STREAM RESTORATION PLAN

Beaver Creek
Surry County, North Carolina

N.C. Wetlands Restoration Program
_____________________NCDENR_DWQ

December 2001

EARTH TECH

A tyco INTERNATIONAL LTD. COMPANY

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1.0 INTRODUCTION

The North Carolina Wetlands Restoration Program (NCWRP) has identified Beaver Creek as a potential stream restoration site. A tributary to the Fisher River, Beaver Creek (NCDWQ Stream Index Number – 12-63-12) is located on agricultural land southeast of the town of Dobson in Surry County, North Carolina (Figure 1).

The Surry County Soil and Water Conservation District (SCSWCD) staff first identified Beaver Creek as a potential restoration site after landowners complained about active erosion and flooding adjacent to the stream. The stream was actively eroding along a tight meander located within property owned by Mr. Mike Jones. The meander eroded to the point where the radius was so tight that water was overtopping the bank and flooding the adjacent landowners (Mr. Wayne Draughn) field during storm events. Mr. Draughn is using the land adjacent to the meander as a garden. Mr. Jones attempted to stop the erosion by placing logs and other cuttings along the outside meander of the eroding bank. Mr. Draughn complained that this increased the flooding to his property. An on-site assessment determined that the small radius of curvature of the meander was likely the cause of the increased flooding. The placement of the logs more then likely did not significantly increase flooding frequency or magnitude.

Beyond the above stated problem area, Beaver Creek has other areas of significant active bank erosion throughout the proposed project limits. There is evidence of historic straightening and degradation resulting from this straightening. Thinning and removal of riparian vegetation has also accelerated the degradation process. The incised condition of the existing channel is accelerating the erosion process by forcing the channel to contain larger then bankfull storm events. One of the three tributaries within the project limits has also been straightened. The restoration site is located entirely within undeveloped land consisting of agricultural land predominantly being used for hay production, woodland, and sparse crop production. There are no utilities within the project limits. All of these characteristics combine to make Beaver Creek an excellent potential restoration site.

Restoration requires determining how far the stream has departed from its natural stability and then, establishing the stable form of the stream under the current hydrologic conditions within the drainage area. The proposed restoration will construct a stable meander geometry, modify channel cross-sections, raise the existing streambed elevation where possible, and establish a floodplain at the new stream elevation, thus, restoring a stable dimension, pattern and profile. This restoration is based on analysis of current watershed hydrologic conditions, evaluation of the project site, and assessments of stable reference reaches. The following recommendations are included in this restoration plan:

- Form a stable channel with the proper dimension, pattern and profile.
- Raise the existing streambed elevation where possible.
- Establish a floodplain along the stream channel.

- Place natural material structures in the stream to improve stability and enhance aquatic habitat.
- Stabilize stream banks with herbaceous and woody vegetation

1.1 PROJECT DESCRIPTION

Beaver Creek project site is located southeast of Dobson in Surry County, North Carolina. The project is fully contained within the property of five landowners. The project reach is bound by a stable bedrock section of channel to the east (upstream) and the Fisher River to the west (downstream) (Figure 2). Adjacent hill slopes to the north and south approach the stream bank in several areas along the project limits. An access road parallels the stream throughout the project. The access road varies in distance from the 10 to 400 feet away from the existing channel.

1.2 GOALS AND OBJECTIVES

This project has the following goals and objectives:

1. Restore 4620 linear feet of Beaver Creek (as measured along the thalweg) and 380 linear feet of an unnamed tributary to Beaver Creek.
2. Provide a stable stream channel that neither aggrades nor degrades while maintaining its dimension, pattern, and profile with the capacity to transport its watershed's water and sediment load.
3. Improve water quality and reduce further property loss by stabilizing eroding stream banks.
4. Reconnect the stream to its floodplain or establish a new floodplain at a lower elevation.
5. Improve aquatic habitat with the use of natural material stabilization structures such as root wads, rock vanes, woody debris and a riparian buffer.
6. Provide aesthetic value, wildlife habitat and bank stability through the creation or enhancement of a riparian zone.

1.3 STREAM SURVEY METHODOLOGY

The US Forest Service General Technical Report RM-245, Stream Channel Reference Sites: An Illustrated Guide to Field Technique is used as a guide when taking field measurements. Accurate field measurements are critical to determine the present condition of the existing channel, conditions of the floodplain, and watershed drainage patterns.

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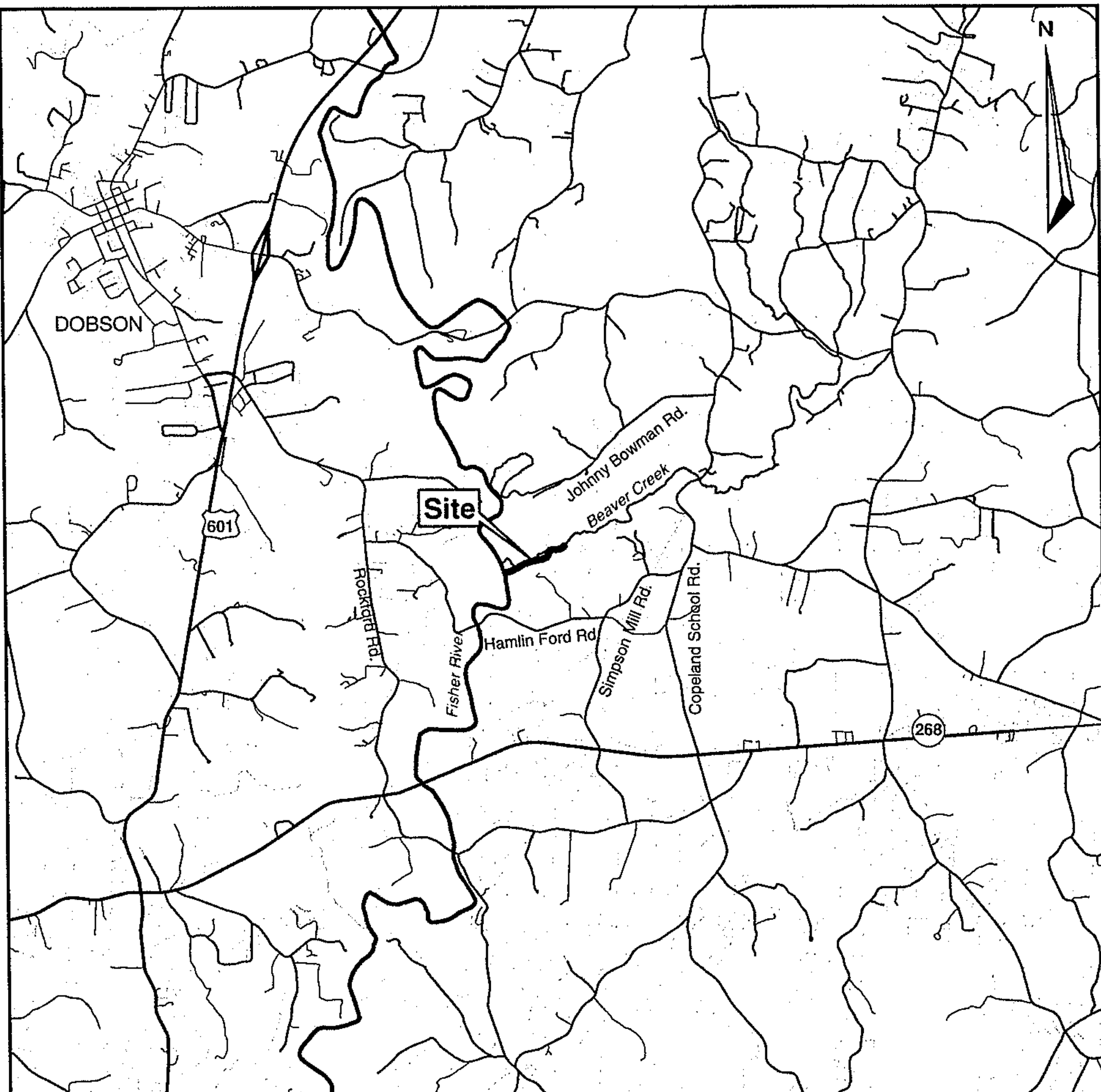

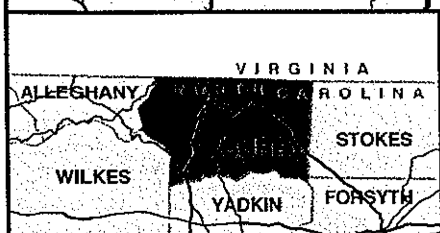

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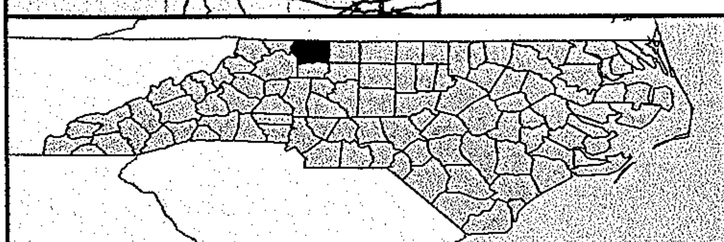

FIGURE 1
Location Map

Beaver Creek Restoration Plan
Surry County, North Carolina

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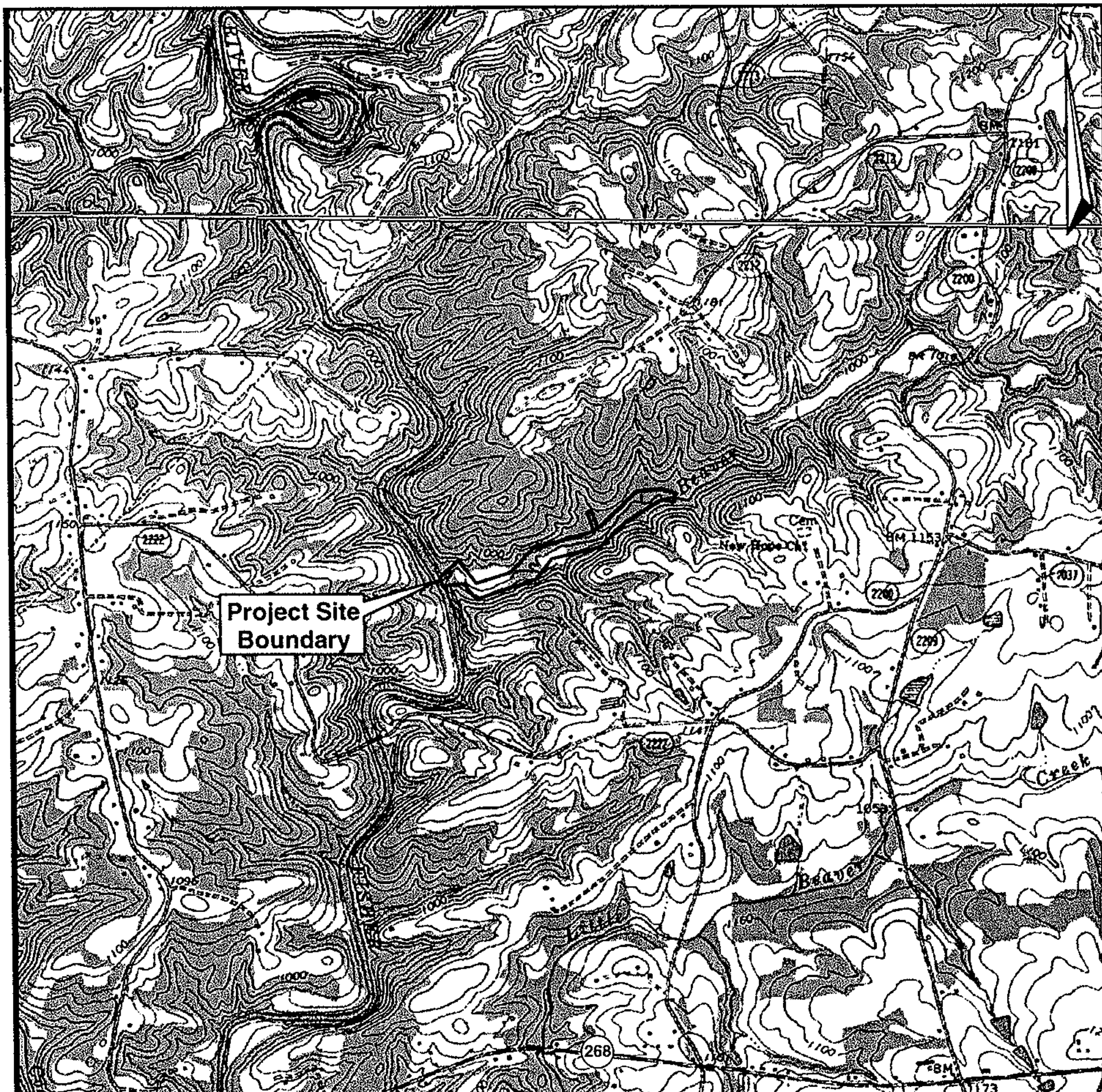

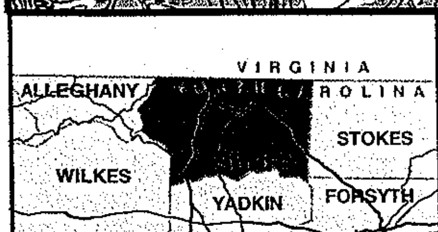

Source: USGS Quadrangles:
Dobson, NC, 1971, Revised 1994;
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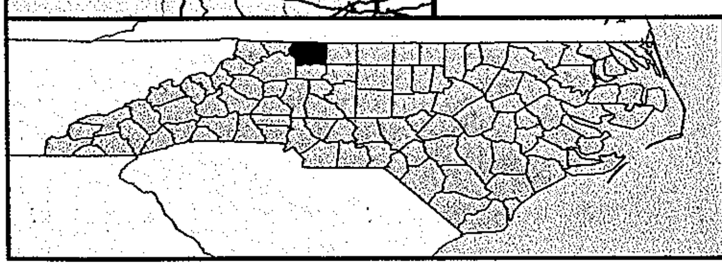

FIGURE 2
Vicinity Map

Beaver Creek Restoration Plan
Surry County, North Carolina

Earth Tech contracted surveyors with The Rose Group to conduct a topographic survey of the restoration site in September 2001. This mapping was used to evaluate present conditions, new channel alignment and grading volumes. Mapping also provided locations of property pins, large trees, vegetation lines, culverts, roads, and elevation contours.

A walkover of the property was conducted to better evaluate the drainage properties of the area surrounding the restoration site. SCSWCD provided Geographic Information System (GIS) data to evaluate the watershed. A windshield survey was also conducted to determine the existing conditions within the watershed.

During the site visits, eight cross-sections were taken using standard differential leveling techniques. These cross-sections were used to gather detail on the present dimension and condition of the channel. Cross-sectional area was calculated using the bankfull features. See Appendix B for a copy of the existing condition surveys.

1.3.1 Stream Delineation Criteria - Classification

Dave Rosgen developed his stream classification system in order to accomplish the following:

1) Predict a river's behavior
2) Develop specific hydraulic and sediment relationships for a given stream type and its state
3) Provide a mechanism to extrapolate site-specific data to stream reaches having similar characteristics
4) Provide a consistent frame of reference for communicating stream morphology and condition among a variety of disciplines and interested parties

The Rosgen Stream Classification System is based on five criteria: width/depth ratio, entrenchment ratio, slope, sinuosity, and channel materials. All cross-sections were classified using this system.

1.3.2 Bankfull Verification

The foundation of Dave Rosgen's classification system is the concept of bankfull stage, which is the point of incipient flooding. The width/depth and entrenchment ratios described above depend on the correct assessment of bankfull. If bankfull is incorrectly determined in the field, the entire restoration effort will be based on faulty data. It is important to verify the physical indicators observed in the field with either gage data or a regional curve to ensure the correct assessment of the bankfull stage.

The bankfull stage is determined in the field using physical indicators. The following is a list of commonly used indicators that define bankfull (Rosgen, 1996):

- The presence of a floodplain at the elevation of incipient flooding.
- The elevation associated with the top of the highest depositional feature (*e.g.* point bars, central bars within the active channel). These depositional features are especially good stage indicators for channels in the presence of terrace or adjacent colluvial slopes.
- A break in slope of the bank and/or a change in the particle size distribution, since finer material is associated with deposition by overflow, rather than deposition of coarser material within the active channel.
- Evidence of an inundation feature such as small benches below bankfull.
- Staining of rocks.

The most dominant bankfull indicators along Beaver Creek are high scour lines and breaks in slope along the backs of point bars.

The most common method of verifying bankfull stage is to compare the field determined bankfull stage with measured stages at a stream gaging station. This calibration can be performed if there is a stream gage within the study area's hydrophysiographic region.

In ungaged areas, Dave Rosgen recommends verifying bankfull with the development of regional curves. The regional curves normally plot bankfull discharge (Q_{bkf}), cross-sectional area, width, and depth as a function of drainage area. The cross-sectional areas of Beaver Creek and the reference reach sites used for this report are plotted on the Rural and Urban, Piedmont Regional Curve of North Carolina developed by the North Carolina State University (NCSU) Water Quality Group, 2000 (Figure 3).

Data obtained from field surveys described in Section 2.2.2 was used to compute the morphological characteristics shown on the graph. The cross-sectional area for Beaver Creek plots along the trend line for the Rural Regional Curve. The bankfull cross-sectional area for the design channel was determined from evaluating the North Carolina regional curve relationships and comparing them to the reference reach sites surveyed near the restoration site. HEC-RAS will be used to verify the design cross-sectional area for the project.

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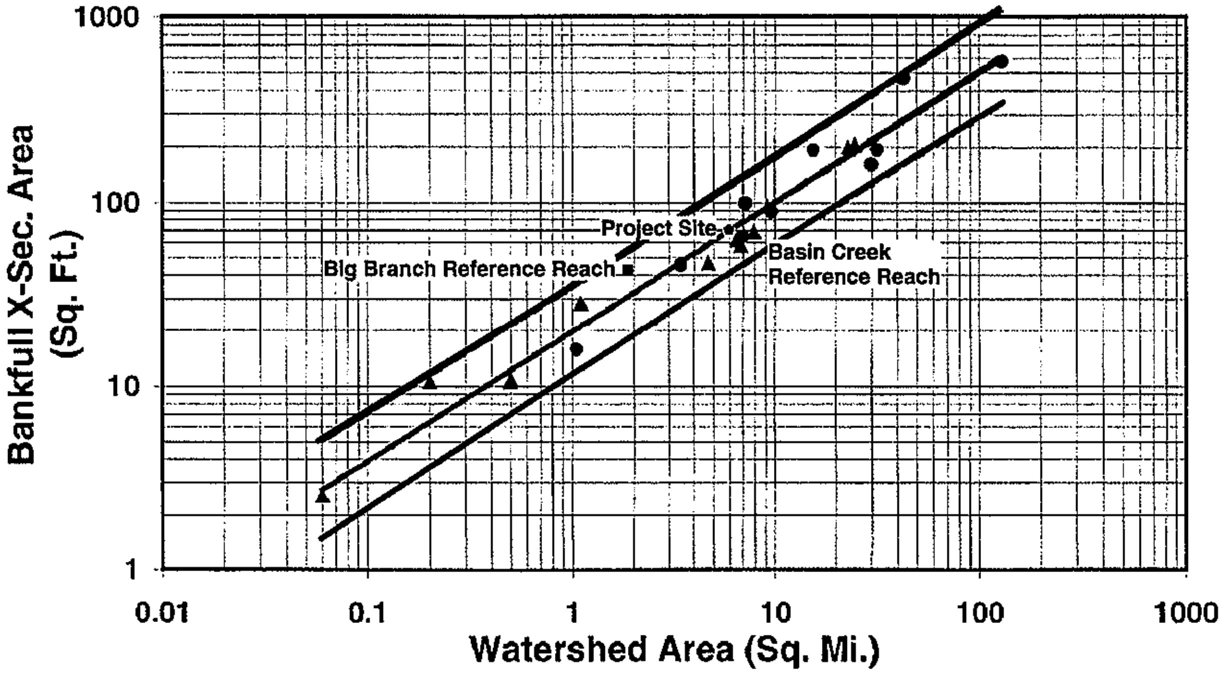

$A_{bkf} = 18.21\ A_w^{0.75}$; ($R^2 = 0.98$)
A_w = watershed drainage area (mi^2)
A_{bkf} = bankfull cross sectional area (ft^2)

- ▲ Reference Reaches
- ● Gage Stations
- ■ Reference Reaches
- ⭑ Project Site
- Upper 95%
- Predicted
- Lower 95%

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FIGURE 3
North Carolina Regional Curve

Beaver Creek Restoration Plan
Surry County, North Carolina

2.0 EXISTING CONDITIONS

2.1 WATERSHED

2.1.1 General Description of the Watershed

Beaver Creek, a second order stream, is located within the Piedmont Physiographic Province of the Yadkin-Pee Dee River Basin (USGS Cataloging Unit 03040101). The watershed is located to the southeast of Dobson, in Surry County, North Carolina. The headwaters of the project originate approximately 4 miles to the north-northeast of the restoration site. From the headwaters, Beaver Creek flows for approximately 5.5 miles before joining with the Fisher River. Several tributaries enter Beaver Creek along its extent.

The watershed is approximately 5.9 square miles (3,760 Acres)(Figure 4). The watershed is oriented north to south bending to the west before the project site. The watershed has a relatively constant width of approximately 5,500 ft from the headwaters to its outlet. The topography ranges from gently sloping to steep with relatively flat floodplains occurring along the larger drainages. Land surface elevations range from approximately 940 to 1,420 feet above mean sea level.

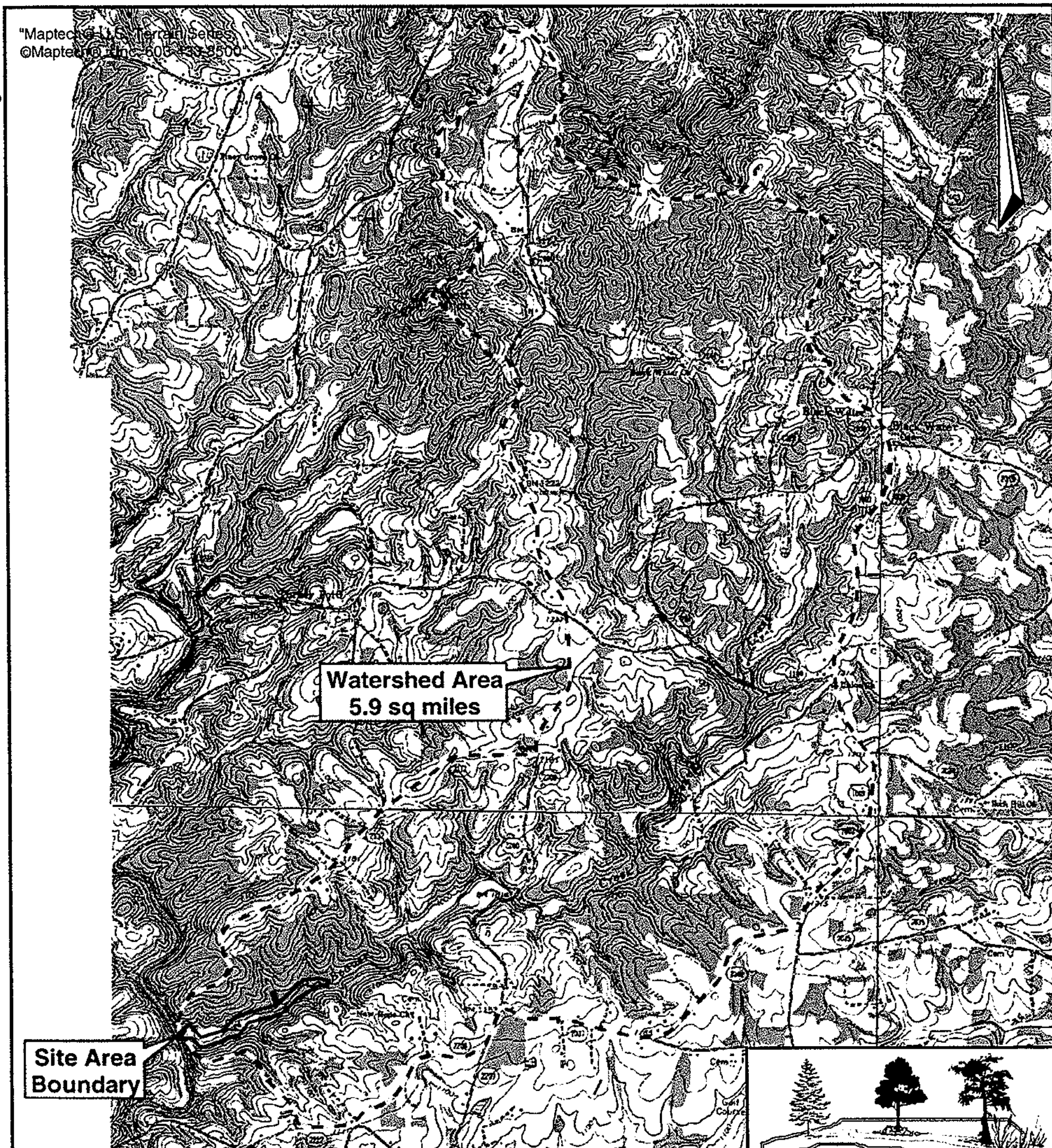
2.1.2 Surface Waters Classification

Surface waters in North Carolina are assigned a classification by the DWQ that is designed to maintain, protect, and enhance water quality within the state. Beaver Creek (NCDWQ Stream Index Number – 12-63-12) is classified as a class *C* water body (NCDENR, 2001). *Class C* water resources are waters protected for aquatic life propagation and survival, fishing, wildlife, secondary recreation, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. There are no restrictions on watershed development activities.

2.1.3 Soils of the Watershed

The soils found in the watershed and adjacent to the stream can help determine the bed and bank materials occurring in the stream. The Rosgen stream classification system uses average particle size within the bankfull channel to help classify the stream. Knowing the make up of the soils in the watershed, assists in understanding the anticipated bedload and sediment transport capacity of the stream.

Soils in upland areas within the watershed consist primarily of Fairview sandy clay loam, Clifford sandy loam, and Braddock fine sandy loam, (draft maps and descriptions of the soils in the project area – Surry County Soil Survey Office, Natural Resources Conservation Service [NRCS]). Depth to bedrock is mapped as greater than 60 inches for most soils in the watershed. A few steep areas mapped as Fairview-Stott Knob



Source: USGS Quadrangles:
Dobson, NC, 1971, Revised 1994;
Copeland, NC, 1970, Revised 1994.

0 1,500 3,000 6,000
Feet

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FIGURE 4
Beaver Creek Watershed

Beaver Creek Restoration Plan
Surry County, North Carolina

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complex may have a depth to bedrock of less than 40 inches. The upland soils have clayey sub-soils with rock fragments ranging from gravel to cobble up to larger flagstone size.

Fairview sandy clay loam occurs on the side slopes, shoulders and summits of ridges. These very deep soils are well drained, have medium to very rapid runoff, and moderate permeability. They have formed in residuum from felsic crystalline rock. The depth to the water table is greater than 6 feet. Within the watershed, Fairview soils also occur in the steep Fairview-Stott Knob complex. The Fairview-Stott Knob complex has 25 to 45 percent slopes. These soils are not separated into individual mapping units because of difficulty in distinguishing them at this mapping scale and similarity in management. Both the Fairview and Stott Knob soils are most likely in the hydrologic soil group C.

Clifford sandy loam occurs on the summits, shoulders, and sides of ridges. These soils are well drained, have medium to very rapid runoff, and a moderate permeability. The depth to the water table is 6 feet or greater. They have clayey sub-soils and have formed in residuum weathered from felsic crystalline rocks. Clifford soils are in the hydrologic soil group C.

Braddock fine sandy loam typically occurs on the footslopes of ridges and colluvial fans, and adjacent high terraces. These soils are very deep, well drained, and have slow to moderately permeability in the subsoil. The underlying substratum has moderate to moderately rapid permeability. Runoff ranges from low to moderate on nearly level slopes to very high on steep slopes. They have formed in colluvium and alluvium from a mixture of crystalline rocks. The Braddock soils are in hydrologic soil group B.

2.1.4 Land Use of the Watershed

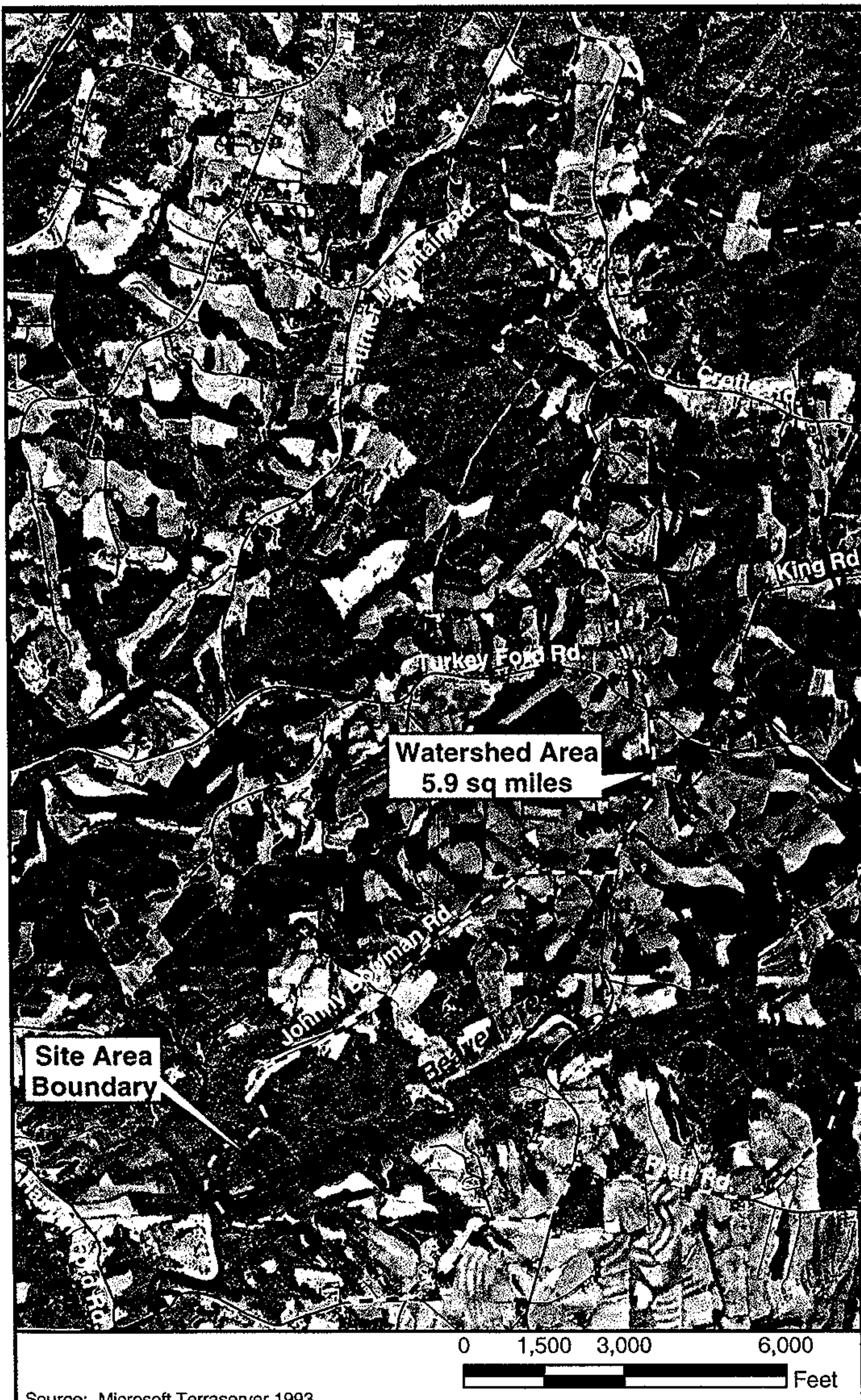
Land use within the watershed is predominately forest or agricultural (Figure 5). Evaluation of a 1993 aerial obtained from the Microsoft Terraserver reveals that approximately 45% of the watershed is forested and 50% is agriculture. The remaining 5% is low density residential.

2.2 RESTORATION SITE

The following sections provide a description of existing site conditions. This includes the current stream conditions, soils, and surrounding plant communities.

2.2.1 Site Description

The Beaver Creek restoration site begins approximately 4,620 feet (as measured from the thalweg) from its confluence with the Fisher River. The project is located within the property boundaries of 5 different landowners (Figure 6). Beaver Creek flows from east



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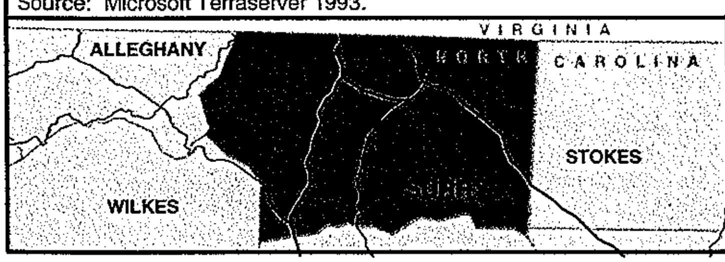

FIGURE 5
Watershed Aerial

Beaver Creek Restoration Plan
Surry County, North Carolina

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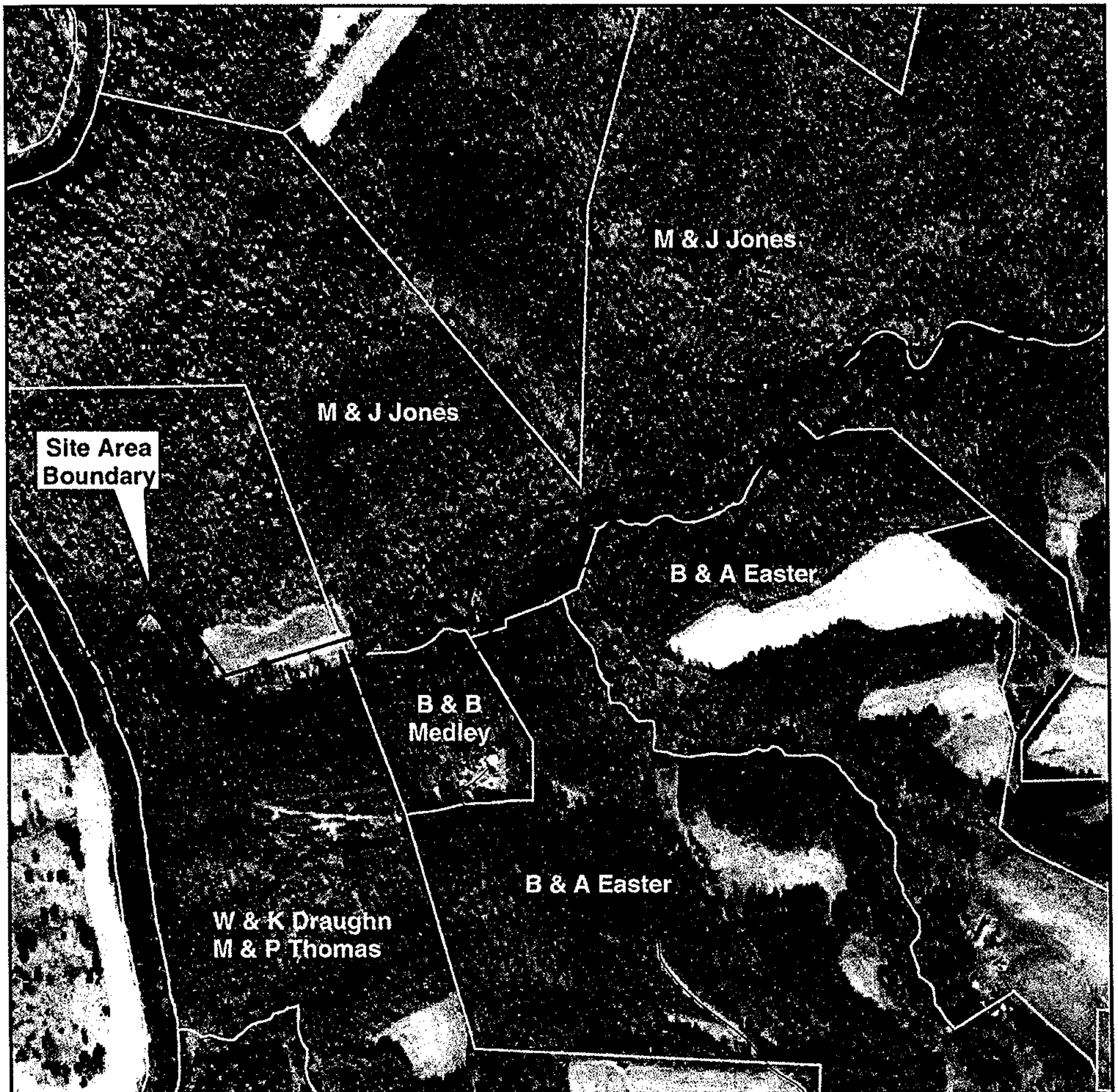

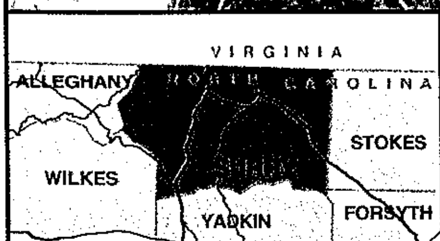

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Source: Microsoft Terraserver 1993.

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NCDENR DWQ

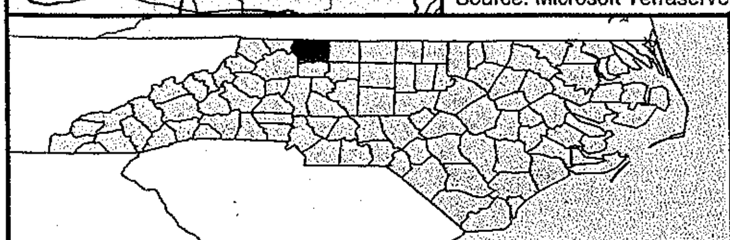

FIGURE 6
Parcels

Beaver Creek Restoration Plan
Surry County, North Carolina

to west through a 200 to 400-foot wide floodplain. The majority of the floodplain is located on the north side of the stream and consists of pasture, clear-cut, and vegetable garden areas. The floodplain to the streams left (south) is wooded. The floodplain typically ends abruptly at the toe of the adjoining steep slopes. A segment of the stream runs along a shear rock face of the hill slope for 150 to 200 feet. The majority of the channel has long straight reaches with small areas of concentrated meanders. Channel sinuosity for the entire reach is 1.35, but the majority of the pattern is located within three tight meanders bends. Sinuosity of the meander bends range from 1.6 to 2.5. High banks and areas of severe bank erosion can be found throughout the project reach.

Three small streams enter Beaver Creek within the restoration area. These unnamed tributaries are small perennial streams that flow year round. These streams have small areas of poorly drained soils associated with them. All of these small streams flow over steep terrain before entering Beaver Creek's floodplain. The first drains into Beaver creek through a culvert. This tributary appears to be stable. The second tributary entering Beaver Creek from the north is approximately 2 to 3 feet wide and 1 to 3 feet deep, increasing to 5 feet in depth as it enters Beaver Creek. This tributary has previously been straightened. The existing bedform is predominantly a run and the channel is heavily overgrown with shrub vegetation. This tributary is part of the overall restoration project. The channel entering Beaver Creek from the south (third tributary) is 2 to 3 feet wide and is 1 to 2 feet in depth, increasing in depth as it enters Beaver Creek. This tributary will not be modified as part of this project. All of the side channels had moderate to low flow on the day of the sight visit.

The main factor in the degradation and impairment for Beaver Creek appears to be historic straightening of the channel and removal of riparian vegetation. Straightening has increased the channel slope and decreased the stream sinuosity. The channel has incised to bedrock in several areas. The increased slope and bedrock control have resulted in lateral erosion as a means to decrease slope through meandering. Meandering has accelerated in areas where the riparian vegetation has been disturbed by thinning or completely removed. Erosion has caused increased sediment supply and channel widening. This has combined to lead to the development of central bars in several straight sections of the channel. Further development of central bars will increase erosion and lateral migration of the channel.

2.2.2 Existing Stream Characteristics

Field surveys of the existing stream channel and site were conducted on August 25, 2001. Photographs of the site were taken and are provided in Appendix A. Beaver Creek Restoration Site can be typically defined as a predominantly straight channel with moderate habitat and an unstable pattern actively migrating. Stream banks are steep with areas of active erosion, particularly along outside meander bends. Long straight sections of the channel have central bars forming; indicating the channel is over-wide. Instead of focusing the flow along the thalweg, the central bars deflect the streamflow toward the banks and accelerate bank erosion.

Riffle bankfull widths for Beaver Creek range from 27.0 to 37.5 feet with mean depths ranging from 1.8 to 2.8 feet. The cross-sectional areas for these riffles range from 53.3 to 89.7 square feet. The first cross-section (#101) was taken in a stable riffle upstream of the project. The stream at this point is classified as a C-type under the Rosgen classification system. All other cross-sections were taken within the reach to be restored. All cross-sections classed as type-F or G channels as the amount of incision increases downstream. The data for the existing channel is included in Appendix B. The stream has the following average characteristics:

Bankfull Width:	30.6 feet
Cross-sectional Area:	70.6 square feet
Mean Depth:	2.3 feet
Maximum Depth:	3.1 feet
Average Water Surface Slope:	0.005 feet/feet
Entrenchment Ratio:	>6.0
Sinuosity:	1.35
Bank Height Ratio	2.0

2.2.3 Soils of the Restoration Site

According to the preliminary soil maps for Surry County, soils adjacent to Beaver Creek within the restoration site are mapped as Colvard and Suches soils (Figure 7). Investigation of the soils adjacent to the stream indicates that both soils are present, although Suches soils dominate the site. Suches soils are very deep soils and are well drained to moderately well drained. These moderately permeable soils occur on nearly level floodplains along creeks and rivers. Suches soils have formed in alluvial sediments washed largely from soils formed in residuum from metamorphic and crystalline rocks.

Soil textures encountered include sandy loams, sandy clay loams, and clay loams. Significant amounts of gravel and cobbles were noted in some horizons in some locations. Gravel and cobbles were more common in the eastern portion of the project. The seasonal high water table was observed to be greater than 40 inches for most soils within the project. Slopes range from 0 to 6 percent.

A few inclusions of an unmapped poorly drained soil were noted. These small areas occur where small tributaries enter the floodplain of Beaver Creek. The small areas of poorly drained soils are silty clay loams and included significant rock content. The seasonal high water table for these soils was observed to be less than 22 inches, with small areas less than 12 inches.

The channel has incised into the floodplain deep enough to expose cobbles and boulders in many places along the stream banks.

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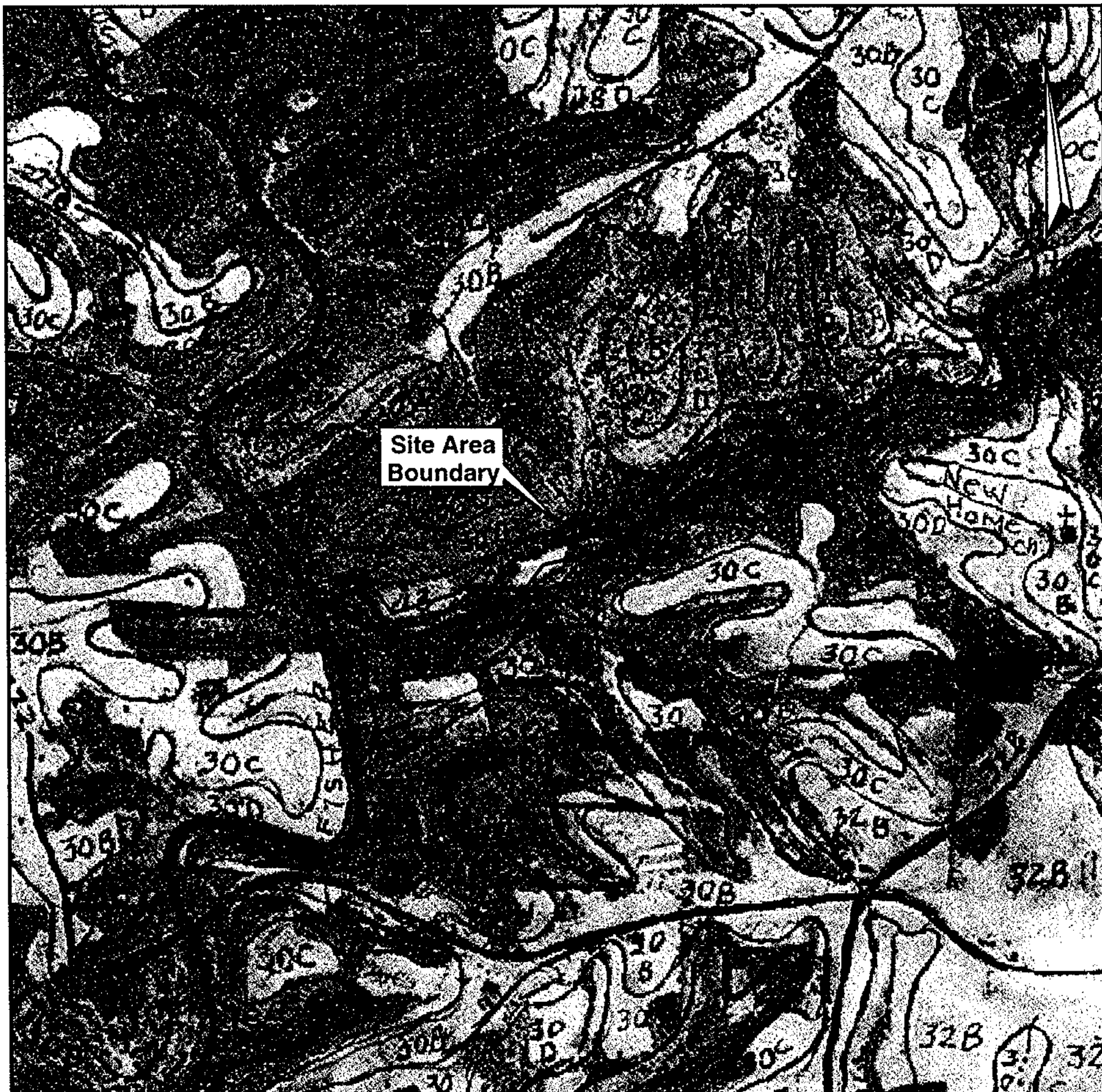

LEGEND

30B Pacolet sandy clay loam, 2-8% slopes, eroded
30C Pacolet sandy clay loam, 8-15% slopes, eroded
30D Pacolet sandy clay loam, 15-25% slopes, eroded
30E Rion, Pacolet and Wateree soils, 25-45% slopes
78E Wateree-Rion-Rock outcrop complex, 45-95% slopes
13 Riverview and Toccoa soils, 0-4% slopes, occasionally flooded

0 500 1,000 2,000 Feet

Source: Surry County Soil Conservation Service, Soil Survey Field Sheet F-6, 1988.

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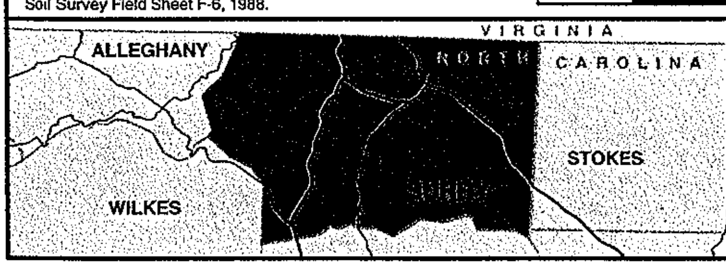

FIGURE 7
Soils

Beaver Creek Restoration Plan
Surry County, North Carolina

2.2.4 Terrestrial Plant Communities

The following sections describe the existing plant communities on and adjacent to the restoration site (Figure 8). For purposes of this project, four plant communities are described: Managed Land, Cutover Land, Bottomland Forest, and Upland Hardwood Forest. Nomenclature follows Radford (1968).

2.2.4.1 Managed Land

Managed Land consisting of grazed pastureland is present in the floodplain on the north side of Beaver Creek at the eastern end of the project. The vegetation is herbaceous and includes fescue grasses (*Festuca* sp.), broomsedge (*Andropogon virginica*), pokeberry (*Phytolacca americana*), and wing stem (*Verbesina alternifolia*). Included within this community type is a cultivated garden at the western end of the project near the Fisher River on land owned by Mr. Wayne Draughn.

2.2.4.2 Cutover Land

Recent clear cutting has removed trees and woody vegetation from most of the floodplain on the northern side of Beaver Creek. This disturbed community is dominated by herbaceous vegetation that has grown to a height of 7 to 10 feet. Vegetation includes: blackberry (*Rubus* sp.), black willow (*Salix nigra*), goldenrod (*Solidago canadensis*), Joe-pye-weed (*Eupatorium fistulosum*), pokeberry, rough boneset (*Eupatorium pilosum*), rush (*Juncus effusus*), tick-seed (*Bidens* sp.), and wingstem.

2.2.4.3 Bottomland Forest

A Bottomland Forest community is present along the floodplain and stream banks that have not been clear-cut. This a mature forest with trees reaching 70 feet in height. The understory is relatively open except where this community adjoins the disturbed areas. Trees in this community include black walnut (*Juglans nigra*), red maple (*Acer rubrum*), river birch (*Betula nigra*), and tulip poplar (*Liriodendron tulipifera*). Understory trees include umbrella tree (*Magnolia tripetala*), cucumber tree (*Magnolia acuminata*), mountain magnolia (*Magnolia fraseri*), ironwood (*Carpinus caroliniana*), rhododendron (*Rhododendron minus*), and flowering dogwood (*Cornus florida*). The herbaceous layer is diverse and includes prostrate ticktrefoil (*Desmodium rotundifolium*), wingstem, jewel weed (*Impatiens capensis*), Japanese grass (*Microstegium vimineum.*), phlox (*Phlox* sp.), and various vines. The stream bank is also vegetated and includes yellow root (*Xanthorhiza simplissima*) and groundnut (*Apios americana*).

2.2.4.4 Upland Hardwood Forest

An Upland Hardwood Forest community covers most of the upland areas adjacent to the project. This is a mature forest reaching 80 feet in height. The canopy trees in this

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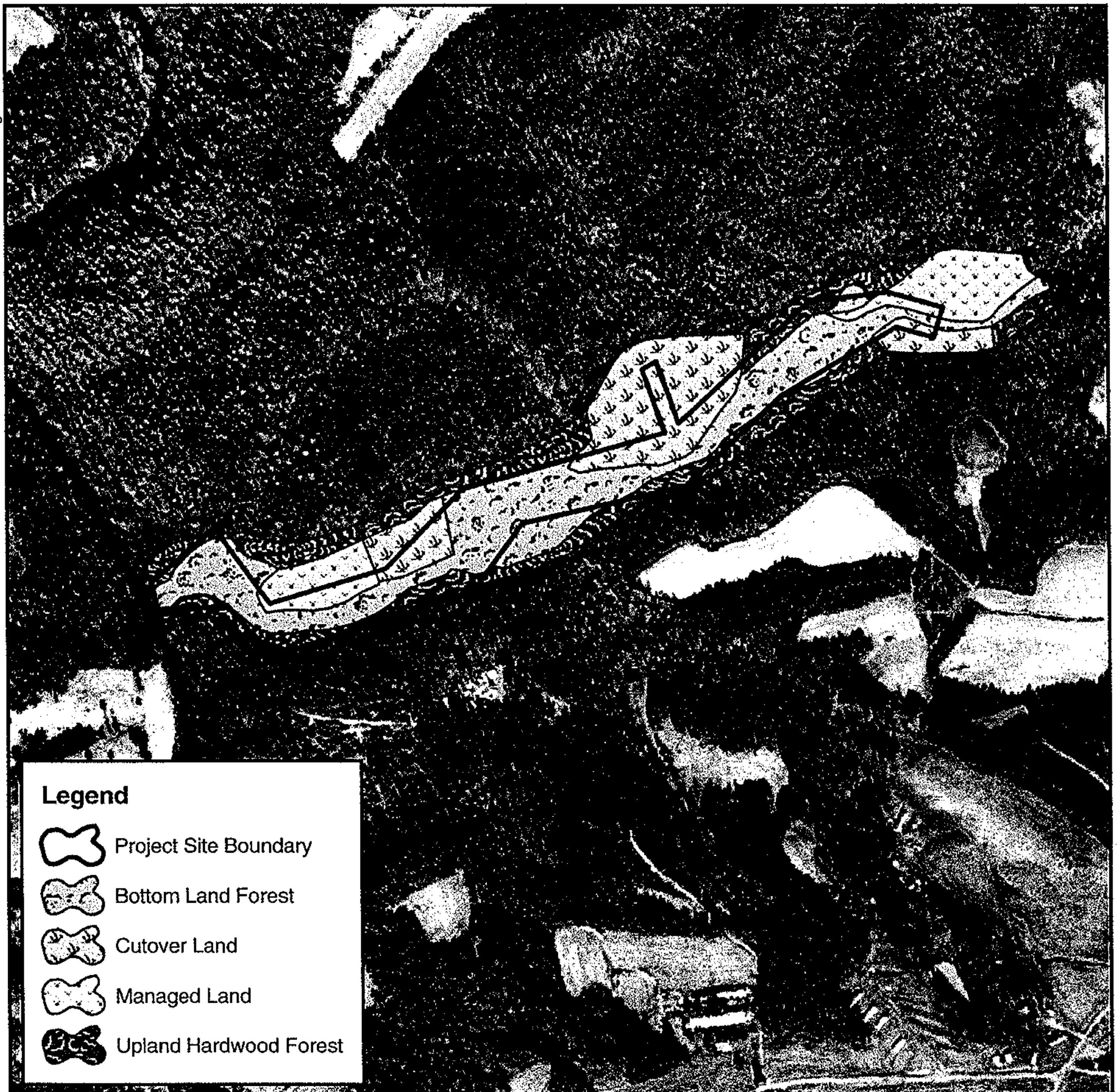

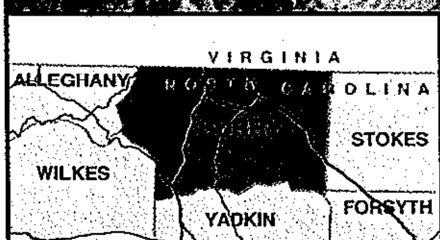

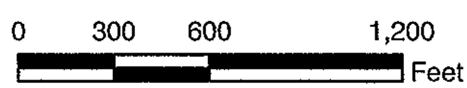

Source: Microsoft Terraserver 1993.

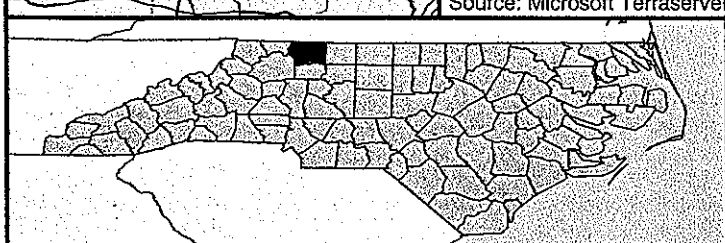

FIGURE 8
Natural Communities

Beaver Creek Restoration Plan
Surry County, North Carolina

community include white oak (*Quercus alba*), tulip poplar, and magnolias. Prominent on the north facing slopes is an understory dominated by rhododendron, forming a continuous cover over large portions of the side slopes. On the south facing slopes the canopy species include additional species such as Virginia pine (*Pinus virginiana*) and various oaks. The understory lacks rhododendron and is not a dense as the north-facing slope. Understory species include flowering dogwood and sourwood (*Oxydendrum arboreum*).

2.2.5 Wildlife Observations

Wildlife and signs of wildlife were noted during on-site visits, however, a formal wildlife survey was not performed. Tracks of white tailed deer (*Odocoileus virginianus*) and raccoon (*Procyon lotor*) were observed along the stream banks. A variety of birds were observed in the thickets and shrubs surrounding the stream channel and forest, including: blue jay (*Cyanocitta cristata*), loggerhead shrike (*Lanius ludovicianus*), and various sparrows.

The USFWS lists 2 species under federal protection and one species of federal concern for Surry County as of March 2001 (USFWS 2001). These species are listed in Table 1.

Table 1. Species Under Federal Protection in Surry County

Scientific Name	Common Name	Federal Status
Vertebrates		
Bog turtle	*Clemmys muhlenbergii*	T(S/A)
Invertebrates		
Brook floater	*Alasmidonta varicosa*	FSC
Vascular Plants		
Small-whorled pogonia	*Isotria medeoloides*	E

Notes: E — Endangered-A species that is threatened with extinction throughout all or a significant portion of its range.
T — Threatened-A species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
T(S/A) — Threatened due to similarity of appearance.
FSC — Federal species of concern.

No Threatened, Endangered or Species of Federal Concern were observed during the site visit, and none are recorded at NC National Heritage Program as occurring within 2 miles (3.2 km) of the project area. Habitat may be present for the brook floater, however Earth Tech biologists did not conduct searches for this species. Habitat for the small-whorled pogonia and the bog turtle is not present on the site.

3.0 REFERENCE REACHES

3.1 BIG BRANCH

Big Branch, a second order stream, is located 1.5 miles south of Blevins Store in Surry County, North Carolina (Figure 9). Big Branch flows into the Fisher River approximately 1000 feet downstream of the reach surveyed. The stream has a drainage area of 1216 acres or 1.9 square miles. The watershed is mildly sloped (2.3 percent) with forested and agricultural areas throughout. The area surrounding the creek is forested and hilly on the south side. The north side has a thin row of trees along a road embankment. The vegetation is similar to that of the project site with dense shrub and deciduous vegetation lining its banks and adjacent floodplain. The floodplain area upstream of this reach is used for cattle grazing. The riparian area is fenced out so the cattle do not have access to the stream.

A complete biological assessment of the stream was conducted on August 16, 1999. A total of 204 benthic macroinvertebrates making up 38 taxa were found in Big Branch. Seventeen of these taxa were EPT taxa. According to this biological assessment, this stream appears to be in excellent condition. The NC biotic index value was 3.26 and the percentage of chironomids were low (6 percent).

The stream was surveyed on August 12, 1999. Channel dimension, pattern, and profile were measured for 330 linear feet of stream. The end point of the survey is located approximately 80 feet upstream of the Red Hill Creek Road bridge. The stream had a bankfull channel width of 21.5 feet and a bankfull mean depth of 2.0 feet. Big Branch is an E4 stream type from Rosgen Classification system. Longitudinal profile, cross-sections, and the pebble count for this reference reach is located in Appendix C.

3.2 BASIN CREEK

Basin Creek, a fourth order stream, is located entirely within Doughton Recreational Area in Allegheny and Wilkes Counties (Figure 10). The reach surveyed is located approximately 4000 feet up Grassy Gap Road within the park boundaries and below the junction of West Branch Basin Creek and Cove Creek. The drainage area for the reach surveyed is 4607 acres or 7.2 square miles. The watershed is steeply sloped (10.3 percent) with a heavily forested stable landuse. The entire watershed is located within State Park boundaries. Dense shrub and deciduous vegetation line the banks and adjacent hillslopes. The surveyed reach is located immediately downstream from the confluence of two colluvial B type streams.

A survey crew from Natural Resources Conservation Service and SCSWCD surveyed the stream on October 28, 1998. Channel dimension, pattern, and profile were measured for 953 linear feet of stream. The stream had a bankfull channel width of 33.2 feet and a bankfull mean depth of 2.1 feet. Basin creek is a C4 stream type. A biological assessment was not conducted on this stream. Longitudinal profile, cross-sections, and the pebble count for this reference reach is located in Appendix D.

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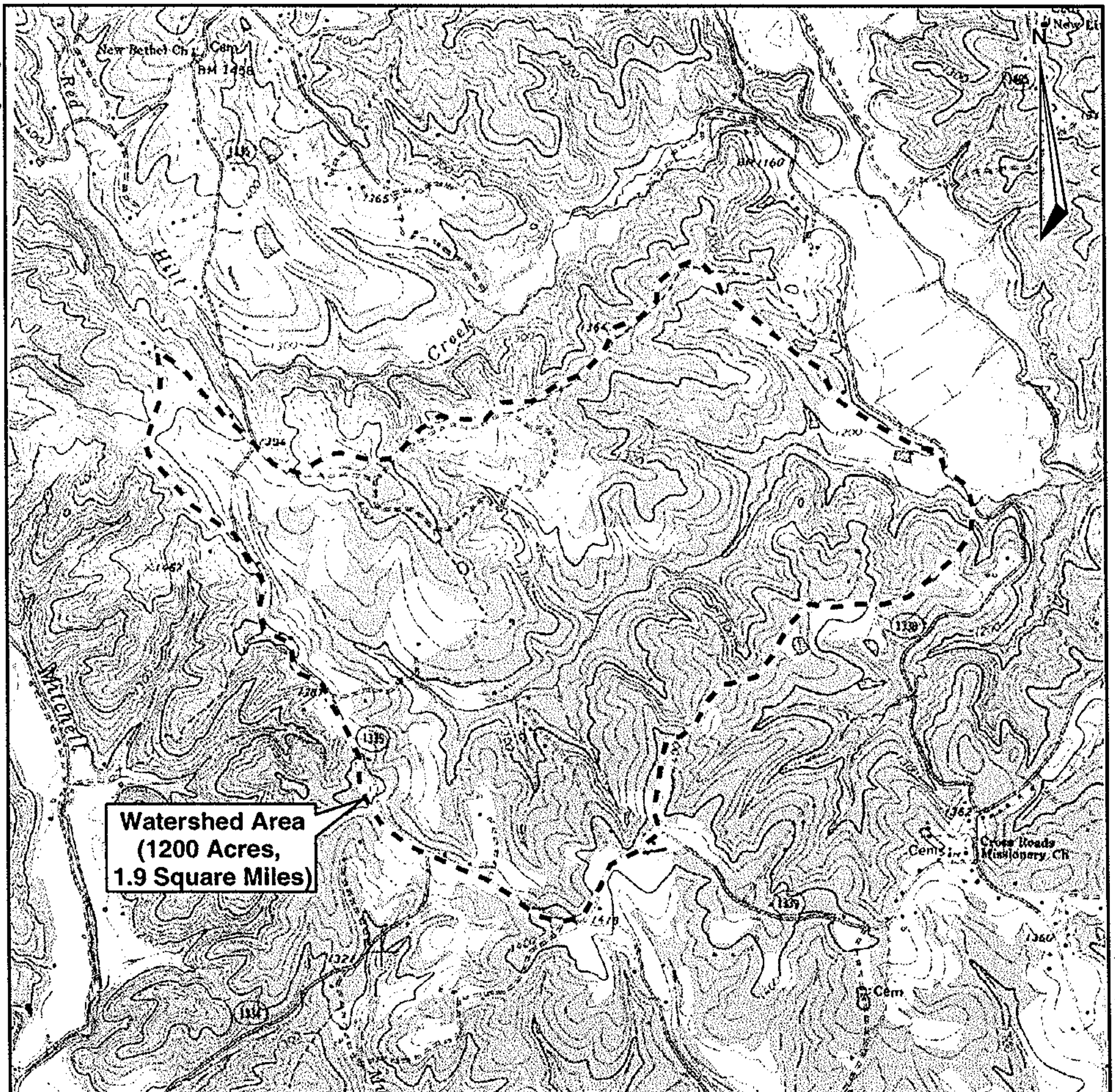

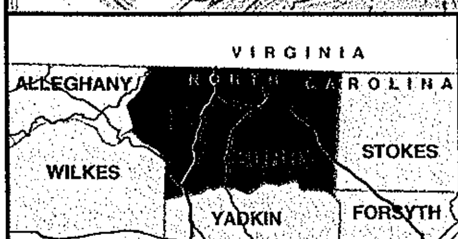

0 1,000 2,000 4,000 Feet

Source: USGS Quadrangles:
Bottom, NC, 1971.
"Maptech® U.S. Terrain Series,
©Maptech®, Inc. 603-433-8500"

N.C. Wetlands Restoration Program
NCDENR DWQ

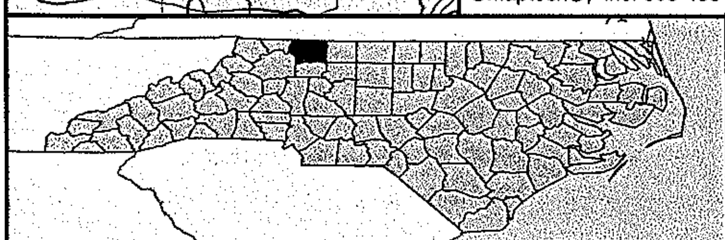

FIGURE 9
Big Branch Watershed
Reference Reach
Beaver Creek Restoration Plan
Surry County, North Carolina

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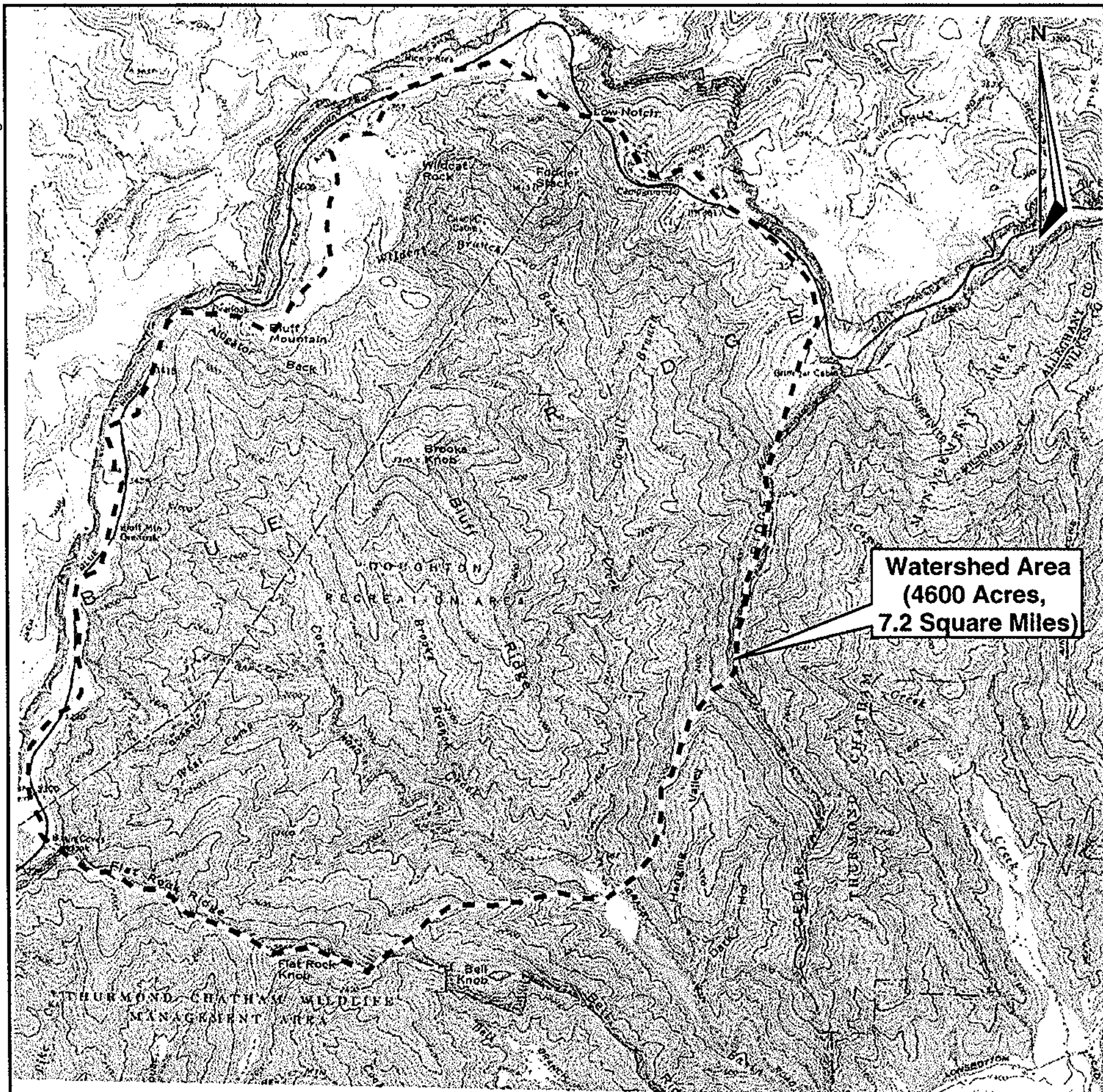
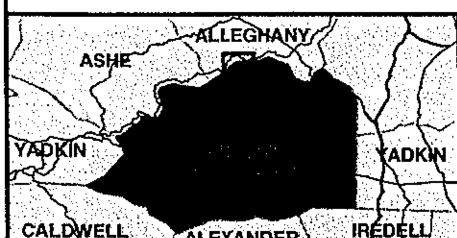




0 1,500 3,000 6,000
Feet

Source: USGS Quadrangles:
Whitehead, NC, 1968.
"Maptech® U.S. Terrain Series,
©Maptech®, Inc. 603-433-8500"

N.C. Wetlands Restoration Program
NCDENR DWQ

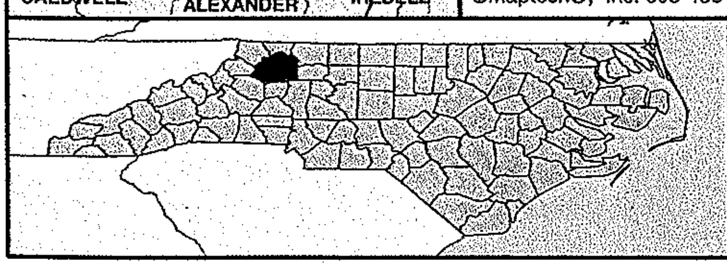


FIGURE 10
Basin Creek Watershed, Wilkes County
Reference Reach
Beaver Creek Restoration Plan
Surry County, North Carolina

4.0 STREAM CHANNEL DESIGN

This restoration will classify as a Priority 2 restoration (Rosgen, 1997). The floodplain will be re-established to fit the existing or slightly raised stream profile. The grade of the stream will be raised in some areas and a floodplain will be established at the new bankfull elevation. Table 2 describes and summarizes the four priorities of incised river restoration (Rosgen, 1997). The proposed stream restoration will restore the natural meander pattern, modify channel cross-section restore bedform, improve sediment transport capacity, enhance habitat, and re-establish a floodplain for the stream.

The design was based upon Dave Rosgen's natural channel design methodology. As described in Section 4.0, Big Branch and Basin Creek were utilized as reference reaches on which the morphological characteristics were measured to determine a range of values for the stable dimension, pattern, and profile of the proposed channel. The measured and proposed morphological characteristics are shown in Table 3.

360-feet of a straightened tributary will also be restored as part of this restoration project. The previously straightened tributary will be meandered through the open valley and stabilized with natural material structures and vegetation. Design parameters will based upon reference data from Big Branch.

A conceptual design was developed from the range of values listed in Table 3. This stream restoration project will result in approximately 4,300 restored linear feet (as measure from the thalweg) of Beaver Creek and 430 restored linear feet of the unnamed tributary to Beaver Creek. The plan view of the proposed restoration design can be seen in Figures 11, 11a and 11b.

Table 2. Priorities, Description and Summary for Incised River Restoration

DESCRIPTION	METHODS	ADVANTAGES	DISADVANTAGES
PRIORITY 1 Convert G and/or F stream types to C and/or E at previous elevation w/floodplain	Re-establish channel on previous floodplain using relic channel or construction of new bankfull discharge channel. Design new channel for dimension, pattern and profile characteristic of stable form. Fill in existing incised channel or with discontinuous oxbow lakes level with new floodplain elevation.	Re-establishment of floodplain and stable channel: 1) reduces bank height and streambank erosion 2) reduces land loss 3) raises water table 4) decreases sediment 5) improves aquatic and terrestrial habitats 6) improves land productivity, and 7) improves aesthetics.	1) floodplain re-establishment could cause flood damage to urban agricultural and industrial development. 2) downstream end of project could require grade control from new to previous channel to prevent head-cutting.
PRIORITY 2 Convert G and/or F stream types to C or E. Re-establishment of floodplain at existing or higher, but not at original level	If belt width provides for the minimum meander width ratio for C or E stream types, construct channel in bed of existing channel, convert existing bed to new floodplain. If belt width is too narrow, excavate streambank walls. End-hall material or place in streambed to raise bed elevation and create new floodplain in the deposition.	1) decreases bank height and streambank erosion 2) allows for riparian vegetation to help stabilize banks 3) establishes floodplain to help take stress of channel during flood 4) improves aquatic habitat 5) prevents wide-scale flooding of original land surface 6) reduces sediment 7) downstream grade transition for grade control is easier.	1) does not raise water table back to previous elevation 2) shear stress and velocity higher during flood due to narrower floodplain 3) upper banks need to be sloped and stabilized to reduce erosion during flood.
PRIORITY 3 Convert to a new stream type without an active floodplain, but containing a floodprone area. Convert G to B stream type, or F to Bc	Excavation of channel to change stream type involves establishing proper dimension, pattern and profile. To convert G to B stream involves an increase in width/depth and entrenchment ratio, shaping upper slopes and stabilizing both bed and banks. A conversion from F to Bc stream type involves a decrease in width/depth ratio and an increase in entrenchment ratio.	1) reduces the amount of land needed to return the river to a stable form. 2) developments next to river need not be re-located due to flooding potential 3) decreases flood stage for the same magnitude flood 4) improves aquatic habitat.	1) high cost of materials for bed and streambank stabilization 2) does not create the diversity of aquatic habitat 3) does not raise water table to previous levels.
PRIORITY 4 Stabilize channel in place	A long list of stabilization materials and methods have been used to decrease stream bed and bank erosion, including concrete, gabions, boulders and bio-engineering methods	1) excavation volumes reduced 2) land needed for restoration is minimal	1) high cost for stabilization 2) high risk due to excessive shear stress and velocity 3) limited aquatic habitat depending on nature of stabilization methods used.

Source: Rosgen, 1997, "A Geomorphological Approach to Restoration of Incised Rivers"

Table 3. Beaver Creek Morphology (Existing, Proposed, and Reference)

Variables	Existing Channel	Reference Reach - Big Branch	Reference Reach-Basin Creek	Proposed Bankfull Channel
Stream Type (Rosgen)	C4, G4, and F4	E4	C4	E4
Drainage Area (sq. mi.)	5.9	1.9	7.2	5.9
Bankfull Width (W_{bkf}, ft)	27.0 - 37.5	20.0 - 21.5	29.5 - 36.9	28
MEAN	30.6	20.8	33.2	-
Bankfull Mean Depth (d_{bkf}, ft)	1.8 - 2.8	2.0	1.9 - 2.2	2.5
MEAN	2.3	2.0	2.1	-
Width/depth Ratio (W_{bkf}/d_{bkf})	9.5 - 16.0	9.8 - 10.8	13.4 - 19.4	11.2
MEAN	13.6	10.3	16.4	-
Bankfull Cross-sectional Area (A_{bkf} sq. ft.)	53.3 - 89.7	40.9 - 42.8	64.9 - 71.9	70.0
MEAN	70.6	41.9	68.4	-
Bankfull Maximum Depth (d_{max} ft)	2.5 - 3.3	2.5 - 2.7	3.0 - 3.2	4.2
MEAN	3.1	2.6	3.1	-
Ratio Bankfull Maximum Depth to Mean Bankfull Depth (d_{max}/d_{bkf})	1.3	1.4 - 1.3	1.5	1.7
Lowest Bank Height to Bankfull Maximum Depth Ratio	1.6 - 2.4	1.0	1.0	1.0
MEAN	2.0	-	-	
Width of Flood Prone Area (W_{fpa} ft)	230	130	329	230
Entrenchment Ratio (W_{fpa}/W_{bkf})	7.5	65	8.9	7.5
Meander Length (L_m ft)	116 - 802	185 - 260	350	192 - 485
MEAN	338	222	350	305
Ratio of Meander Length to Bankfull Width	3.8 - 26.2	8.9 - 12.6	10.5	6.9 - 17.3
(L_m/W_{bkf}) MEAN	11.1	10.7	10.5	10.9
Radius of Curvature (R_c ft)	16.0 - 285	42 - 63	40.1 - 69.3	45 - 76
MEAN	99	55	51.2	65.5
Ratio of Radius of Curvature to Bankfull Width	0.5 - 9.3	2.0 - 3.0	1.2 - 2.1	1.6 - 2.7
(R_c/W_{bkf}) MEAN	3.2	2.6	1.5	2.3
Belt Width (W_{blt} ft)	34 - 256	31 - 44	59 - 75	43 - 208
MEAN	107	37	64.7	99
Meander Width Ratio (W_{blt}/W_{bkf})	1.1 - 8.4	1.5 - 2.1	1.7 - 2.3	1.5 - 7.4
MEAN	3.5	1.8	1.9	3.5
Sinuosity (Stream Length/Valley Length, k - ft/ft)	1.35	1.1	-	1.22
Valley Slope (S_{valley}) ft/ft	0.006	0.009	-	0.006
Average Water Surface Slope (S_{avg})	0.005	0.0087	0.0144	0.005*
Pool Slope (S_{pool})**	-	0 - 0.0004	0.0 - 0.005	0.0 - 0.008
MEAN	-	0.0001	0.006473	0.0004
Ratio of Pool Slope to Average Slope (S_{pool}/S_{avg})	-	0.011	0.45	0.08
Riffle Slope (S_{riff} ft/ft)*	-	0.015 - 0.019	0.018 - 0.02	0.004 - 0.032
MEAN	-	0.017	0.02082	0.010
Ratio of Riffle Slope to Average Slope (S_{riff}/S_{avg})	-	1.95	1.44	2.0
MEAN	-	1.95	1.39	
Maximum Pool Depth (d_{pool} ft)	3.4 - 5.3	3.5 - 4.0	4.1 - 5.2	-
MEAN	4.3	3.8	4.8	5.5
Ratio of pool depth to mean bankfull depth (d_{pool}/d_{bkf})	1.9	1.9	2.3	2.2
Pool Width (W_{pool} ft)	23.1 - 35.3	17.8 - 19.0	35 - 68	30
MEAN	30.3	18.4	50.3	-
Ratio of Pool Width to Bankfull Width (W_{pool}/W_{bkf})	0.8 - 1.2	0.9	1.5	1.1
MEAN	1.0	-	-	-
Pool to Pool Spacing (P-P ft)	80 - 440	98 - 180	271 - 334	94 - 321
MEAN	215	139	305	159
Ratio of P-P to Bankfull Width (P-P/W_{bkf})	2.6 - 14.4	4.7 - 8.7	8.2 - 10.1	3.4 - 11.5
MEAN	7.0	6.7	9.2	5.7

*The avg. water surface slope neglects the final 200 feet of stream where grade will be lowered to tie into Fisher River.
**Existing Riffle and Pool slopes were not measured.
***The Max. Riffle Slope do not include grade changes produced by cross-vanes.

4.1 RESTORATION TECHNIQUES

Stream dimension, pattern, and profile will be adjusted so the new stream channel can maintain stability while transporting its water and sediment load. The Priority 2 restoration (see Table 2) will involve modifying the existing channel at its existing elevation to create a stable channel (Figures 11, 11a and 11b).

Vegetation will be utilized to provide stability and provide habitat along the stream banks and in the riparian area. The greatest advantage of this Priority 2 restoration will be to create a floodplain that the active channel can actively access. Other advantages of a Priority 2 restoration include improving aesthetics, improving habitat, reduction of bank height and streambank erosion, and lowering of the in-channel shear stress.

4.1.1 Dimension

The present bankfull channel width ranges from 27.0 to 37.5 feet with a cross-sectional area ranging from 53.3 to 89.7 square feet. The design channel will be constructed to bankfull target dimensions that are based on a combination of reference reach surveys, HEC RAS modeling, and regional curve information. Typical cross-sections can be seen in Figure 12.

A design width of 28 feet will be applied to the proposed reach. This width was back-calculated from the cross-sectional area taken from the NC Piedmont Regional Curve and a width-to-depth ratio of 11.2. Required mean depth of the channel was verified using critical dimensionless shear stress relationships to ensure there is enough design depth to transport the channel bedload without aggrading or degrading. These characteristics will provide a stream channel that classifies as an E-type channel according to the Rosgen classification system.

The existing channel, with bank height ratio's ranging from 1.6 to 2.4, will have benches cut at the bankfull elevation. This bankfull bench will establish a floodplain at the bankfull elevation of the existing channel. Channel width will be addressed by using double wing deflectors to narrow the existing channel in areas where the channel is over-wide. Bankfull dimension will also be modified by grading banks to fit typical design cross-sections. The proposed channel will be able to access a floodplain and effectively transport the sediment load.

4.1.2 Pattern

The existing pattern of Beaver Creek can be described as long straight reaches followed by severely tight meanders. The current sinuosity in Reach 1 is 1.35. This sinuosity of 1.35 is not representative of the reach as a whole since the majority of the channel has a sinuosity of typically 1.1 or less. This is common on channels that have been previously straightening. The stream will continue to meander until a stable planform is established.

Existing pattern measurements were taken from the topographic mapping are included in Table 3. A stable pattern will be established by softening of tight meanders and establishing new meanders in long straight sections of the channel. This will be achieved by introducing meanders into the stream with appropriate radius of curvatures and lengths based on reference reach data and existing constraints. The maximum sinuosity has been designed into the new channel based on the reference data and project constraints. Introduction of these meanders will improve habitat while lowering slope and shear stress.

4.1.3 Bedform

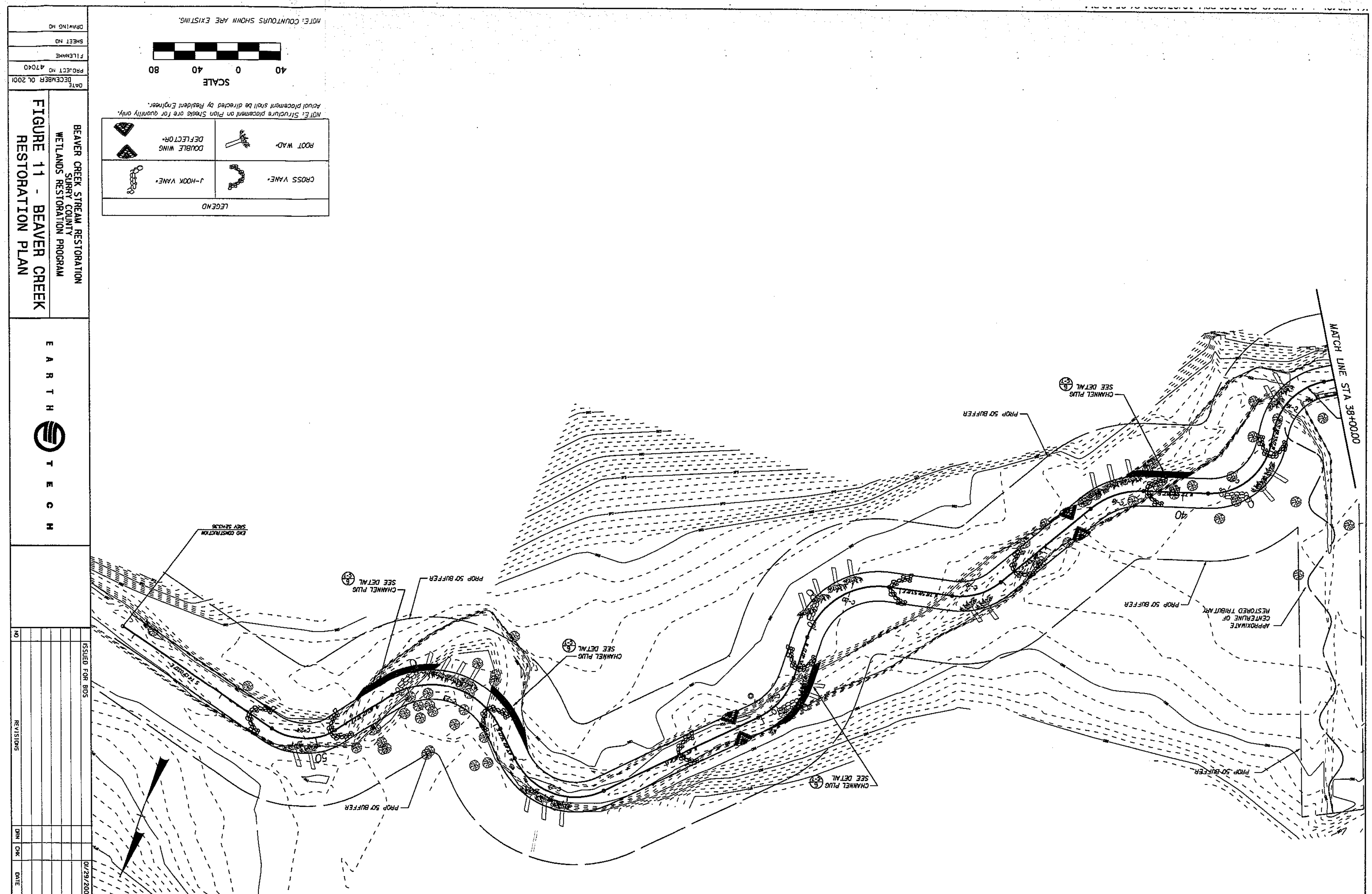
The existing bedform along Beaver Creek is in fair condition. Long, straight sections of the channel consist of predominantly run bedform features. The design channel will incorporate riffles and pools to provide bedform common to E4 stream types with gravel substrate (Figure 13). Pools will be located in the outside of meander bends with riffles in the inflection points between meanders. The riffles will have a thalweg depth of 4.2 feet while the pools will be deeper with a maximum depth of 5.5 feet. A graph of the proposed profile can be seen in Figure 14. The profile may be adjusted slightly during the final design phase of the project.

Cross-vanes will be utilized as grade control structures and to tie the relocated sections back into the existing channel. The cross vanes will be constructed out of natural materials such as boulders and wood. In effort to minimize the cut requirements, cross-vanes will be used to raise the streambed in some locations. Two existing bedrock outcroppings will be incorporated into the proposed stream profile.

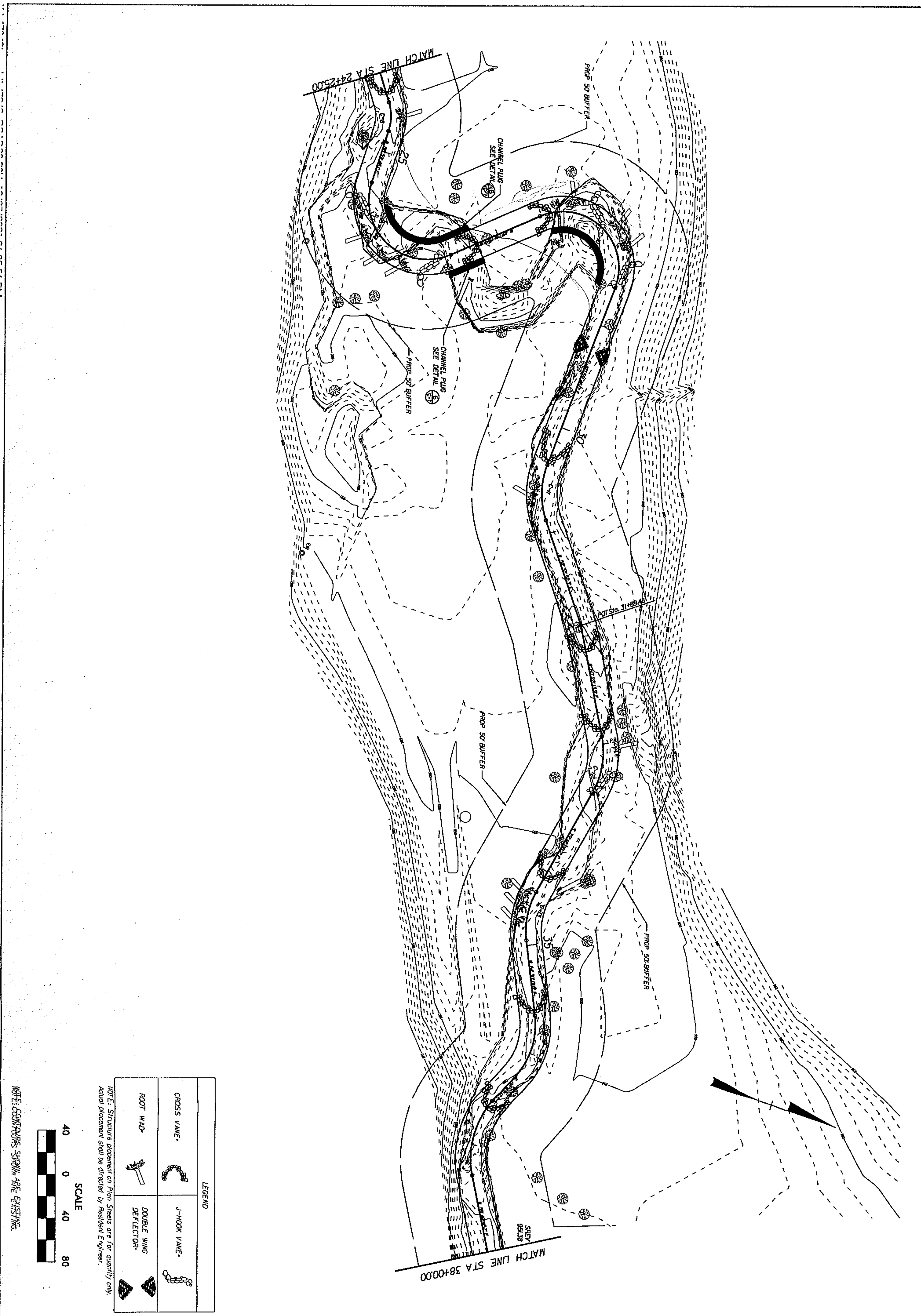
The existing pool-to-pool spacing is impaired in areas due to tight meander geometry. The proposed spacing is 94 to 321 feet, which is within the range of 3 and 12 bankfull widths as determined from the reference reach data. To accomplish this, pools will be realigned or constructed such that they will be located in the outside of the meander bends. Bedform will also be addressed through the strategic placement of natural material structures such as cross vanes, root wads and large woody debris. Double wing deflectors will be used in key locations to narrow the low flow channel and improve habitat. Modifications to the bedform will provide stability and habitat to the channel.

4.1.4 Riparian Areas

A riparian zone will be created around the new proposed stream channel to enhance both aquatic and terrestrial habitat as well as stabilize the stream channel. The riparian zone will extend at least 50 feet on either side of the channel from the top of bank (Figure 14). These areas will be planted with appropriate riparian vegetation as described in Section 6.0 Habitat Restoration.



NOTE: CONTOURS SHOWN ARE EXISTING.
SCALE
40 0 40 80
LEGEND
CROSS VANE*
J-HOOK VANE*
ROOT WAD*
DOUBLE WING DEFLECTOR*
NOTE: Structure placement on Plan Sheets are for quantity only.
Actual placement shall be directed by Resident Engineer.
DATE DECEMBER 01, 2001
PROJECT NO 47040
FILENAME
SHEET NO
DRAWING NO
BEAVER CREEK STREAM RESTORATION
SURRY COUNTY
WETLANDS RESTORATION PROGRAM
FIGURE 11 - BEAVER CREEK RESTORATION PLAN
EARTH TECH
ISSUED FOR BIDS
REVISIONS
NO
DRN
CHK
DATE
MATCH LINE STA 38+00.00
CHANNEL PLUG SEE DETAIL
PROP 50' BUFFER
APPROXIMATE CENTERLINE OF RESTORED TRIBUTARY
END CONSTRUCTION



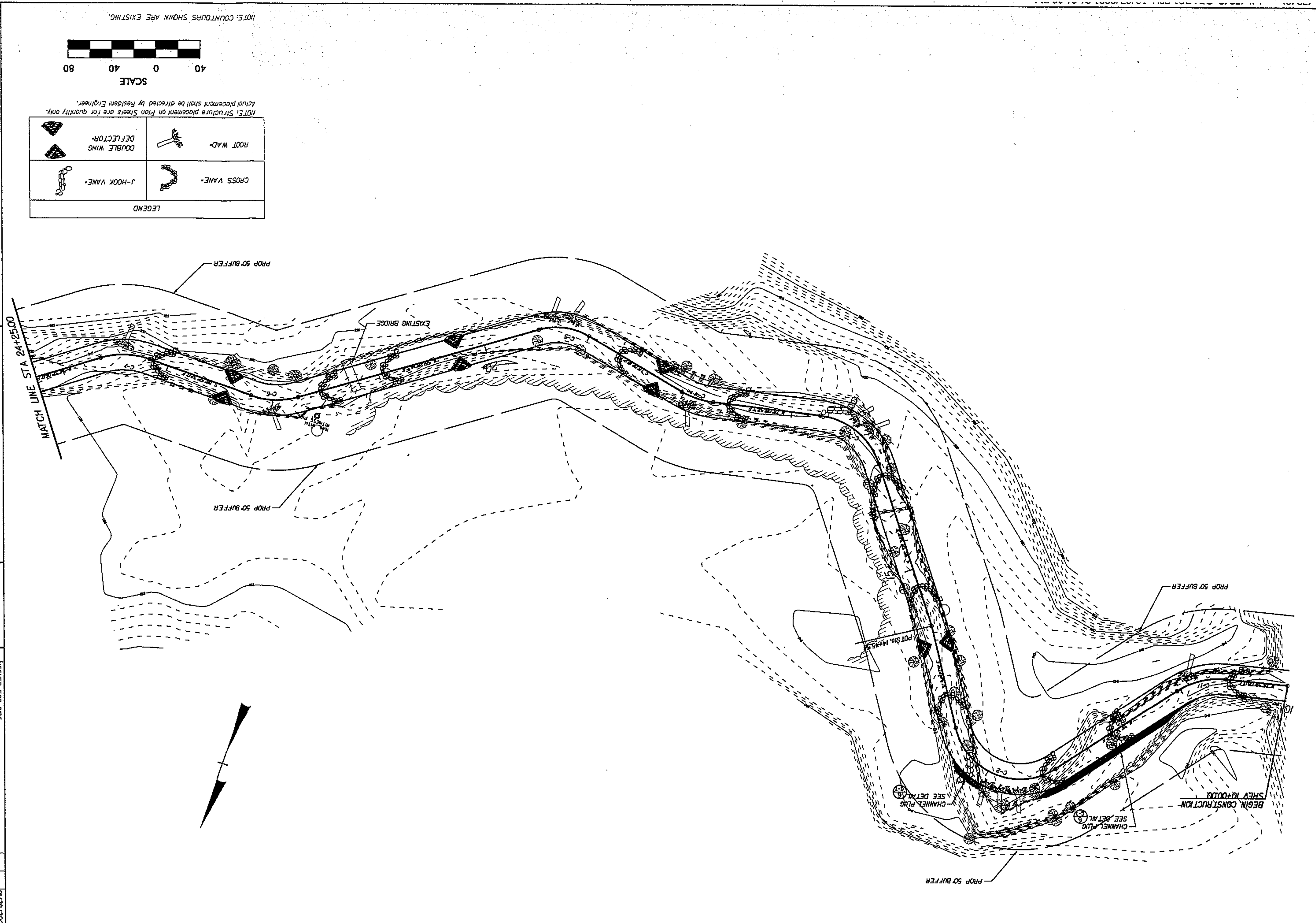
DATE	DECEMBER 01, 2001
PROJECT NO	47040
FILENAME	
SHEET NO	
DRAWING NO	

BEAVER CREEK STREAM RESTORATION
SURRY COUNTY
WETLANDS RESTORATION PROGRAM

FIGURE 11A - BEAVER CREEK RESTORATION PLAN

EARTH TECH

NO	REVISIONS	DRN	CHK	DATE
	ISSUED FOR BIDS			01/29/2001



BEAVER CREEK STREAM RESTORATION
SURRY COUNTY
WETLANDS RESTORATION PROGRAM

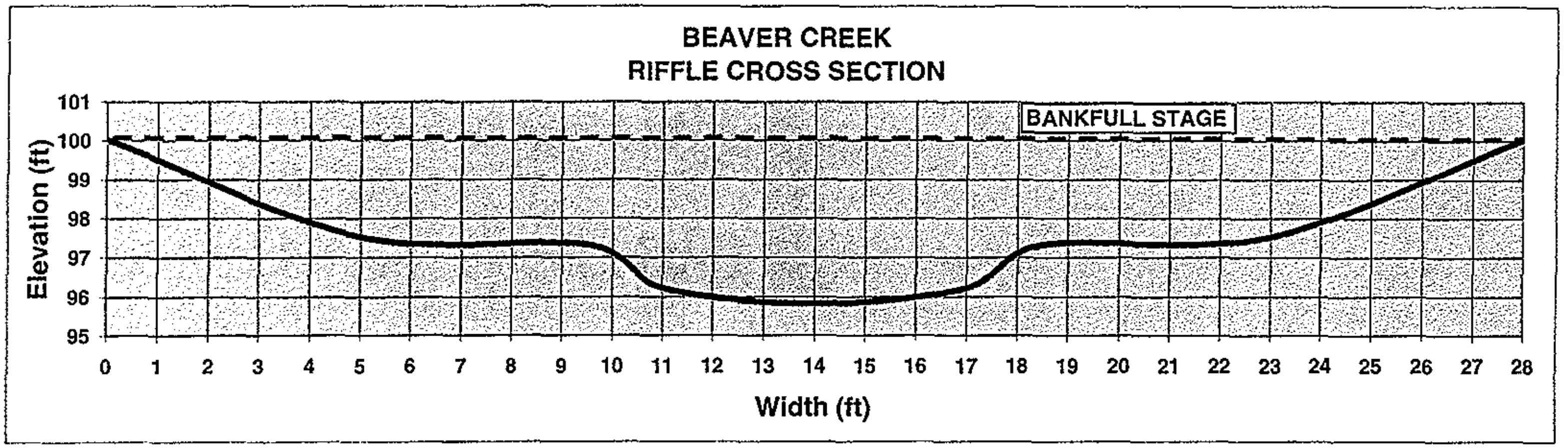
FIGURE 11B - BEAVER CREEK RESTORATION PLAN

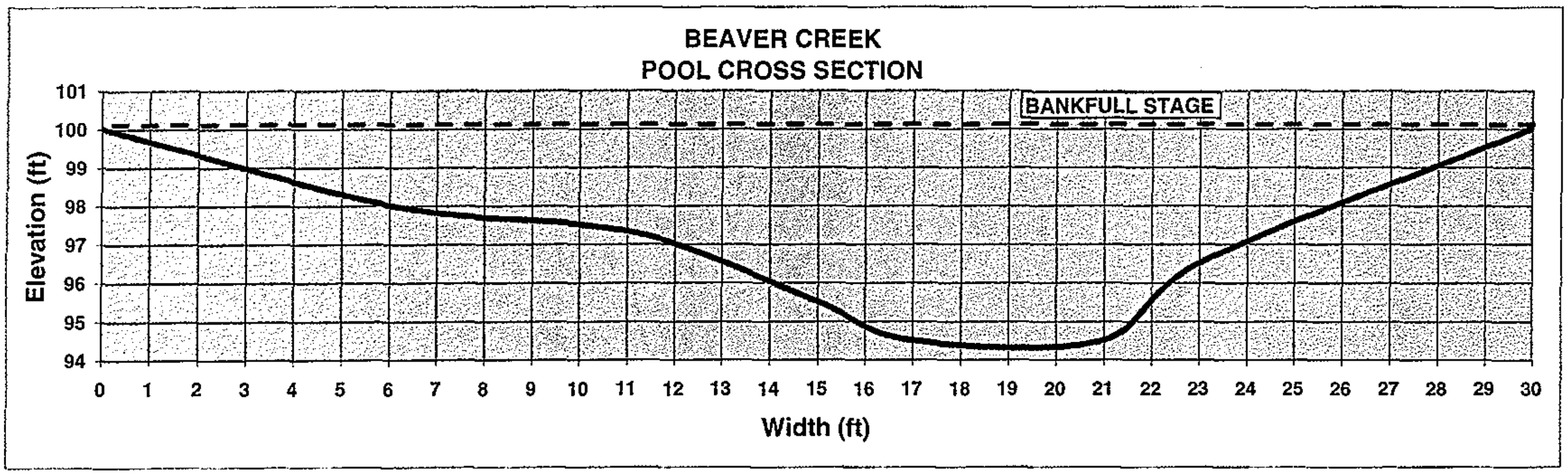
EARTH TECH

DATE	DECEMBER 01, 2001
PROJECT NO	47040
FILENAME	
SHEET NO	
DRAWING NO	

NO	REVISIONS	DRN	CHK	DATE
	ISSUED FOR BIDS			01/29/2001

FIGURE 12
Typical Cross-Sections of New Channel





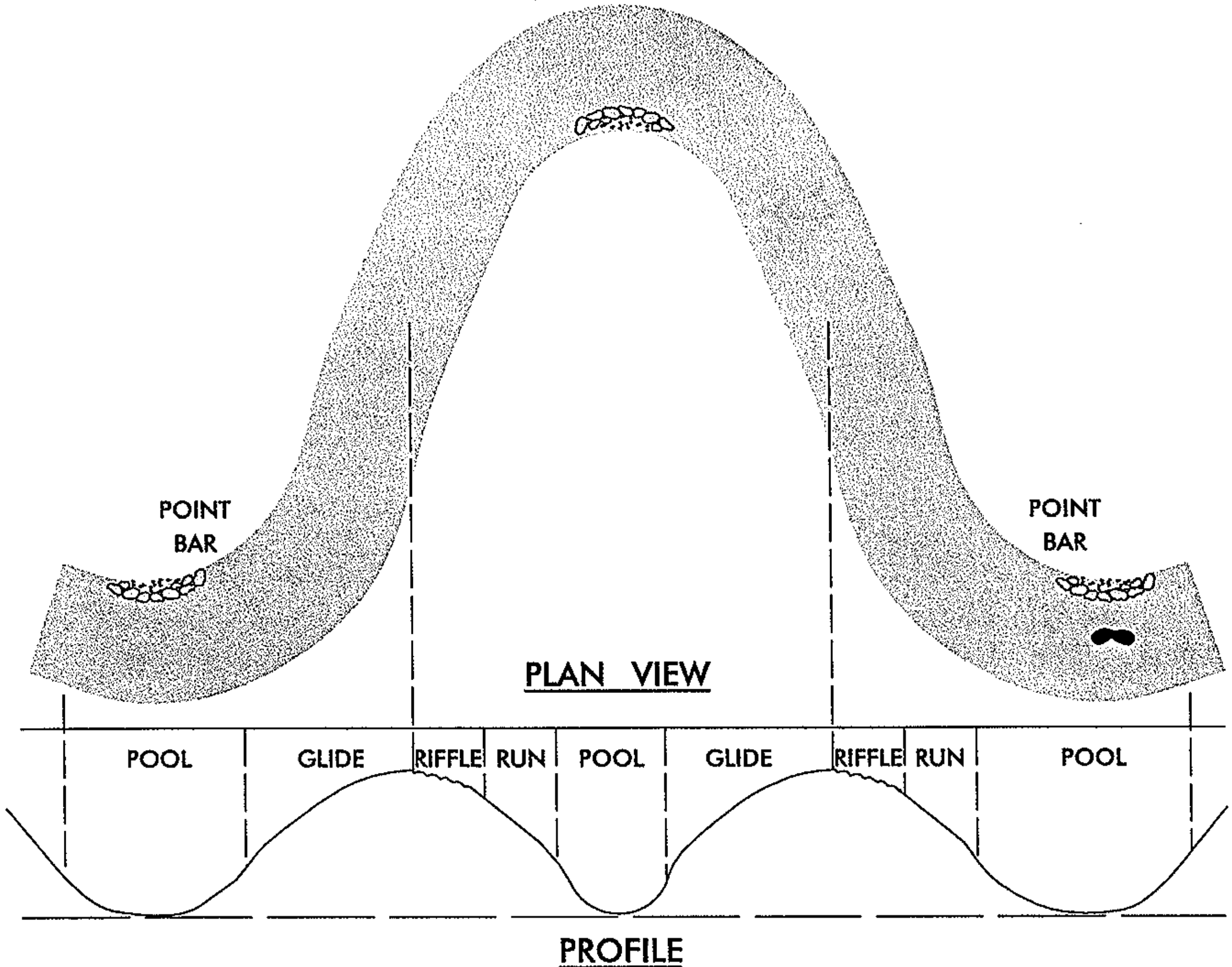


FIGURE 13
Bedform
Beaver Creek Restoration Plan
Surry County, North Carolina

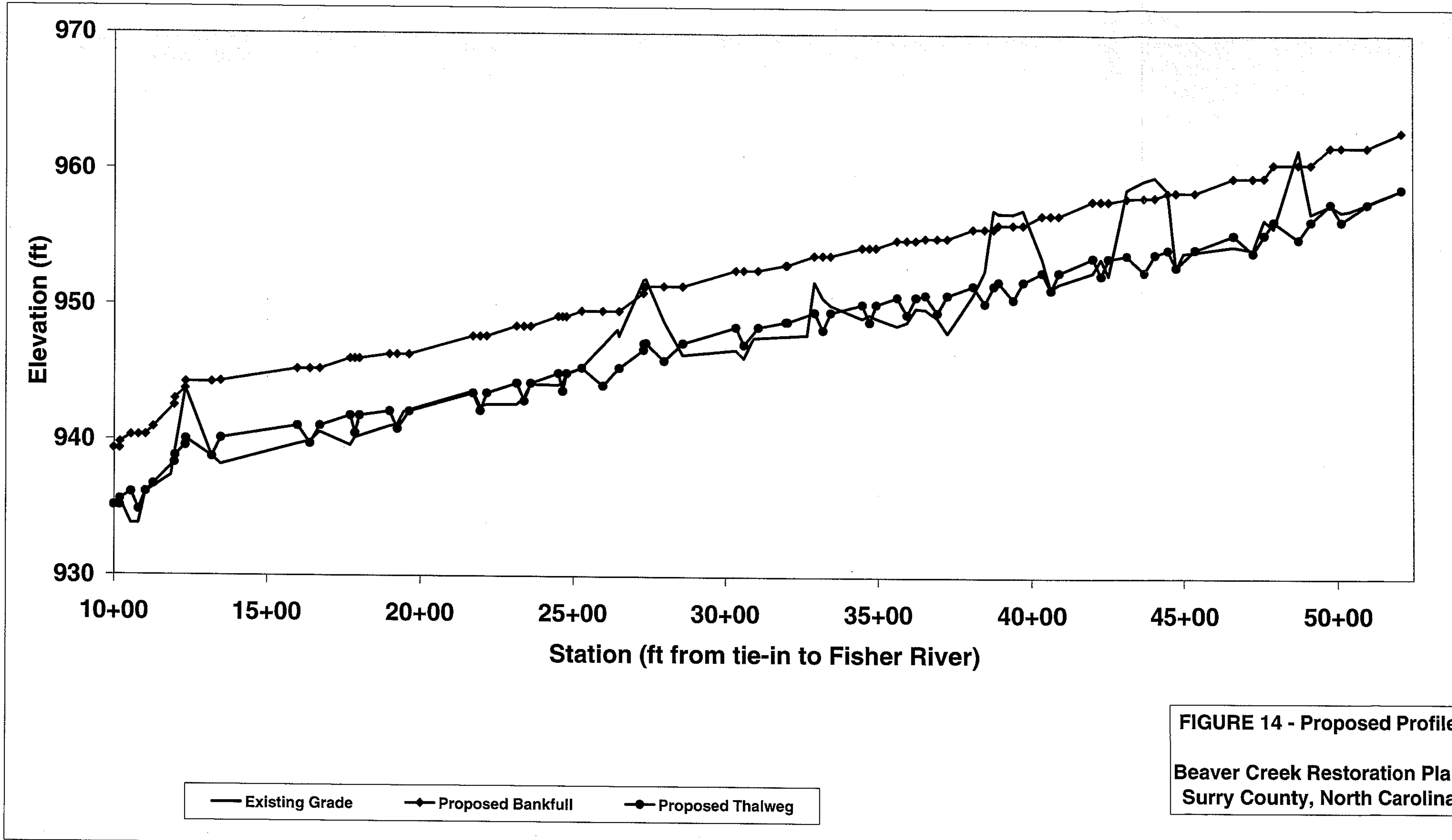


FIGURE 14 - Proposed Profile

Beaver Creek Restoration Plan
Surry County, North Carolina

4.2 SEDIMENT TRANSPORT

A stable stream has the capacity to move its sediment load without aggrading or degrading. The total load of sediment can be divided into bed load and wash load. Wash load is normally composed of fine sands, silts and clay and transported in suspension at a rate that is determined by availability and not hydraulically controlled. Bed load is transported by rolling, sliding, or hopping (saltating) along the bed. At higher discharges, some portion of the bed load can be suspended, especially if there is a sand component in the bed load. Bed material transport rates are essentially controlled by the size and nature of the bed material and hydraulic conditions (Hey 1997).

Critical dimensionless shear stress ($\tau*_{ci}$) can be calculated using a surface and subsurface particle sample from a representative riffle in the reach. Since taking a subsurface sample is difficult, it is often estimated using the median grain size from a point bar sample. The sample is taken on the point bar face halfway between the thalweg and bankfull.

$$\tau*_{ci} = 0.0834\left(\frac{d_i}{\hat{d}_{50}}\right)^{-0.872}$$

where, $\tau*_{ci}$=critical dimensionless shear stress
d_i=d_{50} of riffle bed surface from pebble count (mm)
$\hat{d}_{50}$=subpavement d_{50} or bar d_{50} (mm)

A riffle bed surface pebble count was taken at a riffle on Beaver Creek using a method suggested by Angela Jessup of the Natural Resources Conservation Service, Yadkinville office. 100 particles were randomly selected along the wetted area throughout the entire length of a riffle. The riffle bed surface d50 was then calculated to be 27.5 mm. A subsurface sample was taken at the same riffle and sieved to determine the subsurface d50. The subpavement d50 was then calculated to be 10.7 mm. The data and particle distribution graphs can be found in Appendix B.

The critical dimensionless shear stress is then calculated as follows,

$$\tau*_{ci} = 0.0834\left(\frac{27.5mm}{10.7mm}\right)^{-0.872} = 0.037$$

Critical dimensionless shear stress can then be used to predict the water depth required to move the largest particle found within the active channel, which is 70 mm or 0.23 ft for the Beaver Creek site. The water depth is calculated by:

$$d = \frac{(\tau*_{ci})(\rho_{sand} - \rho_{water})(D_i)}{s}$$

where, d=water depth (ft)
τ^*_{ci}=critical dimensionless shear stress
ρ_{sand}=density of sand (2.65 lb/ft^3)
ρ_{water}=density of water (1.0 lb/ft^3)
D_i=largest particle found in the bar sample (ft)
s=average bankfull slope

Thus,

$$d = \frac{(0.037)(2.65\frac{lb}{ft^3} - 1.0\frac{lb}{ft^3})\left(\frac{70mm}{25.4\frac{mm}{in} * 12\frac{in}{ft}}\right)}{0.0055\frac{ft}{ft}} = 2.5ft$$

For a critical dimensionless shear stress value of 0.037, the depth of water required to move a 70 mm particle was predicted to be 2.5 ft. The proposed channel dimensions have an average bankfull depth of 2.5 ft, with a maximum depth of 5.5 ft. This design provides the depth required to move the 70 mm particle found in the bar sample. The channel dimensions will provide sufficient shear stress to accommodate sediment transport.

Shear stress at the riffle was also checked using Shield's Curve. The shear stress placed on the sediment particles is the force that entrains and moves the particles, given by:

$$\tau = \gamma R s$$

where, τ=shear stress (lb/ft^2)
γ=specific gravity of water (62.4 lb/ft^3)
R=hydraulic radius (ft)
s=average bankfull slope (ft/ft)

Hydraulic radius is calculated by:

$$R = \frac{A}{P}$$

where, R=hydraulic radius
A=cross-sectional area (ft^2)
P=wetted perimeter (ft)

Thus,

$$R = \frac{70\,ft^2}{29.9\,ft} = 2.3\,ft$$

Wetted perimeter was measured off of a CADD file of the typical riffle cross-section drawn to scale.

Therefore,

$$\tau = (62.4\frac{lb}{ft^3})(2.3ft)(0.0055\frac{ft}{ft}) = 0.79lb/ft^2$$

The critical shear stress for the proposed channel has to be sufficient to move the D_{84} of the riffle bed material, which is 45 mm. Based on a shear stress of 0.79 lb/ft^2, Shield's Curve predicts that this stream can move a particle that is, on average, greater than 50 mm. Since the D_{84} was 45 mm and Shield's Curve predicts 50 mm, the proposed stream has the competency to move its bed load.

4.3 FLOODING ANALYSIS

This restoration site is in a FEMA/regulatory floodway zone and therefore, is subject to FEMA regulations. Currently there are no structures located in the floodway that would be impacted by floodplain alterations. The Priority 2 restoration of the stream will leave the stream's existing profile elevations essentially the same. A new floodplain will be established so that the active stream will be able to access it during larger storm events. Considering the type of restoration it is assumed that for smaller events the water surface elevations along the stream shall remain the same. During storms where the stream accesses the newly establishment floodplain the new water surface elevations are expected to be lower than the existing water surface elevations of storms of the same magnitude. The restoration will create neither positive nor negative water surface elevation changes during the larger storm events (greater than 50-year). HEC-RAS will be used to analyze both existing and proposed conditions once the design is completed. Sheer stress and flood stages will be compared between the two conditions to evaluate the design.

4.4 STRUCTURES

Several different structures made of natural materials will be installed along Beaver Creek. These structures include cross vanes, J-hook vanes, double wing deflectors, and root wads. Natural materials such as boulders, rocks and root wads will be used to create these structures from off-site sources.

4.4.1 Cross Vane

A cross vane structure serves to maintain the grade of the stream. The design shape is roughly that of the letter "U" with the apex located on the upstream side at the foot of the ripple. Footer rocks are placed in the channel bottom for stability. Rocks are then placed on these footer rocks in the middle of the channel at approximately the same elevation as the ripple. On either side of the channel, rocks are placed at an angle to the stream bank, gradually inclining in elevation until they are located above the bankfull surface directly adjacent to the stream bank. Water flowing downstream is directed over the vane towards the middle of the channel. Rocks placed at the apex determine the bed elevation upstream. A cross vane is primarily used for grade control and to protect the stream banks.

4.4.2 Root Wads

The objectives of these structure placements are as follows: (1) protect the stream bank from erosion; (2) provide in-stream and overhead cover for fish; (3) provide shade, detritus, terrestrial insect habitat; (4) look natural, and (5) provide diversity of habitats (Rosgen 1996). A footer log and boulder are placed on the channel bottom abutting the stream bank along an outside meander that will provide support for the root wad and additional stability to the bank. A large tree root wad is then placed on the stream bank with additional boulders and rocks on either side for stability. Flowing water is deflected away from the bank and towards the center of the channel.

4.4.3 Double Wing Deflectors

Double wing deflectors are used to narrow the low flow channel in streams that are over-wide. The structure is made of logs and a graded mixture of rocks. It creates a run bedform by narrowing the low flow channel thus reducing the possibility of central bars in an over-wide channel. The resulting channel has an improved sediment transport capacity and enhanced habitat. The long straight sections of Beaver Creek are excellent locations for double wing deflectors since the channel is over-wide and central bars are forming within the active channel.

Specific location of these structures will be determined during final design.

5.0 HABITAT RESTORATION

The restoration plan requires the establishment of riparian vegetation at the site. The proposed vegetation is described in the following sections.

5.1 Vegetation

Vegetation that develops a quick canopy has extensive root system, and a substantial above-ground plant structure is needed to help stabilize the banks of a restored stream channel in order to reduce scour and runoff erosion. In natural riparian environments, pioneer plants that often provide these functions are alder, river birch, silky dogwood, and willow. Once established, these trees and shrubs create an environment that allows for the succession of other riparian species including ashes, black walnuts, red maples, sycamores, oaks and other riparian species.

In the newly restored stream channel, revegetation will be vital to help stabilize the stream banks and establish a riparian zone around the restored channel. Revegetation efforts on this project will emulate natural vegetation communities found along relatively undisturbed stream corridors. To quickly establish dense root mass along the channel bank, a native grass mixture will be planted on the stream bed and bank. Shrubs will be utilized on the stream bank and along the floodplain to provide additional root mass. Extra care will be given to the outside of the meander bends to ensure a dense root mass in those areas of high stress. Coir matting will be used to provide erosion protection until vegetation can be established. Along the tops of the channel banks, trees, shrubs and a native grass mixture will be planted.

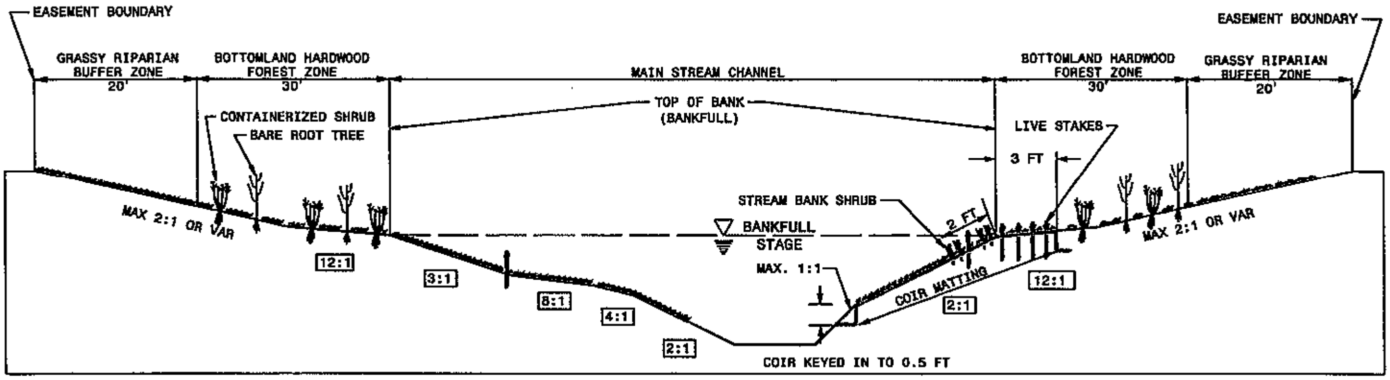
A mixture of seeds, livestakes, bare root nursery stock, and transplants will be utilized to stabilize the banks. Proposed species to be planted include

Trees
Blackgum (*Nyssa sylvatica*)
Black walnut (*Juglans nigra*)
Ironwood (*Carpinus caroliniana*)
River birch (*Betula nigra*)
Sycamore (*Platanus occidentalis*)
Persimmon (*Diospyros virginiana*)

Shrubs
Dog-hobble (*Leucothoe* sp.)
Rhododendron (*Rhododendron minum*)
Serviceberry (*Amelanchier* arborea)
Silky dogwood (*Cornus amomum*)
Silky willow (*Salix sericea*)
Tag alder (*Alnus serrulata*)
Winterberry (*Ilex verticillata*)

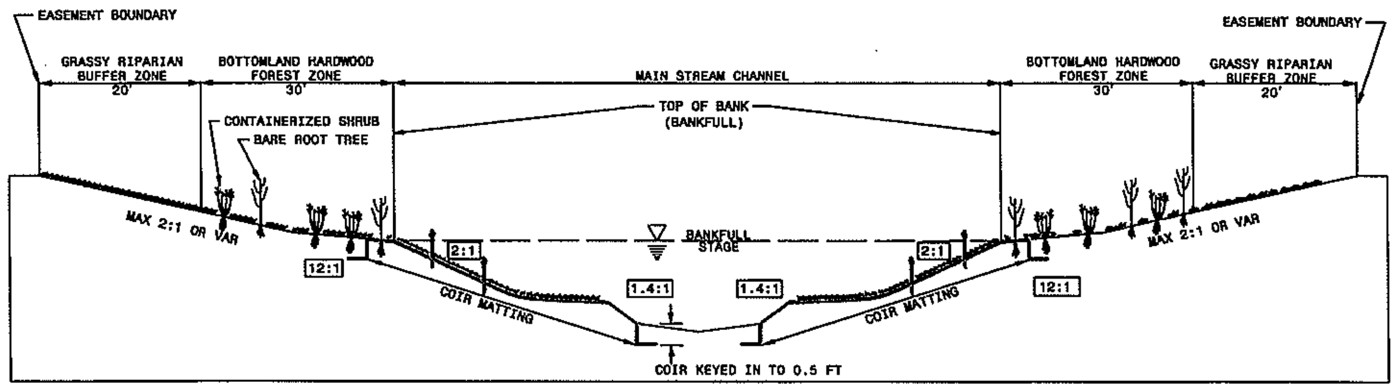
Herbs- Permanent seed mixture

Gramminoids
Bluestem (*Andropogon glomeratus*)
Tussock sedge (*Carex stricta*)
River oats (*Chasmanthium latifolium*)
Virginia wildrye (*Elymus virginicus*)
Deertongue (*Panicum clandestinum*)
Silver plumegrass (*Saccharum alopecurodium*)
Little blue stem (*Schizachyrium scoparium*)
Woolgrass (*Scirpus cyperinus*)



VEGETATION ZONE DETAIL-POOL

SCALE: NTS



VEGETATION ZONE DETAIL- RIFFLE

SCALE: NTS

FIGURE 15

TYPICAL CROSS - SECTION SHOWING VEGETATION ZONES

BEAVER CREEK RESTORATION PLAN
SURRY COUNTY, NORTH CAROLINA

Other herbaceous vegetation

Cut-leaved coneflower (*Rudbeckia laciniata*)
Wrinkle leaved goldenrod (*Solidago rugosa*)
Ironweed (*Vernonia noveboracensis*).

Woody vegetation will be planted between February and May to allow plants to stabilize during the dormant period and set root during the spring season. In the areas where invasive and exotic species are located, during construction and monitoring control by removal or appropriate herbicides will be implemented to prevent competition with the revegetation efforts.

5.2 Riparian Buffers

Two different types of riparian buffers will be utilized to vegetate the floodplain. In areas that are not currently being farmed any areas disturbed will be replanted with bottomland hardwood forest vegetation to the existing tree line. In areas that are currently being farmed or in pasture two separate zones will be established (Figure 15). The inner zone will extend for a distance of 30 feet from the top of bank and will be planted with bottomland hardwood forest vegetation. The outer zone will extend and additional 20 feet and will be planted with grassy herbaceous vegetation.

5.2.1 Bottomland Hardwood Forest

The inner forested zone will contain dominant vegetation similar to the Piedmont/Low Mountain Alluvial Forest community type described in Classification of the Natural Communities of North Carolina: Third Approximation (Schafle and Weakly 1990). Proposed species to be planted include trees, shrubs and permanent seed mixture listed under Streambank Vegetation (Section 6.1).

5.2.2 Grassy Riparian Buffer

The grassy buffer area will consists only of native grasses and herbaceous vegetation to slow and filter runoff from the adjacent farmed areas. Proposed species to be planted are listed in the permanent seed mixture listed under Streambank Vegetation (Section 6.1).

5.2.3 Temporary Seeding

A temporary seed mixture will be applied to all disturbed areas immediately after construction activities have completed. This temporary seed mixture will provide erosion control until permanent seed can become established.

6.0 MONITORING

6.1 STREAM CHANNEL

Monitoring of the stability of the channel is recommended to occur approximately 6 months after restoration is complete or after bankfull (or greater) events and should continue annually for a period of 3 to 5 years. Monitoring practices may include, but are not limited to, installing bank erosion pins and a toe pin, monumented cross-sections, scour chains, macroinvertebrate studies, longitudinal profiles, conducting the bank erosion hazard rating guide and establishing photo reference points. The purpose of monitoring is to determine bank stability, bed stability, morphological stability and overall channel stability. Table 4, below, can be used for selecting practices.

Table 4. Stream Monitoring Practices

PRACTICE	STABILITY ASSESSMENT
Bank Erosion Pins with Toe Pin	-Lateral or bank stability
Monumented Cross-Section	-Vertical or bed stability -Lateral or bank stability
Scour Chains	-Vertical or bed stability -Scour depth for a particular storm
Scour Chain w/ Monumented Cross-Section	-Vertical or bed stability -Sediment transport relations -Biological interpretations
Longitudinal Profile	-Channel profile stability
Bank Erosion Hazard Guide	-Bank erosion potential
Photo Reference Points	-Overall channel stability
Macroinvertebrate Studies	-Biological indication of water quality

6.2 VEGETATION

Prior to planting, the site will be inspected and checked for proper elevation and suitability of soils. Availability of acceptable, good quality plant species will be determined. The site will be inspected at completion of planting to determine proper planting methods, including proper plant spacing, density, and species composition.

Competition control will be implemented if determined to be necessary during the early stages of growth and development of the tree species. Quantitative sampling of the vegetation will be performed between August 1 and November 30 at the end of the first year and after each growing season until the vegetation criteria is met.

In preparation for the quantitative sampling, 50 by 50 feet (0.05-acre) vegetative plots will be established in the reforested area. Plots will be evenly distributed throughout the site. For each plot, species composition and density will be reported. Photo points will be taken within each zone. Monitoring will take place once each year for five years.

Success will be determined by survival of target species within the sample plots. At least six different representative tree species should be present on the entire site. If the vegetative success criteria are not met, the cause of failure will be determined and appropriate corrective action will be taken.

6.3 MACROINVERTEBRATES

A monitoring period of 3 to 5 years is commonly suggested to determine changes in macroinvertebrate populations within a newly restored stream. The North Carolina Wetlands Restoration Program will determine a macroinvertebrate monitoring policy.

7.0 REFERENCES

Amoroso, J.L., ed. 1999. *Natural Heritage Program List of the Rare Plant Species of North Carolina.* North Carolina Natural Heritage Program, Division of Parks and Recreation, North Carolina Department of Environment and Natural Resources. Raleigh, North Carolina.

Cowardin, L.M., V. Carter, F.C. Golet and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-79/31. U.S. Department of the Interior, Washington, DC.

Choate, J.R., J.K. Jones, Jr., and C. Jones. 1994. Handbook of Mammals of the South-Central States. Louisiana State University Press, Baton Rouge, Louisiana.

Doll, B. A., et al. 2000. Hydraulic Geometry Relationships for Urban Streams throughout the Piedmont of North Carolina. American Water Resources Association.

Godfrey, R.K., and J.W. Wooten. 1979. Aquatic and Wetland Plants of Southeastern United States. Monocotyledons. The University of Georgia Press, Athens, Georgia.

Godfrey, R.K., and J.W. Wooten. 1981. Aquatic and Wetland Plants of Southeastern United States. Dicotyledons. The University of Georgia Press, Athens, Georgia.

Harrelson, Cheryl, C.L. Rawlins and John Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. United States Department of Agriculture, Forest Service. General Technical Report RM-245.

Hey, Richard and Dave Rosgen. 1997. Fluvial Geomorphology for Engineers. Wildland Hydrology, Pagosa Springs, Colorado.

LeGrand, H.E., Jr. and S.P. Hall, eds. 1999. *Natural Heritage Program List of the Rare Animal Species of North Carolina.* North Carolina Natural Heritage Program, Division of Parks and Recreation, North Carolina Department of Environment and Natural Resources. Raleigh, North Carolina.

NCDENR. "Water Quality Stream Classifications for Streams in North Carolina." *Water Quality Section.* http://h2o.enr.state.nc.us/wqhome.html (16 July 2001).

Radford, A.E., H.E. Ahles and G.R. Bell. 1968. Manual of the Vascular Flora of the Carolinas. The University of North Carolina Press, Chapel Hill, North Carolina.

Rosgen, Dave. 1997. A Geomorphological Approach to Restoration of Incised Rivers. Wildland Hydrology. Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision.

Schafale, M. P. and A. S. Weakley. 1990. Classification of the Natural Communities of North Carolina: Third Approximation. North Carolina Natural Heritage Program. Raleigh, North Carolina

United States Department of Agriculture – Soil Conservation Service. December, 1977. "Soil Survey of Guilford County, North Carolina." US Government Printing Office, Washington, DC.

United States Fish and Wildlife Service. "Region 4, Southeast Region/Endangered Species." North Carolina Ecological Services. http://nc-es.fws.gov/ (August 2001).

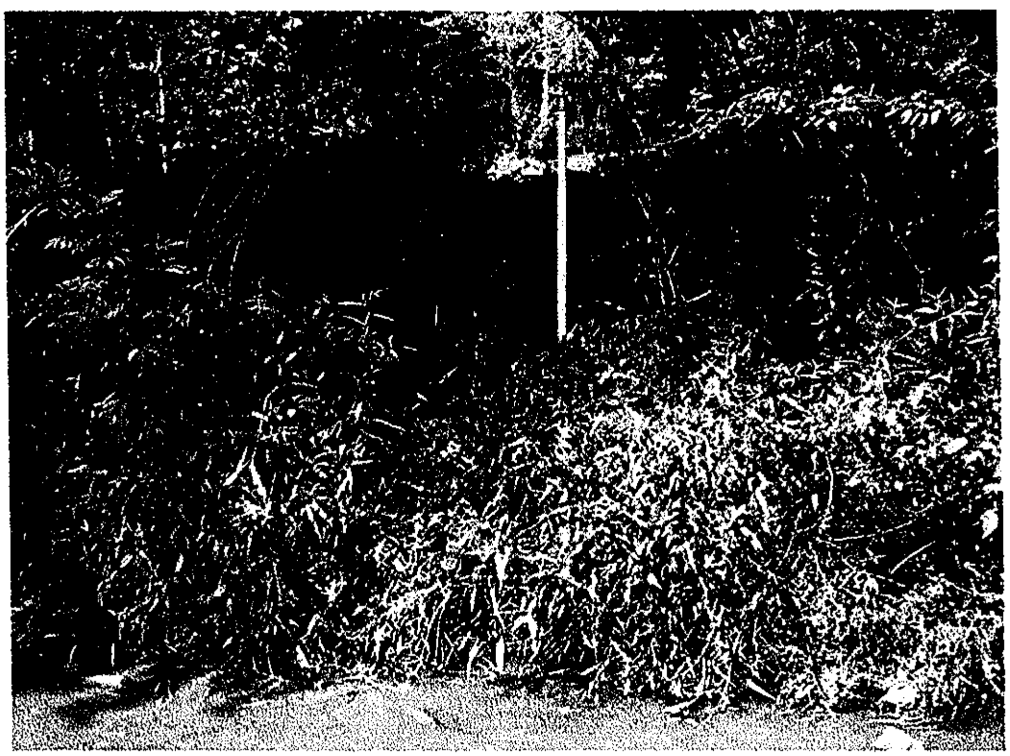
USDA, NRCS. 2001. The PLANTS Database, Version 3.1 (http://plants.usda.gov). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

Appendix A
Beaver Creek Photo Log
Existing Conditions

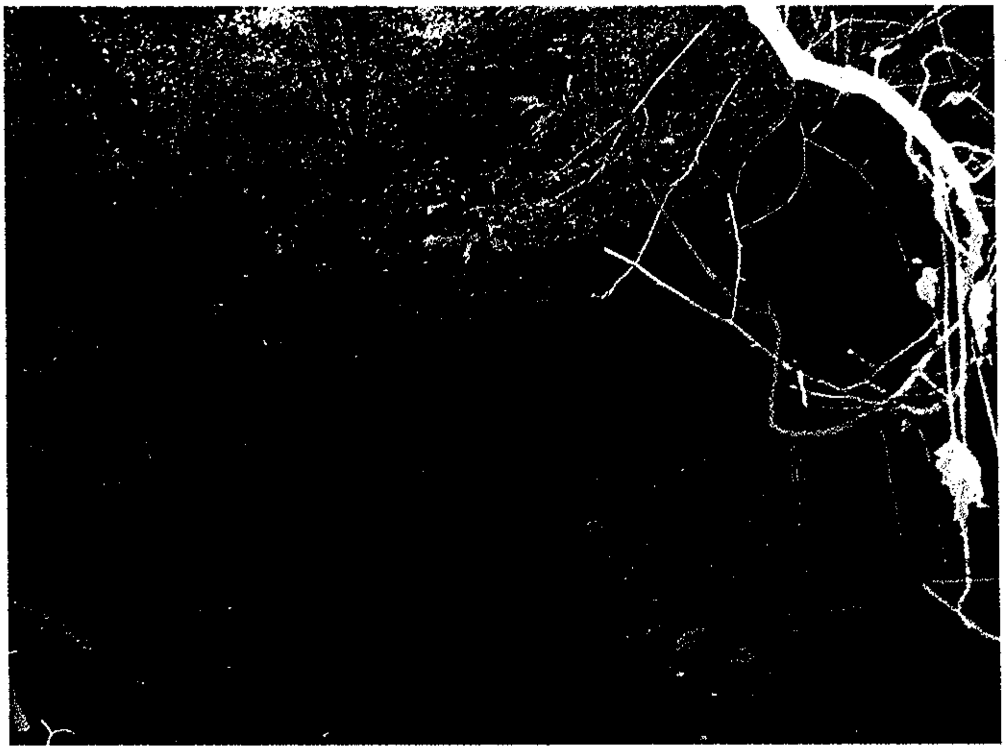
Picture 1. Bedrock outcropping near the start of the project.

Picture 2. Riffle cross-section at station 58+00.

Picture 3. Run cross-section at station 56+50.



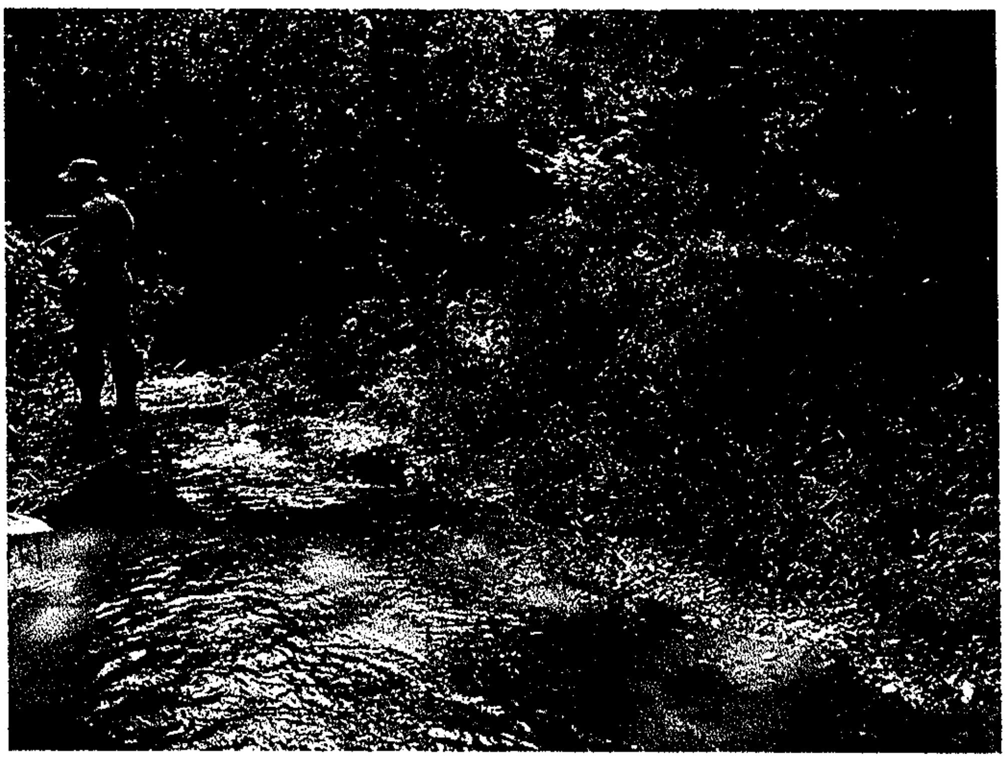
Picture 4. Bankfull Bench at run cross-section.



Picture 5. Pool cross-section at station 52+40.

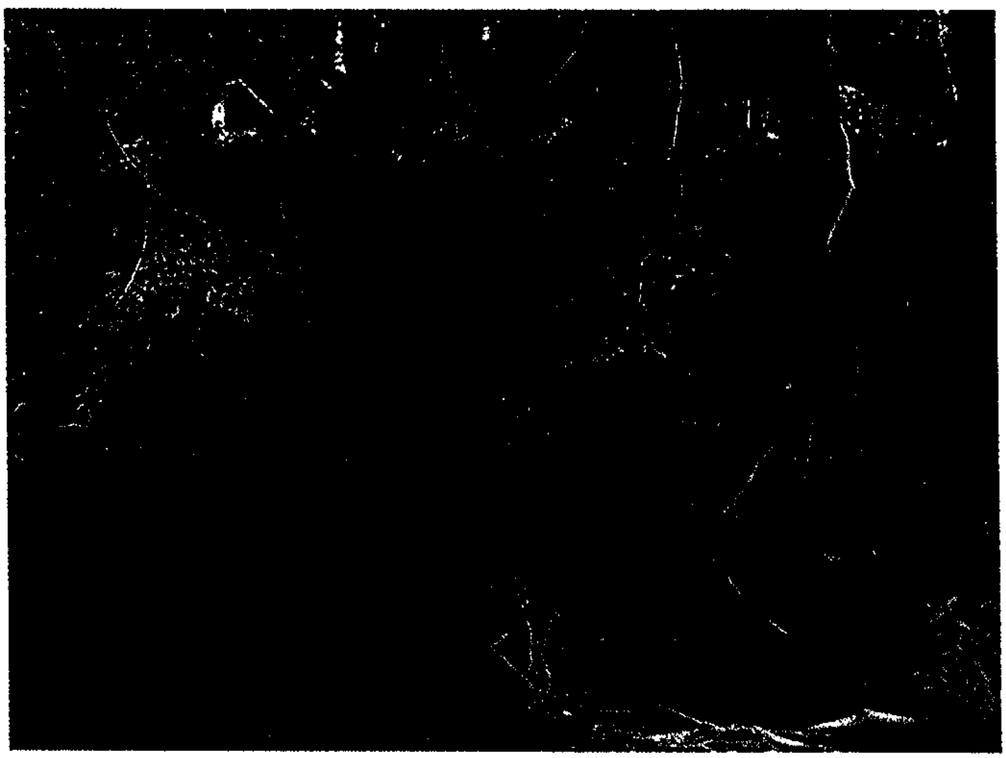
Picture 6. Point bar of pool cross-section.

Picture 7. Riffle cross-section at station 46+00 with central bar.



Picture 8. Pool cross-section at station 33+30.

Picture 9. Pool cross-section at station 17+20.



Picture 10. Pool cross-section at station at 13+20.

Picture 11. Existing bridge to be replaced.

Picture 12. Eroding bank with exposed roots.

Picture 13. Stream with no vegetation.

Picture 14. Overwidening channel with debris jam and central bar.

Picture 15. Mass wasting along one side of a central bar.

Picture 16. Central bar, typical throughout the mitigation site.

Summary of Cross Section Data

Prepared By: Ben Goetz, Dan Clinton and George Lankford
River Basin: Yadkin-Pee Dee
Watershed: Beaver Creek
Stream Reach:
Drainage Area (sq mi): 5.9
Date: 8/25/2001

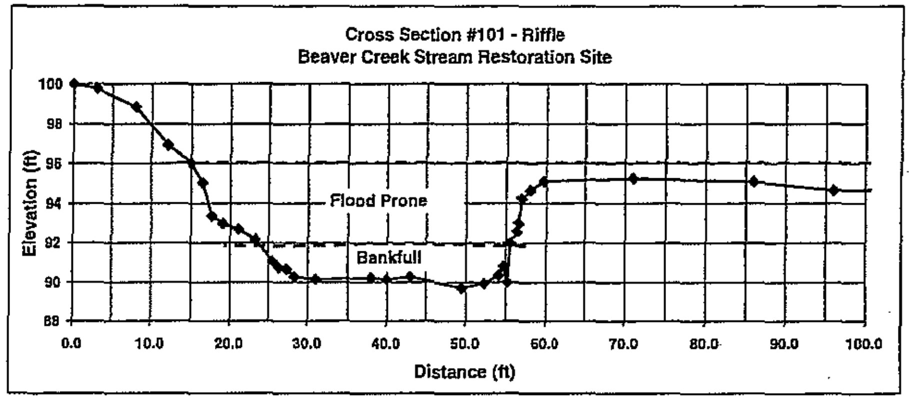
Parameter	Cross Section							
	101	102	103	104	105	106	107	108
Station	58+00	56+50	13+20	17+20	24+60	33+30	46+00	52+40
Feature	Riffle	Run	Pool	Pool	Riffle	Pool	Riffle	Pool
Stream Type	C	F	F	F	G	F	F	F
Bankfull Width, Wbkf (ft)	37.5	28.7	35.3	28.3	27.0	35.9	29.2	34.5
Bankfull Mean Depth, Dbkf (ft)	2.4	2.2	3.2	2.2	2.8	1.3	1.8	2.4
Width/Depth Ratio, Wbkf/Dbkf	15.7	13.1	10.9	12.7	9.5	27.5	16.0	14.6
Bkf Cross Sec Area, Abkf (sq ft)	89.7	63.1	113.9	63.0	76.4	46.8	53.3	81.5
Bank Height Ratio	1.6	2.0	1.7	2.5	2.0	2.0	2.4	1.8
Bankfull Maximum Depth, Dmax (ft)	3.3	3.3	5.3	4.1	3.3	3.8	2.5	4.2

Prepared By: Julie Elmore, Ben Goetz, Dan Clinton and George Lankford
River Basin: Yadkin-Pee Dee
Watershed: Beaver Creek
Cross Section #: 101
Drainage Area (sq mi): 5.9
Date: 8/27/2001
Station: 58+00
Feature: Riffle

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	0.00	100.00	
3.0	100.00	0.21	99.79	
8.0	100.00	1.16	98.84	
12.0	100.00	3.06	96.94	
15.0	100.00	3.97	96.03	
16.5	100.00	4.96	95.04	
17.6	100.00	6.63	93.37	
19.0	100.00	7.00	93.00	LBKF
21.0	100.00	7.30	92.70	
23.3	100.00	7.83	92.17	
25.5	100.00	8.92	91.08	
26.3	100.00	9.24	90.76	
27.3	100.00	9.32	90.68	
28.3	100.00	9.71	90.29	LEW
31.0	100.00	9.85	90.15	
38.0	100.00	9.76	90.24	
40.0	100.00	9.86	90.14	
43.0	100.00	9.71	90.29	
49.5	100.00	10.30	89.70	TW
52.3	100.00	10.05	89.95	
54.1	100.00	9.65	90.35	REW/WS
54.7	100.00	9.19	90.81	
55.2	100.00	9.98	90.02	
55.5	100.00	8.00	92.00	
56.3	100.00	7.43	92.57	
56.5	100.00	7.00	93.00	RBKF
56.9	100.00	5.76	94.24	
58.0	100.00	5.33	94.67	
59.7	100.00	4.88	95.12	RTOB
71.0	100.00	4.73	95.27	
86.0	100.00	4.90	95.10	
96.0	100.00	5.34	94.66	
121.0	100.00	5.26	94.74	
146.0	100.00	4.21	95.79	
171.0	100.00	2.95	97.05	
190.0	100.00	1.74	98.26	
211.0	100.00	0.55	99.45	

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0.0	0.00	0
2.0	0.30	0.30
2.3	0.83	1.30
2.2	1.92	3.03
0.8	2.24	1.66
1.0	2.32	2.28
1.0	2.71	2.52
2.7	2.85	7.51
7.0	2.76	19.64
2.0	2.86	5.62
3.0	2.71	8.36
6.5	3.30	19.53
2.8	3.05	8.89
1.8	2.65	5.13
0.6	2.19	1.45
0.5	2.98	1.29
0.3	1.00	0.60
0.8	0.43	0.57
0.2	0.00	0.04
37.5	SUM	89.71



Summary Data

BKF A	89.7	sq ft
BKF W	37.5	ft
Max d	3.3	ft
Mean d	2.4	ft
W/D Ratio	15.7	
FPW	156.0	approx.
Entrenchment Ratio	4.16	
Stream Type	C	
Bank Height Ratio	1.6	

NC Regional Curve (Rural)

Watershed Size	6.0	sq mi
Bkf Area	72.5	sq ft
Bkf Width	27.0	ft
Bkf Depth	2.7	ft
CN #		
Discharge	323.5	cfs

BANK EROSION POTENTIAL

Date: 8/27/2001
Stream: Beaver Creek
Feature: Riffle
Station: 101
Notes: In more stable section near bedrock

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	2	7.9
Root Depth/Bank Ht	1.0 - 0.9	1.0 - 1.9	0.89 - 0.50	2.0 - 3.9	0.49 - 0.30	4.0 - 5.9	0.29 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.55	3.5
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	25	7.5
Bank Angle (Degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	80	5.9
Surface Protection (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	10 - 15	8.0 - 9.0	< 10	10	11	9.0
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		Sub-total:	33.8
													Adjustments:	0
													TOTAL	33.8
													Bank Erosion Potential:	High

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	Julie Elmore, Ben Goetz, Dan Clinton and George Lankford
River Basin:	Yadkin-Pee Dee
Watershed:	Beaver Creek
Cross Section #:	102
Drainage Area (sq mi):	6.0
Date:	8/27/2001
Station:	56+50
Feature:	Run

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	5.30	94.70	
11.0	100.00	4.75	95.25	
15.0	100.00	4.99	95.01	
20.0	100.00	4.75	95.25	
25.0	100.00	5.16	94.84	LTOB
27.5	100.00	6.20	93.80	
29.5	100.00	7.14	92.86	
30.0	100.00	8.36	91.64	LBKF
31.0	100.00	8.83	91.17	
32.5	100.00	9.79	90.21	
33.1	100.00	10.25	89.75	
34.0	100.00	10.71	89.29	
34.5	100.00	11.00	89.00	LEW/WS
37.0	100.00	11.32	88.68	
39.0	100.00	11.47	88.53	
43.0	100.00	11.55	88.45	
45.2	100.00	11.61	88.39	TW
48.0	100.00	11.23	88.77	
48.9	100.00	11.34	88.66	
49.8	100.00	11.00	89.00	REW/WS
51.0	100.00	10.20	89.80	
53.5	100.00	9.71	90.29	
54.6	100.00	9.72	90.28	
57.0	100.00	8.85	91.15	
58.7	100.00	8.45	91.64	RBKF
60.7	100.00	7.50	92.50	
61.3	100.00	4.97	95.03	
62.5	100.00	4.35	95.65	RTOB
68.0	100.00	4.62	95.38	
74.0	100.00	5.15	94.85	
84.0	100.00	4.96	95.04	
90.0	100.00	4.46	95.54	
110.0	100.00	1.19	98.81	
135.0	100.00	0.65	99.35	

BKF Hydraulic Geometry

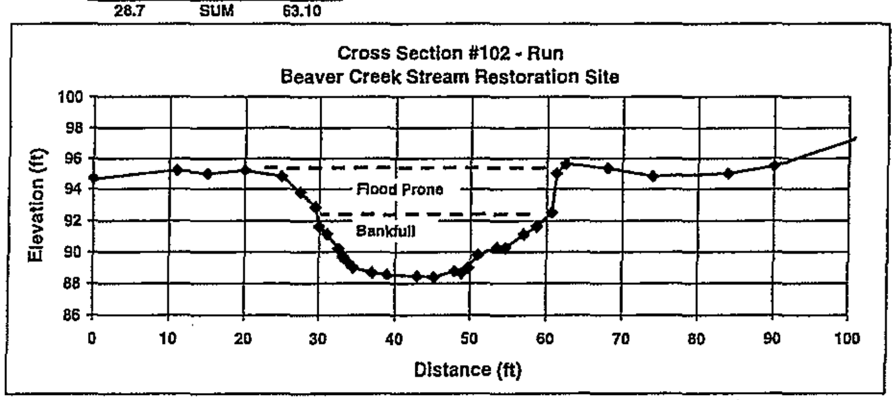
Width Feet	Depth Feet	Area Sq. Ft.
0.0	0.00	0
1.0	0.47	0.23
1.5	1.43	1.42
0.6	1.89	1.00
0.9	2.35	1.91
0.5	2.64	1.25
2.5	2.96	7.00
2.0	3.11	6.07
4.0	3.19	12.60
2.2	3.25	7.08
2.8	2.87	8.57
0.9	2.98	2.63
0.9	2.64	2.53
1.2	1.84	2.69
2.5	1.35	3.99
1.1	1.36	1.49
2.4	0.49	2.22
1.7	0.00	0.42
28.7	SUM	63.10

Summary Data

BKF A	63.1	sq ft
BKF W	28.7	ft
Max d	3.3	ft
Mean d	2.2	ft
W/D Ratio	13.1	
FPW	62.0	approx.
Entrenchment Ratio	2.16	
Stream Type	F	
Bank Height Ratio	2.0	

NC Regional Curve (Rural)

Watershed Size	6.0	sq mi
Bkf Area	72.5	sq ft
Bkf Width	27.0	ft
Bkf Depth	2.7	ft
CN #		
Discharge	323.5	cfs



BANK EROSION POTENTIAL

Date: 8/27/2001
Stream: Beaver Creek
Feature: Run
Station: 102
Notes: In area where stream was proviously wider and has now narrowed.

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	2	7.9
Root Depth/Bank Ht	1.0 - 0.9	1.0 - 1.9	0.89 - 0.50	2.0 - 3.9	0.49 - 0.30	4.0 - 5.9	0.29 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.55	3.5
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	25	7.5
Bank Angle (Degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	80	5.9
Surface Protection (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	10 - 15	8.0 - 9.0	< 10	10	11	9.0
TOTALS		5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50	Sub-total:	33.8
													Adjustments:	0
													TOTAL	33.8
													Bank Erosion Potential:	High

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

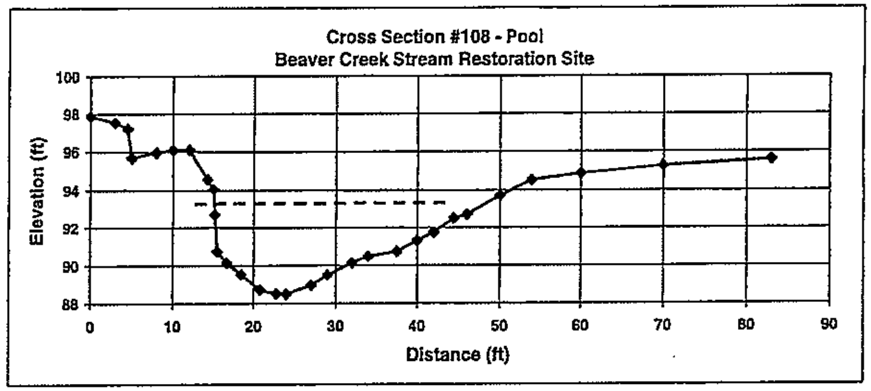
Beaver Creek Stream Restoration
Wetlands Restoration Program

Prepared By:	Ben Goetz, Dan Clinton and George Lankford
River Basin:	Yadkin-Pee Dee
Watershed:	Beaver Creek
Cross Section #:	108
Drainage Area (sq mi):	6.0
Date:	8/27/2001
Station:	52+40
Feature:	Pool

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	2.13	97.87	
3.0	100.00	2.46	97.54	
4.5	100.00	2.78	97.22	
5.0	100.00	4.30	95.70	
8.0	100.00	4.03	95.97	
10.0	100.00	3.90	96.10	
12.0	100.00	3.89	96.11	
14.3	100.00	5.43	94.57	
15.0	100.00	5.94	94.06	
15.2	100.00	7.30	92.70	LBKF
15.5	100.00	9.24	90.76	
16.7	100.00	9.85	90.15	LEW
18.5	100.00	10.46	89.54	
20.8	100.00	11.30	88.70	
22.8	100.00	11.49	88.51	
24.0	100.00	11.52	88.48	TW
27.0	100.00	11.04	88.96	
29.0	100.00	10.48	89.52	
32.0	100.00	9.86	90.14	REW/WS
34.0	100.00	9.50	90.50	
37.5	100.00	9.25	90.75	
40.0	100.00	8.68	91.32	
42.0	100.00	8.26	91.74	
44.4	100.00	7.49	92.51	
46.0	100.00	7.30	92.70	RBKF
50.0	100.00	6.29	93.71	
54.0	100.00	5.47	94.53	RTOB
60.0	100.00	5.14	94.86	
70.0	100.00	4.72	95.28	
83.0	100.00	4.40	95.60	

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0.0	0.00	0
1.2	1.94	1.16
1.8	2.55	4.04
2.3	3.16	6.57
2.0	4.00	7.16
1.2	4.19	4.91
3.0	4.22	12.62
2.0	3.74	7.96
3.0	3.18	10.38
2.0	2.56	5.74
3.5	2.20	8.33
2.5	1.95	5.19
2.0	1.38	3.33
2.4	0.96	2.81
1.6	0.19	0.92
4.0	0.00	0.38
34.5	SUM	81.5



Summary Data

BKF A	81.5	sq ft
BKF W	34.5	ft
Max d	4.2	ft
Mean d	2.4	ft
W/D Ratio	14.6	
Stream Type	F	
Bank Height Ratio	1.8	

BANK EROSION POTENTIAL

Date: 8/27/2001
Stream: Beaver Creek
Feature: Pool
Station: 108
Notes: Big meander near the beginning of the project

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME			
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE OBSERVED	SCORE
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1.8	7.0
Root Depth/Bank Ht	1.0 - 0.9	1.0 - 1.9	0.89 - 0.50	2.0 - 3.9	0.49 - 0.30	4.0 - 5.9	0.29 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.15	7.9
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	5	9.0
Bank Angle (Degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	60	3.9
Surface Protection (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	10 - 15	8.0 - 9.0	< 10	10	5	10.0
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		Sub-total:	37.8
													Adjustments:	0
													TOTAL	37.8
													Bank Erosion Potential:	High

Adjustments

Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By: Ben Goetz, Dan Clinton and George Lankford
River Basin: Yadkin-Pee Dee
Watershed: Beaver Creek
Cross Section #: 107
Drainage Area (sq mi): 6.0
Date: 8/27/2001
Station: 46+00
Feature: Riffle

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	4.52	95.48	
12.0	100.00	5.04	94.96	
21.0	100.00	4.61	95.39	
27.0	100.00	4.95	95.05	
31.0	100.00	4.81	95.19	LTOB
33.0	100.00	5.37	94.63	
35.0	100.00	6.84	93.16	
36.0	100.00	7.58	92.42	
37.0	100.00	8.27	91.73	LBKF
37.7	100.00	8.92	91.08	
37.9	100.00	10.46	89.54	LEW
40.6	100.00	10.57	89.43	
45.5	100.00	10.31	89.69	Start of central bar
47.0	100.00	9.59	90.41	
50.5	100.00	9.67	90.33	
51.4	100.00	10.14	89.86	
56.7	100.00	10.03	89.97	
58.9	100.00	10.18	89.82	end of central bar/WS
60.0	100.00	10.25	89.75	
61.8	100.00	10.59	89.41	
63.3	100.00	10.73	89.27	TW
64.7	100.00	10.34	89.66	REW
64.9	100.00	9.18	90.82	
66.0	100.00	8.41	91.59	
66.2	100.00	8.27	91.73	RBKF
66.3	100.00	7.98	92.02	
67.0	100.00	7.72	92.28	
67.4	100.00	4.96	95.04	
70.0	100.00	4.32	95.68	RTOB
78.0	100.00	4.83	95.17	
87.0	100.00	4.93	95.07	
95.0	100.00	4.55	95.45	
103.0	100.00	4.10	95.90	

BKF Hydraulic Geometry

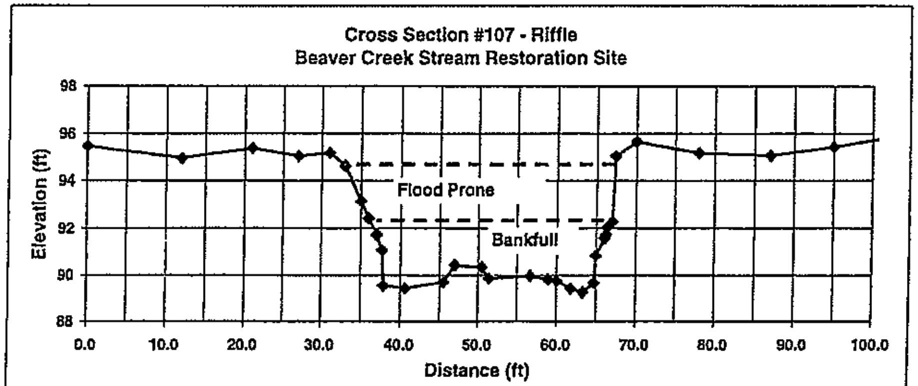
Width Feet	Depth Feet	Area Sq. Ft.
0.0	0.00	0
0.7	0.65	0.23
0.2	2.19	0.28
2.7	2.30	6.06
4.9	2.04	10.63
1.5	1.32	2.52
3.5	1.40	4.76
0.9	1.87	1.47
5.3	1.76	9.62
2.2	1.91	4.04
1.1	1.98	2.14
1.8	2.32	3.87
1.5	2.46	3.59
1.4	2.07	3.17
0.2	0.91	0.30
1.1	0.14	0.58
0.2	0.00	0.01
29.2	SUM	53.27

Summary Data

BKF A	53.3	sq ft
BKF W	29.2	ft
Max d	2.5	ft
Mean d	1.8	ft
W/D Ratio	16.0	
FPW	34.4	approx.
Entrenchment Ratio	1.2	
Stream Type	F	
Bank Height Ratio	2.4	

NC Regional Curve (Rural)

Watershed Size	6.0	sq mi
Bkf Area	72.5	sq ft
Bkf Width	27.0	ft
Bkf Depth	2.7	ft
CN #		
Discharge	323.5	cfs



BANK EROSION POTENTIAL

Date: 8/27/2001
Stream: Beaver Creek
Feature: Riffle
Station: 107
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	2.4	7.0
Root Depth/Bank Ht	1.0 - 0.9	1.0 - 1.9	0.89 - 0.50	2.0 - 3.9	0.49 - 0.30	4.0 - 5.9	0.29 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.4	5.0
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	50	5.5
Bank Angle (Degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	65	4.5
Surface Protection (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	10 - 15	8.0 - 9.0	< 10	10	50	5.5
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		Sub-total:	27.5
													Adjustments:	0
													TOTAL	27.5
													Bank Erosion Potential:	Moderate

Adjustments

Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

Beaver Creek Stream Restoration
Wetlands Restoration Program

Prepared By:	Julie Elmore, Ben Goetz, Dan Clinton and George Lankford
River Basin:	Yadkin-Pee Dee
Watershed:	Beaver Creek
Cross Section #:	106
Drainage Area (sq mi):	6.0
Date:	8/27/2001
Station:	33+30
Feature:	Pool

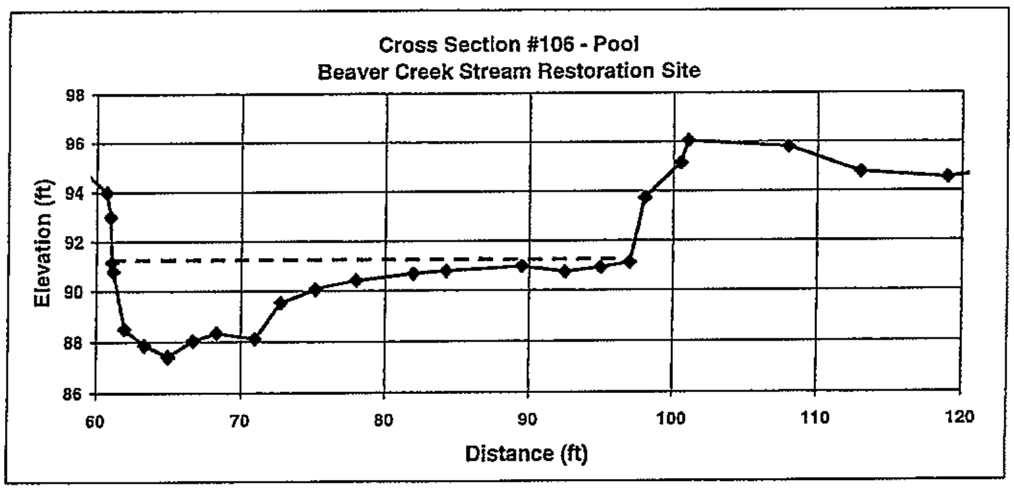
Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	5.37	94.63	
21.0	100.00	4.70	95.30	
33.0	100.00	4.38	95.62	
42.0	100.00	4.33	95.67	
50.5	100.00	4.02	95.98	
55.0	100.00	4.56	95.44	
59.0	100.00	5.12	94.88	LTOB
60.7	100.00	6.02	93.98	
61.0	100.00	7.00	93.00	slump
61.1	100.00	8.82	91.18	
61.2	100.00	9.20	90.80	LBKF
62.0	100.00	11.48	88.52	LEW
63.4	100.00	12.13	87.87	
65.0	100.00	12.57	87.43	TW
66.7	100.00	11.95	88.05	
68.3	100.00	11.65	88.35	
71.0	100.00	11.88	88.12	REW/WS
72.8	100.00	10.46	89.54	
75.2	100.00	9.93	90.07	
78.0	100.00	9.57	90.43	
82.0	100.00	9.30	90.70	
84.3	100.00	9.20	90.80	RBKF
89.5	100.00	9.02	90.98	
92.5	100.00	9.25	90.75	cut through
95.0	100.00	9.07	90.93	
97.0	100.00	8.86	91.14	edge of bank
98.0	100.00	6.27	93.73	
100.5	100.00	4.86	95.14	
101.0	100.00	3.94	96.06	RTOB
108.0	100.00	4.20	95.80	
113.0	100.00	5.22	94.78	
119.0	100.00	5.46	94.54	
123.0	100.00	5.12	94.88	
133.0	100.00	4.96	95.04	
144.0	100.00	4.55	95.45	
153.0	100.00	3.58	96.42	edge of road
162.0	100.00	2.60	97.40	edge of road

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0.1	0.38	0.02
0.8	2.66	1.22
1.4	3.31	4.18
1.6	3.75	5.65
1.7	3.13	5.85
1.6	2.83	4.77
2.7	3.06	7.95
1.8	1.64	4.23
2.4	1.11	3.30
2.8	0.75	2.60
4.0	0.48	2.46
2.3	0.38	0.99
5.2	0.20	1.51
3.0	0.43	0.95
2.5	0.25	0.85
2.0	0.04	0.29
35.9	SUM	46.81

Summary Data

BKF A	46.8	
BKF W	35.9	
Max d	3.8	
Mean d	1.3	
W/D Ratio	27.5	sq ft
Stream Type	F	ft
Bank Height Ratio	2.0	ft
		ft



BANK EROSION POTENTIAL

Date: 8/27/2001
Stream: Beaver Creek
Feature: Pool
Station: 106
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	2.2	8.3
Root Depth/Bank Ht	1.0 - 0.9	1.0 - 1.9	0.89 - 0.50	2.0 - 3.9	0.49 - 0.30	4.0 - 5.9	0.29 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.15	7.9
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	12	8.8
Bank Angle (Degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	70	5.2
Surface Protection (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	10 - 15	8.0 - 9.0	< 10	10	9	10.0
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		Sub-total:	40.2
													Adjustments:	0
													TOTAL	40.2
													Bank Erosion Potential:	Very High

Adjustments

Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	Julie Elmore, Ben Goetz, Dan Clinton and George Lankford
River Basin:	Yadkin-Pee Dee
Watershed:	Beaver Creek
Cross Section #:	105
Drainage Area (sq mi):	6.0
Date:	8/27/2001
Station:	24+60
Feature:	Riffle

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	3.80	96.20	
3.0	100.00	3.75	96.25	on road
7.0	100.00	5.55	94.45	on road
10.0	100.00	3.93	96.07	
15.0	100.00	6.28	93.72	LTOB
16.0	100.00	6.53	93.47	Top of slump
17.0	100.00	8.08	91.92	
17.7	100.00	8.65	91.35	Edge of slump
18.0	100.00	9.72	90.28	LBKF
18.2	100.00	12.40	87.60	WS
18.2	100.00	12.69	87.31	LEW
20.3	100.00	12.66	87.34	
23.5	100.00	12.62	87.38	
26.8	100.00	12.61	87.39	
30.0	100.00	12.77	87.23	
32.9	100.00	12.84	87.16	
35.0	100.00	12.64	87.36	
38.8	100.00	12.84	87.16	
40.0	100.00	13.01	86.99	TW
42.0	100.00	12.72	87.28	
42.5	100.00	12.35	87.65	REW/WS
43.0	100.00	11.96	88.04	
43.8	100.00	10.81	89.19	
45.0	100.00	9.72	90.28	RBKF
46.0	100.00	9.03	90.97	
48.0	100.00	6.52	93.48	
50.0	100.00	6.16	93.84	
56.0	100.00	6.14	93.86	
60.0	100.00	6.32	93.68	RTOB
70.0	100.00	6.44	93.56	
81.0	100.00	6.21	93.79	
88.0	100.00	6.44	93.56	
94.0	100.00	6.34	93.66	
98.0	100.00	7.35	92.65	
100.0	100.00	8.15	91.85	
103.0	100.00	7.58	92.42	
107.0	100.00	6.24	93.76	

BKF Hydraulic Geometry

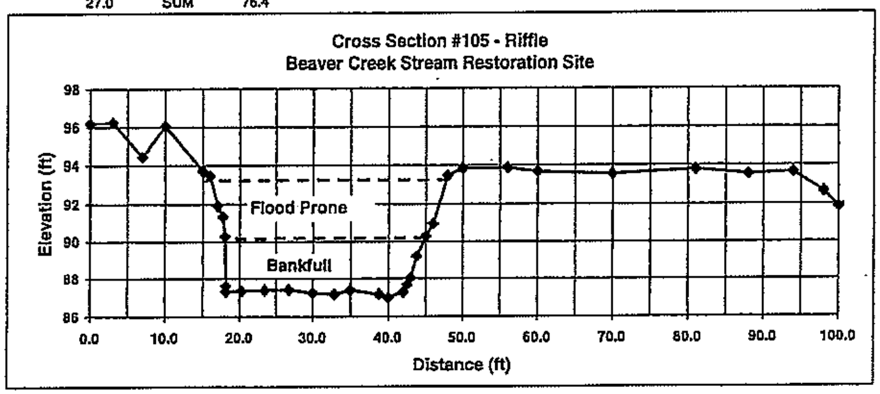
Width Feet	Depth Feet	Area Sq. Ft.
0.0	0.00	0
0.2	2.68	0.27
0.0	2.97	0.00
2.1	2.94	6.21
3.2	2.90	9.34
3.3	2.89	9.55
3.2	3.05	9.50
2.9	3.12	8.95
2.1	2.92	6.34
3.8	3.12	11.48
1.2	3.29	3.85
2.0	3.00	6.29
0.5	2.63	1.41
0.5	2.24	1.22
0.8	1.09	1.33
1.2	0.00	0.65
27.0	SUM	76.4

Summary Data

BKF A	76.4	sq ft
BKF W	27.0	ft
Max d	3.3	ft
Mean d	2.8	ft
W/D Ratio	9.5	
FPW	35.0	approx.
Entrenchment Ratio	1.3	
Stream Type	G	
Bank Height Ratio	2.0	

NC Regional Curve (Rural)

Watershed Size	6.0	sq mi
Bkf Area	72.5	sq ft
Bkf Width	27.0	ft
Bkf Depth	2.7	ft
CN #		
Discharge	323.5	cfs



BANK EROSION POTENTIAL

Date: 8/27/2001
Stream: Beaver Creek
Feature: Riffle
Station: 105
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	2	7.9
Root Depth/Bank Ht	1.0 - 0.9	1.0 - 1.9	0.89 - 0.50	2.0 - 3.9	0.49 - 0.30	4.0 - 5.9	0.29 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.2	7.5
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	9	8.5
Bank Angle (Degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	115	8.5
Surface Protection (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	10 - 15	8.0 - 9.0	< 10	10	5	10.0
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		Sub-total:	42.4
													Adjustments:	0
													TOTAL	42.4
													Bank Erosion Potential:	Very High

Adjustments
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

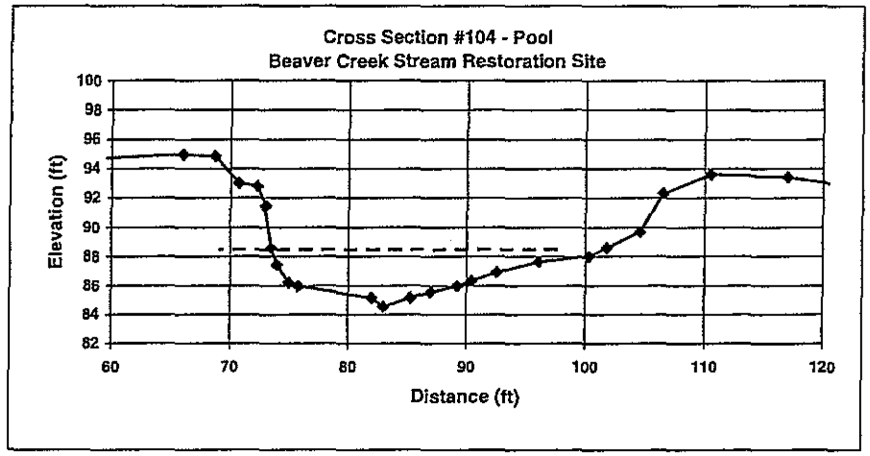
Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By: Julie Elmore, Ben Goetz, Dan Clinton and George Lankford
River Basin: Yadkin-Pee Dee
Watershed: Beaver Creek
Cross Section #: 104
Drainage Area (sq mi): 6.0
Date: 8/27/2001
Station: 17+20
Feature: Pool

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	1.19	98.81	
12.0	100.00	3.67	96.33	
25.0	100.00	4.90	95.10	
44.5	100.00	5.61	94.39	Toe of slope
57.0	100.00	5.36	94.64	
66.0	100.00	5.03	94.97	
68.7	100.00	5.14	94.86	LTOB
70.7	100.00	6.98	93.02	slump
72.3	100.00	7.19	92.81	
73.0	100.00	8.55	91.45	
73.5	100.00	11.38	88.62	LBKF
74.0	100.00	12.56	87.44	
75.0	100.00	13.80	86.20	
75.8	100.00	14.03	85.97	LEW
82.0	100.00	14.84	85.16	
83.0	100.00	15.45	84.55	TW
85.3	100.00	14.83	85.17	
87.0	100.00	14.45	85.55	
89.2	100.00	14.03	85.97	REW/WS
90.4	100.00	13.66	86.34	
92.5	100.00	13.08	86.92	
96.0	100.00	12.35	87.65	
100.3	100.00	12.00	88.00	
101.8	100.00	11.38	88.62	RBKF
104.6	100.00	10.32	89.68	
106.5	100.00	7.68	92.32	
110.5	100.00	6.37	93.63	RTOB
117.0	100.00	6.56	93.44	
124.0	100.00	7.41	92.59	
138.0	100.00	7.92	92.08	Edge of field
151.0	100.00	7.85	92.15	
174.0	100.00	7.99	92.01	
200.0	100.00	7.85	92.15	

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0.0	0.00	0
0.5	1.18	0.30
1.0	2.42	1.80
0.8	2.65	2.03
6.2	3.46	18.94
1.0	4.07	3.77
2.3	3.45	8.65
1.7	3.07	5.54
2.2	2.65	6.29
1.2	2.28	2.96
2.1	1.70	4.18
3.5	0.97	4.67
4.3	0.62	3.42
1.5	0.00	0.47
28.3	SUM	63.00



<u>Summary Data</u>

BKF A	63.0	sq ft
BKF W	28.3	ft
Max d	4.1	ft
Mean d	2.2	ft
W/D Ratio	12.7	
Stream Type	F	
Bank Height Ratio	2.5	

NC Regional Curve (Rural)
Watershed Size 6.0 sq mi

BANK EROSION POTENTIAL

Date: 8/27/2001
Stream: Beaver Creek
Feature: Pool
Station: 104
Notes:

CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME		VALUE OBSERVED	SCORE
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX		
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	2.5	8.5
Root Depth/Bank Ht	1.0 - 0.9	1.0 - 1.9	0.89 - 0.50	2.0 - 3.9	0.49 - 0.30	4.0 - 5.9	0.29 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.1	8.5
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	10	8.5
Bank Angle (Degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	62	4.1
Surface Protection (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	10 - 15	8.0 - 9.0	< 10	10	15	8.0
TOTALS	5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50		Sub-total:	37.6
													Adjustments:	0
													TOTAL	37.6
													Bank Erosion Potential:	High

Adjustments

Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

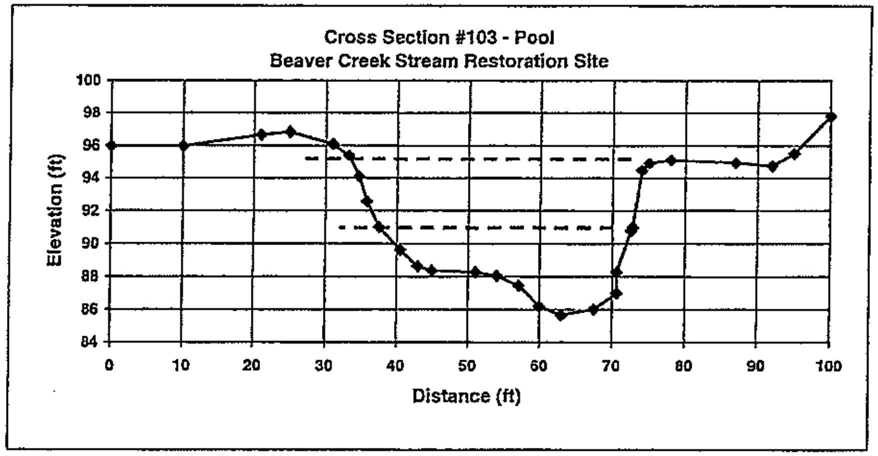
Stratification - 5 to 10 point upward adjustment depending on location of layers

Prepared By:	Julie Elmore, Ben Goetz, Dan Clinton and George Lankford
River Basin:	Yadkin-Pee Dee
Watershed:	Beaver Creek
Cross Section #:	103
Drainage Area (sq mi):	6.0
Date:	8/27/2001
Station:	13+20
Feature:	Pool

Station	HI Feet	FS Feet	Elevation Feet	Notes
0.0	100.00	4.01	95.99	
10.0	100.00	4.01	95.99	
21.0	100.00	3.36	96.64	
25.0	100.00	3.19	96.81	
31.0	100.00	3.91	96.09	LTOB
33.2	100.00	4.60	95.40	
34.7	100.00	5.90	94.10	
35.8	100.00	7.42	92.58	
37.5	100.00	9.00	91.00	LBKF
40.5	100.00	10.39	89.61	
43.0	100.00	11.38	88.62	
45.0	100.00	11.63	88.37	
51.0	100.00	11.73	88.27	LEW/WS
54.0	100.00	11.95	88.05	
57.0	100.00	12.54	87.46	
60.0	100.00	13.80	86.20	
63.0	100.00	14.34	85.66	TW
67.5	100.00	13.98	86.02	
70.6	100.00	13.01	86.99	REW
70.6	100.00	11.73	88.27	WS
72.5	100.00	9.26	90.74	
72.8	100.00	9.00	91.00	RBKF
74.0	100.00	5.55	94.45	
75.0	100.00	5.10	94.90	RTOB
78.0	100.00	4.89	95.11	
87.0	100.00	5.06	94.94	
92.0	100.00	5.25	94.75	
95.0	100.00	4.48	95.52	
100.0	100.00	2.21	97.79	

BKF Hydraulic Geometry

Width Feet	Depth Feet	Area Sq. Ft.
0.0	0.00	0
0.0	0.00	0.00
3.0	1.39	2.09
2.5	2.38	4.71
2.0	2.63	5.01
6.0	2.73	16.08
3.0	2.95	8.52
3.0	3.54	9.73
3.0	4.80	12.51
3.0	5.34	15.21
4.5	4.98	23.22
3.1	4.01	13.93
0.0	2.73	0.00
1.9	0.26	2.84
0.3	0.00	0.04
35.3	SUM	113.90



Summary Data

BKF A	113.9	sq ft
BKF W	35.3	ft
Max d	5.3	ft
Mean d	3.2	ft
W/D Ratio	10.9	
Stream Type	F	
Bank Height Ratio	1.7	

NC Regional Curve (Rural)

Watershed Size 6.0 sq mi

BANK EROSION POTENTIAL

Date: 8/27/2001
Stream: Beaver Creek
Feature: Pool
Station: 103
Notes:

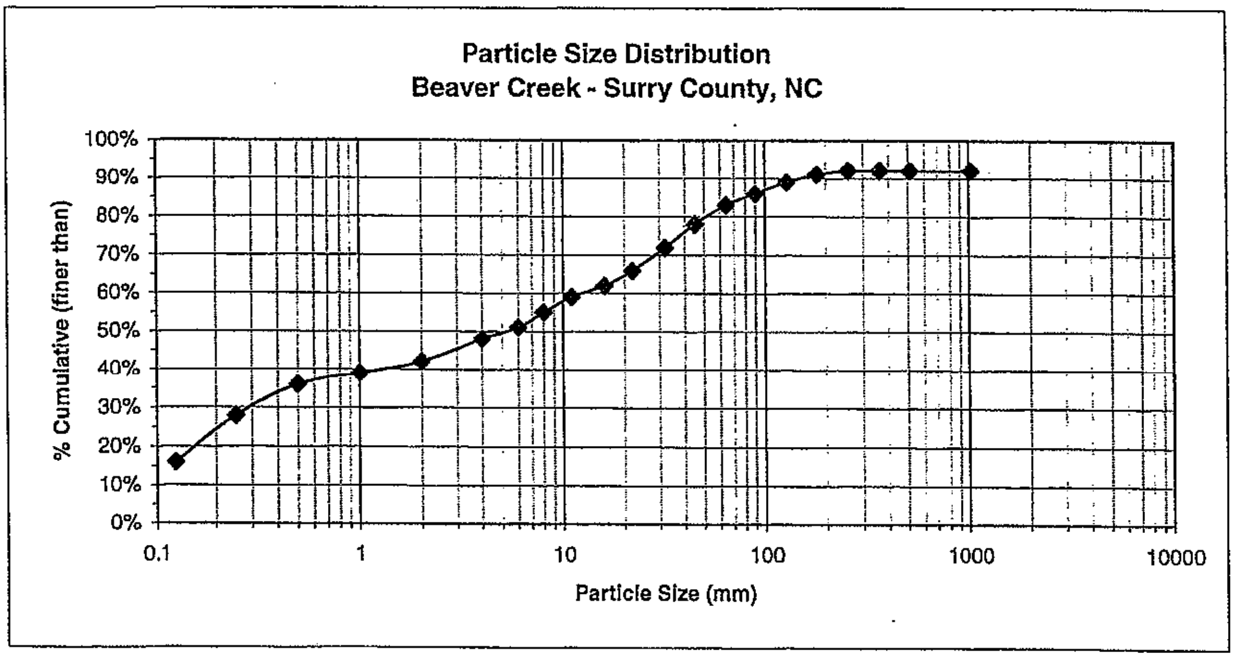
CRITERIA	VERY LOW		LOW		MODERATE		HIGH		VERY HIGH		EXTREME			
	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE	INDEX	VALUE OBSERVED	SCORE
Bank Height Ratio (Bank Ht/BKF Ht)	1.0 - 1.1	1.0 - 1.9	1.1 - 1.19	2.0 - 3.9	1.2 - 1.5	4.0 - 5.9	1.6 - 2.0	6.0 - 7.9	2.1 - 2.8	8.0 - 9.0	> 2.8	10	1.7	6.5
Root Depth/Bank Ht	1.0 - 0.9	1.0 - 1.9	0.89 - 0.50	2.0 - 3.9	0.49 - 0.30	4.0 - 5.9	0.29 - 0.15	6.0 - 7.9	0.14 - 0.05	8.0 - 9.0	< 0.05	10	0.2	7.5
Root Density (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	5 - 14	8.0 - 9.0	< 5.0	10	4	10.0
Bank Angle (Degrees)	0 - 20	1.0 - 1.9	21 - 60	2.0 - 3.9	61 - 80	4.0 - 5.9	81 - 90	6.0 - 7.9	91 - 119	8.0 - 9.0	> 119	10	90	7.9
Surface Protection (%)	80 - 100	1.0 - 1.9	55 - 79	2.0 - 3.9	30 - 54	4.0 - 5.9	15 - 29	6.0 - 7.9	10 - 15	8.0 - 9.0	< 10	10	5	10.0
TOTALS		5.0 - 9.5		10 - 19.5		20 - 29.5		30 - 39.5		40 - 45		46 - 50	Sub-total:	41.9
													Adjustments:	0
													TOTAL	41.9
													Bank Erosion Potential:	Very High

Adjustments

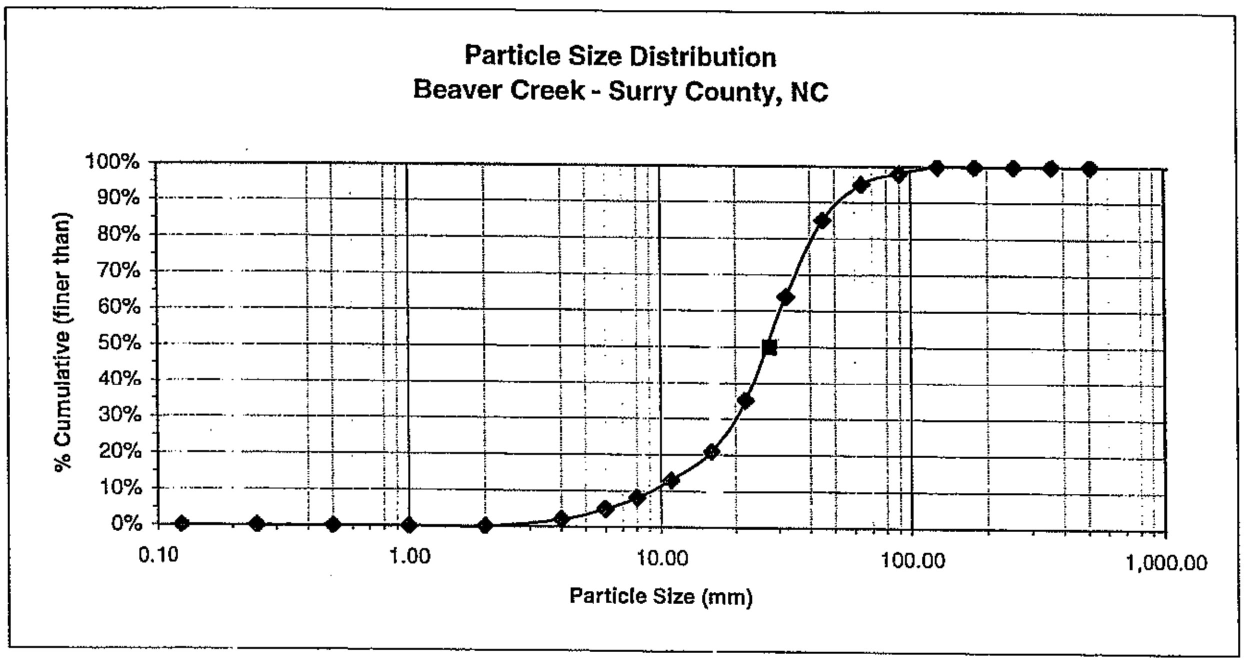
Bedrock - Bank Erosion Potential Always Very Low
Boulders - Bank Erosion Potential Always Low
Gravel - Adjust value up by 5 to 10 points depending on composition of sand
Sand - Adjust values up by 10 points

Stratification - 5 to 10 point upward adjustment depending on location of layers

PEBBLE COUNT									
Site: Beaver Creek						8/27/2001			
Party: Ben Goetz, George Lankford, Dan Clinton						Reach: WRP Restoration			
				Particle Counts					
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	6	5	11	11%	11%
	Very Fine	.062 - .125	S	1	4	5	5%	16%
	Fine	.125 - .25	A	5	7	12	12%	28%
	Medium	.25 - .50	N	2	6	8	8%	36%
	Coarse	.50 - 1.0	D	0	3	3	3%	39%
.04 -.08	Very Coarse	1.0 - 2.0	S	0	3	3	3%	42%
.08 - .16	Very Fine	2.0 - 4.0		3	3	6	6%	48%
.16 - .22	Fine	4.0 - 5.7	G	2	1	3	3%	51%
.22 - .31	Fine	5.7 - 8.0	R	3	1	4	4%	55%
.31 - .44	Medium	8.0 - 11.3	A	2	2	4	4%	59%
.44 - .63	Medium	11.3 - 16.0	V	2	1	3	3%	62%
.63 - .89	Coarse	16.0 - 22.6	E	4	0	4	4%	66%
.89 - 1.26	Coarse	22.6 - 32.0	L	3	3	6	6%	72%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	4	2	6	6%	78%
1.77 - 2.5	Very Coarse	45.0 - 64.0		4	1	5	5%	83%
2.5 - 3.5	Small	64 - 90	C	3	0	3	3%	86%
3.5 - 5.0	Small	90 - 128	O	3	0	3	3%	89%
5.0 - 7.1	Large	128 - 180	B	1	1	2	2%	91%
7.1 - 10.1	Large	180 - 256	L	1	0	1	1%	92%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0%	92%
14.3 - 20	Small	362 - 512	L	0	0	0	0%	92%
20 - 40	Medium	512 - 1024	D	0	0	0	0%	92%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0%	92%
	Bedrock		BDRK	1	7	8	8%	100%
			Totals	50	50	100	100%	100%



PAVEMENT PEBBLE COUNT								
Site: Beaver Creek						12/3/2001		
Party: Ben Goetz and Dan Clinton						Reach: WRP Restoration		
				Particle Counts				
Inches	Particle	Millimeter		Riffles	Pools	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0	0	0	0%	0%
	Very Fine	.062 - .125	S	0	0	0	0%	0%
	Fine	.125 - .25	A	0	0	0	0%	0%
	Medium	.25 - .50	N	0	0	0	0%	0%
	Coarse	.50 - 1.0	D	0	0	0	0%	0%
.04 -.08	Very Coarse	1.0 - 2.0	S	0	0	0	0%	0%
.08 - .16	Very Fine	2.0 - 4.0		2	0	2	2%	2%
.16 - .22	Fine	4.0 - 5.7	G	3	0	3	3%	5%
.22 - .31	Fine	5.7 - 8.0	R	3	0	3	3%	8%
.31 - .44	Medium	8.0 - 11.3	A	5	0	5	5%	13%
.44 - .63	Medium	11.3 - 16.0	V	8	0	8	8%	21%
.63 - .89	Coarse	16.0 - 22.6	E	14	0	14	14%	35%
.89 - 1.26	Coarse	22.6 - 32.0	L	29	0	29	29%	64%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	21	0	21	21%	85%
1.77 - 2.5	Very Coarse	45.0 - 64.0		10	0	10	10%	95%
2.5 - 3.5	Small	64 - 90	C	3	0	3	3%	98%
3.5 - 5.0	Small	90 - 128	O	2	0	2	2%	100%
5.0 - 7.1	Large	128 - 180	B	0	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0%	100%
	Bedrock		BDRK	0	0	0	0%	100%
			Totals	100	0	100	100%	100%

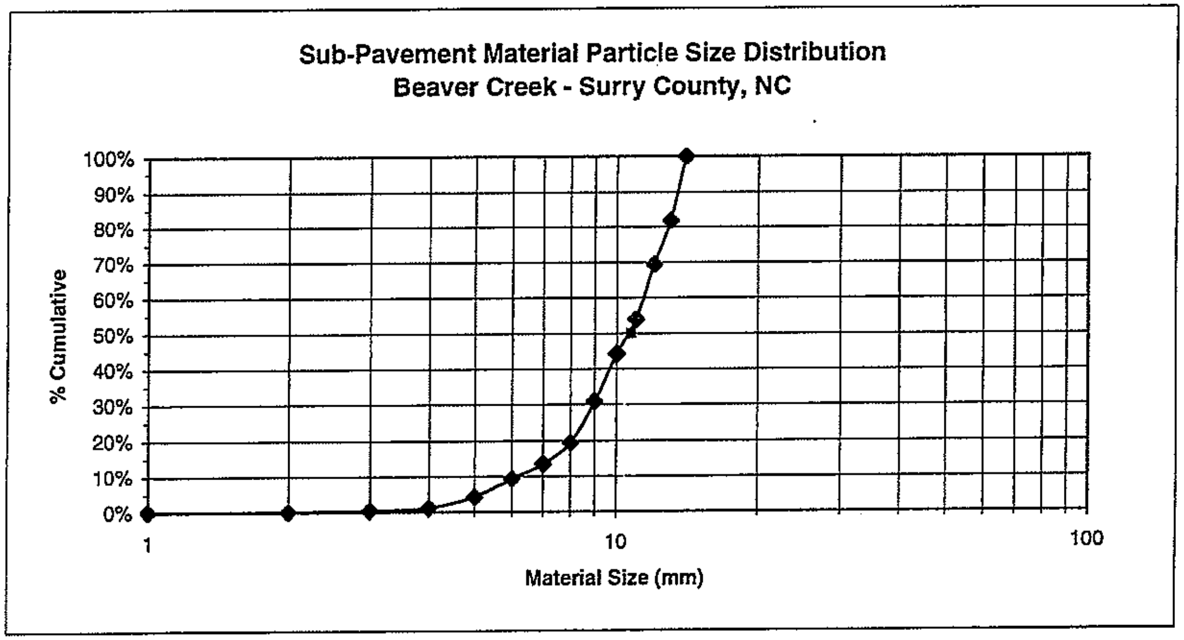


BEAVER CREEK RESTORATION PROJECT
Entrainment Calculation

Sub Pavement Sample
Beaver Creek
12/3/2001

Sieve Size (mm)	<0.0085	0.075	0.106	0.25	0.3	0.6	0.85	1.18	2	4.75	9.5	12.7	19	25	
micro		75	106	250	300	600	850								
Tare Weight(lbs)	0.78	0.72	0.74	0.79	0.8	0.84	0.92	0.92	1	1.09	1.17	1.19	1.25	1.25	
Sample Weight (lbs)	0.79	0.73	0.79	0.89	1.28	1.58	1.54	1.8	2.72	3.08	2.62	3.51	3.12	3.96	TOTAL
Net Sample Weight(lbs)	0.01	0.01	0.05	0.1	0.48	0.74	0.62	0.88	1.72	1.99	1.45	2.32	1.87	2.71	14.95 lbs
%	0%	0%	0%	1%	3%	5%	4%	6%	12%	13%	10%	16%	13%	18%	
% Cumulative	0%	0%	0%	1%	4%	9%	13%	19%	31%	44%	54%	69%	82%	100%	

D50 Subpavement	10.7 mm	50%
D50 Riffle Pavement	27.5 mm	
Tc=	0.037	
Largest Particle	0.23 ft	
Slope	0.006	
Depth required	2.53	
Area Required	70 sq ft	
Width/Depth Ratio	11.2	
Bankfull Width	28.0	
Design mean depth	2.50	



BASIN CREEK REFERENCE REACH - Rosgen Type C4
Location: Wilkes County, NC - Take Traphill Road to Long Bottom Road (SR 173:
Reach: Station 0+00 at confluence of Basin and Cove Creek
Quad Sheet: Whitehead, NC **Drainage Area:** 7.2 sq. mi.

LONGITUDINAL PROFILE

						Difference in Bankfull and Water Surface Elevations			Ratio of Low TOB to Max BKF Depth	
STA	Thalweg	LEW	REW	LBF	RBF	Diff (left)	Diff (rgt)	Low Top of Bank		Feature
0	95.2	97.0	97.0	99.4		2.4		100.6	1.3	TOP=Top of Pool
16	94.6	97.0	97.0	99.3		2.3				
33	95.0	97.0	97.0	99.4		2.4				
50	96.0	97.0	97.0	99.4		2.4				
53	96.2	96.9	96.9	99.4		2.5		99.8	1.1	SOG=Start of Glide
66	95.7	96.6	96.6	99.3	99.3	2.7	2.7	99.6	1.1	Glide X-Section
76	96.0	96.3	96.3	98.9		2.6				TOR=Top of Riffle
111	95.3	95.4	95.4	98.0		2.6				
143	94.0	94.6	94.6	97.1		2.5		98.1	1.3	
202	93.6	93.9	93.9	96.8	96.8	2.9	2.9	97.5	1.2	Riffle X-Section
277	91.8	92.4	92.4	94.9		2.5				
321	90.6	91.4	91.5	94.0	94.0	2.6				SOR=Start of Run
331	90.5	91.3	91.3	93.9	93.9	2.6				
334	89.7	91.3	91.3	94.1	94.1	2.8				TOP
356	88.9	91.2	91.3	94.1	94.1	2.9	2.8	95.1	1.2	Pool X-Section
376	90.2	91.3	91.3	94.1		2.8				SOG
383	90.5	91.3	91.3	94.3	94.3	3.0	3.0	95.1	1.2	Glide X-Section
392	90.7	91.3	91.3	93.8		2.5				TOR
434	89.0	89.9	89.9	92.8		2.9				SOR
447	89.0	89.9	89.9	92.8	92.8	2.9	2.9	93.7	1.2	Run X-Section
466	89.0	89.8	89.8	92.6		2.8				TOR
509	88.4	89.3	89.3	91.8		2.5				SOR
527	88.8	89.3	89.2	91.8	91.7	2.5				TOR
557	87.8	88.5	88.8	91.0		2.5				SOR
602	87.6	88.3	88.2	90.8		2.5				TOR
634	86.8	87.8	87.8	90.5		2.7				SOR
644	86.7	87.8	87.8	90.4		2.6				TOP
652	85.3	87.8	87.8	90.4	90.3	2.6	2.5	91.4	1.2	Pool X-Section
661	86.7	87.7	87.8	90.4		2.7				SOG
676	87.2	87.8	87.7	90.3		2.5				TOR
735	86.2	86.9	87.0	89.4	89.5	2.5	2.5			
763	85.3	86.5	86.1	89.0		2.5				
803	86.5	87.0	87.0	89.5		2.5				
823	84.8	85.3	85.3	87.8	87.8	2.5	2.5	88.6	1.3	Riffle X-Section
851	84.0	84.7	84.7	87.6		2.9				SOR
883	83.7	84.6	84.6	87.5	87.6	2.9	3.0	87.5	1.0	Run X-Section
915	83.3	84.5	84.5	87.0		2.5				TOP
937	82.9	84.5	84.5	87.0	87.0	2.5	2.5	87.0	1.0	Pool X-Section
953	83.8	84.5	84.4	87.0		2.5				TOR

BASIN CREEK C4 Reference Reach
Surveyed by: A Jessup, D Everhart, G Goings,
J Pate, J Mickey on 10-26-98

CROSS SECTIONS

Sta. 0+66 (Glide)

Distance	Elevation	Comments
0	99.6	LBF
4	99.3	
7	98.9	
10	98.4	
14	97.6	
15	97.3	
15	97	LEW
15	95.7	
18	96.2	
21	96.6	
25	96.6	
30	96.2	
35	96.2	
38	96.2	
41	96.0	TW
43	96.5	
44	97.0	REW
44	97.9	
45	98.6	
48	99.6	
50	99.7	RBF

Sta. 2+02 (Riffle)

Distance	Elevation	Comments
0	96.8	LBF
4	96.3	
8	95.6	
11	94.7	
12	94.3	
13.5	94.1	LEW
16	93.9	
19.4	93.6	TW
23	93.7	
27	94.1	REW
30	94.2	
33	95.6	
37.5	97.0	RBF

Sta. 3+56 (Pool)

Distance	Elevation	Comments
0	95.1	LTOB
0	94.1	LBF
0	93.2	Bedrock
2	92.8	
4	91.9	
7	91.2	LEW
7	90.5	
9.5	89	
10.5	88.9	TW
13	89.6	
16	90.4	
18	90.4	
20	90.9	
21	91.3	REW
29	93.1	
35	94.1	RBF
40	94.7	
46	95.1	RTOB

Sta. 3+83 (Glide)

Distance	Elevation	Comments
0	95.1	LTOB
3	93.1	
3	91.4	
3.5	91.3	LEW
5	91.0	
8	90.8	
12	90.5	TW
14	90.5	TW
17	91.1	
21	91.1	
25	91.3	REW
28	91.4	
31.5	91.6	
33.5	93.0	
34	93.5	
34.5	94.3	
38	94.5	
44	94.7	
50	95.1	RTOB

Sta. 4+47 (Run)

Distance	Elevation	Comments
0.0	93.7	LTOB
3.0	91.5	
4.0	91.3	
10.0	91.2	
14.0	90.3	
18.0	90.2	
20.0	89.9	LEW
23.0	89.5	
25.0	89.1	
28.0	89.0	TW
30.0	89.2	
33.0	89.9	REW
36.0	90.7	
39.0	91.0	
41.0	92.3	
43.0	91.3	
48.0	92.8	
51.0	93.2	
59.5	93.6	
59.8	93.7	

Sta. 6+52 (Pool)

Distance	Elevation	Comments
0	91.4	
2	90.4	LBF
5	89.8	
6.5	88.7	
6.5	87.7	LEW
6.5	87	
9	86.2	
11	85.5	
14	85.3	
16	85.2	TW
19	85.6	
21	85.8	
24	86.9	
29	87.3	
34.5	87.8	REW
38	88.3	
39	88.9	
44	89.9	
47	89.9	
49.5	90.3	RBF
52	90.7	
57	91.3	
59	91.4	

BASIN CREEK C4 Reference Reach
Surveyed by: A Jessup, D Everhart, G Goings,
J Pate, J Mickey on 10-26-98

Cross Sections

Sta. 8+23 (Riffle)

Distance	Elevation	Comments
0	88.6	LTOB
2	88.3	
8	88.3	
10.5	87.8	LBF
13	87.2	
15	86.3	
16	85.9	
16	85.3	
18	85.1	
22	85	
24	84.8	TW
26	84.9	
29	85	
31	85.2	
33	85	
35	85.2	
37	85.3	REW
38	86.9	
40	87.8	RBF
46	88.6	RTOB

Sta. 8+83 (Run)

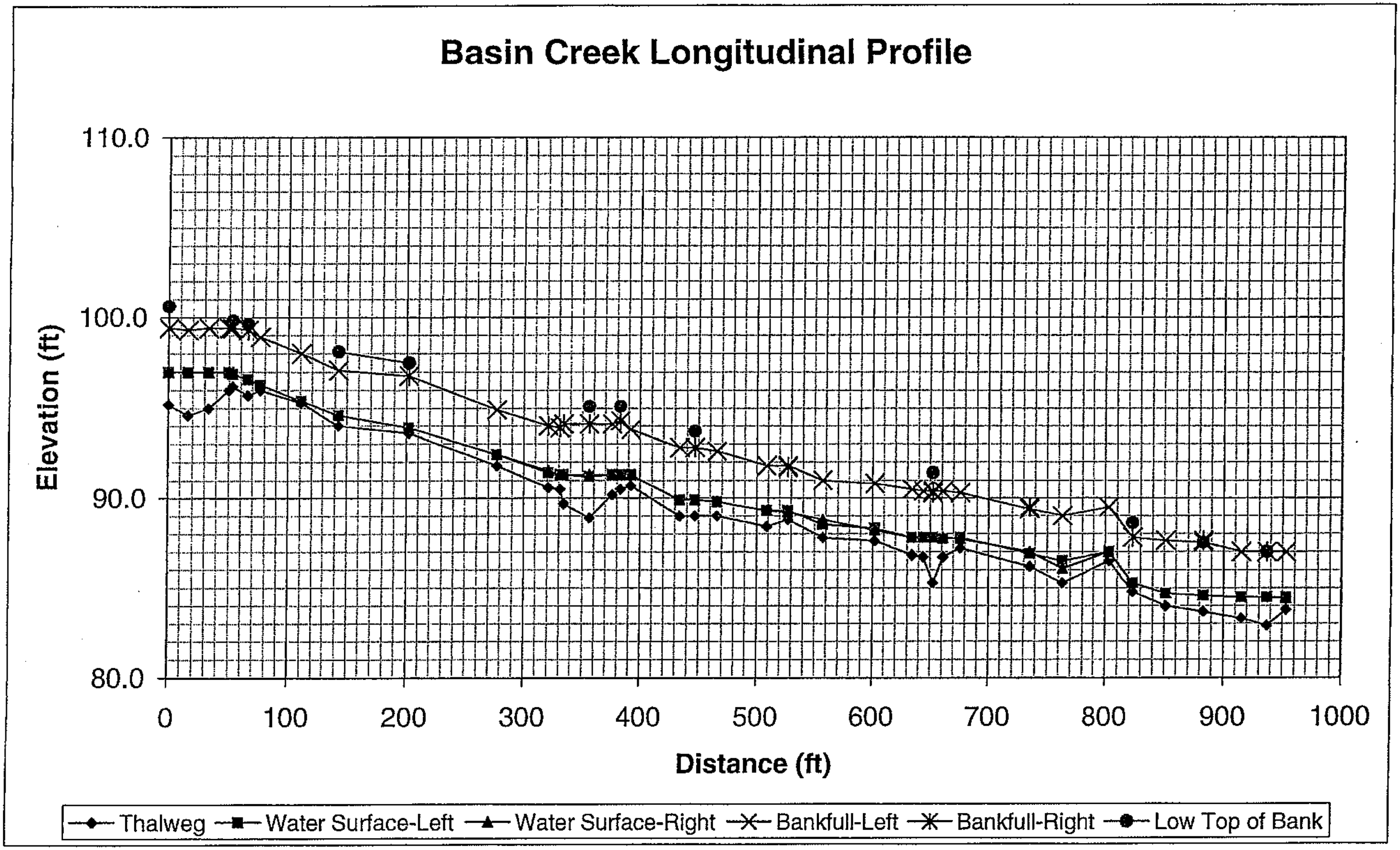
Distance	Elevation	Comments
0	87.5	LBF
4	86.9	
8	86.5	
12	85.9	
12	85.1	
16	84.6	LEW
19	84.4	
23	84.2	
25	84.2	
28	84.2	
31	83.7	TW
33	84	
35	84.6	REW
36	85.2	
40	86.9	
42.5	87.6	RBF

Sta. 9+37 (Pool)

Distance	Elevation	Comments
0	87	LBF
2	86.4	
6	86	
10	86.2	
15	86.2	
20	85.9	
24	86.2	
29	86.1	
33	85.8	
34.5	84.8	
40	84.7	
43	84.5	LEW
47	84.2	
50	84.3	
55	83.4	
57	82.9	TW
58	84.5	REW
60	85.3	
61.5	85.2	
62	85.7	
63	86	
65	86.5	
68	87	RBF

BASIN CREEK C4 Reference Reach
Surveyed by: A Jessup, D Everhart, G Goings, J Pate, J Mickey on 10-26-98

Wilkes County, NC



Rosgen Type C4 Reference Reach

Surveyed by: A. Jessup, D. Everhart, G. Goings, J. Mickey, J. Pate on 10-26-98

Basin Creek - Reference Reach Data									
Channel Dimensions @ Bankfull Elevation									
Riffle									
Station	Feature	Mean Depth (ft)	Max Depth (ft)	Width (ft)	Area (ft2)	FPA width (ft)	Facet Slope (ft/ft)	w/d	ER
2+02	Crossover	1.9	3.2	36.9	71.9	329	0.02	19.4	8.9
8+23	Crossover	2.2	3.0	29.5	64.9	No measurement	0.0177	13.4	n/a
	Total	4.1	6.2	66.4	136.8	329	0.0377	32.8	8.9
	Average	2.1	3.1	33.2	68.4	329	0.018850	16.4	8.9
				Avg facet slope for all riffle reaches			0.020821		
Run									
Station	Feature	Mean Depth (ft)	Max Depth (ft)	Width (ft)	Area (ft2)	FPA width (ft)	Facet Slope (ft/ft)	w/d	ER
4+47	Middle	2.2	3.8	47.0	102	No measurement	0.003125	21.4	n/a
8+83	Middle	2.2	3.8	42.5	93.4	No measurement	0.003125	19.3	n/a
	Total	4.4	7.6	89.5	195.4	0	0.00625	40.7	0
	Average	2.2	3.8	44.8	97.7		0.003125	20.4	
				Avg facet slope for all run reaches			0.003064		
Glide									
Station	Feature	Mean Depth (ft)	Max Depth (ft)	Width (ft)	Area (ft2)	FPA width (ft)	Facet Slope (ft/ft)	w/d	ER
0+66	Middle	2.3	3.6	43.0	98.5	No measurement	0.026087	18.7	n/a
3+83	Middle	3.0	3.8	33.5	98.9	No measurement	-0.0066667	11.2	n/a
	Total	5.3	7.4	76.5	197.4	0	0.0194203	29.9	0
	Average	2.7	3.7	38.3	98.7	#DIV/0!	0.009710	15.0	#DIV/0!
				Avg facet slope for all glide reaches			0.006473		
Pool									
Station	Feature	Mean Depth (ft)	Max Depth (ft)	Width (ft)	Area (ft2)	FPA width (ft)	Facet Slope (ft/ft)	w/d	ER
3+56	Middle	2.6	5.2	35.0	89.3	no measurement	0.0000000	13.5	n/a
6+52	Middle	2.8	5.2	48.0	132.5	no measurement	0.0058824	17.1	n/a
9+37	Middle	n/a	4.1	68.0	107.1	no measurement	0.0000000	42.5	n/a
	Total	5.4	14.5	151.0	328.9	0	0.01	73.1	10.2
	Average	2.7	4.8	50.3	109.6	500	0.002941	24.4	10.2
				Avg facet slope for all pool reaches			0.0019423		

BASIN CREEK REFERENCE REACH - Rosgen Type C4
Location: Wilkes County, NC - Take Traphill Road to Long Bottom Road (SR 1737)
Reach: Station 0+00 at confluence of Basin and Cove Creeks
Quad Sheet: Whitehead, NC **Drainage Area:** 7.2 sq. mi.

Length		Riffles	Runs	Glides	Pools	
		42	10	13	17	
		43	18	15	38	
		30	32	16	42	
		32	45	23	53	
		175	64			
		245				
	Total	567	169	67	150	953
	Avg	94.5	33.8	16.8	37.5	
%		59%	18%	7%	16%	
%Riffles & Glides =		84%				

Channel Dimensions:

Riffle Depth (ft)	2.1	Riffle Width (ft)	33.2	Riffle Area (sq ft)	68.4
Run Depth (ft)	2.2	Run Width (ft)	44.8	Run Area (sq ft)	97.7
Glide Depth (ft)	2.7	Glide Width (ft)	38.3	Glide Area (sq ft)	98.7
Pool Depth (ft)	2.7	Pool Width (ft)	50.3	Pool Area (sq ft)	109.6

Ratios:

Pool Depth/Riffle Depth =	1.3	
Pool Width/Riffle Width =	1.5	
Pool Area/Riffle Area =	1.6	
Max Pool Depth/Mean Bankfull Depth =	2.3	
Lowest Bank Height/Max Bankfull Depth=	1.0 to 1.3	Mean value 1.2

Streamflow:

Est Mean Velocity @ BKF (ft/sec) =	5.5
Est Discharge @ BKF (cfs) =	375

Channel Pattern:

Meander Length (ft)		Belt Width (ft)		Radius of Curvature (ft)	
	350		60		44.3
			59		69.3
			75		40.1
Total	350	Total	194	Total	153.7
Average	350	Average	64.7	Average	51.2

Ratios:

MWR = belt width/bkf width =	1.9
Rc/bkf width =	1.5
Lm/bkf width =	10.5

Channel Profile:

Valley Slope (ft/ft) =		Avg Water Surface Slope (ft/ft) =	0.01437
Riffle Slope (ft/ft) =	0.02082	Pool Slope (ft/ft) =	0.001942
Run Slope (ft/ft) =	0.003064	Glide Slope (ft/ft) =	0.006473

Pool to Pool Spacing (ft)		Pool Length (ft)	
	334		17
	310		38
	271		42
			53
Sum	915	Sum	150
Average	305.0	Average	37.5

Ratios:

Riffle slope/Avg WS slope =	1.4
Run slope/Avg WS slope =	0.2
Pool slope/Avg WS slope=	0.1
Glide slope/Avg WS slope=	0.5
Glide depth/mean bkf depth =	1.3
Pool length/bkf width =	1.1
Pool to Pool spacing/bkf width =	9.2

Pebble Count

Date: 10/28/1998
Party: Dick Everhart, Jerry Pate, Greg Goings and Joe Mickey

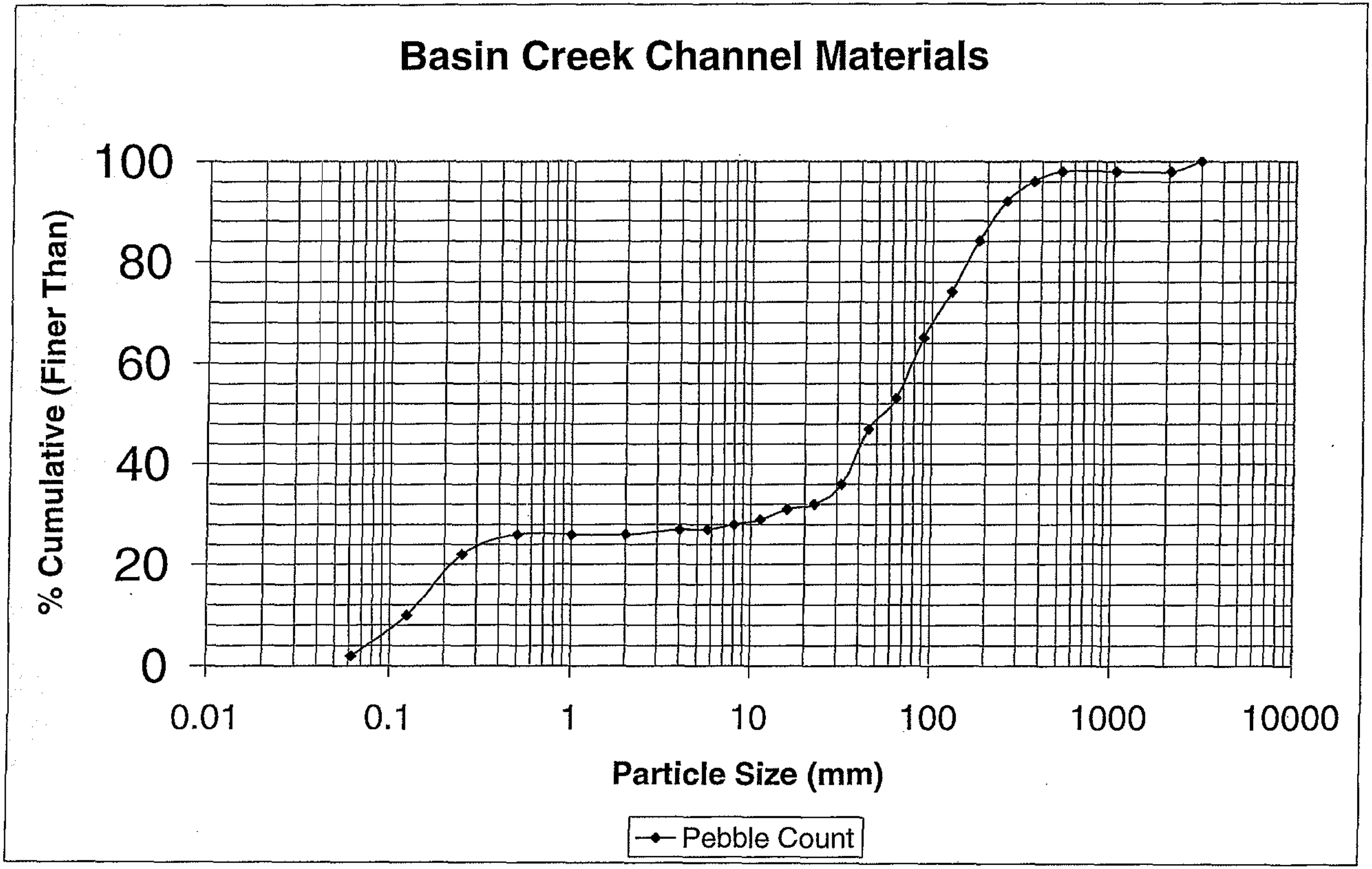
	Particle	Size(mm)	Total #	% Cum.
	Silt/Clay	<0.062	2	2
SAND	Very Fine	0.062-0.125	8	10
	Fine	0.125-0.25	12	22
	Medium	0.25-0.50	4	26
	Course	0.50-1.0	0	26
	Very Course	1.0-2.0	0	26
GRAVEL	Very Fine	2-4	1	27
	Fine	4-5.7	0	27
	Fine	5.7-8	1	28
	Medium	8-11.3	1	29
	Medium	11.3-16	2	31
	Course	16-22.6	1	32
	Course	22.6-32	4	36
	Very Course	32-45	11	47
	Very Course	45-64	6	53
COBB	Small	64-90	12	65
	Small	90-128	9	74
	Large	128-180	10	84
	Large	180-256	8	92
BOULD	Small	256-362	4	96
	Small	362-512	2	98
	Medium	512-1024	0	98
	Large-Vry Lrg	1024-2048	0	98
	Bedrock	>2048	2	100
				100

Channel Materials:

% Sand = 26
% Gravel = 27
% Cobble = 39
% Boulder = 6
% Bedrock = 2

D16 = 0.17 mm
D35 = 29 mm
D50 = 58 mm
D84 =180 mm
D95 = 300 mm

C4 Reference Reach 11/29/2001



Party: Dick Everhart, Greg Goings, Joe Mickey Jerry Pate

Data Collected: 10-28-98

REFERENCE REACH SURVEY
Stream Name: Big Branch
Location:
Purpose: Longitudinal Profile and Cross-section measurements for Graduate Work
Date: 8/12/1999
Crew: Dan Clinton, Jan Patterson, Jim Buck
Ending Point LAT/LONG:
Watershed Area: 1.9 sq mi   STREAM TYPE: E4

REFERENCE REACH Summary Data

Channel Dimensions

	Mean	Median	Min	Max
Max. Riffle Depth(drmax)(ft.):	2.6	2.6	1.4	1.5
Riffle Width(Wr)(ft.):	20.8	20.8	0.0	0.0
Riffle X-Sect. Area(Ar)(ft^2):	41.8	41.8	15.0	15.5
Riffle Mean Bankfull Depth(dmbkf):	2.0	2.0	0.9	0.9

	#1	#2
Max. Pool Depth(dpmax)(ft.):	4.0	3.5
Pool Width(Wp)(ft.):	17.8	19.0
Pool X-Sect. Area(Ap)(ft.):	51.7	51.0

	Mean	Median	Min	Max
Ratio: Max. Pool Depth/Max. Riffle Depth(dpmax/drmax):	1.53	1.53	2.49	2.64
Ratio: Pool Width/Riffle Width(Wp/Wr):	0.86	0.86	#DIV/0!	#DIV/0!
Ratio: Pool Area/Riffle Area(Ap/Ar):	1.24	1.24	3.45	3.34
Ratio: Max. Pool Depth/Mean Bankfull Depth(dpmax/dbkf):	1.96	1.96	4.40	4.40
Ratio: Lowest Bank Height/Max. Bankfull Depth(Bhlow/dmbkf):	1			
Streamflow: Estimated Mean Velocity(u) @ Bankfull Stage:		ft./sec.		
Streamflow: Estimated Discharge(Q) @ Bankfull Stage:		CFS		

Channel Pattern

	Mean	Median	Min	Max	
Meander Wavelength(Lm):	54	55	42	63	ft.
Radius of Curvature(Rc):	223	223	185	260	ft.
Beltwidth(Wblt):	37	37	31	44	ft.

Meander Width Ratio(MWR=Wblt/Wbkf):	1.80	1.80	#DIV/0!	#DIV/0!
RATIO: Radius of Curvature/Bankfull Width(Rc/Wbkf):	10.72	10.72	#DIV/0!	#DIV/0!
RATIO: Meander Wavelength/Bankfull Width(Lm/Wbkf):	2.58	2.67	#DIV/0!	#DIV/0!

Channel Profile

	Mean	Median	Min	Max	
Valley Slope:	0.0087	ft./ft			
Water Surface Slope:	0.0087	ft./ft			
Riffle Slope:	0.0169	0.0163	0.02	0.0192	ft./ft
Pool Slope:	0.0001	0.0000	0.0000	0.0004	ft./ft
Run Slope:	0.0011	0.0011	0.001	0.0011	ft./ft
Glide Slope:	0.0015	0.0015	0.00	0.0030	ft./ft
Riffle Length:	58.5	74.0	23.4	78.0	ft.
Pool Length:	26.9	25.0	23.6	32.0	ft.
Run Length:	66.0	66.0	66.0	66.0	ft.
Glide Length:	9.0	9.0	8.0	10.0	ft.
Riffle to Riffle Spacing:	128.2	128.2	82.3	174.0	ft.
Pool to Pool Spacing:	138.7	138.7	97.5	179.8	ft.
Riffle to Pool Spacing:	63.0	44.5	23.5	121.0	ft.

RATIO: Riffle Slope/ Water Surface Slope:	1.95	1.87	1.76	2.21
RATIO: Pool Slope/Water Surface Slope:	0.02	0.00	0.00	0.05
RATIO: Run Slope/Water Surface Slope:	0.12	0.12	0.12	0.12
RATIO: Glide Slope/ Water Surface Slope:	0.17	0.17	0.00	0.34
RATIO: Max. Riffle Depth/Mean Bankfull Depth:	1.28			
RATIO: Max.Pool Depth/Mean Bankfull Depth:	1.96			
RATIO: Max. Run Depth/Mean Bankfull Depth:	n/a			
RATIO: Max. Glide Depth/Mean Bankfull Depth:	n/a			
RATIO: Riffle Length/Bankfull Width:	2.82	3.57	1.13	3.76
RATIO: Pool Length/Bankfull Width:	1.29	1.20	1.14	1.54
RATIO: Run Length/Bankfull Width:	3.18	3.18	3.18	3.18
RATIO: Glide Length/Bankfull Width:	0.43	0.43	0.39	0.48
RATIO: Riffle to Riffle Spacing/Bankfull Width:	6.18	6.18	3.97	8.39
RATIO: Pool to Pool Spacing/Bankfull Width:	6.68	6.68	4.70	8.67
RATIO: Riffle to Pool Spacing/Bankfull Width:	3.04	2.14	1.13	5.83

REFERENCE REACH SURVEY
Stream Name: Big Branch
Location: Tributary to the Little Fisher River on Blevins Store Road past Red Hill Creek
Purpose: Longitudinal Profile and Cross-section measurements for Graduate Work
Date: 8/12/1999
Crew: Dan Clinton, Ian Patterson, Jim Buck
Ending Point LAT/LONG:
Watershed Area: 1.9 sq. miles STREAM TYPE: E4

LONGITUDINAL PROFILE
(Using Level)

TR= Top of riffle
TP=Top of Pool
TG= Top of glide
Trun= Top of Run
MP= Max Pool
LBKF = Left Bankfull
RBKF= Right Bankfull
TW= Thal Wag
LEW= Left Edge of Water
REW= Right Edge of Water

	Bench Mark #1=	100	ft.				
BS = 4.79	HI =	104.79	BM1 is nail at base of hemlock				
TP1 BS= 4.68	TP1 HI=	104.30	TP1 FS=	5.17	TP1 El.=	99.62	
TP2 BS= 3.97	TP2 HI=	102.81	TP2 FS=	5.46	TP2 El.=	98.84	
TP3 BS= 5.39	TP3 HI=	104.23	TP3 FS=	3.97	TP3 El.=	98.84	
TP4 BS= 4.8	TP4 HI=	104.41	TP4 FS=	4.62	TP4 El.=	99.61	
			FS to BM= 4.41		BM El.=	100.00	
					ERROR=	0.00	

Distance	Thawl Wag (FS)	Thawl Wag Elev.	Water Surface (FS)	Water Surface Elev.	LBKF (FS)	BKF Elev.	IB (FS)	IB Elev.	Notes			Mid Feature Location	Feature
0.0	7.6	97.2	7.25	97.5	5.2	99.6			TR			11.7	R
3.0	7.5	97.3	7.27	97.5	5.0	99.8			x-sect #1				
11.0	7.7	97.1	7.50	97.3	5.4	99.4							
23.4	7.9	96.9	7.70	97.1	5.5	99.3	6.54	98.3	TP			35.2	P
35.0	9.2	95.6	7.62	97.2					X-Sect #2				
41.0	9.5	95.3	7.67	97.1	5.6	99.2			Pmax				
47.0	8.9	95.9	7.66	97.1	5.2	99.6			TG			51.0	G
55.0	8.0	96.8	7.64	97.2	5.3	99.5			TR			94.0	R
84.0	8.5	96.3	8.09	96.7	5.7	99.1							
92.0	8.4	96.4	8.11	96.7	5.7	99.1	7.17	97.6	X-Sect#3				
133.0	9.2	95.6	8.91	95.9	6.5	98.3	8.1	96.7	Trun			166.0	Run
166.0	9.4	94.9	8.45	95.9	6.1	98.2	7.4	96.9					
199.0	8.8	95.5	8.49	95.8	6.1	98.2			TP			215.0	P
216.0	9.3	95.0	8.47	95.8	6.0	98.3	7.75	96.6	Pmax				
231.0	8.8	95.5	8.49	95.8					TR			268.0	R
259.0	7.7	95.1	7.33	95.5	5.2	97.7							
305.0	8.4	94.5	8.13	94.7	5.7	97.1			TP			312.5	P
313.0	9.2	93.6	8.17	94.6	5.7	97.1	7.1	95.7	X-sect #4				
315.0	9.4	93.4	8.14	94.7					Pmax				
320.0	9.0	93.8	8.11	94.7					TG			325.0	G
330.0	8.5	94.3	8.14	94.7	5.7	97.1	7.35	95.5	TR				R

X_SECTION MEASUREMENTS
Riffle X-Section #1
Location : 0+03
HI= 104.79 (arbitrary... used depth off rod)

Distance	FS	Elev	Notes	Depth from BKF	Width	Area
0	0.6	104.2				
7	3.8	101.0				
12	4	100.8				
15	4.2	100.6				
17	4.4	100.4	LTOB			
19.5	5	99.8	LBKF	0.0	0.0	0.0
21	5.8	99.0		0.8	1.5	0.6
21.2	7.5	97.3	LEW	2.5	0.2	0.3
23	7.5	97.3	TW	2.5	1.8	4.5
26	7.4	97.4		2.4	3.0	7.4
29	7.4	97.4		2.4	3.0	7.2
30.5	7.27	97.5	REW/WS	2.3	1.5	3.5
34	7.1	97.7		2.1	3.5	7.6
36	6.9	97.9		1.9	2.0	4.0
38.5	7.1	97.7		2.1	2.5	5.0
41	5	99.8	RBKF	0.0	2.5	2.6
43	4.4	100.4			TOTAL	42.8
46	3.6	101.2	RTOB			
50	3.8	101.0				
56	4.2	100.6				
64.5	3.8	101.0				

BKF Width =	21.5
Area =	42.8
Max depth =	2.5
FPW =	130
ER =	6.0
Mean Depth =	2.0
Width/Depth Ratio =	10.8
Sinuosity =	1.2
Water Surface Slope =	0.0087
Stream Type =	E4

Riffle X-Section #2
Location : 0+92
HI= 100.02 (arb.)

Distance	FS	Elevation	Notes	Depth from BKF	Width	Area
0.0	0.0	100.0				
5.0	1.1	98.9				
9.0	0.6	99.4				
11.0	0.4	99.6				
13.0	0.7	99.3	LTOB			
14.0	0.9	99.1	LBKF	0.0	0.0	0.0
16.0	2.1	97.9		1.2	2.0	1.2
16.7	2.7	97.3		1.8	0.7	1.0
16.8	3.6	96.4	LEW	2.7	0.1	0.2
18.8	3.5	96.5		2.6	2.0	5.2
21.0	3.3	96.7		2.4	2.2	5.4
23.3	3.4	96.6		2.5	2.3	5.5
28.2	3.6	96.4	TW	2.7	4.9	12.5
30.7	3.34	96.68	REW/WS	2.4	2.5	6.3
31.1	2.4	97.6	RIB	1.5	0.4	0.8
32.3	2.2	97.8		1.3	1.2	1.6
34	0.94	99.1	RBKF	0.0	1.7	1.1
37	0.1	99.9	RTOB			

BKF Width =	20.0
Area =	40.9
Max depth =	2.7
FPW =	130.0
ER =	6.5
Mean Depth =	2.0
Width/Depth Ratio =	9.8
Stream Type =	E4

sum = 40.9 sq. ft.

Pool X-Section #1
Location : 0+35
HI= 100 (arb.)

Distance	FS	Elev	Notes	Depth from BKF	Width	Area
0.0	1.8	98.2				
3.0	3.6	96.4				
6.4	4.5	95.5				
10	4.9	95.1				
23	4.9	95.1				
24.5	4.8	95.2				
26	5.1	94.9	LTOB			
26.5	5.24	94.76	LBKF	0	0	0
27	5.59	94.41		0.4	0.5	0.1
29	6.8	93.2		1.6	2	1.9
29.2	7.9	92.1	LEW	2.7	0.2	0.4
32	8.2	91.8		3.0	2.8	7.9
35	9.1	90.9		3.9	3	10.2
37	9.2	90.8	TW	4.0	2	7.8
40	9	91		3.8	3	11.6
43	7.62	92.38	REW/WS	2.4	3	9.2
44.2	7.2	92.8		2.0	1.2	2.6
44.3	5.24	94.76	RBKF	0.0	0.1	0.1
44.4	5	95				
46	3.9	96.1	RTOB	sum:	51.7	sq. ft.

BKF Width = **17.8**
Area = **51.7**
Max. depth = **4.0**
Mean Depth= **2.9**
Width/Depth Ratio= **6.1**

Pool X-Section #2
Location : 3+13
HI= 104.79 (arbitrary... used depth off rod)

Distance	FS	Elev	Notes	Depth from BKF	Width	Area
0	5.53	99.3				
0.5	5.72	99.1	LBKF	0.0	0.0	0.0
2	8.17	96.6	LEW/WS	2.5	1.5	1.8
4	8.87	95.9		3.2	2.0	5.6
7	9.2	95.6	TW	3.5	3.0	9.9
9	9.15	95.6		3.4	2.0	6.9
10	9.19	95.6		3.5	1.0	3.5
12	9.03	95.8		3.3	2.0	6.8
14	8.81	96.0		3.1	2.0	6.4
17	8.39	96.4	REW	2.7	3.0	8.6
17.1	7.1	97.7	RIB	1.4	0.1	0.2
18	6.35	98.4		0.6	0.9	0.9
18.8	5.79	99.0		0.1	0.8	0.3
19.5	5.72	99.1	RBKF	0.0	0.7	0.0
21	5.21	99.6	RTOB		TOTAL	51.0

BKF Width = **19.0**
Area = **51.0**
Max. depth = **3.5**
FPW = **130**
ER = **6.8**
Mean Depth= **2.7**
Width/Depth Ratio= **7.1**

Stream Type = E4