT2) to Elk Branch, in Mitchell County, NC.

The Elk Branch project site is located about one mile northeast of Bakersville in Mitchell County, North Carolina, as shown in the Project Location Map (Figure 1.1). To reach the project site, follow I-26 North from Asheville for approximately 20 miles and take U.S. Highway 19N Exit 9, towards Burnsville and Spruce Pine. Continue along U.S. Highway 19 (which becomes 19-E), for 25 miles. Turn left onto N.C. Highway 226 and continue until you reach the Town of Bakersville. Once in Bakersville, turn right (northeast) onto North Mitchell Avenue and after approximately a half mile, North Mitchell Avenue turns into Cane Creek Road. Continue another 0.7 miles, then turn left off of Cane Creek Road onto Nora Lane (SR 1219). The project site begins just below a spring head at the head of the valley, approximately 1,500 feet beyond the end of Nora Road (paved).

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

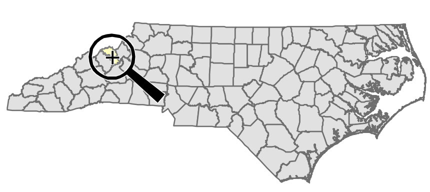
The Elk Branch project site lies in the French Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 04-03-06 and the United States Geological Survey (USGS) local watershed unit 06010108040010.

Elk Branch is shown as a solid blue-line stream while spring-fed tributaries UT 1 and UT 2 are apparent from the topography but are not drawn in on the USGS topographic quadrangle map (Figure 1.2). After referencing USGS topographic quadrangle maps to determine stream classifications for the project, a field evaluation using the North Carolina Division of Water Quality (NCDWQ) stream assessment protocol was conducted. Based on field data, Elk Branch, UT 1 and UT 2 are classified as perennial streams. NCDWQ Stream Identification Forms completed for the project reaches are included in Appendix A. The total existing length of stream within the project is 3,169 LF; proposed stream lengths do not include easement breaks.



Ecosystem Enhancement PROGRAM

Map Inset



Mitchell County, NC

LEGEND:

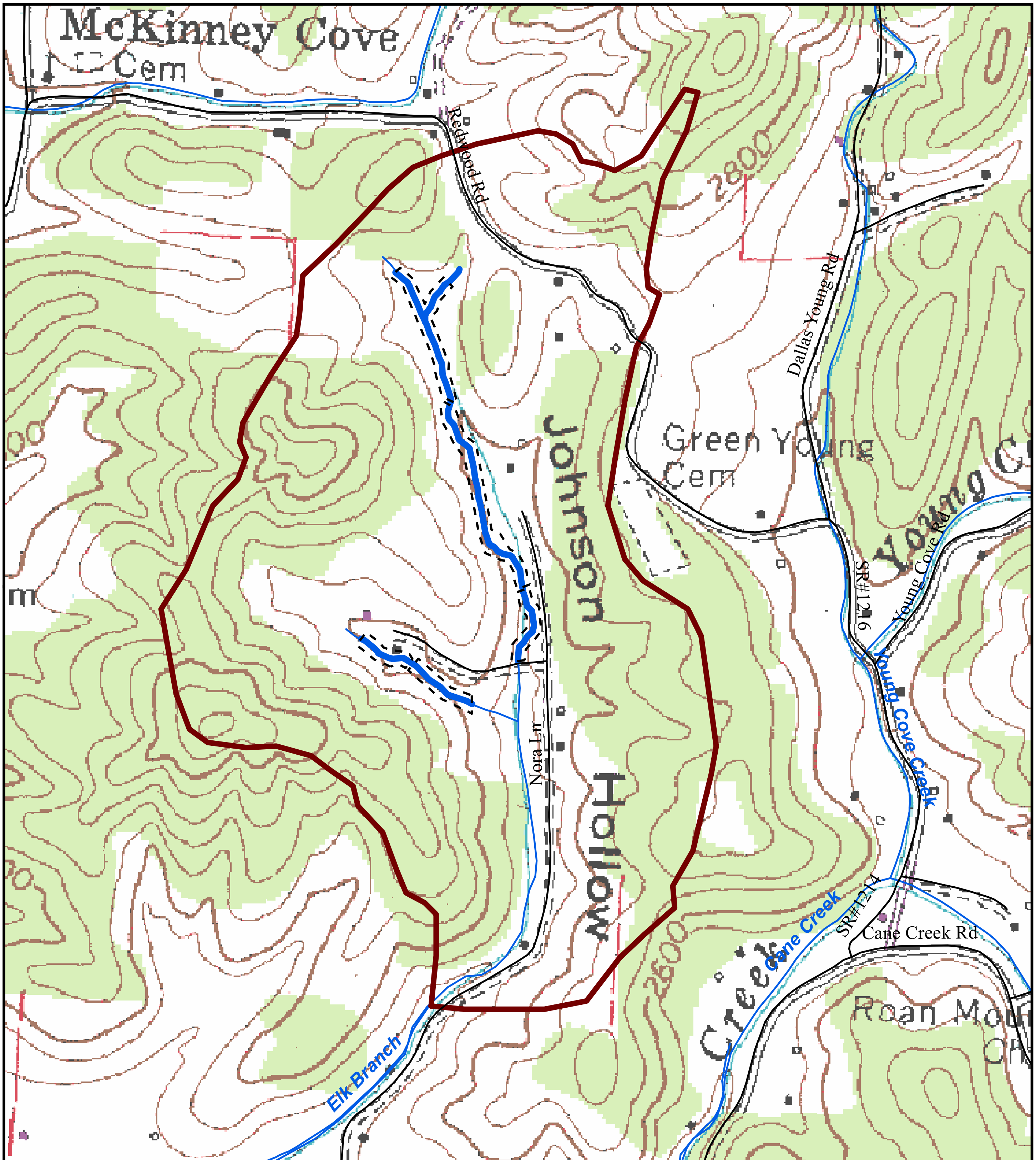
- NCDWQ Sub-basin
- Counties
- USGS Hydrologic Unit
- Project Hydrologic Unit
- Mitchell County

0 1 2 4 Miles

Figure 1.1 Project Location Map

Elk Branch Restoration Project
Mitchell County, NC

Baker



LEGEND:

- Project Reach
- Proposed Easement Boundary
- Streams
- Watershed Boundary

0 200 400 800 Feet

Figure 1.2 USGS Topographic Map (Bakersville Quadrangle)

Elk Branch Restoration Project
Mitchell County, NC

Ecosystem Enhancement PROGRAM

Baker

1.3 Project Components and Structure

The pro3ject components are broken down into reaches by their restoration level, target restoration stream type, and approach and are depicted in the Project Components figure in the Executive Summary (ES.1). Discontinuities in these characteristics are depicted in Figure ES.1. Distinct project reaches are described in Table 1.0. Table 1.1 summarizes project component attributes of Elk Branch and its tributaries.

Table 1.0 Elk Branch Project Components

Elk Branch Restoration Plan- EEP Project # D06125-B

Project Component or Reach ID	Existing Feet	Restoration Level	Approach	Proposed Footage	Mitigation Ratio	Mitigation Units	Proposed Stationing (LF)	Buffer Acres	Comment
Elk Branch Reach 1	2,020	R	P1	1,913	1:1	1,913	0+00 to 7+27, 7+49 to 18+12 18+27 to 19+50	3.09	Easement excludes 7+27 to 7+49 and 18+12 to 18+27
Elk Branch Reach 2	279	E	L1	279	1.5:1	186	19+50 to 22+29	0.44	
UT1	685	R	P1	654	1:1	654	0+00 to 2+89, 3+10 to 6+75	1.16	Easement excludes 2+89 to 3+10
UT2	185*	R	P1	244	1:1	244	0+89 to 3+33	0.27	0+00 to 0+89 is not within the conservation easement * buried portion not included in existing length

Mitigation Unit Summations

Restoration Level	Stream (LF)	Buffer (Ac)
Restoration	2,811	4.52
Enhancement I	186	0.44
Totals	**2,997**	**4.96**

Table 1.1 Project Attribute Table Elk Branch Restoration Plan- EEP Project # D06125-B				
Project County	Mitchell			
Physiographic Region	Blue Ridge			
Ecoregion	Blue Ridge Mountains-Southern Crystalline Ridges and Mountains			
Project River Basin	French Broad			
USGS HUC for Project	6010108040010			
NCDWQ Sub-basin for Project	04-03-06			
Planning Area	Not located in a specially designated watershed			
WRC Class	Cold			
% of Project Easement Fenced or Demarcated	100 (post-construction)			
Beaver Activity Observed During Design Phase	No			
Restoration Component Attribute Table				
	Elk Branch.		UT1	UT2
	Reach 1	Reach 2		
Drainage Area (Mi^2)	0.07	0.14	0.06	0.01
Stream Order	1st	2nd	1st	1st
Restored Length (feet)	1,913	279	654	244
Perennial or Intermittent	P	P	P	P
Watershed Type	Rural			
Watershed LULC Distribution*(Cumulative acreage)				
Developed Open Space	7.6			
Deciduous Forest	79.6			
Evergreen Forest	16.6			
Mixed Forest	14.9			
Shrub/Scrub	11.3			
Pasture/Hay	64.4			
Watershed Impervious Cover (%)	<10%			
NCDWQ AU/Index Number	7-2-59-8			
NCDWQ Classification	C; Tr		-	-
303d Listed	No		No	No
Upstream of 303d Listed Segment	No		No	No
Reasons for 303d Listing or Stressor	N/A		N/A	N/A
Total Acreage of Easement (Cumulative)	4.96			
Total Vegetated Acreage Within the Easement	-			

Total Planted Acreage As Part of the Restoration	~4.96			
Rosgen Classification of Pre-existing	Cb/B/G/Eb		Fb	B
Rosgen Classification of As-built (Design)	B4		B4	B4
Valley Type	II		II	II
Valley Slope	0.03		0.04	0.04
Valley Side Slope Range	U		U	U
Valley Toe Slope Range	U		U	U
Cowardin Classification	N/A		N/A	N/A
Trout Waters Designation	Yes*		-	-
Species of Concern, Endangered, etc.	No		No	No
Dominant Soil Series and Characteristics				
Series	Saunook-Thunder Complex, Fannin sandy clay loam	Saunook-Thunder Complex, Bandana sandy loam	Saunook-Thunder Complex	Saunook-Thunder Complex, Saunook silt loam
Depth	>60	>60	>60	>60
Clay %	7-20/ 12-27, 5-35	7-20/ 12-27, 10-20	7-20/ 12-27	7-20/ 12-27,12-35
K	.24/.05, .32	.24/.05, .20	.24/.05	.24/.05,.15-.32
T	5	5, 4	5	5

*Project streams are tributaries to designated trout waters.

2.0 WATERSHED CHARACTERIZATION

2.1 Watershed Delineation

The Elk Branch Restoration project is located in Mitchell County in the French Broad River Basin (Cataloging Unit 06010108). Figure 1.2 provides a delineated topographic view of the watershed drainage area for Elk Branch and its tributaries on a 7.5 minute topographic quadrangle map. The total drainage area for Elk Branch is 0.05 square miles at the beginning of the project and 0.14 square miles at the downstream project limit; tributaries UT1 and UT2 account for 0.06 and 0.01 square miles, respectively. The project area encompasses 4.96 acres that have been put under conservation easement to be held by the EEP.

2.2 Surface Water Classification/ Water Quality

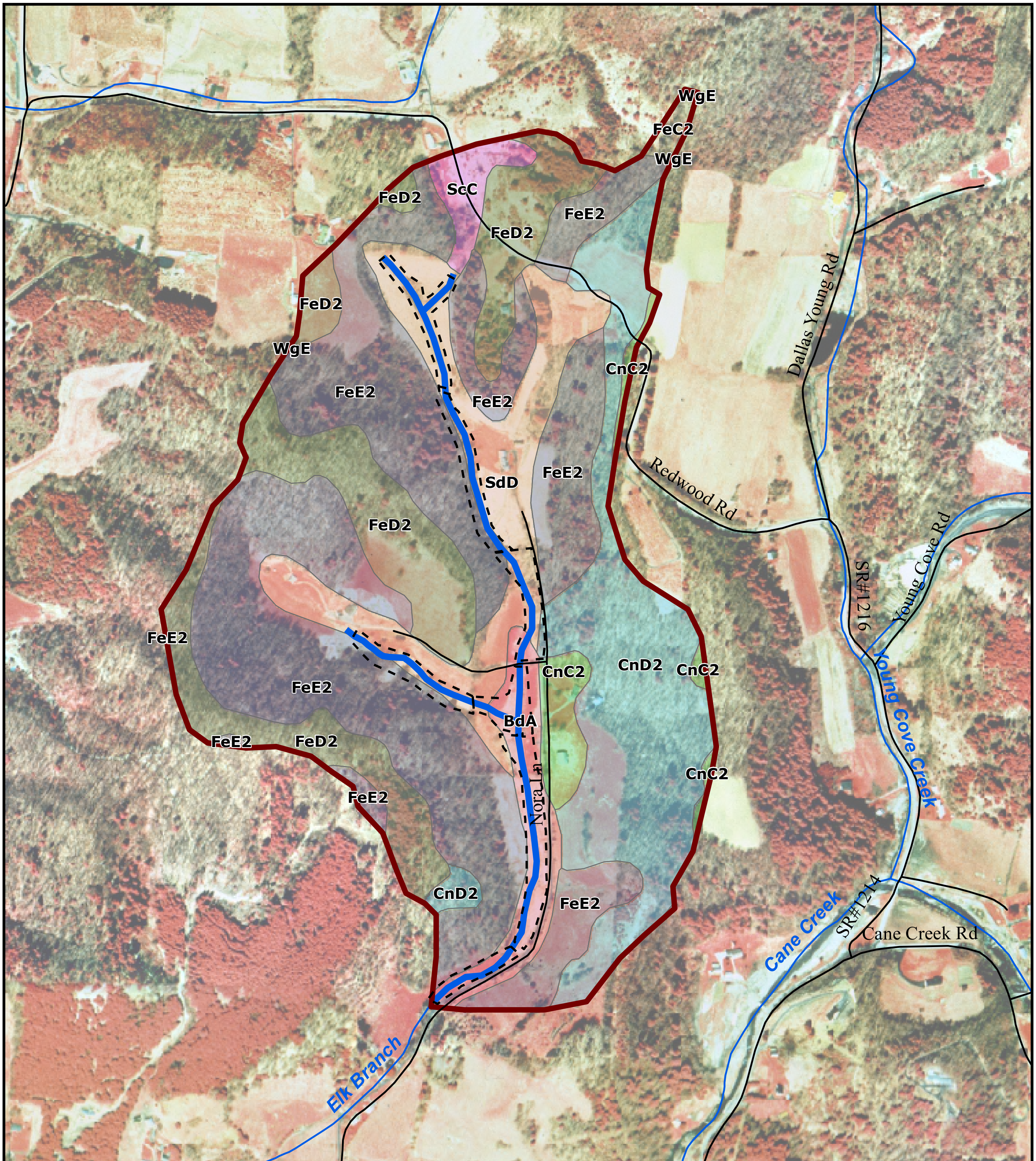
The NCDWQ designates surface water classifications for water bodies such as streams, rivers, and lakes which define those uses to be protected within these waters (e.g., swimming, fishing, and drinking water supply). These classifications are associated with a set of water quality standards to protect those uses. All surface waters in North Carolina must at least meet the standards for Class C (fishable/swimmable) waters. Other classifications provide additional levels of protection for primary water contact recreation (Class B) and drinking water supplies (WS). In addition to these primary classifications, supplemental classifications are sometimes assigned to water bodies to protect special uses or values.

The NCDWQ has classified Elk Branch [NCDWQ Stream Index No. 7-2-59-8] as a Class C waterbody with a supplemental classification of “Tr.” The Tr supplemental classification is intended to protect habitat for natural trout propagation and survival of stocked trout. This classification primarily affects the quality of permitted discharges and recognizes a 25 foot riparian buffer administered by the Division of Land Quality.

2.3 Physiography, Geology and Soils

The Elk Branch project area lies within the Blue Ridge physiographic province of western North Carolina. The Blue Ridge province is mostly underlain by Precambrian crystalline and metasedimentary rocks. The Blue Ridge Belt contains a complex mixture of igneous, sedimentary and metamorphic rock that has repeatedly been squeezed, fractured, faulted and twisted into folds. In the Middle to Late Proterozoic era, sedimentary, volcanic and igneous rocks formed in the Blue Ridge and metamorphosed to gneisses and schists. Geological features underlying the project site are classified under the Ashe Metamorphic Suite and Tallulah Falls Formation. According to the 1985 North Carolina State Geologic Map (North Carolina Geological Survey) and information extrapolated from the 1 degree by 2 degree geologic map of the Charlotte Quadrangle prepared by the USGS (Goldsmith, Milton, and Horton, 1988, Map I-1251-E), much of the site is set on muscovite-biotite gneiss which can be locally sulfidic. The muscovite-biotite gneiss is interlayered with mica schist, minor amphibolite, and horneblende gneiss. The project area also features an abundance of thin sills and dikes classified as Bakersville Metagabbro from the Late Proterozoic. A section of unconformity classified as migmatitic biotite-hornblende gneisses from the Middle Proterozoic period is located northwest of the project area. A pre-metamorphic thrust fault near the project site trends toward the southeast.

Soil types at the site were researched using Natural Resources Conservation Service (NRCS) soil survey data for Mitchell County, along with on-site evaluations to determine any hydric soil areas. A map depicting the boundaries of each soil type is presented in Figure 2.1. There are four general soil types found within the project boundaries. A discussion of each soil type is presented in Tables 2.0 and 2.1. On-site observations of soil conditions do not indicate any limitations to performing the work described in this proposal. The presence of shallow bedrock in some areas has been designed around and should not be a factor during construction. The predominant soil series within the floodplain area of the site is mapped as the Bandana series. This soil type is considered a partially hydric soil type in Mitchell County, indicating that in some areas of mapped Bandana soils, inclusions of hydric soils can compose up to 3% of the mapped areas.



LEGEND:

Soils

- BdA, Bandana
- CnC2, Clifton
- CnD2, Clifton
- FeD2, Fannin
- FeE2, Fannin
- ScC, Saunook
- SdD, Saunook-Thunder
- WgE, Watauga
- Project Reach
- Proposed Easement Boundary
- Streams
- Watershed Boundary

0 200 400 800 Feet

Figure 2.1 Project Soil Types

Elk Branch Restoration Project
Mitchell County, NC

Pockets of hydric soils were observed outside the construction area and will be flagged during construction to prevent incidental impact. It is anticipated that the proposed Priority 1 Restoration strategy through much of the project will improve the hydrology in these soils and has the potential to create wetland habitat.

Table 2.0 Project Soil Types and Descriptions
Elk Branch Restoration Plan- EEP Project # D06125-B

Soil Name	Taxonomic Class	Location	Description
Bandana sandy loam	Coarse-loamy, mixed, active, nonacid, mesic Aeric Fluvaquents	Nearly level floodplains	The Bandana series consists of a somewhat poorly drained, moderately permeable upper soil layer with rapid or very rapid permeability in the lower part of the soil. Formed in recent alluvium consisting of loamy soil material that is underlain by sandy-skeletal soil material within a depth of 40 inches. Slopes range from 0 to 3 percent.
Saunook-Thunder complex	Fine-loamy, mixed, superactive, mesic Humic Hapludults/ Loamy-skeletal, mixed, active, mesic Humic Hapludults	Benches, fans and toe slopes in coves/ Colluvial toe slopes, drainageways and coves.	The Saunook-Thunder complex consists of very deep, well drained, moderately permeable soils. Soils in this complex originated in colluvium consisting of weathered felsic to mafic, igneous and high-grade metamorphic rocks. Slopes typically range from 15% to 30%.
Fannin sandy clay loam	Fine-loamy, paramicaceous, mesic Typic Hapludults	Uplands	These eroded soils are very deep, well drained soils on moderately steep upland terrain. Fannin soils formed in residuum weathered from mica schist and mica gneiss. Slopes typically range from 15 % to 30%.
Saunook silt loam	Fine-loamy, mixed, superactive, mesic Humic Hapludults	Fans on mountain slopes, mountains.	Saunook soils are well drained and typically occur on stony slopes 8% to 15%. This soil unit is made up of colluvium from igneous and metamorphic rock.

Note: NRCS, USDA. Official Soil Series Descriptions
http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi,
http://soildatamart.nrcs.usda.gov/Report.aspx?Survey=NC121&UseState=NC

Table 2.1 Project Soil Type Characteristics
Elk Branch Restoration Plan- EEP Project # D06125-B

Series	Max Depth (in)	% Clay on Surface	Erosion Factor K	Erosion Factor T	Runoff Class	OM%
Bandana sandy loam	>60	10-20	.20	4	Very Low	4.0-8.0
Saunook-Thunder complex	>60	7-20/ 12-27	.24/.05	5/5	Very low to medium/ Low on gentle slopes; high on steeper slopes	4.0-10.0
Fannin sandy clay loam	>80	5-35	.32	5	Well drained. Runoff is slow in forested areas; becomes medium to rapid where forest cover is removed.	0-2.0
Saunook silt loam	>99	12-35	.15-.32	5	Well drained; runoff is very low to medium.	0-10.0

Note: NRCS, USDA. Official Soil Series Descriptions
http://ortho.ftw.nrcs.usda.gov/cgi-bin/osd/osdname.cgi,
http://soildatamart.nrcs.usda.gov/Report.aspx?Survey=NC121&UseState=NC

2.4 Historic Land Use and Development Trends

The Elk Branch watershed drains predominantly forested and agricultural lands. A small number of residences are also located within this drainage area. This project watershed has been impacted by previous activities including timber harvesting, agriculture, livestock grazing and channelization. The current land use adjacent to the project site is grazed pasture and the upper portions of the watersheds have been reforested. Potential for land use change in the area adjacent to the conservation easement is low.

A considerable portion of the watershed remains under forested cover with abundant wildlife. The percentage of land in the watershed available to agriculture is 33% with approximately 60% of the watershed remaining as forest land (Table 2.2). Management of land in the watershed for agricultural purposes has induced changes to Elk Branch and its tributaries primarily through alteration of drainage patterns, removal of vegetation in the riparian zone, and open access of cattle to the channels.

Under the present condition, riparian buffers are small or non-existent, stream banks are trampled, worn down and eroding throughout the project, exotic vegetation is widespread, and lingering effects of stream channelization and channel dredging are evident through much of the project site. As a result of these practices, streams and buffers throughout the project site have been adversely impacted by sediment and nutrient loading which is carried downstream to Cane Creek.

Although located in close proximity to the town of Bakersville, the Elk Branch watershed is not located near any major population centers. Management of land in the project area for agricultural purposes has induced changes to Elk Branch and its tributaries primarily through alteration of drainage patterns, removal of vegetation in the riparian zone, and open access of cattle and horses to the branches. Restoration of the site and removal of livestock from the stream corridors will reduce the sediment and nutrient loading to Elk Branch and in turn improve water quality in Cane Creek.

Table 2.2 Elk Branch Watershed Land Use/Land Cover
Elk Branch Restoration Plan- EEP Project # D06125-B

Land Use Category[1]	Area (acres)	Percent Area
Developed, Open Space	7.6	3.9%
Deciduous Forest	79.6	40.9%
Evergreen Forest	16.6	8.5%
Mixed Forest	14.9	7.7%
Shrub/Scrub	11.3	5.8%
Pasture/Hay	64.4	33.1%

Note: 1. Values calculated using USGS land use data from 2001.

2.5 Watershed Planning

The Elk Branch project site lies within the Cane Creek Watershed. Cane Creek, which lies within the NCDWQ French Broad River sub-basin 04-03-06 and USGS local watershed unit 06010108040010, has not been designated as a targeted watershed. The Right Fork of Cane Creek (AU#7-2-59-1), which lies upstream of the confluence of Elk Branch and Cane Creek was previously considered an impaired waterbody. Although some problems persist with bank erosion and riparian width, the NCDWQ recommended this stream be removed from the state's 2006 303(d) list of impaired waters based on biological sampling completed by the state (NCDENR 2005). Streambank and channel stabilization measures proposed under this plan for the Elk Branch watershed will ultimately contribute to improving water quality in Cane Creek and the North Toe River downstream which contains Appalachian elktoe habitat.

Some of the key measures of the Elk Branch restoration project will involve stabilizing channels and restoring access of the streams to their floodplains, as well as improving in-stream habitat by incorporating woody debris and providing a more diverse bedform with improved riffle/step-pool sequencing. Terrestrial habitat will also be improved by re-establishing riparian areas with vegetation native to the area. These buffers will be protected under a conservation easement and will improve water quality by aiding in sediment and nutrient removal from stormwater runoff. These measures ultimately support the state's efforts of water quality improvement within the Cane Creek Watershed through a reduction in site runoff from unstable streambanks and channel dimension as well as restoration of both aquatic and terrestrial habitat.

2.6 Endangered/Threatened Species

Some populations of plants and animals are declining because of either natural forces or their inability to compete for resources with the encroachment of humans. The North Carolina Natural Heritage Program (NCNHP) and United States Fish and Wildlife Service (USFWS) composed a list of rare and protected animal and plant species that contains eleven federally listed species known to exist in Mitchell County (USFWS, 2008 and NCNHP, 2009).

Legal protection for federally listed species, Threatened (T) or Endangered (E) status, is conferred by the Endangered Species Act of 1973, as amended (16 U.S.C. 1531-1534). This act makes illegal the killing, harming, harassing, or removing of any federally listed animal species from the wild; plants are similarly protected but only on federal lands. Section 7 of this act requires federal agencies to ensure that actions they fund or authorize do not jeopardize any federally listed species.

Organisms that are listed as Endangered (E), Threatened (T), or Special Concern (SC) on the NCNHP list of Rare Plant and Animal Species are afforded state protection under the State Endangered Species Act and the North Carolina Plant Protection and Conservation Act of 1979. A current inventory of state listed organisms can be located at the NCNHP website (http://149.168.1.196/nhp/find.php).

Species that the NCNHP lists under federal protection Mitchell County as of September 8, 2009 are listed in Table 2.3. A brief description of the characteristics and habitat requirements of the federally protected species is included in the following section, along with a conclusion regarding potential project impacts.

Table 2.3 Species Under Federal Protection in Mitchell County

Elk Branch Restoration Plan- EEP Project # D06125-B

Family	Scientific Name	Common Name	Federal Status	State Status	Habitat Present / Biological Conclusion
Vertebrate					
Accipitridae	*Haliaeetus leucocephalus*	Bald Eagle	BGPA	T	No/No effect
Vespertilionidae	*Myotis sodalis*	Indiana Bat	E	E	No/No Effect
Sciuridae	*Glaucomys sabrinus coloratus*	Carolina Northern Flying Squirrel	E	E	No/No Effect
Emydidae	*Glyptemys muhlenbergii*	Bog Turtle	T (S/A)	T	No/No Effect
Invertebrate					
Unionidae	*Alasmidonta raveneliana*	Appalachian Elktoe	E	E	No/No Effect
Dipluridae	*Microhexura montivaga*	Spruce-Fir Moss Spider	E	SR	No/No Effect
Vascular Plant					
Rubiaceae	*Houstonia montana*	Roan Mountain Bluet	E	E	No/No Effect
Rosaceae	*Geum radiatum*	Spreading Avens	E	E-SC	No/No Effect

Asteraceae	*Liatris helleri*	Heller's Blazing-Star	T	T-SC	No/No Effect
Asteraceae	*Solidago spithamaea*	Blue Ridge Goldenrod	T	E	No/No Effect
Rosaceae	*Spiraea virginiana*	Virginia Spiraea	T	E	No/No Effect
Lichen					
Cladoniaceae	*Gymnoderma lineare*	Rock Gnome Lichen	E	T	No/No Effect

Notes:

BGPA: Bald and Golden Eagle Protection Act. As of August 8, 2007, the Bald and Golden Eagle Protection Act (Eagle Act) (16 U.S.C. 668 d) is the primary law protecting bald and golden eagles. The Eagle Act prohibits take of bald and golden eagles and provides a statutory definition of "take" that includes "disturb".
E: An endangered species is one whose continued existence as a viable component of the state's flora or fauna is determined to be in jeopardy.
EX: Extirpated – a species which is no longer believed to exist in the state.
T: Threatened
S/A: The Endangered Species Act authorizes the treatment of a species (subspecies or population segment) as threatened even though it is not otherwise listed as threatened if: (a) The species so closely resembles in appearance a threatened species that enforcement personnel would have substantial difficulty in differentiating between the listed and unlisted species; (b) the effect of this substantial difficulty is an additional threat to a threatened species; and (c) such treatment of an unlisted species will substantially facilitate the enforcement and further the policy of the Act. The Bog Turtle (southern population) has this designation due to similarity of appearance to Bog Turtles in the threatened northern population.
SR: Reported from North Carolina, but without persuasive documentation for either accepting or rejecting the report.
SC: A Special Concern species is one that requires monitoring but may be taken or collected and sold under regulations adopted under the provisions of Article 25 of Chapter 113 of the General Statutes (animals) and the Plant Protection and Conservation Act (plants).

A March 4, 2008 search of the NCNHP virtual database indicated there have been twelve occurrences of federally and state listed species noted within five miles of the study area (http://www.nhpweb.enrn.state.nc.us). Of these twelve occurrences, six were of federally listed species. The federally listed species observed include the Indiana bat, Carolina Northern Flying Squirrel and the Bog Turtle. A pedestrian survey of the project area was conducted on May 1, 2007 for species listed in Table 2.3. No federal protected species were observed in or adjacent to the project area during the field survey. No additional listings of populations or occurrences of these species have been added to the NCNHP list as of August 2, 2009.

The North Carolina Wildlife Resources Commission (WRC) has been contacted and has indicated that due to the presence of wild trout, in channel work and land disturbance within the 25-foot wide buffer zone should be prohibited during the rainbow trout spawning season of January 1 through April 15 (Appendix B). Baker will adhere to this requirement. In addition, Baker will consider the effects of construction activities and plan to minimize direct and indirect impacts during the project.

The USFWS was notified of the project on March 23, 2007. To date, no letter of response has been received.

2.6.1 Federally Listed Endangered Species

2.6.1.1 Vertebrates

Haliaeetus leucocephalus (Bald Eagle)

Bald eagles are large raptors, 32 to 43 inches long, with a white head, white tail, yellow bill, yellow eyes, and yellow feet. The lower section of the leg has no feathers. Wingspread is about seven feet. The characteristic plumage of adults is dark brown to black with young birds completely dark brown. Juveniles have a dark bill, pale markings on the belly, tail, and under the wings and do not develop the white head and tail until five to six years old.

According to the NHP species account, bald eagles in the Southeast frequently build their nests in the transition zone between forest and marsh or open water. Nests are cone-shaped, six to eight feet from top to bottom, and six feet or more in diameter. They are typically constructed of sticks lined with a combination of leaves, grasses, and Spanish moss. Nests are built in dominant live pines or cypress trees that provide a good view and clear flight path, usually less than 0.5 miles from open water. Winter roosts are usually in dominant trees, similar to nesting trees, but may be somewhat farther from water. In North Carolina, nest building takes place in December and January, with egg laying (clutch of one to three eggs) in February and hatching in March. Bald eagles are opportunistic feeders consuming a variety of living prey and carrion. Up to 80 percent of their diet is fish, which is self caught, scavenged, or robbed from osprey. They may also take various small mammals and birds, especially those weakened by injury or disease.

(Henson 1990, Potter et al. 1980, USFWS 1992a)

Biological Conclusion: No Effect

According to the NCNHP virtual workroom website, a recorded occurrence of bald eagle habitat has not been documented within five miles minimum of the project site. This five mile radius includes the nearest large body of water, the North Toe River, approximately three and a half miles from the project area. The Elk Branch project area consists of headwater streams with small drainage areas. Elk Branch does support prey-sized fish while its tributaries are too small to support bald eagle populations. However, the lack of recorded observations and the fact that the bald eagle is not listed as occurring in Mitchell County make it highly unlikely that bald eagles would be adversely affected by this project.

Canopy improvements made to the riparian zone within the restoration and enhancement reaches of the project area could actually support bald eagles in the long term should any of the planted trees become dominant canopy trees. Therefore, a determination was made that the proposed project will have no adverse effect on this species.

Myotis sodalis (Indiana Myotis)

The Indiana bat is 3.5 inches long, with mouse-like ears, plain nose, dull, grayish fur on the back, and lighter, cinnamon-brown fur on the belly. Its “wingspread” ranges from 9.5 to 10.5 inches. From early October until late March and April, Indiana bats hibernate in large clusters of hundreds or even thousands in limestone caves and abandoned mines, usually near water. During summer, females establish maternity colonies of two dozen to several hundred under the loose bark of dead and dying trees or shaggy-barked, live trees, such as the shagbark hickory. Hollows in live or dead trees are also used. Most roost trees are usually exposed to the sun and are near water. Males and non-reproductive females typically roost singly or in small groups. Roost trees can be found within riparian areas, bottomland hardwoods, and upland hardwoods (Adams 1987, USFWS 1992a).

Biological Conclusion:

The preferred summer habitat for maternity colonies (female and young) of the Indiana bat populations consists of tree hollows and trees with loose bark such as the shagbark hickory. In addition, the bats favor trees near small-to medium-sized streams. Because the few trees located along the project reach are primarily tag alder, a tight-barked species, they do not offer roosting opportunities. Any other large trees that are located in the project area will be avoided and protected during construction. Because no potential habitat will be impacted by this project there should be no effect on this species.

Glaucomys sabrinus coloratus (Carolina Northern Flying Squirrel)

The Carolina northern flying squirrel is a small nocturnal gliding mammal some 260 to 305 millimeters (10 to 12 inches) in total length and 95-140 grams (3-5 ounces) in weight. It possesses a long, broad, flattened tail (80 percent of head and body length), prominent eyes, and dense, silky fur. The broad tail and folds of skin between the wrist and ankle form the aerodynamic surface used for gliding. Adults are gray with a brownish, tan, or reddish wash on the back, and grayish white or buffy white ventrally. Juveniles have uniform dark, slate-gray backs, and off-white undersides. The northern flying squirrel can be distinguished from the southern flying squirrel by its larger size, the gray base of its ventral hairs as opposed to a white base in the southern species, the relatively longer upper tooth row; and the short, stout baculum (penis bone) of the males.

(Cooper et al. 1977, Terwilliger et al. 1995, USFWS 1992a, Weigl 1987)

Biological Conclusion:

The Carolina northern flying squirrel prefers the ecotone between coniferous and mature northern hardwood forests usually above 4,500 feet or narrow, north-facing valleys above 4,000 feet. The project site is located in pasture land with very few trees and does not contain habitat as described above. Dominant woody vegetation observed during a May 1, 2007 site visit consisted of tag alder, fescue and multiflora rose. The elevation of the site is approximately 2,600 feet and well below what would be expected for this animal. Due to a lack of suitable habitat, there should be no effect on this species.

Clemmys muhlenbergii (Bog Turtle)

The Bog Turtle is among the smallest turtles of North America at only 3-4.5 inches in length with an average weight of 4 ounces. Its shell is light brown to ebony in color and it has a notable bright orange, yellow or red blotch on each side of its head. The bog turtle's preferred habitat in the southern Appalachians includes sphagnum bogs, slowly drained swamps, and mucky, slow moving spring-fed streams in meadows and pastures that are typically less than 4 acres in size (USFWS 1997a).

Biological Conclusion: No Effect

The Elk Branch site is located in a sunny, open area, but it lacks shallow spring-fed fens, and sphagnaceous bogs. There are several small, depressional, moist areas located in pastureland near the project, the largest of which is .25 to .50 acres in size. However, these areas lacked evidence that conditions remained wet enough to support bog turtles. Streams at the Elk Branch site are fairly fast flowing. Insignificant areas of marginal habitat quality make the presence of this species highly unlikely and no individuals were observed during the site assessment. Preliminary discussions with USFWS staff indicate that the project streams are unlikely to be suitable habitat for bog turtles. Therefore the project should have no effect on this species.

2.6.1.2 Invertebrates

Alasmidonta raveneliana (Appalachain Elktoe)

The Appalachian elktoe has a thin, but not fragile, kidney-shaped shell, reaching up to about 3.2 inches in length, 1.4 inches in height, and one inch in width (Clarke 1981). Like other freshwater mussels, the Appalachian elktoe feeds by filtering food particles from the water column. The specific food habits of the species are unknown, but other freshwater mussels have been documented to feed on detritus, diatoms, phytoplankton, and zooplankton (Churchill and Lewis 1924). The species has been found in relatively shallow, medium-sized creeks and rivers with cool, clean, well-oxygenated, moderate- to fast-flowing water. The species is most often found in riffles, runs, and shallow flowing pools with stable, relatively silt-free, coarse sand and gravel substrate associated with cobble, boulders, and/or bedrock. Stability of the substrate appears to be critical to the Appalachian elktoe, and the species is seldom found in stream reaches with accumulations of silt or shifting sand, gravel, or cobble. Individuals that have been encountered in these areas are believed to have been scoured out of upstream areas during periods of heavy rain, and have not been found on subsequent surveys (USFWS Webpage; C. McGrath, pers. comm. 1996; J.A. Fridell, pers. observation 1995, 1996, 1999).

Biological Conclusion: No Effect

The Appalachian elktoe prefers morphologically stable stream reaches with no silt accumulation or heavily shifting substrate, which does not currently exist on the site. Preliminary discussions with NCWRC and USFWS staff indicate that the project streams are unlikely to be suitable habitat for the Appalachian elktoe. The project streams are very small with a bankfull width less than 10 feet and high levels of silt. Both stream banks are very unstable due to cattle trampling. The described habitat does not exist within the project reach and no individual specimens were observed. This project should have no direct impacts to a population or habitat for this species. Project erosion control measures will insure that impacts to downstream habitats are minimized or avoided. Project objectives may produce improved long-term habitat conditions.

Microhexura montivaga (Spruce-fir Moss Spider)

The spruce-fir moss spider prefers to occupy moist, well-drained moss and liverwort mats growing on rocks or boulders in relatively undisturbed forested areas. Specifically, these moss-covered rocks and boulders should be located within well-shaded areas of mature, high-elevation Fraser fir and fir dominated spruce-fir forests.

Biological Conclusion:

No stands of high-elevation Fraser fir or spruce-fir forests exist within the project site. Additionally, the project area is located in a previously disturbed area that remains actively managed as pastureland for livestock. This project will have no direct impacts to a population or habitat for this species.

2.6.1.3 Vascular Plants

Houstonia Montana (Roan Mountain Bluet)

Roan Mountain bluet is a shallow-rooted, perennial herb of the coffee family that grows 4-6 inches (10-15 cm) tall. According to a species account summarized by the NHP, small leaves are located along the four-cornered stem of the Roan Mountain bluet. Its leaves can be lance or ellipse-shaped and are 0.2-1.2 inches (0.8-3 cm) long. The Roan Mountain bluet is also characterized by a rosette of leaves that grows at the base of the plant which is not always visible during flowering. The deep-purple colored flowers of the plant are funnel-shaped and grow in clusters of 1-4. The N.C. Natural Heritage Program and USFWS websites list the preferred habitat for the Roan Mountain Bluet as grassy balds, cliffs, outcrops, and steep slopes with full sun at high elevations 4,590-6,230'ASL (1400-1900 m). This plant is typically found in gravelly soils among rock outcrops. Soils requirements consist of units derived from metamorphic, acidic rock. Adjacent forests are usually spruce-fir forests. In the southern Appalchians, these forests are dominated by red spruce (*Picea rubens*) and Fraser fir (*Abies fraseri*).

(Radford et al. 1964; USFWS 1992a, 1996b)

Biological Conclusion:

The project area is located at an elevation of approximately 2,600 feet and does not contain spruce-fir forests or gravelly outcrops. Current and favored site conditions are not conducive to sustaining populations of the Roan Mountain Bluet. It is not anticipated that the project will have a direct impact on this species or its habitat.

Geum radiatum (Spreading Avens)

Spreading avens is a perennial herb of the rose family. It can grow 8-20 inches (20-50 cm) high and has dense, spreading hairs. Most leaves of the spreading avens grow from a rosette at the plant base. These leaves are large and kidney shaped, with uneven, serrated edges. Spreading avens plant stems typically have between two to five smaller leaves. According to the NHP species account, "…an indefinite cyme of 1-3 flowers grows at the end of each stem, with 5 lance-shaped sepals, and 5 bright yellow petals 0.5-0.8 inch (1.3-2 cm) long, with numerous stamens and pistils." Similar to the Roan Mountain Bluet, the Spreading avens thrives on (preferably north-facing) high-elevation cliffs,

outcrops, grassy balds, and steep slopes that receive full sunlight. Adjacent forests in which the spreading avens occurs are dominated by red spruce *(Picea rubrens)* and Fraser fir *(Abies fraseri).* Spreading avens prefers shallow, acidic soils located in the cracks and crevices of weathering igneous, metamorphic and metasedimentary rocks. This plant can survive in well drained soil, though the soil must receive a constant source of moisture.
(Early 1991; Hardin 1977; Radford et al. 1964; USFWS 1992a and 1993c.)

Biological Conclusion:

Topographical and exposed geologic features of the project site are not favored by the Spreading avens. The lack of habitat indicators in the project site has been visually confirmed during previous field visits. This project will have no direct impacts to a population or habitat of this species.

Liatris helleri (Heller's Blazing-Star)

According to the NHP and USFWS species accounts, Heller's Blazing-star is a perennial herb of the aster family. It can have one or more erect stems that grow to 16 inches (40 cm) tall, out of a tuft of pale green leaves at the base of the plant. Its upper leaves are alternate, long and narrow. The flowers of this perennial are scattered in 3-8 inch long spiky clusters along the stem(s). Individual flowers are tubular-shaped and lavender in color. Habitat conditions suited for Heller's Blazing-star consist of high-elevation, rock ledges and shallow acidic soils which are exposed to full sunlight (Radford et al. 1964, USFWS 1992a).

Biological Conclusion:

Current and favored site conditions are not conducive to the presence of Heller's Blazing-star. This project will have no direct impacts to a population or habitat for this species.

Solidago spithamaea (Blue Ridge Goldenrod)

The NHP species account for the Blue Ridge goldenrod lists the plant as a hairy perennial with erect and and angled stems that is strongly ribbed at the base. The Blue Ridge goldenrod can grow 4-16 inches (10-41 cm) tall and has yellow-green leaves alternate leaves that line the stem. Its elliptical shaped leaves can be 1 to 2.5 inches (3-6 cm) long, and have a smooth surface with serrated edges. The flowering head consists of 20-30 flat-topped, yellow flowers. Flower petals on the edge of the flower head are usually 0.8-1.6 inches (2-4 cm) long. The N.C. Natural Heritage Program lists the preferred habitat for the Blue Ridge Goldenrod as grassy balds, cliffs, outcrops, and ledges of higher mountain peaks, above 4600'ASL (1400 m) in elevation that are exposed to full sun (Hardin 1977; Lowe et al. 1990; Radford et al. 1964; USFWS 1987 and 1992a.). The Blue Ridge Goldenrod favors soils that are generally acidic and consist of shallow humus or clay loams that are intermittently saturated.

Biological Conclusion:

Both sites are at an elevation of approximately 2,600 feet and have no spruce-fir forests or rocky areas. None of the described habitat for this species was present at either site. This project will have no direct impacts to a population or habitat for this species.

Spiraea virginiana (Virginia Spiraea)

Preferred habitat of the Virginia spiraea ranges from flood-scoured, high-gradient rocky riverbanks, gorges, and canyons to braided areas of stream reaches. Virginia spiraea have also been observed in disturbed rights-of-way. Virginia spiraea prefer sunlight and moist, acidic soils (primarily sandstones). This plant grows in thickets, and is commonly associated with a variety of grape species (Vitis spp.) and royal fern (Osmunda regalis), though it may still be located in thickets where these other plants are not present. Habitat conditions for the Virginia spiraea must be present in some combination in order for the spiraea to flourish. Due to the specificity of site conditions needed, the Virginia spiraea is limited to a specific ecological niche (Radford et al. 1964, USFWS 1992a.).

Biological Conclusion:

Elk Branch and its tributaries are very small with a bankfull width less than 10 feet, high levels of silt and have a medium gradient. Both stream banks are very unstable due to cattle trampling. The ecological niche described does not exist within the project area; Virginia spiraea has not been observed on-site during previous field visits. This project will not directly impact a population of Virginia spiraea or its habitat.

2.6.1.4 Lichen

Gymnoderma lineare (Rock Gnome Lichen)

Rock Gnome Lichen grows in dense colonies of narrow straps (squamules) that appear a bluish-grey on the surface and a shiny white on the lower surface. The squamules are about 1 millimeter across near the tip, tapering to the blackened base, sparingly and subdichotomously branched, and generally about 1 to 2 centimeters (.39 to .79 inches) long, although they can vary somewhat in length, depending upon environmental factors. Flowering occurs between July to September; fruiting bodies are located at the tips of the squamules and are also black. The squamules are nearly parallel to the rock surface, with the tips curling away from the rock, in a near perpendicular orientation to the rock surface.

The rock gnome lichen is endemic to the southern Appalachian Mountains of North Carolina and Tennessee, where it is limited to 32 populations. Only seven of the remaining 32 populations cover an area larger than 2 square meters (2.4 square yards). Most populations are 1 meter (3.3 feet) or less in size (USFWS, 1997b).

Rock gnome lichen habitat is located around humid, high elevation rock outcrops or vertical cliff faces or in rock outcrops in humid gorges at lower elevations. Most populations occur above an elevation of (5,000 feet) (USFWS, 1997b).

Biological Conclusion:

Due to the degraded stream conditions within the project site and the lack of other habitat criteria necessary, it is not likely that the rock gnome lichen is present with the project area. No rock gnome lichen have been observed during previous field visits to the project area, nor are there any known populations of the lichen within five miles of the site. Project activities are not expected to adversely impact rock gnome lichen populations or their habitat in Mitchell County.

2.7 Cultural Resources

A letter was sent to the North Carolina State Historic Preservation Office (SHPO) on March 23, 2007, requesting a review and comment on how this project may impact cultural resources in the vicinity of the Elk Branch restoration site. A response was received on April 25, 2007, indicating that the SHPO had reviewed the proposed project and was not aware of any historic resources that would be affected by the project. A letter was sent to the Eastern Band of Cherokee Indians Tribal Historic Preservation Office (THPO) on April 6, 2007, requesting comment for the potential of cultural resources in the vicinity of the Elk Branch project area. To date, no response has been received. No formal surveys have been performed at the site previously. A copy of the SHPO correspondence is included in Appendix B.

2.8 Potential Constraints

Baker assessed the Elk Branch project site in regards to potential fatal flaws and site constraints. No fatal flaws have been identified during project design development.

2.8.1 Property Ownership and Boundary

Baker has obtained a conservation easement from the current landowners for the Elk Branch project property. The easement is held by the State of North Carolina and was recorded at the Mitchell County Courthouse (Deed Book 494, Page Numbers 630-645 and Deed Book 493, Page Numbers 771-776) on September 9, 2009. The easement allows Baker to proceed with the restoration project and restricts the land use in perpetuity.

The site can be accessed for construction and post-restoration monitoring. Construction access and staging areas will be identified during final design.

2.8.2 Utilities

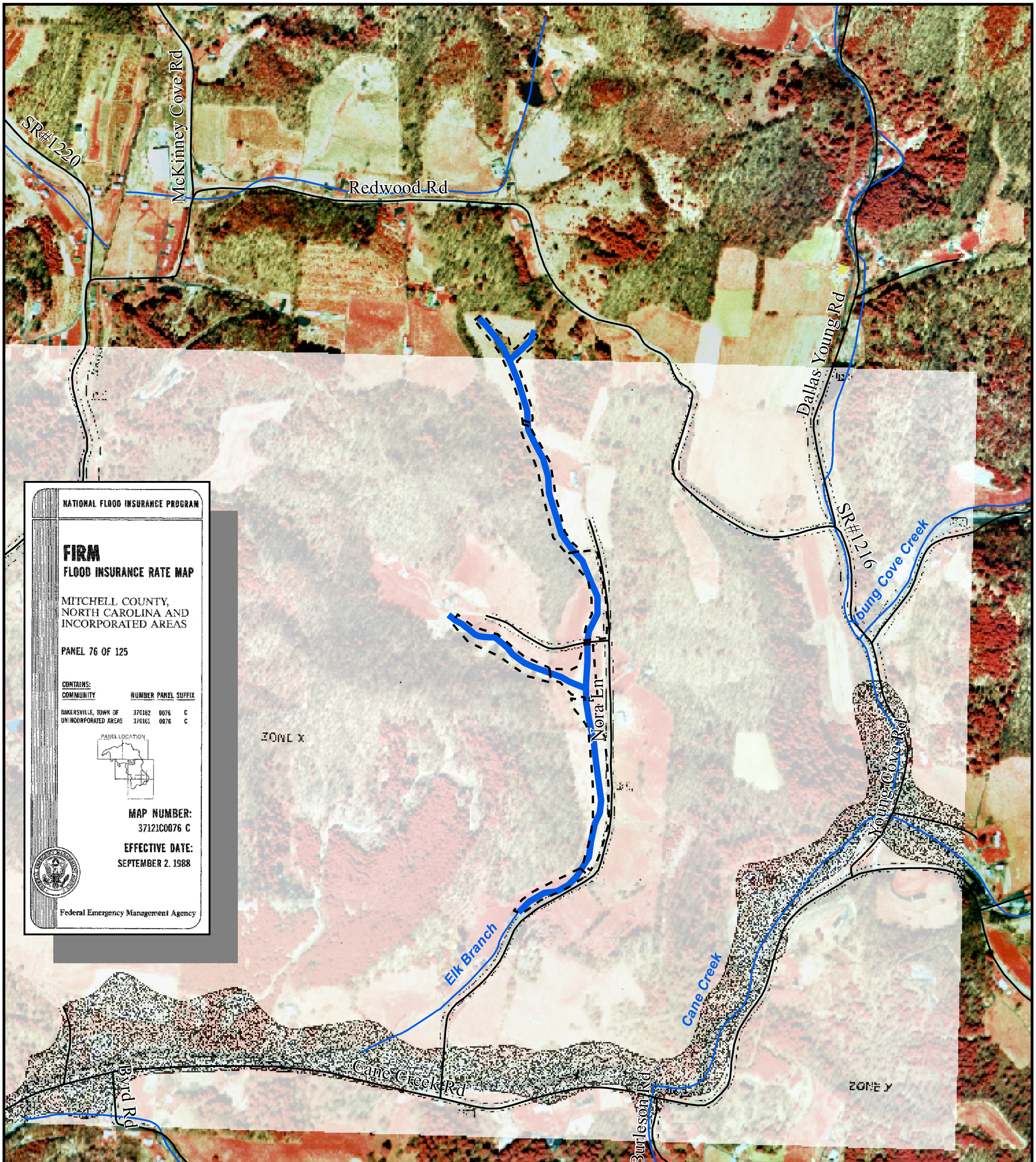
Power poles are presently situated within the easement; utility lines run through portions of the easement and construction corridor for the Elk Branch project. Baker has arranged with the French Broad Electric Company and land owners to bury this line outside of the conservation easement. No other utilities are known to exist in the project area.

2.8.3 Hydrologic Trespass and Floodplain Characterization

Elk Branch is a small, second order tributary to Cane Creek. The Federal Emergency Management Administration (FEMA) Preliminary Flood Insurance Rate Map (FIRM) dated December 7, 2007, for Mitchell County, NC, (Panel Numbers 3710087400J and 3710087300J) indicates that the project is not located within a special flood hazard area (see Figure 2.2). Therefore, no flood study is planned as part of this project. Although this project entails re-connecting segments of Elk Branch with its floodplain, it is not anticipated that the design approach will result in a significant change in flood elevations. Furthermore, no insurable structures are in the area of the stream project and any change in the 100-year water surface is expected to be minimal and contained within the conservation easement.

2.9 Potentially Hazardous Environmental Sites

An EDR Transaction Screen Map Report that identifies and maps real or potential hazardous environmental sites within the distance required by the American Society of Testing and Materials (ASTM) Transaction Screen Process (E 1528) was prepared for the site on April 6, 2007. A copy of the report with an overview map is included in Appendix C. The overall environmental risk for this site was determined to be low. Environmental sites including Superfund (National Priorities List, NPL); hazardous waste treatment, storage, or disposal facilities; the Comprehensive Environmental Response, Compensation, and Liability Act Information System (CERCLIS); suspect state hazardous waste, solid waste or landfill facilities; or leaking underground storage tanks were not identified by the report in the proposed project area. During field data collection, there was no evidence of these sites in the proposed project vicinity, and conversations with landowners did not reveal any further knowledge of hazardous environmental sites in the area.



LEGEND:

Project Reach

Streams

Proposed Easement Boundary

0 200 400 800 Feet

Figure 2.2 FEMA Floodplain Map
Flood Insurance Rate Map
Map Number 37121C0076 C

Elk Branch Restoration Project
Mitchell County, NC

Ecosystem Enhancement Program

Baker

3.0 PROJECT SITE STREAMS (EXISTING CONDITIONS)

3.1 Existing Conditions Survey

Valley topography was obtained by utilizing aerial LIDAR to produce atopographic survey with sufficient accuracy to create a 1-foot contour topography survey map. Baker performed a total station survey of the project reaches and floodplain to capture existing topography and measure existing geomorphic conditions. The survey enabled the creation of a topographic surface model so that the existing ground profile along the new channel alignment could be shown on the construction drawings.

Along with providing a longitudinal profile, the total station survey included 2 detailed cross-sections supplemented by dozens of “mini” cross-sections (field survey data of the top of bank, toe of channel, and thalweg). The “mini” cross-sections were spaced at intervals so as to adequately define changes in both the planform and channel dimension; additional survey shots were taken to capture the profile in detail. This resulted in a “mini” cross-section spacing ranging from 10-100 LF. The “mini” cross-sections were used to help guide design as described in Section 6.3.1. Figure 3.1 illustrates the locations of cross-section surveys and each project reach. Surveyed cross-sections and profiles are included in Appendix D. A photo log that depicts the existing conditions at the Elk Branch project site is provided in Appendix E.

Baker also collected a substrate sample to characterize stream sediments. A cumulative frequency graph based on this sample is included in Appendix F.

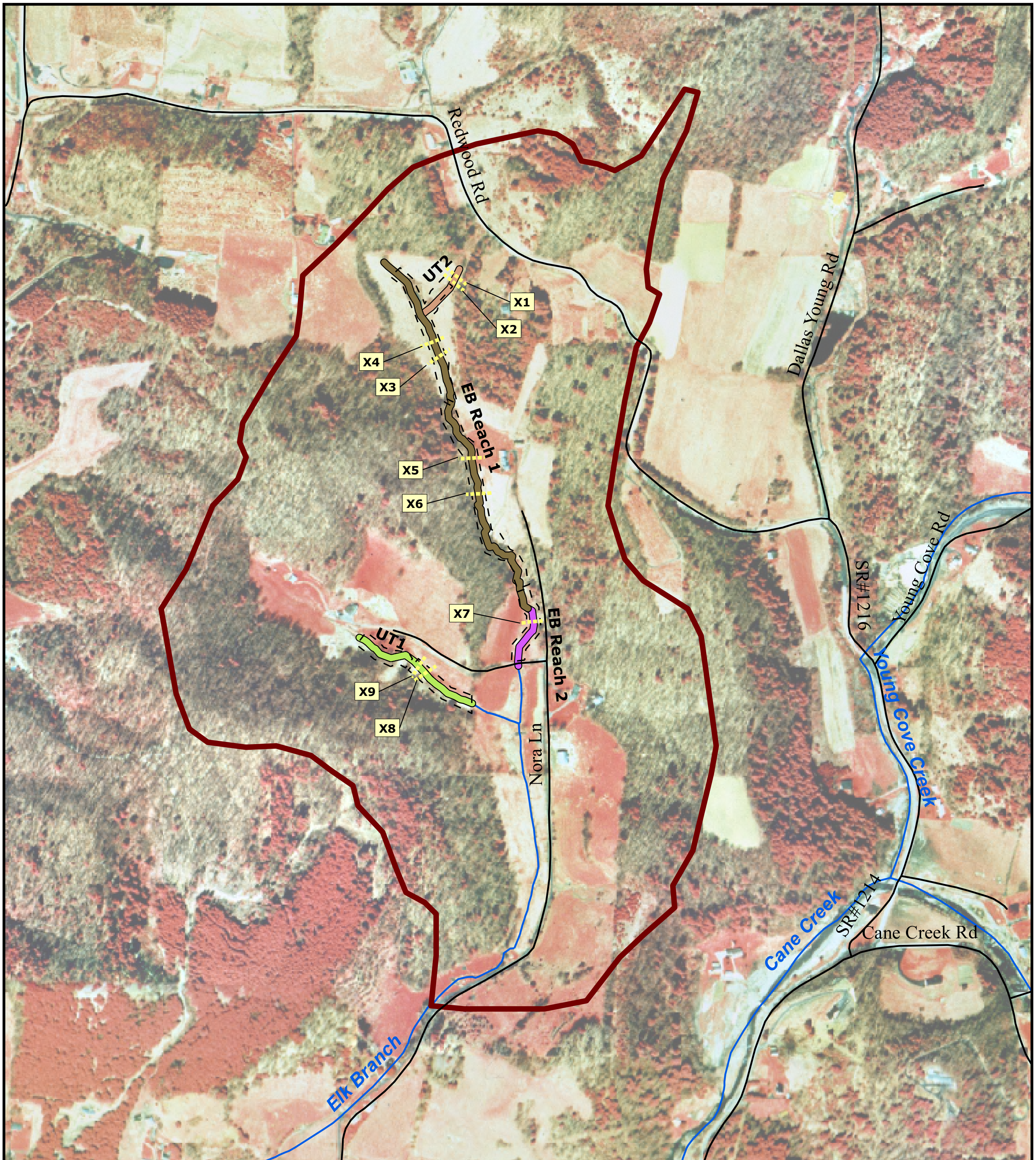
The existing conditions of designated project reaches are described below and Table 3.0 summarizes the representative geomorphic conditions currently present at the Elk Branch restoration site. The table also provides regional curve data for comparison based on the drainage area of each reach. A more detailed discussion of the assessment conducted to determine channel stability and channel forming discharge for project streams is included in Sections 3.5 through 3.7.

Baker assessed the stream and valley types present and considered their evolutionary stage and likely endpoint in order to develop a basis for the proposed restoration efforts. The project area primarily consists of colluvial valleys. There are Cb, B, G, Eb and Fb stream types found within the project reaches. All streams have been altered by straightening, manmade levy creation, or livestock impacts.

3.2 Channel Classification

Reach 1 of Elk Branch contains subreaches that may be classified by the following stream types: B, G, and straightened Eb. High bank height ratios are common in this reach. Streams have been straightened and moved; in some cases, material has been built up along the top of the bank as a manmade levy. Reach 2 of Elk Branch is classified as an Eb-type stream, but has stability issues related to toe erosion and a lack of profile diversity. There are no pools in the reach and there is a concern that long term stability could be compromised if some grade control is not established and toe erosion continues. Unnamed Tributary 1 drains a steep side valley at the lower limits of the project area and is an Fb stream type that has high bank height ratios and entrenchment ratio suggestive of a G streamtype. Its high bank height ratio (2-3) is a result of straightening and casting of dredged material on the banks. Unnamed Tributary 2 is a smaller B-type stream near the top of the project that converges with Elk Branch to form the headwaters of the mainstem. UT2 has been heavily disturbed and is mostly buried through the project reach as a result of human disturbance.

The largely colluvial valley types present (discussed in the next section) should support the B-type, step-pool channel designed for the Elk Branch project site. Streams classified as B systems are usually moderately entrenched and have a moderate width-depth ratio. B-type streams are usually found in stable alluvial fans, colluvial deposits and drainageways managed by structures on gradients between 2-4%.



LEGEND:

Project Reaches
- Elk Branch Reach 1
- Elk Branch Reach 2
- UT1
- UT2

- Cross-sections
- Proposed Easement Boundary
- Streams
- Watershed Boundary

0 200 400 800 Feet

Figure 3.1 Project Reaches and Surveyed Cross-Section Locations

Elk Branch Restoration Project
Mitchell County, NC

3.3 Valley Classification

In addition to determining stream types present at the Elk Branch project site, valley types were also considered. All of the reaches in the Elk Branch restoration project are located in a Type II valley setting. Type II valleys are moderately steep colluvial valleys with gently sloping side slopes (Rosgen 1996). The channel types present in the project are commonly seen in Valley Type II drainages throughout the Blue Ridge Province where channelization, dredging and other practices associated with agricultural land use activities have directly impacted the channel and riparian zone, resulting in an unstable system.

Table 3.0 Representative Geomorphic Data for Elk Branch
Elk Branch Restoration Plan- EEP Project # D06125-B

Reach	Existing Reach Length (LF)	Watershed Size (square miles)	NC Mountain Regional Curve (Wbkf) (ft)	NC Mountain Regional Curve (Dbkf) (ft)	NC Mountain Regional Curve (Abkf) (sq ft)
Elk Branch Reach 1	2,020	0.05-0.14	6.3-9.3	0.44-0.61	3.6-6.8
Elk Branch Reach 2	279	0.14	9.3	0.61	6.8
Unnamed Tributary 1	685	0.06	6.9	0.47	4.1
Unnamed Tributary 2	185	0.01	3.7	0.28	1.5
Total Existing Stream Length	3,169 LF				

3.4 Project Reach Characterization

3.4.1 Elk Branch Reach 1

Reach 1 of Elk Branch begins about 100 feet below a spring head at the north end of the Wylie property and is 2,020 LF in length. This reach ends past the valley pinch point on the Craig property whereupon the proposed stream restoration strategy changes. Throughout the reach, the bankfull flow has very little access to the floodplain and the stream has been channelized. There are three subreaches that differ slightly in the specifics of their respective impacts but are generally in the same existing condition and warrant the same restoration approach. These segments are described below as the "upper" (0+00 to 7+27), "middle" (7+27 to ~15+00) and "lower" (15+00 to 19+50).

In the upper segment of Reach 1 above station 7+27, Elk Branch has been straightened and moved to the middle of a moderately sloping valley. The modest buffer present at the top of the reach disappears after station 3+00. Between 0+00 to 3+00, cattle access the creek for watering and the creek was previously manipulated when a small, soil dam was created for water storage (the dam has since been breached but the stream needs to be repaired). The existing channel elevation will have to be brought up since this area of the creek was excavated to hold more water.

After the confluence with UT2 (presently UT2 seeps into the stream from underground channels due to its having been buried), the straightened channel no longer has a vegetated buffer and has an average valley slope of approximately 0.03 ft/ft. However, this slope is not uniform, providing further evidence that the channel has been severely manipulated. Multiple knick points are present in the profile and no bedrock or other grade control is present. Greater incision is prominent below these features. A portion of the reach appears to have aggraded or, more likely, filled. Other supporting evidence of tampering with the stream include plastic drain pipe in the bottom of the creek bed, manmade levies on portions of the reach, and a sinuosity of 1.02.

Two cross-sections (X3 and X4) were selected from multiple surveyed cross-sections in this upstream segment of the reach; these illustrate channel dimensions which are representative of the existing geomorphic parameters in this portion of the reach. These data are provided in Table 3.1 at the end of this section and figures are provided in Appendix D; HEC-RAS was used as a guide in selecting bankfull based on the lack of any reliable physical indicators.

In many cases, reliable "bankfull" indicators were not present due to channelization, filling, and other prior anthropogenic impacts. To compensate for this, a detailed model was built in HEC-RAS with a combination of "mini" cross-sections (channel survey data on top of bank, toe of channel, and thalweg) and floodplain data from aerial survey. The model was used to provide estimates of the bankfull stage based on regional curve and USGS regression (2-year) flows. The discharge-stage relationship for the regional curve "bankfull" flow was found to be in close agreement with physical indicators in less manipulated reaches downstream (the model produced extends well beyond the project limits). Section 6.3.1 ("Existing Conditions Data") and 3.3.4 ("Role of Hydraulic Modeling Using HEC-RAS 3.1.3 in Design Discharge Selection") provide a discussion of some of the modeling results.

The Rosgen classification system for natural channels was used to assess the cross-sections; however, this system is less than ideal for channels with the level of disturbance exhibited at the Elk Branch project site. In this segment upstream of the culvert, there is no sinuosity or defined bedform, both suggesting (with other evidence) prior channelization - a common, but significant geomorphic event that causes channel degradation. Cross-section X3 classifies as a Cb-type channel (which is inconsistent with the valley type, and for which the sinuosity is not within the typical range). Cross-section X4, which is more representative of most of this segment (except that it does not portray the level of incision below the head cuts that are present), classifies as an Eb-type stream. However, this stream has no sinuosity and has a high bank height ratio. Bank height ratios in the reach are in the "highly unstable" category according to Rosgen's Channel Stability Assessment table (Table 3.7). This rating is corroborated by multiple headcuts migrating up the system and bank erosion resulting from tall steep banks. Overall, the upper part of the reach is behaving more like a G-type stream. From a geomorphological perspective, streams in this part of the watershed with slopes in this range, should typically be B-type streams with step-pool morphology providing grade control. There is no indication of the stream moving towards equilibrium. There is no riparian buffer, and the dominant species (other than pasture grasses) are invasives. The factors presented yield the conclusion that restoration will be necessary to re-establish what floodplain processes exist in steep valleys and halt erosion and headcutting.

Downstream of the 15" PVC culvert at station 7+27, the reach has been moved up against the valley wall and is similar in character to the upper part of the reach. It runs against the valley wall with trees on the hill side (right bank) and a grassed field on the valley side (left bank). The reach ends just below this field and just below a pinch-point in the valley. Cross-sections X5 and X6 in Table 3.1 represent this segment below the culvert. They were surveyed as "mini" cross-sections during the existing conditions total station survey (they include the top of bank, channel toe, and thalweg points – the floodplain topography can be used with these sections to assess relevant geomorphic ratios). This portion of the reach has a valley slope of approximately 0.03 ft/ft and has little pattern and an abundance of fine sediments filling the channel. Cross-section 5 is representative of most of the reach; it has a high bank height ratio (in this case 3.1), low W/D ratio, and medium range entrenchment ratio. It is best classified as a G-type stream, however, the entrenchment ratio is somewhat higher than a typical G due to the bowl-like channel shape. Cross-section 6 is representative of a few areas where erosion has caused a new bench to form. These areas typically have an eroding bank on one side, and a bench forming on the opposite bank. For the reach, erosion is prominent both on the valley wall side and on the field side. There is a general lack of grade control through the reach; HEC-RAS modeling indicated that the reach has poor connectivity with the floodplain.

At the bottom end of Reach 1, the channel is again experiencing stability problems resulting from the channel being against the valley wall. There is a hard bend in the creek at station 16+38. Downstream, trees have fallen in the channel and many of the banks are not at stable slopes. The best solution in this area is to pursue restoration of the channel that will move the stream away from the valley wall, create a stable channel dimension with vegetated banks, and remove debris from fallen trees.

Modeling of the USGS 2, 5, and 10-year flows indicated that the majority of Reach 1did not have a good connection with the floodplain (Pope et al., 2001). The channel invert or thalweg ("Ground"), regional curve and 10-year water surface elevations, and left and right top of bank ("LOB", "ROB") are shown in Figures 3.2 and 3.3. For the majority of the reach, there is no overbank flow at the regional curve bankfull flow or even at the 2-year flow. Significant portions of the reach hold flows higher than USGS 10-year within the channel.

Table 3.1 Geomorphic Parameters for Reach 1 Based on Cross-sections X3 - X6
Elk Branch Restoration Plan- EEP Project # D06125-B

Parameter	Elk Branch Reach 1 X3	Elk Branch Reach 1 X4	Elk Branch Reach 1 X5	Elk Branch Reach 1 X6	NC Mountain Regional Curve	Units of Measurement
Feature Type	Run	Run	Run	Riffle	Riffle	
Drainage Area	0.05-0.07	0.05-0.07	0.07-0.14	0.07-0.14	0.14	Square miles
Bankfull Width (W_{bkf})	7.8	3.9	4.7	5.3	5.1-6.3	Feet
Bankfull Mean Depth (d_{bkf})	0.54	0.76	0.64	0.6	□□□□□□.44	Feet
Cross-Sectional Area (A_{bkf})	4.3	2.9	3.0	3.2	2.5-3.6	Square feet
Width/Depth Ratio (W/D ratio)	14.4	51	7.3	8.9	13.8-14.3	
Bankfull Max Depth (d_{mbkf})	1.43	1.06	0.99	0.85	N/A	Feet
Floodprone Area Width (W_{fpa})	49	11.2	7.4	6.1	N/A	Feet
Entrenchment Ratio (ER)	6.3	2.9	1.6	4	N/A	
Bank Height Ratio (BH)	1.1	1.6	3.1	1.1	N/A	
Channel Materials (Particle Size Index – d_{50})						
d_{16}	N/A	N/A	N/A	N/A	N/A	mm
d_{35}	N/A	N/A	N/A	N/A	N/A	mm
d_{50}	N/A	N/A	N/A	N/A	N/A	mm
d_{84}	N/A	N/A	N/A	N/A	N/A	mm
d_{95}	N/A	N/A	N/A	N/A	N/A	mm
Water Surface Slope (S)	0.028	0.028	0.026	0.026	N/A	Feet per foot
Channel Sinuosity (K)	1.02	1.02	1.02	1.02	N/A	
Rosgen Stream Type[2]	Cb[1]	Eb[2]	G[3]	Eb[4]	N/A	

Notes: Due to lack of reliable indicators, bankfull stage corroborated by HEC-RAS modeling of USGS 1.5 and 2-year flows.
[1]Channel has no sinuosity but has not become severely entrenched due to the cohesive bed and bank material, high BHR indicative of instability.
[2] XS#4 is more representative of the reach than XS#3. It does not fit in well with the classification system but is most applicably a B-type channel which is functioning like a G-type channel due to the high BHR and low W/D.
[3]XS# 5 is considered to be a moderately entrenched G-type stream; the W/D ratio is too low to be a B-type stream.
[4]XS#6 classifies as an Eb but has been straightened and moved against the valley wall. Also, it represents areas of the channel that have eroding vertical banks. It is not a stable E-type channel.

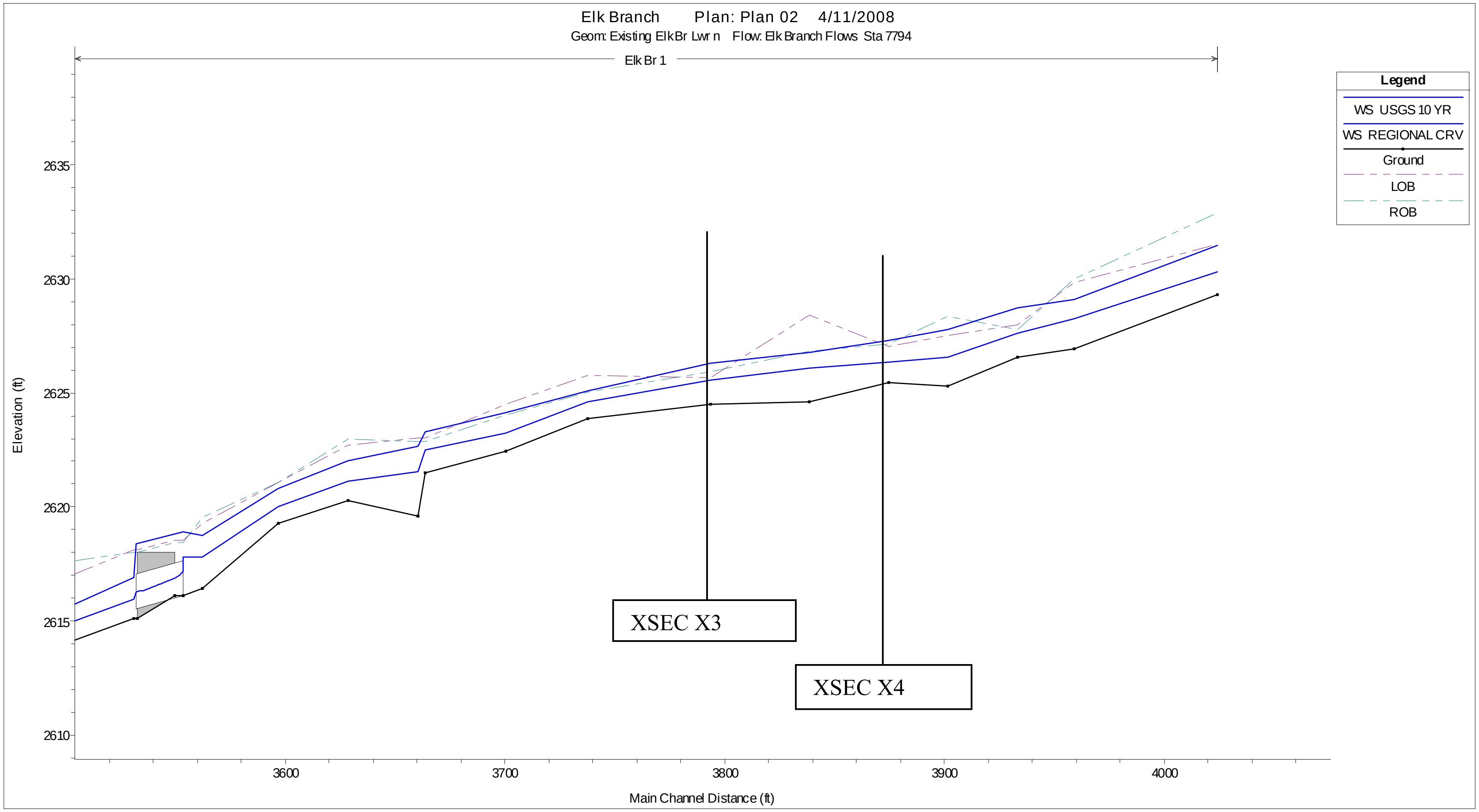


Figure 3.2. **HEC-RAS Water Surfaces for Regional Curve (WS REGIONAL CRV) and USGS 10-Year (WS USGS 10 YR) Flows in Reach 1 with Locations of Detailed-survey Cross-sections (X3 and X4) Described in Table 3.1**

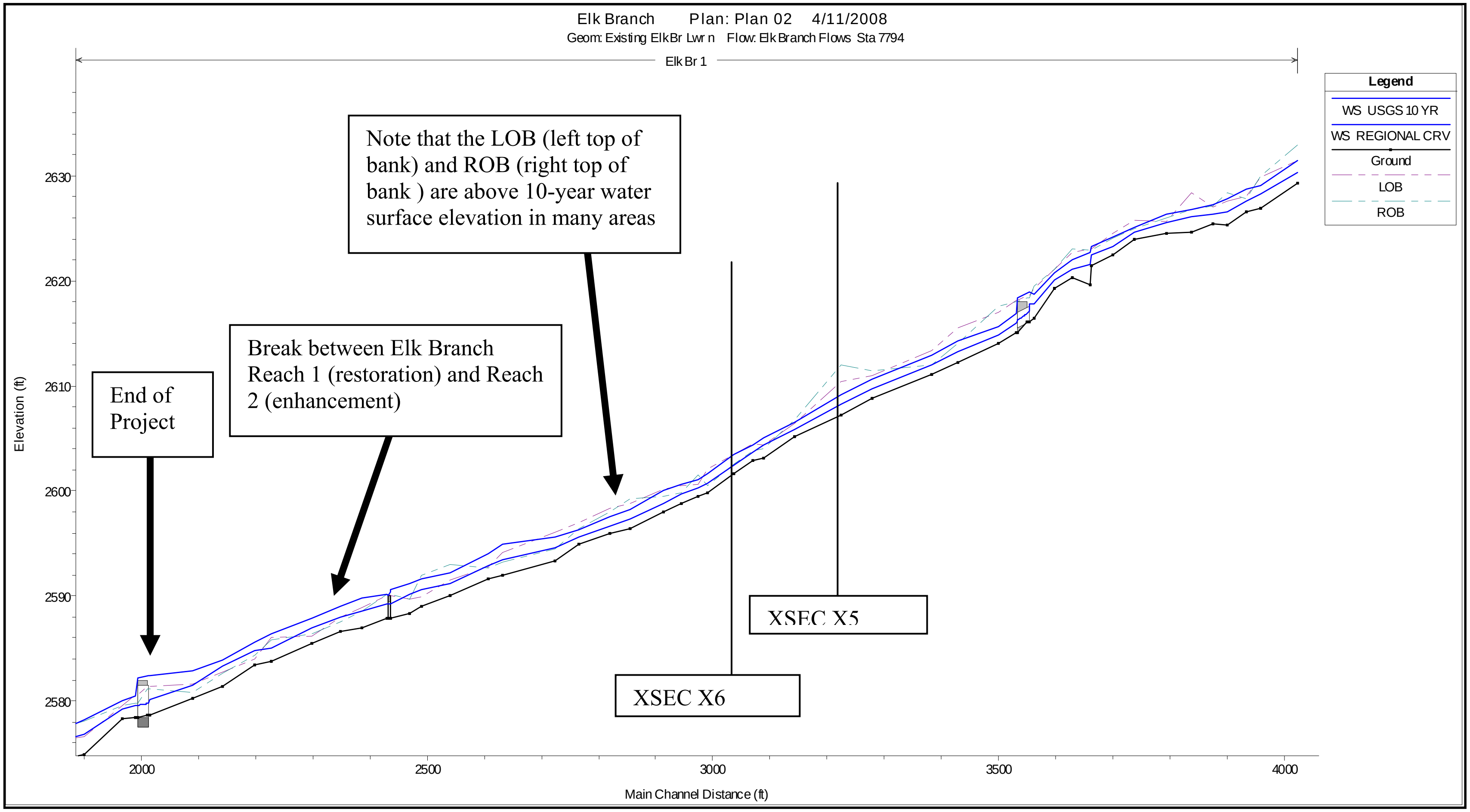


Figure 3.3 HEC-RAS Bankfull and 10-Year Water Surface Profiles, Entire Mainstem Project Reach

3.4.2 Elk Branch Reach 2

Reach 2 starts immediately downstream of Reach 1 at station 19+50. Despite being used for reference cross-section data, the reach has problems with toe erosion and a lack of bedform diversity. Table 3.2 below provides existing conditions data for the representative cross-section X7; geomorphic data is also available in Appendix D. The constant riffle slope through the reach is contributing to the channel erosion and is cause for long term stability concern. The reach ends at a 48-inch culvert that flows under a paved driveway. The reach was also surveyed with a total station and, as before, this data was used to assess geomorphic and hydraulic character of the reach by assessing the “mini” cross-sections and HEC-RAS model results.

The reach has a valley slope of approximately 0.03 ft/ft and has a pattern that is transitioning from a B-type confined valley to a slightly broader E-type alluvial valley. Similar to other impacted reaches, fine sediment deposition is present in the reach. Enhancement of this reach will focus on restoring a stable channel dimension to eliminate the toe erosion that can cause long-term instability. In addition, grade control features will be incorporated to protect the reach from down-cutting and to provide a greater diversity of aquatic habitat and help improve sediment transport through the reach.

There is a lack of deep rooted vegetation in this area, especially on the right bank. Typical riparian vegetation will be planted at the site and exotic invasive vegetation will be removed.

Table 3.2 Geomorphic Parameters for Reach 2 Based on Cross-section X7
Elk Branch Restoration Plan- EEP Project # D06125-B

Parameter	**Elk Branch Reach 2 X7**	**NC Mountain Regional Curve (supplemented)**	**Units of Measurement**
Feature Type	Run	Riffle	
Drainage Area	0.14	0.14	Square miles
Bankfull Width (W_{bkf})	5.3	7.3	Feet
Bankfull Mean Depth (d_{bkf})	0.52	0.63	Feet
Cross-Sectional Area (A_{bkf})	2.7	4.6	Square feet
Width/Depth Ratio (W/D ratio)	10.2	11.5	
Bankfull Max Depth (d_{mbkf})	1.05	N/A	Feet
Floodprone Area Width (W_{fpa})	30.7	N/A	Feet
Entrenchment Ratio (ER)	5.8	N/A	
Bank Height Ratio (BH)	1.0	N/A	
Channel Materials (Particle Size Index – d_{50})			
d_{16}	N/A	N/A	mm
d_{35}	N/A	N/A	mm
d_{50}	N/A	N/A	mm
d_{84}	N/A	N/A	mm
d_{95}	N/A	N/A	mm
Water Surface Slope (S)	0.03	N/A	Feet per foot
Channel Sinuosity (K)	1.1	N/A	
Rosgen Stream Type[2]	Eb*	N/A	

Notes:
*Channel dimension is presently within reasonable range of stable channel. However, the toe erosion present and the lack of grade control are stability issues.

Table 3.3 Geomorphic Parameters for UT1 Based on Cross-section X8 Elk Branch Restoration Plan- EEP Project # D06125-B				
Parameter	**Unnamed Tributary (UT) 1, XS #8**	**Unnamed Tributary (UT) 1, XS #9**	**NC Mountain Regional Curve**	**Units of Measurement**
Feature Type	Riffle/Run	Riffle/Run	Riffle	
Bankfull Width (W_{bkf})	8.5	6.8	6.7	Feet
Bankfull Mean Depth (d_{bkf})	0.48	0.63	0.49	Feet
Cross-Sectional Area (A_{bkf})	4.1	4.3	4	Square feet
Width/Depth Ratio (W/D ratio)	17.7	10.8		
Bankfull Max Depth (d_{mbkf})	0.74	0.77		Feet
Floodprone Area Width (W_{fpa})	11.7	8.8		Feet
Entrenchment Ratio (ER)	1.4	1.3		N/A
Bank Height Ratio (BH)	2.6	2.3		N/A
Channel Materials (Particle Size Index – d_{50})				
d_{16}	N/A	N/A		mm
d_{35}	N/A	N/A		mm
d_{50}	N/A	N/A		mm
d_{84}	N/A	N/A		mm
d_{95}	N/A	N/A		mm
Water Surface Slope (S)	0.04	0.04		Feet per foot
Channel Sinuosity (K)	1.03	1.03		
Rosgen Stream Type	Fb	Fb		
Notes:				

3.4.3 Unnamed Tributary 1 (UT 1)

Unnamed Tributary 1 is one of two perennial tributaries entering Elk Branch in the project area. The confluence with this tributary is located further down valley from the end of Reach 2 on Elk Branch and enters from the west side of the valley. Originally, the confluence and the property downstream of the culvert, at the end of Reach 2, was a part of this project but due to the landowner changing his commitment to the project. The side valley is impacted from a horse pasture and prior channelization. The tributary starts from a spring head just above the upstream start of the project easement and courses out of its valley into the wider valley of Elk Branch.

Unnamed Tributary 1 has a valley slope of 0.038 ft/ft and has a coarse bed which is clogged with fine sediment in some areas. The channel is confined in a step valley and has moved to the middle of that valley and straightened.

From a geomorphological perspective, streams in this part of the watershed and with slopes in this range would be mainly subject to colluvial processes. Two cross-sections (X8 and X9) have been presented in Appendix D to characterize the reach. Since reliable bankfull indicators are not present, the exercise conducted to assess the cross-sections was to start by choosing bankfull at the top of the bank. This yielded bankfull areas between 6-10 square feet. Based on the watershed size of UT 1 (0.06 square miles), extrapolated regional curve data estimates that the bankfull area should be between 2-4 square feet. Baker opted to choose a liberal estimate of 4-5square feet for bankfull area and the corresponding stage was chosen to calculate the bankfull dimensions. The main purpose of this was to estimate the degree of incision since no hydraulic modeling was performed. The results in Table 3.3 are based on this exercise and are given limited weight for decision-making due to the methodology that had to be used. Besides the bank height ratios being well above the desired range of 1-1.2, the channelization of the creek has left it devoid of grade control elements.

Based on these data, the reach was classified as an F-type channel. The stream is typically entrenched with high W/D ratios. There is a lack of grade control elements that would be found in an undisturbed A or B-type stream. The banks and bed are poorly protected from erosion and areas of erosion were present during the existing conditions analyses.

The channel is situated in the middle of an open pasture with no riparian buffer. Aside from pasture grass, the dominant species are exotic invasives which occur immediately adjacent to the channel.

The approach on UT1 will be to establish grade control, build benches to enhance the entrenchment ratio allowing for better floodplain relief, establish vegetation on the banks and exclude livestock from the channel by fencing the easement area. These elements should help the stream to progress rapidly to a state of equilibrium and will provide shading, hydraulic diversity, and water quality improvements.

3.4.4 Unnamed Tributary 2 (UT 2)

The unnamed tributary entering near the top of Reach 1 on Elk Branch is referred to as UT2. Within the easement, the stream has been essentially buried and the stream was moved over to the side of the valley. It appears that logs or another material may have been laid in the channel to direct subsurface flow. As a result of the subsurface flow, soil collapse has occurred in certain areas adjacent to the buried channel location.

A restoration strategy proposes to address this reach by removing the trash and debris and creating a new stable channel to convey flow from the upstream stable reach through a location in the middle of the valley down to the confluence with the main branch. The stable upstream reach will serve as a pattern for restoration and supports the fact that the stream should be an above ground perennial channel. Two upstream cross-sections have been provided from the upstream reach in the Appendix D. By reproducing the upstream conditions in the restoration reach, a new stable channel can be achieved which will restore buried habitat and convey stream flow into Elk Branch.

This approach will also remove exotic invasive plants, clear trash from the stream, and restore a floodplain with native species.

Table 3.4 Geomorphic Parameters for UT2 Based on Cross-sections X1 and X2
Elk Branch Restoration Plan- EEP Project # D06125-B

Parameter	Unnamed Tributary (UT) 2, X1	Unnamed Tributary (UT) 2, X2	NC Mountain Regional Curve	Units of Measurement
Feature Type	Riffle	Riffle	Riffle	
Bankfull Width (W_{bkf})	8.9	8.2	6.7	Feet
Bankfull Mean Depth (d_{bkf})	0.34	0.72	0.49	Feet
Cross-Sectional Area (A_{bkf})	3.0	5.9	4.0	Square feet
Width/Depth Ratio (W/D ratio)	26.6	11.4		

Bankfull Max Depth (d_{mbkf})	0.66	1.26		Feet
Floodprone Area Width (W_{fpa})	11.6	15.1		Feet
Entrenchment Ratio (ER)	1.3	1.8		N/A
Bank Height Ratio (BH)	2.0	2.0		N/A
Channel Materials (Particle Size Index – d_{50})				
d_{16}	N/A	N/A		mm
d_{35}	N/A	N/A		mm
d_{50}	N/A	N/A		mm
d_{84}	N/A	N/A		mm
d_{95}	N/A	N/A		mm
Water Surface Slope (S)	0.04	0.04		Feet per foot
Channel Sinuosity (K)	N/A	N/A		
Rosgen Stream Type	B	B		
Notes: X1 has a low entrenchment ratio based on it being nested within a previously large incised channel				

3.5 Channel Stability Assessment

Channel stability is defined here as the ability of a stream to transport the incoming flows and sediment loads supplied by the watershed without undergoing significant changes over a geologically short time-scale. A generalized relationship of stream stability was proposed by Lane (1955); it states that the product of sediment load and sediment size is in balance with the product of stream slope and discharge, or stream power. A change in any one of these variables induces physical adjustment of one or more of the other variables to compensate and maintain the proportionality.

Longitudinally, the water and sediment flows delivered to each subsequent section are the result of the watershed and upstream or downstream conditions. Water and sediment pass through the channel, which is defined by its shape, material, and vegetative condition. Flow and sediment are either stored or passed through each section along the reach. The resulting physical changes are a balancing act between gravity, friction, and the sediment and water being delivered into the system (Leopold et al., 1964).

Observed stream response to induced instability, as described by Simon's (1989) Channel Evolution Model, involves extensive modifications to channel form resulting in profile, cross-sectional dimension, and plan form changes which often take decades or longer to achieve equilibrium. The Simon (1989) Channel Evolution Model characterizes typical evolution in six steps:

1. Pre-modified
2. Channelized (disturbance)
3. Degradation
4. Degradation and widening
5. Aggradation and widening
6. Quasi-equilibrium

The channel evolution process is initiated once a stable, well-vegetated stream that interacts frequently with its floodplain is disturbed. Channelization, dredging, changing land use, removal of streamside vegetation, upstream or downstream channel modifications, and/or change in other hydrologic variables result in adjustments in channel morphology to compensate for the new condition(s). Disturbance commonly results in an increase in stream power that can cause degradation, often referred to as channel incision (Lane, 1955). Incision eventually leads to over-steepening of the banks and, when critical bank heights are exceeded, the banks begin to fail and mass wasting of soil and rock leads to channel widening. Incision and widening continue moving upstream in the form of a head-cut. Eventually the mass wasting slows, and the stream begins to aggrade. A new, low-flow channel begins to form in the sediment deposits. By the end of the evolutionary process, a stable stream with dimension, pattern, and profile similar to those of undisturbed channels forms in the deposited alluvium. The new channel is at a lower elevation than its original form, with a new floodplain constructed of alluvial material (FISRWG, 1998).

Channels within the project area are perennial, have experienced prior channelization or other kinds of disturbance, and are currently impacted by grazing. Channel stability was assessed with the following methods: qualitative and quantitative site observations, comprehensive site-specific hydraulic modeling using detailed topographic data collected for the project, and hydraulic sediment modeling. Conclusions reached from these methods were used to define site stability and determine appropriate restoration approaches for each sub-reach. All of the streams in the project reach have narrower, B-type, valleys. They are not as confined as many 1st order NC mountain streams and both colluvial and alluvial processes factor into the channel geomorphology. All of the reaches have been physically moved or otherwise altered and are following a channel evolution scenario based on a root cause of past (and present) anthropogenic alteration rather than natural processes. The most likely scenario based on the current condition has been provided in Tables 3.5 and 3.6; the evolution of these channels following the antecedent disturbance has been and will continue to be a slow process. The primary factors influencing the channel evolution are low sediment supply, small watershed size and a non-erosive cohesive soil layer at a depth of 18-24". The evolution to a G-type channel, as provided in the tables, may be abbreviated in favor of a widening of the channel. The presence of cohesive subsoil will result in a greater likelihood of lateral erosion occurring in conjunction with or instead of vertical erosion. The banks are also cohesive in nature, but less so than the aforementioned subsoil.

The mainstem channel within the project area is a perennial, mostly channelized stream with a flow regime dominated by storm water runoff from a watershed that is approximately 63% forested, 33% agricultural and 4% developed. The mainstem channel is incised at certain locations in the system as evidenced by bank height ratios approaching 2 in these areas. UT 2 within the project area is a buried stream that is open and perennial upstream. Its watershed is predominately forested with some contributing area of pasture land. UT 1 within the project area is perennial and has been channelized; storm water runoff from its watershed is both forested and pasture and has one residence above the project and has adjacent pasture through the project reach. It exhibits high bank height ratios, has eroding banks impacted by channelization and livestock trampling, and has minimal riparian vegetation. Table 3.5 summarizes the geomorphic parameters related to channel stability.

Table 3.5 Stability Indicators – Elk Branch
Elk Branch Restoration Plan- EEP Project # D06125-B

Parameter	Elk Branch Mainstem	
	Reach 1	**Reach 2**
Stream Type	Channelized Cb/Eb*	Erosional Eb*
Riparian Vegetation	Sporadic buffer ranging from 0 to 5 feet transitioning to pasture. Then stream moves against valley wall with forested hillside on right side and pasture on left. Invasive exotics (primarily multi-flora rose) prevalent.	Mature forested buffer on on left bank with maintained lawn on the right. Exotic vegetation intermittently present throughout reach.
Channel Dimension		
Bankfull Area (SF)	2.9-4.3	3.0-3.2 (banks nearly vertical)
Width/Depth Ratio	5.1-14.4	7.3-8.9
Channel Pattern		
Meander Width Ratio	N/A	N/A
Sinuosity	1.02-1.10	1.03
Vertical Stability		
Bank Height Ratio (BHR)	1.1-3.0	1.4
Entrenchment Ratio (ER)	1.9-7.0	7.7
Evolution Scenario	Eb-G-B*	Eb-G-B*
Simon Evolution Stage[2]	I→II	I→II

Notes:
1. N/A: Meander Width Ratio not measured because channel has been straightened.
2. Simon Channel Evolution

*The project reaches have a narrower, B-type valley that broadens as you go downstream. All of the reaches have been physically moved or otherwise altered and are not following a typical evolution scenario. The most likely scenario based on the current condition has been provided; the evolution has been and will continue to be a slow process, retarded by the cohesive soils that are limiting the rate of downcutting. The evolution to a G-type channel may be abbreviated in favor of a widening of the channel that would not be confined by the non-erosion sub-soil as the down-cutting is.

Table 3.6 Stability Indicators – Unnamed Tributaries to Elk Branch Elk Branch Restoration Plan- EEP Project # D06125-B		
Parameter	**Tributaries to Elk Branch**	
	UT 1	**UT 2**
Stream Type	Channelized Fb	B (buried)
Riparian Vegetation	Mostly horse pasture	Early successional forested buffer ranging from 3-5 feet. Pasture on either side of thin buffer.
Channel Dimension		
Bankfull Area (SF)	4 feet	Channel predominantly filled with debris, soil, and trash
Width/Depth Ratio	9-24	N/A
Channel Pattern		
Meander Width Ratio	N/A	N/A
Sinuosity	1.06	N/A
Vertical Stability		
Bank Height Ratio (BHR)	2.1-3.0	N/A
Entrenchment Ratio (ER)	1.3-1.8	N/A
Evolution Scenario	Anthropogenic impacts – recent channelization (1980s) B-G-Fb-B	Anthropogenic impacts - buried
Simon Evolution Stage[2]	II or III→IV	N/A

Notes:
1. N/A: Not measured due to conditions or not applicable to channel type
2. Simon Channel Evolution
   * functioning like G due to high Bank Height Ratio

Table 3.7 Rosgen Channel Stability Assessment Elk Branch Restoration Plan- EEP Project # D06125-B	
Stability Rating	**Bank Height Ratio (BHR)**
Stable (low risk of degradation)	1.0-1.05
Moderately unstable	1.06-1.3
Unstable (high risk of degradation)	1.3-1.5
Highly unstable	>1.5

Notes: Rosgen, D. L. (2001) A stream channel stability assessment methodology. Proceedings of the Federal Interagency Sediment Conference. Reno, NV. March, 2001.

3.6 Bankfull Verification

Baker engaged in several methods to assess channel-forming discharge. In stable systems, the "bankfull" or channel top-of-bank discharge represents the channel-forming discharge. It is widely accepted that the bankfull discharge has a recurrence interval in the range of 1 to 2 years (1.5 years is a commonly used average). Flows in the 1-year to 5-year range of return intervals were focused on for their relative differences in resulting water surface elevations as determined by HEC-RAS and their resulting contribution to floodplain processes. The end result of the methods employed is a best estimate of the channel-forming discharge given the unavailability of gauge or sediment data.

In summary, the following steps were taken:

1. Identified and surveyed representative cross-sections with physical bankfull indicators.
2. Compared the surveyed cross-sections with each other to ensure consistency.
3. Compared values to regional empirical data (regional curves).
4. Used Manning's equation to estimate design discharge through cross-sections.
5. Built and ran a HEC-RAS existing conditions model with estimated flows.
6. Finally, considered all results and determined dimensions and flow that corresponds to bankfull.

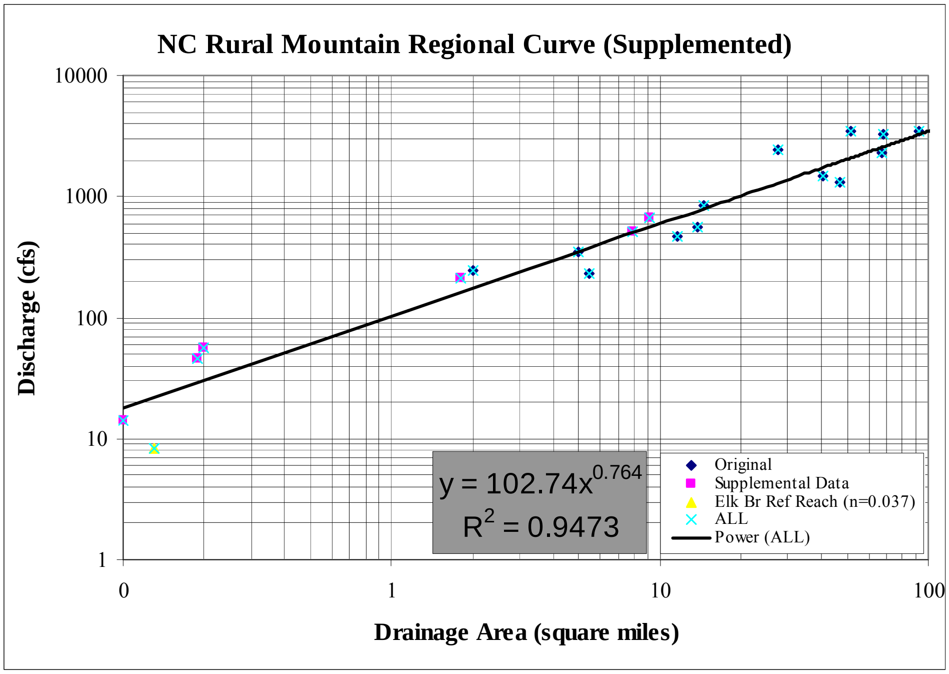
3.6.1 Regional Curve Equations

Publicly available and in-house bankfull regional curves are available for a range of stream types and physiographic provinces. The North Carolina Mountain (Harman et al., 2000) Regional Curve (Harman et al., 1999) was used for comparison to other more site-specific means of estimating bankfull discharge. Elk Branch and its tributaries are in a small headwater system; therefore, the contributing watershed areas to the streams in this project are not adequately represented by the regional curve.

3.6.2 Supplemented Regional Curve Data

In-house and publicly available reference stream data was obtained for streams characterized by comparable drainage area size, physiographic and geomorphologic similarity, and relative geographical proximity to the Elk Branch project. The resulting data were used to enhance and extend the published Mountain Regional Curves by including more data on the lower end of the curve (smaller drainage areas). The resulting "mini" curve for discharge, and the new power function fit to those sites which were hand selected for their similarity to the project site, are depicted in Figure 3.4.

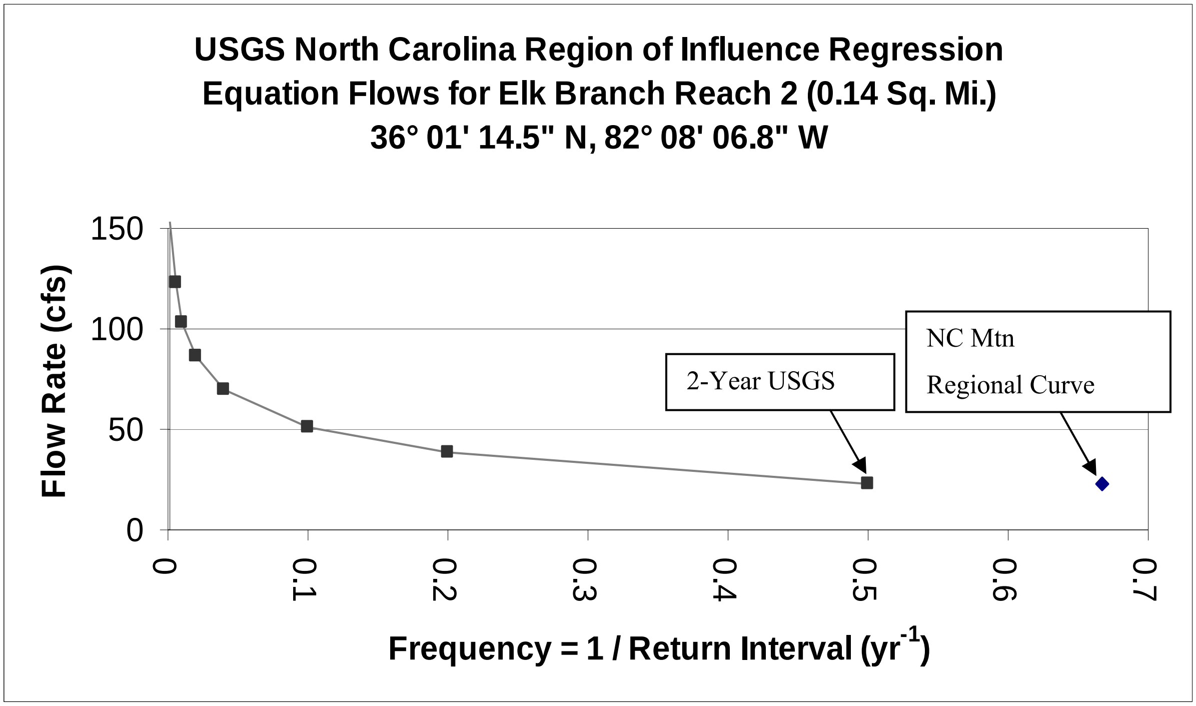
Figure 3.4 Supplemented NC Mountain Regional Curve for Discharge



3.6.3 USGS Regression Equations

North Carolina USGS Regionalized Regression Equations (Pope et al. 2001) incorporate latitude, longitude, and drainage area information when used to calculate flood estimates based on data from USGS gauges. These regression equations were used to calculate the estimates for the 2-, 5-, 10-, and 25-year floods. An example for Elk Branch Reach 2 (drainage area = 0.14 square miles) is plotted in Figure 3.5 below, with the supplemented regional curve flow for this project at the far right (assumed return interval of 1.5 or 0.66 frequency for plotting purposes). These regression equation flows were used as comparative estimates of different flow frequencies.

Figure 3.5 USGS Regional Regression Equation Flood Events

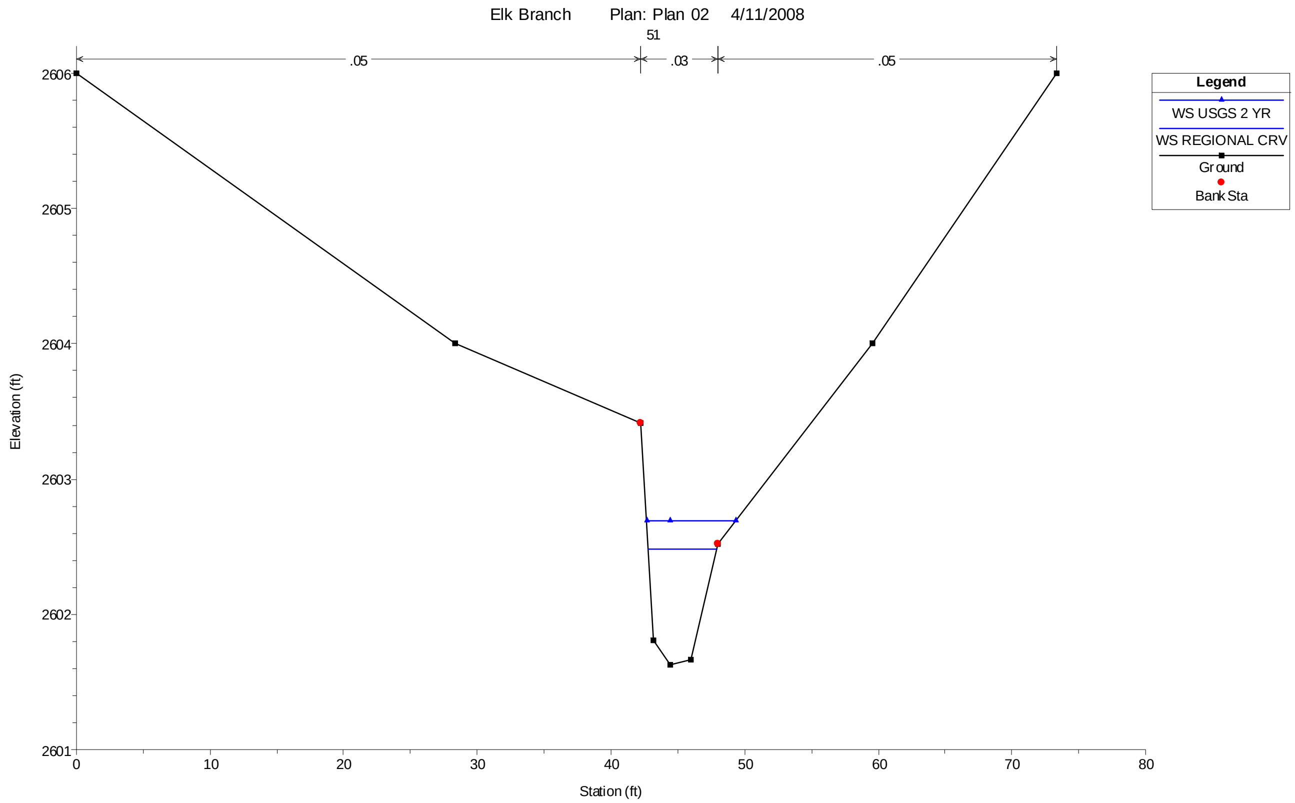


3.6.4 Role of Hydraulic Modeling Using HEC-RAS 3.1.3 in Design Discharge Selection

Total station survey data and 1' accuracy topographic data obtained through aerial photogrametry was used to produce a detailed hydraulic model consisting of just over 70 cross-sections in HEC-RAS 3.1.3 for the main stem of Elk Branch. This includes the reaches downstream of the project area that were originally supposed to be included with the project and whose modeling still has value for analyses.

The model was used to determine the stage-discharge relationship throughout the restoration reach. In this manner, the model was used to assess the degree of connectivity to the floodplain that segments of stream exhibited at different modeled flow rates (mainly those flow rates thought to be reasonable estimates of the bankfull flow as determined from the previously described methods). Physical indicators such as the top of the bank and depositional benches and point bars were used to assess which flow rates of the estimates available were most consistent estimates of bankfull flow in each of the design reaches. Figures 3.2 and 3.3 in an earlier section of the report depict longitudinal profiles for the regional curve bankfull flow and the USGS 10-year flow. This profile shows the lack of floodplain connectivity for this flow throughout the project. Cross-sectional data (see example in Figure 3.6 was scrutinized against water surface data to assess coincidence with top of bank, benches, slope breaks, and other depositional features throughout reaches of constant drainage area.

Figure 3.6 Cross-section and HEC-RAS Water Surface Elevations for Mountain Regional Curve Flow (14 cfs) and USGS 2-Year Flow (21 cfs) at Arbitrary Section of Elk Branch Reach 1



3.7 Conclusions for Channel Forming Discharge

The insight gained from the HEC-RAS model, the field identified bankfull indicators, and the Manning's discharge estimation method provided valuable information for selecting design discharge. As the drainage area increases along Elk Branch, the slopes become more in-line with data from the regional curve, and the bankfull indicators and Manning's flow estimates exhibit a stronger correlation with the NC rural regional curve estimate. The mountain regional curve was developed from higher order streams, so it is logical that this technique would become a more accurate prediction method as drainage area increases.

Table 3.8 provides a discharge analyses based on the regional curve flows for the drainage area being considered, and the design discharge calculated based on the proposed design cross-sections for each reach of the Elk Branch restoration project.

Table 3.8 Summary of Design Discharge by Reach Elk Branch Restoration Plan- EEP Project # D06125-B							
Stream	Reach	Drainage Area (square miles)	Q, Supplemented Mountain Regional Curve (cfs)	Q, USGS Regression Equation (cfs)			Design Q (cfs)
				1.25 year	1.5 year	1.75 year	
Elk Branch Mainstem	1	0.03-0.05	7-10	9.7-16.9	9.0-18.2	8.4-19.5	7
	1	0.05-0.07	10-13	16.9-21.4	18.2-23.1	19.5-24.6	14
	2	0.07-0.14	13-23	21.4-34.7	23.1-37.4	24.6-39.9	21
UT1	1	0.06	10-12	19.2	20.7	22.1	10
UT2	1	0.01	2-3	5.5	5.9	6.4	6

3.8 Vegetation Community and Disturbance History

The habitat within and adjacent to the proposed project area primarily consists of agricultural pastureland and herbaceous cover, dry mesic oak forest, and mesic hardwood forest as described by Schafale and Weakely (1990) below. The riparian area within the project site was generally very disturbed. The major disturbance is active livestock grazing and mowing associated with residences nearby. A general description of each community follows.

3.8.1 Dry Mesic Oak-Hickory Forest

This ecological community is located on the upland fringes of the agricultural areas and low ridges near the project area. The dominant canopy species of the dry mesic oak forest area included white oak (*Quercus alba*), northern red oak (*Quercus rubra*), black oak (*Quercus velutina*), mockernut hickory (*Carya alba* (*tomentosa*)), red hickory (*Carya ovalis*), and pignut hickory (*Caryus glabra*). In addition to oaks, yellow poplar (*Liriodendron tulipifera*) is also common at the site. Understory species included red maple (*Acer rubrum*), flowering dogwood (*Cornus florida), sourwood (Oxydendrum arborem),american holly (Ilex opaca),* and *black tupelo (Nyssa sylvatica).* Shrubs include downy arrowwood (*Viburnum rafinesquianum),*deerberry *(Vaccinium stamineum),*Blue Ridge blueberry *(Vaccinium pallidum (vacillans),* and strawberry bush *(Evonymus americana).* Muscadine grapevines *(Vitis rotundifolia)* and poison ivy *(Toxicodendron (Rhus) radicans)* often are present. Herbs are fairly sparse, with *Hexastylis spp., downy rattlesnake plantain, striped prince's pine (Chimaphila maculata),* nakedflower ticktrefoil *(Desmodium nudiflorum)*, and rattlesnakeweed commonly present.

3.8.2 Mesic Mixed Hardwood Forest

This ecological community is located on the hillsides and slopes surrounding the project area. Although similar to the Dry Mesic Oak Forest community type, this forest type is dominated less by white oak and more by northern red oak (*Quercus rubra*), tulip poplar (*Liriodendron tulipifera*), and American beech (*Fagus grandifolia*).

3.8.3 Agricultural Areas

The existing riparian buffer throughout the project site is under agricultural land use. The pastures along Reach 1 and Reach 2 are grazed by livestock or are mowed by landowners . The plant species in the adjacent pastureland are composed primarily of herbaceous species that include fescue (*Fescue* spp.), golden rod (*Solidago* spp.), jewelweed (*Impatiens capensis*), poison oak (*Toxicodendron diversilobum*), joe pye weed (*Eupatorium maculatum*), cardinal flower (*Lobelia cardinalis*), stinging nettle (*Urtica dioica*), and soft rush (*Juncus effusus*).

4.0 REFERENCE STREAMS

Design ratios for pattern and profile were based on evaluating dimensionless ratios from reference reach sites in the NCDOT database. Design ratios used by Baker that have been successful at many similar sites were also referenced (Table 4.1).

To determine suitable reference reaches for the design we reviewed data from prior projects in the mountains, internal and publicly available reference reach data, and on-site data from a fairly stable section of stream within Reach 2 of the Elk Branch project reach. On-site data, restoration project design data, and a reference reach were used directly for raw geomorphic data. The latter two are described below and summarized for Elk Branch and its unnamed tributaries in Tables 4.1 and 4.2.

Upon review of the data, a number of reference sites were chosen to supplement the mountain regional curve data in order to cover drainage areas closer to the project drainage size. In the process of extending the curve beyond the range of the published data, slightly modified regional curve power functions were developed to account for the increased range in data. The regional curve results were used as part of the design decision making process as described in Section 6.3.2.

A section of Elk Branch Reach 2 is located adjacent to undisturbed woods on the left and an ungrazed pasture on the right. It has a smaller channel which appears to have been relatively undisturbed in comparison to the channelized reaches above and below. There was minimal erosion, good floodplain connectivity, and good habitat present in the reach.

Mickey Reach is a previous Baker restoration project in Surry County. It is an unnamed tributary to the Mitchell River with similar design conditions. The design stream type for Mickey Reach was a B4 channel with structures installed to restore a step-pool stream system with appropriate bedform diversity. The project has been monitored for six years following construction and has remained stable, with diverse bedform and excellent aquatic habitat.

Craig Creek is located in the Pisgah National Forest and was evaluated by NC State University as part of a thesis research project evaluating morphology relationships in reference streams. The stream is an example of a B4 stream type with a small drainage area, similar to the project reaches. The stream was also used as a reference reach for the Micky Reach design (described above).

Table 4.1 Ratios from Reference Reaches used in the Design of Elk Branch and its Tributaries
Elk Branch Restoration Plan

Parameter	MIN	MAX	MIN	MAX
Stream Type (Rosgen)	B4		Eb4	
Bankfull Mean Velocity, Vbkf (ft/s)	4.0	6.0	3.5	5.0
Width to Depth Ratio, W/D (ft/ft)	12.0	18.0	10.0	14.0
Riffle Max Depth Ratio, Dmax/Dbkf	1.2	1.4	1.1	1.3
Bank Height Ratio, Dtob/Dmax (ft/ft)	1.0	1.1	1.0	1.1
Sinuosity, K	1.1	1.2	1.2	1.6
Riffle Slope Ratio, Srif/Schan	1.1	1.8	1.5	2.0
Pool Slope Ratio, Spool/Schan	0	0.4	0	0.2
Pool Max Depth Ratio, Dmaxpool/Dbkf	2.0	3.5	2.0	3.5
Pool Width Ratio, Wpool/Wbkf	1.1	1.5	1.3	1.7
Pool-Pool Spacing, Lps/Wbkf	1.5	5.0	4.0	7.0

Table 4.0 Elk Branch Geomorphic Design Table Elk Branch Restoration Plan- EEP Project # D06125-B	**Elk Branch Design**		**Elk Branch Existing Conditions**		**Mickey Reach Design**		**Craig Creek Reference Reach**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
1. Stream Type	B4		straightened Cb/B/G/Eb4		B4		B4	
2. Drainage Area – square miles	0.07	0.14	0.07	0.14	0.45	0.45	1.6	1.6
3. Bankfull Width (w_{bkf}) – feet	4	10.5	3.9	7.8	11.7	21.7	27.6	27.6
4. Bankfull Mean Depth (d_{bkf}) – feet	0.4	0.75	0.48	1.12	0.6	1	1	1.1
5. Width/Depth Ratio (w/d ratio)	10	14	5	14	10.7	17	25	27
6. Cross-sectional Area (A_{bkf}) – SF	3	7	2.9	14.5	13.1	10.2	26	33
7. Bankfull Mean Velocity (v_{bkf}) – fps	2	6	----------	----------	----------	----------	----------	----------
8. Bankfull Discharge (Q_{bkf}) – cfs	7	21	----------	----------	----------	----------	----------	----------
9. Bankfull Max Depth (d_{mbkf}) – feet	0.5	1.0	0.9	1.7	0.9	2.5	1.6	1.6
10. d_{mbkf} / d_{bkf} ratio	1.2	1.4	----------	----------	1.1	3.1	1.6	1.6
11. Low Bank Height to d_{mbkf} Ratio	----------	----------	----------	----------	1	1	----------	----------
12. Bank Height Ratio dlow/dmax	1	1.1	1.4	3.1	1	1	----------	----------
13. Floodprone Area Width (w_{fpa}) – feet	9	80	5.2	55	20	410	36	38.6
14. Entrenchment Ratio (ER)	3	7.6	1.6	7.0	1.7	32	1.3	1.4
15. Meander length (L_m) – feet	21	82	9.1	37.7	70	260	----------	----------
16. Meander length to bankfull width (L_m/w_{bkf})	7	8.2	1.7	7.1	4.4	17.6	----------	----------
17. Radius of curvature (R_c) – feet	5.4	25	2	6.6	28	47	----------	----------
18. Radius of curvature to bankfull width (R_c / w_{bkf})	1.8	2.5	0.4	1.2	2	3	----------	----------
19. Belt width (w_{blt}) – feet	10.5	80	2	4.3	16	55	----------	----------
20. Meander Width Ratio (w_{blt}/W_{bkf})	3.5	8	0.4	0.8	1.1	4.1	----------	----------
21. Sinuosity (K) Stream Length/ Valley Distance	1.02	1.3	1.02	1.1	1.19	1.19	1.1	1.1
22. Valley Slope – feet per foot	0.0204	0.02875	0.0204	0.02875	0.0398	0.0396	0.0364	0.0364
23. Channel Slope ($s_{channel}$) – feet per foot	0.020	0.022	0.020	0.026	0.0333	0.0333	0.0331	0.0331
24. Pool Slope (s_{pool}) – feet per foot	0	0.004	----------	----------	0	0.005	0	0
25. Pool Slope to Average Slope (s_{pool} / $s_{channel}$)	0	0.2	----------	----------	0	0.15	0	0
26. Maximum Pool Depth (d_{pool}) – feet	0.8	2.8	----------	----------	2.2	2.5	2.1	2.1
27. Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	2	3.5	----------	----------	2	4	2.1	
28. Pool Width (w_{pool}) – feet	4.4	16	----------	----------	14.3	14.6	26	26
29. Pool Width to Bankfull Width (w_{pool} / w_{bkf})	1.1	1.5	0.9	1.1	0.9	0.9	0.9	0.9
30. Pool Area (A_{pool}) – square feet	3.3	8.4	2.5	4	14.8	15.9	37.1	37.1
31. Pool Area to Bankfull Area (A_{pool}/A_{bkf})	1.1	1.2	1.4	1.4	1.1	1.2	1.1	1.4
32. Pool-to-Pool Spacing – feet	9	50	42	156.5	48	231	42	156.5
33. Pool-to-Pool Spacing to Bankfull Width ($p\text{-}p/w_{bkf}$)	1.5	5	1.5	6.7	3	7	1.5	6.7
34. Riffle Slope (4((s_{riffle}) – feet per foot	0.022	0.051	0.02	0.03	0.2	1.9	1.9	7.6

Table 4.0 Elk Branch Geomorphic Design Table Elk Branch Restoration Plan- EEP Project # D06125-B	**Elk Branch Design**		**Elk Branch Existing Conditions**		**Mickey Reach Design**		**Craig Creek Reference Reach**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
35. Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	1.1	1.8	1.9	7.6	0.2	1.9	1.9	7.6
36. Pool Length, Lp	----------	----------	----------	----------	13	16	----------	----------
37. Pool Length Ratio Lp/Wbkf	----------	----------	----------	----------	0.8	1.1	----------	----------
Material (d_{50})							Very Coarse Sand	
d_{16} – mm	0.6-1.5		1.2		1		5	5.6
d_{35} – mm	2.0-7		6.6		14		14.3	
d_{50} – mm	6.2-19		13		39		30.8	
d_{84} – mm	19-65		65		51.2		88.4	
d_{95} – mm	26-130		130		2100		110	
- : data not available								

Table 4.1 Unnamed Tributaries Geomorphic Design Table Elk Branch Restoration Plan- EEP Project # D06125-B	**UT1&UT2 Design**		**UT1&UT2 Existing Conditions**		**Mickey Reach Design**		**Craig Creek Reference Reach**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
1. Stream Type	B4		B4/G		B4		B4	
2. Drainage Area – square miles	0.01	0.06	0.01	0.06	0.45	0.45	1.6	1.6
3. Bankfull Width (w_{bkf}) – feet	3	8.4	3.5	11.9	11.7	21.7	27.6	27.6
4. Bankfull Mean Depth (d_{bkf}) – feet	0.3	.6	0.34	0.72	0.6	1	1	1.1
5. Width/Depth Ratio (w/d ratio)	10	14	2.1	8.1	10.7	17	25	27
6. Cross-sectional Area (A_{bkf}) – SF	3	6	5.5	9.9	13.1	10.2	26	33
7. Bankfull Mean Velocity (v_{bkf}) – fps	2	6	----------	----------	----------	----------	----------	----------
8. Bankfull Discharge (Q_{bkf}) – cfs	3	10	----------	----------	----------	----------	----------	----------
9. Bankfull Max Depth (d_{mbkf}) – feet	0.4	1.0	0.9	1.7	0.9	2.5	1.6	1.6
10. d_{mbkf} / d_{bkf} ratio	1.3	1.4	----------	----------	1.1	3.1	1.6	1.6
11. Low Bank Height to d_{mbkf} Ratio	----------	----------	----------	----------	1	1	----------	----------
12. Bank Height Ratio dlow/dmax	1	1.1	1	1.9	1	1	----------	----------
13. Floodprone Area Width (w_{fpa}) – feet	9	25	6.8	52	20	410	36	38.6
14. Entrenchment Ratio (ER)	3.0	3.0	1.9	7.7	1.7	32	1.3	1.4
15. Meander length (L_m) – feet	----------	----------	----------	----------	70	260	----------	----------
16. Meander length to bankfull width (L_m/w_{bkf})	N/a	N/a	N/a	N/a	4.4	17.6	----------	----------
17. Radius of curvature (R_c) – feet	----------	----------	----------	----------	28	47	----------	----------
18. Radius of curvature to bankfull width (R_c / w_{bkf})	N/a	N/a	N/a	N/a	2	3	----------	----------
19. Belt width (w_{blt}) – feet	----------	----------	----------	----------	16	55	----------	----------
20. Meander Width Ratio (w_{blt}/W_{bkf})	N/a	N/a	N/a	N/a	1.1	4.1	----------	----------
21. Sinuosity (K) Stream Length/ Valley Distance	1.03	1.2	1.02	1.1	1.19	1.19	1.1	1.1
22. Valley Slope – feet per foot	0.0215	0.038	0.0215	0.038	0.0398	0.0396	0.0364	0.0364
23. Channel Slope ($s_{channel}$) – feet per foot	0.0195	0.0316	0.02	0.035	0.0333	0.0333	0.0331	0.0331
24. Pool Slope (s_{pool}) – feet per foot	0	0.00632	----------	----------	0	0.005	0	0
25. Pool Slope to Average Slope (s_{pool} / $s_{channel}$)	0	0.2	----------	----------	0	0.15	0	0
26. Maximum Pool Depth (d_{pool}) – feet	0.3	2.5	----------	----------	2.2	2.5	2.1	2.1
27. Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	2	3.5	----------	----------	2	4	2.1	
28. Pool Width (w_{pool}) – feet	3.6	12.6	----------	----------	14.3	14.6	26	26
29. Pool Width to Bankfull Width (w_{pool} / w_{bkf})	1.2	1.5	----------	----------	0.9	0.9	0.9	0.9
30. Pool Area (A_{pool}) – square feet	----------	----------	----------	----------	14.8	15.9	37.1	37.1
31. Pool Area to Bankfull Area (A_{pool}/A_{bkf})	----------	----------	----------	----------	1.1	1.2	1.1	1.4
32. Pool-to-Pool Spacing – feet	9	42	----------	----------	48	231	42	156.5
33. Pool-to-Pool Spacing to Bankfull Width ($p\text{-}p/w_{bkf}$)	1.5	5	----------	----------	3	7	1.5	6.7
34. Riffle Slope [4((s_{riffle}) – feet per foot	0.023	0.061	0.022	0.038	0.2	1.9	1.9	7.6

Table 4.1 Unnamed Tributaries Geomorphic Design Table Elk Branch Restoration Plan- EEP Project # D06125-B	**UT1&UT2 Design**		**UT1&UT2 Existing Conditions**		**Mickey Reach Design**		**Craig Creek Reference Reach**	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
35. Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	1.1	1.6	1.1	1.3	0.2	1.9	1.9	7.6
36. Pool Length, Lp	----------	----------	----------	----------	13	16		
37. Pool Length Ratio Lp/Wbkf	----------	----------	----------	----------	0.8	1.1		
Material (d_{50})	----------		----------				Very Coarse Sand	
d_{16} – mm	----------		----------		1		5	5.6
d_{35} – mm	----------		----------		14		14.3	
d_{50} – mm	----------		----------		39		30.8	
d_{84} – mm	----------		----------		51.2		88.4	
d_{95} – mm	----------		----------		2100		110	
- : data not available								

5.0 PROJECT SITE WETLANDS (EXISTING CONDITIONS)

5.1 Jurisdictional Wetlands

The proposed project area was reviewed for the presence of wetlands and waters of the United States in accordance with the provisions on Executive Order 11990, the Clean Water Act, and subsequent federal regulations. Wetlands have been identified by the USACE as "those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas" (33 CFR 328.3(b) and 40 CFR 230.3 (t)).

Following an in-office review of the National Wetland Inventory (NWI) map, NRCS soil survey, and USGS quadrangle map, a field survey of the project area was conducted to assess the presence of wetlands and waters of the U. S. The project area was examined utilizing the jurisdictional definition detailed in the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory, 1987). Supplementary information to further support wetland determinations was found in the *National List of Plant Species that Occur in Wetlands: Southeast (Region 2)* (Reed, 1988).

A comprehensive field survey throughout the project area was conducted on May 15, 2008 to assess vegetation, soils, and hydrology for determination of the presence of jurisdictional wetlands. No jurisdictional wetlands are present in the project reach.

5.2 Reference Wetlands

No wetland restoration or enhancement activities are proposed under the Elk Branch restoration project. Therefore, no reference wetlands were required for this project.

6.0 PROJECT SITE RESTORATION PLAN

This section discusses the design objectives selected for stream restoration on the Elk Branch project site. The proposed stream restoration designs will include Rosgen Priority Level 1 and 2 approaches. A Priority Level 1 approach involves the construction of a new channel with bankfull flood relief on the existing primary floodplain. This approach requires that the streambed be raised when applied to incised channels. A Priority Level 2 approach involves the excavation of a floodplain at a lower elevation, such that the bed elevation of the stream does not change or changes only slightly. Both priority levels will involve the use of the existing channel as well as the construction of new channel segments where pattern adjustments are necessary.

Priority Level 1 Restoration will be targeted on all restoration reaches, although some sections of Elk Branch and UT 1 may require a highbred approach with some minor grading beyond the channel to construct floodplain benching. Restoration of Elk Branch Reaches 1 and UT2 on the Wylie and Craig properties and of UT 1 on the Hall property are justified for the following reasons:

1. Albeit on a small scale due to the size of the streams, there is evidence of incision and bank erosion due to past straightening activities and buffer impacts;
2. The streams would benefit significantly from channel pattern, profile (grade control) and dimension modifications that will better move fine sediments through the system. The creation of better riffle and pool sequences through the project will facilitate this;
3. Restoration of streams that are eroding into the valley wall will reduce erosion, improve floodplain connectivity, and improve floodplain hydrology;
4. The recommended Priority 1 Restoration efforts are likely to raise the water table in the valley and result in improved floodplain hydrology;
5. Enhancement measures would fall short of achieving the highest possible level of restoration.

Enhancement Level I measures are proposed for Elk Branch Reach 2. This reach is in the low point in the valley but is in need of bank repairs to stabilize the toe and the establishment of grade control and proper channel dimension. Addition of significant pattern is not appropriate for the valley type; the bed and banks do not exhibit widespread degradation. In these enhancement reaches, the design will focus on creating stable step-pool sequences, re-grading banks to reference dimensions, and removing invasive species and establishing native riparian buffers. Figure ES.1 presented in the Executive Summary, shows the proposed restoration and enhancement reach lengths.

The stream types for the restored and enhanced streams will be predominantly Rosgen “B” channels with design dimensions based on reference reaches, sediment transport modeling and past projects. The reaches in the project corridor will have minor pattern adjustments due to the steep valley slopes and the corresponding design channel type. These channels are already in the low points of their valleys and will dissipate energy vertically (through step-pools).

Where abandoned, the old stream channels will be backfilled using fill material generated by the grading of new channel and floodplain benches. Any excess fill material that is generated during construction will be disposed of on-site in designated disposal areas, at least 50 feet from any live stream, and stabilized.

The restoration and enhancement designs will allow stream flows larger than bankfull flows to spread onto the restored floodplain, dissipating flow energies and reducing the stress on streambanks. In-stream structures will be used to control streambed grade, reduce stresses on streambanks, and promote bedform sequences and habitat diversity. In-stream structures may consist of root wads, constructed riffles, log vanes, and log weirs to provide reach-wide grade control. Both wood and rock will be incorporated into the structures to promote a diversity of habitat features. Streambanks will be stabilized with a combination of bioengineering measures, erosion control matting, bare-root plantings, and live staking. This section discusses the design criteria selected for stream restoration on the Elk Branch project site.

6.1 Restoration Project Goals and Objectives

The design objectives for Elk Branch and the unnamed tributaries were based on the general goals listed in the introduction:

Improve hydrologic connections between creeks and floodplains.
Improve the water quality in the Elk Branch watershed.
Improve aquatic and terrestrial habitat along the project corridor.
Create geomorphically stable conditions on the project reaches.

Design objectives are a set of guidelines used to accomplish these goals effectively and efficiently. The following objectives were incorporated into the design of the streams on this site:

Make important design decisions with supporting information from hydraulic modeling in order to incorporate analytical design elements with typical geomorphic analyses.
Use constructability as a guiding consideration in order to produce a realistic design that will be possible to build given field constraints and construction tolerances. Design ideas should be discussed with knowledgeable construction personnel to determine the constructability, likely footprint, and severity of impacts to on-site resources.
Minimize disturbance to ecologically functional and physically stable areas; mimic the character of these areas and borrow materials from them where appropriate to create a more natural design
Structures and overall design will attempt to use native materials and minimize materials brought on-site in order to produce habitat favoring native flora and fauna, reduce compaction and site disturbance from material transport, and produce an aesthetically pleasing result with the goal being minimal evidence of site disturbance. The accompanying plans show the proposed restoration measures. The application of these measures area described below according to reach location.

Elk Branch-Reach 1

The upper part of Reach 1 of Elk Branch has a small buffer bordered on each side by pasture. The restoration strategy will restore a stream that has been tampered with and return the riparian buffer to a natural state and increase the buffer width to significantly reduce the impacts of grazing from the adjacent pasture. A watering trough will provide water to the cattle without the need for access to the creek or low-lying areas. The manmade watering area in the creek will be removed and the stream will be rebuilt.

Priority 1 Restoration of the next portion of the reach will address the channelization of the reach by re-creating step-pool morphology. The reconstruction of the stream will facilitate the removal of the existing headcuts propagating up the channel, eliminate the presence of vertical, eroding banks, and remove exotic invasive vegetation. These trends would otherwise continue to plague the reach and the downstream reaches with the continuing siltation, lack of stability, and lack of an adequate riparian buffer. Proposed efforts will restore grade control, lateral stability, and habitat features to the reach improving both its health and function and that of the downstream system.

Below the culvert, the Priority 1 approach will continue in order to maintain floodplain connectivity and a high entrenchment ratio. Vertical and lateral stability will be achieved with small grade drops over structures. A Priority 1 approach will allow the stream to be moved off the valley wall in most places. The result will be a wider belt width and access to a floodplain. The proposed approach will restore stable and self-maintained silt-free riffles, increase the amount and quality of pool habitat, remove exotic invasive species, and plant the corridor with native riparian herbaceous and woody species. Some of the Reach will tie into existing channel and then depart on new alignment. These existing channel segments exhibit stability or potential for easy repair, floodplain connectivity, and a potential source of aquatic species recolonization.

Elk Branch-Reach 2

Reach 2 has some good qualities that were recognized and used for reference purposes. However, in total the reach suffers from toe erosion problems and vertical banks. In addition, there is a lack of grade control and profile heterogeneity. A high level of enhancement (I) will be pursued in order to address these issues and ensure long term stability to protect the restoration reach above. Improvements will be achieved by conducting dimension and profile adjustment. The re-graded channel will be matted and revegetated to help stabilize the banks. Small log and boulder drops will be used intermittently to drop grade, form pools, and vertically stabilize the creek. The channel will typically have a W/D ratio that is in the range of a B stream type but may be close to the W/D ratio typical of a Eb-type channel at existing stable areas, which will be left intact. Newly constructed pool cross-sections will have a higher W/D ratio to prevent bank erosion.

UT1

UT1 is the larger of the tributaries located on the Hall property and confluences with the mainstem below the project reach due to the loss of one of the project participants. Never-the-less, the restoration of this reach will be a significant benefit to the watershed. Step-pool morphology will be restored to this reach which has been severely impacted from channelization and livestock access. The riparian corridor will be fenced off and the stream will be rebuilt with access to the floodplain typical of a B stream-type. Invasive vegetation will be removed and the corridor will be planted with native species.

UT2

UT2 confluences with Elk Branch around station 3+00. The tributary has undergone significant modification and flows mostly underground. A restoration strategy will be pursued to build a new stable channel on the existing floodplain using the upstream reach and other design data as a template. This channel will incorporate grade control structures to hold grade and form a B-type, step-pool channel.

6.2 Design Criteria Selection for Stream Restoration

A number of analyses and data were incorporated into the development of site-specific natural channel design approaches. Among these are estimates of hydrology, hydraulic and sediment transport analyses, data from existing stable areas on site, incorporation of reference reach databases, regime equations, and evaluation of results from past projects.

Design criteria are dependent on the general restoration approach that was determined to be a best fit for the Elk Branch site (Table 6.0). The approach for restoration and enhancement was based on an assessment of each reach and it's potential. After selection of the general restoration approach, specific design criteria were developed. The plan view layout, cross-section dimensions, and profile have been designed to meet the design targets and limits and are consistent with the analyses and data available.

Assigning an appropriate stream type for the corresponding valley that accommodates the existing and future hydrologic and sediment contributions was considered conceptually prior to selecting reference reach streams. Design criteria for the proposed stream concept were selected based on the range of the reference data and the desired performance of the proposed channel.

During the application of the design criteria, spot-specific solutions were tailored to incorporate the existing valley morphology, to avoid encroachment on easement boundaries and the valley wall, to minimize unnecessary disturbance of any existing riparian forest, and to promote natural channel adjustment following construction. The construction documents have been laid out to produce a cost- and resource-efficient design that is constructible. The project design is intended to maximize the chance of project success in accommodating the existing and future hydrologic and sediment contributions. The underlying philosophy of the design and subsequent construction is that the streams will adapt to the inherent uniformity of the restoration project and be allowed to reform nuances and a greater physical diversity over long periods of time under the processes of flooding, re-colonization of vegetation, and geologic influences.

Table 6.0 Project Design Stream Types and Rationale
Elk Branch Restoration Plan- EEP Project # D06125-B

Reach	Proposed Stream Type	Rationale
Elk Branch Reach 1	B	Priority I Restoration will eliminate high bank height ratios, reroute the channel away from erosional areas and valley wall impingement and create a stable step-pool channel appropriate to the valley
Elk Branch Reach 2	B/Eb	Enhancement level I will address dimension to halt toe erosion that is widely present in the reach. Profile will be addressed by adding grade control that will incorporate pools into the reach. The improvements to water quality and vertical grade control will promote better habitat and ensure long term stability.
UT 1	B	Priority I Restoration will be used to reconnect the channelized tributary with the floodplain. A new plan and bedform will increase habitat diversity and eliminate eroding streambanks. Invasive vegetation will be removed; the riparian buffer will be revegetated with native species.
UT 2	B	Priority I Restoration will bring the channel back to the surface as it has been buried by previous human activity. The new channel will be constructed with a stable dimension, pattern and profile. Trash and debris will be removed.

6.3 Stream Project Design & Justification

The primary objective of the restoration design is to construct geomorphically stable stream reaches so that natural process will create the hydrologic and ecologic functional uplift necessary to sustain a vigorous ecosystem. The philosophy applied by Baker throughout the Elk Branch project design combined the on-site form-based information with physical modeling and process-based data to create a stable channel design. Data for design guidance was produced using the existing conditions survey, applicable reference data used to produce supplemented curves based on the published regional curves, HEC-RAS output data, and consideration of constructability and equipment limitations. The resulting design is a primarily B-type with higher width-depth ratios to promote bank stability and step-pool profile to dissipate energy vertically. The channels will be free to naturally adjust according to the prevailing geomorphologic trends in the system. Table 6.1 provides an analysis of the existing conditions data collected. The proposed design for each of the reaches is detailed in Tables 6.2 and 6.3.

The design rationale and design parameters for all of the design reaches are presented below.

6.3.1 Existing Conditions Data

The existing conditions survey data was divided into assessment reaches to observe and assess channel condition under prevailing conditions (with consideration of the affects of prior human intervention). In particular, it was hoped that the impact of watershed area and slope would be reflected in the existing conditions data in order to help assess these trends in order to inform the design.

Survey data consists of "mini" cross-sections which capture the top of channel bank, toe of bank, and thalweg locations and elevations. For most streams, especially those of small size such as Elk Branch, these 5 points can provide a representation of the channel cross-sectional characteristics. To expedite the analyses, top of bank cross-sectional characteristics (area, width, and depth) were statistically analyzed (as a surrogate for "bankfull") to determine reach averages, extremes, and trends. In addition, slope-normalized ratios of the width and depth were also considered; depth to slope ratio analyses are presented. Slope is an important factor in determining water surface profiles, velocities, cross-sectional areas and is therefore an relevant factor to assess for its affect on existing conditions.

The most unstable cross-sections were removed from the datasets by eliminating those sections that had an area of less than 2 square feet or greater than 10 square feet. This range is based on outer confidence limits from regional curve and reference reach data for streams of similar size drainage area as presented in the next section. Additionally, cross-sections subject to abnormal flow conditions such as culverts, confluences, those with extreme slope values, or other considerations based on best judgment were also eliminated.

A table of results has been provided (Table 6.1) to show some of the data and some tables produced to assess the impact of slope on channel dimensions. Statistical assessment on a reach or sub-reach scale in the form of averages and standard deviation values may be more easily taken in by the reader in Figure 6.1. The moving average of the W/D ratio for these cross-sections has been plotted. The analysis did provide some information about changes in dimensions potentially related to downstream distance and changes potentially related to slope.

Table 6.1 Existing Conditions Data Analysis ("tob" = top of bank)
Elk Branch Restoration Plan- EEP Project # D06125-B

ELK BRANCH ANALYSIS REACH 1

	CAD SEC#	Ex. Cond. Sta.	Atob*	Wtob	Dtob	W/D	Statistics Std. Dev.	% Confid.	***Dtob***
START	59.5	473.8	NOT APPROPRIATE FOR DESIGN				2σ	95.45%	0.50
	57.0	623.7	5.2	6.0	0.86	6.9	σ	68.27%	0.61
	55.5	751.0	6.0	7.5	0.80	9.4		mean	0.71
	54.5	831.7	4.0	5.5	0.73	7.5	σ	68.27%	0.82
	54.0	867.8	9.7	11.5	0.84	13.7	2σ	95.45%	0.92
	52.0	941.0	6.1	11.3	0.54	20.8			***Wtob***
	51.0	974.5	4.0	5.7	0.70	8.2	2σ	95.45%	2.2
	50.5	1007.7	3.8	5.0	0.75	6.7	σ	68.27%	4.8
	50.0	1020.9	3.0	5.1	0.59	8.6		mean	7.4
	49.0	1037.2	6.9	10.0	0.69	14.4	σ	68.27%	10.0
	48.0	1066.0	3.9	6.2	0.63	9.9	2σ	95.45%	12.5
END	44.5	1211.4	NOT APPROPRIATE FOR DESIGN						

*Abkf criteria of 2-10 sq ft

	Slopes				AVG	AVG		
Dtob/Slp	*0.018*	*0.02*	*0.022*	*0.024*	***0.026***	***0.028***	*0.03*	*0.032*
11	0.2	0.22	0.24	0.26	0.29	0.31	0.33	0.35
18	0.32	0.36	0.4	0.43	0.47	0.5	0.54	0.58
25	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8
32	0.58	0.64	0.7	0.77	0.83	0.89	0.96	1.02
38.9	0.7	0.78	0.86	0.93	1.01	1.09	1.17	1.25

ELK BRANCH ANALYSIS REACH 2

	CAD SEC#	Ex. Cond. Sta.	Atob*	Wtob	Dtob	W/D
START	44	1248.6	NOT APPROPRIATE FOR DESIGN			
	43	1290.7	6.2	6.7	0.93	7.2
	42.8	1317.9	4.4	8.0	0.55	14.4
	42.6	1349.1	6.7	7.5	0.89	8.4
	42.4	1358.8	6.0	6.0	0.99	6.0
	42.2	1383.1	5.2	6.5	0.80	8.1
	41.6	1400.2	5.5	5.9	0.93	6.3
	41	1418.9	3.1	4.3	0.73	5.9
	40.5	1449.9	4.4	6.1	0.72	8.5
	39.5	1515.8	6.2	5.8	1.07	5.4
	39	1535.6	4.4	5.0	0.89	5.6
	38	1556.1	2.7	3.0	0.91	3.3
	37.5	1568.6	3.7	4.5	0.83	5.4
	35	1642.2	4.2	3.8	1.11	3.4
	34	1679.0	2.9	4.0	0.71	5.6
	33.5	1703.1	4.5	7.9	0.57	13.8
	32	1800.1	5.4	7.0	0.77	9.0
END	28.0	2013.8	NOT APPROPRIATE FOR DESIGN			

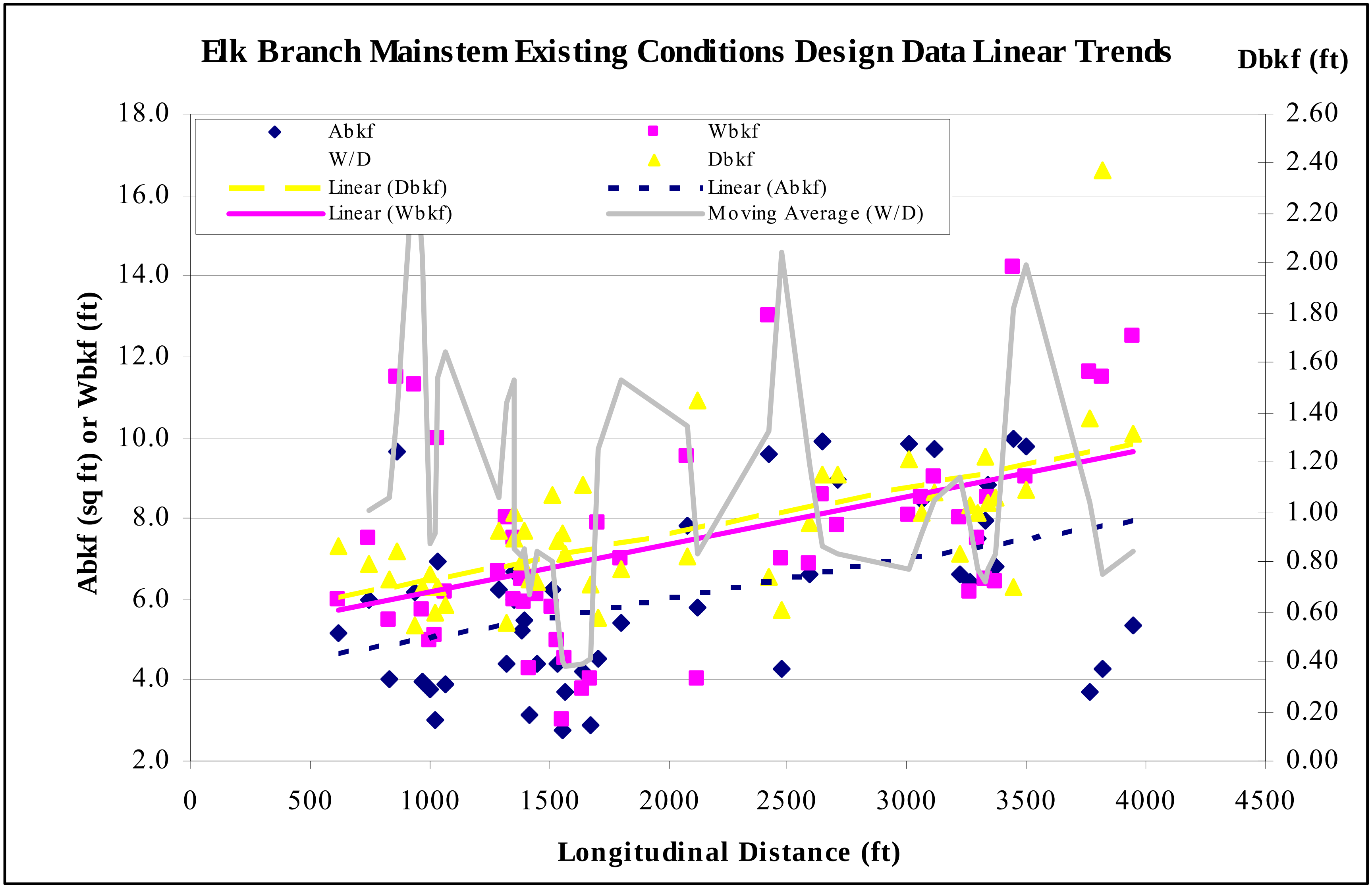
*Abkf criteria of 2-10 sq ft

Statistics

Std. Dev.	% Confid.	***Dtob***
2σ	95.45%	0.52
σ	68.27%	0.68
	mean	0.84
σ	68.27%	1.00
2σ	95.45%	1.16
		Wtob
2σ	95.45%	2.7
σ	68.27%	4.2
	mean	5.8
σ	68.27%	7.3
2σ	95.45%	8.8

	Slopes			AVG	AVG			
Dtob/Slp	*0.014*	*0.016*	*0.018*	***0.02***	***0.022***	*0.024*	*0.026*	*0.028*
13	0.18	0.21	0.23	0.26	0.29	0.31	0.34	0.36
30.9	0.43	0.49	0.56	0.62	0.68	0.74	0.8	0.86
48.8	0.68	0.78	0.88	0.98	1.07	1.17	1.27	1.37
66.6	0.93	1.07	1.2	1.33	1.47	1.6	1.73	1.87
84.5	1.18	1.35	1.52	1.69	1.86	2.03	2.2	2.37

Figure 6.1 Elk Branch Existing Condition Data Trends (In figure, "bkf" is a misnomer, dimensions are from top of bank measurements)



6.3.2 Regional Curve and Supplemental Reference Reach Data

Regional curve, reference reach database, and on-site reference data was used to create "mini" (also referred to as "supplemented") curves for the Elk Branch project (See Figures 6.2, 6.3, and 6.4). Some of the data points from the Mountain Regional Curve with large drainage areas were eliminated from the data set. The remaining points are from similar valley types and have a cap on the drainage area size to view a subset of streams with smaller drainage areas. New R^2 values for the "mini" curve were as good as, or better than, the published Regional Curve.

The on-site reference data from a subreach of Reach 2 of Elk Branch plotted below all of the best fit curves. This is attributed in part to the fact that the data was taken from a nearly perfect rectangular cross-section with a low W/D ratio. Channels of this shape are called efficient because of their ability to carry a larger discharge within a smaller channel because of the minimization of roughness in the form of wetted perimeter (shape roughness). Since constructed channels will be built with a higher W/D ratio, these channels will have a cross-sectional area slightly larger than the reference reach in order to carry the design discharge at the bankfull elevation.

Figure 6.2 Elk Branch Supplemented Regional Curve for Bankfull Cross-sectional Area

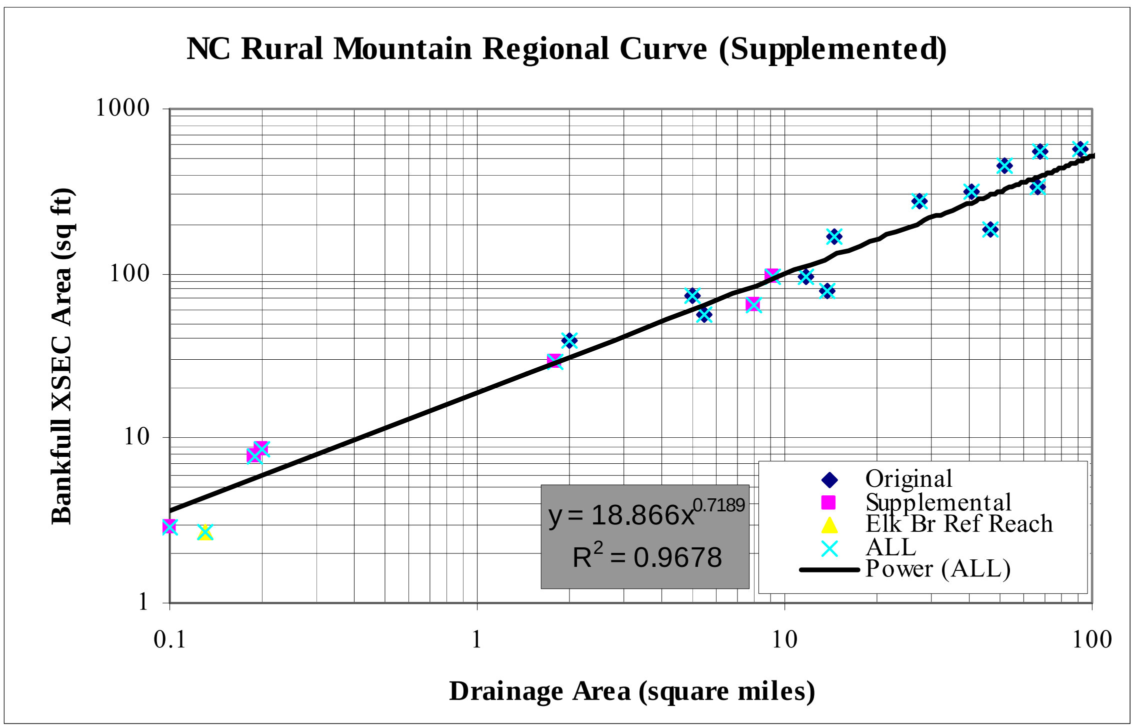


Figure 6.3 Elk Branch Supplemented Regional Curve for Bankfull Width

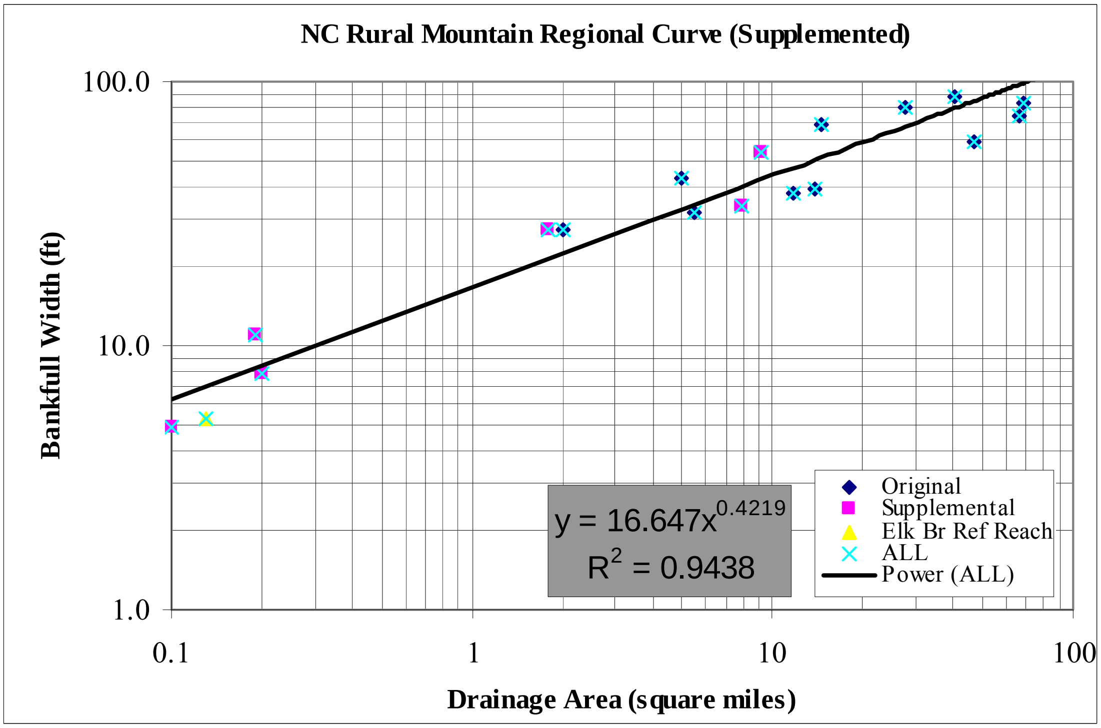
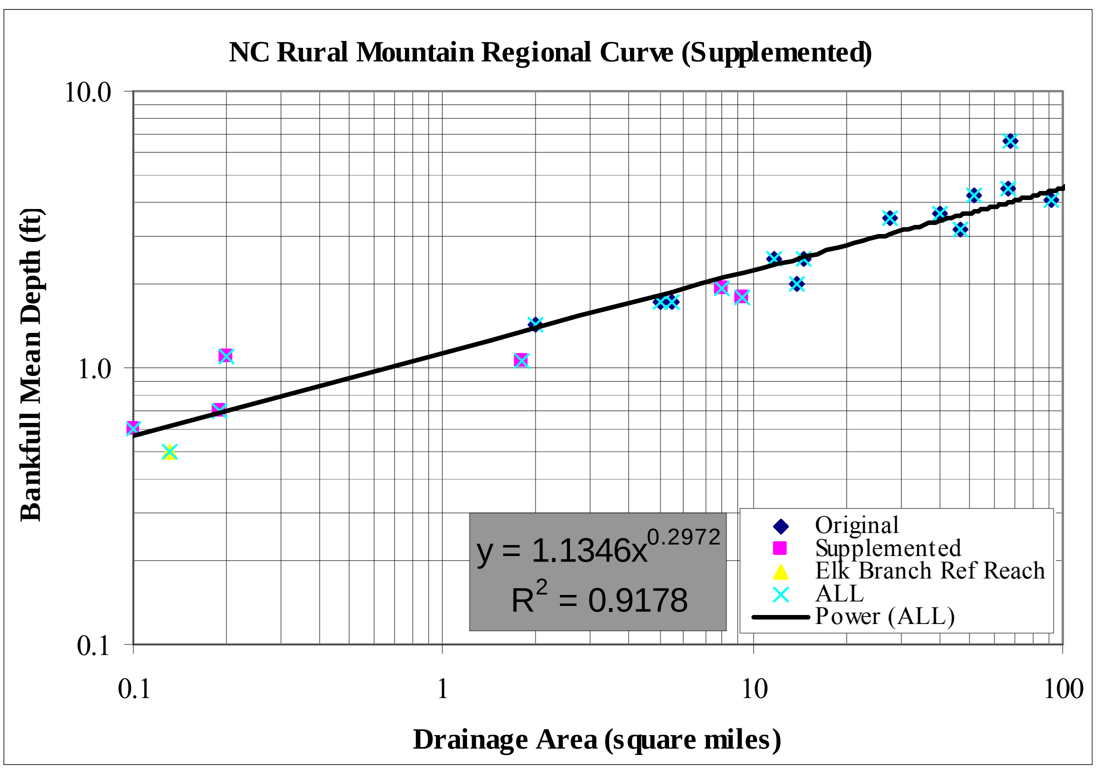


Figure 6.4 Elk Branch Supplemented Regional Curve for Bankfull Depth



6.3.3 Results for Design Guidance

Data for design guidance was produced using the existing conditions survey, applicable reference data used to produce supplemented curves based on the published regional curves, HEC-RAS output data, and consideration of constructability and equipment limitations. The design rationale and design parameters for all of the design reaches are presented below.

Dimension

Many sections of the design reaches involve creation of a new channel with floodplain connectivity, sediment transport continuity, and bank stability. The selected design parameters reduce erosive boundary stresses, provide the appropriate degree of sediment transport, and restore access to the floodplain. The lower end of a B-type channel width to depth ratio was chosen; the channel may narrow to an E-type morphology over time. E-type channels are difficult to construct due to high instability immediately after construction. A low bank height ratio (BHR) of 1.0 was designed so the channel has access to the floodplain during events having flows in excess of the design discharge. Typical sections are shown on the plan sheets.

Pattern

The proposed channel alignments are intended to create a hybrid step-pool and riffle-pool morphology with stable slopes. Higher meander width ratios on the restored channels are proposed to allow for lateral dissipation of energy and provide a floodplain sufficient for future natural channel development. Some isolated lengths of the channel were constrained by a narrow valley. In these locations, the proposed belt width is limited but profile diversity will be restored. Plan views of the main channels are shown on the attached plan sheets.

Aside from reaches that are confined, radii of curvature fall into the range of approximately two to three times the channel's proposed bankfull width. A balance of tighter curves which are likely to produce deeper pools and gentler curves which enhance stability immediately following completion of construction were incorporated into the design.

Profile/Bedform

Except in areas where the existing bedform is sufficiently stable and diverse, the design intent is to establish a pool-riffle sequence which is both hydraulically diverse and stable. Riffles throughout the design reaches are within a range that was observed to produce high quality stable riffles within the project and was verified by dimensionless ratio guidance of 1.5 and 2 times the average slope of the channel. The maximum pool depth is proposed to be constructed from the meander curve apex to a point one-half of the distance along the profile from the apex to the head of the next downstream riffle.

Table 6.2 Geomorphic Characteristics of the Proposed Elk Branch Restoration Plan Elk Branch Restoration Plan- EEP Project # D06125-B	Elk Branch			
	Min	Max	Min	Max
1. Stream Type	B4			
2. Drainage Area – mi^2	0.05		0.14	
3. Bankfull Width (w_{bkf}) – ft	7.0		9.0	
4. Bankfull Mean Depth (d_{bkf}) – ft	0.60		0.65	
5. Width/Depth Ratio (w/d ratio)	11.7		13.8	
6. Cross-sectional Area (A_{bkf}) – ft^2	4.2		5.85	
7. Bankfull Mean Velocity (v_{bkf}) - ft/sec	1.7		2.4	
8. Bankfull Discharge (Q_{bkf}) – ft^3/sec	7		14	
9. Bankfull Max Depth (d_{mbkf}) - ft	0.8		0.9	
10. d_{mbkf} / d_{bkf} Ratio	1.33		1.38	
11. Low Bank Height to d_{mbkf} ratio	1.0		1.0	
12. Floodprone Area Width (w_{fpa}) – feet	17 (min)		21 (min)	
13. Entrenchment Ratio (ER)	2.2-3.2		2.2-5.0	
14. Meander Length (L_m) – ft*	N/A		N/A	
15. Meander Length to Bankfull Width (L_m/w_{bkf})*	N/A		N/A	
16. Radius of Curvature (R_c) – ft*	N/A		N/A	
17. Radius of Curvature to Bankfull Width (R_c / w_{bkf})*	N/A		N/A	
18. Belt Width (w_{blt}) – ft*	N/A		N/A	
19. Meander Width Ratio (w_{blt}/W_{bkf})*	N/A		N/A	
20. Sinuosity (K) (Stream Length / Valley Length)	1.02		1.11	
21. Valley Slope	0.028		0.027	
22. Average Channel Slope (S_{bkf})	0.027		0.024	
23. Pool Slope (s_{pool})	0		0.0048	
24. Pool Slope to Average Slope (S_{pool} / S_{bkf})	0		0.20	
25. Maximum Pool Depth (d_{pool}) – ft	2.0		2.0	
26. Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	3.3		3.1	
27. Pool Width (w_{pool}) – ft	12		13	
28. Pool Width to Bankfull Width (w_{pool} / w_{bkf})	1.7		1.4	
29. Pool Area (A_{pool}) – ft^2	---		---	
30. Pool Area to Bankfull Area (A_{pool}/A_{bkf})	---		---	
31. Pool-to-Pool Spacing (p-p) – ft	10		42	
32. Pool-to-Pool Spacing to Bankfull Width (p-p/w_{bkf})	1.4		4.7	
33. Riffle Slope (s_{riffle})	0.028		0.035	
34. Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	1.04		1.3	

Table 6.3 Geomorphic Characteristics of the Proposed Elk Branch Tributaries Restoration Plan Elk Branch Restoration Plan- EEP Project # D06125-B	UT 1&2 to Elk Branch	
	UT 2	UT 1
1. Stream Type	B4	B4
2. Drainage Area – mi^2	0.01	0.06
3. Bankfull Width (w_{bkf}) – ft	6	8
4. Bankfull Mean Depth (d_{bkf}) – ft	0.38	0.52
5. Width/Depth Ratio (w/d ratio)	16.2	15.4
6. Cross-sectional Area (A_{bkf}) – ft^2	2.25	4.3
7. Bankfull Mean Velocity (v_{bkf}) - ft/sec	2.7	2.3
8. Bankfull Discharge (Q_{bkf}) – ft^3/sec	6	10
9. Bankfull Max Depth (d_{mbkf}) - ft	0.50	0.70
10. d_{mbkf} / d_{bkf} Ratio	1.3	1.3
11. Low Bank Height to d_{mbkf} ratio	---	---
12. Floodprone Area Width (w_{fpa}) – feet	14 (min)	18 (min)
13. Entrenchment Ratio (ER)	2.2	3.2
14. Meander Length (L_m) – ft*	N/A	N/A
15. Meander Length to Bankfull Width (L_m/w_{bkf})*	N/A	N/A
16. Radius of Curvature (R_c) – ft*	N/A	N/A
17. Radius of Curvature to Bankfull Width (R_c / w_{bkf})*	N/A	N/A
18. Belt Width (w_{blt}) – ft*	N/A	N/A
19. Meander Width Ratio (w_{blt}/W_{bkf})*	N/A	N/A
20. Sinuosity (K) (Stream Length / Valley Length)	1.04	1.04
21. Valley Slope	0.038	0.044
22. Average Channel Slope (S_{bkf})	0.036	0.042
23. Pool Slope (s_{pool})	0 – 0.0084	0 - 0.0072
24. Pool Slope to Average Slope (S_{pool} / S_{bkf})	0 - 0.20	0 - 0.20
25. Maximum Pool Depth (d_{pool}) – ft	2.0	2.0
26. Pool Depth to Average Bankfull Depth (d_{pool}/d_{bkf})	5.3	3.8
27. Pool Width (w_{pool}) – ft	10	12
28. Pool Width to Bankfull Width (w_{pool} / w_{bkf})	1.7	1.5
29. Pool Area (A_{pool}) – ft^2	---	---
30. Pool Area to Bankfull Area (A_{pool}/A_{bkf})	---	---
31. Pool-to-Pool Spacing (p-p) – ft	9-17	9-17
32. Pool-to-Pool Spacing to Bankfull Width (p-p/w_{bkf})	1.5-2.8	1.1-2.1
33. Riffle Slope (s_{riffle})	0.041-0.060	0.048-0.070
34. Riffle Slope to Average Slope (s_{riffle}/ s_{bkf})	1.1-1.7	1.1-1.7

Table 6.4 presents supplemental curve bankfull channel dimensions based on the drainage area of the project reaches. This was one of the elements of guidance used in design.

Table 6.4 Design Parameters and Geomorphic Characteristic Ranges Based on Supplemented Regional Curve
Elk Branch Restoration Plan- EEP Project # D06125-B

	Reach 1		**Reach 2**		**UT 1 and 2**	
	Min	Max	Min	Max	Min	Max
Drainage Area (Mi^2)	0.05-0.14		0.14		0.01-0.06	
Bankfull Flow (Qbkf) - cfs	10-23		23		3-12	
Bankfull Width (w_{bkf}) – feet	4.7-7.3		7.3		2.4-5.1	
Bankfull Mean Depth (d_{bkf}) – feet	0.46-0.63		0.63		0.29-0.49	
Width/Depth Ratio (w/d ratio)	10.2-11.6		11.6		8.3-10.4	
Cross-sectional Area (A_{bkf}) – SF	2.2-4.6		4.6		0.7-2.5	

6.3.4 Sediment Transport

As discussed in the channel stability assessment, Lane (1955) describes a generalized relationship of stream stability wherein the product of sediment load and sediment size is proportional to the product of stream slope and discharge. But whereas sediment size, stream slope, and stream discharge can be assessed in a straight-forward manner, sediment load is difficult to quantify because of the numerous processes controlling sediment delivery and movement within the stream system.

Sediment transport competency is a measure of a stream’s ability to move a particle of a certain size and is an important part of understanding geomorphic process at work in the system. The dimension of the channel was designed with consideration of the slope of the energy grade line in order to produce a design dimension that was competent for at least the D50 at the bankfull flow. Elk Branch is a system with a mix of alluvial and colluvial particles and so the coarsest fractions of the sediment load may only move during extreme events.

From a mass-balance standpoint, sediment transport capacity is a much more important analysis. Sediment transport capacity refers to the stream’s ability to move a mass of sediment past a cross-section per unit of time, expressed in pounds/second or tons/year. Sediment transport capacity can be assessed directly by developing a sediment transport rating curve using measured sediment transport data from the site taken during flow events. But since measured rating curve development is extremely difficult, other empirical relationships are often used to assess sediment transport capacity. In this case, sediment transport capacity was calculated based on the empirically-developed Meyer-Peter & Müller Equation, which is one of the options available in HEC-RAS for transport calculation (Bruner, 2005). It is important to note that sediment transport capacity estimates do not reveal sediment supply to the stream, such that a stream may be carrying much less sediment than it has the potential to carry, if the sediment transport is limited by sediment supply. However, by estimating sediment transport capacity in the stream reach immediately upstream of the project reach and creating similar capacity to carry sediment in the design reach, sediment transport continuity can be achieved by balancing potential sediment supply with transport capacity using a mass-balance approach between reaches.

The sediment transport modeling capabilities of HEC-RAS were used to assess stable channel designs (cross-sectional shape and energy slope) given sediment supply and design discharge for existing cross-sections within the project which were chosen for design based on their present stability. Design based on a capacity limited approach assumes that the sediment supply into the reach will be sufficient. If the sediment load entering the project reach is not severely limited, the reach is not at risk of down-cutting and is not at risk of aggrading if the channel is designed according to the stable channel design calculations, provided that proper assumptions are made. Being a head-water watershed, Elk Branch is naturally a sediment limited system. In order to compensate for this condition, larger colluvial particles may protect smaller particles from movement. This armoring effect limits the potential down-cutting of the stream. The newly constructed channel will be constructed with an engineered bed material that will include colluvial-size particles in order to recreate the natural armoring present in a developed channel.

In this system, sediment transport capacity analysis provides confidence in the capability of the design to transport a long-term balanced volumetric sediment load through all segments of the restoration reach. A design incorporating sediment transport results has a higher likelihood of maintaining its vertical stability while adjusting within stable limits to watershed and in-stream changes.

6.3.4.1 Methodology

Numerous data, as described earlier, were used to create a detailed HEC-RAS model. An average of existing sediment transport capacity was determined eliminating extreme high and low values found in unstable sections and at culverts and other irregularities. Based on the findings of bulk and pavement/sub-pavement sampling from point bar and mid-channel bar locations, appropriate sediment distributions were determined for sediment transport. The sediment transport predictor equations used were not developed with the larger particles present in the Elk Branch sediment distribution curve but provide a relative comparison from existing stable to design conditions. There are no sediment transport equations available in HEC-RAS that incorporate data for larger particles. The HEC-RAS sediment transport module incorporates sediment distribution data from field samples to estimate the concentration of sediment moving during design flow conditions based on the results of the water surface profile and velocities and shear stresses produced by the physical characteristics of the channel and floodplain. The result is a volumetric sediment discharge (or capacity) for the chosen design flow rate.

6.3.4.2 Sediment Transport Analysis Discussion

Appendix F contains cumulative frequency graphs for sediment samples used in the sediment transport analyses. Project reaches have median particle sizes in the range of small to large gravel. The analyses were also checked for sensitivity to design sediment size; transport capacity had an acceptably small sensitivity to the variations in distribution exhibited in the sediment samples.

Volumetric sediment discharge was analyzed at existing stable cross-sections in the project reach. These reference cross-sections are used to determine what the design sediment discharge should be. Chapter 12 of the HEC-RAS Hydraulic Reference Manual (Bruner, 2005) discusses the Copeland Method for stable channel design. This method allows the modeler to incorporate design sediment discharge and design flow rate data in order to produce dimensions and energy slopes that will capably transport the sediment and water. Various combinations of channel cross-section and profile were assessed for their capability to move the design sediment discharge. These stable dimensions and slopes were incorporated into the typical riffle cross-section and design slope of the project.

6.3.5 HEC-RAS Analysis

6.3.5.1 Preliminary Modeling and Hydrologic Trespass

Elk Branch is a low order tributary to Cane Creek. It is not necessary to conduct a flood study based on the following information: according to the FEMA Preliminary Flood Insurance Rate Map (FIRM) for Mitchell County, NC, (Map Numbers 3710087400J and 3710087300J), the project is not within a special flood hazard area (see Figure 2.3). Flood modeling is not required for non-regulatory floodplains. Furthermore, no insurable structures are in the area of the stream project and any change in the 100-year water surface is expected be minimal and be contained within the conservation easement.

6.4 Site Construction

6.4.1 Site Grading, Structure, Installation, and Other Project Related Construction

6.4.1.1 Narrative

A construction sequence is provided below and can be found within the accompanying restoration plan set for the Elk Branch project.

1. Equipment and materials shall be mobilized to the site.

2. The contractor shall have all underground utilities within the project limits located and marked prior to beginning construction.

3. A gravel "construction entrance" that consists of class A stone, at least 50 feet in length, shall be incorporated into every access point that connects to a public road.

4. Temporary and permanent stream crossings and temporary check dams shall be installed as shown in the plan set. Temporary check dams shall be removed when grading work upstream has been completed.

5. Construction shall proceed upstream to downstream. Grading of bankfull benches within a work area shall be done before new channels are graded.

6. Temporary sand bag coffer dams shall be installed upstream of each work area and flow in the work reach shall be diverted by pumping and piping around the work area. The length of each diversion shall be approximately 300 to 500 linear feet. Pumping will be done when work is required in a channel where the stream is flowing and where new off-line channel segments are tied in to the existing channel.

7. The limited clearing and grubbing required within the grading limits shall be performed so as to limit sediment migration off-site. Logs and root wads from trees larger than 10 inches in diameter shall be stockpiled for use as in-stream structures. Salvageable native vegetation (black willow, tag alder, silky dogwood, etc.) shall be harvested for transplanting or for cutting and live-staking materials.

8. The new channel sections shall be stabilized with in-stream structures, erosion control matting, seed, and transplants before turning water into these sections. Compacted soil channel plugs shall be installed in areas where the new channel diverges from the original channel, and the original, abandoned channel sections will be backfilled.

9. Dewatering of off-line sections shall be diverted through a sediment filter before being discharged into the downstream reach.

10. Earthwork shall be staged such that no more channel will be disturbed than can be stabilized by the end of the work day or before flow is diverted into a new channel segment.

11. Disturbed areas within the first 25 feet of buffer adjacent to the channel will be seeded, mulched or otherwise stabilized with temporary ground cover daily until a more permanent ground cover is established across the buffer area disturbed during construction. If temporary ground cover is not applied daily, straw wattles will be staked down at the top of the bank where erosion control matting ends to prevent sediment loading from upland portions of the buffer that have not stabilized.

12. Excess soil materials shall be stockpiled in designated staging and stockpile areas, with silt fence installed on the stream side(s) of the base of the stockpiles and maintained when sediment has accumulated above one third of the height of the silt fence and/or the silt fence has failed. Excess soil shall be hauled outside the conservation easement before demobilization.

13. The flow diversions and temporary stream crossings shall be removed when no longer needed and the banks in these areas stabilized with seeding and matting.

14. Bank and floodplain vegetation, including brush materials and live stakes, are preferably installed during the dormant season, November to April.

15. Construction entrances, staging and stockpile areas, and silt fences shall be removed and ground shall be repaired to its original conditions once planting is complete or once they are no longer needed.

6.4.1.2 In-stream Structures

A variety of in-stream structures are proposed for the Elk Branch site. Structures such as root wads, log drops, and log vanes will be used to create flow acceleration and deep pool development; bioengineering such as vegetated geolifts and brush mattresses will be used to stabilize the new channel. Wood structures will primarily be used on this site because that is the material observed in the existing system. Table 6.4 summarizes the use of in-stream structures at the site.

Table 6.5 Proposed In-Stream Structure Types and Locations
Elk Branch Restoration Plan- EEP Project # D06125-B

Structure Type	Location
Root Wad	Outside bank of smaller radius meander bends.
Brush Mattress	Outside bank of shorter arcs and larger radius meander bends in sections of cut.
Vegetated Geolift	To create new banks in areas where cutting a new channel is not an option.
Log Vane	For hydraulic diversity and flow diversion.
Cover Log	In pools to provide habitat features.

Root Wad

Root wads are placed at the toe of the stream bank in the outside of meander bends for the creation of habitat and for stream bank protection. Root wads include the root mass or root ball of a tree plus a portion of the trunk. They are used to armor a stream bank by deflecting stream flows away from the bank. In addition to stream bank protection, they provide structural support to the stream bank and habitat for fish and other aquatic animals. They also serve as a food source for aquatic insects. Root wads will be placed where appropriate to provide bank protection and improve habitat diversity in the Elk Branch project.

Brush Mattress

Brush mattresses are placed on bank slopes on the outside of meander bends for stream bank protection. Layers of live, woody cuttings are tied together and staked into the bank. Brush mattresses help to establish dense vegetation on the bank to secure the soil. Once the vegetation is established, the cover also provides habitat for wildlife

Vegetated Geolift

Geolifts are used to create a geotechnically stable bank in areas where building a bank or making a significant change in slope or vegetation to a bank is necessary and shear stresses are expected to be moderate or high. They may also be used to create a steeper bank than can be constructed with only fill soil. Geolifts are often used for bank sloping on the outside of meander bends for stream bank protection. A stone toe is usually built at the base of the structure to prevent undermining. Lifts of soil are placed in 1-2 foot thick layers and are supported above and below by a coir fabric which covers the outward facing side of the lift in order to guard against erosion of the face. Live, woody cuttings are layered on top of the lifts with the tops facing outward and subsequent lifts are placed. Geolifts establish an immediately stable slope which is enhanced by the growth of the vegetation sandwiched between the soils lifts.

Log Vane

A log vane is used to turn the thalweg away from the bank. The length of a single vane structure can span one-half to two-thirds the bankfull channel width. Vanes can be located either upstream or downstream along a meander bend where they function to initiate or complete the redirecting the flow thereby reducing shear stresses on the outside bank or fixing the alignment. Vanes are located just downstream of the point where the stream flow intercepts the bank at acute angles.

Cover Log

A cover log is placed in the outside of a meander bend to provide habitat in the pool area. The log is buried into the outside bank of the meander bend; the opposite end extends through the deepest part of the pool and may be buried in the inside of the meander bend, in the bottom of the point bar. The placement of the cover log near the bottom of the bank slope on the outside of the bend encourages scour in the pool. This increased scour provides a deeper pool for bedform variability.

6.4.2 Natural Plant Community Restoration

Native riparian vegetation will be established in the restored stream buffer. Also, areas of invasive vegetation will be managed so as not to threaten the newly-established native plants within the conservation easement. Known invasive species to be treated include multiflora rose, chinese privet and japanese honeysuckle.

6.4.2.1 Soil Preparation and Amendments

Soil amendments will be prepared according to the dominant soil types present within the floodplains for Elk Branch and its unnamed tributaries. Application of soil amendments will occur as site stabilization measures are implemented and during installation of permanent bank and riparian vegetation.

6.4.2.2 Stream Buffer Vegetation

Bare-root trees, live stakes, and permanent seeding will be planted within designated areas of the conservation easement. A buffer measured from the top of banks of 30' on average will be established along the restored stream reaches. Bare-root vegetation will be planted at a target density of 680 stems per acre, or an 8-foot by 8-foot grid. The proposed species to be planted are listed in Table 6.5. Planting of bare-root trees and live stakes will be conducted during the first dormant season following construction. If construction activities are completed in summer/fall of a given year, all vegetation will be installed prior to the start of the growing season of the following calendar year.

Species selection for re-vegetation of the site will generally follow those suggested by Schafale and Weakley (1990) and tolerances cited in the USACE Wetland Research Program (WRP) Technical Note VN-RS-4.1 (1997). Tree species selected for stream restoration areas will be generally weakly tolerant to tolerant of flooding. Weakly tolerant species are able to survive and grow in areas where the soil is saturated or flooded for relatively short periods of time. Moderately tolerant species are able to survive in soils that are saturated or flooded for several months during the growing season. Flood tolerant species are able to survive on sites in which the soil is saturated or flooded for extended periods during the growing season (WRP, 1997).

Observations will be made during construction regarding the relative wetness of areas to be planted. Planting zones will be determined based on these observations, and planted species will be matched according to their wetness tolerance and the anticipated wetness of the planting area.

Live stakes will be installed two to three feet apart using triangular spacing or at a density of 160 to 360 stakes per 1,000 square feet along the stream banks between the toe of the stream bank and bankfull elevation. Site variations may require slightly different spacing.

A permanent riparian seed mixture will be applied to all disturbed areas of the project site. Table 6.6 lists the species composition of the seed mixture and application rates that will be used. Mixtures will also include temporary seeding (rye grain or browntop millet). The permanent seed mixture specified for floodplain areas will be applied to all disturbed areas outside the banks of the restored stream channel and is intended to provide rapid growth of herbaceous ground cover and biological habitat value. The species provided are deep-rooted and have been shown to proliferate along restored stream channels, providing long-term stability.

Temporary seeding will be applied to all disturbed areas of the site that are susceptible to erosion. These areas include constructed streambanks, access roads, side slopes, and spoil piles. If temporary seeding is applied from November through April, rye grain will be used and applied at a rate of 130 pounds per acre. If applied from May through October, temporary seeding will consist of browntop millet, applied at a rate of 45 pounds per acre.

Table 6.6 Proposed Bare-Root and Live Stake Species (may also include species to be seeded or installed as container plantings)
Elk Branch Restoration Plan- EEP Project # D06125-B

Common Name	Scientific Name	% Planted by Species	Wetness Tolerance
Riparian Buffer Plantings			
Trees Overstory			
Sycamore *s	*Platanus occidentalis*	8	FACW-
River Birch *s	*Betula nigra*	7	FACW
White Oak *s	*Quercus alba*	5	FACU
Red Maple *s	*Acer rubrum*	10	FAC
Tulip Poplar *s	*Liriodendron tulipifera*	5	FAC
Yellow Birch *	*Betula alleghaniensis (lutea)*	5	FACU+
Black (Sweet) Birch	*Betula lenta*	5	FACU
Northern Red Oak	*Quercus rubra*	5	FACU
Sugar Maple	*Acer saccharum*	5	FACU-
Mockernut Hickory	*Carya alba (tomentosa)*	3	N/A

Scarlet Oak	*Quercus coccinea*	2	N/A
Trees Understory			
Black Willow*	*Salix nigra*	4	OBL
Ironwood*	*Carpinus caroliniana*	7	FAC
Witch Hazel*	*Hamamelis virginiana*	4	FACU
Sourwood	*Oxydendrum arboreum*	7	FACU
Flowering Dogwood	*Cornus florida*	6	FACU
Rhododendron*	*Rhododendron maximum*	7	FAC-
Tag Alder*	*Alnus serrulata*	10	
Redbud	*Cercis canadensis*	6	FACU
Shrubs			
Rivercane (giant cane)	*Arundinaria gigantea*	15	FACW
Spicebush	*Lindera benzoin*	15	FACW
Deerberry	*Vaccinium stamineum*	10	FACU
Eastern Sweetshrub, Sweetshrub	*Calycanthus floridus, Calycanthus spp.*	10	FACU
Sweetpepperbush	*Clethra spp.*	15	N/A
Winterberry	*Ilex verticillata*	10	FACW
Virginia Sweetspire	*Itea virginica*	15	FACW+
Chokeberry	*Photinia*	5	N/A
Alternate Species			
Blight-resistant American Chestnut	*Castanea dentata*	N/A	N/A
Dog Hobble	*Leucothoe fontanesiana (axilarris var. editorum)*	N/A	N/A
Mountain Laurel	*Kalmia latifolia*	N/A	FACU
American Hazelnut	*Corylus americana*	N/A	FACU
Blue Ridge Blueberry	*Vaccinium pallidum*	N/A	N/A
Riparian Livestake Plantings			
Ninebark	*Physocarpus opulifolius*	10	FAC-
Elderberry	*Sambucus canadensis*	20	FACW-
Buttonbush	*Cephalanthus occidentalis*	10	OBL
Sycamore	*Platanus occidentalis*	5	FACW-
River Birch	*Betula nigra*	10	FACW
Silky Willow	*Salix sericea*	25	OBL
Silky Dogwood	*Cornus amomum*	20	FACW+

Note: Species selection may change due to refinement or availability at the time of planting.
* Schafale, M. P., and A. S. Weakley. 1990.
s-listed in soil survey

Table 6.7 Proposed Permanent Seed Mixture Elk Branch Restoration Plan- EEP Project # D06125-B				
Common Name	**Scientific Name**	**% Planted by Species**	**Density (lbs/ac)**	**Wetness Tolerance**
Creeping Bentgrass	*Agrostis stolonifera*	10%	1.5	FACW
Big Blue stem	*Andropogon gerardii*	2%	0.3	N/A
Devil's Beggartick	*Bidens frondosa (or aristosa)*	3%	0.45	FACW
Northern Long Sedge	*Carex folliculata*	2%	0.3	N/A
Nodding Sedge	*Carex gynandra*	5%	0.75	N/A
Upright Sedge	*Carex stricta*	2%	0.3	OBL
Lance-leaved Tick Seed	*Coreopsis lanceolata*	3%	0.45	N/A
Virginia Wildrye	*Elymus virginicus*	15%	2.25	FAC
Soft rush, NC Ecotype	*Juncus effusus*	2%	0.3	FACW+
Tioga Deer Tongue	*Panicum clandestinum*	10%	1.5	FACW
Switch Grass	*Panicum virgatum*	15%	2.25	FAC+
Pennsylvania Smartweed	*Polygonum pensylvanicum*	5%	0.75	FACW
Broadleaf Arrowhead	*Sagittaria latifolia var pubescens*	1%	0.15	OBL
Little Blue stem	*Schizachyrium scoparium*	5%	0.75	FACU
Roundleaf Goldenrod	*Solidago patula*	3%	0.45	OBL
Indian Grass	*Sorghastrum nutans*	10%	1.5	FACU
Eastern Gamma Grass	*Tripsacum dactyloides*	5%	0.75	FAC+
Joe Pye Weed	*Eupatorium fistulosum*	2%	0.3	N/A
	Total	**100**	**15**	
Note: Species selection may change due to refinement or availability at the time of planting.				

6.4.2.3 On-Site Invasive Species Management

The site has multiple infestations of multiflora rose (*Rosa multiflora*). These areas have been identified in the planting plan and will be treated and monitored so that the invasive species do not threaten the newly-planted riparian vegetation. Other species present that will be treated include Japanese honeysuckle (*Lonicera japonica*), Chinese privet (*Ligustrum sinense*), and various grasses.

Fields within the easement boundaries are predominantly planted in fescue. Fescue will be treated by physical and chemical means in order to reduce competition for native grasses.

The most appropriate means of treating invasive grasses growing in the creek and on the margins of the channel will be assessed and implemented prior to vegetation removal. In many cases, building a new offline channel will reduce or eliminate this issue and the long-term development of a forested creek will shade out this and other invasive grass species.

These areas will be treated and monitored so that the invasive species do not threaten the newly-planted riparian vegetation.

7.0 PERFORMANCE CRITERIA

The Baker team has been involved in obtaining recent approvals from the regulatory agencies for a series of mitigation and restoration plans for wetland and stream projects. The stream restoration and enhancement success criteria for the project site will follow approved success criteria presented in recent restoration and mitigation plans developed for numerous NCEEP full delivery projects. These plans were based on the Stream Mitigation Guidelines issued in April 2003 by the USACE and the NCDWQ. Specific success criteria components are presented below.

7.1 Stream Monitoring

Channel stability and vegetation survival will be monitored on the Elk Branch project site. Post-restoration monitoring of restored stream reaches will be conducted for five years to evaluate the effectiveness of restoration and enhancement practices implemented. Monitored stream parameters include stream dimension (cross-sections), pattern (longitudinal survey), profile (profile survey), and photographic documentation. The methods used and any related success criteria are described below for each parameter.

7.1.1 Bankfull Events

The occurrence of bankfull events within the monitoring period will be documented by the use of a crest gauge and photographs. The crest gauge will be installed on the floodplain within 10 feet of the restored channel. The crest gauge will record the highest watermark between site visits, and the gauge will be checked each time there is a site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events in separate years must be documented within the five year monitoring period. Otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

7.1.2 Cross-Sections

Two permanent cross-sections will be installed per 1,000 linear feet of stream restoration work, with one located at a riffle cross-section and one located at a pool cross-section. Each cross-section will be marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently used to facilitate easy comparison of year-to-year data. The annual cross-section survey will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections will be classified using the Rosgen Stream Classification System, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

7.1.3 Longitudinal Profile

A longitudinal profile will be surveyed immediately after construction and annually for the duration of the five-year monitoring period. The as-built survey will be used as the baseline for year one monitoring. The entire 3,090 LF project length will be surveyed. Measurements will include thalweg, water surface, bankfull, and top of low bank. These measurements will be taken at the head of each feature (e.g., riffle, pool) and at the maximum pool depth. The survey will be tied to a permanent benchmark.

The longitudinal profiles should show that the bedform features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep, with flat water surface slopes, and the riffles should remain steeper and more shallow than the pools. Bedform observed should be consistent with those observed for channels of the design stream type.

7.1.4 Bed Material Analyses

Pebble counts will be conducted for at least three permanent cross-sections across the Elk Branch project site. Pebble counts will be conducted immediately after construction and annually thereafter at the time the cross-section and longitudinal surveys are performed throughout the five year monitoring period. These samples will reveal any changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes.

7.1.5 Photo Reference Sites

Photographs will be used to visually document restoration success. Reference stations will be photographed before construction and continued annually for at least five years following construction. Photographs will be taken from a height of approximately five to six feet. Permanent markers will be established to ensure that the same locations (and view directions) on the site are monitored in each monitoring period.

Lateral reference photos. Reference photo transects will be taken at each permanent cross-section. Photographs will be taken of both banks at each cross-section. The survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame, and as much of the bank as possible will be included in each photo. Photographers should make an effort to consistently maintain the same area in each photo over time.

Structure photos. Photographs will be taken of grade control structures along the restored stream and will be limited to log vanes and weir structures. Vantage points of grade control structures will be considered in the selection of reference station locations; a sufficient number of photographs of structures will be taken to evaluate the effectiveness of vanes and weirs installed. Photographers will make every effort to consistently maintain the same area in each photo over time.

Photographs will be used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures subjectively. Lateral photos should not indicate excessive erosion or continuing degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation.

7.2 Storm Water Management Monitoring

No storm water best management practices (BMPs), are proposed at the Elk Branch restoration project.

7.3 Wetland Monitoring

As stated in Section 5.0, no wetlands are present within the conservation easement area of the Elk Branch restoration project. Therefore, no formal wetland monitoring will be conducted for this project site.

7.4 Vegetation Monitoring

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, vegetation monitoring quadrants will be installed across the restoration site. The

NCEEP's formula for determining the number of vegetation plots required per mitigation site will be used to figure the number of quadrants needed for the Elk Branch project. The size of individual quadrants will vary from 100 square meters for tree species to 1 square meter for herbaceous vegetation. Vegetation monitoring will occur in spring, after leaf-out has occurred. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

At the end of the first growing season, species composition, density, and survival will be evaluated. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between July and November.

Specific and measurable success criteria for plant density on the project site will be based on the recommendations found in the WRP Technical Note and past project experience.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. While measuring species density is the current accepted methodology for evaluating vegetation success on restoration projects, species density alone may be inadequate for assessing plant community health. For this reason, the vegetation monitoring plan will incorporate the evaluation of additional plant community indices to assess overall vegetative success.

7.5 Benthic Monitoring

If required as part of the permitting requirements of the project, benthic macroinvertebrate sampling will be conducted at the restored site prior to construction. Sampling will then occur for three years following construction during years one, three and five of the monitoring period. Appropriate sampling methodologies will be based on current sampling protocols approved by the NCDWQ. However, Baker does not plan to do benthic sampling at this time.

7.6 Schedule/Reporting

Annual monitoring reports containing the information defined herein will be submitted to the NCEEP by December 31 of the year during which the monitoring was conducted. Project success criteria should be met by the fifth monitoring year. If success criteria are not met by year 5, further monitoring and management needs will be determined in conjunction with EEP and the regulatory community.

8.0 PRELIMINARY MONITORING

Once construction is complete, geomorphic data collected during the design phase will be compared to post-construction survey data to evaluate the success of restoration measures implemented. Post-construction data will be summarized in a mitigation plan which will also include Baker's monitoring approach for evaluating the success of the Elk Branch restoration site for five years following the collection of As-built data. Preliminary monitoring of the site included the collection of longitudinal profile data as well as cross-sectional data to assess existing channel dimension and hydraulic function. Other data collected during the preliminary monitoring phase included sediment transport data and vegetative data as well as an evaluation of invasive vegetation present.

9.0 SITE PROTECTION AND ADAPTIVE MANAGEMENT STRATEGY

The Elk Branch restoration project area will be protected by a permanent conservation easement that will be held by the state. Baker will monitor the project site for five years following construction. Post-construction monitoring activities will be conducted to evaluate site performance, to identify maintenance and/or repair concerns, and to maintain the integrity of the project boundaries. If during the post-construction monitoring period it is determined project compliance is jeopardized, Baker shall take the necessary action to resolve the project concerns and bring the project back into compliance. If maintenance or site repairs become necessary, Baker will evaluate the level of response required, secure a contractor to make the repairs and monitor the work performed by the construction contractor.

Maintenance requirements vary from site to site and are generally driven by the following conditions:

- Projects without established, woody floodplain vegetation are more susceptible to erosion from floods than those with a mature, hardwood forest.
- Projects with sandy, non-cohesive soils are more prone to short-term bank erosion than cohesive soils or soils with high gravel and cobble content.
- Alluvial valley channels with wide floodplains are less vulnerable than confined channels.
- Wet weather during construction can make accurate channel and floodplain excavations difficult.
- Extreme and/or frequent flooding can cause floodplain and channel erosion.
- Extreme hot, cold, wet, or dry weather during and after construction can limit vegetation growth, particularly temporary and permanent seed.
- The presence and aggressiveness of invasive species can affect the extent to which a native buffer can be established.

Maintenance issues and recommended remediation measures will be detailed and documented in the as-built and monitoring reports. The conditions listed above and any other factors that may have necessitated maintenance will be discussed. If more substantial repair work is required Baker will coordinate with the NCEEP and regulatory agencies to determine whether work performed merits an extended monitoring period. At the conclusion of the post-construction monitoring period the project shall be transferred to the NCDENR Division of Natural Resource Planning and Conservation Stewardship Program for long-term management and stewardship.

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APPENDIX A. NCDWQ Stream Identification Forms

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

Date: 10/6/06	Project: ELK BRANCH	Latitude: 036°01'23" N
Evaluator: AB	Site: UT 2	Longitude: 082°08'10" W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 37.5	County: MITCHELL	Other *e.g. Quad Name:* BAKERSVILLE

A. Geomorphology (Subtotal = 23.5)	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 = 10)				
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 = 4)				
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:	10/6/06	**Project:**	ELK BRANCH	**Latitude:**	036° 01' 12" N
Evaluator:	AB	**Site:**	UT 1	**Longitude:**	082° 08' 16" W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30*	34.5	**County:**	MITCHELL	**Other** *e.g. Quad Name:*	BAKERSVILLE

A. Geomorphology (Subtotal = 24.5)	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 = 7)				
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 = 3)				
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: 10/6/06	Project: ELK BRANCH	Latitude: 036° 00' 55"N
Evaluator: AB	Site: MAIN STEM	Longitude: 082° 08' 11"W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 38.0	County: MITCHELL	Other *e.g. Quad Name*: BAKERSVILLE

A. Geomorphology (Subtotal = 23)	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 = 5.5)				
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: 10/6/06	Project: ELK BRANCH	Latitude: 036°01'23" N
Evaluator: AB	Site: UT 2	Longitude: 082°08'10" W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 37.5	County: MITCHELL	Other *e.g. Quad Name:* BAKERSVILLE

A. Geomorphology (Subtotal = 23.5)	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 <u>existing</u> 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 = 10)				
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 = 4)				
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:	10/6/06	**Project:**	ELK BRANCH	**Latitude:**	036° 01' 12" N
Evaluator:	AB	**Site:**	UT 1	**Longitude:**	082° 08' 16" W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30*	34.5	**County:**	MITCHELL	**Other** *e.g. Quad Name:*	BAKERSVILLE

A. Geomorphology (Subtotal = 24.5)	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 = 7)				
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 = 3)				
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: 10/6/06	Project: ELK BRANCH	Latitude: 036° 00' 55"N
Evaluator: AB	Site: MAIN STEM	Longitude: 082° 08' 11"W
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 38.0	County: MITCHELL	Other *e.g. Quad Name*: BAKERSVILLE

A. Geomorphology (Subtotal = 23)	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 = 5.5)				
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:

APPENDIX B. Regulatory Correspondence

Baker

Tyler Howe
Tribal Historic Preservation Specialist
Eastern Band of Cherokee Indians
Tribal Historic Preservation Office
P.O. Box 455
Cherokee, NC 28719

April 6, 2007

Subject: EEP stream mitigation project in Mitchell County.

Dear Mr. Howe,

The Ecosystem Enhancement Program (EEP) requests review and comment on any possible issues that might emerge with respect to archaeological or religious resources associated with a potential stream restoration project on the attached site (vicinity map and a USGS site map with areas of potential ground disturbance are enclosed).

A similar letter has been sent to the North Carolina State Preservation Office for compliance with Section 106 of the Historic Preservation Act.

The Elk Branch site has been identified for the purpose of providing in-kind mitigation for unavoidable stream channel impacts. No architectural structures or archeological artifacts have been observed or noted during preliminary surveys of the site for restoration purposes. In addition, the majority of this site has historically been disturbed due to agricultural purposes such as tilling. It should be noted that all project work will be confined to the floodplain of Elk Branch and two unnamed tributaries.

We ask that you review this site based on the attached information to determine if you know of any existing resources that we need to know about. In addition, please let us know the level your future involvement with this project needs to be (if any).

We thank you in advance for your timely response and cooperation. Please feel free to contact the below referenced EEP Project Manager with any questions that you may have concerning the extent of site disturbance associated with this project.

Sincerely,

Ken Gilland

Ken Gilland
Baker Engineering NY, Inc.
8000 Regency Parkway, Suite 200
Cary, NC 27511,
Phone: (919) 459-9035, Email: kgilland@mbakercorp.com

cc:

Guy Pearce
1652 Mail Service Center
Raleigh, NC 27699

Baker

Renee Gledhill-Earley
State Historic Preservation Office
4617 Mail Service Center
Raleigh, NC 27699-4617

March 23, 2007

Subject: EEP stream mitigation project in Mitchell County.

Dear Ms. Gledhill-Earley,

The Ecosystem Enhancement Program (EEP) requests review and comment on any possible issues that might emerge with respect to archaeological or cultural resources associated with a potential stream restoration project on the attached site (a vicinity map, USGS site map with areas of potential ground disturbance, and a soils map are enclosed).

The Elk Branch site has been identified for the purpose of providing in-kind mitigation for unavoidable stream channel impacts. The project will involve the restoration of Elk Branch and two unnamed tributaries in the French Broad River Basin, which include sections of channel that are identified as significantly degraded. Project goals include the restoration or enhancement of approximately 5,615 linear feet of stream for the purpose of obtaining stream mitigation credit in the French Broad River Basin.

No architectural structures or archeological artifacts have been observed or noted during preliminary surveys of the site for restoration purposes. In addition, the majority of the site has historically been disturbed due to agricultural purposes such as tilling. As the enclosed aerial photograph shows, the majority of the area within the construction limits of the site consists of floodplain, farmland, or straightened stream channel.

We ask that you review this site based on the attached information to determine the presence of any historic properties. Thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning the extent of site disturbance associated with this project.

Sincerely,

Ken Gilland
Baker Engineering NY, Inc.
8000 Regency Parkway, Suite 200
Cary, NC 27511,
Phone: (919) 459-9035, Email: kgilland@mbakercorp.com
cc:
Guy Pearce
1652 Mail Service Center
Raleigh, NC 27699

North Carolina Department of Cultural Resources
State Historic Preservation Office
Peter B. Sandbeck, Administrator

Michael F. Easley, Governor
Lisbeth C. Evans, Secretary
Jeffrey J. Crow, Deputy Secretary

Office of Archives and History
Division of Historical Resources
David Brook, Director

April 25, 2007

Ken Gilland
Baker Engineering NY, Inc.
8000 Regency Parkway, Suite 200
Cary, NC 27511

Re: EEP, Restoration of Elk Branch and Two Unnamed Tributaries, Mitchell County, ER 07-0691

Dear Mr. Gilland:

Thank you for your letter of March 23, 2007, concerning the above project.

We have conducted a review of the proposed undertaking and are aware of no historic resources that would be affected by the project. Therefore, we have no comment on the undertaking as proposed.

The above comments are made pursuant to Section 106 of the National Historic Preservation Act and the Advisory Council on Historic Preservation's Regulations for Compliance with Section 106 codified at 36 CFR Part 800.

Thank you for your cooperation and consideration. If you have questions concerning the above comment, contact Renee Gledhill-Earley, environmental review coordinator, at 919/733-4763, ext. 246. In all future communication concerning this project, please cite the above referenced tracking number.

Sincerely,

Peter B. Sandbeck
by MPA

Peter Sandbeck

Baker

Marella Buncick,
US Fish and Wildlife Service
Asheville Field Office
160 Zillicoa Street
Asheville, NC 28801

March 23, 2007

Subject: EEP Stream mitigation project in Mitchell County.

Dear Ms. Buncick,

The Elk Branch site has been identified for the purpose of providing in-kind mitigation for unavoidable stream channel impacts. Several sections of channel in Elk Branch and two unnamed tributaries have been identified as significantly degraded.

We have already obtained an updated species list for Mitchell County from your web site (http://nc-es.fws.gov/es/countyfr.html). The threatened or endangered species for this county are: the Carolina Flying Squirrel (*Glaucomys sabrinus coloratus*), Indiana bat (*Myotis sodalis*), Appalachian elktoe, (*Alasmidonta raveneliana*), Spruce-fir moss spider (*Microhexura Montivaga*), Blue Ridge Goldenrod (*Solidago spithamaea*), Heller's blazing star (*Liatris helleri*), Roan Mountain bluet (*Hedyotis purpurea var. Montana*), Spreading avens (*Geum radiatum*), Virginia spiraea (*Spiraea virginiana*), Rock gnome lichen (*Gymnoderma leneare*) and Bog turtle (*Glyptemys Muhlenbergii*).

There are critical habitat areas for the Appalachian elktoe and Spruce-fir moss spider in Mitchell County. The project area is not in the critical habitat area for the Spruce-fir moss spider. The Appalachian elktoe critical habitat area extends to the North Fork Toe River. As shown in the enclosed vicinity map (Figure 1), Elk Branch flows into Cane Creek, which flows into the North Fork Toe River. The species has been found in relatively shallow, medium-sized creeks and rivers with cool, clean, well-oxygenated, moderate- to fast-flowing water. The species is most often found in riffles, runs, and shallow flowing pools with stable, relatively silt-free, coarse sand and gravel substrate associated with cobble, boulders, and/or bedrock. Stability of the substrate appears to be critical to the Appalachian elktoe, and the species is seldom found in stream reaches with accumulations of silt or shifting sand, gravel, or cobble. Preliminary discussions with NCWRC and USFWS staff indicate that the project streams are unlikely to be suitable habitat for the Appalachian elktoe.

We are requesting that you please provide any known information for each species in the county. The USFWS will be contacted if suitable habitat for any listed species is found or if we determine that the project may affect one or more federally listed species or designated critical habitat.

Please provide comments on any possible issues that might emerge with respect to endangered species, migratory birds or other trust resources from the construction of a wetland and/or stream restoration project on the subject property. A vicinity map and a USGS map showing the approximate areas of potential ground disturbance are enclosed.

If we have not heard from you in 30 days we will assume that our species list is correct, that you do not have any comments regarding associated laws, and that you do not have any information relevant to this project at the current time.

We thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning the extent of site disturbance associated with this project.

Sincerely,

Ken Gilland

Ken Gilland
Baker Engineering NY, Inc.
8000 Regency Parkway, Suite 200
Cary, NC 27511,
Phone: (919) 459-9035, Email: kgilland@mbakercorp.com

cc:

Guy Pearce
1652 Mail Service Center
Raleigh, NC 27699

Baker

Shannon Deaton
North Carolina Wildlife Resource Commission
Division of Inland Fisheries
1721 Mail Service Center
Raleigh, NC 27699

March 23, 2007

Subject: EEP stream mitigation project in Mitchell County.

Dear Ms. Deaton,

The purpose of this letter is to request review and comment on any possible issues that might emerge with respect to fish and wildlife issues associated with a potential stream restoration project on the attached site (vicinity map and USGS site map with approximate areas of potential ground disturbance are enclosed).

The Elk Branch site has been identified for the purpose of providing in-kind mitigation for unavoidable stream channel impacts. Several sections of channel have been identified as significantly degraded.

We thank you in advance for your timely response and cooperation. Please feel free to contact us with any questions that you may have concerning the extent of site disturbance associated with this project.

Sincerely,

Ken Gilland

Ken Gilland
Baker Engineering NY, Inc.
8000 Regency Parkway, Suite 200
Cary, NC 27511,
Phone: (919) 459-9035, Email: kgilland@mbakercorp.com

cc:

Guy Pearce
1652 Mail Service Center
Raleigh, NC 27699

North Carolina Wildlife Resources Commission

Richard B. Hamilton, Executive Director

April 3, 2007

Mr. Ken Gilland
Baker Engineering NY, Inc.
8000 Regency Parkway, Suite 200
Cary, North Carolina 27511

RE: Ecosystem Enhancement Program (EEP) Stream Project, Elk Branch, Mitchell County

Dear Mr. Gilland:

This correspondence is in response to your letter of March 23, 2007 concerning the proposed stream mitigation site indicated above. Biologists with the North Carolina Wildlife Resources Commission (NCWRC) are familiar with habitat values in the area. The NCWRC is authorized to comment and make recommendations which relate to the impacts of this project on fish and wildlife pursuant to Clean Water Act of 1977, North Carolina Environmental Policy Act, US National Environmental Policy Act, Endangered Species Act (16 U. S. C. 1531-1543; 87 Stat 884), and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661-667d) as applicable.

The Elk Branch site is being considered as an EEP in-kind mitigation site for unavoidable wetland and stream impacts. Your letter indicates that the streams are significantly degraded. Area streams support wild Rainbow trout. No listed species are known for the area based on our in-office data review.

As wild trout are present, in channel work and land disturbance within the 25-foot wide buffer zone should be prohibited during the rainbow trout spawning season of January 1 through April 15 to protect the egg and fry stages of trout. Please be advised that this office only reviews for animal species. Federal animal (and plant) issues should be discussed with the NC Natural Heritage Program and the US Fish and Wildlife Service.

In addition, only autochthonous plants should be used for the project. State-of-the-art stream and wetland natural channel restoration calculations and designs are appropriate for these stream improvements. Stream restoration in this area should increase downstream equilibrium and stability.

Thank you for the opportunity to comment on your proposed project during early planning stages. If you have any questions regarding these comments, please contact me at 336-769-9453.

Sincerely,

Ron Linville
Regional Coordinator
Habitat Conservation Program

Baker

Mr. Cliff Vinson
District Conservationist
11943 South 226 Highway, Suite C
Spruce Pine, NC 28777-3423

April 6, 2007

Subject: Prime and Important Farmland Soils RE: NCEEP Full Delivery Project, Elk Branch Stream Restoration Site, Mitchell County, NC

Dear Mr. Vinson:

The purpose of this letter is to request your assistance in completing a Farmland Conversion Impact Rating form for the subject site. Enclosed please find a copy of the form, site and locations mapping, and a soils map of the project site. For this stream restoration site, areas where ground disturbing activities are expected to take place are marked on the maps. The total area of the site is approximately 11 acres. The area of proposed ground disturbing activities includes approximately 4.6 acres of Bandana sandy loam soils with 0 to 3 percent slopes that are occasionally flooded. Based on our review, this soil is considered to be Prime Farmland if drained. While it appears this soil is confined to the floodplain of Elk Branch (as shown in Figure 3), a conservative estimate would place the total acreage of Prime and Important Farmland directly converted for this project at 4.6 acres.

We know that you have greater familiarity with farmland issues in this area than we do, and we will be happy to make any changes to the form that you deem appropriate. Please return to form to us with your determinations and we will fill out the rest of the form if needed. Our Fax number is (919) 463-5490.

If you have any questions, please feel free to contact me at kgilland@mbakercorp.com or by phone at (919) 459-9035. Thank you for your assistance in this matter.

Sincerely,

Ken Gilland
Environmental Scientist
Baker Engineering NY, Inc.
8000 Regency Parkway, Suite 200
Cary, NC 27511

NRCS
Natural Resources Conservation Service
589 Raccoon Road, Suite 246
Waynesville, NC 28786
Phone 828 456-6341 ext. 5 FAX 828 452-7031

April 26, 2007

Ken Gilland
Baker Engineering
8000 Regency Parkway, Suite 200
Cary, NC 27511

Re: USDA Farmland Conversion Impact Rating Form (AD-1006)
Elk Branch Stream Restoration--Mitchell County, NC

Mr. Gilland:

Attached you will find two copies of the completed AD-1006. Based on statements from Cliff Vinson, District Conservationist in Mitchell County, it appears that no prime farmland or other important farmland will be impacted by the proposed stream restoration project.

If I can be of further assistance, please feel free to contact me.

M. Kent Clary

M. Kent Clary
Area Resource Soil Scientist
USDA-NRCS

cc: Cliff Vinson, District Conservationist, USDA-NRCS, Spruce Pine, NC

U.S. Department of Agriculture

FARMLAND CONVERSION IMPACT RATING

PART I *(To be completed by Federal Agency)*	Date Of Land Evaluation Request 3/27/07
	Federal Agency Involved FHWA
Name Of Project Elk Branch Site	County And State Mitchell, NC
Proposed Land Use Stream Restoration	Date Request Received By NRCS 4-11-07

PART II *(To be completed by NRCS)*		Yes	No	Acres Irrigated	Average Farm Size
Does the site contain prime, unique, statewide or local important farmland? *(If no, the FPPA does not apply -- do not complete additional parts of this form).*		☐	☒		
Major Crop(s) Pasture	Farmable Land In Govt. Jurisdiction Acres: 0 %			Amount Of Farmland As Defined in FPPA Acres: %	
Name Of Land Evaluation System Used	Name Of Local Site Assessment System			Date Land Evaluation Returned By NRCS 4-11-07	

	Maximum Points	Alternative Site Rating Site A	Site B	Site C	Site D
PART III *(To be completed by Federal Agency)*					
A. Total Acres To Be Converted Directly		4.6			
B. Total Acres To Be Converted Indirectly		0.0			
C. Total Acres In Site		~~0.0~~ 11	0.0	0.0	0.0
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		0			
C. Percentage Of Farmland In County Or Local Govt. Unit To Be Converted		0			
D. Percentage Of Farmland In Govt. Jurisdiction With Same Or Higher Relative Value		0			
PART V *(To be completed by NRCS)* Land Evaluation Criterion Relative Value Of Farmland To Be Converted *(Scale of 0 to 100 Points)*		0	0	0	0
PART VI *(To be completed by Federal Agency)* Site Assessment Criteria *(These criteria are explained in 7 CFR 658.5(b)*					
1. Area In Nonurban Use					
2. Perimeter In Nonurban Use					
3. Percent Of Site Being Farmed					
4. Protection Provided By State And Local Government					
5. Distance From Urban Builtup Area					
6. Distance To Urban Support Services					
7. Size Of Present Farm Unit Compared To Average					
8. Creation Of Nonfarmable Farmland					
9. Availability Of Farm Support Services					
10. On-Farm Investments					
11. Effects Of Conversion On Farm Support Services					
12. Compatibility With Existing Agricultural Use					
TOTAL SITE ASSESSMENT POINTS	160	0	0	0	0
PART VII *(To be completed by Federal Agency)*					
Relative Value Of Farmland *(From Part V)*	100	0	0	0	0
Total Site Assessment *(From Part VI above or a local site assessment)*	160	0	0	0	0
TOTAL POINTS *(Total of above 2 lines)*	260	0	0	0	0

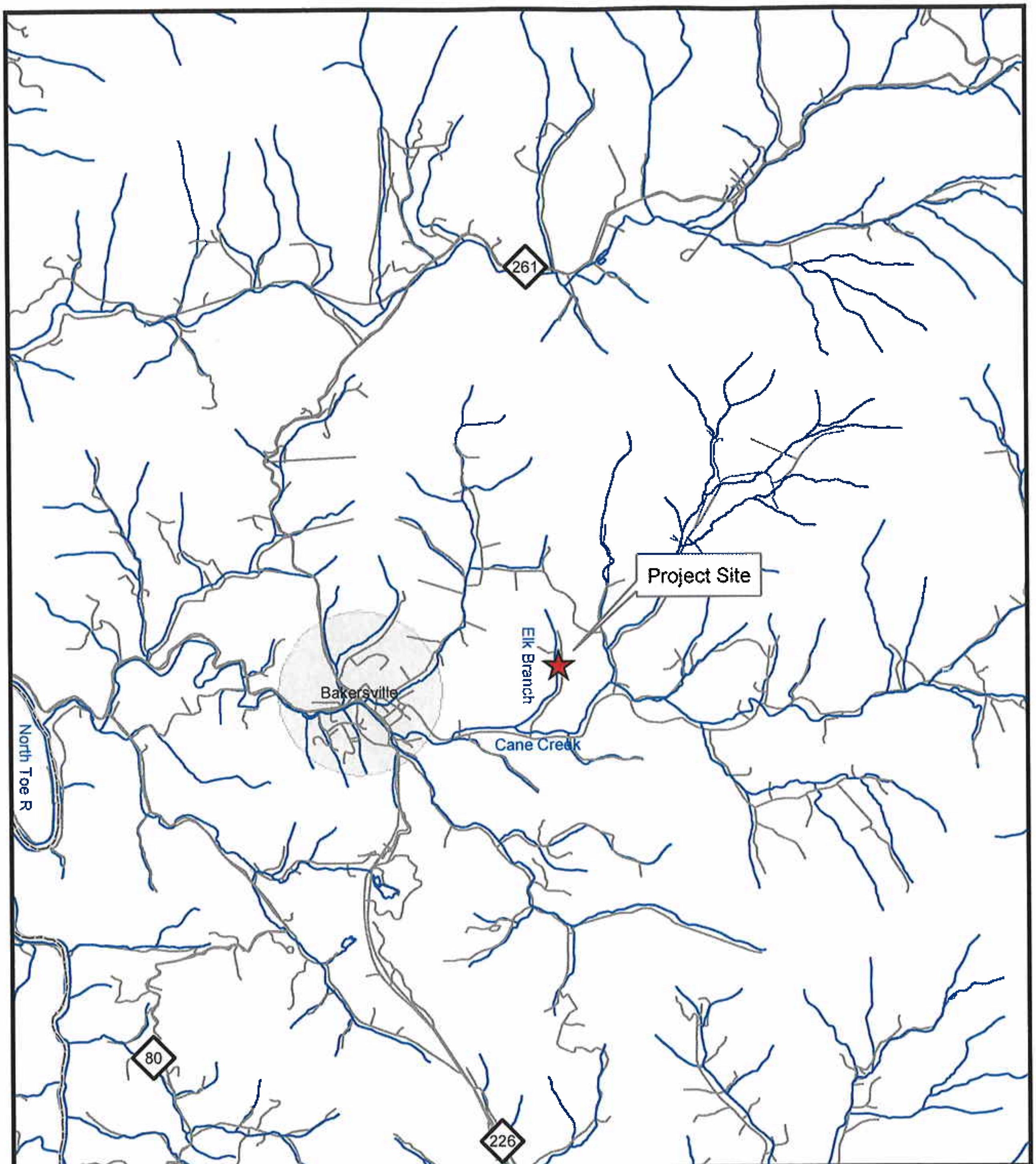
Site Selected:	Date Of Selection	Was A Local Site Assessment Used? Yes ☐ No ☐

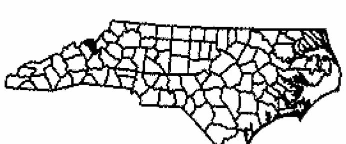
Reason For Selection: NO Prime And unique FARMLAND DUE TO LOCATION IN the FLOOD PLAIN of Elk Branch. J. Clifford Vinson D.C. NRCS

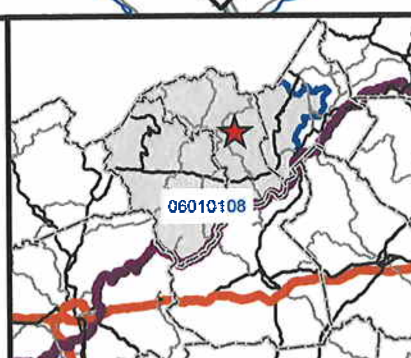
Form AD-1006 (10-83)

(See Instructions on reverse side)

This form was electronically produced by National Production Services Staff





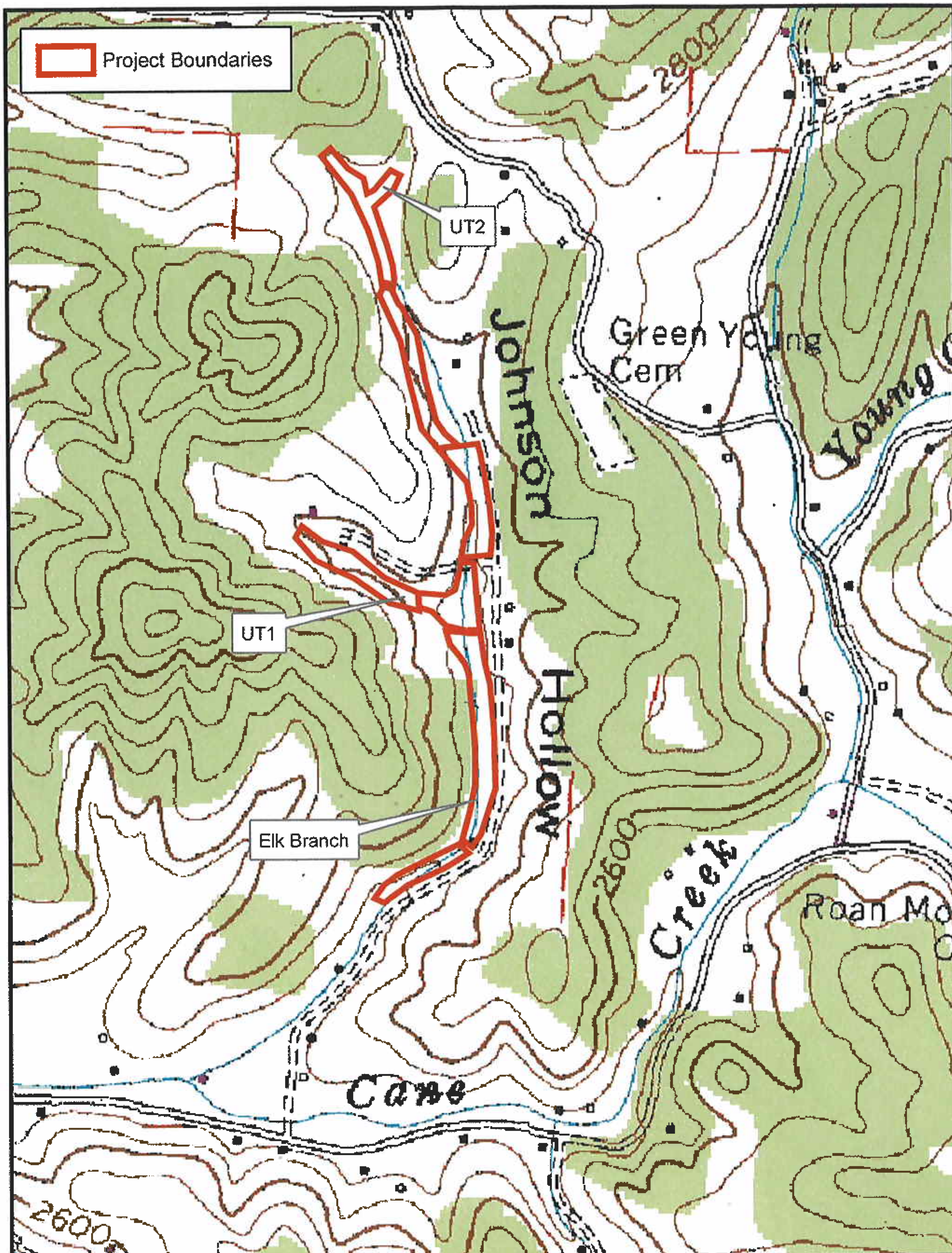


Baker
797 Haywood Road, Suite 201
Asheville, NC 28806

N

Figure 1. Project Vicinity Map
Elk Branch Site

0 0.25 0.5 1
Miles

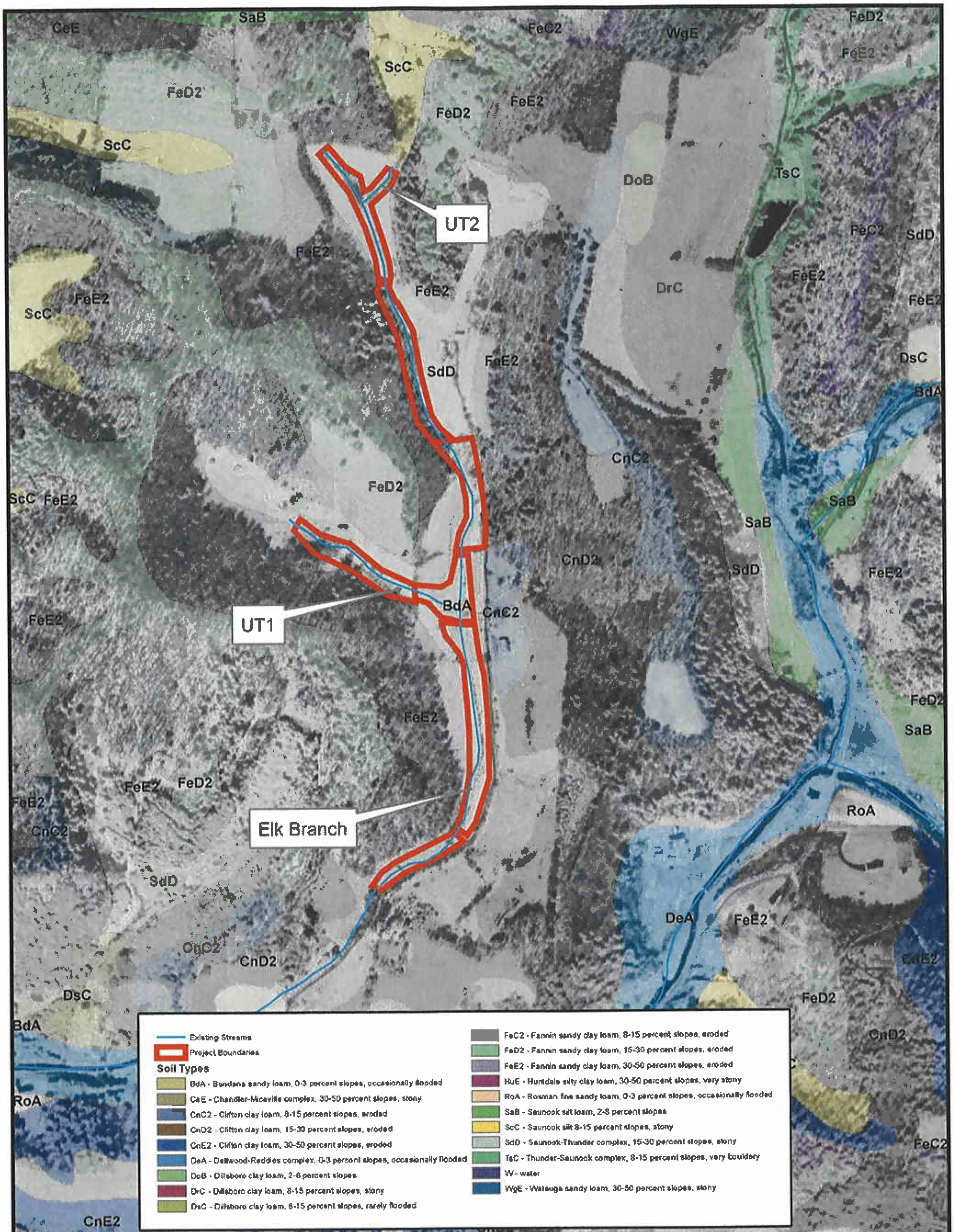


Baker
797 Haywood Road, Suite 201
Asheville, NC 28806

0 500 1,000 Feet

N

Figure 2.
Watershed Map
Elk Branch Site



Baker
797 Haywood Road, Suite 201
Asheville, NC 28806

0 500 1,000 Feet

N

**Figure 3.
Soils Map
Elk Branch Site**

APPENDIX C. EDR Report

EDR LoanCheck® Basic: Environmental Risk Review

April 6, 2007

Property Name

ELK BRANCH STREAM RESTORATION SITE
626 CANE CREEK RD
BAKERSVILLE, NC 28705

440 Wheelers Farms Road
Milford, CT 06460
Phone:800-352-0050
Fax:800-231-6802
Web:www.edrnet.com

EDR™ Environmental Data Resources Inc

ENVIRONMENTAL RISK LEVEL

To help evaluate environmental risk, the *EDR LoanCheck®Basic* provides an Environmental Risk Level, based on a search of current government records requested to be searched by Baker Engineering.

[ ]	**ELEVATED RISK**	Based on the records found in this report, the environmental risk level for this property is elevated.
X	**LOW RISK**	Based on the records found in this report, the environmental risk level for this property is minimal.

User Instructions

For more information regarding this Environmental Risk Level, please refer to page 2 and other supporting reports.

User Comments

Reports and Databases

The following reports an/or databases were requested by customer and were included in the Environmental Risk Level where available:

- EDR Radius Map Report

EDR LoanCheck® Basic: Environmental Risk Review

FINDINGS CONTRIBUTING TO THE ENVIRONMENTAL RISK LEVEL

The environmental LOW RISK is based upon the findings listed below. Refer to the supporting report(s) for additional detail.

TARGET PROPERTY

Current Govt. Records

No records identified (if any) were determined to be of elevated risk.

EDR Proprietary Records

No records identified (if any) were determined to be of elevated risk.

SURROUNDING PROPERTIES

Current Govt. Records

No records identified (if any) were determined to be of elevated risk.

EDR Proprietary Records

No records identified (if any) were determined to be of elevated risk.

EDR LoanCheck®
Basic
with Geocheck®

Elk Branch Stream Restoration Site
626 Cane Creek Rd
Bakersville, NC 28705

Inquiry Number: 1897001.1s

April 06, 2007

EDR® Environmental Data Resources Inc

The Standard in Environmental Risk Information

440 Wheelers Farms Road
Milford, Connecticut 06461

Nationwide Customer Service

Telephone: 1-800-352-0050
Fax: 1-800-231-6802
Internet: www.edrnet.com

TABLE OF CONTENTS

Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

EXECUTIVE SUMMARY

A search of available environmental records was conducted by Environmental Data Resources, Inc. (EDR).
The results of this search follow:

TARGET PROPERTY ADDRESS

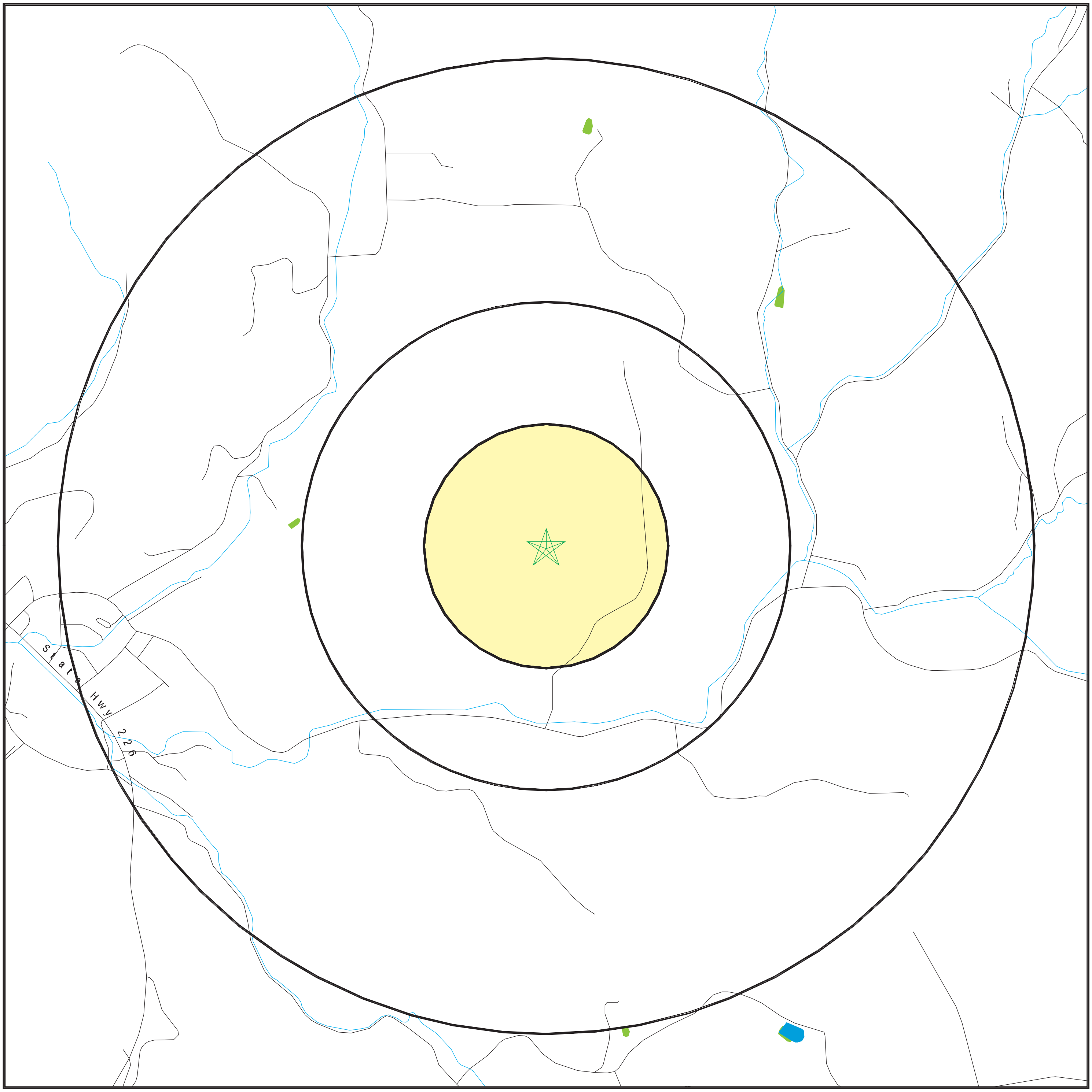
ELK BRANCH STREAM RESTORATION SITE
626 CANE CREEK RD
BAKERSVILLE, NC 28705
Elevation: 2633 ft.
EDR Inquiry Number: 1897001.1s

TARGET PROPERTY SEARCH RESULTS		**FEDERAL RECORDS**																																	
Site	Direction Distance Distance ft.	NPL	Proposed NPL	Delisted NPL	NPL RECOVERY	CERCLIS	CERC-NFRAP	CORRACTS	RCRA TSD	RCRA Lg. Quan. Gen.	RCRA Sm. Quan. Gen.	ERNS	HMIRS	US ENG CONTROLS	US INST CONTROL	DOD	FUDS	US BROWNFIELDS	CONSENT	ROD	UMTRA	ODI	TRIS	TSCA	FTTS	SSTS	ICIS	LUCIS	CDL	RADINFO	PADS	MLTS	MINES	FINDS	RAATS

TARGET PROPERTY SEARCH RESULTS		**STATE AND LOCAL RECORDS**															**TRIBAL RECORDS**			**EDR PROPRIETARY RECORDS**
Site	Direction Distance Distance ft.	State Haz. Waste	NC HSDS	IMD	State Landfill	OLI	HIST LF	LUST	LUST TRUST	UST	AST	INST CONTROL	VCP	DRYCLEANERS	BROWNFIELDS	NPDES	INDIAN RESERV	INDIAN LUST	INDIAN UST	EDR MGP

Surrounding sites were not identified.

OVERVIEW MAP - 1897001.1s

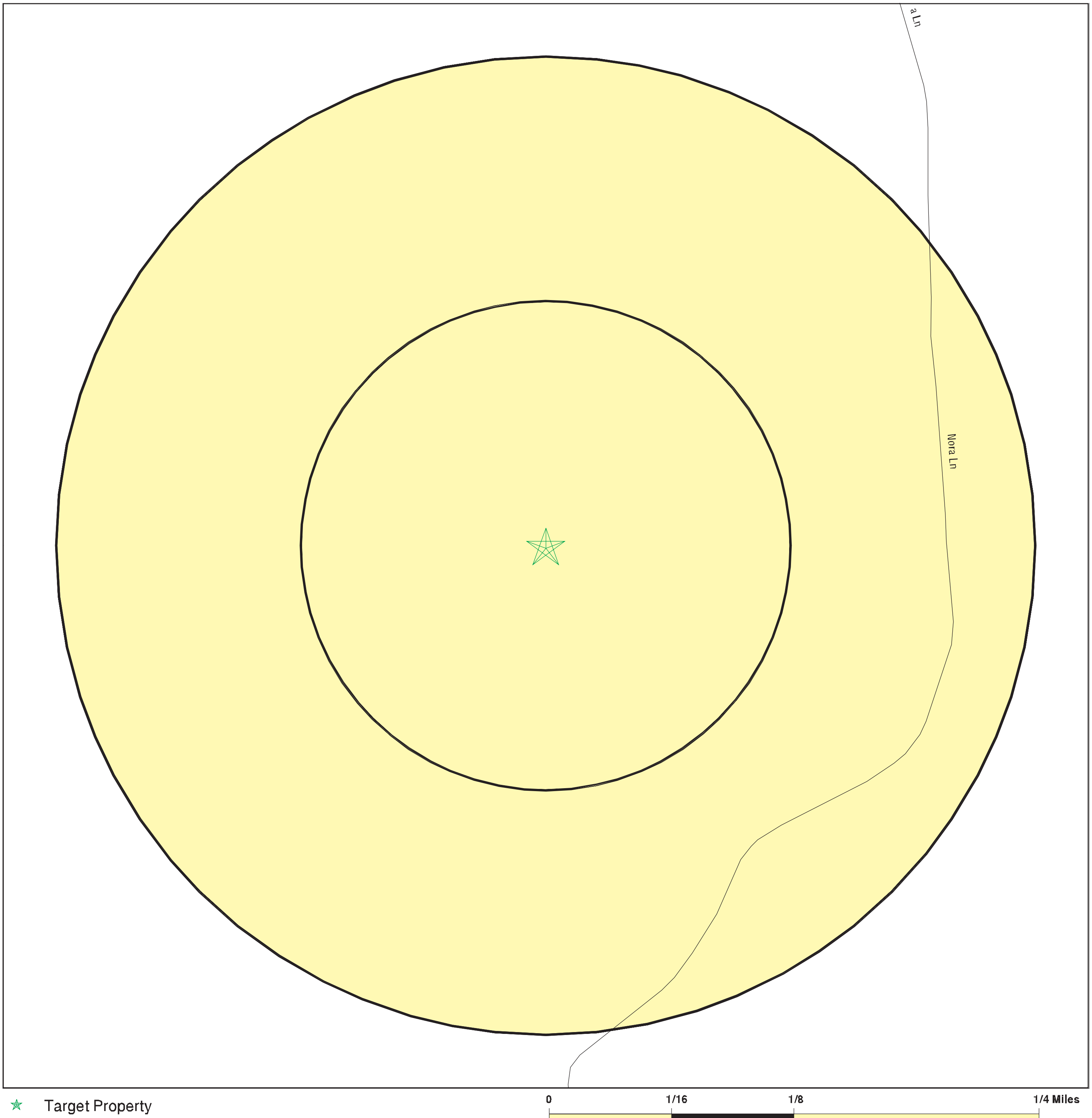


0 1/4 1/2 1 Miles

- Target Property
- Sites at elevations higher than or equal to the target property
- Sites at elevations lower than the target property
- Manufactured Gas Plants
- National Priority List Sites
- Landfill Sites
- Dept. Defense Sites
- Indian Reservations BIA
- Oil & Gas pipelines
- National Wetland Inventory
- State Wetlands
- Hazardous Substance Disposal Sites

SITE NAME:	Elk Branch Stream Restoration Site	CLIENT:	Baker Engineering
ADDRESS:	626 Cane Creek Rd Bakersville NC 28705	CONTACT:	Ken Gilland
		INQUIRY #:	1897001.1s
LAT/LONG:	36.0176 / 82.1387	DATE:	April 06, 2007 1:24 pm

DETAIL MAP - 1897001.1s



- Target Property
- Sites at elevations higher than or equal to the target property
- Sites at elevations lower than the target property
- Manufactured Gas Plants
- Sensitive Receptors
- National Priority List Sites
- Landfill Sites
- Dept. Defense Sites
- Indian Reservations BIA
- Oil & Gas pipelines
- Hazardous Substance Disposal Sites

SITE NAME:	Elk Branch Stream Restoration Site	CLIENT:	Baker Engineering
ADDRESS:	626 Cane Creek Rd	CONTACT:	Ken Gilland
	Bakersville NC 28705	INQUIRY #:	1897001.1s
LAT/LONG:	36.0176 / 82.1387	DATE:	April 06, 2007 1:24 pm

MAP FINDINGS SUMMARY

Database	Target Property	Search Distance (Miles)	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
FEDERAL RECORDS								
NPL		1.000	0	0	0	0	NR	0
Proposed NPL		1.000	0	0	0	0	NR	0
Delisted NPL		1.000	0	0	0	0	NR	0
NPL RECOVERY		TP	NR	NR	NR	NR	NR	0
CERCLIS		0.500	0	0	0	NR	NR	0
CERC-NFRAP		0.500	0	0	0	NR	NR	0
CORRACTS		1.000	0	0	0	0	NR	0
RCRA TSD		0.500	0	0	0	NR	NR	0
RCRA Lg. Quan. Gen.		0.250	0	0	NR	NR	NR	0
RCRA Sm. Quan. Gen.		0.250	0	0	NR	NR	NR	0
ERNS		TP	NR	NR	NR	NR	NR	0
HMIRS		TP	NR	NR	NR	NR	NR	0
US ENG CONTROLS		0.500	0	0	0	NR	NR	0
US INST CONTROL		0.500	0	0	0	NR	NR	0
DOD		1.000	0	0	0	0	NR	0
FUDS		1.000	0	0	0	0	NR	0
US BROWNFIELDS		0.500	0	0	0	NR	NR	0
CONSENT		1.000	0	0	0	0	NR	0
ROD		1.000	0	0	0	0	NR	0
UMTRA		0.500	0	0	0	NR	NR	0
ODI		0.500	0	0	0	NR	NR	0
TRIS		TP	NR	NR	NR	NR	NR	0
TSCA		TP	NR	NR	NR	NR	NR	0
FTTS		TP	NR	NR	NR	NR	NR	0
SSTS		TP	NR	NR	NR	NR	NR	0
ICIS		TP	NR	NR	NR	NR	NR	0
LUCIS		0.500	0	0	0	NR	NR	0
CDL		TP	NR	NR	NR	NR	NR	0
RADINFO		TP	NR	NR	NR	NR	NR	0
PADS		TP	NR	NR	NR	NR	NR	0
MLTS		TP	NR	NR	NR	NR	NR	0
MINES		0.250	0	0	NR	NR	NR	0
FINDS		TP	NR	NR	NR	NR	NR	0
RAATS		TP	NR	NR	NR	NR	NR	0
STATE AND LOCAL RECORDS								
State Haz. Waste		1.000	0	0	0	0	NR	0
NC HSDS		1.000	0	0	0	0	NR	0
IMD		0.500	0	0	0	NR	NR	0
State Landfill		0.500	0	0	0	NR	NR	0
OLI		0.500	0	0	0	NR	NR	0
HIST LF		0.500	0	0	0	NR	NR	0
LUST		0.500	0	0	0	NR	NR	0
LUST TRUST		0.500	0	0	0	NR	NR	0
UST		0.250	0	0	NR	NR	NR	0
AST		0.250	0	0	NR	NR	NR	0
INST CONTROL		0.500	0	0	0	NR	NR	0

MAP FINDINGS SUMMARY

Database	Target Property	Search Distance (Miles)	< 1/8	1/8 - 1/4	1/4 - 1/2	1/2 - 1	> 1	Total Plotted
VCP		0.500	0	0	0	NR	NR	0
DRYCLEANERS		0.250	0	0	NR	NR	NR	0
BROWNFIELDS		0.500	0	0	0	NR	NR	0
NPDES		TP	NR	NR	NR	NR	NR	0
TRIBAL RECORDS								
INDIAN RESERV		1.000	0	0	0	0	NR	0
INDIAN LUST		0.500	0	0	0	NR	NR	0
INDIAN UST		0.250	0	0	NR	NR	NR	0
EDR PROPRIETARY RECORDS								
Manufactured Gas Plants		1.000	0	0	0	0	NR	0

NOTES:

TP = Target Property

NR = Not Requested at this Search Distance

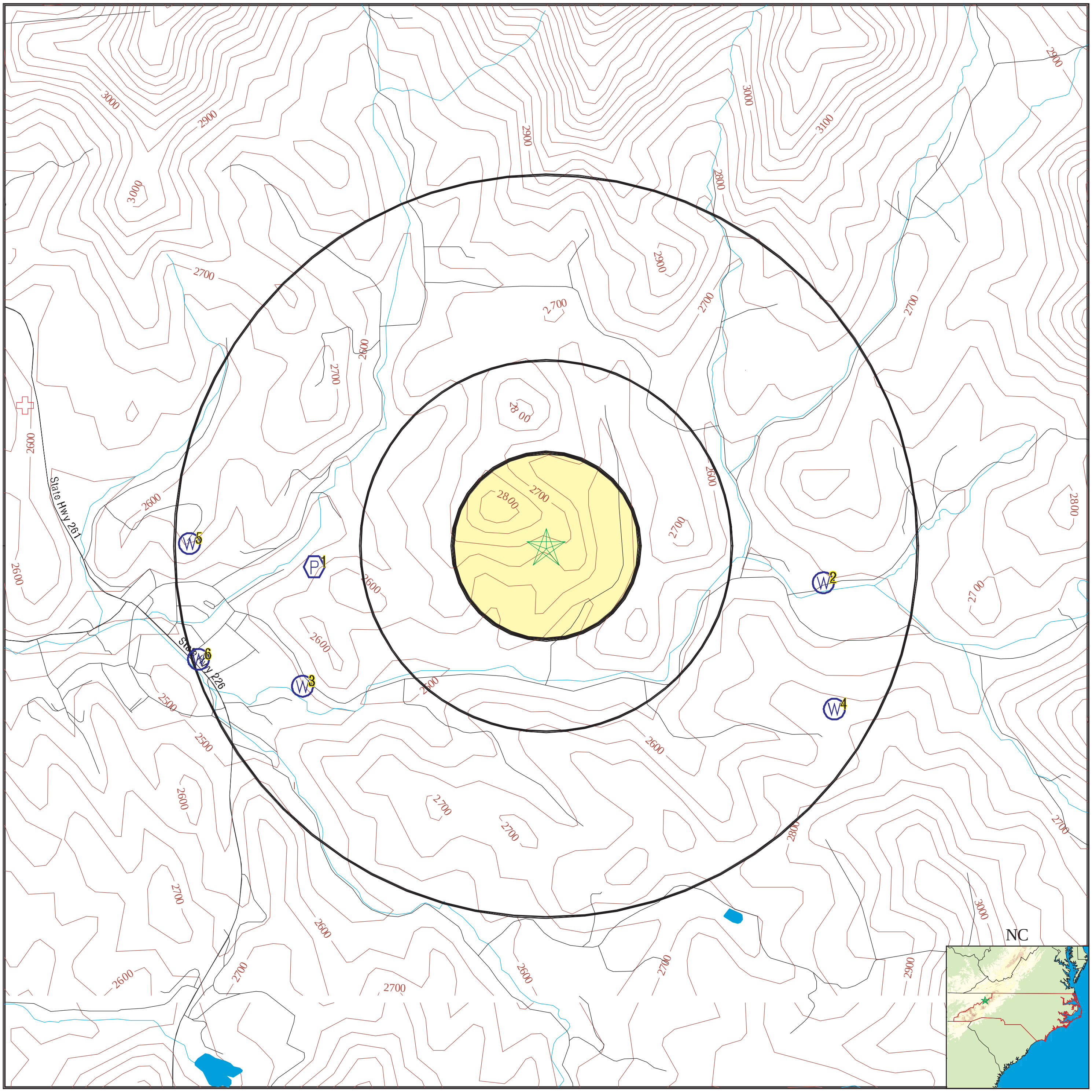
Sites may be listed in more than one database

MAP FINDINGS

Map ID Direction Distance Distance (ft.) Elevation	Site	Database(s)	EDR ID Number EPA ID Number

NO SITES FOUND

PHYSICAL SETTING SOURCE MAP - 1897001.1s



County Boundary
Major Roads
Contour Lines
Earthquake epicenter, Richter 5 or greater
Water Wells
Public Water Supply Wells
Cluster of Multiple Icons

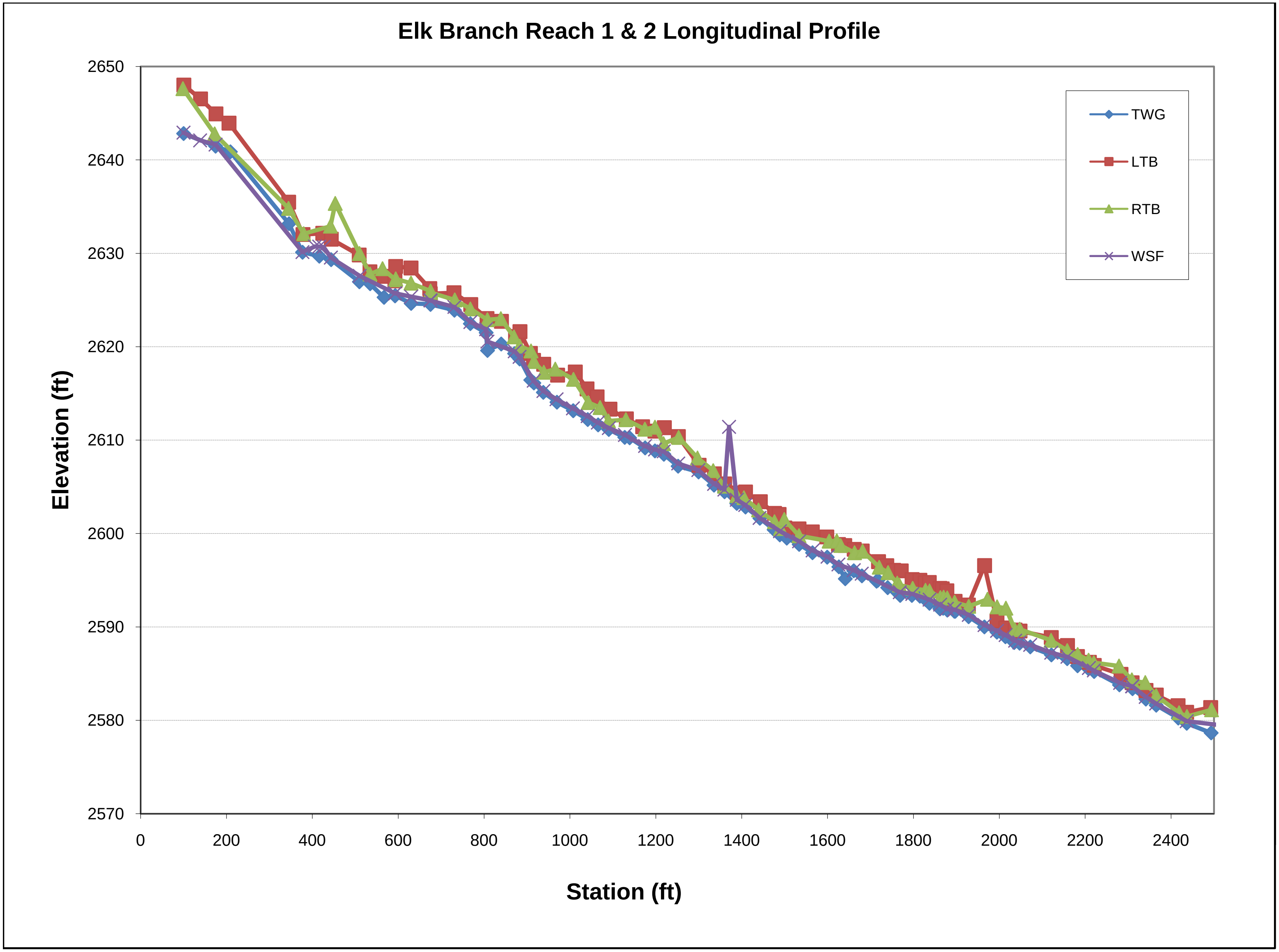
0 1/4 1/2 1 Miles

Groundwater Flow Direction
Indeterminate Groundwater Flow at Location
Groundwater Flow Varies at Location

Wildlife Areas
Natural Areas
Rare & Endangered Species

SITE NAME: Elk Branch Stream Restoration Site ADDRESS: 626 Cane Creek Rd Bakersville NC 28705 LAT/LONG: 36.0176 / 82.1387	CLIENT: Baker Engineering CONTACT: Ken Gilland INQUIRY #: 1897001.1s DATE: April 06, 2007 1:24 pm

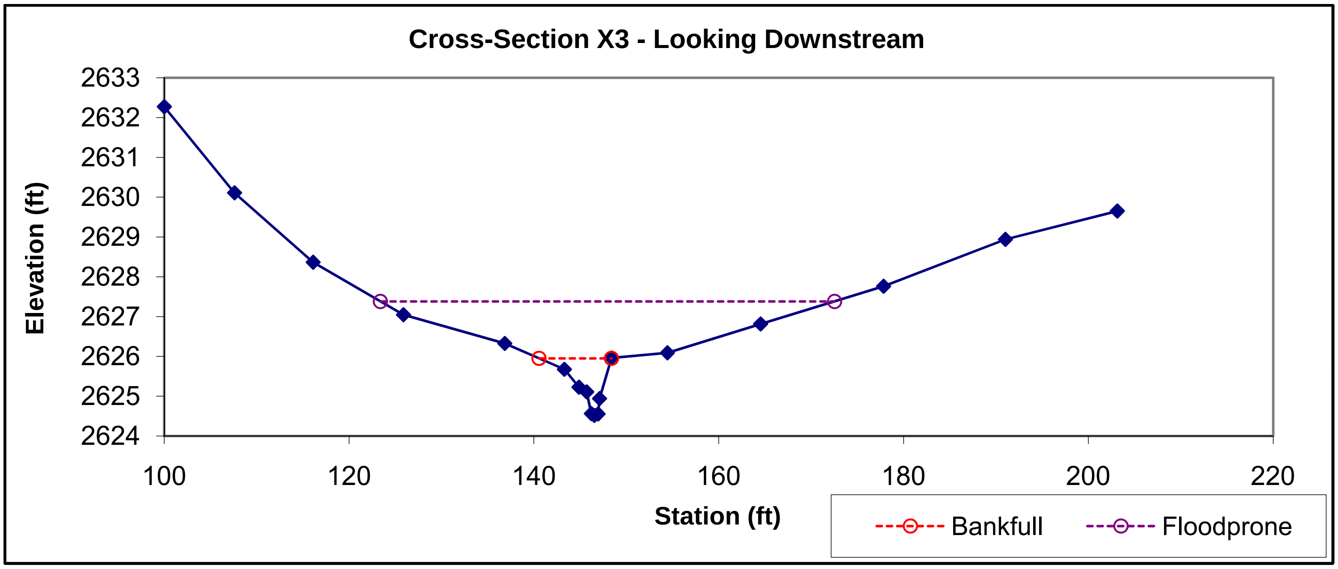
APPENDIX D. Existing Conditions Geomorphic Data



Elk Branch Reach 1 & 2 Longitudinal Profile
Elevation (ft)
2650
2640
2630
2620
2610
2600
2590
2580
2570
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
Station (ft)
TWG
LTB
RTB
WSF

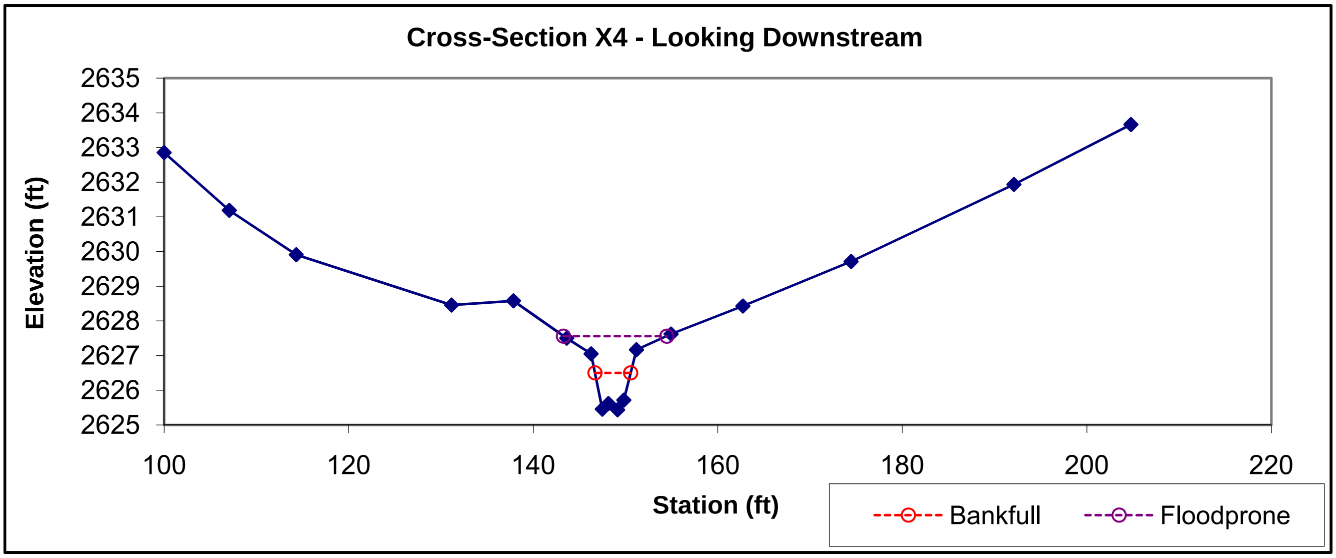
Cross-section Data: Elk Branch Mainstem (Reach 1)

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Run	Cb	4.3	7.83	0.54	1.43	14.41	1.1	6.3	2625.95	2626.09

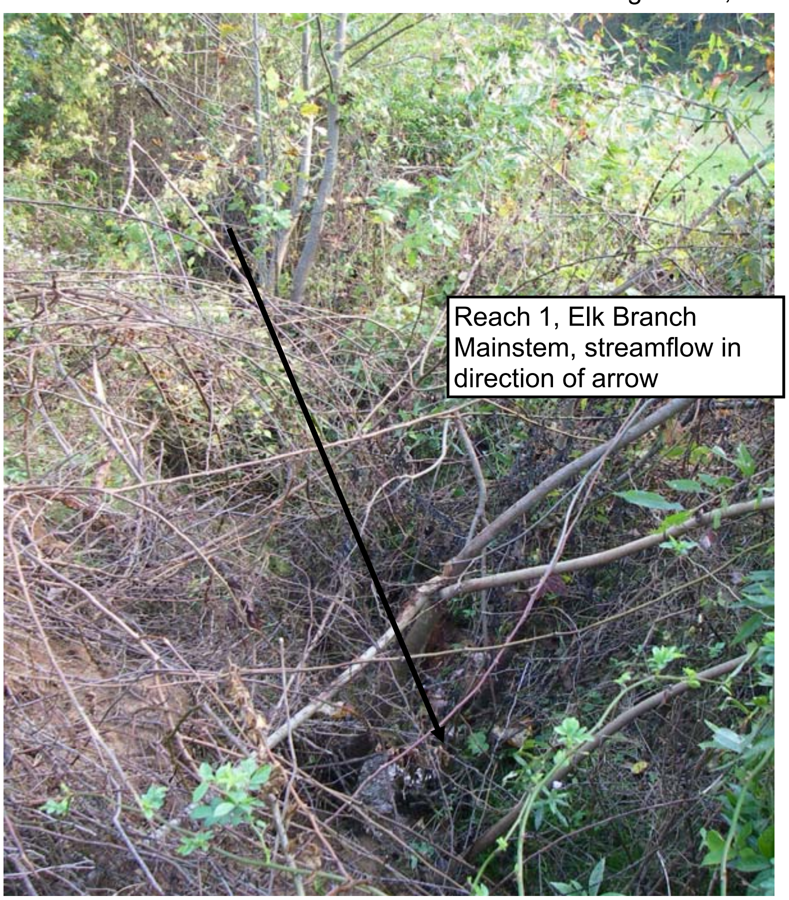


Cross-section Data: Elk Branch Mainstem (Reach 1)

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Run	Eb*	2.9	3.86	0.76	1.06	5.09	1.6	2.9	2626.5	2627.17

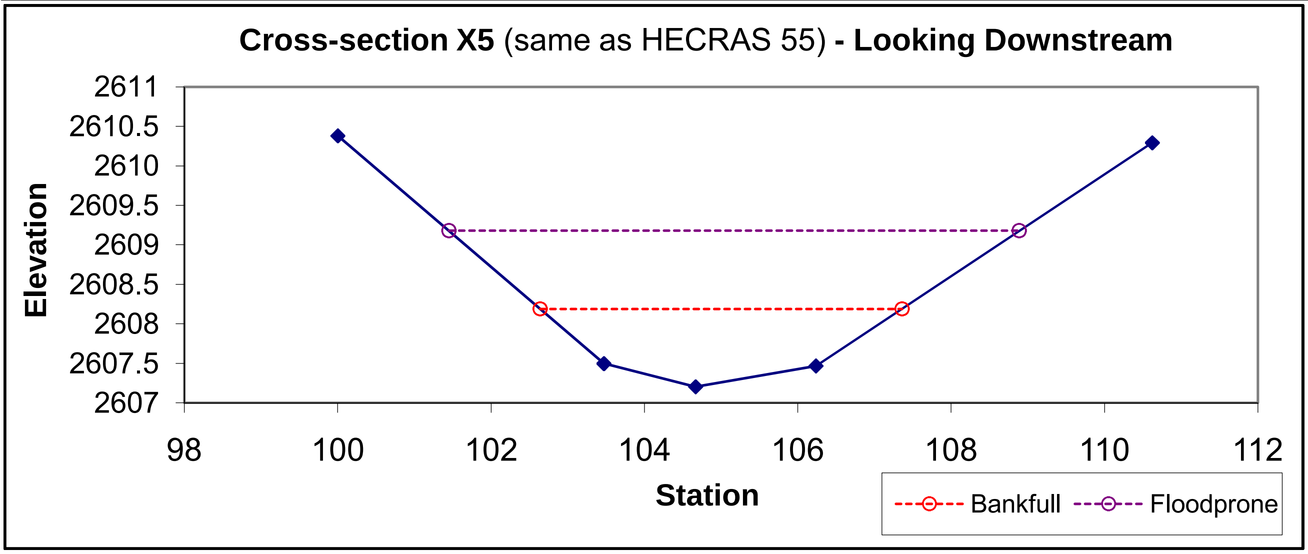


* Has been channelized and has an unstable bank height ratio, moving towards G

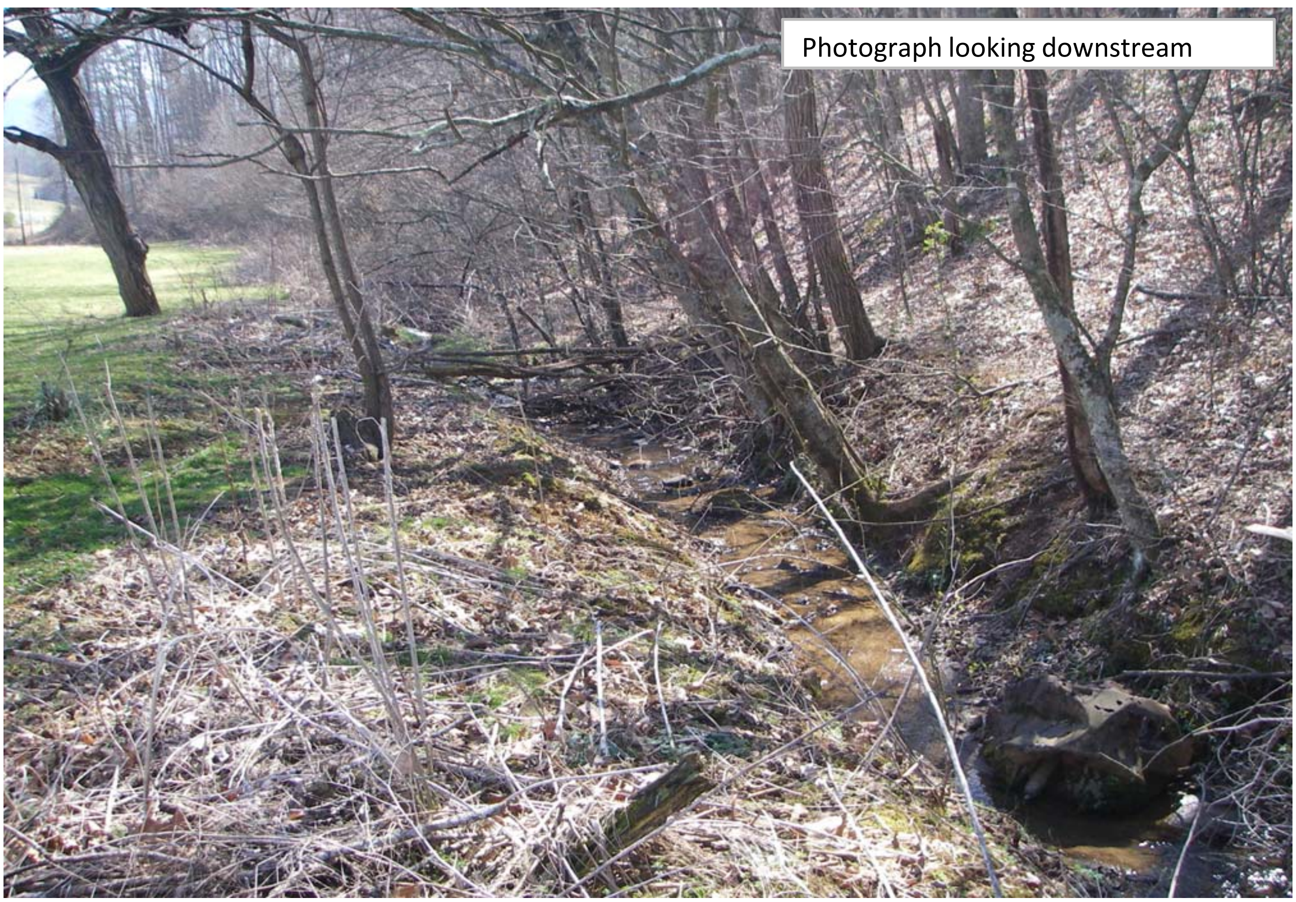


Cross-section Data: Elk Branch Mainstem (Reach 1)

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Run	G*	3.0	4.72	0.64	0.99	7.3	3.1	1.6	2608.19	2610.29

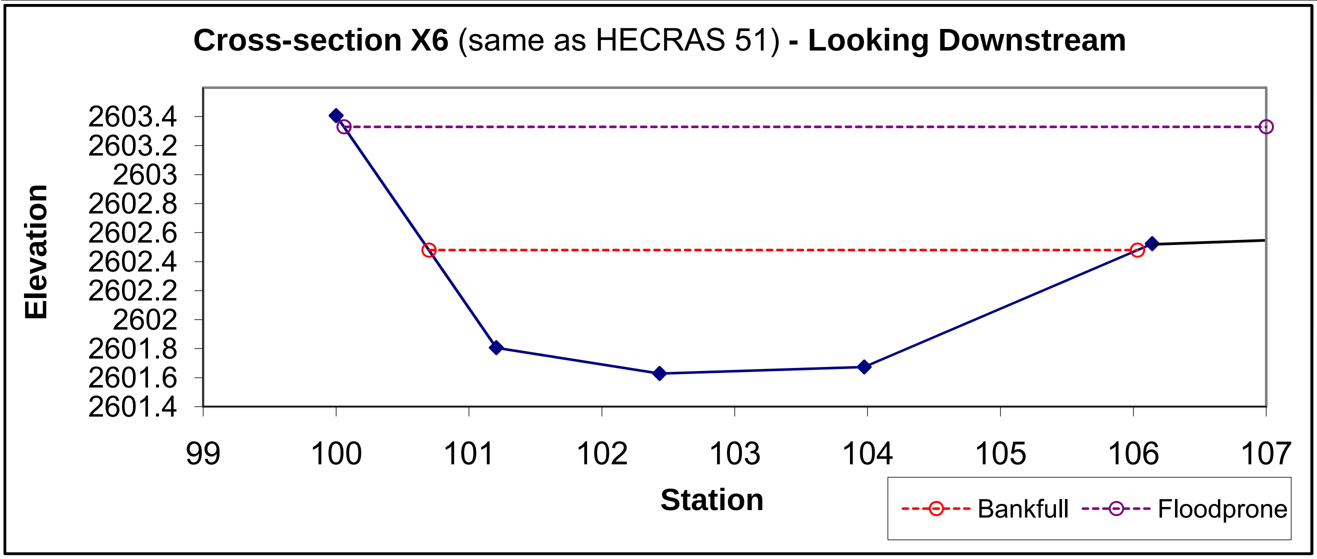


* This stream is a G that is closer to moderately entrenched than typical G-type streams, for purposes of classification, ER can vary by +/- 0.2 units, the W/D ratio is too low to be a B-type stream



Cross-section Data: Elk Branch Mainstem (Reach 1)

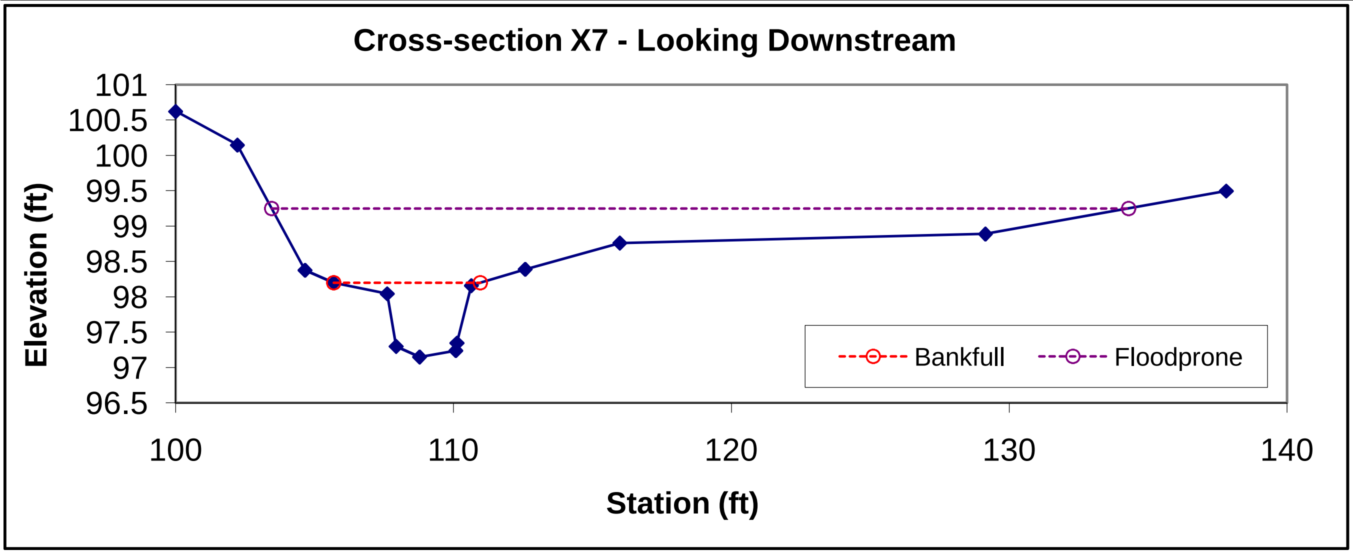
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb*	3.2	5.33	0.6	0.85	8.9	1.1	4	2602.48	2602.52

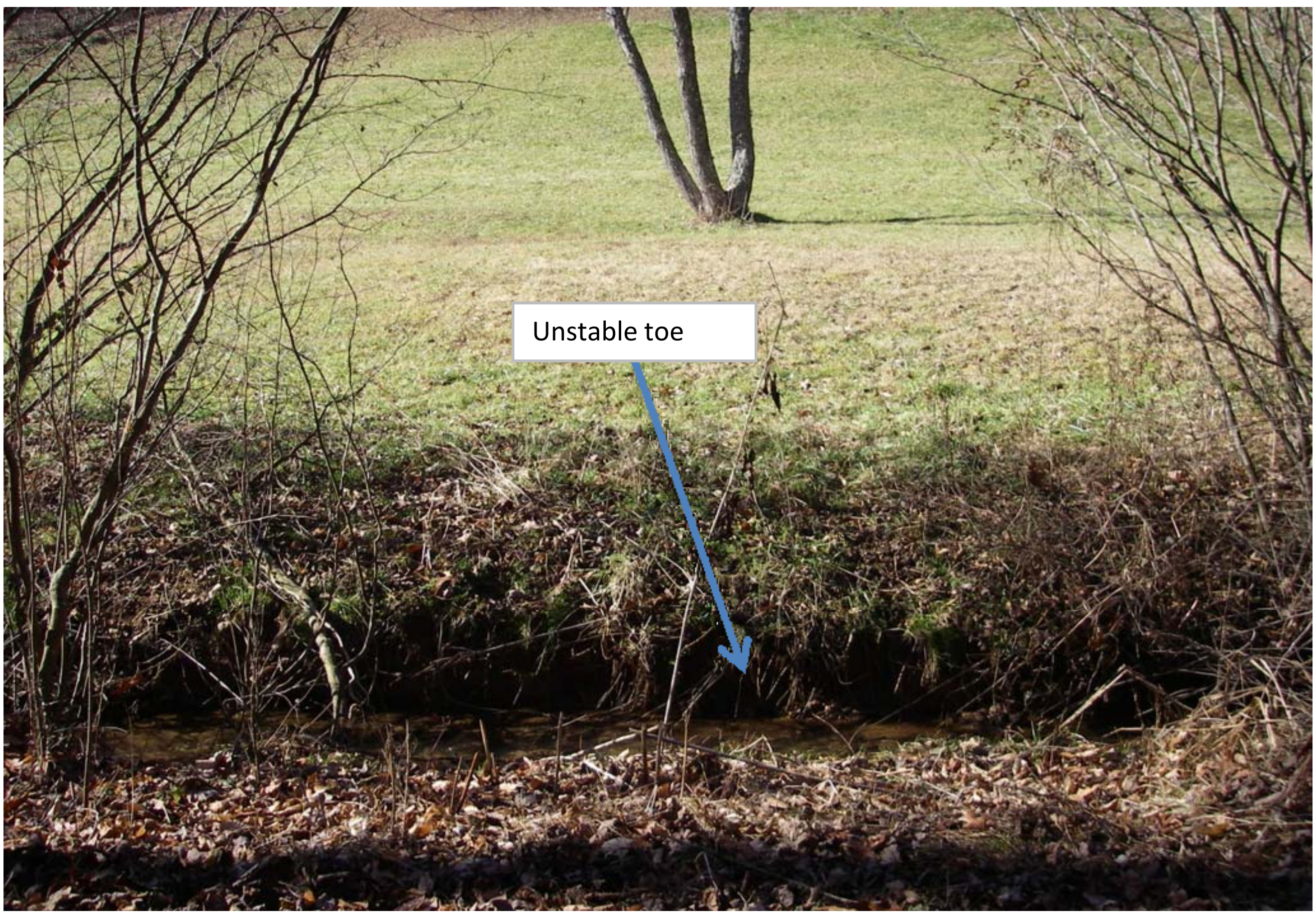


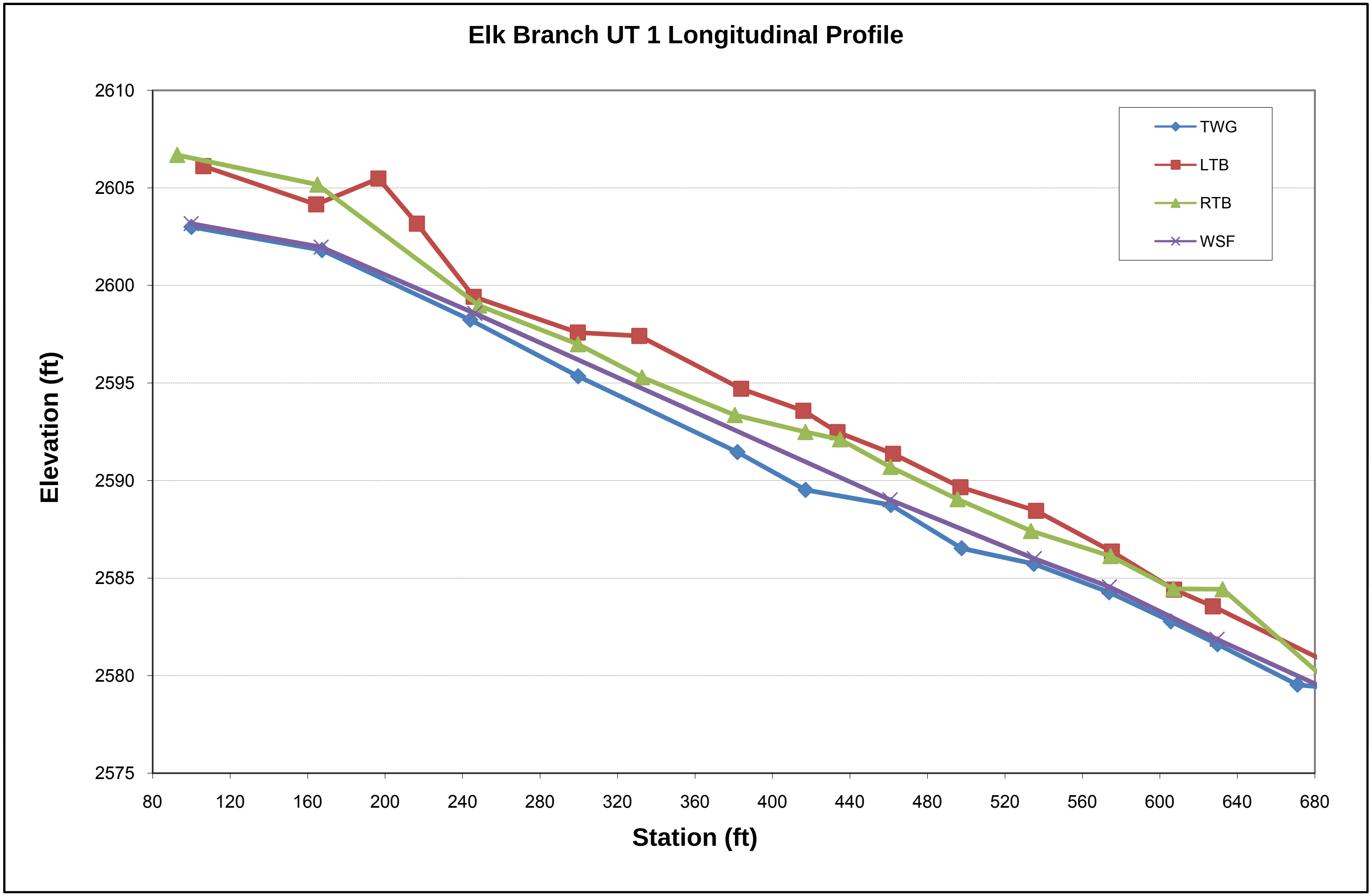
* In this reach, the channel is either entrenched as shown in XS# 55 or it is eroding as shown in this photograph. In all cases, the channel is near the right valley wall, and confined by the left bank

Cross-section Data: Elk Branch Mainstem (Reach 2)

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	2.7	5.3	0.52	1.05	10.2	0.9	5.8	98.2	98.04



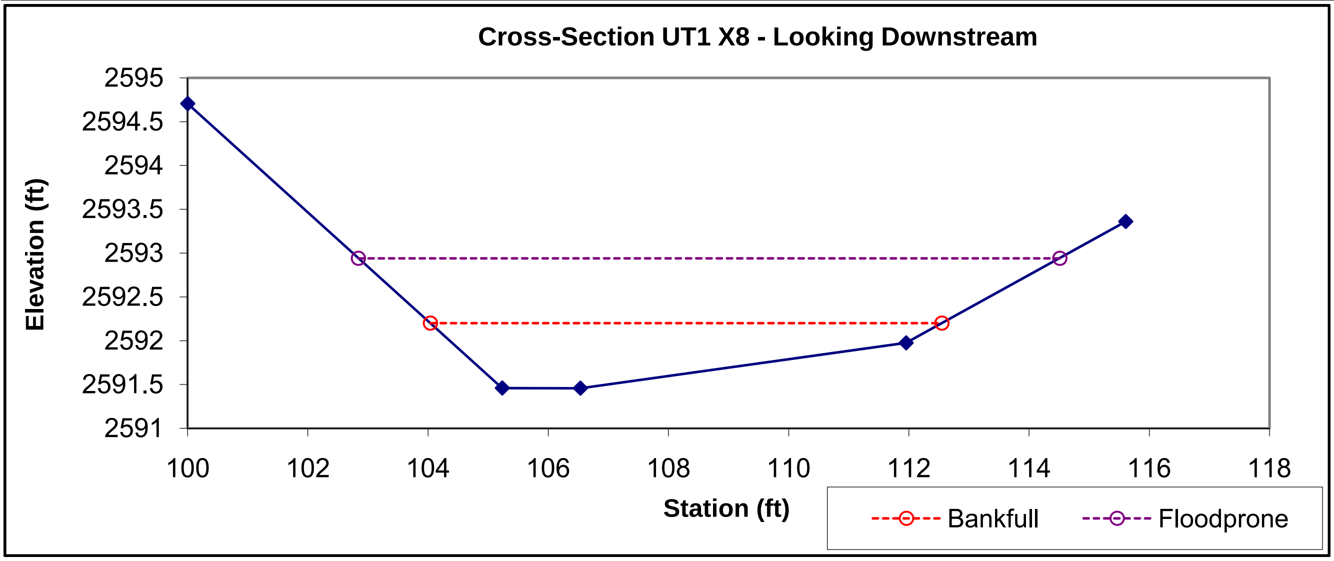




Elk Branch UT 1 Longitudinal Profile
Elevation (ft)
Station (ft)
2610
2605
2600
2595
2590
2585
2580
2575
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
680
TWG
LTB
RTB
WSF

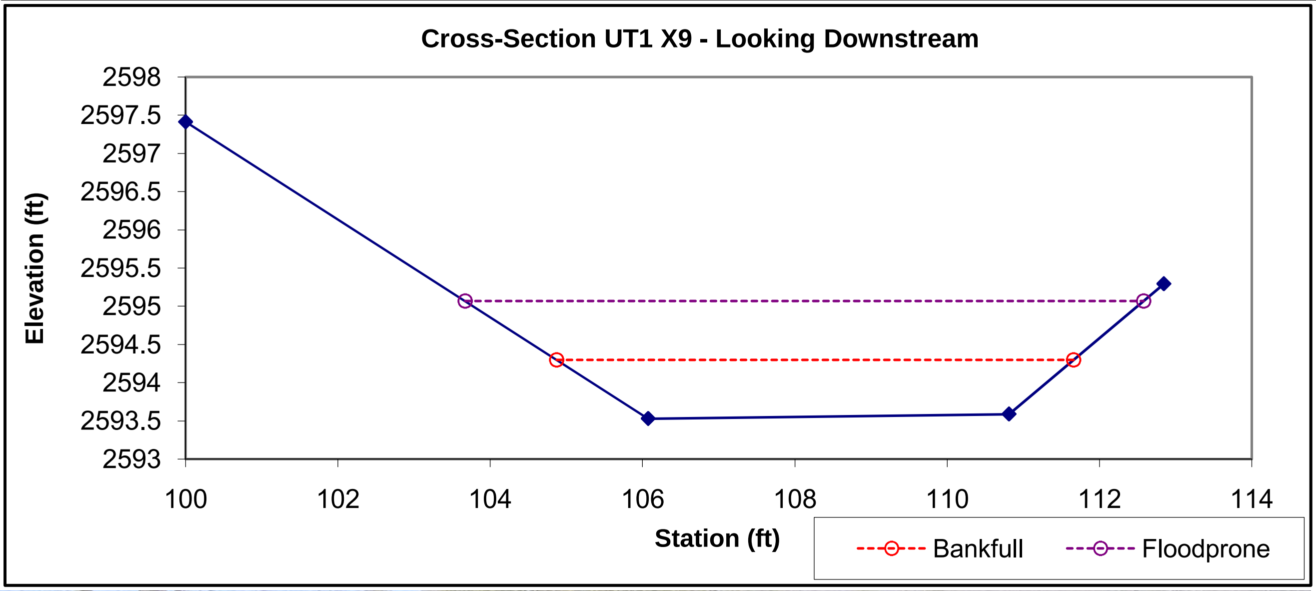
Cross-section Data: UT1 to Elk Branch

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Run	Fb	4.1	8.51	0.48	0.74	17.67	2.6	1.4	2592.2	2593.36



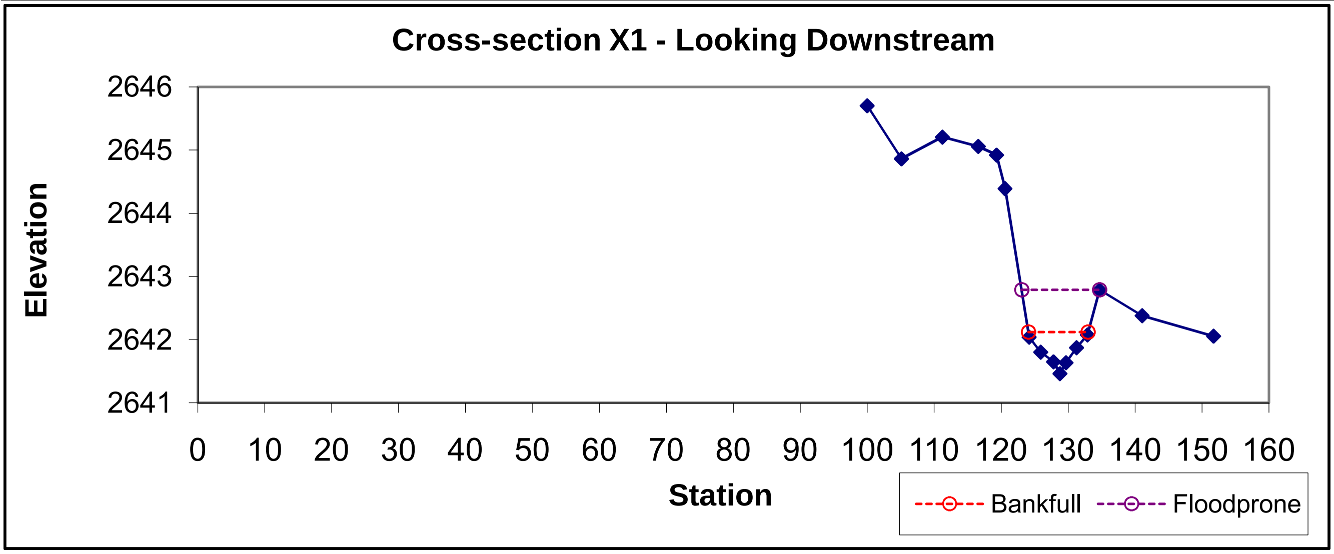
Cross-section Data: UT1 to Elk Branch

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Run	Fb	4.3	6.79	0.63	0.77	10.8	2.3	1.3	2594.3	2595.29



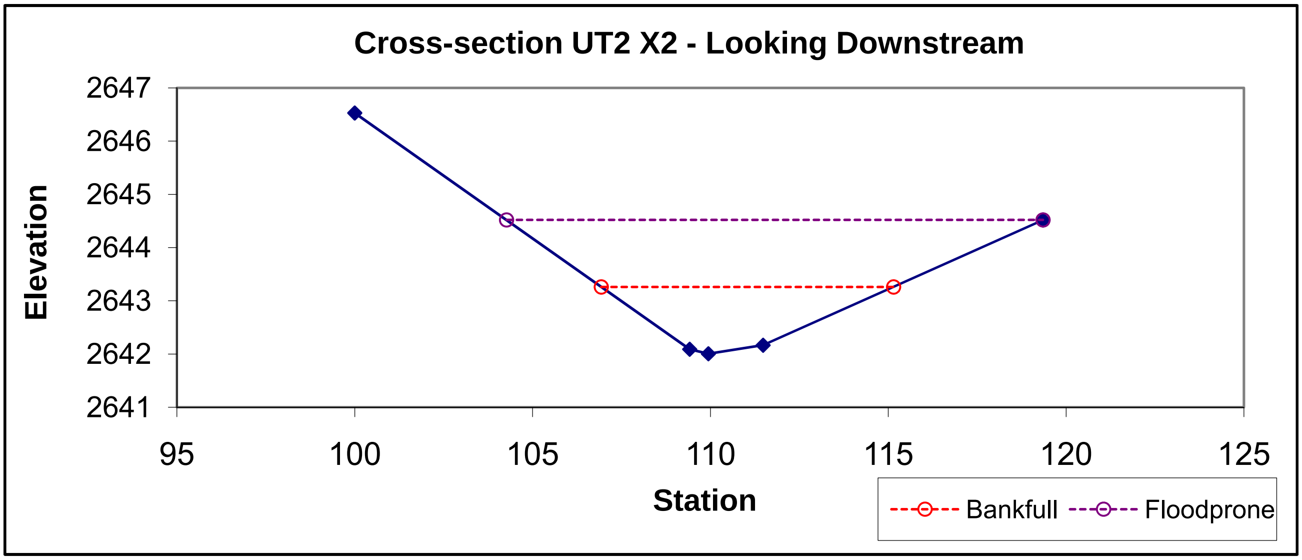
Cross-section Data: UT2 to Elk Branch

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	3.0	8.94	0.34	0.66	26.6	2.0	1.3	2642.12	2642.79



Cross-section Data: UT2 to Elk Branch

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	5.9	8.22	0.72	1.26	11.4	2.0	1.8	2643.26	2644.52



APPENDIX E. Existing Conditions Photo Log

Elk Branch Reach 1

Upstream end of Elk Branch Reach 1
Banks and adjacent area impacted by cattle

Upstream end of Elk Branch Reach 1
Fencing and water relocation to be performed

Upstream end of Elk Branch Reach 1
Fencing and water relocation to be performed

View of creek looking upstream from dredged area on upper part of Reach 1 of Elk Branch

Elk Branch Reach 1 channelized section through pasture

Elk Branch Reach 1 section through field with bank erosion, head cutting, and lack of deep-rooted vegetation

Elk Branch Reach 1


Elk Branch Reach 1 downstream of 15" culvert stream against valley wall


Elk Branch Reach 1 close-up of stream against valley wall and resulting erosion of banks


Previously channelized and lacking bank vegetation, Reach 1 of Elk Branch


Channelized area against valley wall with leaning and fallen trees in Reach 1 of Elk Branch


Bank erosion in Reach 1 of Elk Branch


Eroding bend in Reach 1 of Elk Branch

Elk Branch Reach 2

Elk Branch eroding into valley wall at upper part
of Reach 2

Footbridge between Reach 1 and Reach 2 of
Elk Branch (location of easement break)

Eroding toe in Elk Branch Reach 2

Elk Branch Reach 2 (lower half of reach)

Elk Branch Reach 2, slightly incised and very
narrow resulting in toe erosion

Downstream end of project on Elk Branch Reach 2

UT1 to Elk Branch

Livestock trails and access to creek on upper part of UT1

Head-cutting on UT1 in an area of poorly defined channel due to livestock access and overwidening

Looking down-valley at lower part of UT 1, livestock crossing and trails

Location of proposed easement break, area to be repaired and culvert correctly installed for x-ing

G and F-type stream below the proposed easement break on UT1

Multi-flora rose and lack of deep-rooting vegetation on UT1

UT2 to Elk Branch


Existing location of UT2 (buried), upper half


Close-up of UT2 at location of arrow in adjacent photograph (creek buried)

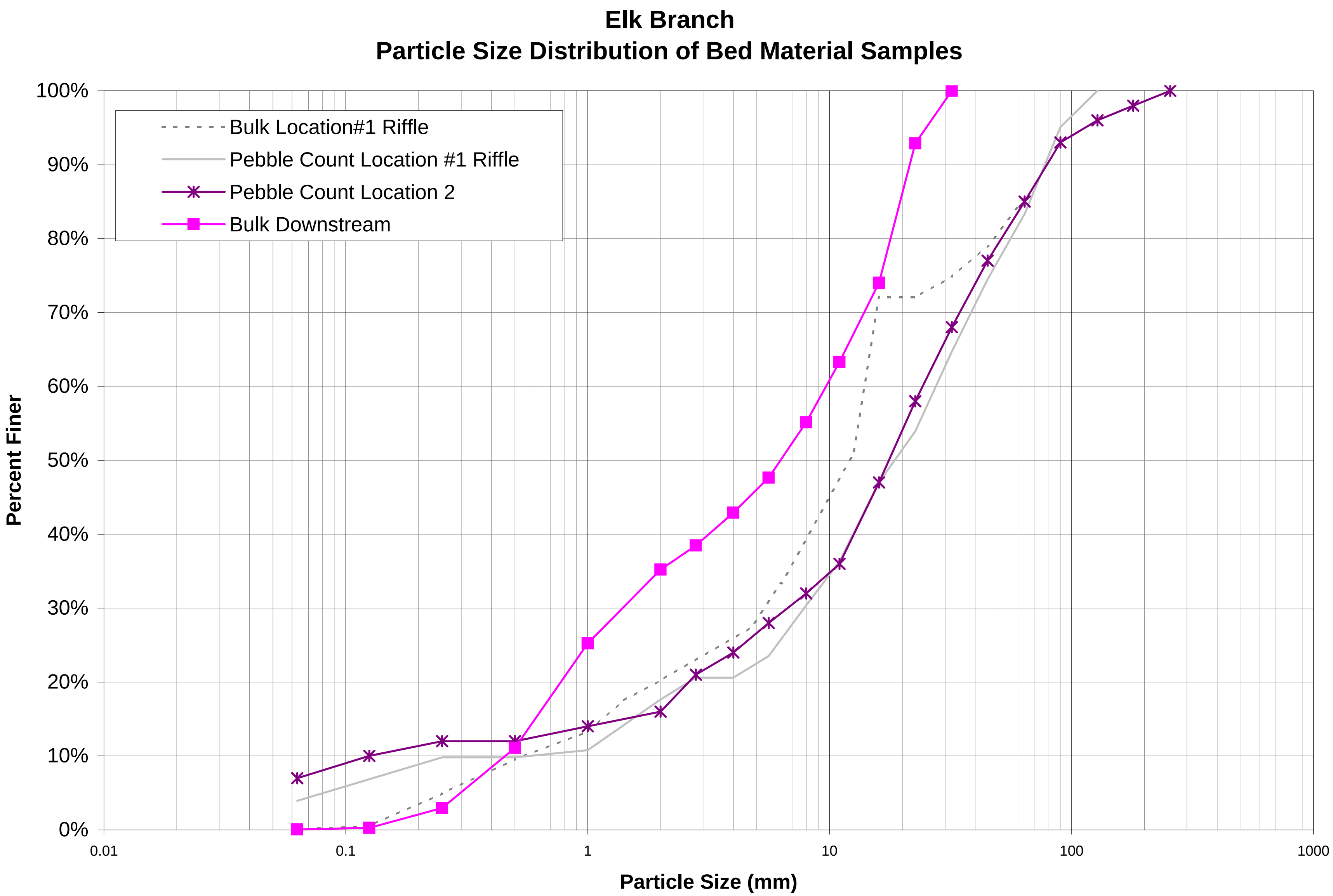

UT2 (buried), lower half


Looking "upstream" from bottom end of UT2

Looking "downstream" towards bottom end of UT2
Sinkhole caused from burial of stream


Immediately upstream of project on UT2, serves as adequate template for buried portion

APPENDIX F. Cummulative Frequency Graphs of Elk Branch Sediment Samples

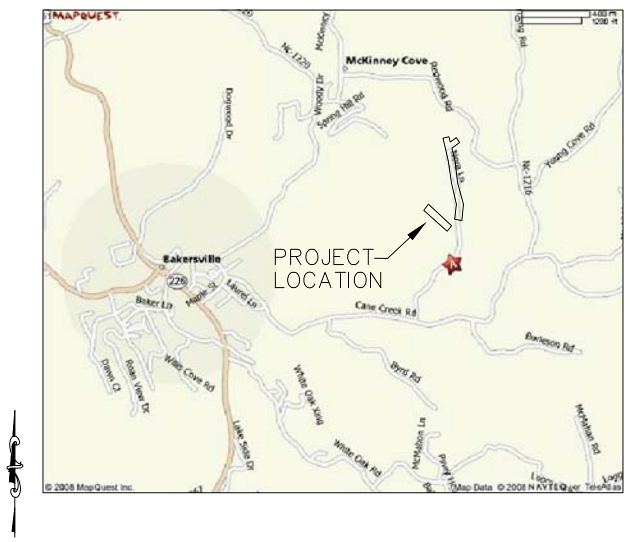


Elk Branch
Particle Size Distribution of Bed Material Samples
Bulk Location#1 Riffle
Pebble Count Location #1 Riffle
Pebble Count Location 2
Bulk Downstream
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Finer
0.01
0.1
1
10
100
1000
Particle Size (mm)

NC Ecosystem Enhancement Program

Elk Branch Restoration Project

Bakersville, North Carolina



VICINITY MAP
NOT TO SCALE

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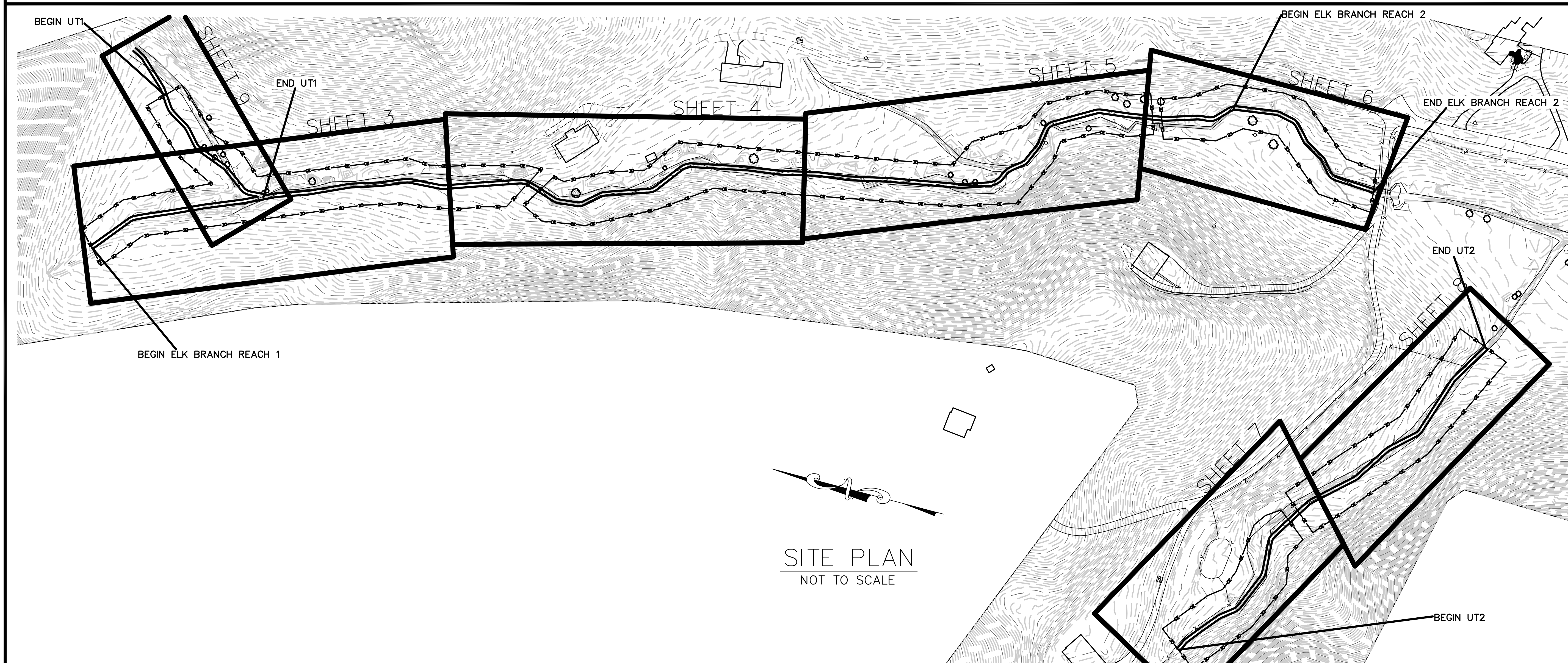
INDEX OF SHEETS

Datum Description:

Horizontal Datum is based on NCGS NAD 83. Temporary contol points are present on site and will be used to establish grade and position by a Baker representative at the time of construction.



SITE PLAN
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Baker

ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA

TITLE SHEET

Prepared for:
Ecosystem Enhancement Program
2728 Capitol Blvd., Suite 1H 103
Raleigh, NC 27604
Phone: 919-715-0476
Fax: 919-715-2219

Project No.	111085
Date:	11/06/09
File Name	coverREDESIGN.dwg
DESIGNED:	JPM
DRAWN:	MDR
APPROVED:	MMC
Drawing No.	1 of 23

LEGEND OF SYMBOLS

- EXISTING TREE
- EXISTING TREE TO BE REMOVED
- PROPOSED TREE
- BCP # BAKER CONTROL POINT
- CONSTRUCTION ENTRANCE
- EXISTING ROAD – PAVED
- FORD CROSSING
- SOIL STOCKPILE AREA
- CHANNEL PLUG
- LOG STEP SEQUENCE
- LOG STEP
- BOULDER STEP
- J–HOOK LOG VANE
- PROPOSED THALWEG / CONTROL LINE
- PROPOSED TOP OF BANK
- CONSERVATION EASEMENT
- SILT FENCE
- EXISTING CONTOUR – INDEX
- EXISTING CONTOUR – INTERMEDIATE
- EXISTING FENCE
- EXISTING POWER POLE
- EXOTIC INVASIVE REMOVAL
- PUMP AROUND
- RIPARIAN PLANTING ZONE
- STREAM BANK PLANTING ZONE

SUMMARY OF QUANTITIES

ITEM	DESCRIPTION	QUANTITY	UNIT
A	MOBILIZATION AND DEMOBILIZATION		
B	CLEARING AND GRUBBING		
C	INVASIVE SPECIES REMOVAL		
D	SAFETY FENCE		
E	SILT FENCE		
F	COIR MATTING		
G	GRADING – CUT		
H	GRADING – FILL		
I	BOULDERS		
J	CLASS A STONE		
K	CLASS B STONE		
L	CLASS 1 STONE		
M	FILTER FABRIC		
N	ROOT WADS		
O	LIVE STAKES		
P	WOODY VEGETATION		
Q	PERMANENT SEEDING		
R	TEMPORARY SEEDING		
S	MULCH		
T			
U			

GENERAL NOTES

1. Equipment and materials shall be mobilized to the site.
2. Utility locations shown on these plans are approximate. The Contractor shall have all underground utilities within the project limits located and marked prior to beginning construction
3. A gravel "construction entrance" that consists of class A stone, at least 50 feet in length, shall be incorporated into every access point that connects to a public road.
4. Temporary and permanent stream crossings and temporary check dams shall be installed as shown in the plans. Temporary check dams shall be removed when grading work upstream has been completed.
5. Construction shall proceed upstream to downstream. Grading of bankfull benches within a work area shall be done before new channels are graded.
6. Temporary sand bag coffer dams shall be installed upstream of each work area and flow in the work reach shall be diverted by pumping and piping around the work area. The length of each diversion shall be approximately 300 to 500 linear feet. Pumping will be done when work is required in a channel where the stream is flowing and where new offline channel segments are tied into the existing channel.
7. The limited clearing and grubbing required within the grading limits shall be performed so as to limit sedimet migration off-site. Logs and root wads from trees larger than 10 inches in diameter shall be stockpiled for use as in-stream structures. Salvageable native vegetation (black willow, tag alder, silky dogwood, etc.) shall be harvested for transplanting or for cutting and used as live-staking materials.
8. The new channel sections shall be stabilized with in-stream structures, erosion control matting, seeding, and transplants before turning water into these sections. Compacted soil channel plugs shall be installed in areas where the new channel diverges from the original channel, and the original, abandoned channel sections will be backfilled.
9. Dewatering of off-line sections shall be diverted through a sediment filter before being discharged into the downstream reach.
10. Earthwork shall be staged such that no more channel will be disturbed than can be stabilized by the end of the work day or before flow is diverted into a new channel segment.
11. Disturbed areas within the first 30 feet of buffer adjacent to the channel will be seeded, mulched or otherwise stabilized with temporary ground cover daily until a more permanent ground cover is established across the buffer area disturbed during construction. If temporary ground cover is not applied daily, straw wattles will be staked down at the top of the bank where erosion control matting ends to prevent sediment loading from upland portions of the buffer that have not been stabilized.
12. Excess soil materials shall be stockpiled in designated staging and stockpile areas, with silt fence installed on the stream side(s) of the base of the stockpiles and maintained when sediment has accumulated above one third of the height of the silt fence and/or the silt fence has failed. Excess soil shall be hauled outside the conservation easement before demobilization.
13. The flow diversions and temporary stream crossings shall be removed when no longer needed and the banks in these areas stabilized with seeding and matting.
14. Bank and floodplain vegetation, including brush materials and live stakes, shall be installed during the dormant season, November to April.
15. Construction entrances, staging and stockpile areas, and silt fences shall be removed and the ground shall be repaired to its original conditions once planting is complete or once they are no longer needed.

NORTH CAROLINA PROFESSIONAL SEAL 035378 ENGINEER JACOB P. McLEAN

PRELIMINARY PLANS
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Baker

ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA

SYMBOLOGY

Prepared for:
Ecosystem Enhancement Program
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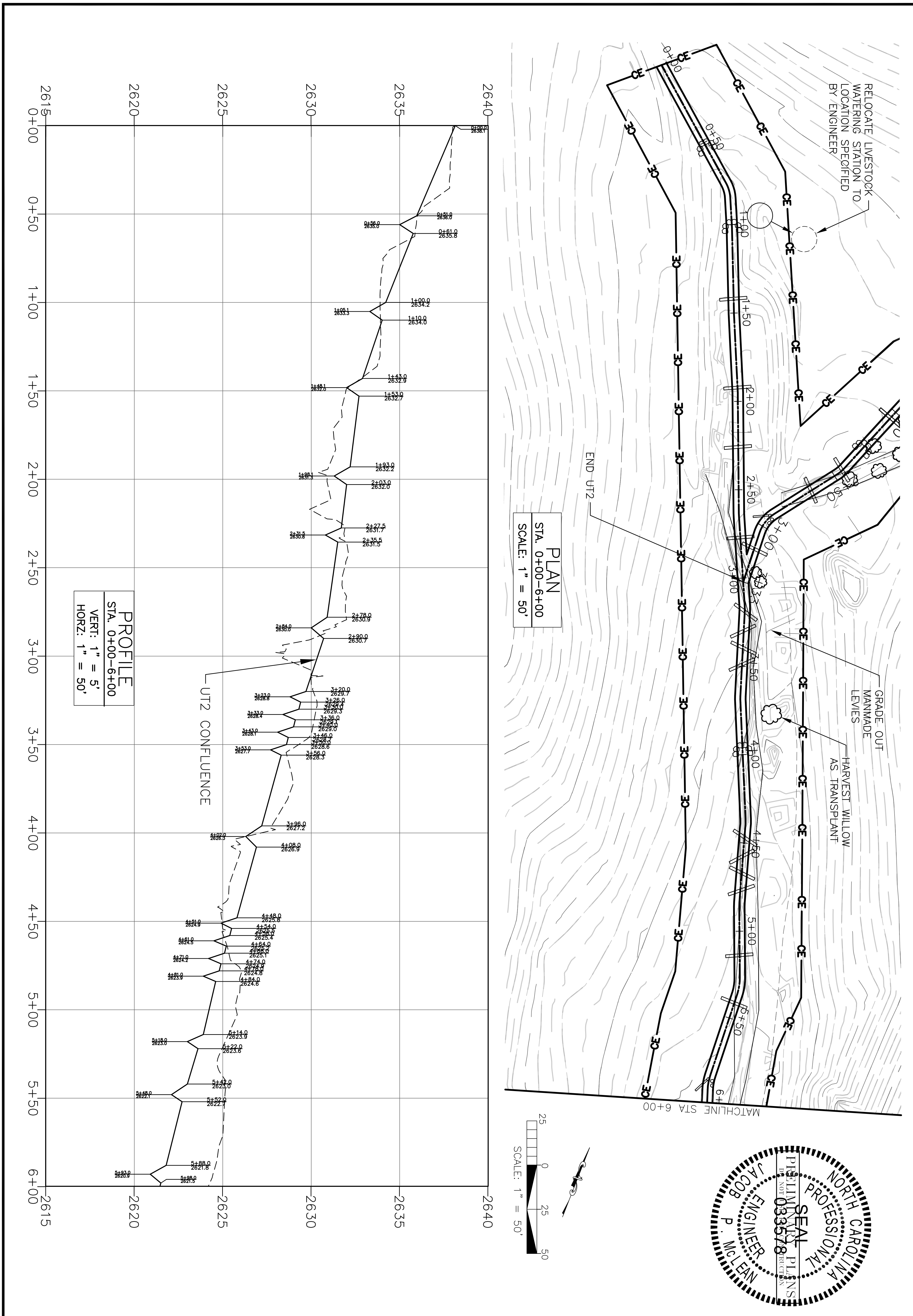
Project No. 111085
Date: 11/06/09
File Name coverREDESIGN.dwg
DESIGNED: JPM
DRAWN: MDR
APPROVED: MMC

Drawing No. 2 of 23



Project No. 111085	Prepared for: Ecosystem Enhancement Program 2728 Capitol Blvd., Suite 1H 103 Raleigh, NC 27604 Phone: 919-715-0476 Fax: 919-715-2219	ELK BRANCH RESTORATION PROJECT NORTH CAROLINA	Baker	Micheal Baker Engineering Inc. 797 Haywood Road Suite 201 Asheville, North Carolina 28806 Phone: 828.350.1408 Fax: 828.350.1409
Date: 11/06/09		PLAN AND PROFILE		
File Name PLANPROFILEREDESIGN.dwg				
DESIGNED: JPM DRAWN: MDR APPROVED: MMC				
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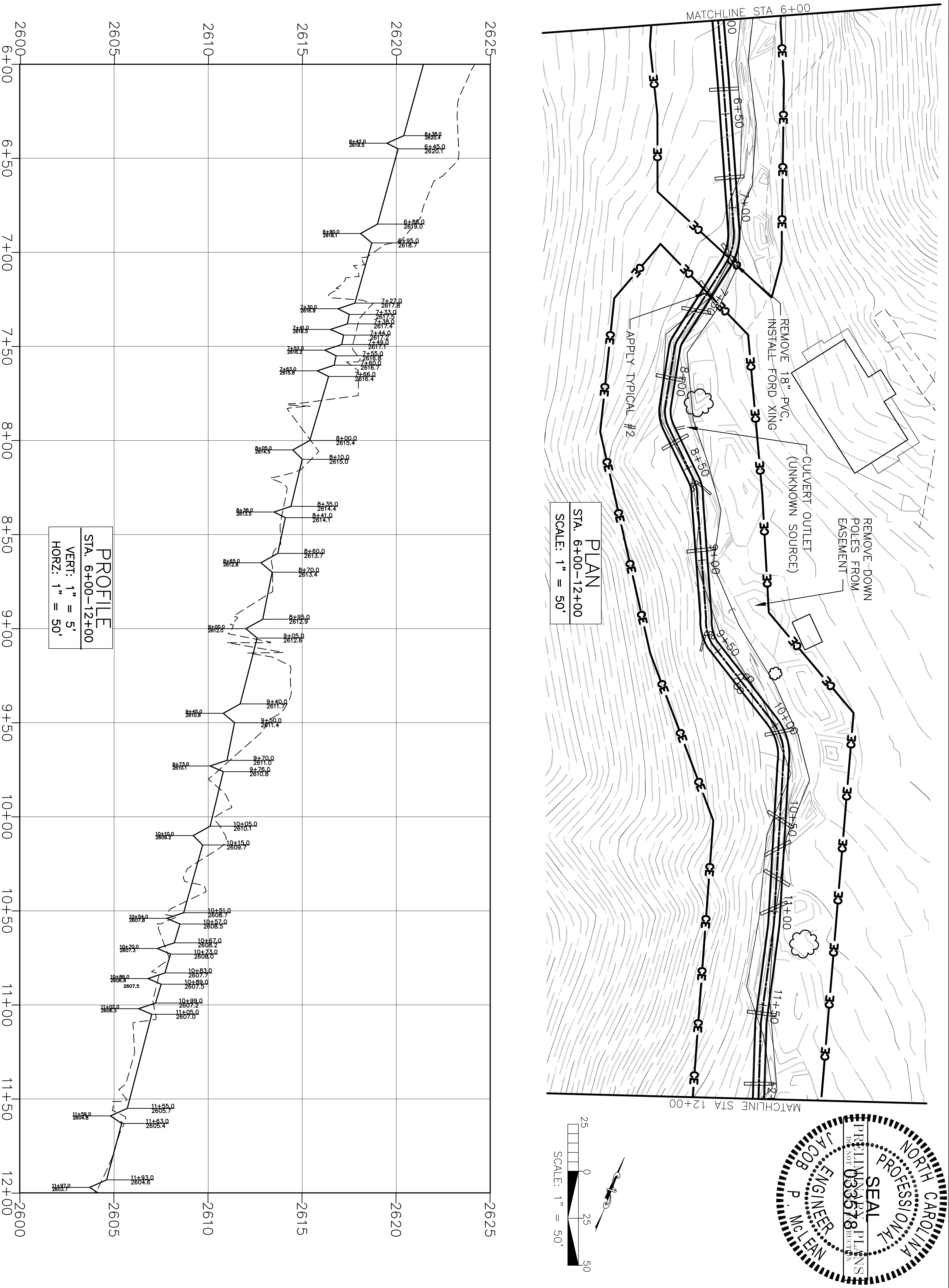

Project No. 111085

Date: 11/06/09

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DRAWN: MDR
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Drawing No. 4 of 23

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ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA

PLAN AND PROFILE

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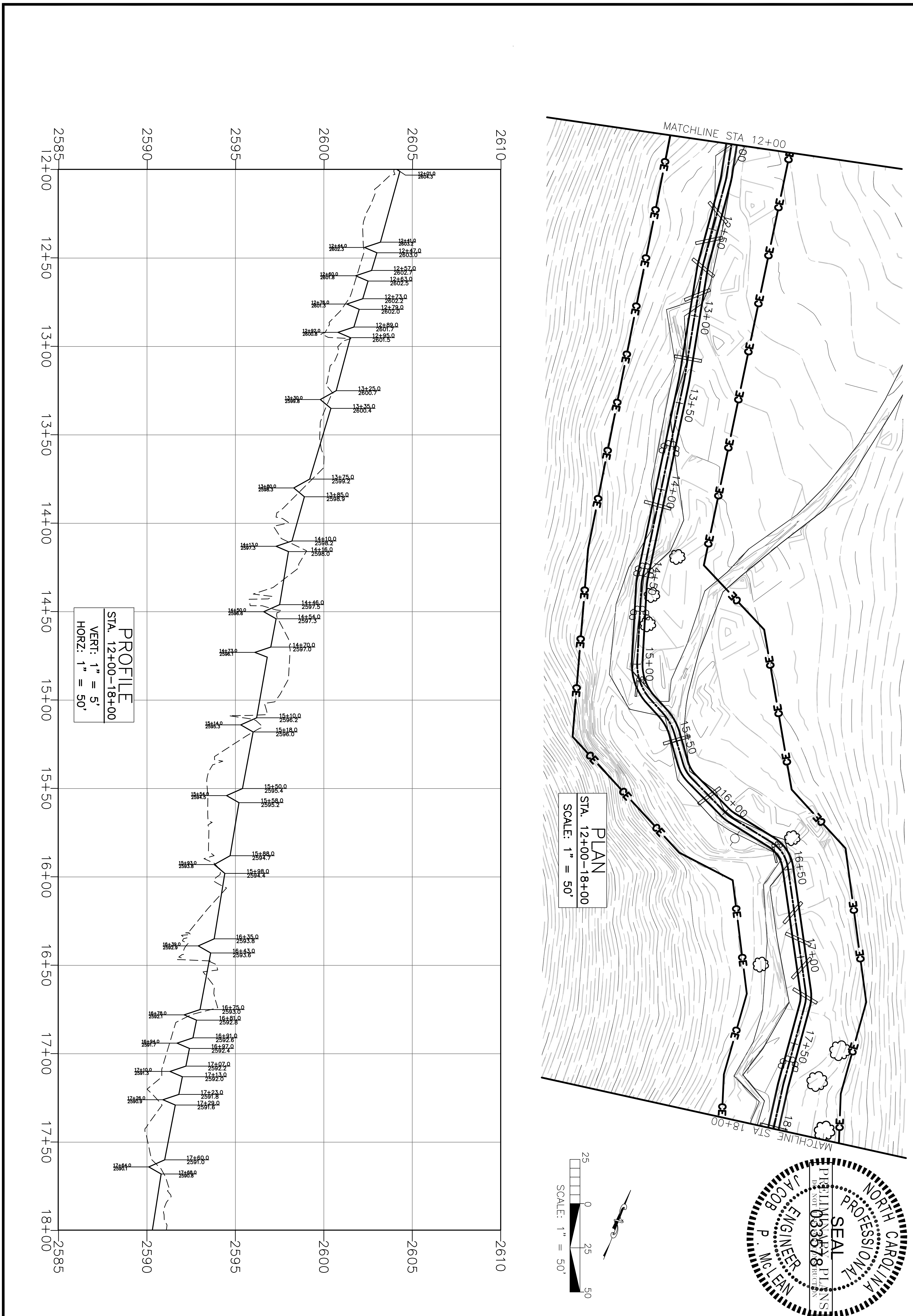

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ELK BRANCH RESTORATION PROJECT
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PLAN AND PROFILE

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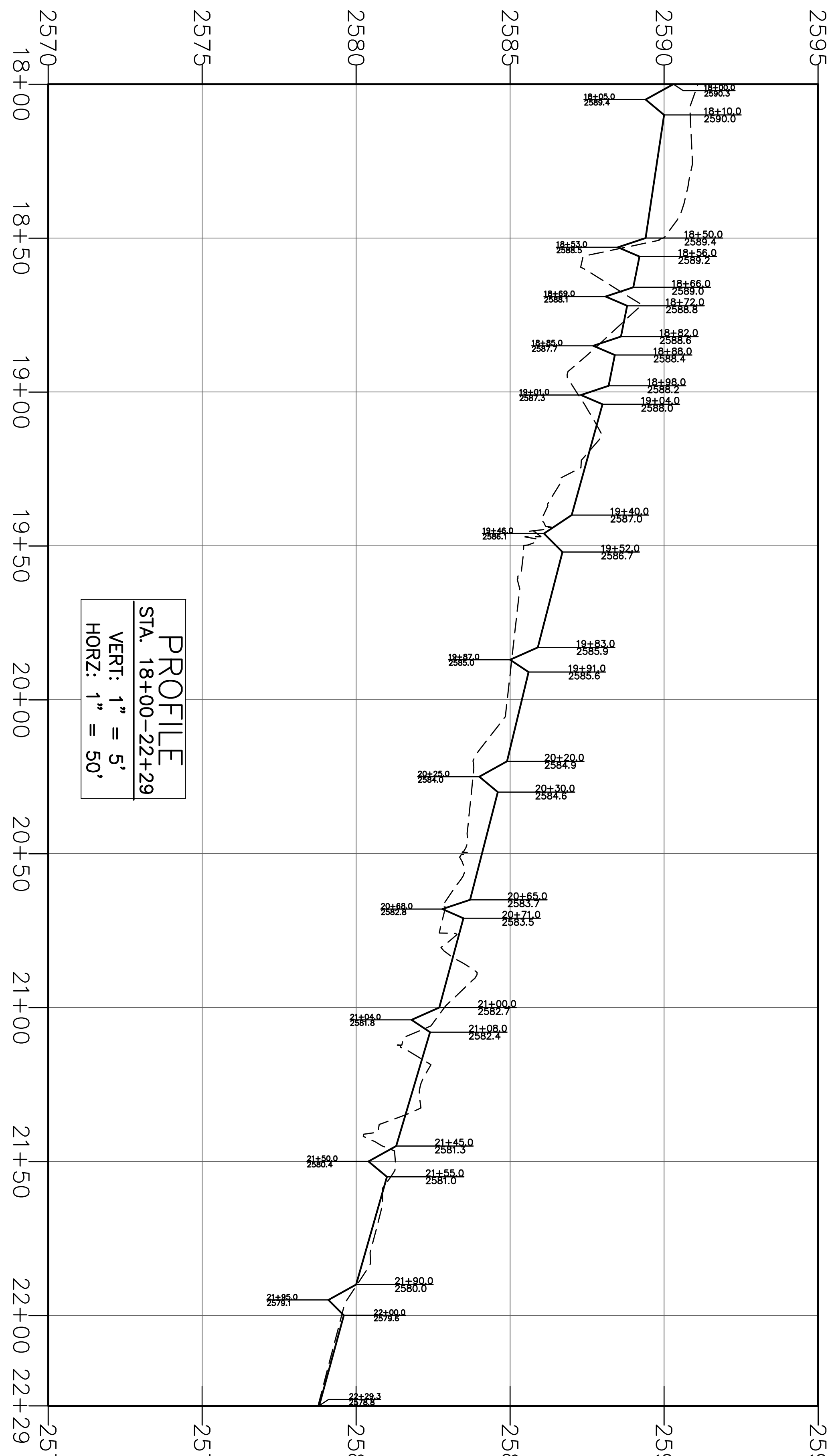

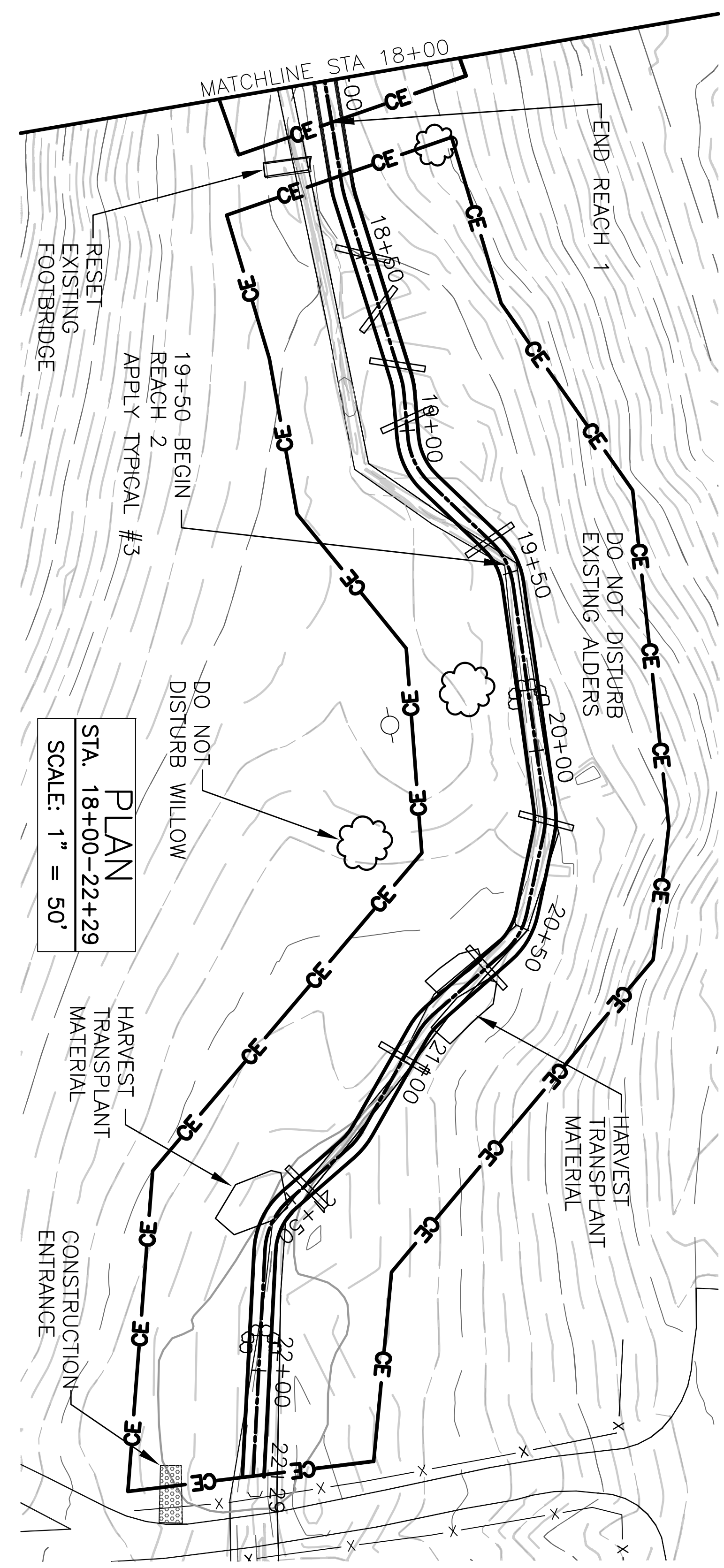

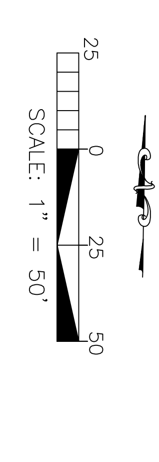

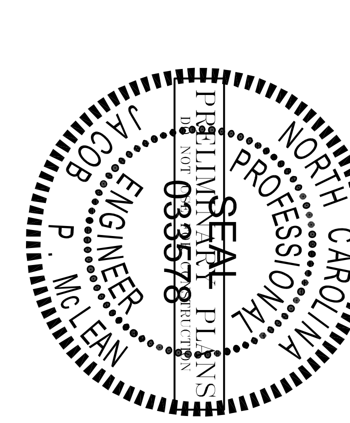

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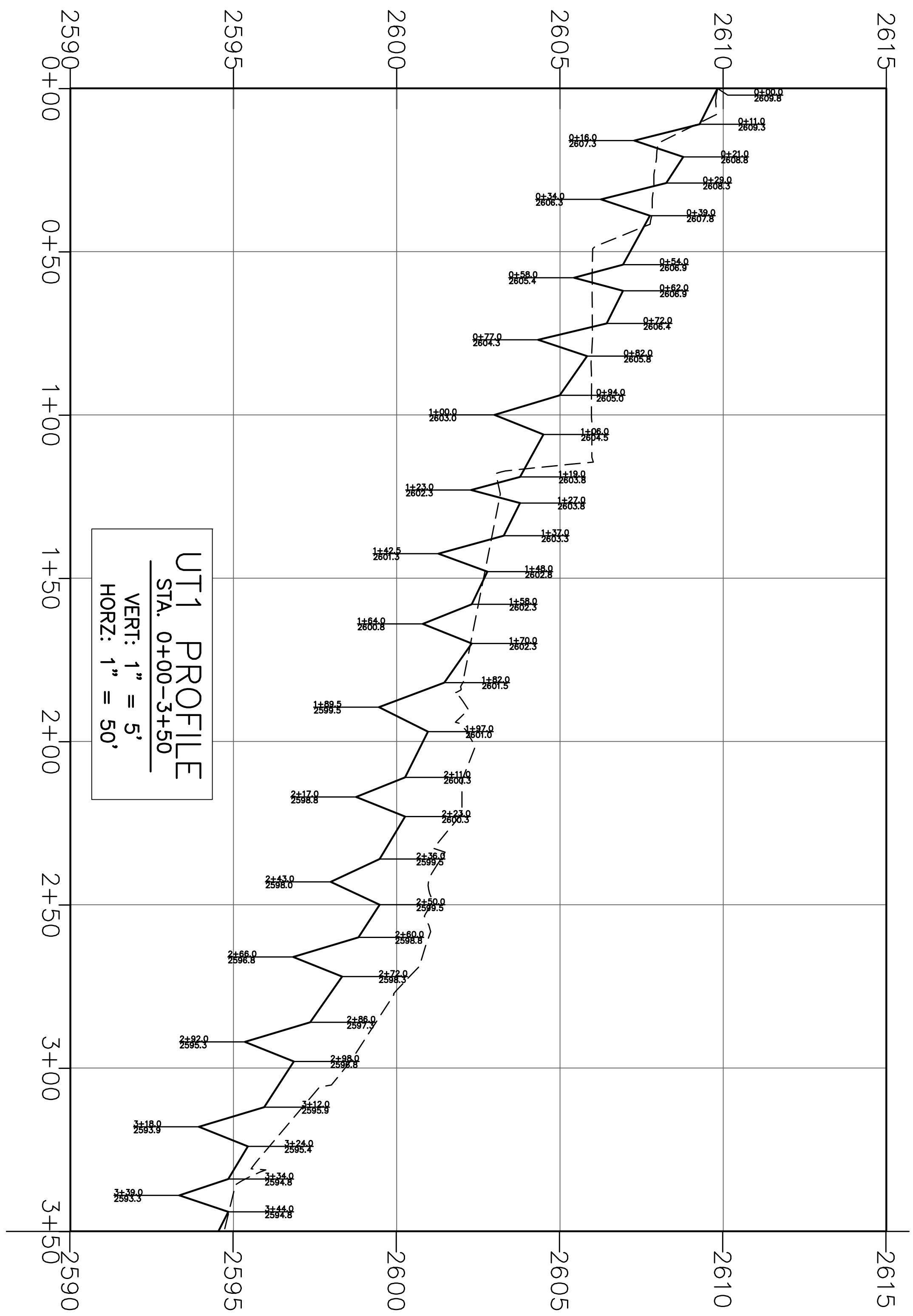

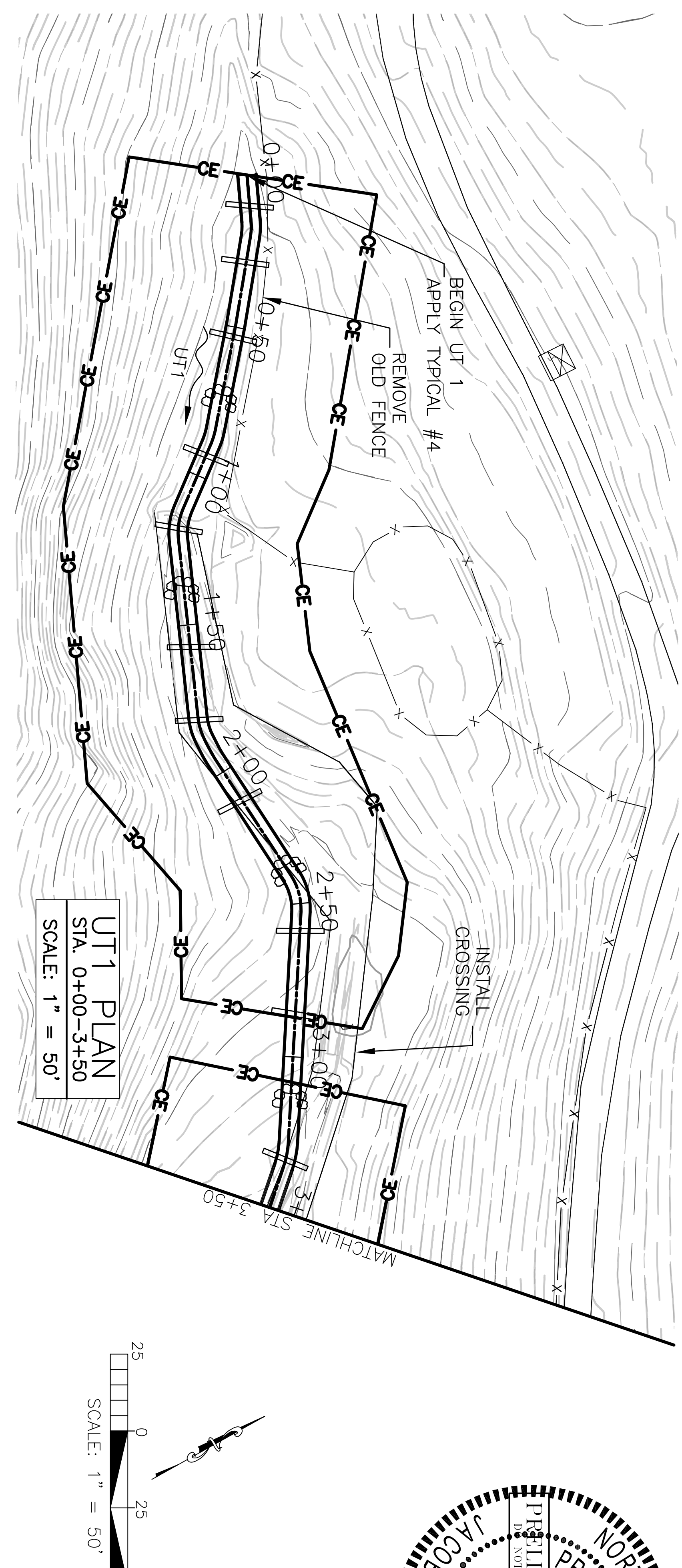

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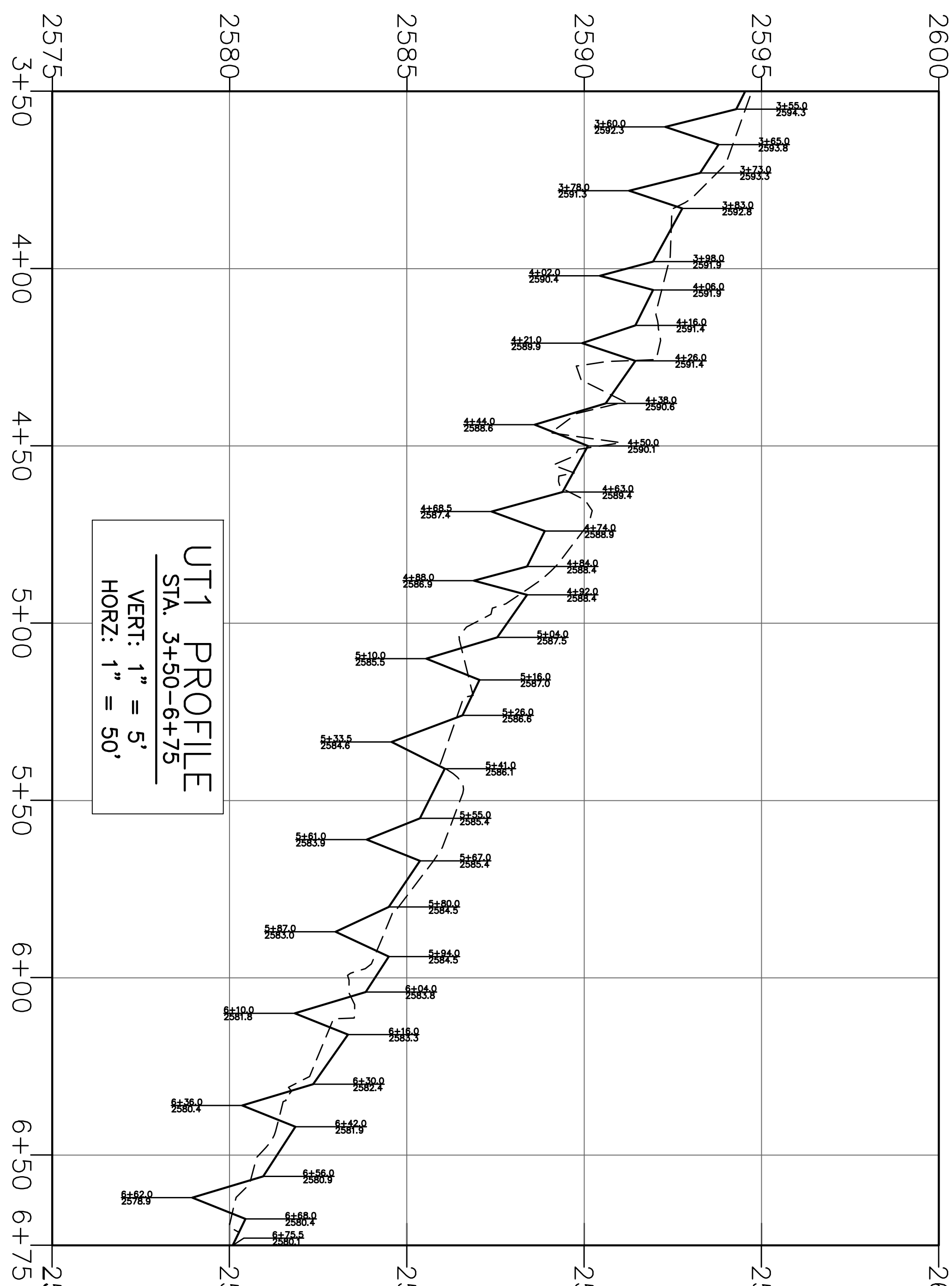
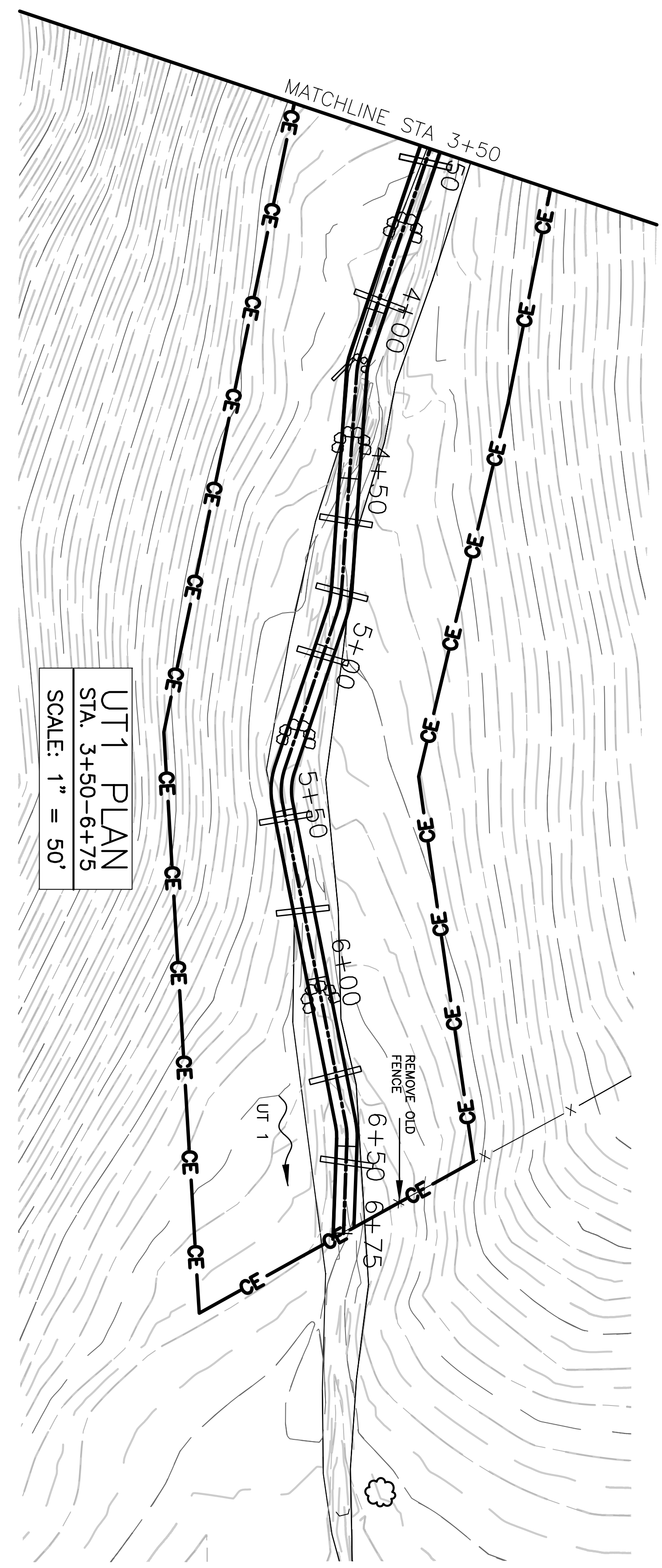
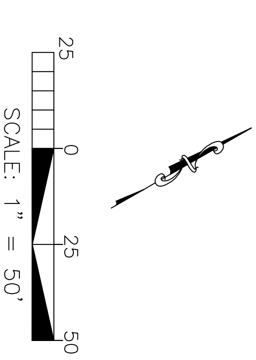
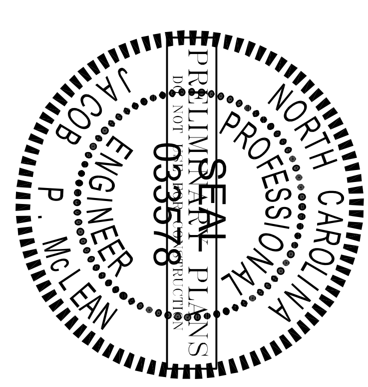
Project No. 111085 Date: 11/06/09 File Name PLANPROFILEREDESIGN.dwg DESIGNED: JPM DRAWN: MDR APPROVED: MMC Drawing No. 7 of 23	Prepared for: Ecosystem Enhancement Program 2728 Capitol Blvd., Suite 1H 103 Raleigh, NC 27604 Phone: 919-715-0476 Fax: 919-715-2219	ELK BRANCH RESTORATION PROJECT NORTH CAROLINA UT1 PLAN / PROFILE	Baker	**Micheal Baker Engineering Inc.** 797 Haywood Road Suite 201 Asheville, North Carolina 28806 Phone: 828.350.1408 Fax: 828.350.1409









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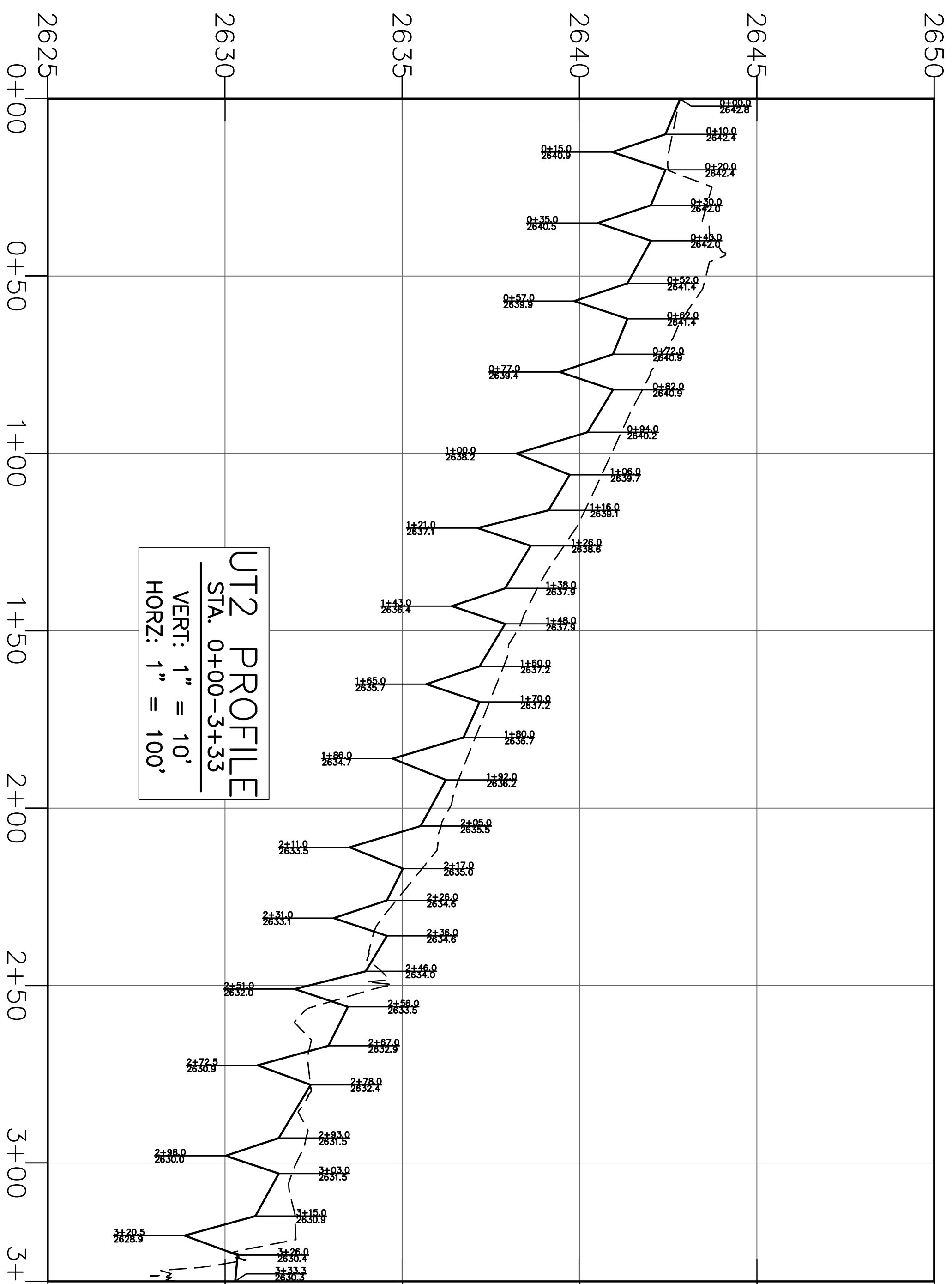

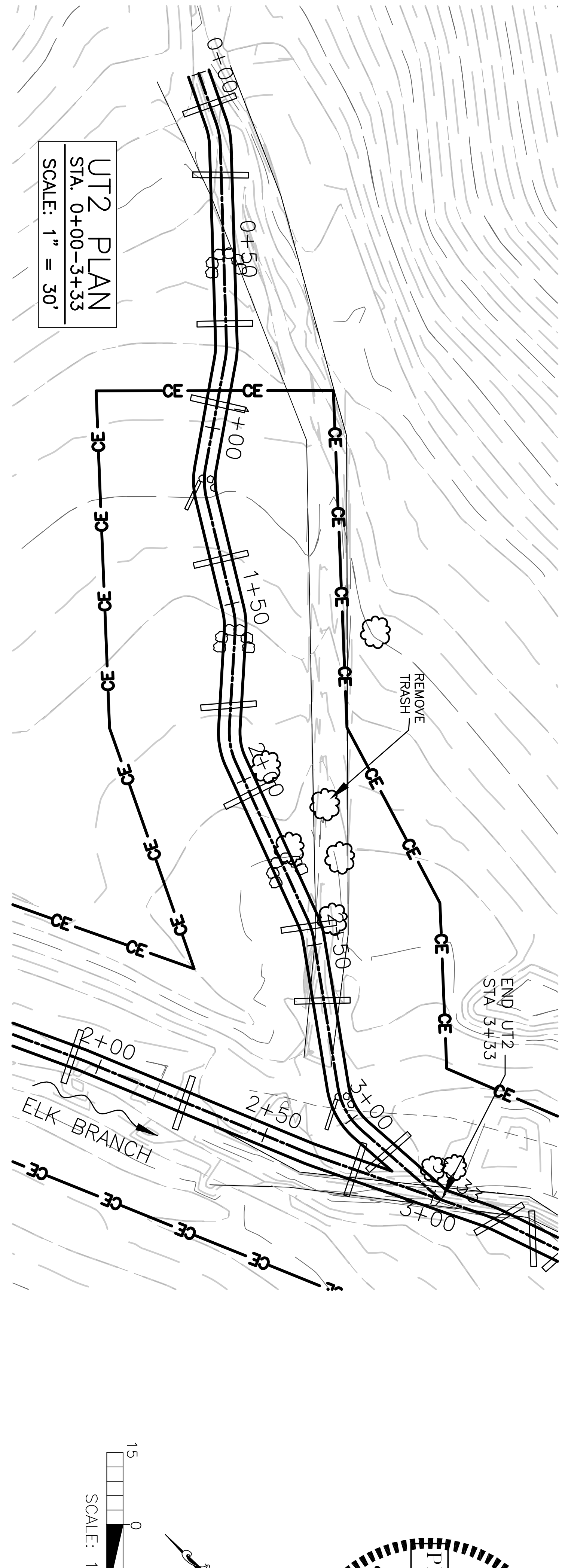

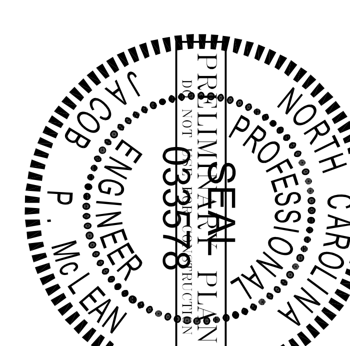

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Date:	11/06/09
File Name	PLANPROFILEREDESIGN.dwg
DESIGNED:	JPM
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Drawing No.	9 of 23

Prepared for:
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ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA

UT 2 PLAN / PROFILE

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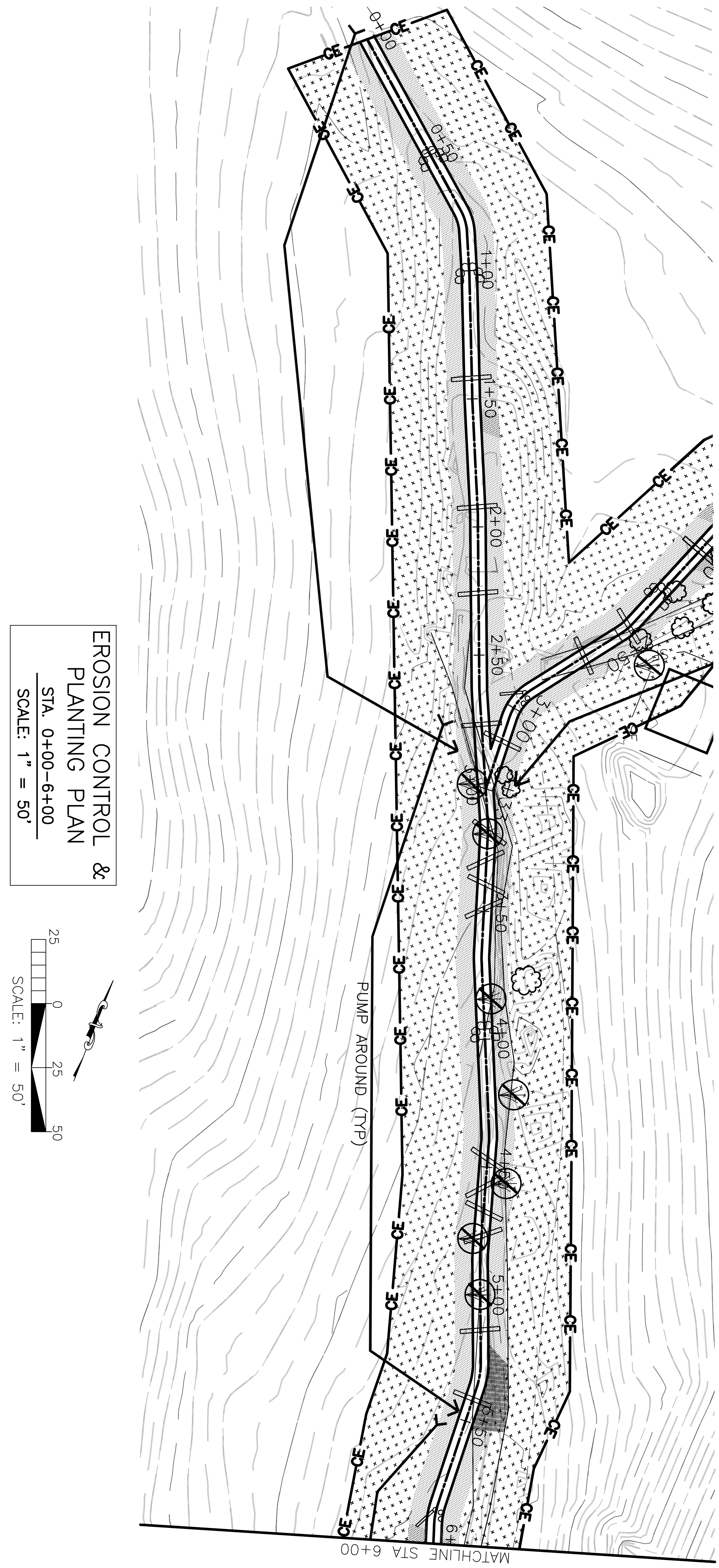

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File Name PLANPROFILEREDESIGN.dwg			
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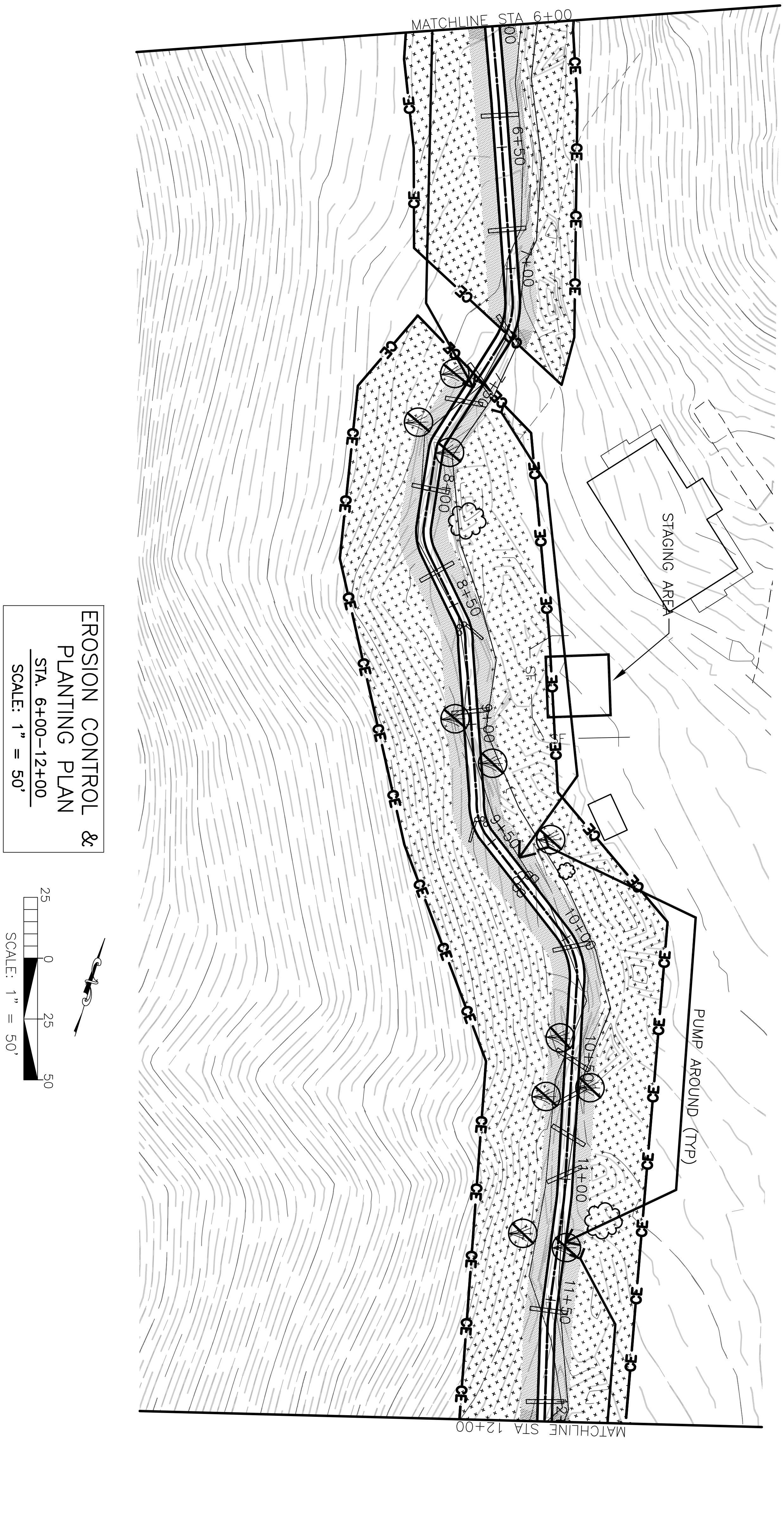
Drawing No. 10 of 23			



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PRELIMINARY PLANS

Project No. 111085

Date: 11/06/09

File Name PLANPROFILEREDESIGN.dwg

DESIGNED: JPM
DRAWN: MDR
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Drawing No. 11 of 23

Prepared for:
Ecosystem Enhancement Program
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ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA

EROSION CONTROL & PLANTING PLAN

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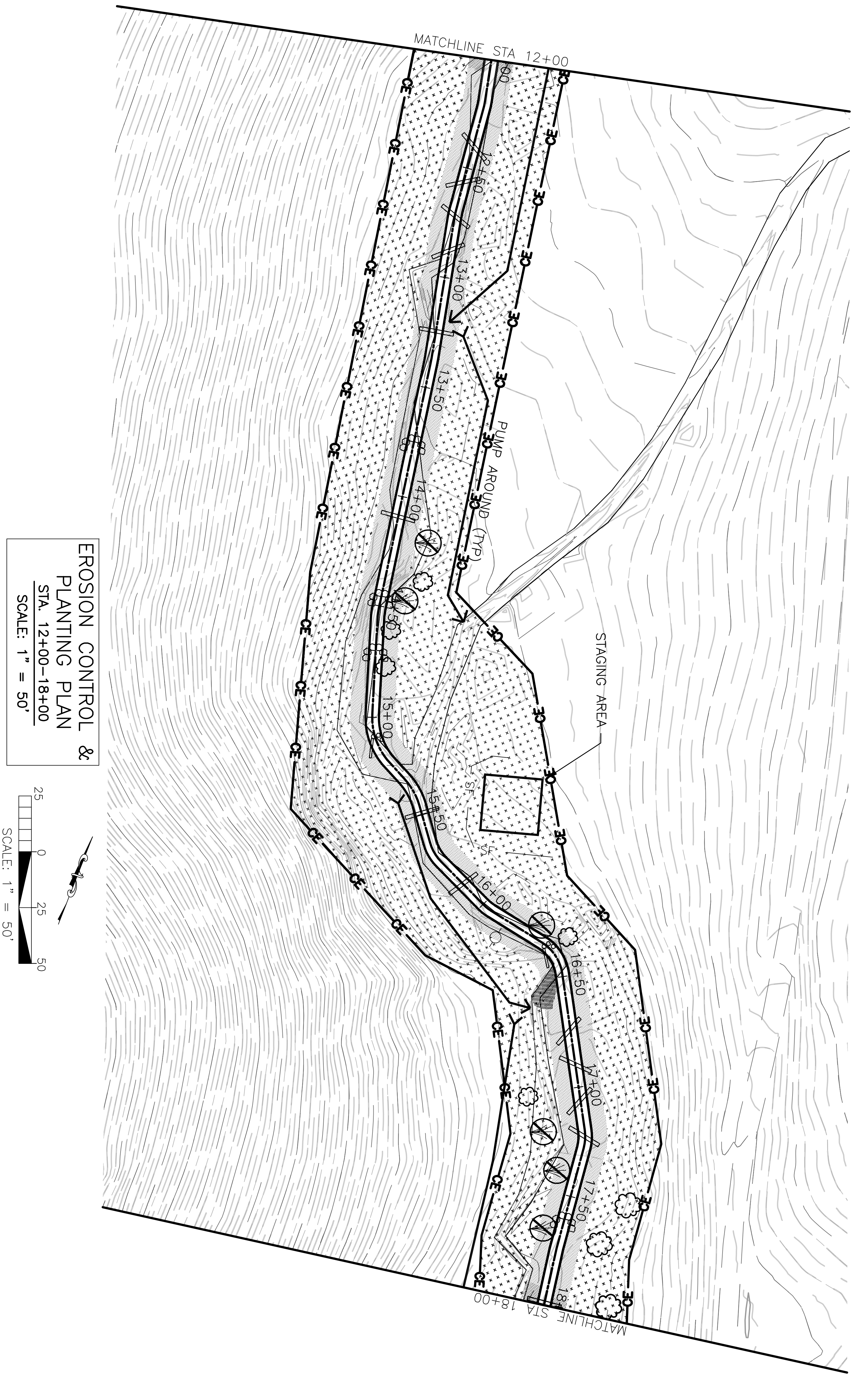
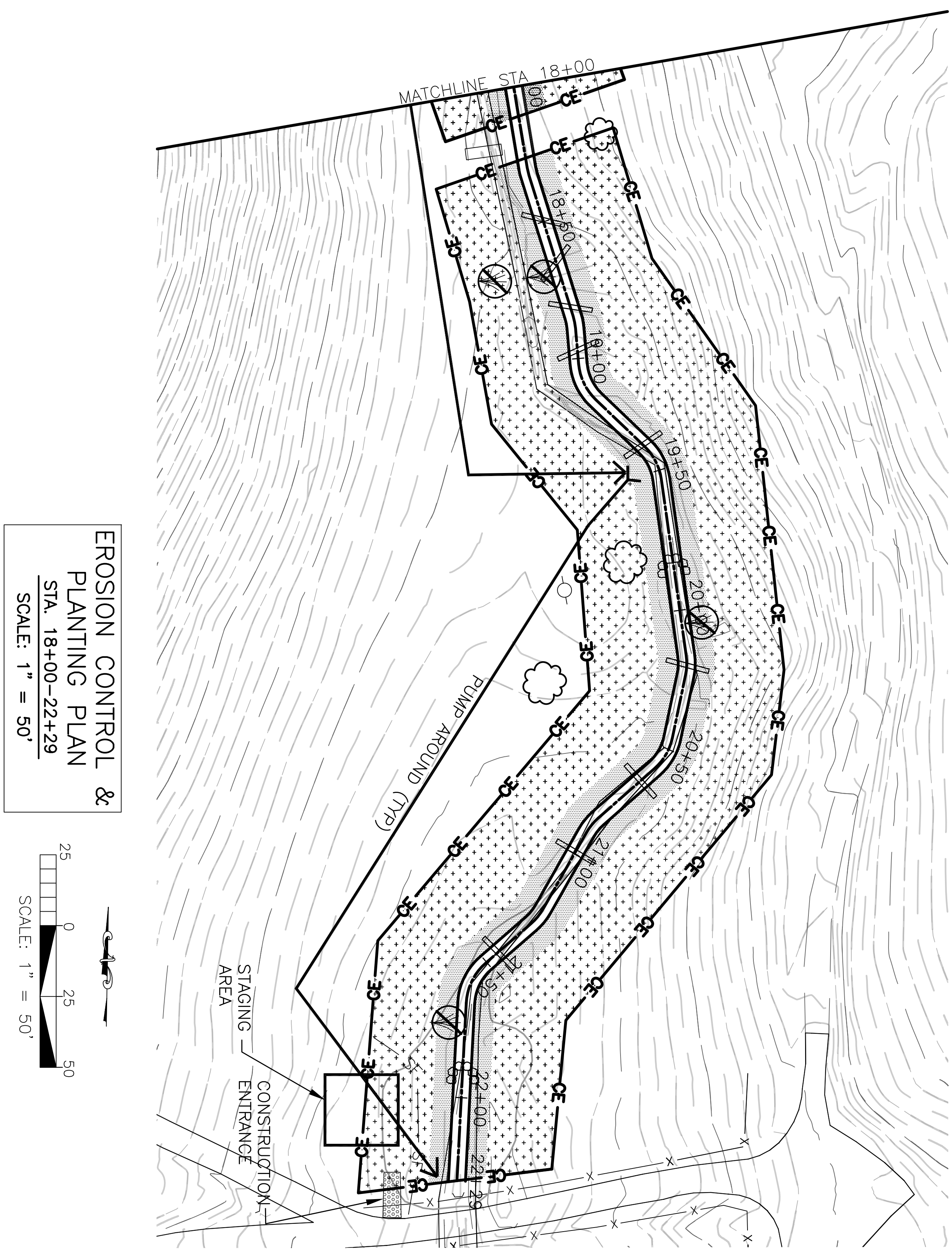


NORTH CAROLINA PROFESSIONAL SEAL 033578 ENGINEER JACOB P. McLEAN
PRELIMINARY PLANS DO NOT USE FOR CONSTRUCTION

Project No. 111085 Date: 11/06/09 File Name PLANPROFILEREDESIGN.dwg DESIGNED: JPM DRAWN: MDR APPROVED: MMC Drawing No. 12 of 23	Prepared for: Ecosystem Enhancement Program 2728 Capitol Blvd., Suite 1H 103 Raleigh, NC 27604 Phone: 919-715-0476 Fax: 919-715-2219	ELK BRANCH RESTORATION PROJECT NORTH CAROLINA EROSION CONTROL & PLANTING PLAN	Baker	Micheal Baker Engineering Inc. 797 Haywood Road Suite 201 Asheville, North Carolina 28806 Phone: 828.350.1408 Fax: 828.350.1409



NORTH CAROLINA PROFESSIONAL SEAL 033578 ENGINEER JACOB P. McLEAN
PRELIMINARY PLANS

Project No.	111085
Date:	11/06/09
File Name	PLANPROFILEREDESIGN.dwg
DESIGNED:	JPM
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Drawing No.	13 of 23

Prepared for:
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ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA
EROSION CONTROL & PLANTING PLAN

Baker

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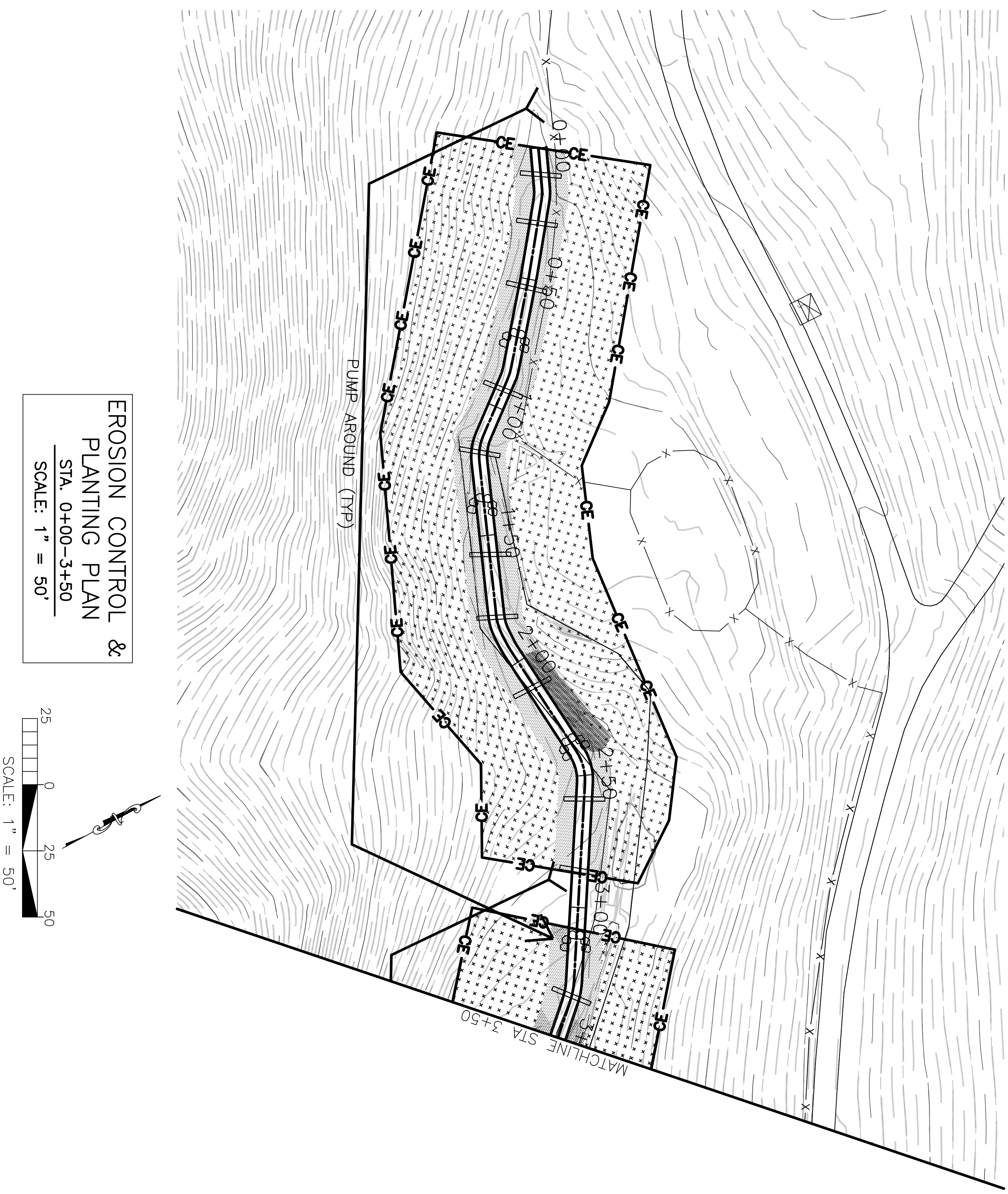

NORTH CAROLINA PROFESSIONAL SEAL 033578 ENGINEER JACOB P. McLEAN

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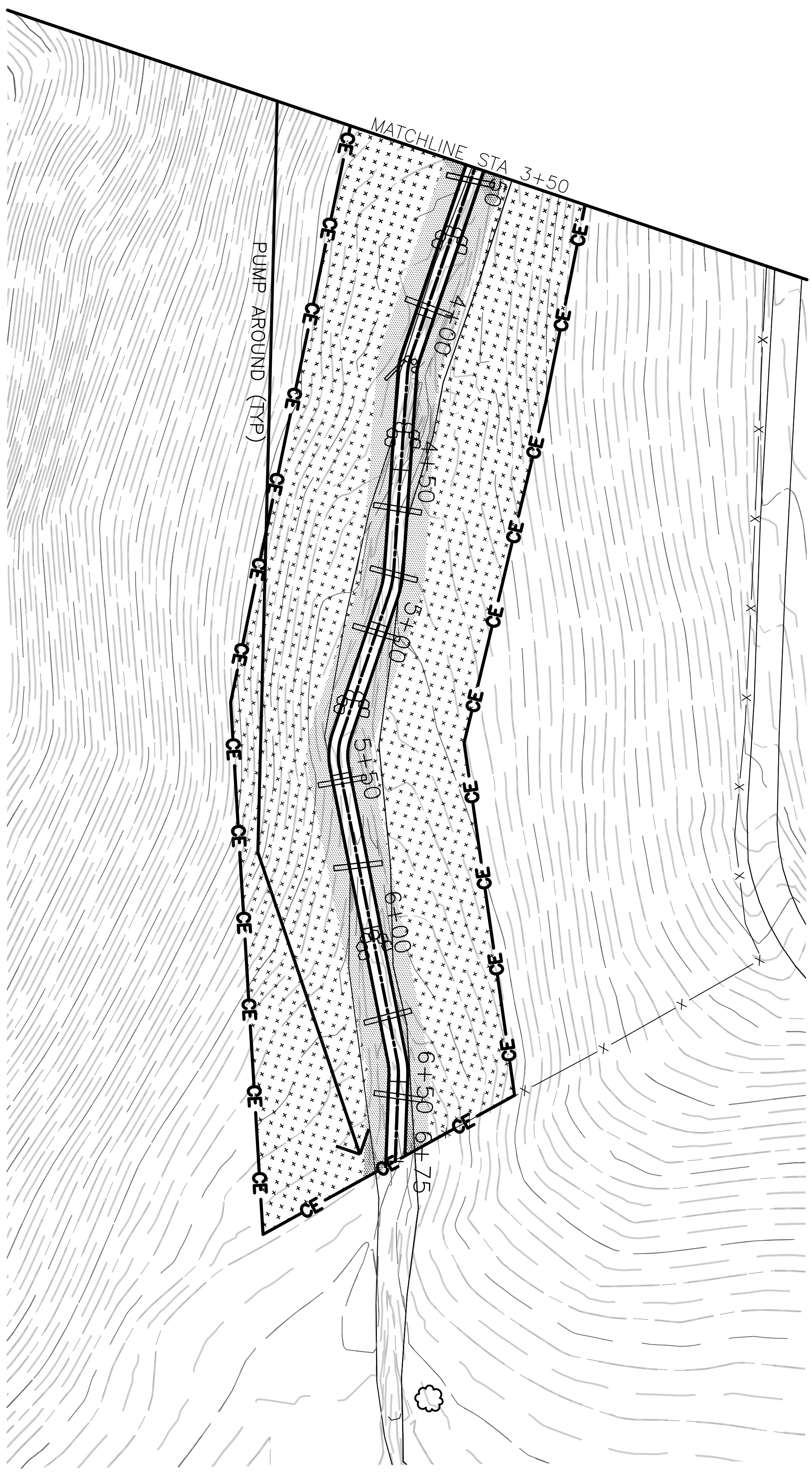
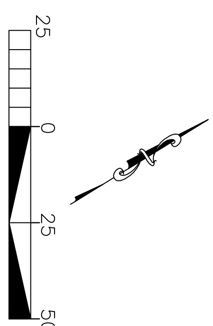
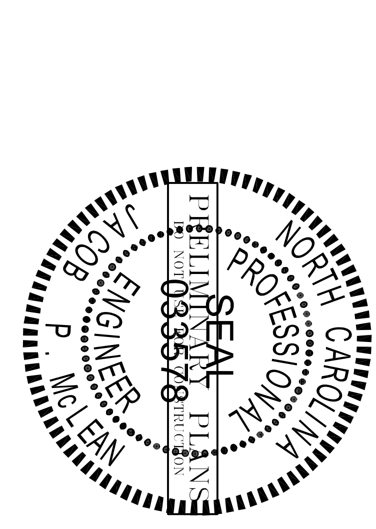
Drawing No.	DESIGNED: JPM DRAWN: MDR APPROVED: MMC	File Name	Date:	Project No.	Prepared for:			
14 of 23		PLANPROFILEREDESIGN.dwg	11/06/09	111085	Ecosystem Enhancement Program 2728 Capitol Blvd., Suite 1H 103 Raleigh, NC 27604 Phone: 919-715-0476 Fax: 919-715-2219	ELK BRANCH RESTORATION PROJECT NORTH CAROLINA EROSION CONTROL & PLANTING PLAN	Baker	**Micheal Baker Engineering Inc.** 797 Haywood Road Suite 201 Asheville, North Carolina 28806 Phone: 828.350.1408 Fax: 828.350.1409



EROSION CONTROL & PLANTING PLAN
STA. 3+50–6+75
SCALE: 1" = 50'





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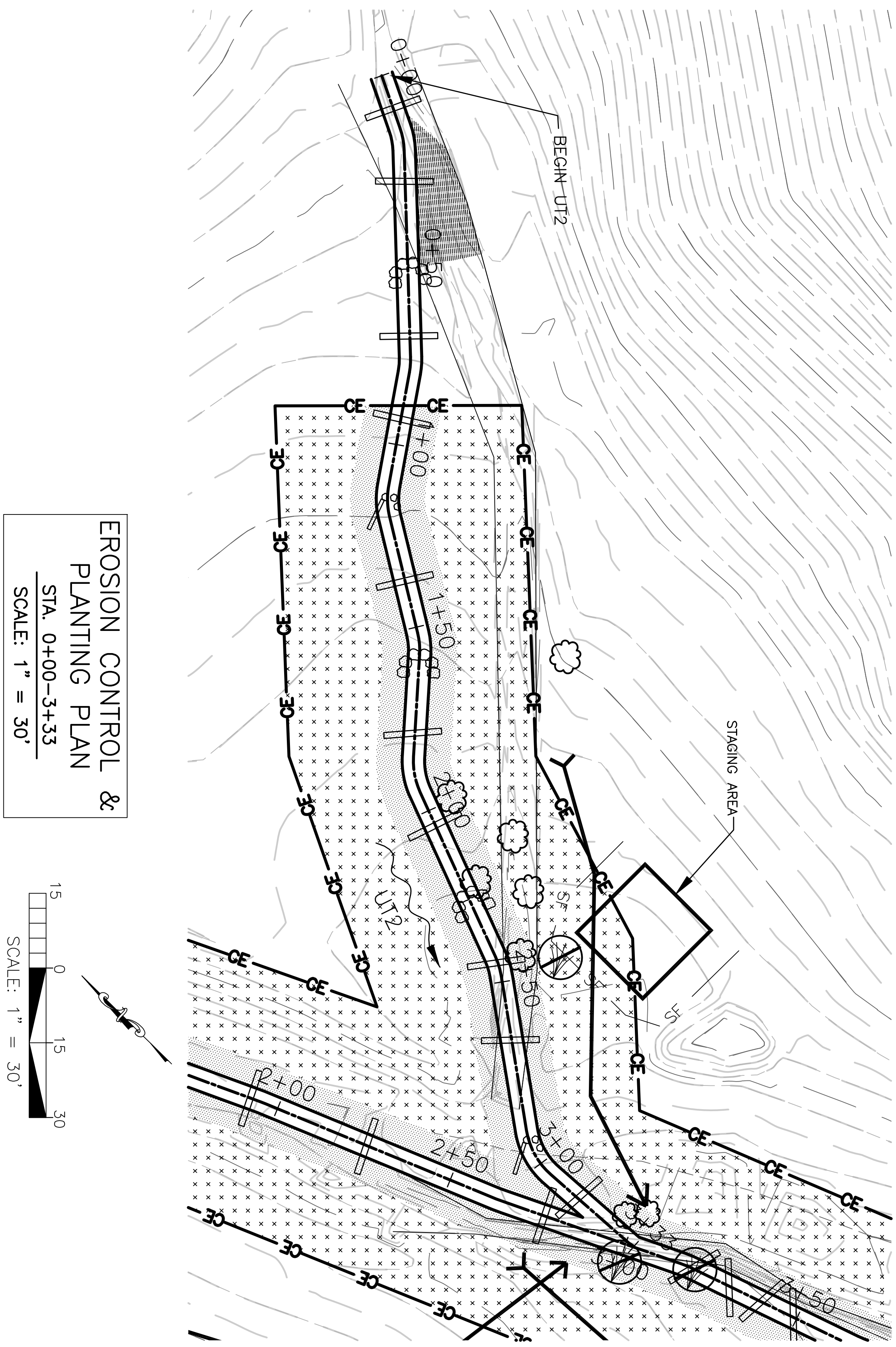

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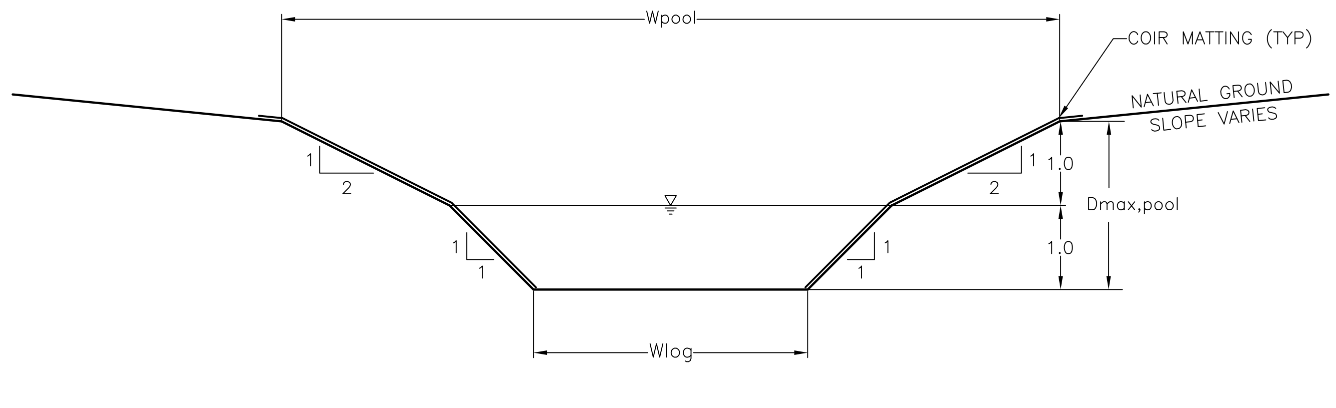
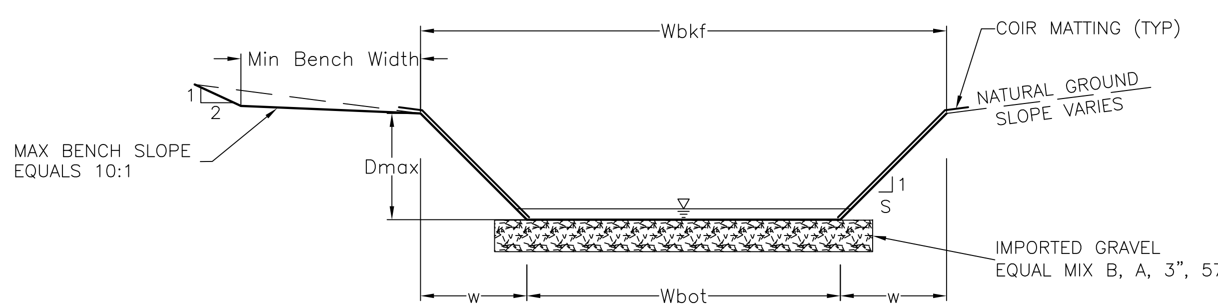
SEAL
033578
JACOB P. McLEAN
PRELIMINARY PLANS

Project No. 111085 Date: 11/06/09 File Name PLANPROFILEREDESIGN.dwg DESIGNED: JPM DRAWN: MDR APPROVED: MMC Drawing No. 16 of 23	**Prepared for:** **Ecosystem Enhancement Program** **2728 Capitol Blvd., Suite 1H 103** **Raleigh, NC 27604** **Phone: 919-715-0476** **Fax: 919-715-2219**	ELK BRANCH RESTORATION PROJECT NORTH CAROLINA EROSION CONTROL & PLANTING PLAN	Baker	**Micheal Baker Engineering Inc.** 797 Haywood Road Suite 201 Asheville, North Carolina 28806 Phone: 828.350.1408 Fax: 828.350.1409	



MAX POOL
N.T.S



RIFFLE CONSTRUCTION
N.T.S

NOTES
1. REFER TO TYPICAL DIMENSIONS IN TABLE FOR THE REACH BEING CONSTRUCTED.

2. BORROW FLOOD PLAIN MATERIAL AS NEEDED FOR FILL.

3. IF EXISTING SUBSTRATE IS OTHER THEN SILT OR CLAY, EXCAVATE AND INCORPORATE INTO NEW CHANNEL BED.

4. USE GEOLIFT OR COIR LOG AS NECESSARY TO STABILIZE FILL SLOPE.

5. APPLY COIR CF700 MATTING TO BANKS PER MATTING DETAIL

6. CONSTRUCT MINIMUM BENCH WIDTH ON BOTH SIDES OF CHANNEL, OR INCREASE ONE SIDE TO COMPENSATE FOR TOTAL OF 2XMIN

7. TIE INTO TERRACE AT MIN SLOPE OF 2:1

TYPICAL#	REACH NAME	BEGIN STA	END STA	Qbkf	Abkf	**Wbkf**	**Dmax**	Dbkf	**Wbot**	**w**	S	**Wlog**	**Wpool**	**Dmax,pool**	ER	Wfpa	Min. Bench Width	W/D	K Sinuosity	WS Slope	Type
1	1	0+00	7+25	7	4.2	7.0	0.8	0.60	3.5	1.75	2.2	6	12	2.0	2.2–3.2	15.4–22.4	5	11.7	1.02	0.028	B
2	1	7+25	18+10	14	5.85	9.0	0.9	0.65	4	2.5	2.8	7	13	2.0	2.2–5.0	19.8–45.0	6	13.8	1.07	0.026	B
3	2	18+10	22+29	20	5.85	9.0	0.9	0.65	4	2.5	2.8	7	13	2.0	2.2–5.0	22.0–50.0	6	13.8	1.11	0.027	B
4	UT1	0+00	6+75	10	4.3	8.0	0.70	0.52	4	2.1	2.9	6	12	2.0	2.2–3.2	17.6–25.6	5	15.4	1.04	0.044	B
5	UT2	0+00	3+33	6	2.25	6.0	0.50	0.38	3	1.5	3.0	4	10	2.0	2.2–3.2	13.2–19.2	4	16.2	1.04	0.038	B

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ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA
TYPICAL CROSS-SECTIONS

Prepared for:
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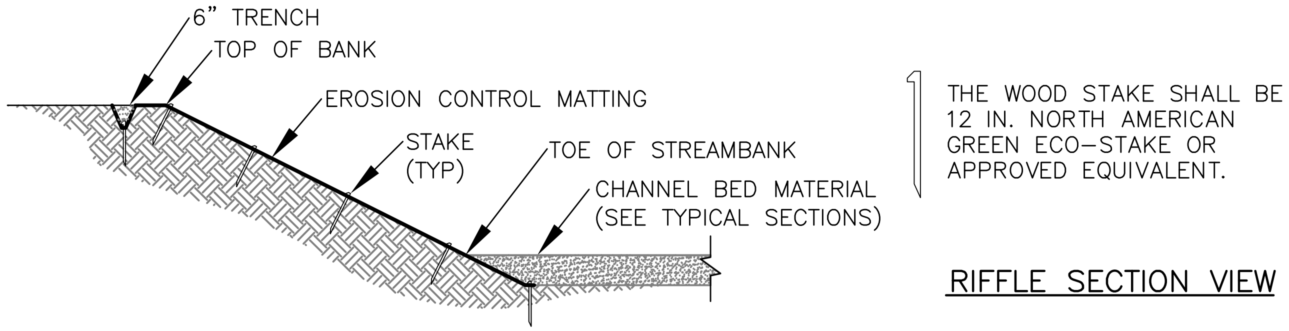
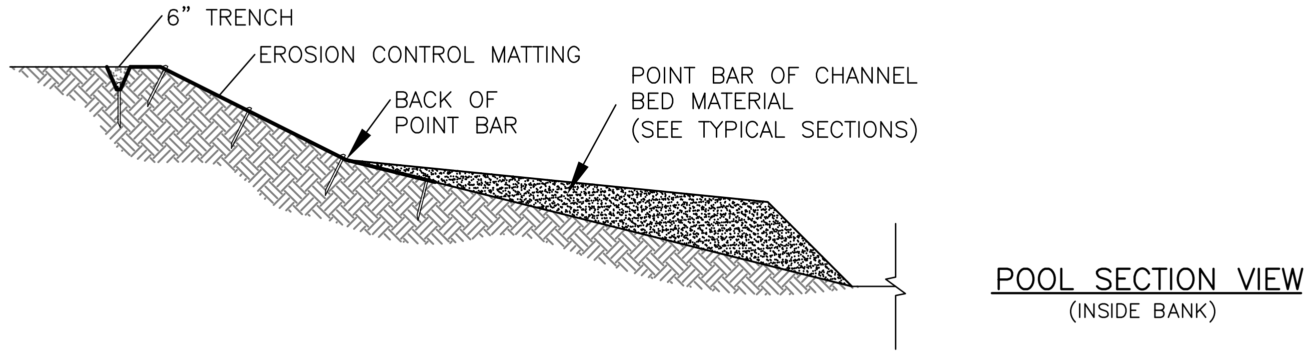
Project No. 111085
Date: 11/06/09
File Name cross-sections.dwg
DESIGNED: JPM
DRAWN: MDR
APPROVED: MMC
Drawing No.



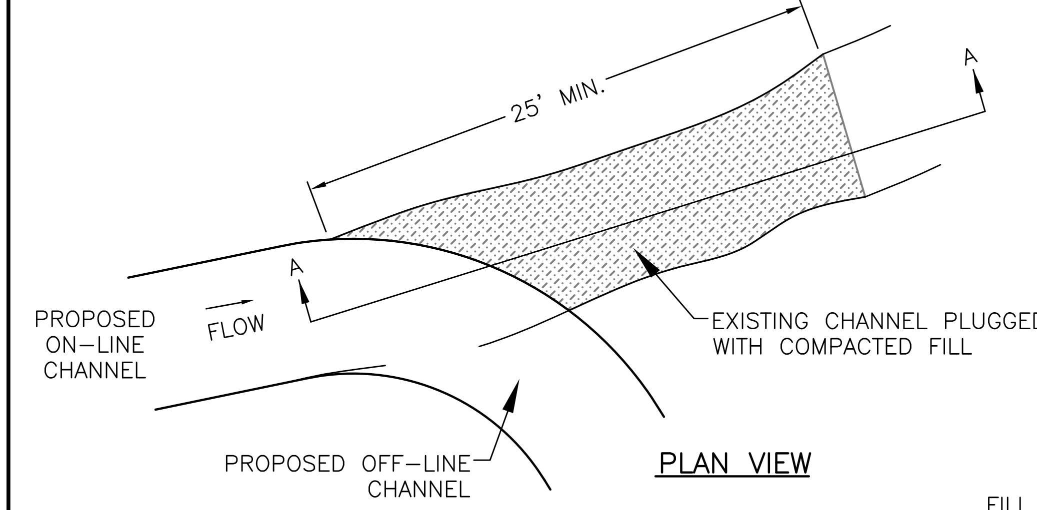
RIFFLE SECTION VIEW



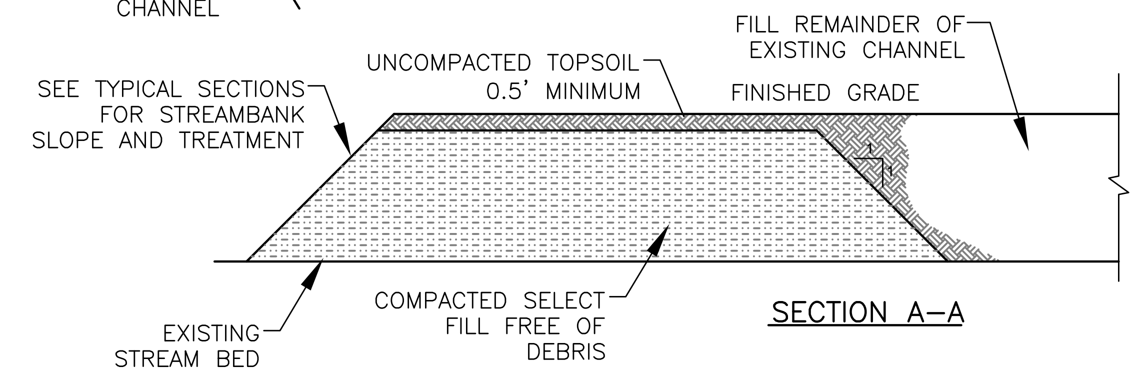
POOL SECTION VIEW
(INSIDE BANK)

NOTES:
1) BANKS SHALL BE SEEDED AND MULCHED PRIOR TO INSTALLATION OF MATTING
2) MATTING SHALL BE PLACED ACCORDING TO MANUFACTURER'S SPECIFICATIONS
3) MATTING SHALL BE STAKED IN DIAMOND PATTERN
4) AT TOP OF BANK, MATTING SHALL BE PLACED IN 6" DEEP TRENCH, STAKED, BACKFILLED, AND COMPACTED

1/18 COIR MATTING
NOT TO SCALE

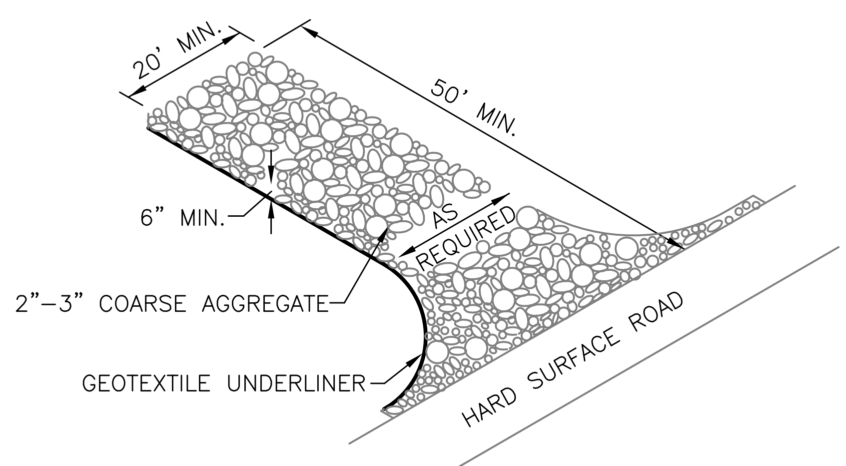


PLAN VIEW



SECTION A–A

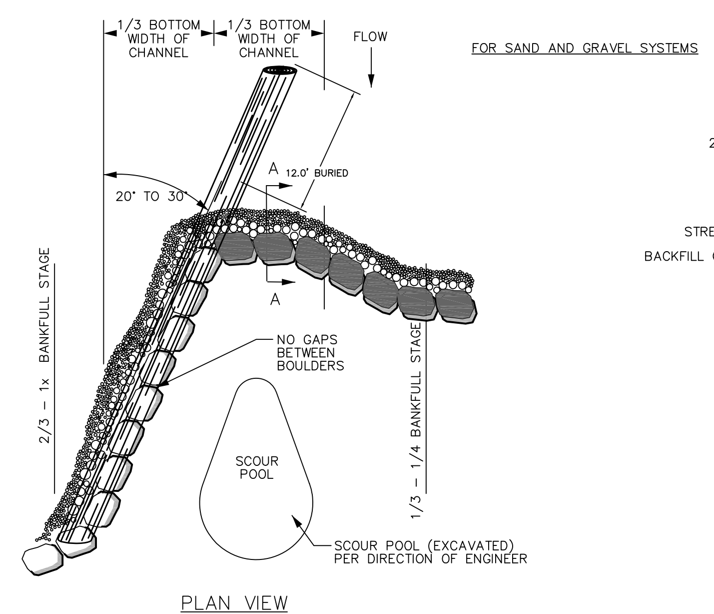
2/18 CHANNEL PLUG
NOT TO SCALE



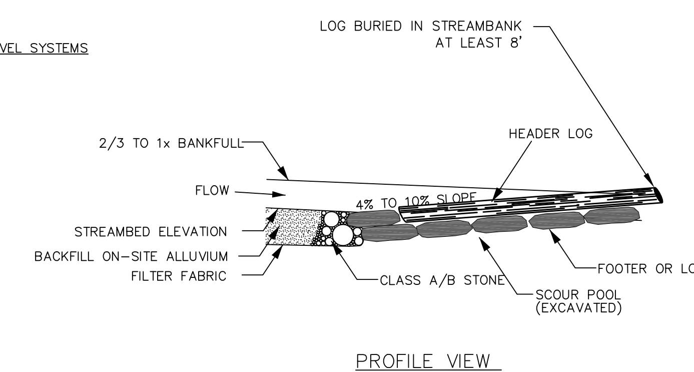
NOTES:
1) EXISTING ENTRANCES ON MILLS GAP AND WESTON ROAD CAN BE USED BUT MUST BE REPAIRED AND MAINTAINED TO MEET STATE STORMWATER STANDARDS.
2) UPON COMPLETION, ENTRANCES WILL BE RETURNED TO PRE-EXISTING CONDITION.
3) MUD TRACKED ONTO STATE ROADS SHALL BE REMOVED IMMEDIATELY.
4) STONE SHALL BE REPLACED IF IT IS FILLED WITH MUD

3/18 CONSTRUCTION ENTRANCE
NOT TO SCALE

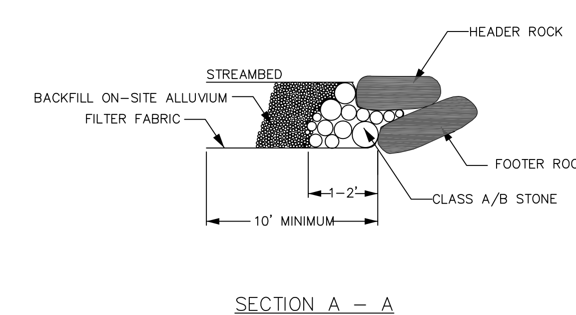
FOR SAND AND GRAVEL SYSTEMS



PLAN VIEW



PROFILE VIEW



SECTION A – A

NOTES FOR ALL VANE STRUCTURES:

1. BOULDERS MUST BE AT LEAST 4' x 3' x 2'.
2. INSTALL FILTER FABRIC FOR DRAINAGE BEGINNING AT THE MIDDLE OF THE HEADER ROCKS AND EXTEND DOWNWARD TO THE DEPTH OF THE BOTTOM FOOTER ROCK, AND THEN UPSTREAM TO A MINIMUM OF TEN FEET.
3. DIG A TRENCH BELOW THE BED FOR FOOTER ROCKS AND PLACE FILL ON UPSTREAM SIDE OF VANE ARMS, BETWEEN THE ARMS AND STREAMBANK.
4. START AT BANK AND PLACE FOOTER ROCKS FIRST AND THEN HEADER (TOP) ROCK.
5. CONTINUE WITH STRUCTURE, FOLLOWING ANGLE AND SLOPE SPECIFICATIONS.
6. AN EXTRA BOULDER CAN BE PLACED IN SCOUR POOL FOR HABITAT IMPROVEMENT.
7. USE CLASS B STONE TO FILL GAPS ON UPSTREAM SIDE OF BOULDERS, AND CLASS A STONE TO FILL GAPS ON UPSTREAM SIDE OF CLASS B STONE.
8. AFTER ALL STONE HAS BEEN PLACED, FILL IN THE UPSTREAM SIDE OF THE STRUCTURE WITH ON-SITE ALLUVIUM TO THE ELEVATION OF THE TOP OF THE HEADER ROCK.

4/18 GRADE CONTROL J-HOOK LOG VANE
NOT TO SCALE

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ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA
DETAILS

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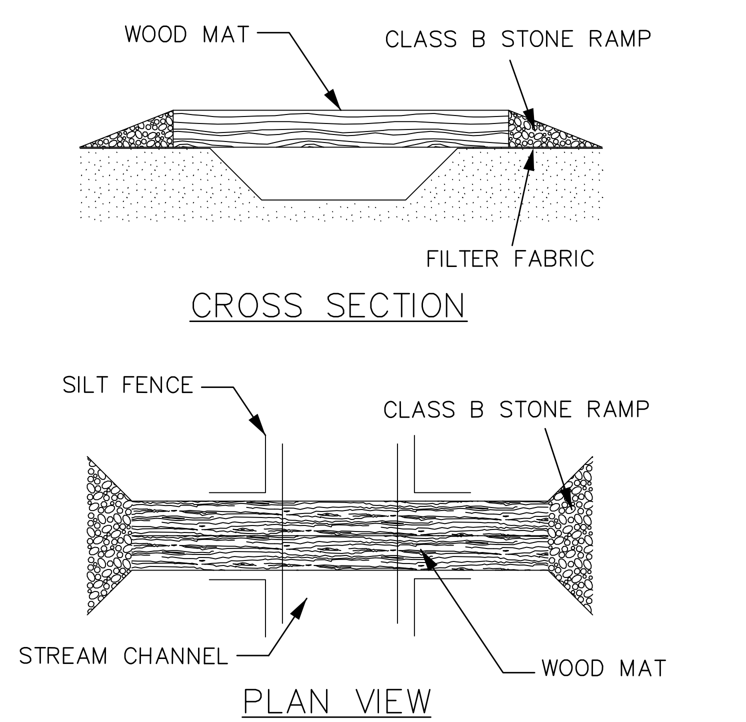
DESIGNED:	JPM
DRAWN:	MDR
APPROVED:	MMC
Drawing No.	18 of 23

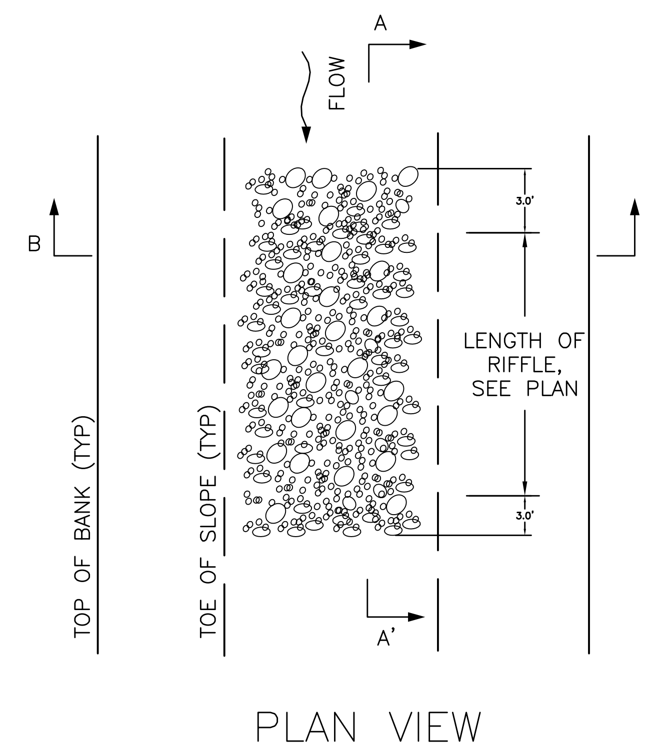


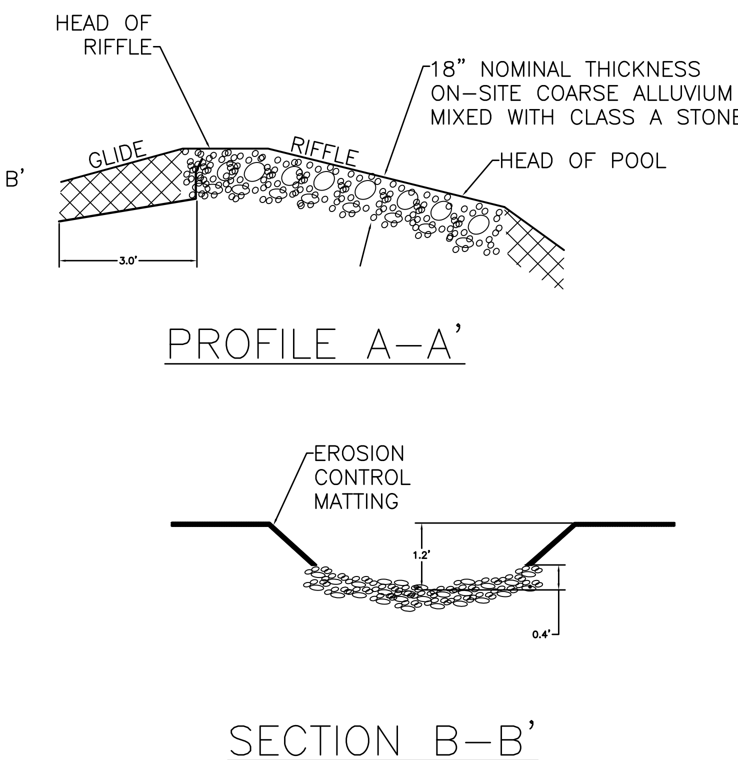
NOTES:

1. CONSTRUCT AT LOW FLOW JUST PRIOR TO BEGINNING WORK.
2. MINIMIZE CLEARING AND EXCAVATION OF STREAMBANKS. DO NOT EXCAVATE CHANNEL BOTTOM
3. LINE STREAMBANK AND ACCESS RAMP AREA WITH NON-WOVEN FILTER FABRIC.
4. CREATE STREAM CROSSING AT RIGHT ANGLE TO THE FLOW
5. PREVENT RUNOFF FROM HAUL ROAD INTO CHANNEL- USE SILT FENCE OR SEDIMENT BARRIER ON ALL FOUR CORNERS AS SHOWN.
6. THE WOOD MAT SHALL BE OF SUFFICIENT SIZE AND WIDTH TO SUPPORT THE LARGEST VEHICLE CROSSING
7. CONTRACTOR TO DETERMINE AN APPROPRIATE RAMP ANGLE ACCORDING TO EQUIPMENT USED (5:1 RECOMMENDED)
8. REMOVE UPON COMPLETION, RESTABILIZE DISTURBED AREA.

1/19 TEMPORARY STREAM CROSSING

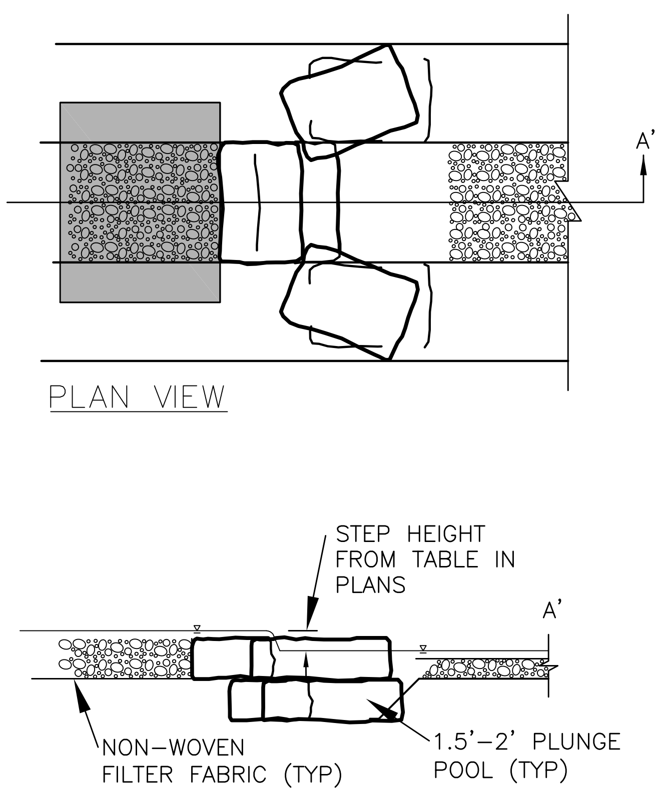
NOT TO SCALE





2/19 CONSTRUCTED RIFFLE/CASCADE

NOT TO SCALE

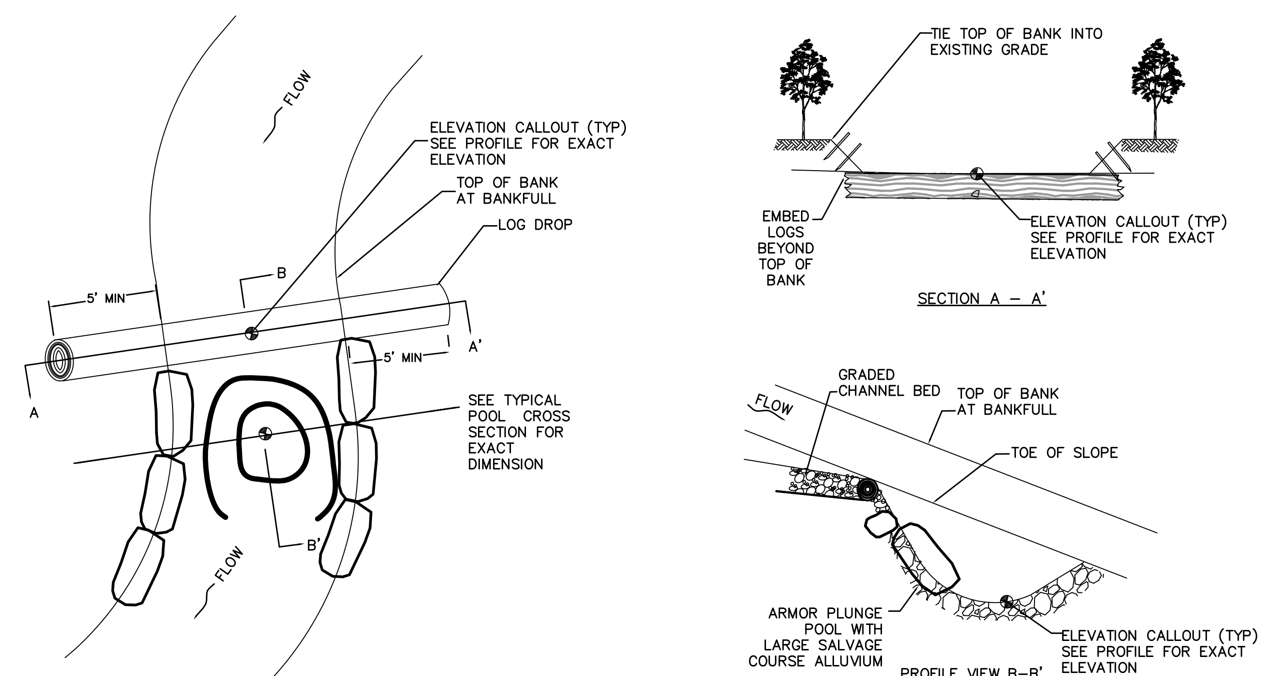


LEGEND:

- APPROXIMATE LEVEL OF BASEFLOW WATER SURFACE
- CHANNEL THALWEG / CONTROL LINE
- CHANNEL BED MATERIAL
- CHANNEL SEDIMENT
- UNDISTURBED IN-SITU SOIL
- NON-WOVEN FILTER FABRIC
- BOULDER: 2'x3'x1'

3/19 BOULDER STEP-POOL SEQUENCE

NOT TO SCALE



NOTES
1. LOGS SHALL BE AT LEAST 10 INCHES IN DIAMETER, RELATIVELY STRAIGHT, HARDWOOD, AND RECENTLY HARVESTED.
2. TOP OF LOG SHALL BE SET AT SAME ELEVATION AS THE STREAMBED.
3. FILTER FABRIC SHALL BE NAILED USING 3" 10d GALVANIZED COMMON NAIL AT TWO-FOOT SPACING ALONG THE LOG.

4/19 LOG STEP

NOT TO SCALE

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ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA
DETAILS

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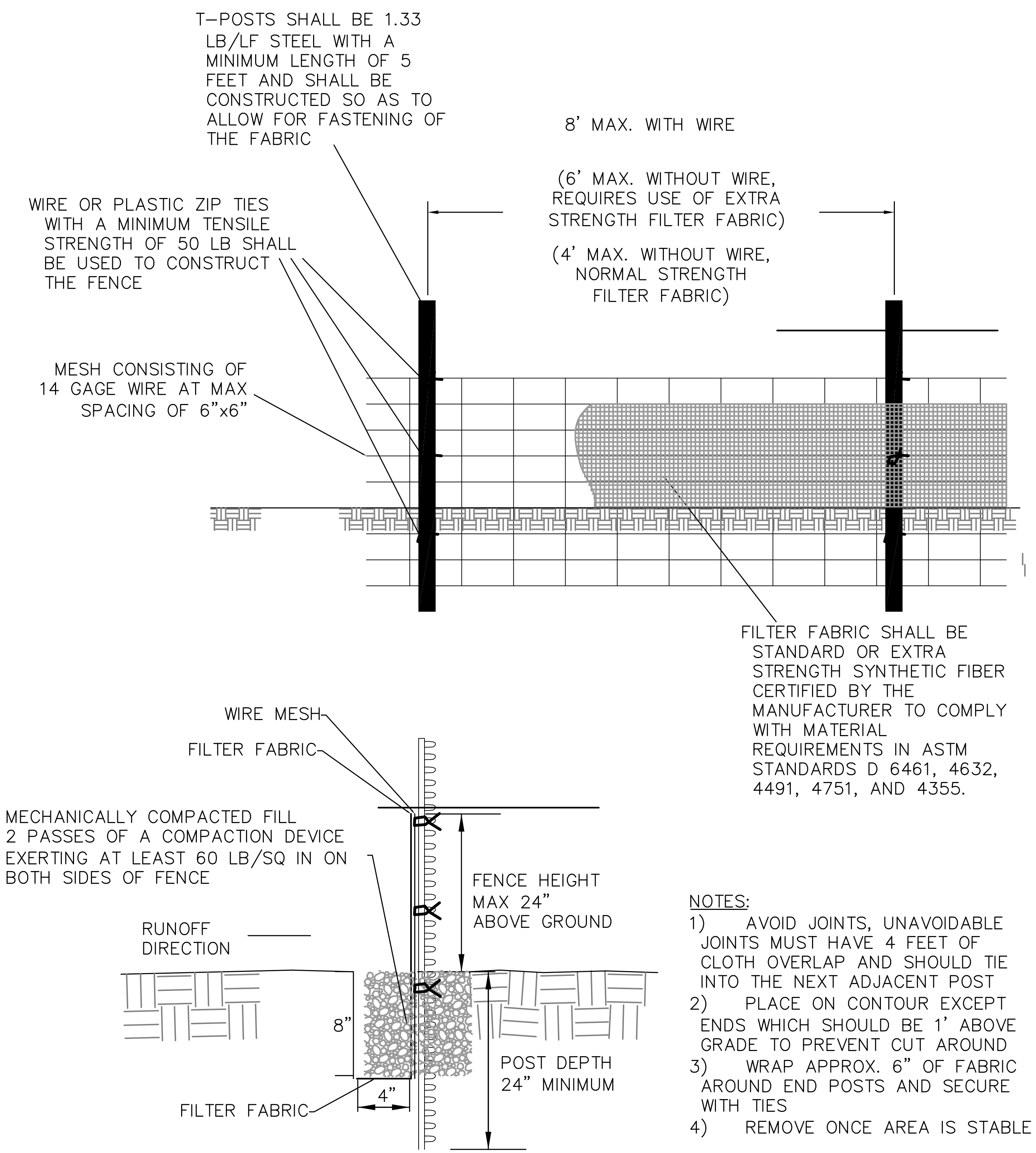
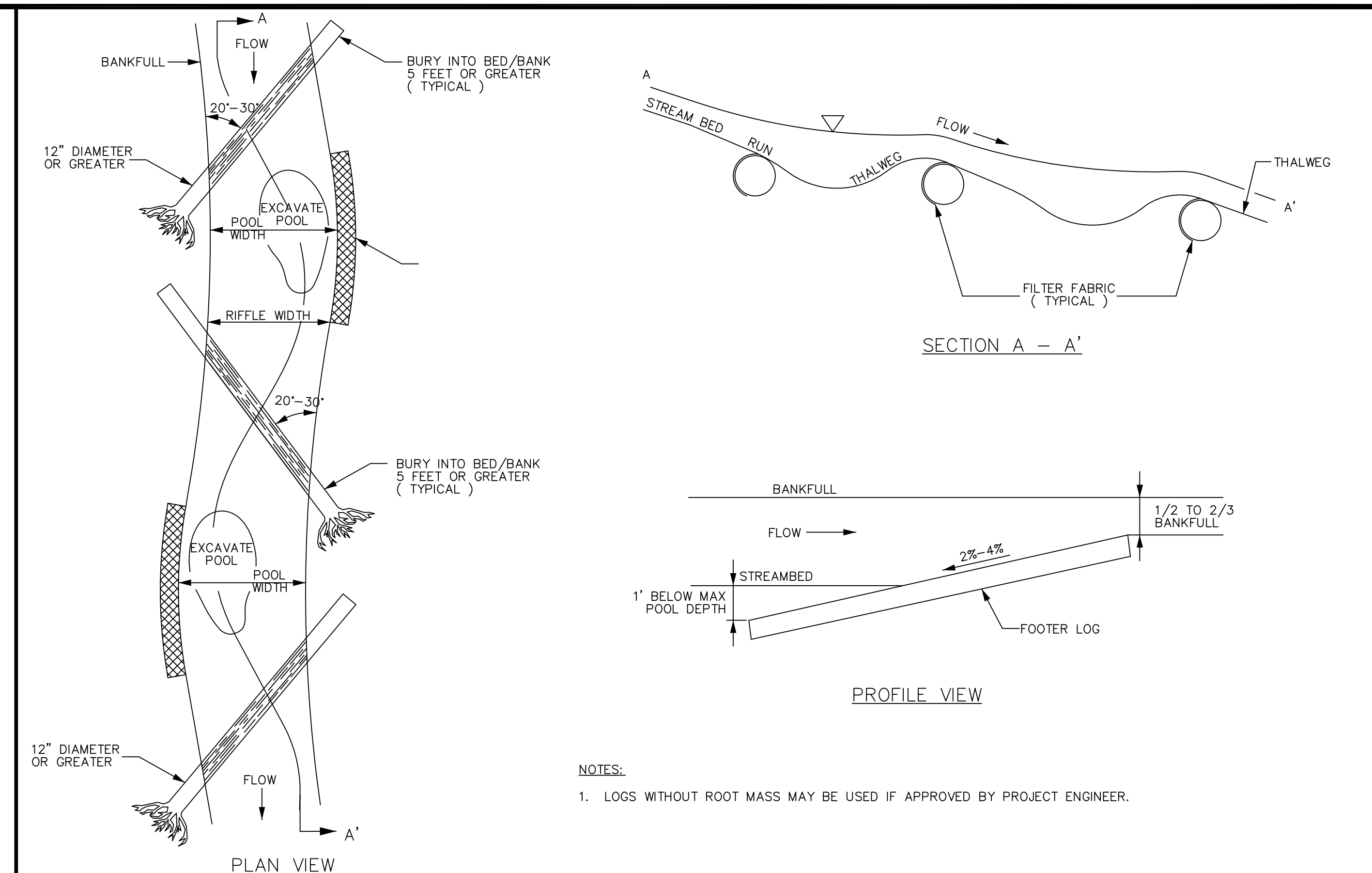


NOTES:

1) AVOID JOINTS, UNAVOIDABLE JOINTS MUST HAVE 4 FEET OF CLOTH OVERLAP AND SHOULD TIE INTO THE NEXT ADJACENT POST
2) PLACE ON CONTOUR EXCEPT ENDS WHICH SHOULD BE 1' ABOVE GRADE TO PREVENT CUT AROUND
3) WRAP APPROX. 6" OF FABRIC AROUND END POSTS AND SECURE WITH TIES
4) REMOVE ONCE AREA IS STABLE

1/20 SILT FENCE
NOT TO SCALE



NOTES:

1. LOGS WITHOUT ROOT MASS MAY BE USED IF APPROVED BY PROJECT ENGINEER.

2/20 LOG / STEP POOL
NOT TO SCALE

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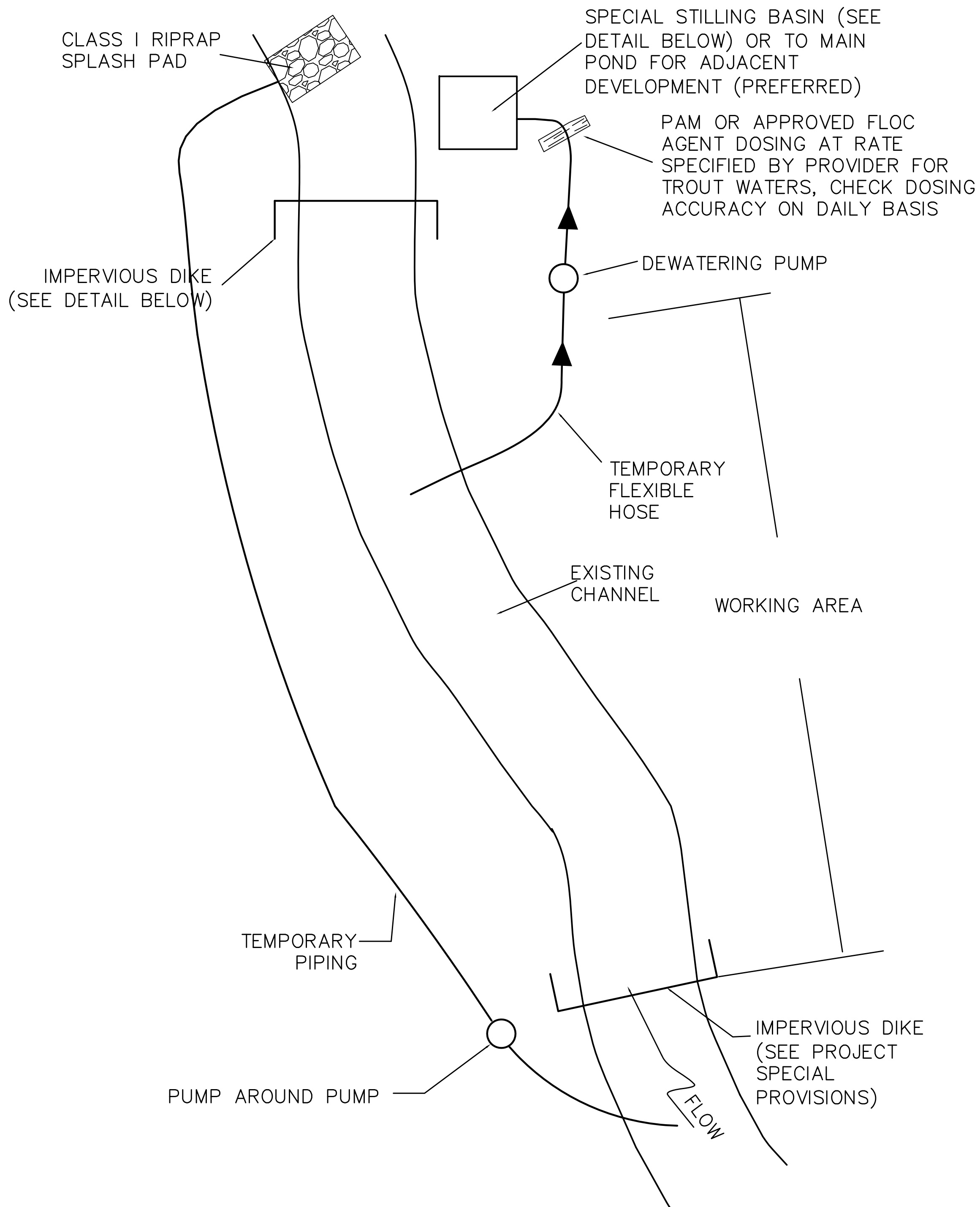
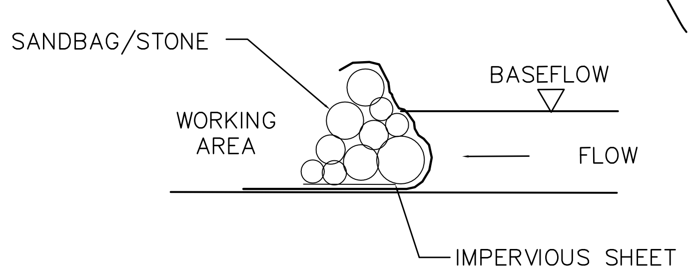




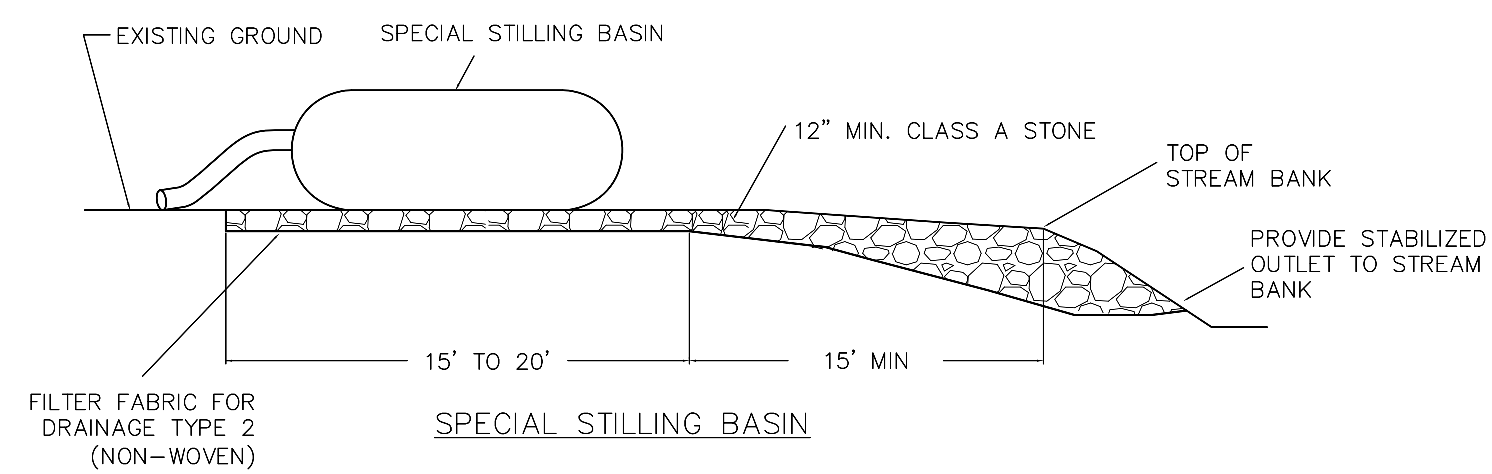
IMPERVIOUS DIKE

SEQUENCE OF CONSTRUCTION FOR TYPICAL PUMP AROUND

1. INSTALL SPECIAL STILLING BASINS AT THE DOWNSTREAM END OF THE DESIGNATED PROJECT WORKING AREA.
2. THE CONTRACTOR WILL INSTALL THE PUMP AROUND AND THE TEMPORARY PIPING THAT WILL CONVEY THE BASE FLOW FROM UPSTREAM OF THE WORK SITE.
3. INSTALL UPSTREAM IMPERVIOUS DIKE AND BEGIN PUMPING OPERATIONS FOR STREAM DIVERSION.
4. INSTALL THE DOWNSTREAM IMPERVIOUS DIKE AND PUMPING APPARATUS IF NEEDED TO DEWATER THE ENTRAPPED AREA. THE PUMP AND HOSE FOR THIS PURPOSE SHALL BE OF SUFFICIENT SIZE TO DEWATER THE WORK AREA. THIS WATER WILL FLOW INTO A SPECIAL STILLING BASIN.
5. THE CONTRACTOR WILL PERFORM STREAM RESTORATION WORK IN ACCORDANCE WITH THE PLAN AND FOLLOWING THE GENERAL CONSTRUCTION SEQUENCE.
6. THE CONTRACTOR WILL EXCAVATE ANY ACCUMULATED SILT AND DEWATER BEFORE REMOVAL OF THE IMPERVIOUS DIKE. REMOVE IMPERVIOUS DIKES, PUMPS, AND TEMPORARY FLEXIBLE HOSE/PIPING STARTING WITH THE DOWNSTREAM DIKE FIRST.
7. ONCE THE WORKING AREA IS COMPLETED, REMOVE THE STILLING BASINS AND STABILIZE DISTURBED AREAS WITH SEED AND MULCH.

NOTES:

1. EXCAVATION SHALL BE PERFORMED IN ONLY DRY SECTIONS OF CHANNEL.
2. IMPERVIOUS DIKES SHOULD BE USED TO ISOLATE WORK AREAS FROM STREAM FLOW.
3. THE CONTRACTOR SHALL NOT DISTURB MORE AREA THAN CAN BE STABILIZED IN ONE WORKING DAY.
4. THE PUMP AROUND PUMP SHOULD ADEQUATELY CONVEY 15 CFS FOR MAINSTEM.
5. THE PUMP AROUND PUMP SHOULD ADEQUATELY CONVEY 5 CFS FOR UNNAMED TRIBUTARY.
6. PROVIDE STABILZED OUTLET TO STREAM BANK.



SPECIAL STILLING BASIN

1
21

PUMP AROUND OPERATION

NOT TO SCALE

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File Name DETAILSREDESIGN.dwg
DESIGNED: JPM
DRAWN: MDR
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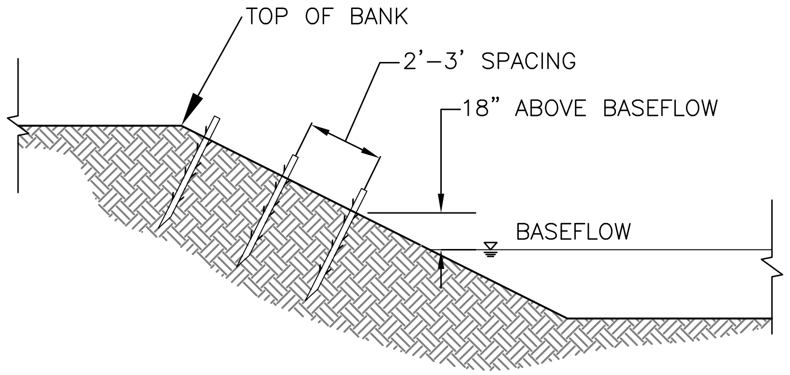
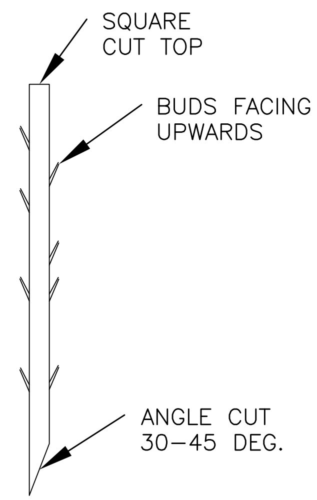
Drawing No. 21 of 23

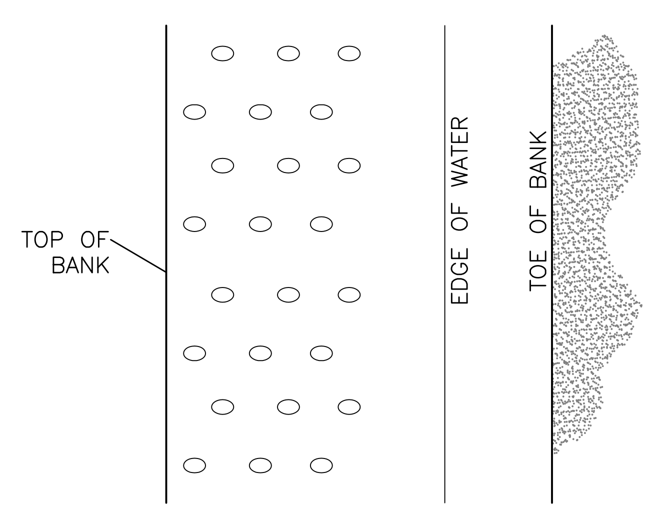
NOTES:
1. STAKES SHALL BE CUT AND INSTALLED ON THE SAME DAY
2. STAKES THAT HAVE BEEN SPLIT SHALL BE REJECTED AND NOT USED FOR CONSTRUCTION
3. STAKES SHALL BE INSTALLED WITH BUDS POINTING UPWARD
4. STAKES SHALL BE INSTALLED PERPENDICULAR TO BANK
5. STAKES SHALL BE 1/2 TO 2 INCHES IN DIAMETER AND 2 TO 3 FT LONG
6. STAKES SHALL BE INSTALLED WITH 1/3 TO 1/5 OF STAKE REMAINING ABOVE GROUND



SECTION VIEW

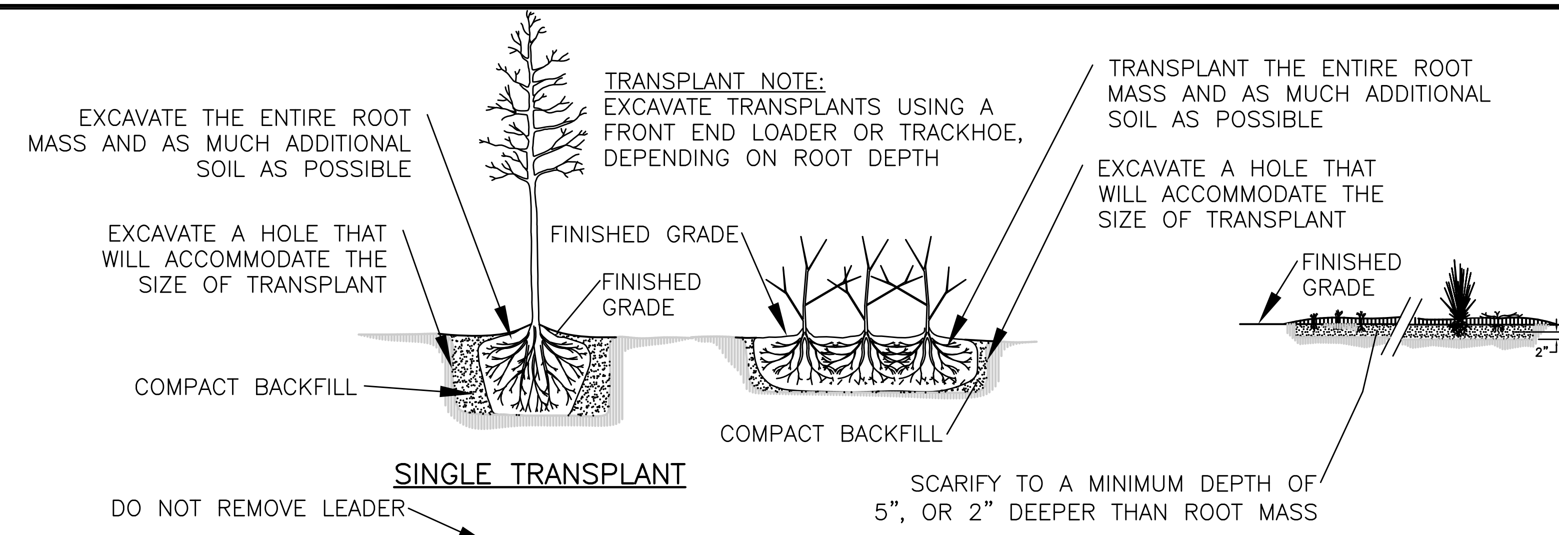


LIVE STAKE DETAIL



PLAN VIEW

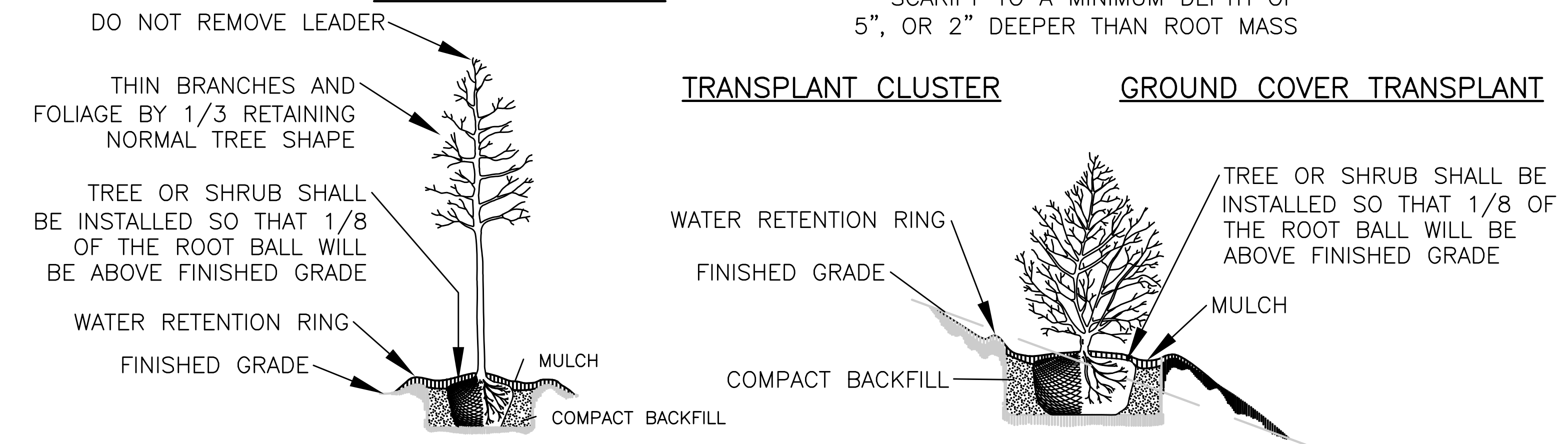
1/22 LIVE STAKING
NOT TO SCALE



SINGLE TRANSPLANT

TRANSPLANT CLUSTER

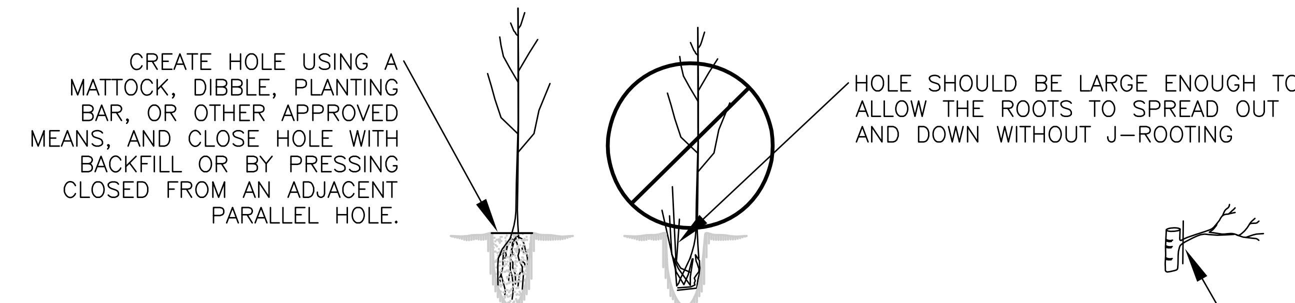
GROUND COVER TRANSPLANT



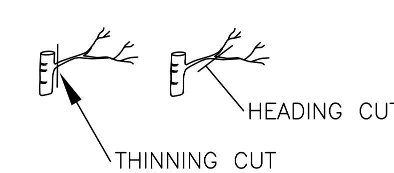
CONTAINERIZED PLANTING
GROUND LEVEL

CONTAINERIZED PLANTING
SLOPING GROUND

CONTAINERIZED PLATING NOTES:
1. WHEN PREPARING THE HOLE FOR A CONTAINERIZED PLANT, EXCAVATE THE HOLE 8 -12 INCHES LARGER THAN THE DIAMETER OF THE POT AND THE SAME DEPTH AS THE POT.
2. REMOVE THE PLANT FROM THE POT. LAY THE PLANT ON ITS SIDE IF NECESSARY TO REMOVE THE POT.
3. IF THE PLANT IS ROOTBOUND (ROOTS GROWING IN A SPIRAL AROUND THE ROOT BALL), MAKE VERTICAL CUTS WITH A KNIFE OR SPADE JUST DEEP ENOUGH TO CUT THE NET OF ROOTS. ALSO MAKE A CRISS-CROSS CUT ACROSS THE BOTTOM OF THE BALL.
4. PLACE THE PLANT IN THE HOLE.
5. FILL HALF OF THE HOLE WITH SOIL (SAME SOIL REMOVED FOR BACKFILL).
6. WATER THE SOIL TO REMOVE AIR POCKETS AND FILL THE REST OF THE HOLE WITH THE REMAINING SOIL.



BARE ROOT TREE PLANTING



PRUNING CUTS

GENERAL NOTES:
1. KEEP ROOTS MOIST WHILE DISTRIBUTING OR WAITING TO PLANT BY MEANS OF WET CANVAS, BURLAP, OR STRAW.
2. HEEL-IN PLANTS IN MOIST SOIL OR SAWDUST IF NOT PROMPTLY PLANTED UPON ARRIVAL TO PROJECT SITE.
3. PRUNE ANY BROKEN LIMBS AND TREAT TORN BARK WITH TREE WOUND DRESSING.
4. EVERY EFFORT SHOULD BE MADE TO KEEP SOIL EXCAVATED FOR PLANTING FROM ENTERING STREAM. ACCIDENTAL FILL SHOULD BE REMOVED IMMEDIATELY

2/22 TREE AND SHRUB PLANTING
NOT TO SCALE

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ELK BRANCH RESTORATION PROJECT
NORTH CAROLINA
DETAILS

Prepared for:
Ecosystem Enhancement Program
2728 Capitol Blvd., Suite 1H 103
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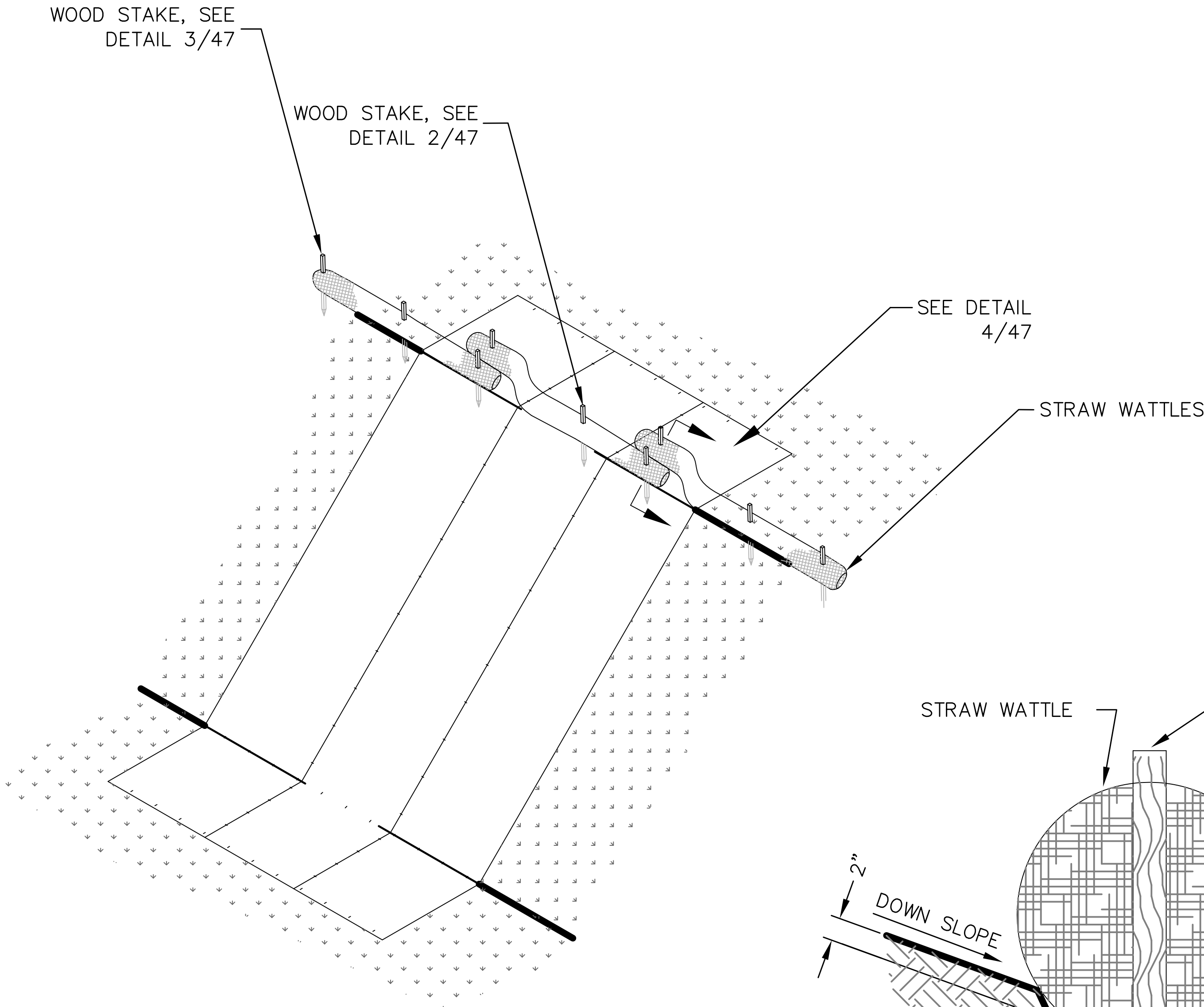
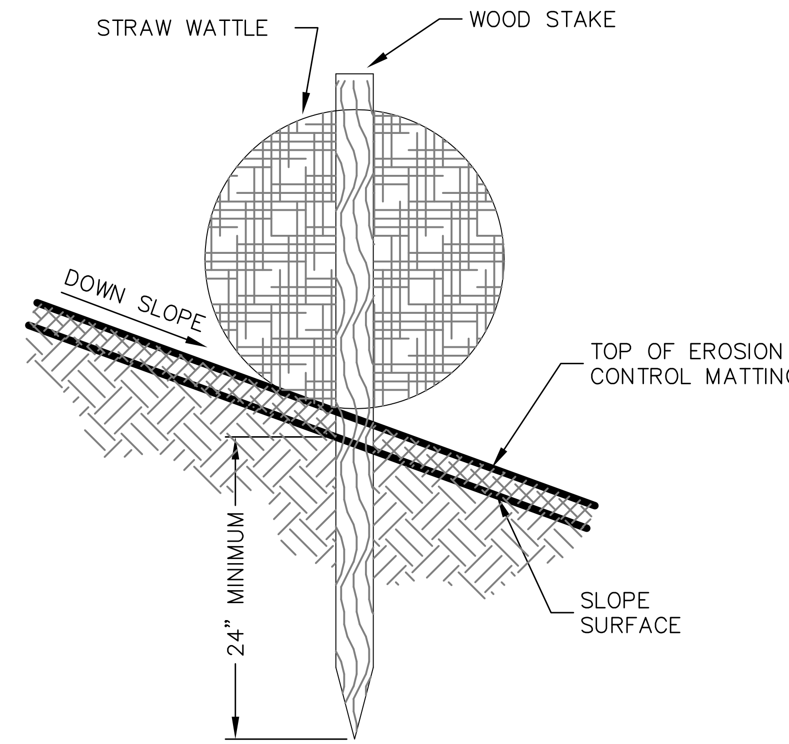
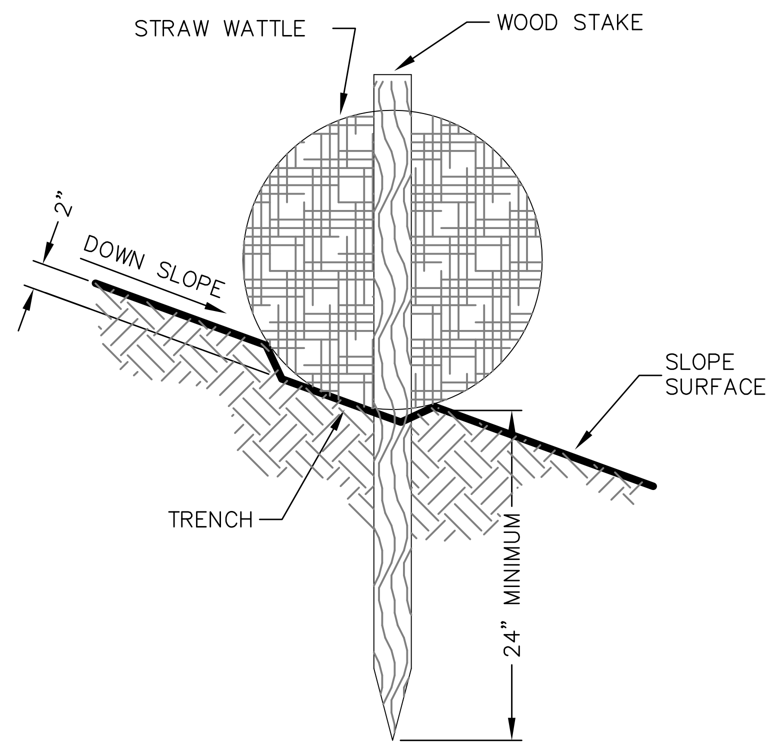
Project No. 111085
Date: 11/06/09
File Name DETAILSREDESIGN.dwg
DESIGNED: JPM
DRAWN: MDR
APPROVED: MMC
Drawing No. 22 of 23



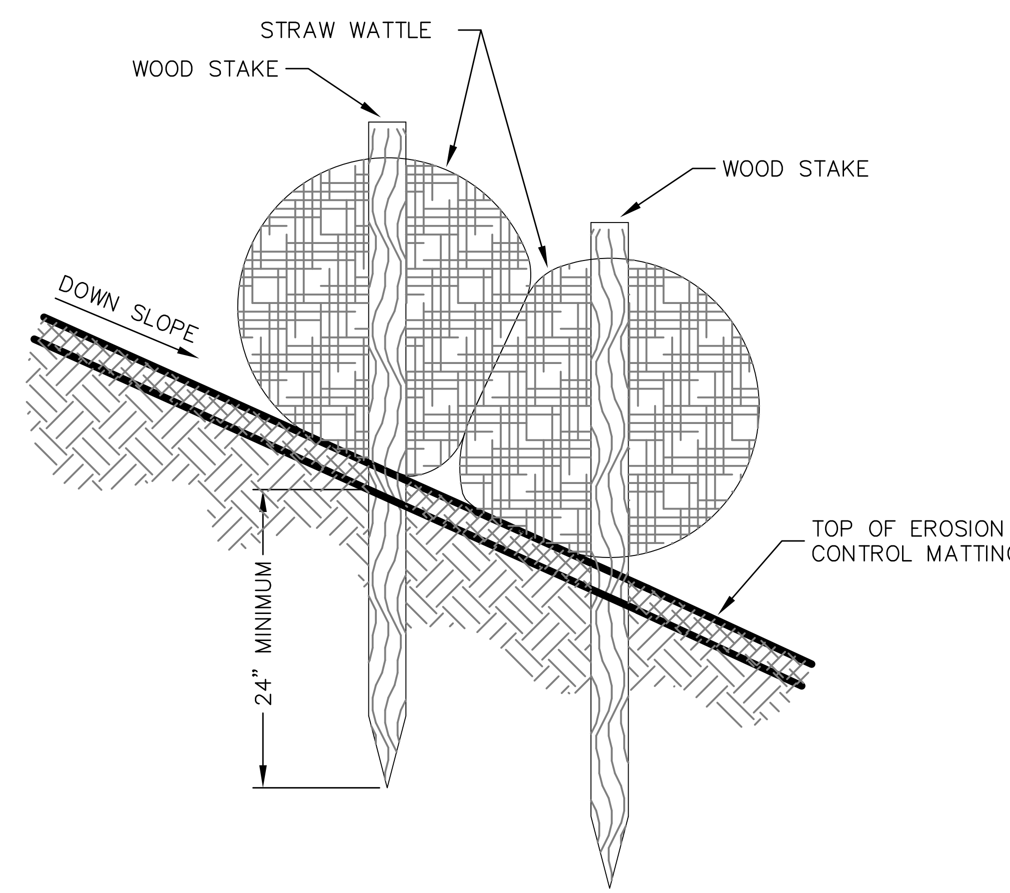
1/23 STRAW WATTLE
NOT TO SCALE



2/23 STAKE DETAIL ON EROSION CONTROL MATTING
NOT TO SCALE



3/23 STAKE DETAIL ON BARE SOIL
NOT TO SCALE



4/23 STAKE DETAIL SECTION VIEW
NOT TO SCALE

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