STREAM & WETLAND RESTORATION PLAN

Little Beaver Creek
Wake County, North Carolina

N.C. Wetlands Restoration Program
NCDENR_DWQ

March **2003**

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1.0 INTRODUCTION

The North Carolina Wetlands Restoration Program (NCWRP) has identified Little Beaver Creek as a potential stream and wetland restoration site. Flowing directly into B. Everett Jordan Lake and once a tributary to Beaver Creek, Little Beaver Creek (NCDWQ Stream Index Number – 16-41-11-(1)) is located on agricultural land southwest of Apex in Wake County, North Carolina (**Figure** 1).

Stream restoration requires determining how far a stream has departed from its natural stability and then, establishing the stable form under the current hydrologic conditions within the drainage area. The proposed stream 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.

The proposed wetlands restoration will restore hydrology and native vegetation in existing soils exhibiting hydric characteristics. These restorations are based on analysis of current watershed hydrologic conditions, evaluation of soils and vegetation of the project site, and assessments of stable stream reference reaches and wetland reference sites.

1.1 PROJECT DESCRIPTION

The Little Beaver Creek project site is located southwest of Apex in Wake County, North Carolina. The project is fully contained within the property of two landowners. Conservation easements have already been purchased by the NCWRP. The conservation easements total 51.1 acres. The project reach is bounded by the property boundaries to the east (upstream) and to the west (downstream) (**Figure** 2). Adjacent hill slopes surround the project reach to the north and south. The project area contains the majority of Little Beaver Creek's floodplain. Olive Farm Road provides access to the project site.

1.2 GOALS AND OBJECTIVES

This project has the following goals and objectives:

- Restore 4,609 linear feet of Little Beaver Creek (as measured along the centerline) and 951 linear feet of unnamed tributaries to Little Beaver Creek.
- 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.
- Improve water quality and reduce erosion by stabilizing the stream banks.
- Reconnect the stream to its floodplain.

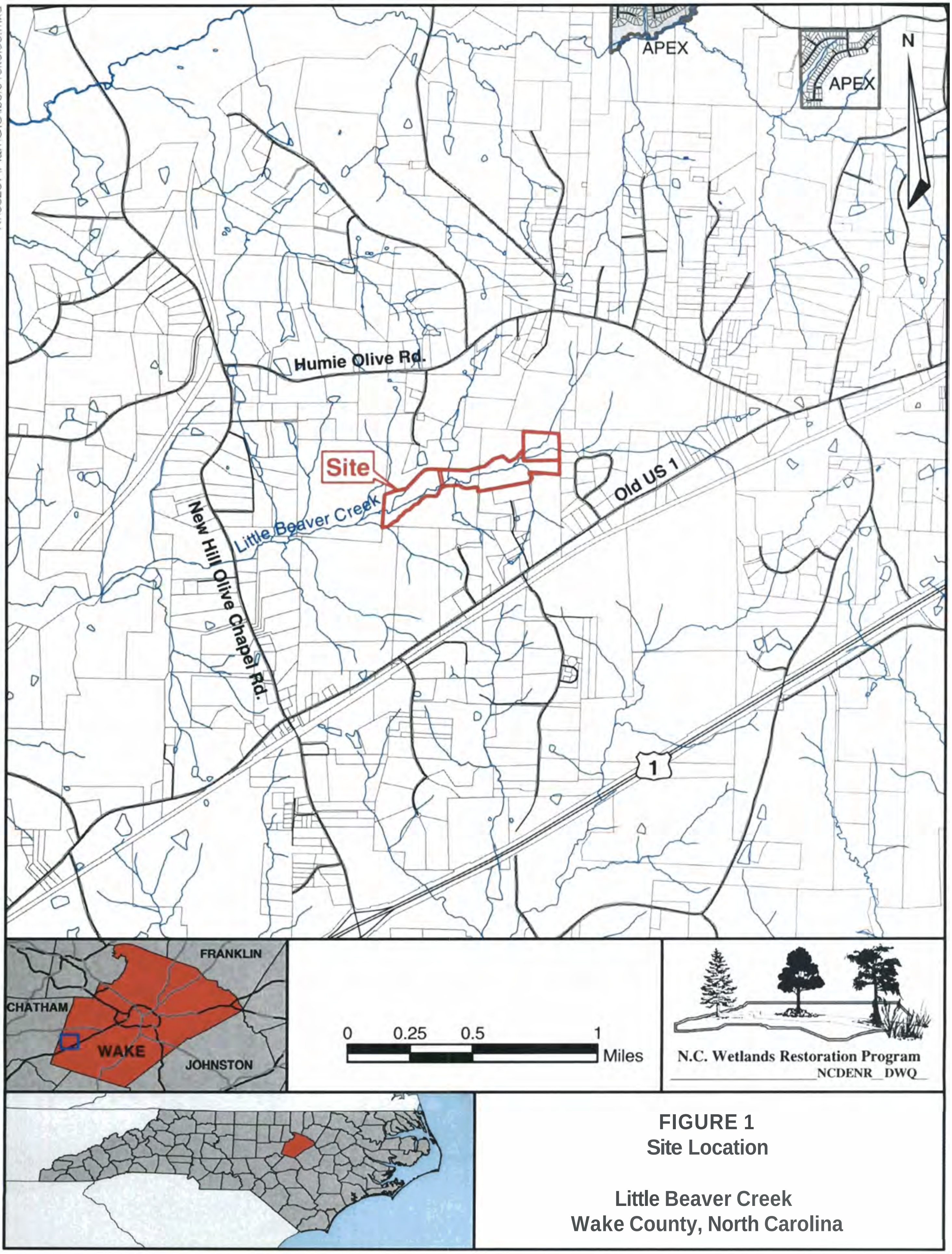

FIGURE 1
Site Location

Little Beaver Creek
Wake County, North Carolina

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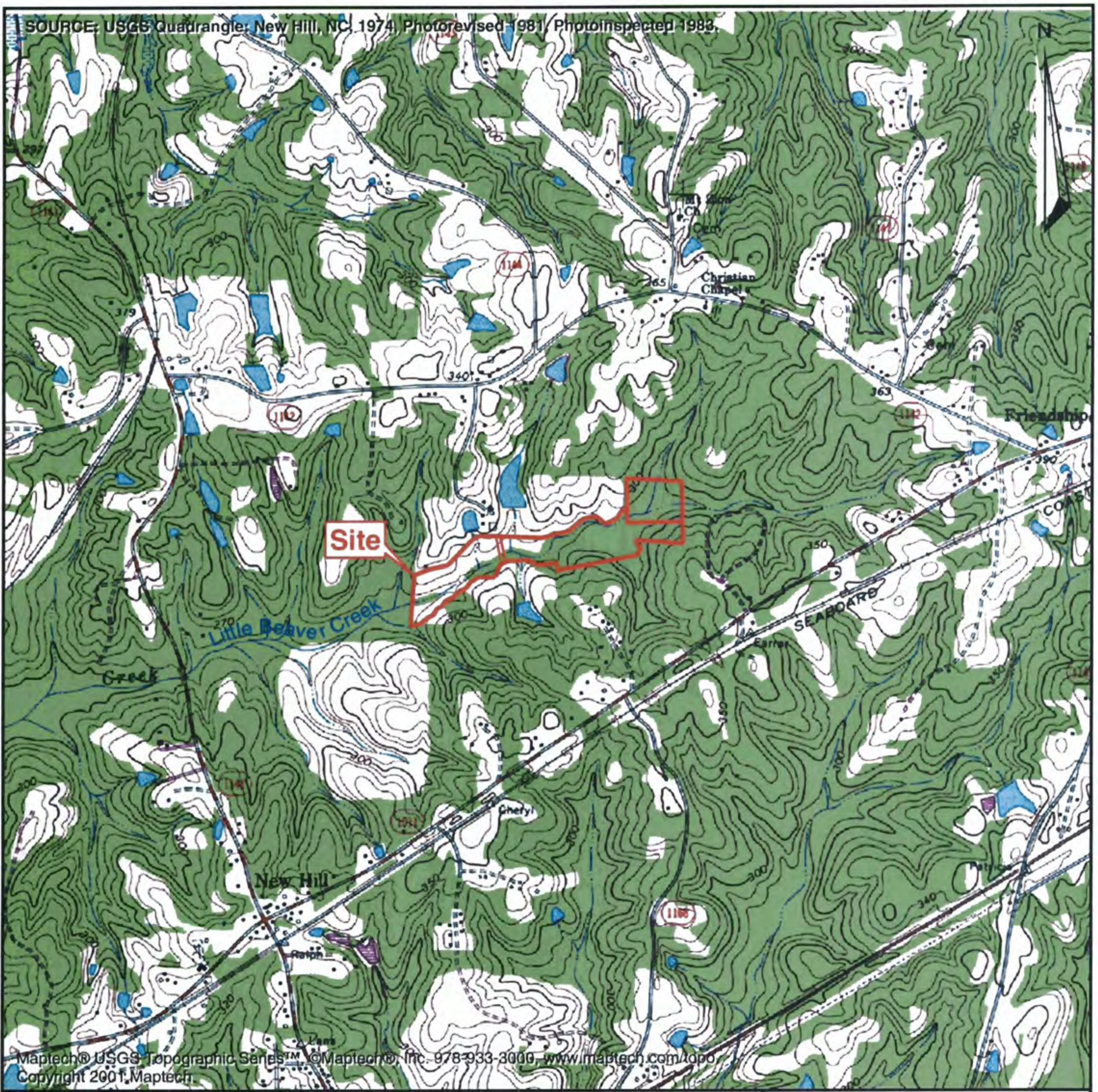

0 0.1 0.2 0.4 0.6 0.8 Miles

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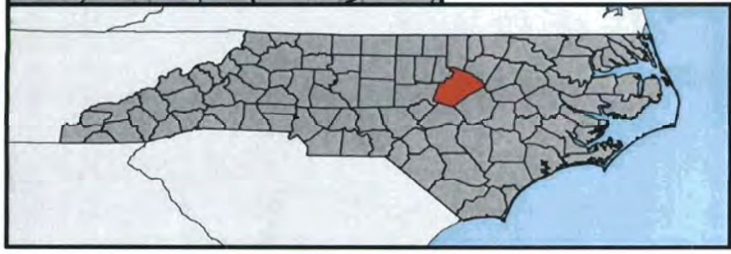

FIGURE 2
Vicinity Map

Little Beaver Creek
Wake County, North Carolina

- Improve aquatic habitat with the use of natural material stabilization structures such as root wads, rock vanes, woody debris, and a riparian buffer.
- Provide aesthetic value, wildlife habitat, and bank stability through the creation or enhancement of a riparian zone.
- Restore characteristic hydrologic regime to disturbed wetlands.
- Restore characteristic plant communities and animal habitat to disturbed wetlands.
- Increase the capacity of disturbed wetlands to perform characteristic functions such as flood storage, biogeochemical cycling, runoff attenuation, and maintenance of plant and animal habitat and species diversity.

1.3 STREAM SURVEY METHODOLOGY

The US Forest Service publication, "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.

Earth Tech contracted surveyors of Chas. H. Sells, Inc. to conduct a topographic survey of the restoration site in February 2002. 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. Wake County provided Geographic Information System (GIS) data to evaluate the watershed. A windshield survey was also conducted to determine the existing conditions within the watershed.

Field surveys of the existing stream channel and site were conducted on March 27 and 28, 2002. Photographs of the site were taken and are provided in **Appendix A.** During the site visits, ten (10) 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.

1.4 BANKFULL VERIFICATION

The foundation of Rosgen 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 dominant bankfull indicators along Little 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, 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 Little Beaver Creek and the reference reach sites used for this report are plotted on the Rural, 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 Little 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.

1.5 WETLAND AND NATURAL COMMUNITIES EVALUATION

Field surveys were conducted by Earth Tech biologists on several occasions between March and July, 2002. Plant communities were identified and classified based on species composition, hydrology, topoedaphic characteristics, disturbance history, and other environmental factors. Associated wildlife was identified by visual observations and characteristic signs (sounds, tracks, scats, and burrows), but no active searches were conducted. Terrestrial community classifications generally follow Schafale and Weakley (1990) and NatureServe (2002) where appropriate. Plant taxonomy follows Radford et *al.* (1968). Vertebrate taxonomy follows Rohde *et al.* (1994), Conant et *al.* (1998), the American Ornithologists' Union (2002), and Webster et *al.* (1985). Vegetative

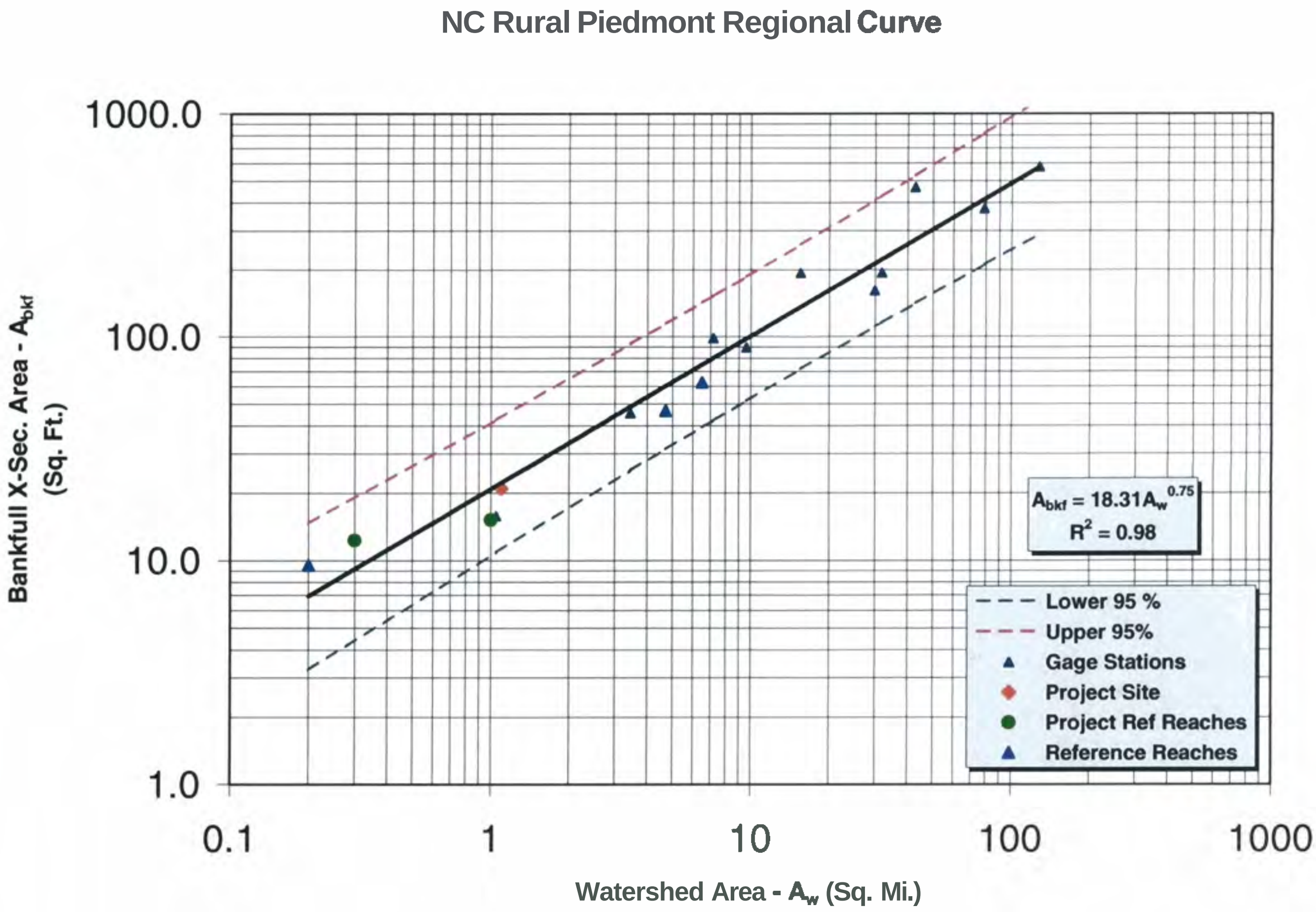

FIGURE 3
North Carolina Regional Curve

Little Beaver Creek
Wake County, North Carolina

communities were mapped using aerial photography of the project site. Predictions regarding wildlife community composition involved general qualitative habitat assessment based on existing vegetative communities and previously published reports.

Earth Tech personnel performed detailed soil surveys to verify the findings of a previous feasibility study and to evaluate a new parcel that was added to the study area. A series of soil borings were performed across the site at selected points based upon field observations, vegetation, and topography. Soil properties and profiles were described, and the depth to groundwater or hydric indicators noted.

Wetland areas were identified and delineated in accordance with criteria established in the U.S. ***Amy Corps of Engineers Wetlands Delineation Munual*** (USACE, 1987). Wetlands identified in the feasibility study were flagged and mapped by the survey crew. Wetlands identified by Earth Tech were flagged and mapped using GPS survey techniques.

Continuously-recording groundwater monitoring gauges (Remote Data Systems, Whiteville, NC) were installed to determine jurisdictional wetland hydrology. Hydrology is considered jurisdictional when groundwater is within 12 inches of the surface for 5 to 12.5% of the growing season (12-29 days for Wake County) under normal rainfall conditions. The growing season in Wake County is from March 26 to November 10, a length of 230 days. Gauges were installed according to the specifications of Technical Note HY-IA-3.1 (USACE 1993). Nine gauges were installed on the study area in April and June 2002. After a reference area was identified and landowner permission was obtained, two wells were also installed on the reference site in August 2002. Monitoring has continued monthly up to the present time.

2.0 EXISTING CONDITIONS

2.1 WATERSHED

2.1.1 General Description of the Watershed

Little Beaver Creek, a first order stream, is located within the Piedmont Physiographic Province of the Cape Fear River Basin (USGS Cataloging Unit 03030002). The watershed is located to the southwest of Apex, in Wake County, North Carolina. The headwaters of the project originate approximately 0.75 miles to the east of the restoration site. From the headwaters, Little Beaver Creek flows for approximately 4.5 miles before emptying into B. Everett Jordan Lake. Several tributaries enter Little Beaver Creek along its extent.

The watershed is approximately 1.11 square miles (711 Acres) and is oriented east to west in the shape of a teardrop (Figure 4). The watershed has an average width of 4,500 feet from the headwaters to its outlet. The topography is gently sloping with relatively flat floodplains occurring along Little Beaver Creek. Land surface elevations range from

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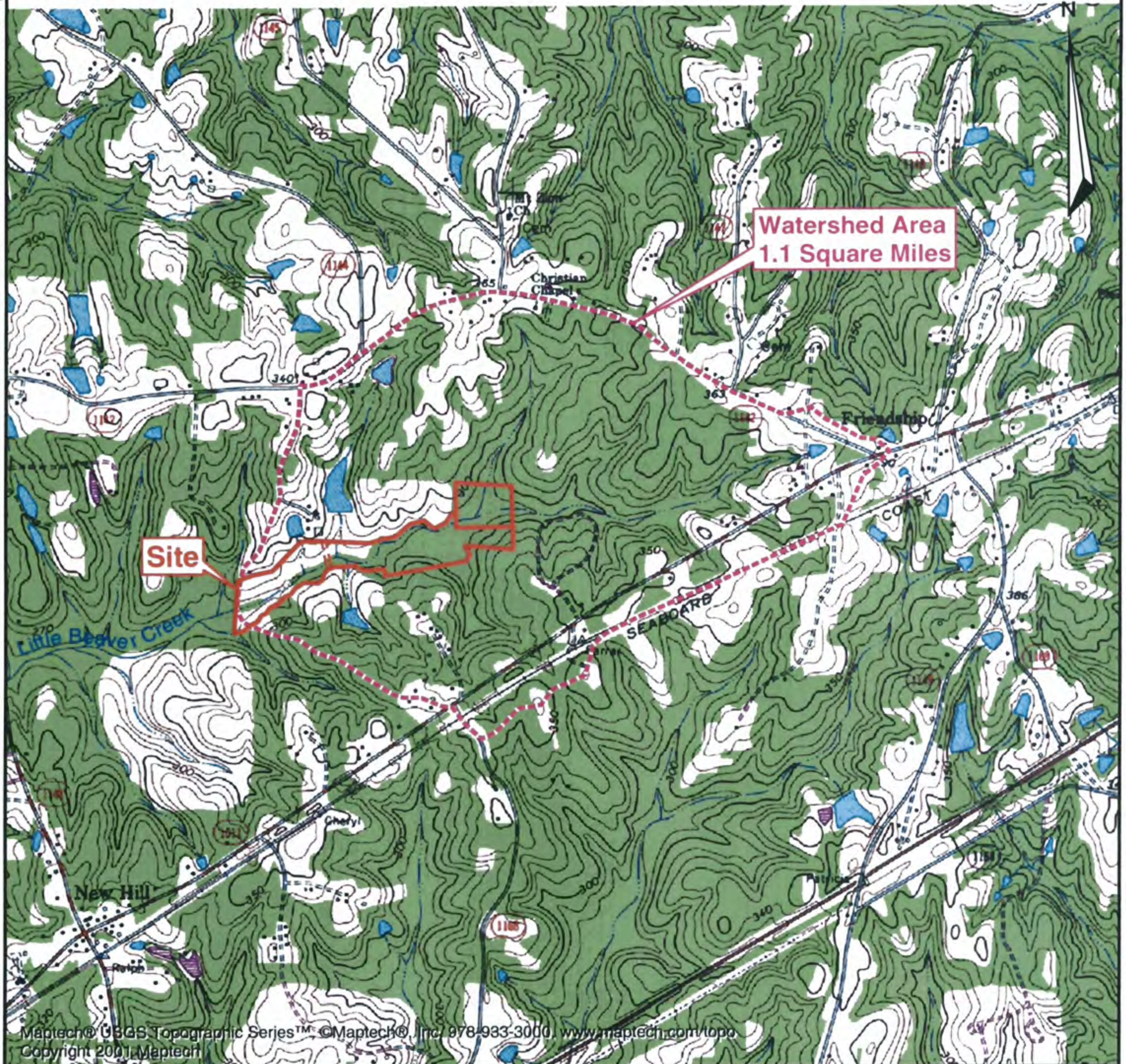
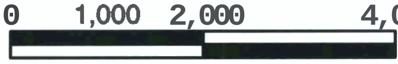
SOURCE: USGS Quadrangle: New Hill, NC, 1974, Photorevised 1981, Photoinspected 1983.





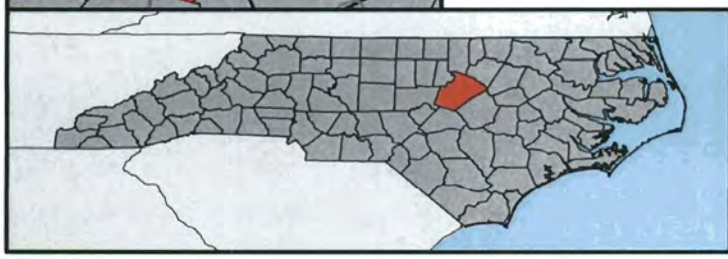


FIGURE 4
Watershed Map

Little Beaver Creek
Wake County, North Carolina

approximately 270 to 390 feet above mean sea level. Areas of hydric soils are common along the flat, narrow drainageways of this watershed. Few intact wetland communities are present, however, as a result of alterations to accommodate agricultural and residential land uses.

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. Little Beaver Creek (NCDWQ Stream Index Number – 16-41-11-(I)) is classified as a Water Supply Watershed IV NSW (WS-IV NSW) (NCDENR, 2001). WS-IV waters are used as sources of water supply for drinking, culinary, or food processing purposes for those users where a more protective classification (WS-I, II or III) is not feasible. WS-IV waters are generally in ***moderately to highly developed*** watersheds or Protected Areas. The NSW classification is for waters that need additional nutrient management strategies for both point and nonpoint source pollution.

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 sandy loam soils listed below. Soil maps and descriptions are taken from the ***Soil Survey of Wake County*** (NRCS 1971).

- **Altavista** fine sandy loam **(Afa)**, 0-4% slopes: This nearly level to gently sloping soil occurs on low terraces near major streams. It was formed in alluvial deposits under forest vegetation. The soil is deep, moderately well drained, and has moderate permeability. Subsoils are a friable sandy clay. Flooding is infrequent and of short duration. Depth to the seasonally high water table is 2 feet.
- Creedmoor sandy loam **(CrB2,CrC2),** 2-6% and **6-10%** slopes, eroded: These soils occur on broad, smooth interstream divides and narrow side slopes. They were formed under forest vegetation in material weathered from sandstone, mudstone, and shale of Triassic origin. Surface layers are 3-7 inches thick. The soils are moderately well drained, have slow permeability, and medium to rapid runoff. Subsoils are a slowly permeable, sandy clay loam that causes a perched water table during wet seasons.
- Creedmoor sandy loam **(CrE),** 10-20% slopes: This soil occurs on narrow side slopes. It was formed under forest vegetation in material weathered from sandstone, mudstone, and shale of Triassic origin. Surface layers are 7-15 inches thick. The soils have good infiltration, but slow permeability and medium to rapid runoff. Subsoils

are a slowly permeable, sandy clay loam that causes a perched water table during wet seasons.

- Granville sandy loam **(GrB),** 2-6% slopes: This deep, well-drained soil occurs on gently sloping uplands. It was formed under forest vegetation in material weathered from sandstone, mudstone, and shale of Triassic origin. Infiltration is good and runoff is medium. The soils have a high aluminum content and are strongly acid. Depth to the seasonally high water table is greater than 10 feet.
- Mayodan sandy loam (MfB), 2-6% slopes: This moderately deep soil occurs over hard rock on broad, smooth interstream divides. It was formed under forest vegetation in material weathered from sandstone, mudstone, and shale of Triassic origin. The surface layer is 7-15 inches thick. The soil is well drained, has moderate permeability, and medium runoff. Subsoils are a firm clay loam to clay. Depth to the seasonally high water table is greater than 10 feet.
- Mayodan sandy loam **(MfB2, MfC2)** 2-6% and 6-10% slopes, eroded: These soils occur on narrow side slopes. They were formed under forest vegetation in material weathered from sandstone, mudstone, and shale of Triassic origin. Surface layers are **3-7** inches thick. The soils are well drained, have moderate permeability, and medium to rapid runoff. Subsoils are a firm clay loam to clay. Depth to the seasonally high water table is greater than 10 feet.
- White Store sandy loam (Ws B2, **WsC2),** 2-6% and 6-10% slopes, eroded: These soils occur on broad, smooth interstream divides and narrow side slopes. They were formed under forest vegetation in material weathered from sandstone, mudstone, and shale of Triassic origin. Surface layers are **3-6** inches thick. The soils are moderately well drained, have slow permeability, and medium to rapid runoff. Subsoils are a slowly permeable, very firm clay that causes a perched water table during wet seasons.

2.1.4 Land Use of the Watershed

Analysis of historic aerials dating as far back as 1954 reveals that the watershed has remained relatively unchanged. The stream appears to have been located in the same area as it currently exists. The most significant changes to the watershed occurred between 1965 and 1971. The land surrounding the northern tributary was reforested, and the three most eastern fields were cleared.

The largest developed area is along the downstream half of the project site with the upper portions of the watershed remaining almost entirely forested. The majority of the developed areas are scattered along the perimeter of the watershed along the major roads. Land use within the watershed is 77% forested (Figure **5). Figure 5** is a current aerial from the Wake County GIS Department with each land use area delineated. Agricultural fields and pastures account for 13% of the area while the remaining 10% is a combination of low-density residential areas, roadways, and waterbodies.

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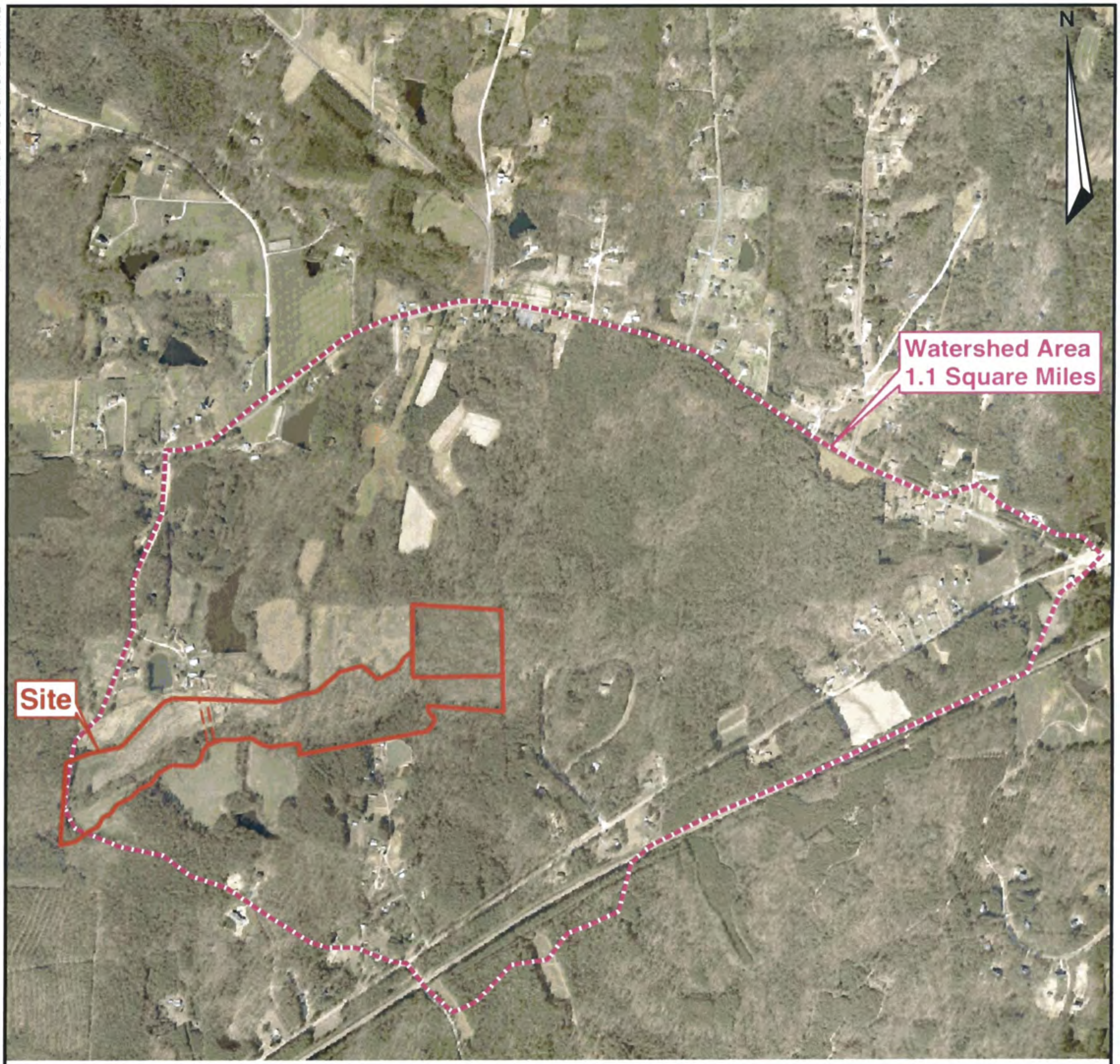
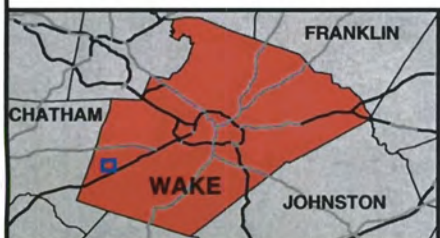


SOURCE: Wake County 1999.



0 625 1,250 2,500 Feet

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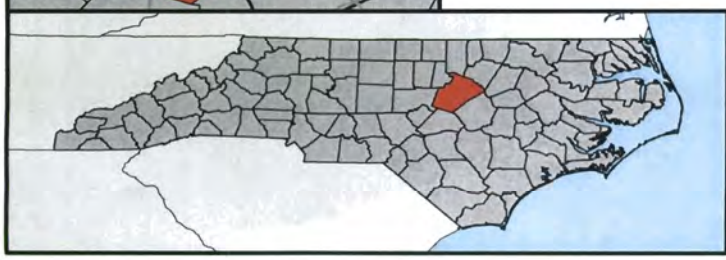

FIGURE 5
Aerial Photograph of Watershed

Little Beaver Creek
Wake County, North Carolina

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 Little Beaver Creek restoration site begins approximately 3.75 miles from its confluence with the B. Everett Jordan Lake. The project is located within the property boundaries of 2 landowners **(Figure** 5). Little Beaver Creek flows from east to west through a 300-foot wide floodplain. The majority of the floodplain is located on the north side of the stream and consists of pasture and crop land. The majority of the channel is deeply incised with near vertical banks. Channel sinuosity for the entire reach is 1.3, but there are long stretches with no meandering. High banks and areas of severe bank erosion can be found throughout the project reach.

Five small tributaries enter Little Beaver Creek within the restoration area. All of the side channels had moderate to low flow on the day of the site visit.

The main factor in the degradation and impairment for Little Beaver Creek appears to be cattle farming. Cattle activity has destroyed the natural riparian vegetation was once bordered the stream. The lack of vegetation on the highly erodible soils has led to increased erosion along the entire reach. Erosion has increased sediment deposition and in response the channel has begun to widen. The presence of central bars throughout the reach support the theory that the channel has overly widened. Further development of central bars will increase erosion and lateral migration of the channel.

2.2.2 Existing Stream Characteristics

Little Beaver **Creek** Restoration Site can be typically defined as an incised channel with moderate habitat and an unstable pattern actively migrating. Stream banks are steep with areas of active erosion, particularly along outside meander bends. Sand bars made of easily erodible material migrate frequently during small storm events. Long straight sections of the channel have central bars **forming;** indicating the channel is too 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 Little Beaver Creek range from 10.5 to 15.5 feet with mean depths ranging from 0.7 to 2.0 feet. The cross-sectional areas for these riffles range from 8.0 to 21.9 square feet. All cross-sections but one classed as type-F or G channel 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:	12.6 feet
Cross-sectional Area:	16.7 square feet

Mean Depth:	1.4 feet
Maximum Depth:	2.1 feet
Average Water Surface Slope:	0.005 feet/feet
Entrenchment Ratio:	>6.0
Sinuosity:	1.5
Bank Height Ratio	2.6

2.23 Soils of the Restoration Site

According to the Wake County soil survey, soils adjacent to Little Beaver Creek within the restoration site are mapped as Augusta, Wehadkee, and Worsham soils (Figure 6). Augusta soils are mapped in a pasture on a low-lying stream terrace along the right bank of Little Beaver Creek. The remainder of the floodplain of Little Beaver Creek is mapped as Wehadkee. The narrow drainageways of some of the small headwater tributaries to Little Beaver Creek are mapped as Worsham. These soil units are described below.

- Augusta fine sandy loam (Au), 0 to 4% slopes: This nearly level to gently sloping soil is deep and somewhat poorly drained. It was formed in alluvium under forested areas. Permeability is moderately slow and surface runoff is slow to medium. Flooding is frequent but of short duration. The seasonally high water table is 1.5 feet deep.
- Wehadkee silt loam (Wn), 0 to 2% slopes: This soil is nearly level and poorly drained. It was formed in fine loamy alluvium. Permeability is moderate to moderately rapid and runoff is slow to ponded. Flooding is frequent and of extended duration. The seasonally high water table is at the surface.
- Worsham sandy loam (Wy), 0 to 4% slopes: This nearly level to gently sloping soil is deep and poorly drained. It was formed in translocated and weathered material under forested areas. Permeability is moderately slow and runoff is slow to ponded. The seasonally high water table is at the surface.

Wehadkee and Worsham soils are on the NRCS list of hydric soils for North Carolina. Portions of the floodplain areas mapped to those units in the published soil survey were confirmed to be hydric by an Earth Tech soil scientist. Some areas mapped to those units, however, did not meet the NRCS criteria for hydric soils. Augusta soils are not considered hydric, but a portion of the unit as mapped in the published soil survey was found to meet the criteria for hydric soils. Wetland restoration is proposed for those areas of hydric soils that will fall within the floodplain of the restored stream and that currently lack jurisdictional wetland hydrology and vegetation. See Figure 7 for hydric soil areas.

2.2.4 Terrestrial Plant Communities

The following sections describe the existing plant communities on and adjacent to the restoration site (Figure 7). Historically, the entire floodplain of Little Beaver Creek most likely was a continuous bottomland hardwood ecosystem, now fragmented by various land uses. The mosaic of microhabitats characteristic of these systems included upland patches formed by coarse depositional material as well as various types of wetlands in

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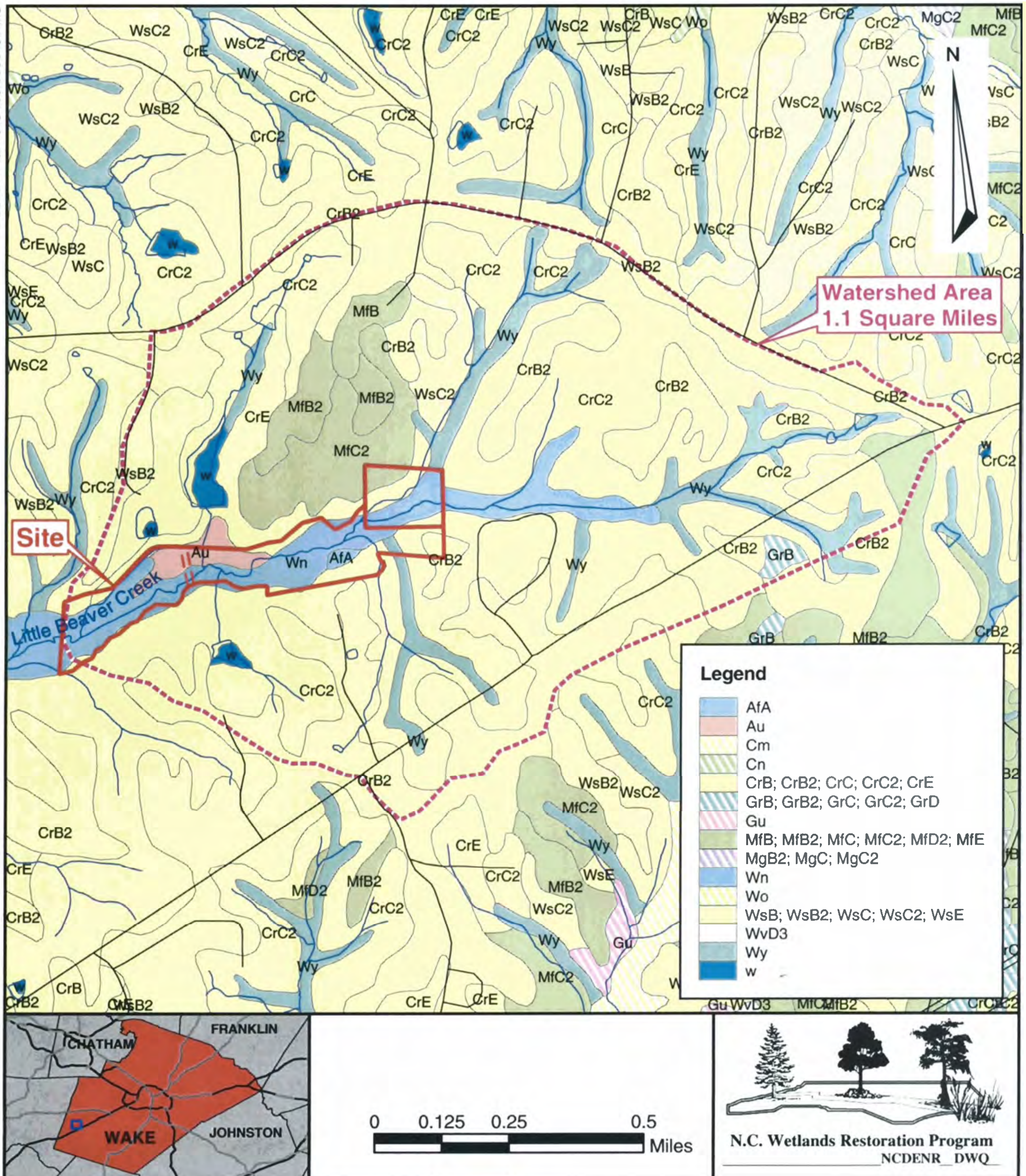


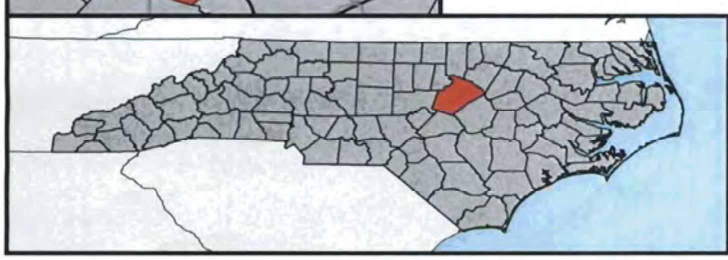


FIGURE 6
Soils

Little Beaver Creek
Wake County, North Carolina

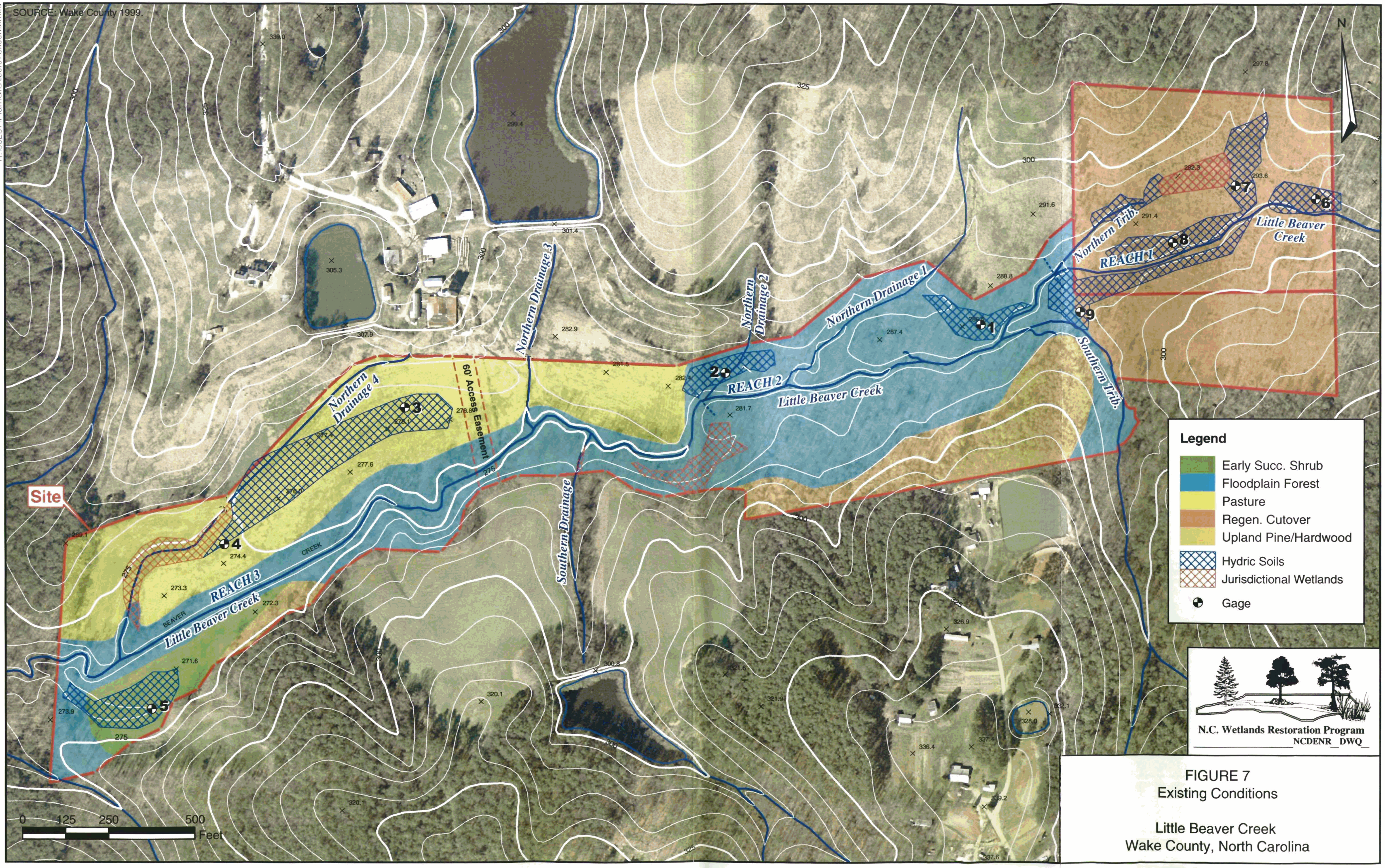


FIGURE 7
Existing Conditions

Little Beaver Creek
Wake County, North Carolina

different topographic positions. The site is now occupied by communities that reflect various types of disturbance and degrees of recovery. For purposes of this project, five plant communities are described. Nomenclature follows Radford *et al* (**1968).**

2.2.4.1 Wetlands

As previously described, areas of hydric soils occur throughout the study area. They occur in all of the community types described below, but not all areas have hydrology sufficient to support wetland vegetation. There are three areas within the project boundaries that have been verified by the USACE as jurisdictional wetlands on the basis of soils, hydrology, and vegetation. One is a narrow band along a drainage feature in the pasture along Reach 3 (0.62 acres). Species in this area are as described in Section 2.2.4.4 below, with the addition of abundant rushes (*Juncus* spp.), sedges (*Carex* spp.) and bulrushes (Scirpus *cyperinus*). The other two areas are between the left bank of Little Beaver Creek and the base of a slope along Reach 2 (0.51 acres). The plant community is as described in Section 2.2.4.3 below, with the addition of rushes, sedges, false stinging-nettle (Boehmeria cylindrica), knotweed (*Polygonum* sp.), and sphagnum moss (Sphagnum sp.).

A fourth area (0.34 acres) has the characteristics of a jurisdictional wetland but has not been verified by the USACE. It is found along the right bank of the Northern Tributary. The plant community in this area is as described in Section 2.2.4.2 below, with the addition of tag alder (*Alnus serrulata*) and highbush blueberry (Vaccinium corymbosum).

2.2.4.2 Regenerating Cutover

Reach 1 of Little Beaver Creek and the Northern Tributary flow through a regenerating cutover forest. This community is situated in a relatively flat area between the slopes of broad upland ridges. The area is dense with saplings of sweetgum (Liquidambar *styraciflua*), tulip poplar (*Liriodendron tulipifera*), red maple (Acer *rubrum*), and loblolly pine (*Pinus* taeda). The understory is thick with giant cane (Arundinaria gigantea), Japanese honeysuckle (*Lonicera japonica*), greenbrier (Smilax *rotundifolia*), multiflora rose (Rosa *multiflora*), and poison ivy (Toxicodendron radicans). Netted chain fern (Woodwardia areolata), sensitive fern (Onoclea sensibilis), royal fern (*Osmunda* regalis), and sphagnum moss (Sphagnum sp.) are present in the wetter areas. Extensive m a s of hydric soils line the floodplain of the two streams, although wetland hydrology is not achieved throughout. The unverified wetland is found here. The remaining area is proposed for restoration.

2.2.4.3 Floodplain Forest

Reaches 2 and 3 of Little Beaver Creek flow through a disturbed floodplain forest community that varies in width from 300 feet along Reach 2 to less than 100 feet along Reach 3. The understory is open and exotic invasive species are abundant as a result of past grazing. The canopy is dominated by large-diameter red maples. Other canopy species include sycamore (Platanus *occidentalis*), American elm (*Ulmus* americana), tulip poplar, sweetgum, willow oak (Quercus *phellos*), water oak (Quercus nigra), and blackgum (*Nyssa* sylvatica). Sub-canopy species include ironwood (Carpinus *caroliniana*), eastern red cedar (Juniperus virginiana), and persimmon (Diospyros virginiana). Loblolly pine seedlings, Japanese honeysuckle, multiflora rose, broomsedge (Andropogon *virginicus*), giant cane, wild onion (*Allium canadense*), violets (Viola spp.), rushes (Juncus spp.), Indian strawberry (Duchesnea indica). and Japanese grass (Microstegium vimineum) are abundant in the understory. Jurisdictional wetlands are present in this community. Other areas in this community with hydric soils lack hydrology and sufficient wetland vegetation and are proposed for restoration.

2.2.4.4 Pasture

The narrow floodplain forest along the lower reach of Little Beaver Creek is bordered by pastures and a cornfield. The pastures are dominated by cultivated grass species such as annual rye (*Lolium multiflorum*) and fescue (Festuca sp.). Foxtail (*Setaria* glauca), teasel (Dipsacus sylvestris), and sow-thistle (*Sonchus asper*) are also present. Rushes (Juncus spp.), sedges (*Carex* spp.), and bulrush (Scirpus *cyperinus*) are present in the jurisdictional wetland found along the small drainage. Some areas of hydric soils are present in the pastures, but lack hydrology and wetland vegetation and are proposed for restoration.

2.2.4.5 Early Successional Shrubland

An abandoned pasture on the left bank of the lower reach of Little Beaver Creek has succeeded to a shrubland dominated by loblolly pine and sweetgum saplings. Annual rye, broomsedge, dogfennel (Eupatorium *capillifolium*), and horseweed (Erigeron canadense) are abundant. Buttonbush (Cephalanthus occidentalis), rushes, and sedges are present in wet areas along the slope. Some hydric soil is present and preliminary gauge data suggest wetland hydrology, so this area is proposed for enhancement.

2.2.4.6 Upland Pine Forest

An upland pine forest community occupies the slopes rising from the floodplain of Little Beaver Creek that weren't cleared for pasture. The community occurs within the easement boundaries, but is not likely to be affected by restoration activities. The canopy is dominated by mature loblolly pines. Red maple, sweetgum, tulip poplar, and water oak make up less than 50 percent of the canopy. Seedlings and saplings of these species are also present in the understory, along with eastern red cedar and Japanese honeysuckle.

2.2.5 Hydrology

Throughout the project area, Little Beaver Creek and most of its tributaries are so incised that they are unable to access their floodplains. Where wetland hydrology exists on the site, it is a result of slope seepage or soils that retain rainfall because of compaction or high clay content.

Groundwater monitoring gauges were installed throughout the site. See **Figure** 7 for gauge locations. Gauges malfunctioned through most of an extremely dry summer, but enough data was obtained in the fall to suggest that wetland hydrology is present for at least 12.5% of the growing season at gauges 5 and 7, which are installed in areas proposed for wetland enhancement, as well as at the reference gauges. Data at gauge locations 2, 3, 4, 6, 8, and 9 suggest that restoration of wetland hydrology is possible if stream bed elevations are raised and regular overbank flow is restored. Gauge 1 is in an area that is not being proposed for wetland restoration. Official rainfall data was obtained from the State Climate Office (coop station Raleigh 4 SW) and the annual total was determined to be within the normal range as calculated on the WETS table. See **Appendix** C for hydrographs and rainfall from the latter part of the growing season.

2.2.6 Wildlife Observations and Protected Species

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. Beaver (Castor canadensis) are active in the stream channel. At least two dams were present when field studies were conducted. A variety of birds were observed in the thickets and shrubs surrounding the stream channel and forest, including: blue jay (Cyanocitta cristata), northern cardinal (Cardinalis cardinalis), white-throated sparrow (Zonotrichia albicollis), common yellowthroat (Geothlypis *trichas*), and rufous-sided towhee (*Pipilo erythrophthalmus*). Red-tailed hawks (Buteo *jamaicensis*) and turkey vultures (Cathartes aura) were observed over the pastures.

The USFWS lists 4 species under federal protection and 12 species of federal concern for Wake County as of January 2003 (USFWS 2002). These species are listed in **Table 1.**

Table 1. Species Under Federal Protection in Wake County

Common Name	Scientific Name	Status
Vertebrates		
Bachman's sparrow	*Aimophila* aestivalis	FSC
Bald eagle	Haliaeetus *leucocephalus*	Threatened (Proposed for Delisting)
Carolina darter	Etheostoma collis lepidinion	FSC
Pinewoods shiner	Lythrurus *matutinus*	FSC
Red-cockaded woodpecker	Picoides borealis	Endangered
Southeastern myotis	Myotis austroriparius	FSC
Southern hognose snake	Heterodon simus	FSC*
Invertebrates		
Atlantic pigtoe	Fusconaia *masoni*	FSC
Diana fritillary butterfly	Speyeria diana	FSC*

Table 1 continued		
Dwarf wedge mussel	*Alasmidonta heterodon*	Endangered
Green floater	*Lasmigona subviridis*	FSC
Yellow lance	*Elliptio lanceolata*	FSC
Vascular Plants		
Bog spicebush	*Lindera subcoriacea*	FSC
Carolina least trillium	*Trillium pusillum* var. *pusillum*	FSC
Michaux's sumac	*Rhus michauxii*	Endangered
Sweet pinesap	*Monotropsis odorata*	FSC

No Threatened, Endangered or Species of Federal Concern were observed, and none are recorded at NC National Heritage Program as occurring within 2 miles (3.2 km) of the project area. There is no habitat present in the project area for any of the listed species.

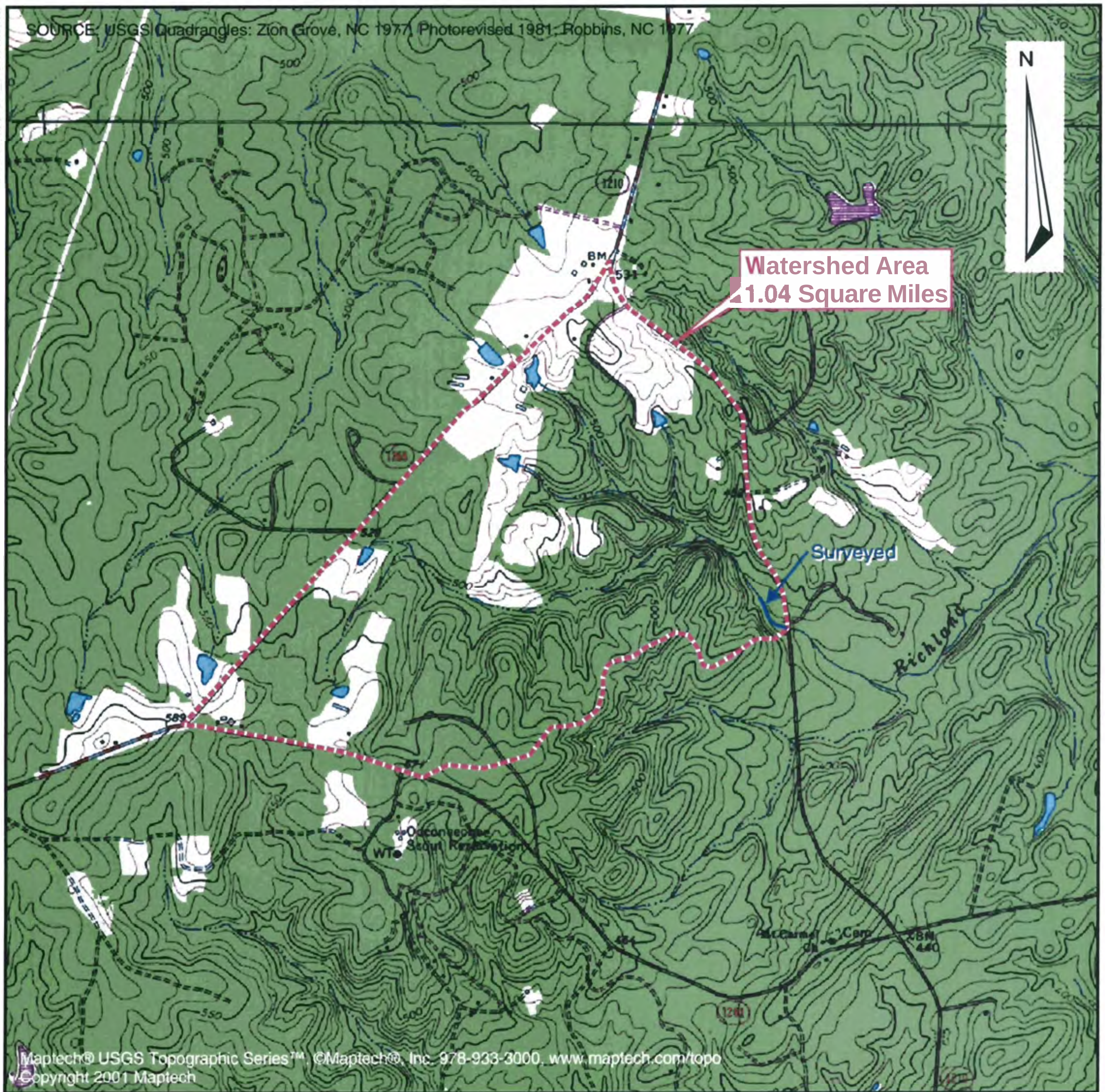
3.0 REFERENCE REACHES AND WETLANDS

The Division of Water Quality preferred that we first find references reaches and wetlands located in the Triassic Basin. One of the reference reaches, Little Beaver Creek, was located upstream of the restoration site within the same watershed. The entire section of the Triassic Basin to the east of Jordan Lake was then searched with no stable reaches located. The decision was then made to use Richland Creek, a reference reach used in the formation of the regional curve, located in a portion of the Triassic basin in Moore County.

The search for a reference wetland was conducted simultaneously with the search for a stream reference reach. As might be expected, the only sizable, hydrologically and morphologically appropriate wetland in the Triassic Basin was found in the floodplain of the stable upstream reference reach of Little Beaver Creek. Descriptions of the reference reaches and wetland are given below.

3.1 RICHLAND CREEK

Richland Creek, a second order stream, is located on private land in Moore County within the Piedmont Physiographic Province of the Cape Fear River Basin. The reach surveyed is located 8 miles west of Carthage along State Road 1210 (Figure 8). Richland Creek flows into McLendon's Creek approximately 9.5 miles downstream of the reach surveyed. The stream has a drainage area of 640 acres or 1.0 square miles. The watershed is comprised of forested and agricultural areas. The area surrounding the creek is forested and hilly on the south side. Richland Creek is an alluvial stream with dense shrub and deciduous vegetation lining the banks and adjacent floodplain. Bankfull indicators include top of bank, high scour lines, breaks in slope, changes in vegetation, moss lines, and depositional benches.



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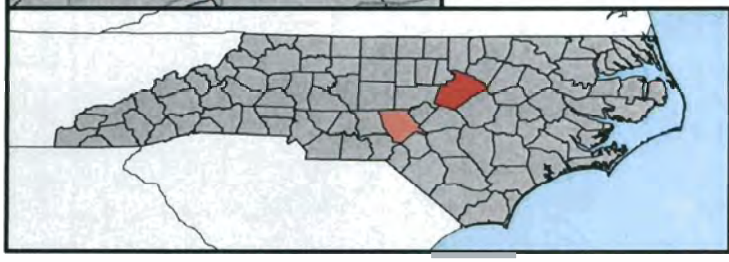

FIGURE 8
Richland Creek Watershed

Little Beaver Creek
Wake County, North Carolina

The stream was surveyed in the summer of 1998 for the development of the North Carolina Regional Curve. Channel dimension, pattern, and profile were measured for 253 linear feet of stream. The end point of the survey is located approximately 10 feet upstream of the State Road 1210 culvert. The stream had a bankfull channel width of 16.5 feet and a bankfull mean depth of 0.9 feet. The bank height ratio of Richland Creek is typically less than 1.1 and the entrenchment ratio is **3.0.** Richland Creek is a C4 stream type according to the Rosgen Classification system. Longitudinal profile, cross-sections, and the pebble count for this reference reach are located in **Appendix** D.

3.2 LITTLE BEAVER CREEK

The Little Beaver Creek Reference Reach, a first order stream, is located directly upstream of the project site. The drainage area is approximately 198 acres or 0.30 square miles **(Figure 9).** The reach surveyed is located to the north of Fairfield Lane, Lots 19 and 20, and begins approximately 900 feet upstream of the Little Beaver Creek project site. The site has a wide floodplain containing wetlands. The floodplain is bordered by rolling hills to the north and Fairfield Lane to the south. The watershed has a 2 percent slope with a stable landuse consisting of large forested areas with few pasture areas. The floodplain has mature forest with a well-developed understory with no signs of recent disturbance. Well-established deciduous vegetation lines the banks and adjacent hillslopes.

Earth Tech surveyed the stream on July 25, 2002. Channel dimension, pattern, and profile were measured for 360 linear feet of stream. The stream had a bankfull channel width of 14.4 feet and a bankfull mean depth of 0.85 feet. The Little Beaver Creek Reference Reach is a C5 stream type. Longitudinal profile, cross-sections, and the pebble count for this reference reach are located in **Appendix** D.

3.3 LITTLE BEAVER CREEK REFERENCE WETLAND

The reference wetland is located along the right bank of Little Beaver Creek upstream of the proposed restoration project **(Figure** 9). It occupies nearly the entire floodplain from a few feet from the top of bank to the base of a gentle slope rising from the edge of the floodplain. Following rainfall events and during the wetter months, small to medium-sized pools of standing water are common.

Wetland hydrology results from a combination of overbank flow from the stream and high groundwater levels. Two groundwater gauges were installed on a transect perpendicular to the stream bank. Although data is not yet available for an entire growing season, the data for October through mid-November show water levels at or near the surface continuously for 39 days. For a growing season of approximately 228 days, that period exceeds 12.5% of the growing season by 10 days. As noted previously, the determination of jurisdictional hydrology can only be made in conjunction with a determination of normal rainfall conditions. See **Appendix C** for gauge data.

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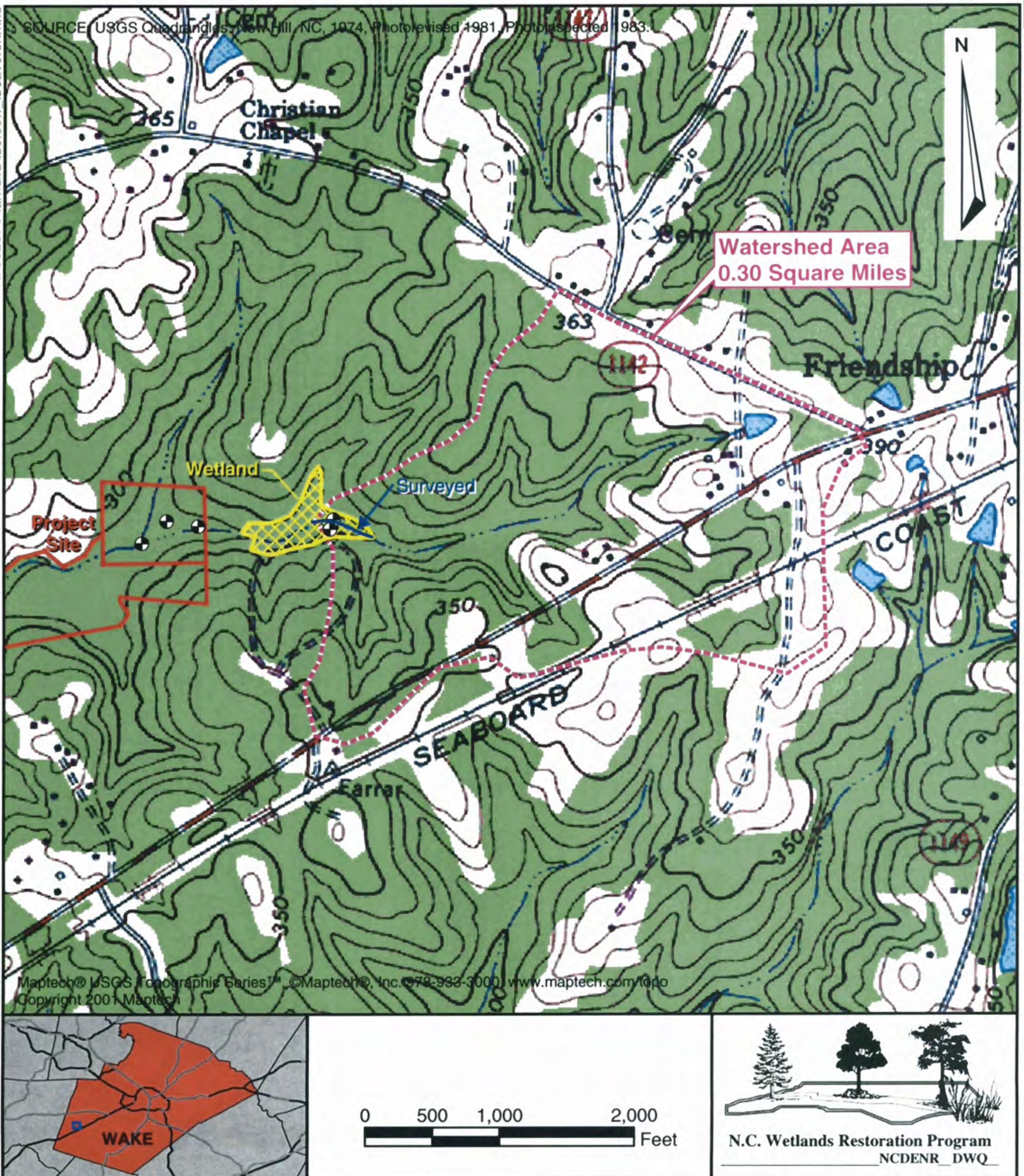

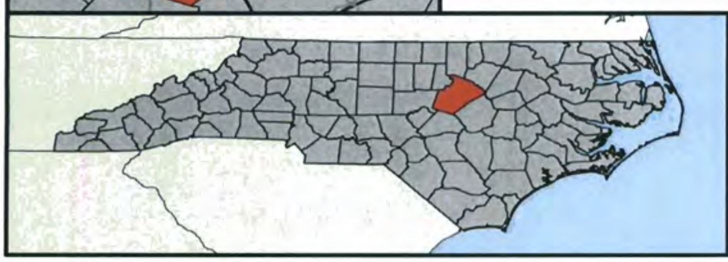

FIGURE 9
Little Beaver Creek Reference Reach
and Reference Wetland
Little Beaver Creek
Wake County, North Carolina

A typical soil profile has a 2-inch surface layer of dark silt loam with many fine roots and oxidized root channels. Textures range from silty clay at 2 inches to coarse sandy clay at 49 inches below the surface. Soils meet the requirement of a chroma of 2 or less throughout the profile, and bright red mottles are present.

The vegetation is of fairly good reference quality, given the difficulty, if not impossibility, of finding an undisturbed stand of forest in the Piedmont. The canopy trees are a mixture of age classes, but very few are of large diameter. However, pines are a minor component, indicating that the stand is approaching maturity. Canopy and subcanopy trees include willow oak (Quercus phellos), yellow poplar (Liriodendron tulipifera), red maple (Acer *rubrum*), white oak (Quercus alba), water oak (Quercus nigra), flowering dogwood (*Cornus florida*), and sweetgum (Liquidambar *styraciflua*). Shrubs and vines are abundant but not dense and include deerberry (Vaccinium stamineum), highbush blueberry (Vaccinium *corymbosum*), strawberry bush (Euonymus americana), black haw (Viburnum *prunifolium*), buttonbush (Cephalanthus occidentalis), greenbrier (Smilax *rotundifolia*), muscadine (Vitis *rotundifolia*), Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (Toxicodendron radicans), and moderate amounts of Japanese honeysuckle (*Lonicera* japonica). The herbaceous layer includes spikegrass (*Chasmanthium sessiliflorum*), deertongue (Panicum clandestinum), giant cane (Arundinaria gigantea), cardinal flower (Lobelia cardinalis), partridge berry (Mitchella *repens*), Christmas fern (Polystichum acrostichoides), royal fern (Osmunda regalis), cinnamon fern (Osmunda *cinnamomea*), a fern (*Dryopteris* sp.), a rush (*Juncus* sp.), sedges (*Carex* spp.), and scattered patches of sphagnum moss (Sphagnum sp.).

4.0 STREAM & WETLAND RESTORATION DESIGN

The stream design was based upon Rosgen's 40-step natural channel design methodology. Morphological characteristics were measured on the existing stream and reference reaches 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** 2.

The wetland design was modeled on the reference community as well as published descriptions of Piedmont bottomland systems and general observations of characteristic wetland structure and function. Areas of hydric soils were delineated and the hydrology and vegetative cover were evaluated. Areas considered suitable for restoration are those on which hydrophytic vegetation can be planted and excessive drainage can be reversed so that groundwater levels remain within 12 inches of the surface for at least 12.5% of the growing season. Areas considered for enhancement are those on which soils are hydric and wetland hydrology is present, but hydrophytic vegetation is absent and can be planted.

Table 2. **Morphological Characteristics: Existing,** Reference, and Proposed Reaches

Variables	Southern Tributary	Northern Tributary	Northern Drainage 1	Northern Drainage 2	Little Beaver Creek above NT (Reach 1)	Little Beaver Creek below NT until border of open field (Reach 2)	Little Beaver Creek bordering fields (Reach 3)	Reference Reach-Little Beaver Creek	Reference Reach-Richland Creek	Proposed Northern Tributary	Proposed Southern Tributary	Proposed Little Beaver Creek above NT (Reach 1)	Proposed Little Beaver Creek below NT until border of open field (Reach 2)	Proposed Little Beaver Creek bordering fields (Reach 3)
Stream Type (Rosgen)	G4	G4	G4	E4	E4	F4-G4	G4	C4/5	C4	C5	C5	C4/5	C4/5	C4/5
Drainage Area (sq. mi.)	0.14	0.17	?	?	0.41	0.72	1.1	0.3	1.0	0.17	0.14	0.41	0.72	1.1
Bankfull Width (W_{bkf}, ft)	6.0	4.7	6	5.2	11.2	10.5-15.1	9.5-15.5	14.0-14.7	16.2-16.7	7.9	7.9	14.5	16.1	17.1
MEAN	---	---	---	---	-	12.8	12.8	14.4	16.5					
Bankfull Mean Depth (d_{bkf}, ft)	0.7	0.9	0.8	0.7	0.7	0.9-1.4	1.4-2.0	0.8-0.9	0.9	0.57	0.57	1.04	1.15	1.22
MEAN	---	---	---	---	-	1.20	1.70	0.85	0.9					
Width/depth Ratio (W_{bkf}/d_{bkf})	8.4	5.5	7.3	7.3	15.6	7.4-16.0	6.8-7.8	15.6-18.4	17.5-18.0	14	14	14	14	14
MEAN	---	---	---	---	-	9.0	7.5	16.9	17.8					
Bankfull Cross-sectional Area (A_{bkf} sq. ft.)	4.3	4	4.9	3.7	8.0	14.3-14.8	19.2-21.9	12.2-12.3	15-15.5	4.5	4.5	15.0	18.5	21
MEAN	---	---	---	---	-	14.6	21	12.3	15.2					
Bankfull Maximum Depth (d_{max} ft)	1.5	1.2	1.5	1.7	1.2	1.9-2.5	2.1-2.6	2	1.4-1.5	1.2	1.2	2.3	2.5	2.7
MEAN	---	---	---	---	-	2.2	2.3	2	1.5					
Ratio Bankfull Maximum Depth to Mean Bankfull Depth (d_{max}/d_{bkf})	2.1	1.3	1.9	2.4	1.7	1.8	1.4	2.2-2.5	1.6-1.7	2.2	2.2	2.2	2.2	2.2
Lowest Bank Height to Bankfull Maximum Depth Ratio	3.1	3.2	2.4	1	3.7	2.8	2.3	1	1	1.0	1.0	1.0	1.0	1.0
Width of Flood Prone Area (W_{fpa} ft)	9	6	9	12	22	17-19	17-23	125-200	50-53	>100	>100	>120	>170	>50
MEAN	---	---	---	---	-	18	20	162.5	51.5					
Entrenchment Ratio (W_{fpa}/W_{bkf})	1.5	1.3	1.5	2.3	2.0	1.4	1.6	8.9-13.6	3-3.3	>13	>13	>8	>11	>3.0
Meander Length (L_m ft)	---	---	---	---	38	40-95	19-135	46-67	90-94	25-45	25-45	46-83	51-91	54-97
MEAN	---	---	---	---	-	60	53	52	92					
Ratio of Meander Length to Bankfull Width	---	---	---	---	3.4	3.1-7.4	1.5-10.5	3.2-4.7	5.5-5.7	3.2-5.7	3.2-5.7	3.2-5.7	3.2-5.7	3.2-5.7
(L_m/W_{bkf}) MEAN	---	---	---	---	-	4.7	4.1	3.6	5.6					
Radius of Curvature (R_c ft)	---	---	---	---	6.0-12	6.0-35	4.0-33	11-19	14-26	16-24	16-24	29-44	32-48	34-51
MEAN	---	---	---	---	8.4	16.5	15	14	19					
Ratio of Radius of Curvature to Bankfull Width	---	---	---	---	.54-1.1	.47-2.7	.31-2.6	.76-1.3	.84-1.6	2.0-3.0	2.0-3.0	*2.0-3.0	*2.0-3.0	*2.0-3.5
(R_c/W_{bkf}) MEAN	---	---	---	---	0.75	1.3	1.2	0.97	1.2					
Belt Width (W_{blt} ft)	---	---	---	---	12-16	10-37	9-79	5-21	25-40	20-36	20-36	36-65	40-72	43-77
MEAN	---	---	---	---	14	20	24	16	31					
Meander Width Ratio (W_{blt}/W_{bkf})	---	---	---	---	1.1-1.4	1.0-2.9	1.0-6.2	.35-1.5	1.5-2.4	2.5-4.5	2.5-4.5	2.5-4.5	2.5-4.5	2.5-4.5
MEAN	---	---	---	---	1.3	1.6	1.9	1.1	1.9					
Sinuosity (Stream Length/Valley Length, k - ft/ft)	---	---	---	---	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.3	1.3	1.3
Valley Slope (S_{valley}) ft/ft	---	---	---	---	0.011	0.0061	0.0074	0.0061	0.014	0.010	0.0061	0.011	0.0061	0.0074
Average Water Surface Slope (S_{avg})	---	---	---	---	0.011	0.0055	0.0067	0.0051	0.013	0.0077	0.0047	0.0066	0.0047	0.0057
Pool Slope (S_{pool})	---	---	---	---	.00-.006	0-0.0045	0.000-.0082	n/a	.0014-.0003	---	---	0.0-.0015	0.0-.001	0.0-.001
MEAN	---	---	---	---	0.003	0.0015	0.0014	n/a	0.0004	---	---	0.0007	0.0003	0.0003
Ratio of Pool Slope to Average Slope (S_{pool}/S_{avg})	---	---	---	---	0.3	0.3	0.3	n/a	0.03-0.11	0.03-0.11	0.03-0.11	0.096	0.06	0.05
Riffle Slope (S_{riff} ft/ft)	---	---	---	---	.009-.067	.009-.045	0.010-.070	n/a	0.01-0.039	---	---	.007-.02	.005-.015	.005-.015
MEAN	---	---	---	---	0.035	0.02	0.023	n/a	0.032	---	---	0.014	0.0095	0.0098
Ratio of Riffle Slope to Average Slope (S_{riff}/S_{avg})	---	---	---	---	1.8-13.4	1.8-9.0	2.0-14	n/a	1.0-3.0	1.0-3.0	1.0-3.0	.95-2.7	1.1-3.2	.88-2.8
MEAN	---	---	---	---	7.0	4	4.6	n/a	2.4	2.0	2.0	2.0	2.0	1.7
Maximum Pool Depth (d_{pool} ft)	---	---	---	---	3.7	3.7	3.7	2.8	1.5	1.4	1.4	3.1	3.4	3.7
Ratio of pool depth to mean bankfull depth (d_{pool}/d_{bkf})	---	---	---	---	5.3	3.1	2.2	3.3	1.7	2.5	2.5	3	3	3
Pool Width (W_{pool} ft)	---	---	---	---	11.6	11.6	11.6	19	11.1	9.6	9.6	19	21	22
Ratio of Pool Width to Bankfull Width (W_{pool}/W_{bkf})	---	---	---	---	1.0	0.9	0.9	1.3	0.7	1.3	1.3	1.3	1.3	1.3
Pool to Pool Spacing (P-P ft)	---	---	---	---	4.0-78	30-86	18-122	14-48	37-96	18-26	10-36	36.5-58	36.5-80.5	33-84
MEAN	---	---	---	---	30	51	64	30	76	23	25	46.5	55	52
Ratio of P-P to Bankfull Width (P-P/W_{bkf})	---	---	---	---	0.36-7.1	2.3-6.7	1.4-9.5	.97-3.3	2.3-5.8	2.3-3.3	3-6	3-6	3-6	3-6
MEAN	---	---	---	---	2.7	4	5	2.1	4.6	4	4	4	4	4

*Rc/Wbkf >2.0 is recommended for stability.

4.1 RESTORATION TECHNIQUES

The stream restoration will include a combination of Priority 1 and Priority 2 restoration. A Priority 1 restoration will be used to adjust the stream dimension, pattern and profile along Reach 1 and 2, to allow the stream to more fully transport its water and sediment load. These adjustments are a key on this particular site because there is an excess amount of sediment in the existing system. A combination of bedform transformations, channel dimension adjustments, pattern alterations, structure installation, and vegetation will be used to accomplish this. Reach **3** will begin as a Priority 1 restoration and become a Priority 2 restoration to comply with the FEMA regulated floodplain and floodway.

All of the existing tributaries and drainages will be connected to the proposed channels. The northern drainage 4 will be filled to provide the conditions necessary to restore the hydrology back to the wetlands located along the slope in the northeast comer of the project site and the wetlands located at the northwestern comer of the property.

The Northern and Southern Tributaries and Northern drainages 1 and 2 will be restored using Priority 1 restoration. Northern drainage **3** and the southern drainage will simply be connected to the proposed channels. Where Little Beaver Creek has been raised, a combination of structures and fill will be used to raise the drainages up to the higher elevations. The existing pattern of the drainages will not be altered.

Throughout the project a combination of oxbows and shallow depression pools will be used along the restored stream to increase habitat diversity. Oxbows will be constructed within portions of Little Beaver Creek's existing channel that will be abandoned. These oxbows will serve as refuge for aquatic life during periods of low or high flows. Shallow depression areas will be incorporated within the floodplain to create areas that are frequently flooded for short periods of time. Areas where these two habitat structures will be constructed **are** located on Figure **10.**

4.1.1 Dimension

Little Beaver Creek stream channel's existing bankfull widths range from 9.5 to 15.5 feet with a cross-sectional areas ranging from 8.0 to 21 square feet. The design channels will be constructed to bankfull target dimensions that are based on reference reach surveys and regional curve information (Figure **3)** for a C-type channels under the Rosgen Stream Classification System.

The main channel of Little Beaver Creek will be split into three distinct reaches with differing drainage areas. The upper most reach, Reach 1, will have a cross-sectional area in riffles of approximately 15 square feet with a width of 14.5 feet. Reach 2 will have a cross-sectional area in riffles of approximately 18.5 square feet with a width of 16 feet.

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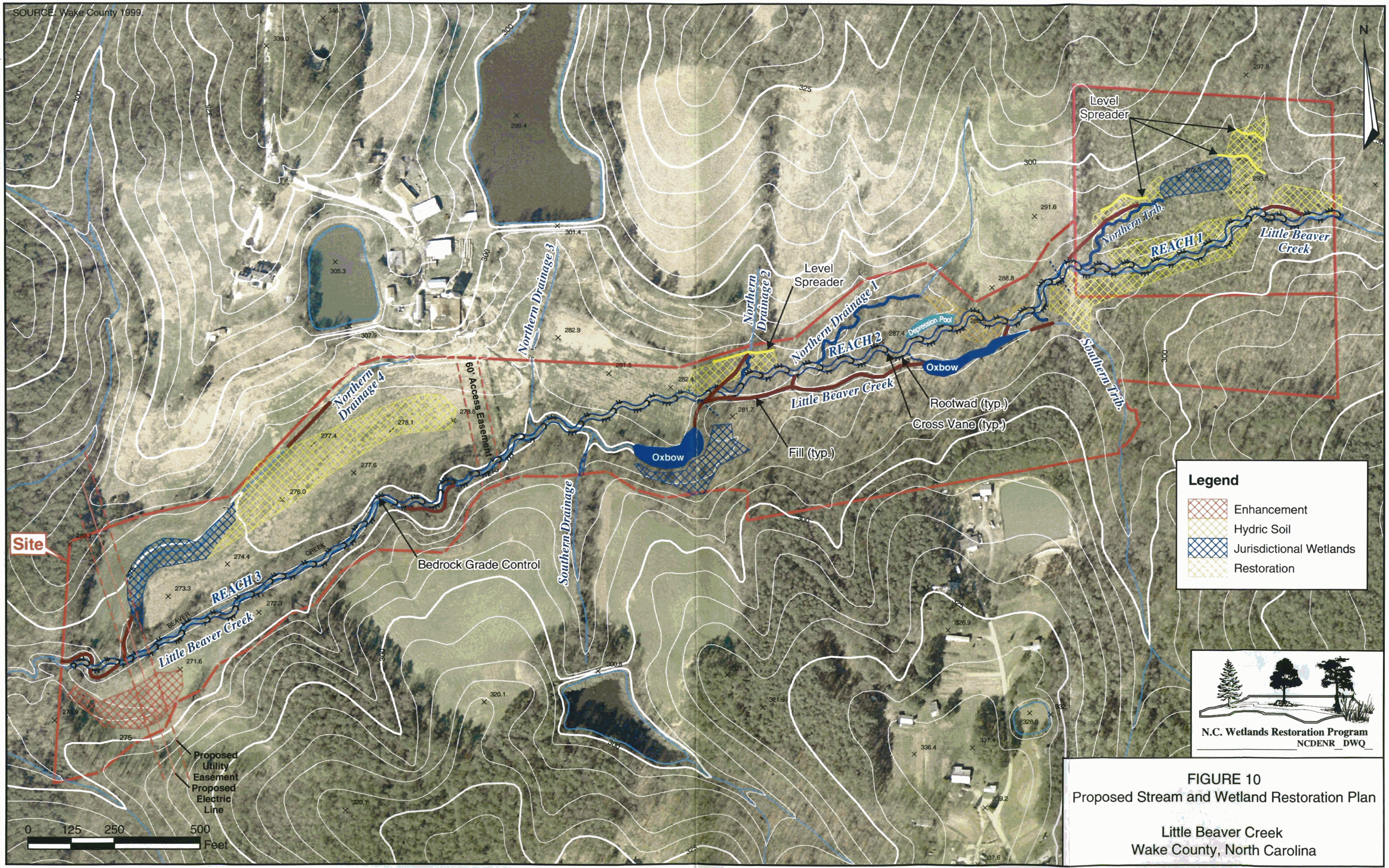

FIGURE 10
Proposed Stream and Wetland Restoration Plan

Little Beaver Creek
Wake County, North Carolina

Reach **3** will have a cross-sectional area in riffles of approximately 21 square feet with a width of **17** feet. The riffle and pool cross-sections for the three reaches are in **Figures 11 A-C** below.

4.1.2 **Pattern**

Pattern will be introduced into the stream by increasing the sinuosity of Little Beaver Creek throughout all three reaches **(Figure 10)**, through a combination of Priority 1 and 2 restorations. A Priority 1 restoration involves building a new C-type channel that is connected to its original floodplain. Meanders will be introduced into the channels with appropriate radius of curvatures and lengths based on the reference reach data and existing site constraints for a C-type stream channel. Because this site has minimal lateral constraints, the sinuosity, based on centerline length will approach that of the two reference reaches or 1.3.

Introduction of these meanders will increase stream length, sinuosity, and habitat while lowering slope and shear stress. The restoration of Reaches 1 and **2** involve Priority 1 restoration, while the changes along Reach 3 would classify as a combination of Priority 1 and 2 restorations. Reach **3** will be meandered within the existing channel, and a new floodplain built at the **bankfull** level.

4.1.3 Bedform

The existing channel lacks significant **bedform** and is mostly a run. The design channel will incorporate **riffles** and pools to provide **bedform** found in C4 stream types with gravel bottoms. Pools will be located in the outside of meander bends with riffles in the inflection points between meanders. The riffles will have average thalweg depth of 2.5 feet in the main stream channel. See **Figure** 12.

Cross vanes will be utilized as grade control structures throughout the proposed channel. The cross vanes will be constructed out of natural materials such as boulders and logs. Modifications to the **bedform** will provide stability and habitat to the channel.

4.1.4 **Structures**

Several structure types will be installed in the stream channel including cross vanes, j-hook vanes, and root wads. These structures will be made from natural materials either on-site or from off-site locations. The need for additional structure types will be assessed during the final design stage.

4.1.5 Wetlands

Various techniques will be employed to restore or enhance characteristic wetland structure and function to areas with hydric soils **(Figure** 10) that have been altered by past disturbances such as logging and agriculture. Characteristic wetland hydrology will be restored by raising the bed elevation of Little Beaver Creek and the Northern Tributary

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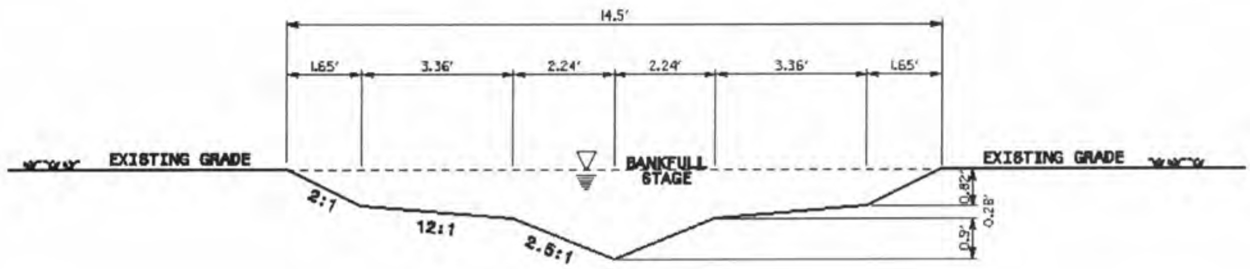
PROPOSED TYPICAL SECTIONS
REACH 1

RIFFLE



POOL

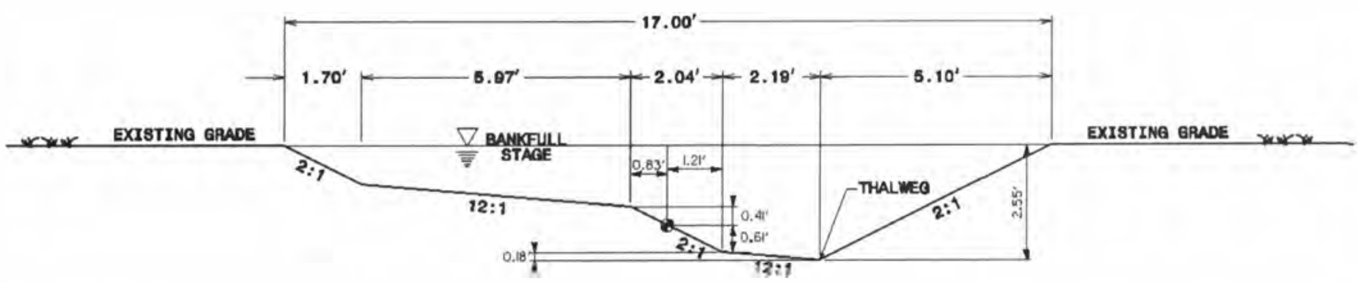


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FIGURE 11a
Proposed Little Beaver Creek Cross Sections
Reach 1
Little Beaver Creek
Wake County, North Carolina

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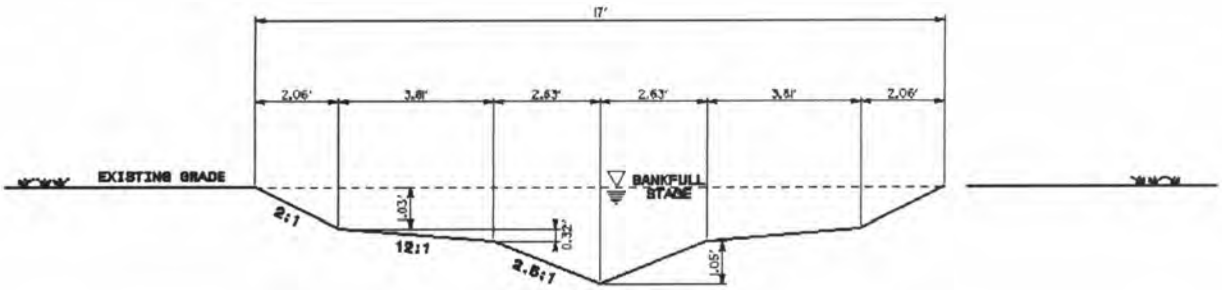
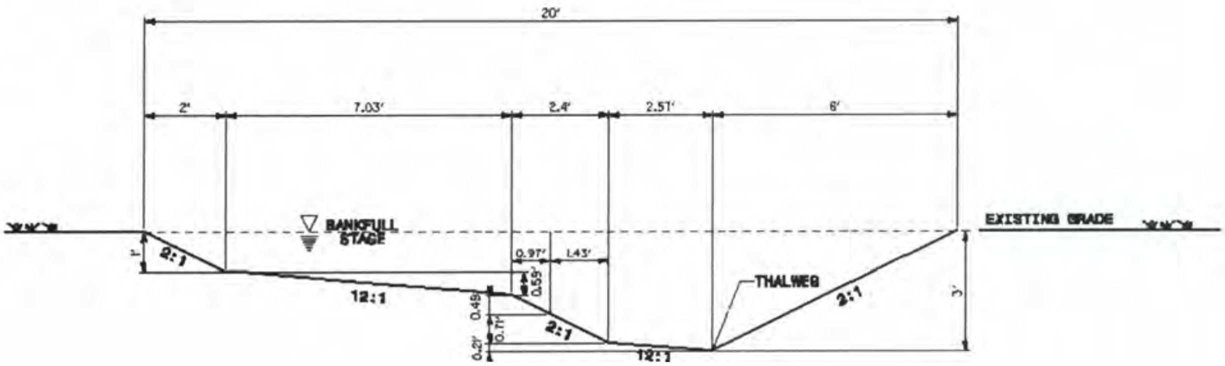
PROPOSED TYPICAL SECTIONS
REACH 2

RIFFLE



POOL



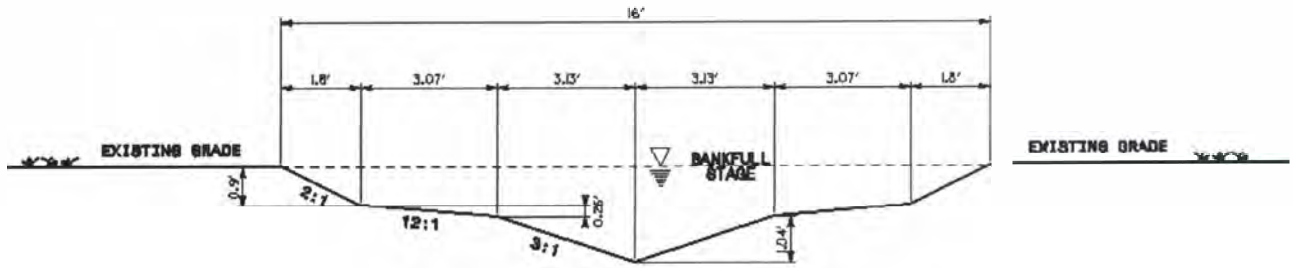
N.C. Wetlands Restoration Program
NCDENR_DWQ

FIGURE 11b
Proposed Little Beaver Creek Cross Sections
Reach 2
Little Beaver Creek
Wake County, North Carolina

K:\53257\Plan\GIS\lbcf11cxsec.mxd

PROPOSED TYPICAL SECTIONS
REACH 3

RIFFLE



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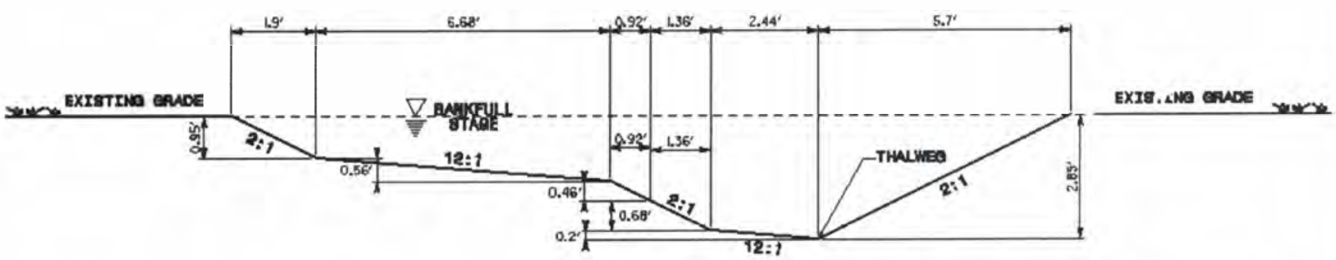

N.C. Wetlands Restoration Program
NCDENR DWQ

FIGURE 11c
Proposed Little Beaver Creek Cross Sections
Reach 3
Little Beaver Creek
Wake County, North Carolina

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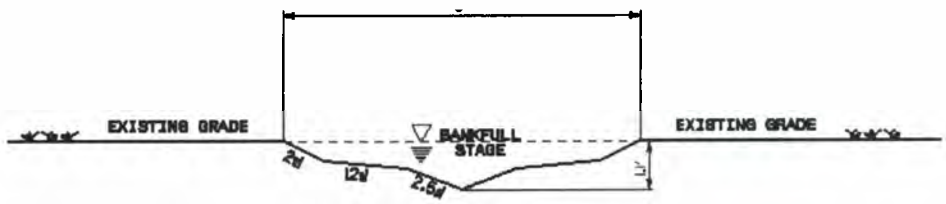
PROPOSED TYPICAL SECTIONS
TRIBUTARIES

RIFFLE



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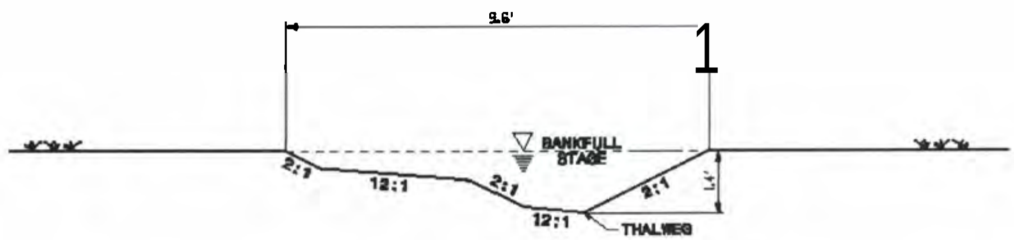

N.C. Wetlands Restoration Program
NCDENR DWQ

FIGURE 11d
Proposed Little Beaver Creek Cross Sections
Tributaries
Little Beaver Creek
Wake County, North Carolina

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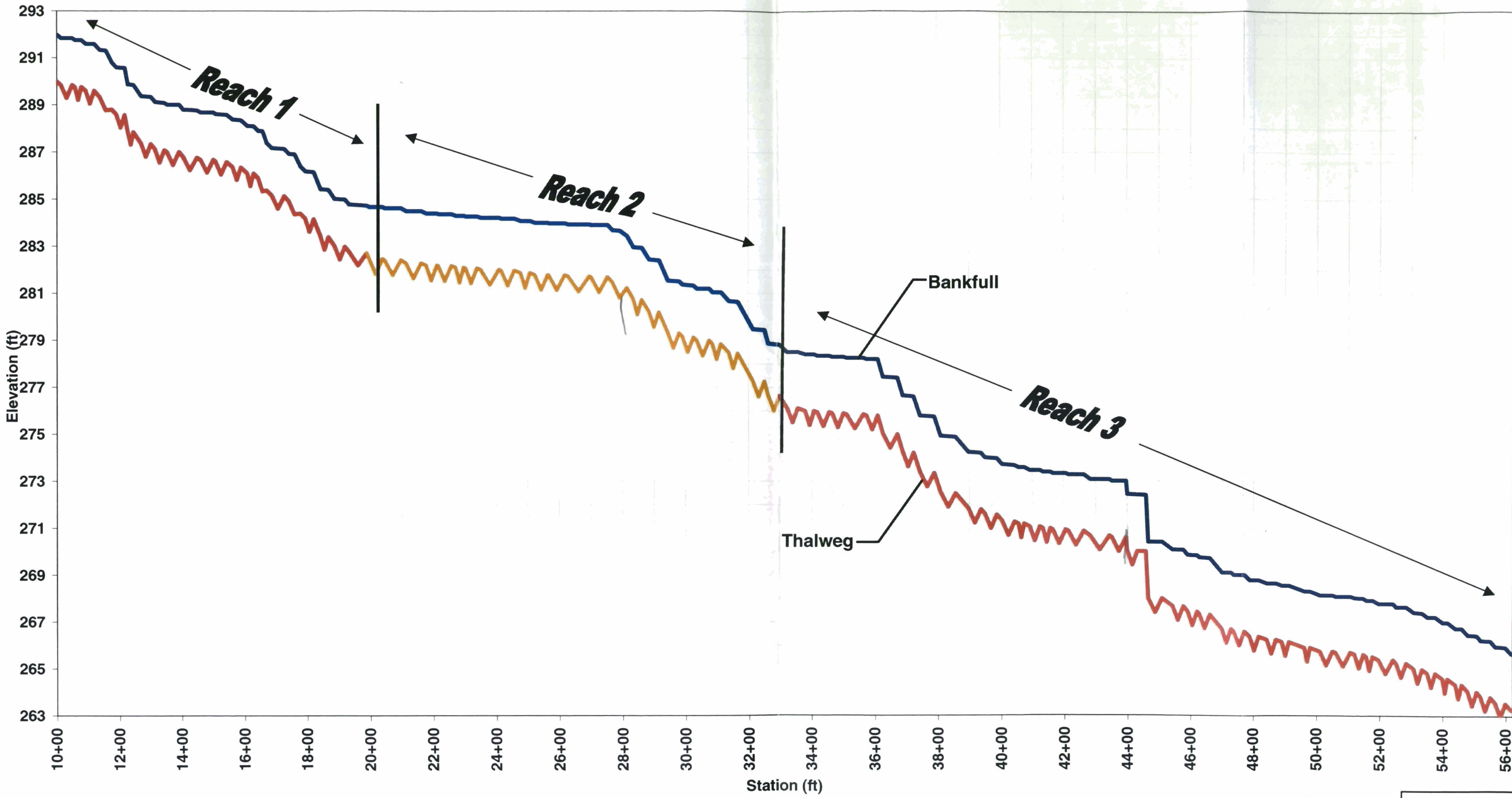

N.C. Wetlands Restoration Program
NCDENR DWQ

FIGURE 12
Proposed Stream Profile

Little Beaver Creek
Wake County, North Carolina

and reconnecting these streams to their floodplains. Northern Drainages 1, 2 and 4 will also be plugged to increase retention time in their drainage areas. Earthen level spreaders will be constructed as needed to prevent the channelization of overland flow. Appropriate hydrophytic vegetation will be planted and habitat enhancements will be incorporated as described in Section 4.4. Approximately 4.75 acres of restoration and 0.7 acres of enhancement are anticipated.

4.1.6 Riparian Buffers

A riparian zone will be created around the new proposed stream channel to provide both aquatic and terrestrial habitat as well as stabilize the stream channel. The riparian zone will extend an average of 50 feet from the top of bank on either side of the channel (**Figure 10**). These areas will be planted with appropriate riparian vegetation as described in Section 4.4.2 and may also include habitat enhancements described in Section 4.4.4.

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 wash load and bed 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).

Shear stress was checked using Shield's Curve for a proposed riffle cross-section. 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 water surface 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,

$$R = \frac{21.0 ft^2}{17.8 ft} = 1.18 ft$$

Therefore,

$$\tau = (62.4\frac{lb}{ft^3})(1.18 ft)(0.0060\frac{ft}{ft}) = 0.44 lb/ft^2$$

$$s = 0.0060\frac{ft}{ft} \text{ (combined average slope for three reaches)}$$

The critical shear stress for the proposed channels has to be sufficient to move the D84 of the bed material, which for the existing riffles is medium gravel (16 mm). Based on a shear stress of 0.44 lb/ft^2, Shield's Curve predicts that this stream can move a particle that is, on average, greater than 25 mm, or coarse gravel. Because the existing bed material is gravel in the riffles, the proposed stream has the competency to move its bed load according to Shield's Curve and preliminary design calculations. The pebble counts and bedload sampling revealed no significant difference in bed material throughout the entire reach of Little Beaver Creek. These findings reveal that the tributaries and ponds that discharge into the reach have little effect on the sediment transport.

4.3 FLOODING ANALYSIS

The USGS Method for estimating the magnitude and frequency of floods in rural basins was used to estimate the 2, 5, 10, 25, 50, and 100-year peak discharges for the 1.11 square mile drainage area as follows:

Q_2 = 130 cfs
Q_5 = 230 cfs
Q_{10} = 320 cfs
Q_{25} = 440 cfs
Q_{50} = 560 cfs
Q_{100} = 680 cfs

The region-of-influence method describe in the USGS publication estimates flood discharges at ungaged basins by deriving, for a given ungaged rural site, regression relations between the flood discharges and basin characteristics of a unique subset of gaged stations. The latitude and longitude (35°42'N, 78°55'W) and drainage area for the Little Beaver Creek site is all the input that is required.

A model of Little Beaver Creek was created using HEC-RAS, version 3.0. The model was run for the 2, 10, 25, and 100-year storm events. The model was used to evaluate velocities and shear stresses along the proposed reaches. The results of the model are in **Appendix E**. The proposed channels have no areas with either excessively high velocities or shear stresses. The proposed channels do not result in increased flooding levels through the entire project site.

4.4 Habitat Restoration

Vegetation that quickly develops a canopy, has an extensive root system, and a substantial aboveground 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 various willow species. 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 in ecologically similar settings. To quickly establish dense root mass along the channel bank, a native herb/grass mixture will be planted on the streambed and bank. Shrubs, vines, and live stakes 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 becomes established. Trees, shrubs and a native grass mixture will be planted along the tops of the channel banks.

In addition to plantings to stabilize the newly excavated streambanks, a characteristic floodplain forest community will be reestablished in a 50-foot wide riparian buffer zone along each stream bank. In areas where some forest canopy exists, trees and shrubs of desirable species will be left undisturbed as much as possible or salvaged for transplanting. Habitat enhancements such as floodplain depression pools and windthrows will be incorporated into the restoration design to further emulate typical floodplain forest structure. These restoration techniques will improve the ability of the floodplain ecosystem to provide the characteristic functions of flood storage, biogeochemical cycling, runoff attenuation, and maintenance of plant and animal habitat and species diversity.

All plant material should be native species collected or propagated from material within the Piedmont physiographic province and within 200 miles north or south latitude. The use of material that is genetically adapted to specific site conditions enhances long-term growth and survival and avoids contaminating the gene pool of the surrounding vegetation with non-adapted ecotypes. Vigorous growth of well-adapted ecotypes can also minimize problems with exotic invasive plants. Appropriate plant material is usually available upon request and can be obtained with planning and foresight.

Woody vegetation will be planted between November and March to allow plants to stabilize during the dormant period and set roots during the spring season. A non-aggressive, rapidly germinating grass will be used for immediate temporary erosion control on all newly excavated surfaces. A seed mix consisting of native graminoids and forbs will be applied during the appropriate season to ensure optimal germination and survival. Removal or control of nuisance vegetation will be implemented as necessary to promote survival of target plants.

The floodplain community recommended for this project is modeled after the Piedmont Small Stream Forest as described in *International Classification of Ecological Communities: Terrestrial Vegetation* (NatureServe 2002). This community is similar to the Piedmont Alluvial Forest described by Schafale and Weakley (1990). Few indicator species of this community, particularly oaks, are present on the site because of longstanding anthropogenic alterations such as cultivation, logging, and grazing. However, the geography and topography of the site match the characteristics of the target community. Recommended plantings are listed in the following sections.

4.4.1 Site Preparation

The potential for infestation and competition by exotic and non-target species presents a strong challenge to the restoration process. Exotic species including Japanese honeysuckle and Japanese grass are abundant in the proposed stream and wetland restoration areas in Reaches 1 and 2 and an established fescue pasture is present along Reach 3. Careful site preparation is critical to providing conditions that will favor the establishment of target species. Given the different cover types on each of the three reaches, site preparation procedures will vary somewhat.

Reach 1 will be cleared by shearing and drum-chopping. Ideally, clearing will be followed by an intense summer burn to kill weed seeds, suppress resprouting of woody species, release soil nutrients, and improve access for further site preparation and construction activities. A consulting forester with extensive experience in prescribed burning should be consulted to develop the burning plan and conduct the burn. If a burn is deemed impractical because of air and water quality, safety of adjacent properties, or other issues, the area should be treated with herbicide to suppress resprouting.

Site preparation on Reaches 2 and 3 will begin with at least one application of herbicide to kill the existing fescue in the pasture along Reach 3 and the Japanese grass and Japanese honeysuckle in Reach 2. Where overgrowth is too thick to allow good coverage and penetration of herbicide, the site should be mowed first.

When weather conditions are suitable, but at least two weeks after the herbicide application, fescue eradication in the pasture should continue with a controlled burn. The burn kills weed seeds, suppresses cool-season non-native species such as fescue, and suppresses woody species that may compete with the planted target species. A burn in Reach 2 is not recommended because of the existing canopy that will be partially preserved and the lack of understory vegetation to serve as fuel.

All planting areas should be ripped on contour to 12 inches where past land uses and current construction have caused compaction. A 2-inch layer of organic matter and other soil amendments if needed should be incorporated into the soil surface of wetland planting areas by disking. Addition of organic matter during site preparation is a fast, easy way to shorten the time it will take for the soil to revert to a characteristic pre-disturbance structure and chemistry supportive of wetland and bottomland forests. Well-seasoned hardwood chips or leaf compost may be used as a source of organic matter. Other planting areas should also be disked to incorporate soil amendments, but including organic matter may not be practical on the entire site. The surface should be left rough and irregular to emulate natural microtopography.

Liming and fertilizing are probably not necessary on this site, given the long history of these treatments on the site as well as nutrient inputs from cattle. Addition of nutrients and a pH greater than 6.0 will favor the growth of ruderal opportunists over the desired native species. However, a soil analysis should be performed to confirm nutrient status on the site. Any required soil amendments will be disked in.

4.4.2 Streambank Vegetation

A combination of seeds, live stakes, and bare root nursery stock will be utilized to stabilize the banks. Species proposed for planting are listed below. Any of the listed species may also be salvaged from construction areas and transplanted on the streambanks.

Live stakes
Elderberry (*Sambucus canadensis*)
Silky dogwood (*Cornus amonum*)
Black willow (*Salix nigra*)

Shrubs and Vines (bare root or container)
Spicebush (*Lindera benzoin*)
Tag alder (*Alnus serrulata*)
Possumhaw (*Ilex decidua*)
Wild raisin (*Viburnum nudum*)
Crossvine (*Bignonia capreolata*)

Graminoids and Forbs (seeds or plugs)
Fringed sedge (*Carex crinita*)
Hop sedge (*Carex lurida*)
River oats (*Chasmanthium latifolium*)
Wood rush (*Luzula echinata*)
Soft rush (*Juncus effusus*)

4.4.3 Riparian Buffer

A 50-foot riparian buffer will be established in the floodplain of the proposed stream channel. Bare-root seedlings of canopy and subcanopy tree species will be planted on 10-foot centers for a planting density of 440 trees/acre of the finest quality 1/0 seedlings. It is recommended that seedlings be at least 12 to 18 inches in height. Proposed species to be planted in these areas include the following:

Trees (bare root)
Green ash (*Fraxinus pennsylvanica*)
Oaks (*Quercus nigra, Q. phellos, Q. rubra*)
Southern sugar maple (*Acer barbatum*)
Black walnut (*Juglans nigra*)
Blackgum (*Nyssa sylvatica*)
Ironwood (*Carpinus caroliniana*)
Silverbell (*Halesia tetraptera*)
Witch hazel (*Hamamelis virginiana*)
Flowering dogwood (*Cornus florida*)
Pignut hickory (*Carya glabra*)

Shrubs and Vines (bare root or container)
Buckeye (*Aesculus sylvatica*)
Hazelnut (*Corylus americana*)
Strawberry bush (*Euonymus americana*)
Coral honeysuckle (*Lonicera sempervirens*)

Any of the trees, shrubs, and vines listed above also may be salvaged from construction areas and transplanted in the buffer. Shrubs and vines should be concentrated along the outer edges of the buffer as a possible barrier to opportunistic invasions of exotic species. Understory species suitable for salvage and transplant are listed below. Transplants of these species should be limited to areas that will be shaded, with the assumption that some mature trees will be left undisturbed by construction, at least in Reach 2.

Graminoids and Forbs
Jack-in-the-pulpit (*Arisaema triphyllum*)
Windflower (*Thalictrum thalictroides*)
Trillium (*Trillium cuneatum*)
Ebony spleenwort (*Asplenium platyneuron*)
Rattlesnake fern (*Botrychium virginianum*)
Christmas fern (*Polystichum acrostichoides*)
Skullcap (*Scutellaria integrifolia*)
Longleaf spikegrass (*Chasmanthium sessiliflorum*)
Sedges (*Carex* spp.)

4.4.4 Wetlands

A minimum of 440 stems per acre of canopy and subcanopy trees will be planted in areas proposed for wetland restoration. Bare-root seedlings of canopy and subcanopy tree species will be planted on 10-foot centers for a planting density of 440 trees/acre of the finest quality 1/0 seedlings. It is recommended that seedlings be at least 12 to 18 inches in height. Understory plantings may be a combination of salvaged plants and a seed mix. Proposed species to be planted in these areas include the following:

Trees (bare root)
Swamp chestnut oak (*Q. michauxii*)
Overcup oak (*Q. lyrata*)
Water oak (*Quercus nigra*)
Willow oak (*Quercus phellos*)
Green ash (*Fraxinus pennsylvanica*)
Ironwood (*Carpinus caroliniana*)
Paw-paw (*Asimina triloba*)

Shrubs and Vines (bare root or container)
Spicebush (*Lindera benzoin*)
Yellow jasmine (*Gelsemium sempervirens*)
Wild raisin (*Viburnum nudum*)
Winterberry (*Ilex verticillata*)

Graminoids and Forbs
Seeds or salvage
Giant cane (*Arundinaria gigantea*)
Sedges (*Carex debilis, C. crinita, C. lurida, C. intumescens, C. squarrosa*)
Rushes (*Juncus effusus, J. coriaceous*)
Lizard's-tail (*Saururus cernuus*)
Salvage
False stinging-nettle (*Boehmeria cylindrica*)
Netted chain fern (*Woodwardia areolata*)
Sensitive fern (*Onoclea sensibilis*)
Royal fern (*Osmunda regalis*)
Cinnamon fern (*Osmunda cinnamomea*)

4.4.5 Habitat Enhancements

Floodplain pools will be created as required by the engineering design and for habitat enhancement purposes. They may occur in hydric soil or riparian areas. These shallow pools will be vegetated using a combination of salvaged materials, container stock, and seeds. Proposed species to be planted around the edges of the pools include the following:

Container or salvage
Buttonbush (*Cephalanthus occidentalis*)
Silky dogwood (*Cornus amomum*)
Arrow-arum (*Peltandra virginica*)
False stinging nettle
Seeds
Three-way sedge (*Dulichium arundinaceum*)
Lizard's tail
Fringed sedge (*Carex crinita*)
Hop sedge (*Carex lurida*)

Windthrows will be simulated by excavating elliptical depressions and laying a tree trunk with its root wad on the ground at the edge of the depression. Trees that must be removed for channel construction or trees that are already down within the construction area will be used for this purpose. The depressions will provide amphibian habitat and additional flood storage. The tree trunks will also provide habitat for amphibians as well as reptiles, and as they decay will enhance biogeochemical functions.

5.0 MONITORING AND SUCCESS CRITERIA

Monitoring of the stream and wetland mitigation site will be performed for 3 years or until success criteria are met. Monitoring is proposed for channel stability, riparian and wetland vegetation, and wetland hydrology.

5.1 REFERENCE PHOTOGRAPHS

Monitoring: Photographs will be taken throughout the monitoring period to evaluate vegetative growth along the stream corridor and in associated wetlands of the mitigation site. Locations of the photographic points will be established and marked with stakes. A map with notations of the photo reference points will be generated. Both lateral as well as longitudinal photographs will be taken at the points.

Success Criteria: Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, growth of riparian vegetation, and the effectiveness of erosion control measures. Longitudinal photographs should indicate the absences of developing bars within the channel or an excessive increase in channel depth. Lateral photographs should not indicate excessive erosion or continuing degradation of the bank over time. A series of photographs over time should indicate successional maturation of riparian and wetland vegetation.

5.2 CHANNEL STABILITY

Monitoring: Permanent cross-sections will be established and monitored along the stream corridor of the mitigation site for each Rosgen classified stream type. Cross-sections will be placed to monitor structures and/or features that may have an increased risk of failure. The location of each cross-section will be marked to establish the exact transect location.

A common benchmark will be used for cross-sections and consistently used to facilitate easy comparison of year-to-year data. Data will be collected once a year for three years.

Success Criteria: Judgments of success or failure of restoration activities using this data will be subjective. It is expected that there will be minimal changes in the cross-sections of the "as-built" and monitored years. Changes in the cross-sections that may occur during the monitoring period will be evaluated to determine if they represent a movement toward a more unstable condition (down-cutting, deposition, erosion) or are minor changes that represent an increase in stability (settling, vegetative changes, decrease in width/depth ratio). Unstable conditions that require remediation will indicate failure of restoration activities.

5.3 PLANT SURVIVAL

Monitoring: The survival of vegetation in riparian buffers and wetlands will be evaluated using survival plots or direct counts. The survival of live stakes will be evaluated along the stream corridor of the mitigation site. Live stake planting will be monitored for three years before success or failure is assessed. The 50-foot buffer on the stream should extend 50 feet from each bank of the stream. Riparian buffers and wetlands should be planted with a native species mix at a rate of 440 trees per acre, with a 3-year survival rate of 380 trees per acre.

Success Criteria: 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. In the wetland areas, cover should be 80% wetland species. If the vegetative success criteria are not met, the cause of failure will be determined and appropriate corrective action will be taken.

5.4 GAUGE MONITORING

Monitoring. Groundwater monitoring gauge data will be collected throughout the monitoring period on a monthly basis. Official rainfall data from the State Climate Office will be obtained on an annual basis to determine if annual totals during the monitoring period fell within the normal range. An on-site rain gauge will be installed and data will be collected on a monthly basis. Groundwater and rain gauge data will be compared and analyzed annually to determine if wetland hydrology is developing in the restoration areas. For research purposes, 2 to 4 stage recorders will be installed in the reference reach and in the restored Little Beaver Creek. Data from the stage recorders will be collected on a monthly basis.

Success Criteria. Hydrologic restoration will be considered successful if groundwater levels are within 12 inches of the surface for at least 12.5% of the growing season or for a hydroperiod comparable to that of the reference wetland. If the period of saturation is between 5 and 12.5% of the growing season, the presence of hydrophytic vegetation and hydric soils will be taken into consideration. In Wake County, the growing season is 228 days, from March 26 to November 11. Five to 12.5% of 228 days is 12 to 29 days. Rainfall normal ranges will be considered when judging hydrologic success.

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Photo Log
Little Beaver Creek Restoration Plan

Picture 1. Existing riffle bed material along the upper reach of Little Beaver Creek (LBC).

Picture 2. Vertical banks and severe erosion along LBC near confluence of the northern tributary. Notice the change in the bed material shown in Picture 1.

Picture 3. Stable reach of Southern Tributary above LBC floodplain.

Picture 4. Typical condition of Little Beaver Creek downstream of the Northern Tributary confluence.

Picture 5. Headwaters of the Northern Drainage #1.

Picture 6. Existing pattern of the Northern Tributary #1(G4).

Picture 7. Condition of LBC above Northern Drainage #2.

Picture 8. Northern Drainage # 2 (E4).

Picture 9. Condition of LBC below Northern Drainage #2. Overwidened.

Picture 10. Field #1 below large pond. Large pond to the right and LBC to the left.

Picture 11. Natural grade control structure located in-between Field #1 and #2.

Picture 12. Field # 2 with LBC to left and silo to the right. Field #1 is behind the viewer.

Picture 13. Condition of LBC along Field #2.

Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson
River Basin:	Cape Fear
Watershed:	**Little Beaver Creek**
Stream Reach:	Olive Tract
Dralange Area:	0.58 sq mi (370 ac)
Date:	2/26/2002
Description:	LBC above southern trib & below northern trib
Feature:	CS#1, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	105.18	5.18	100.00	
0+08.0	105.18	5.19	99.99	
0+14.0	105.18	4.99	100.19	
0+23.0	105.18	4.76	100.42	LTOB
0+24.0	105.18	5.48	99.70	
0+25.0	105.18	6.99	98.19	
0+25.8	105.18	7.72	97.46	
0+26.5	105.18	8.99	96.19	LBKF
0+27.2	105.18	9.42	95.76	
0+29.5	105.18	9.51	95.67	
0+32.5	105.18	9.40	95.78	
0+34.5	105.18	9.59	95.59	
0+35.0	105.18	10.05	95.13	
0+36.3	105.18	10.34	94.84	LEW/WS
0+37.5	105.18	10.71	94.47	
0+39.3	105.18	10.92	94.26	TW
0+41.0	105.18	10.69	94.49	REW
0+41.4	105.18	9.30	95.88	
0+41.6	105.18	8.99	96.19	RBKF
0+42.0	105.18	7.96	97.22	
0+42.8	105.18	7.58	97.60	
0+44.2	105.18	5.82	99.36	
0+46.0	105.18	4.95	100.23	RTOB
0+50.0	105.18	4.90	100.28	
0+62.0	105.18	5.03	100.15	
0+67.0	105.18	4.44	100.74	

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	0.7	0.4	0.2
	2.3	0.5	1.1
	3.0	0.4	1.4
	2.0	0.6	1.0
	0.5	1.1	0.4
	1.3	1.4	1.6
	1.2	1.7	1.8
	1.8	1.9	3.3
	1.7	1.7	3.1
	0.4	0.3	0.4
	0.2	0.0	0.0
TOTALS	15.1		14.3

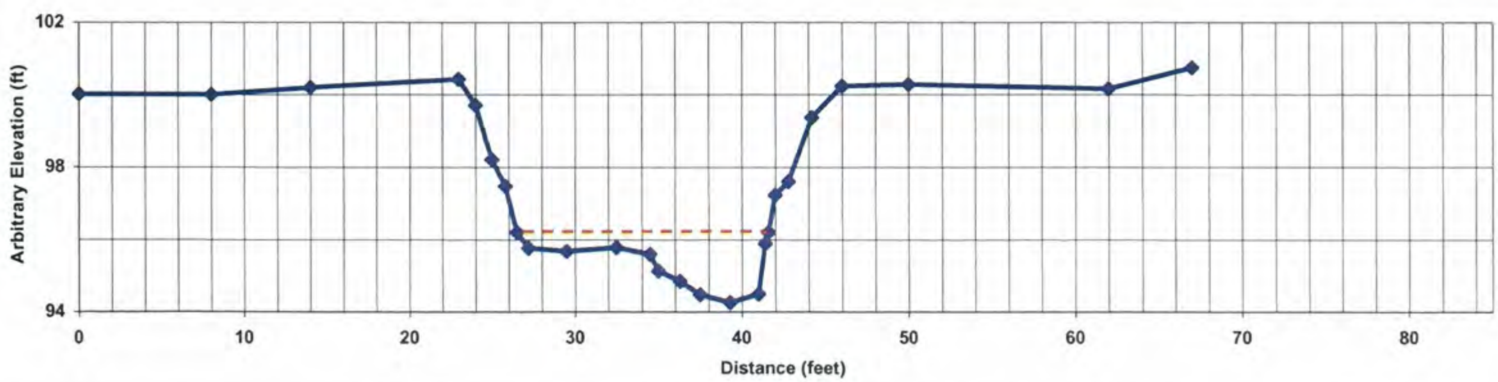
SUMMARY DATA (BANKFULL)

A(BKF)	14.3	W(FPA)	19
W(BKF)	15.1	Slope	0.005
Max d	1.9	Sinuosity	1.3
Mean d	0.9	Area= A	
W/D	16.0	Width= W	
Entrenchment	1.3	Depth= D	
Stream Type	F4	Bankfull= BKF	
Area from Rural Regional Curve			14.8

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	3.1	10	extreme
Root Depth/Bank Ht	1	1	very low
Root Density (%)	30	4	moderate
Bank Angle (Degrees)	51	3.5	low
Surface Protection (%)	80	1.9	very low
Bank Materials	Sand	10	
		30.4	high

Photo of CS#1, riffle looking in the downstream direction.



Field Crew:	Ben Goetz, Jan Pattersor
River Basin:	Cape Fear
Watershed:	Little Beaver Creek
Stream Reach:	Olive Tract
Drainage Area:	0.14 sq mi (90 ac)
Date:	2/26/2002
Description:	Southern Trib atconfluence with LBC
Feature:	CS#2, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	104.28	5.64	98.64	
0+01.4	104.28	6.02	98.26	LTOB
0+02.5	104.28	7.56	96.72	
0+03.5	104.28	8.78	95.50	LBKF
0+04.3	104.28	9.56	94.72	
0+05.4	104.28	9.65	94.63	
0+06.0	104.28	10.24	94.04	
0+06.3	104.28	10.52	93.76	LEW
0+07.0	104.28	10.71	93.57	TW
0+08.0	104.28	10.38	93.90	REW/WS
0+08.4	104.28	9.74	94.54	
0+08.8	104.28	9.56	94.72	
0+09.5	104.28	9.14	95.14	
0+10.5	104.28	8.78	95.50	RBKF
0+11.5	104.28	8.62	95.66	
0+12.5	104.28	7.35	96.93	
0+14.0	104.28	5.46	98.82	RTOB

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	0.8	0.8	0.3
	1.1	0.9	0.9
	0.6	1.5	0.7
	0.3	1.7	0.5
	0.7	1.9	1.3
	1.0	1.6	1.8
	0.4	1.0	0.5
	0.4	0.8	0.3
	0.7	0.4	0.4
	1.0	0.0	0.2
TOTALS	7.0		6.9

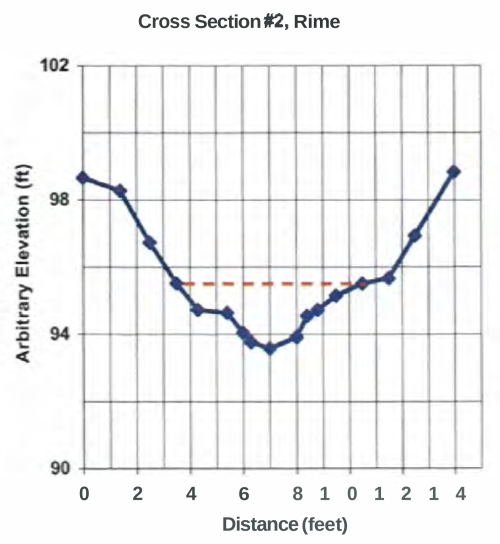
SUMMARY DATA (BANKFULL)

A(BKF)	6.9	W(FPA)	11
W(BKF)	7.0	Slope	n/a
Max d	1.9	Sinuosity	n/a
Mean d	1.0	Area= A	
W/D	7.1	Width= W	
Entrenchment	1.6	Depth= D	
Stream Type	G4	Bankfull= BKF	
Area from Rural Regional Curve			5.6

Bank Erosion Hazard Index (BEHI

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	3.1	10	extreme
Root Depth/Bank Ht	1	1	very low
Root Density (%)	30	4	moderate
Bank Angle (Degrees)	33	26	low
surface Protection (%)	95	1.1	very low
Bank Materials	Sand	10	
		28.7	moderate

Photo of CS#2, riffle looking in the upstream direction.



Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Dan Clinton, Jane Almon
River Basin:	Cape Fear
Watershed:	**Little Beaver Creek**
Stream Reach:	Olive Tract
Dralange Area:	0.14 sq mi (90 ac)
Date:	8/9/2001
Description:	Southern Trib on upland
Feature:	CS #3, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	100.00	4.7	95.30	
0+08.0	100.00	5.27	94.73	
0+16.0	100.00	5.48	94.52	
0+20.0	100.00	5.54	94.46	
0+23.0	100.00	5.28	94.72	
0+27.0	100.00	5.42	94.58	
0+30.0	100.00	5.35	94.65	
0+31.0	100.00	5.39	94.61	LTOB
0+31.6	100.00	5.75	9425	LBKF
0+32.0	100.00	6.01	93.86)	
0+32.4	100.00	6.20	93.80	
0+32.6	100.00	6.50	93.50	LEW/WS
0+33.0	100.00	6.65	93.35	
0+34.0	100.00	6.65	93.35	
0+34.7	100.00	6.73	93.27	
0+35.3	100.00	6.81	93.19	TW
0+36.0	100.00	6.63	93.37	
0+36.7	100.00	6.60	93.40	
0+37.5	100.00	6.54	93.46	REW
0+38.1	100.00	5.75	94.25	
0+39.0	100.00	5.85	94.15	
0+44.0	100.00	5.90	94.10	
0+44.5	100.00	5.75	94.25	RBKF
0+47.0	100.00	5.32	94.68	TOB
0+51.0	100.00	5.07	94.93	

BANKFULL
Hydraulic Geometry

	Width (Feat)	Depth (Feet)	Area (Sq. Ft)
	0.0	0.0	0.0
	0.4	0.3	0.1
	0.4	0.5	0.1
	0.2	0.6	0.1
	0.4	0.9	0.3
	1.0	0.9	0.9
	0.7	1.0	0.7
	0.6	1.1	0.6
	0.7	0.9	0.7
	0.7	0.8	0.6
	0.6	0.6	0.7
	0.6	0.0	0 2
	0.9	0.1	0.0
	5.0	0.2	0.6
	0.5	0.0	0.0
TOTALS	12.9		5.7

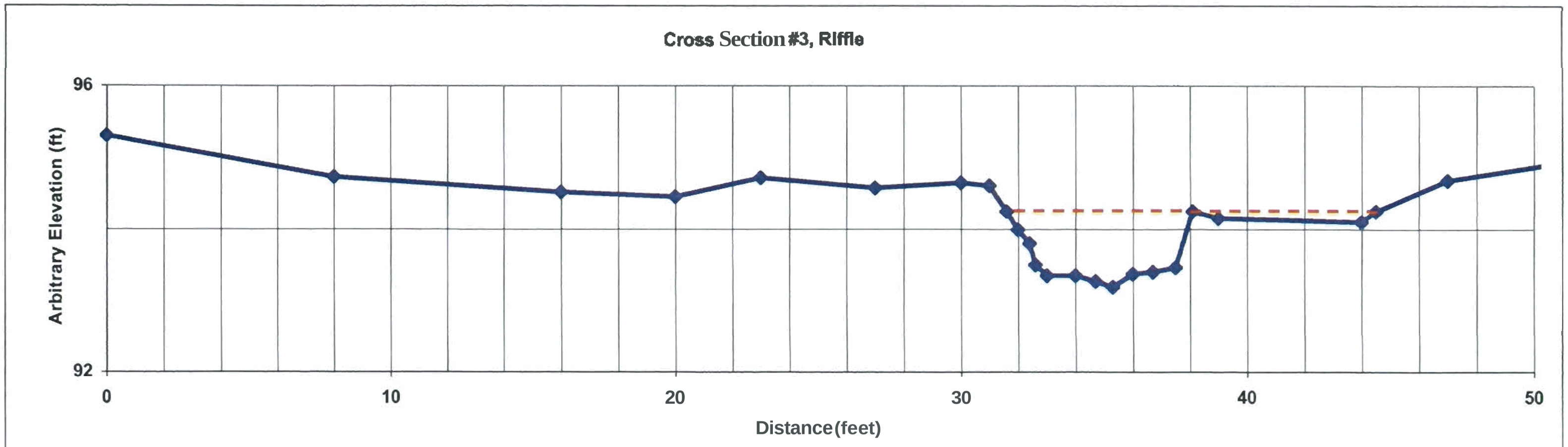
SUMMARY DATA (BANKFULL)

A(BKF)	5.7	W(FPA)	60
			n/a
Max d		Sinuosity	n/a
Mean d	0.4	Area= A	
W/D	29.2	Width= W	
Entrenchment	4.7	Depth= D	
Stream Type	E4	Bankfull= BKF	
Area from Rural Regional Curve			5.6

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	1	1	very low
Root Depth/Bank Ht	1	1	very low
Root Density (%)	54	4	moderate
Bank Angle (Degrees)	53	3.6	low
Surface Protection (%)	54	4	moderate
Bank Materials	Silt/Clay	0	
		13.6	low

Photo of CS#3, riffle looking in the downstream direction.



Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson, Jane Almon
River Basin:	Cape Fear
Watershed:	**Little Beaver Creek**
Stream Reach:	Olive Tract
Drainage Area:	0.41sq mi (260 acres)
Date:	8/9/2001
Description:	LBC above Northern Trib
Feature:	CS#4, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	105.14	5.14	100.00	
0+10.0	105.14	4.83	100.31	
0+14.0	105.14	4.55	100.59	
0+16.0	105.14	4.87	100.27	
0+18.0	105.14	5.06	100.08	LTOB
0+19.5	105.14	5.86	99.28	
0+21.3	105.14	7.15	97.47	LBKF
0+21.8	105.14	8.29	96.85	
0+23.5	105.14	8.45	96.69	
0+25.8	105.14	8.93	96.21	
0+27.4	105.14	9.07	96.07	
0+27.7	105.14	9.45	95.69	LEW
0+30.0	105.14	9.48	95.66	TW
0+32.4	105.14	9.38	95.76	REW
0+32.5	105.14	8.49	96.65	
0+33.0	105.14	8.15	96.99	
0+34.0	105.14	7.67	97.47	RBKF
0+36.0	105.14	7.37	97.77	
0+41.0	105.14	7.28	97.86	
0+42.0	105.14	6.24	98.90	
0+43.0	105.14	5.41	99.73	RTOB
0+45.0	105.14	5.01	100.13	

BANKFULL
Hydraulic Geometry

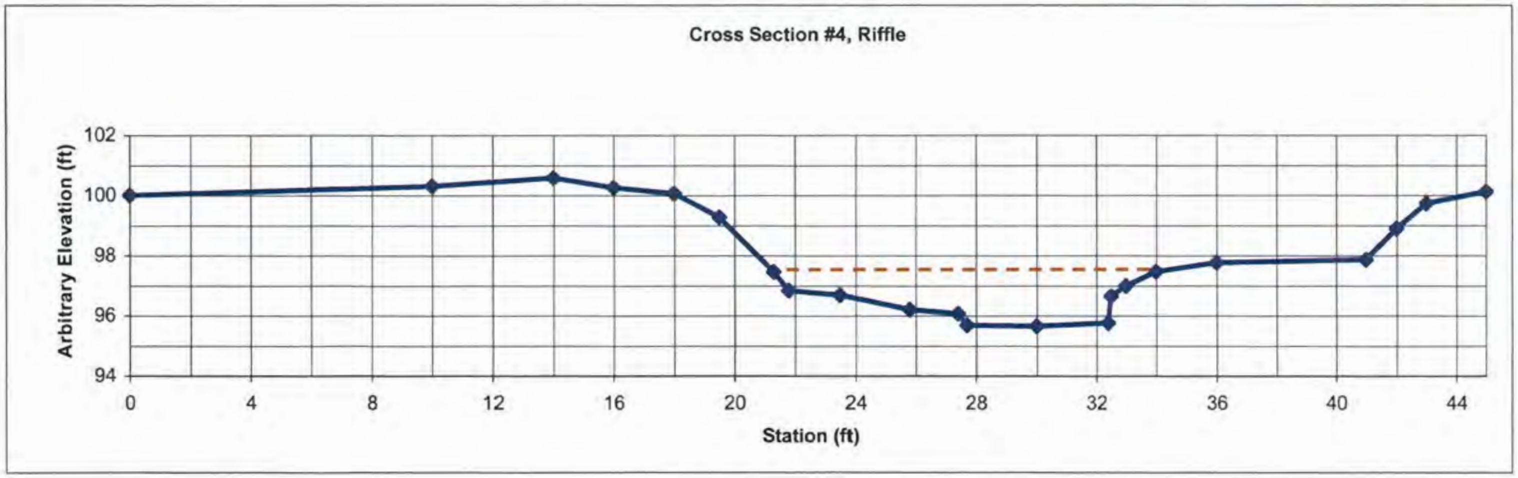
	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0	0	0
	0.5	0.6	0.2
	1.7	0.8	1.2
	2.3	1.3	2.3
	1.6	1.4	2.1
	0.3	1.8	0.5
	2.3	1.8	4.1
	2.4	1.7	4.2
	0.1	0.8	0.1
	0.5	0.5	0.3
	1.0	0.0	0.2
TOTALS	12.7		15.3

SUMMARY DATA (BANKFULL)			
A(BKF)	15.3	W(FPA)	24
W(BKF)	12.7	Slope	0.005
Max d	1.8	Sinuosity	1.3
Mean d	1.2	Area= A	
W/D	10.5	Width= W	
Entrenchment	1.9	Depth= D	
Stream Type	F4	Bankfull= BKF	
Area from Rural Regional Curve			12

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	3.7	10	extreme
Root Depth/Bank Ht	1	1	very low
Root Density (%)	25	7	high
Bank Angle (Degrees)	30	5.9	moderate
Surface Protection (%)	90	7.9	high
Bank Materials	Sand	10	
		41.8	very high

Photo of CS#4, riffle looking in the downstream direction.



Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson, Jane Almon
River Basin:	
Watershed:	Little Bearer Creek
Stream Reach:	
Drainage Area:	0.17 sq mi (110 acres)
Date:	
Description:	Northern tri
Feature:	CS#5, Riffl

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	105.14	4.76	100.38	
0+08.7	105.14	5.42	99.72	LTOB
0+09.2	105.14	7.18	97.96	
0+10.0	105.14	7.99	97.15	LBKF
0+10.5	105.14	8.37	96.77	
0+11.0	105.14	8.73	96.41	
0+11.4	105.14	8.88	96.26	
0+11.8	105.14	9.16	95.98	LEW/WS
0+12.8	105.14	9.22	95.92	TW
0+14.0	105.14	9.12	96.02	REW
0+14.3	105.14	8.37	96.77	
0+14.7	105.14	7.99	97.15	RBKF
0+15.8	105.14	5.30	99.84	TOB
0+20.0	105.14	4.60	100.54	

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0	0	0
	0.5	0.4	0.1
	0.5	0.7	0.3
	0.4	0.9	0.3
	0.4	1.2	0.4
	1.0	1.2	1.2
	1.2	1.1	1.4
	0.3	0.4	0.2
	0.4	0.0	0.1
TOTALS	4.7		4.0

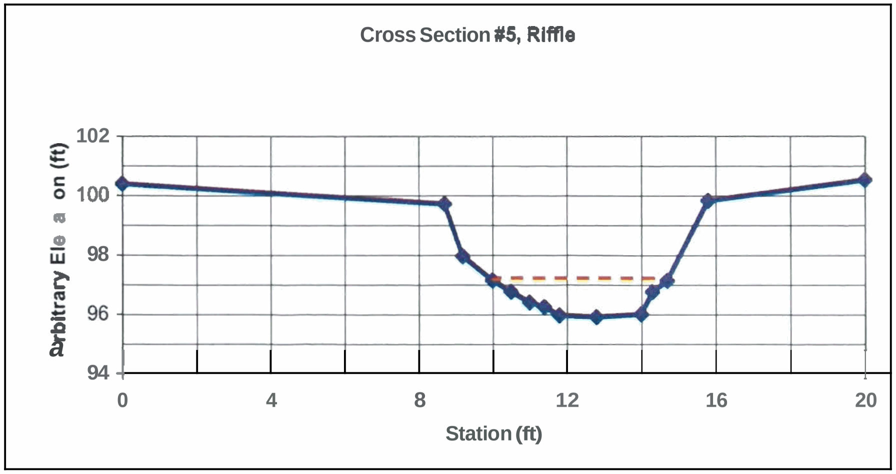
SUMMARY DATA (BANKFULL)

A(BKF)	4.0	W(FPA)	6
W(BKF)	4.7	Slope	n/a
Max d	1.2	Sinuosity	n/a
Mean d	0.9	Area= A	
W/D	5.5	Width= W	
Entrenchment	1.3	Depth= D	
Stream Type	G4	Bankfull= BKF	
Area from Rural Regional Curve			4.8
			6.4

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	3.3	10	extreme
Root Depth/Bank Ht	1	1	very low
Root Density (%)	4	10	extreme
Bank Angle (Degrees)	80	5.9	moderate
Surface Protection (%)	9	10	extreme
Bank Materials	Silt/Clay	0	
		36.9	high

Photo of CS#5, riffle looking in the upstream direction.



K:/53257/Plan/Field Data/Site Survey-LBC-1

Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson, Jane Almon
River Basin:	Cape Fear
Watershed:	**Tick Creek** Little Beaver Creek
Stream Reach	Condoret-R Olive Tract
Drainage Area	0.72 sq mi (460 ac)
Date:	8/9/2001
Station:	N/A
Feature:	CS#6, Pool

STATION (FEET)	HI (FEET)	FS (FEET)	ELEVATION (FEET)	NOTES
0+00.0	103.50	5.30	100.00	
0+08.5	103.50	5.68	97.82	1108
0+10.0	103.50	6.79	96.71	
0+11.0	103.50	8.91	95.18	LBKF
0+11.4	103.50	9.23	94.27	
0+11.5	103.50	11.62	91.88	
0+12.6	103.50	12.01	91.49	TW
0+14.0	103.50	11.88	91.62	
0+16.6	103.50	11.50	92.00	
0+17.2	103.50	10.60	92.90	REW/WS
0+18.0	103.50	10.13	93.37	
0+18.8	103.50	9.54	93.96	
0+19.5	103.50	9.22	94.28	
0+20.2	103.50	8.87	94.63	
0+22.6	103.50	8.32	95.18	RBKF
0+27.5	103.50	7.93	95.57	
0+31.0	103.50	5.88	97.62	RTOB
0+36.5	103.50	5.34	98.16	
0+45.0	103.50	6.18	98.32	

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	0.4	0.9	0.2
	0.1	3.3	0.2
	1.1	3.1	3.8
	1.4	3.6	5.1
	2.6	3.2	8.8
	0.6	2.3	1.6
	0.8	1.8	1.6
	0.8	1.2	1.2
	0.1	0.9	0.1
	0.1	0.6	0.5
	2.4	0.0	0.1
TOTALS	11.6		24.5

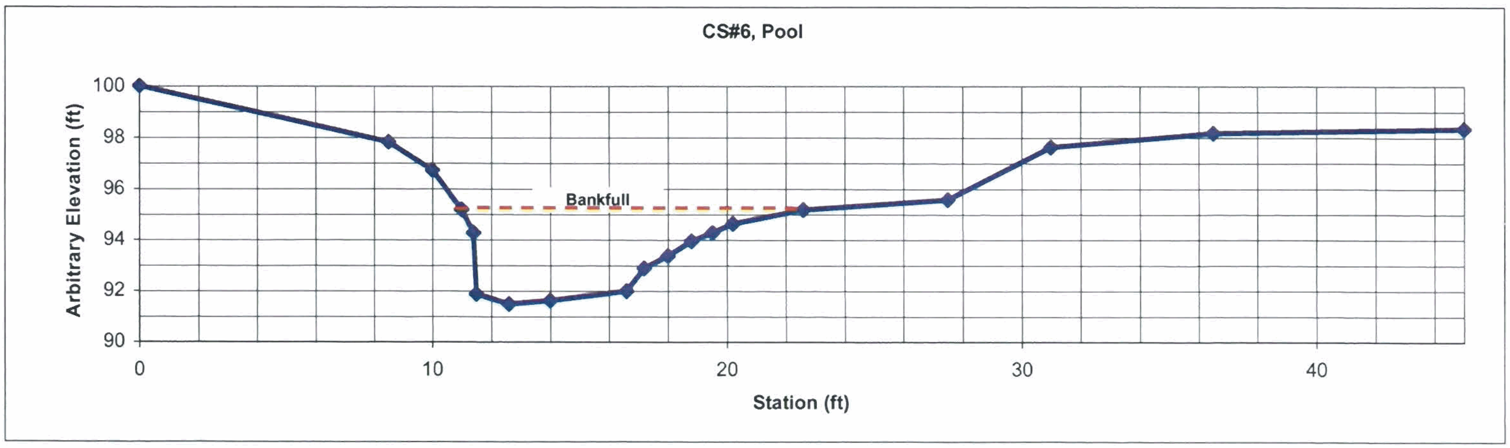
SUMMARY DATA (BANKFULL)

A(BKF)	24.5
W(BKF)	11.6
Max d	3.1
Mean d	2.1

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	2.3	8.2	very high
Root Depth/Bank Ht	1	1	very low
Root Density (%)	4	10	extreme
Bank Angle (Degrees)	90	7.9	high
Surface Protection (%)	9	10	extreme
Bank Materials	sand	10	
		47.1	extreme

Photo of CS#6, pool looking in the downstream direction.



Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson
River Basin:	Cape Fear
Watershed:	**Little Beaver Creek**
Stream Reach:	Olive Tract
Dralange Area:	0.72 sq mi (460 ac)
Date:	2/26/2002
Station:	N/A
Feature:	CS#7, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	102.60	5.75	96.85	
0+06.5	102.60	6.15	96.45	LTOB
0+07.5	102.60	6.94	95.66	
0+08.5	102.60	8.07	94.53	
0+10.0	102.60	8.69	93.91	LBKF
0+12.0	102.60	9.02	93.58	
0+14.0	102.60	9.55	93.05	
0+14.6	102.60	9.95	92.65	
0+15.6	102.60	11.32	91.28	
0+17.5	102.60	11.52	91.08	LEW
0+19.5	102.60	11.19	91.41	TW
0+20.0	102.60	11.11	91.49	REW/WS
0+20.9	102.60	9.95	92.65	
0+21.3	102.60	9.55	93.05	
0+22.5	102.60	9.02	93.58	
0+23.2	102.60	8.69	93.91	RBKF
0+24.7	102.60	6.08	96.52	RTOB
0+31.0	102.60	5.83	96.52	

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	2.0	0.3	0.3
	2.0	0.9	1.2
	0.6	1.3	0.6
	1.0	2.6	1.9
	1.9	2.8	5.2
	2.0	2.5	5.3
	0.5	2.4	1.2
	0.9	1.3	1.7
	0.4	0.9	0.4
	1.2	0.3	0.7
	0.7	0.0	0.1
TOTALS	13.2		18.8

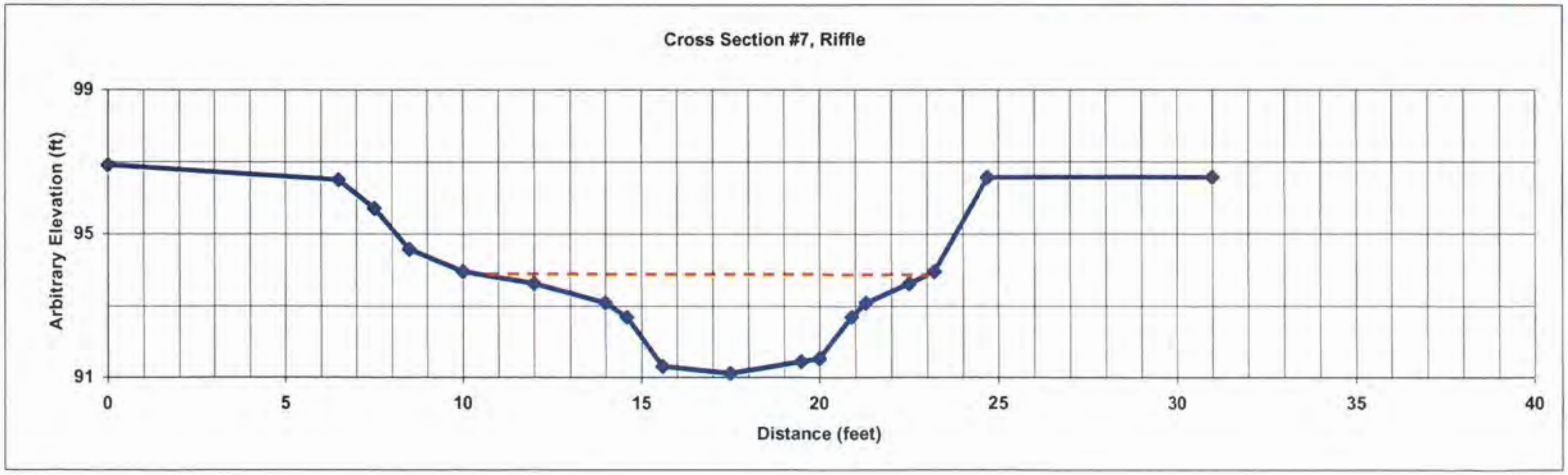
SUMMARY DATA (BANKFULL)

A(BKF)	18.8	W(FPA)	18
W(BKF)	13.2	Slope	0.005
Max d	2.8	Sinuosity	1.3
Mean d	1.4	Area= A	
W/D	9.3	Width= W	
Entrenchment	1.4	Depth= D	
Stream Type	G4	Bankfull= BKF	
Area from Rural Regional Curve			17

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	2.4	8.5	very high
Root Depth/Bank Ht	1	1	very low
Root Density (%)	50	4.2	moderate
Bank Angle (Degrees)	62	4.1	moderate
Surface Protection (%)	30	5.9	moderate
Bank Materials	sand	10	
		33.7	high

Photo of Run CS#7 looking in the downstream direction.



Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson
River Basin:	Cape Fear
Watershed:	**Little Beaver Creek**
Stream Reach:	Olive Tract
Dralange Area:	0.97 sq mi (620 ac)
Date:	2/26/2002
Station:	N/A
Feature:	CS#8, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	102.60	4.74	97.86	
0+04.0	102.60	5.05	97.55	
0+09.3	102.60	5.50	97.10	LTOB
0+12.0	102.60	8.52	94.08	LBKF
0+13.2	102.60	9.24	93.36	
0+14.0	102.60	10.01	92.59	
0+14.1	102.60	10.99	91.61	LEW
0+14.8	102.60	11.14	91.46	TW
0+15.6	102.60	11.02	91.58	
0+16.5	102.60	10.81	91.79	REW/WS
0+19.0	102.60	10.42	92.18	
0+22.5	102.60	9.87	92.73	
0+24.5	102.60	9.27	93.33	
0+26.0	102.60	9.08	93.52	
0+27.5	102.60	8.52	94.08	RBKF
0+31.0	102.60	5.51	94.08	RTOB
0+35.0	102.60	5.47	97.09	

BANKFULL Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	1.2	0.7	0.4
	0.8	1.5	0.9
	0.1	2.5	0.2
	0.7	2.6	1.8
	0.8	2.5	2.0
	0.9	2.3	2.2
	2.5	1.9	5.2
	3.5	1.4	5.7
	2.0	0.8	2.1
	1.5	0.6	1.0
	1.5	0.0	0.4
TOTALS	15.5		21.9

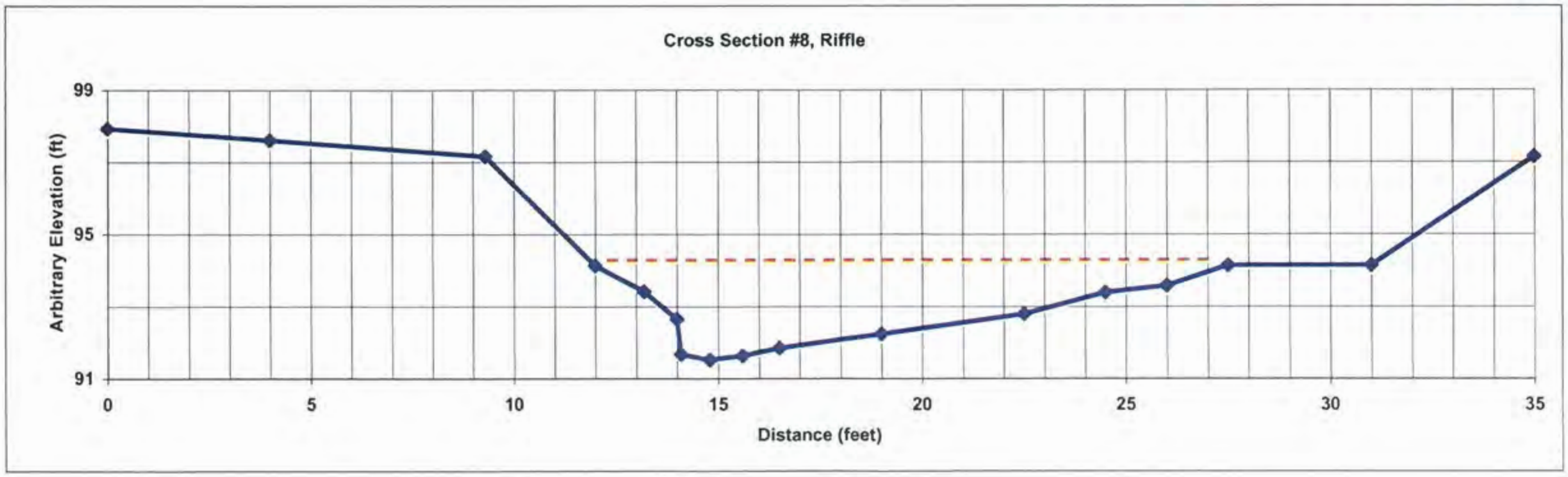
SUMMARY DATA (BANKFULL)

A(BKF)	21.9	W(FPA)	26
W(BKF)	15.5	Slope	0.005
Max d	2.6	Sinuosity	1.3
Mean d	1.4	Area= A	
W/D	11.0	Width= W	
Entrenchment	1.7	Depth= D	
Stream Type	G4	Bankfull= BKF	
Area from Rural Regional Curve			21

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	2.2	8.1	very high
Root Depth/Bank Ht	1	1	very low
Root Density (%)	25	6.3	high
Bank Angle (Degrees)	60	3.9	low
Surface Protection (%)	55	3.9	low
Bank Materials	sand	10	
		33.2	high

Photo of CS#8, riffle looking in the downstream direction.



K:/53257/Plan/Field Data/Site Survey-LBC-1

Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson
River Basin:	Cape Fear
Watershed:	**Little Beaver Creek**
Stream Reach:	Olive Tract
Dralange Area:	0.97 sq mi (620 ac)
Date:	2/26/2002
Station:	N/A
Feature:	CS#9, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	102.60	3.07	99.53	
0+03.0	102.60	5.40	97.20	
0+05.0	102.60	5.90	96.70	
0+07.0	102.60	5.85	96.75	
0+09.0	102.60	5.99	96.61	LTOB
0+11.0	102.60	7.02	95.58	
0+11.5	102.60	7.50	95.10	LBKF
0+12.8	102.60	8.32	94.28	
0+13.5	102.60	9.46	93.14	LEW
0+13.8	102.60	9.48	93.12	
0+16.0	102.60	9.60	93.00	TW
0+18.2	102.60	9.42	93.18	
0+20.8	102.60	9.45	93.15	
0+23.0	102.60	9.35	93.25	REW/WS
0+24.0	102.60	8.20	94.40	
0+25.0	102.60	7.50	95.10	RBKF
0+25.1	102.60	6.00	96.60	RTOB
0+47.6	102.60	4.51	98.09	

BANKFULL Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	1.3	0.8	0.5
	0.7	2.0	1.0
	0.3	2.0	0.6
	2.2	2.1	4.5
	2.2	1.9	4.4
	2.6	2.0	5.0
	2.2	1.8	4.2
	1.0	0.7	1.3
	1.0	0.0	0.4
TOTALS	13.5		21.8

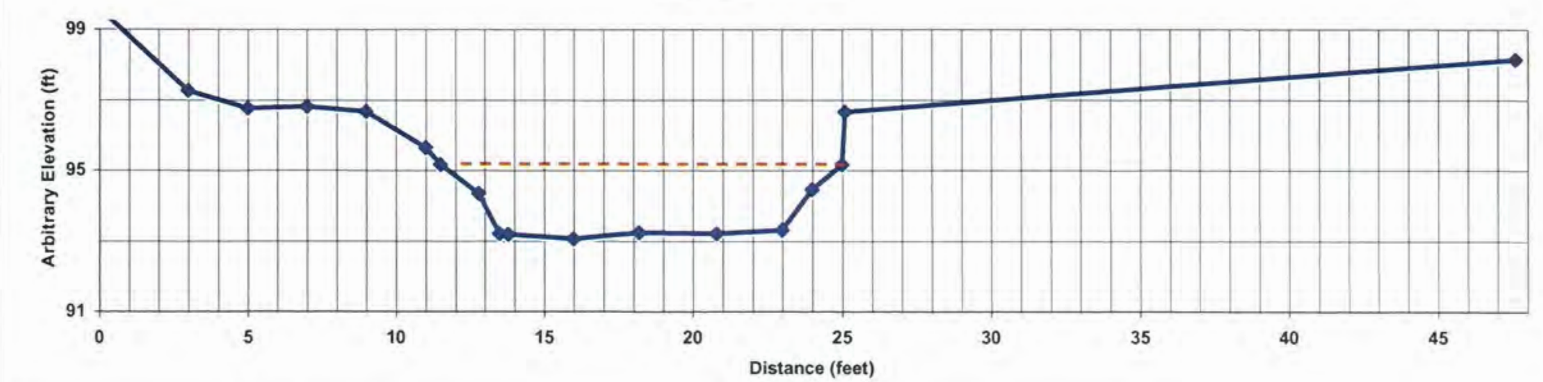
SUMMARY DATA (BANKFULL)

A(BKF)	21.8	W(FPA)	28
W(BKF)	13.5	Slope	0.027
Max d	2.1	Sinuosity	1.3
Mean d	1.6	Area= A	
W/D	8.3	Width= W	
Entrenchment	2.1	Depth= D	
Stream Type	G4	Bankfull= BKF	
Area from Rural Regional Curve			21

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	1.7	6.1	moderate
Root Depth/Bank Ht	1	1	very low
Root Density (%)	30	4.4	moderate
Bank Angle (Degrees)	45	3.3	low
Surface Protection (%)	30	5.9	moderate
Bank Materials	sand	10	
		30.7	high

Photo of CS#9, riffle looking in the downstream direction.



Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson
River Basin:	Cape Fear
Watershed:	**Little Beaver Creek**
Stream Reach:	Olive Tract
Draiange Area:	1.1 sq mi (700 ac)
Date:	2/26/2002
Station:	N/A
Feature:	CS#10, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	102.60	5.08	97.52	
0+05.0	102.60	4.94	97.66	
0+08.0	102.60	5.10	97.50	
0+11.5	102.60	5.82	96.78	LTOB
0+13.0	102.60	6.48	96.12	
0+14.5	102.60	7.95	94.65	
0+16.0	102.60	8.99	93.61	
0+17.5	102.60	9.94	92.66	LBKF
0+18.0	102.60	11.11	91.49	
0+18.5	102.60	12.24	90.36	LEW
0+19.5	102.60	12.07	90.53	
0+21.0	102.60	12.00	90.60	
0+22.4	102.60	12.07	90.53	
0+23.8	102.60	12.17	90.43	
0+24.5	102.60	12.20	90.40	TW
0+25.3	102.60	12.04	90.56	REW/WS
0+27.0	102.60	11.81	90.79	
0+27.0	102.60	9.94	92.66	RBKF
0+30.0	102.60	9.60	93.00	
0+33.0	102.60	6.67	95.93	
0+34.5	102.60	5.30	97.30	RTOB
0+50.0	102.60	5.01	97.59	

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	0.5	1.2	0.3
	0.5	2.3	0.9
	1.0	2.1	2.2
	1.5	2.1	3.1
	1.4	2.1	2.9
	1.4	2.2	3.1
	0.7	2.3	1.6
	0.8	2.1	1.7
	1.7	1.9	3.4
	0.0	0.0	0.0
TOTALS	9.5		19.2

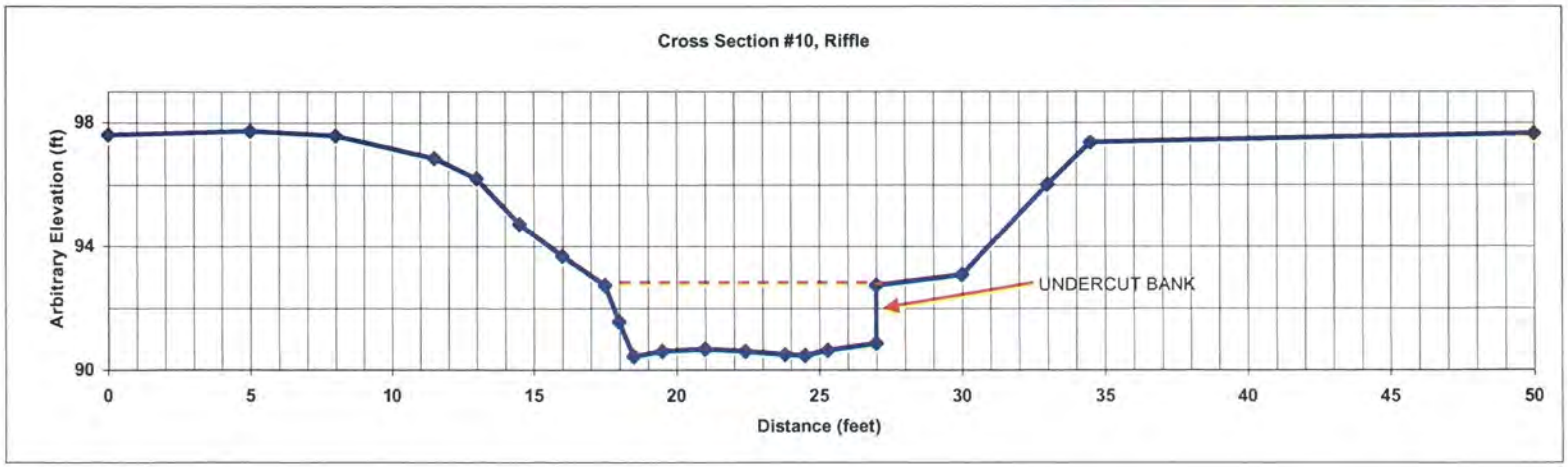
SUMMARY DATA (BANKFULL)

A(BKF)	19.2	W(FPA)	18
W(BKF)	9.5	Slope	0.019
Max d	2.3	Sinuosity	1.3
Mean d	2.0	Area= A	
W/D	4.7	Width= W	
Entrenchment	1.9	Depth= D	
Stream Type	G4	Bankfull= BKF	
Area from Rural Regional Curve			22.9

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	3.1	10	extreme
Root Depth/Bank Ht	1	1	very low
Root Density (%)	4	10	extreme
Bank Angle (Degrees)	70	5	moderate
Surface Protection (%)	9	10	extreme
Bank Materials	sand	10	
		46	extreme

Photo of CS#10, riffle looking in the upstream direction.



Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson
River Basin:	Cape Fear
Watershed:	Little Beaver Creek
Stream Reach:	Olive Tract
Dralange Area:	1.1 sq mi (700 ac)
Date:	2/26/2002
Station:	ND1
Feature:	CS#11, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	102.60	4.76	97.84	
0+05.0	102.60	4.83	97.77	
0+06.0	102.60	5.02	97.58	
0+07.0	102.60	5.33	97.27	LTOB
0+08.0	102.60	5.92	96.68	
0+08.2	102.60	6.81	95.79	
0+09.3	102.60	7.63	94.97	LBKF
0+09.5	102.60	8.08	94.52	
0+09.9	102.60	8.30	94.30	
0+10.5	102.60	8.90	93.70	
0+10.6	102.60	8.94	93.66	LEW
0+11.3	102.60	9.11	93.49	TW
0+11.6	102.60	9.10	93.50	
0+12.0	102.60	8.96	93.64	REW/WS
0+13.0	102.60	8.39	94.21	
0+14.0	102.60	8.08	94.52	
0+15.3	102.60	7.50	94.97	RBKF
0+17.0	102.60	6.31	96.29	
0+18.6	102.60	5.59	97.01	RTOB
0+22.0	102.60	5.29	97.31	

BANKFULL Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	0.2	0.5	0.0
	0.4	0.7	0.2
	0.6	1.3	0.6
	0.1	1.3	0.1
	0.7	1.5	1.0
	0.3	1.5	0.4
	0.4	1.3	0.6
	1.0	0.8	1.0
	1.0	0.5	0.6
	1.3	0.0	0.3
TOTALS	6.0		4.9

SUMMARY DATA (BANKFULL)

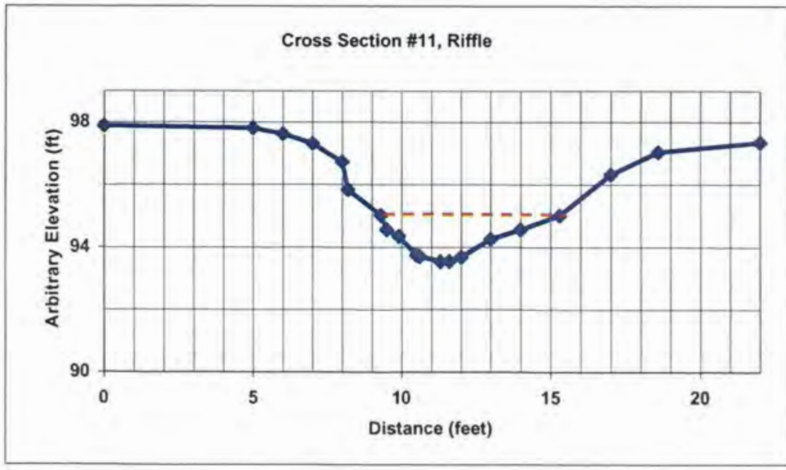
A(BKF)	4.9	W(FPA)	9
W(BKF)	6.0	Slope	0.01
Max d	1.5	Sinuosity	1.24
Mean d	0.8	Area= A	
W/D	7.3	Width= W	
Entrenchment	1.5	Depth= D	
Stream Type	G4	Bankfull= BKF	

Area from Rural Regional Curve

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	3.7	10	extreme
Root Depth/Bank Ht	1	1	very low
Root Density (%)	50	4.2	moderate
Bank Angle (Degrees)	50	3.4	low
Surface Protection (%)	50	4.2	moderate
Bank Materials	Silt/Clay	0	
		22.8	moderate

Photo of CS#11, riffle looking in the upstream direction.



Little Beaver Creek, Wake County

Field Crew:	Ben Goetz, Jan Patterson
River Basin:	Cape Fear
Watershed:	**Little Beaver Creek**
Stream Reach:	Olive Tract
Draiange Area:	1.1 sq mi (700 ac)
Date:	2/26/2002
Station:	ND2
Feature:	CS#12, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	102.60	5.57	97.03	
0+04.0	102.60	6.10	96.50	LTOB
0+06.3	102.60	7.50	95.10	
0+07.5	102.60	7.78	94.82	LBKF
0+10.0	102.60	8.10	94.50	
0+10.6	102.60	9.05	93.55	LEW
0+11.5	102.60	9.50	93.10	TW
0+12.4	102.60	8.95	93.65	REW/WS
0+12.7	102.60	7.78	94.82	RBKF
0+13.4	102.60	6.97	95.63	RTOB
0+16.0	102.60	5.97	96.63	
0+18.0	102.60	5.57	97.03	
0+23.0	102.60	5.14	97.46	

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	2.5	0.3	0.4
	0.6	1.3	0.5
	0.9	1.7	1.3
	0.9	1.2	1.3
	0.3	0.0	0.2
TOTALS	5.2		3.7

SUMMARY DATA (BANKFULL)

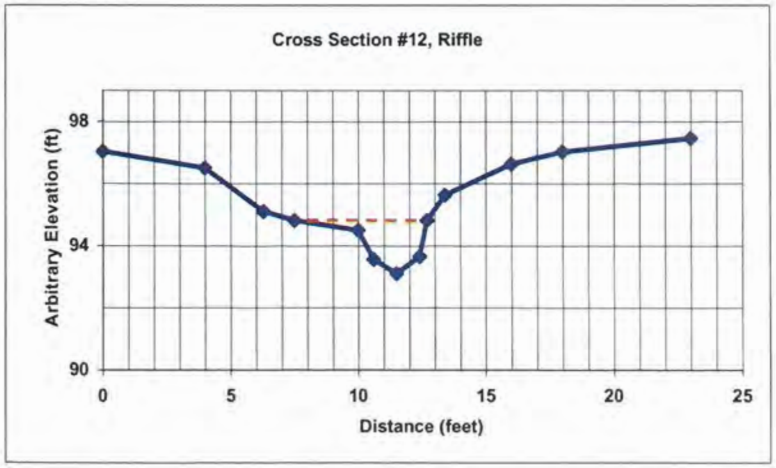
A(BKF)	3.7	W(FPA)	12
W(BKF)	5.2	Slope	0.025
Max d	1.7	Sinuosity	1.1
Mean d	0.7	Area= A	
W/D	7.3	Width= W	
Entrenchment	2.3	Depth= D	
Stream Type	E4	Bankfull= BKF	

Area from Rural Regional Curve

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	1.5	5.9	moderate
Root Depth/Bank Ht	0.13	8.1	very high
Root Density (%)	4	10	extreme
Bank Angle (Degrees)	70	5	moderate
Surface Protection (%)	9	10	extreme
Bank Materials	Silt/Clay	0	
		39	high

Photo of CS#12, riffle looking in the downstream direction.



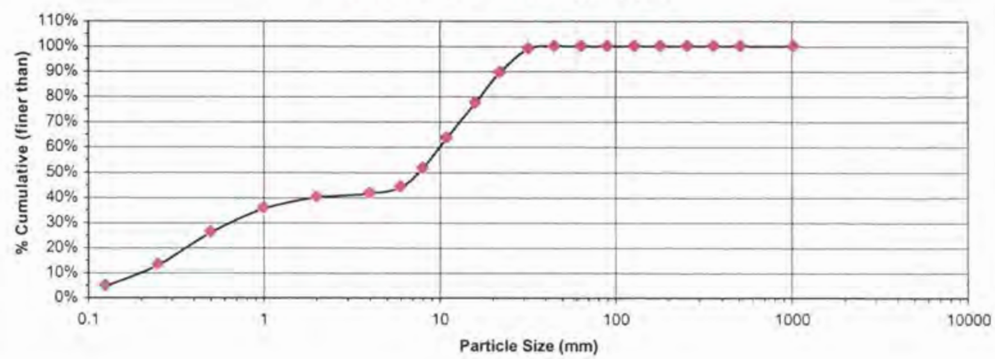
Little Beaver Creek, Wake County

Pattern Data for Little Beaver Creek

Curve	Radius of C	Beltwidth	Wavelength
1	185	82	
2	400		
3	45	128	418
4	150	66	296
5	60	88	251
6	88	89	
7	80		
Avg	144	91	322
Min	45	66	251
Max	400	128	418

Little Beaver Creek, Wake County

PEBBLE COUNT									
Site: Little Beaver Creek							3/25/2002		
Party: Ben Goetz, Jan Patterson							Little Beaver Creek		
				Particle Count					
Inches	Particle	Millimeter		Riffle	Run	Pool	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0	1	2	3	2%	2%
	Very Fine	.062 - .125	S	3	2	1	6	3%	5%
	Fine	.125 - .25	A	9	2	6	17	9%	13%
	Medium	.25 - .50	N	5	10	11	26	13%	26%
	Coarse	.50 - 1.0	D	3	6	10	19	10%	36%
.04 -.08	Very Coarse	1.0 - 2.0	S	0	1	8	9	5%	40%
.08 - .16	Very Fine	2.0 - 4.0		1	1	1	3	2%	42%
.16 - .22	Fine	4.0 - 5.7	G	1	2	2	5	3%	44%
.22 - .31	Fine	5.7 - 8.0	R	5	4	6	15	8%	52%
.31 - .44	Medium	8.0 - 11.3	A	6	11	7	24	12%	64%
.44 - .63	Medium	11.3 - 16.0	V	9	17	2	28	14%	78%
.63 - .89	Coarse	16.0 - 22.6	E	10	11	3	24	12%	90%
.89 - 1.26	Coarse	22.6 - 32.0	L	7	11	1	19	10%	99%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	1	1	0	2	1%	100%
1.77 - 2.5	Very Coarse	45.0 - 64.0		0	0	0	0	0%	100%
2.5 - 3.5	Small	64 - 90	C	0	0	0	0	0%	100%
3.5 - 5.0	Small	90 - 128	O	0	0	0	0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0	0	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0	0	0%	100%
	Bedrock		BDRK	0	0	0	0	0%	100%
			Totals	60	80	60	200	100%	100%



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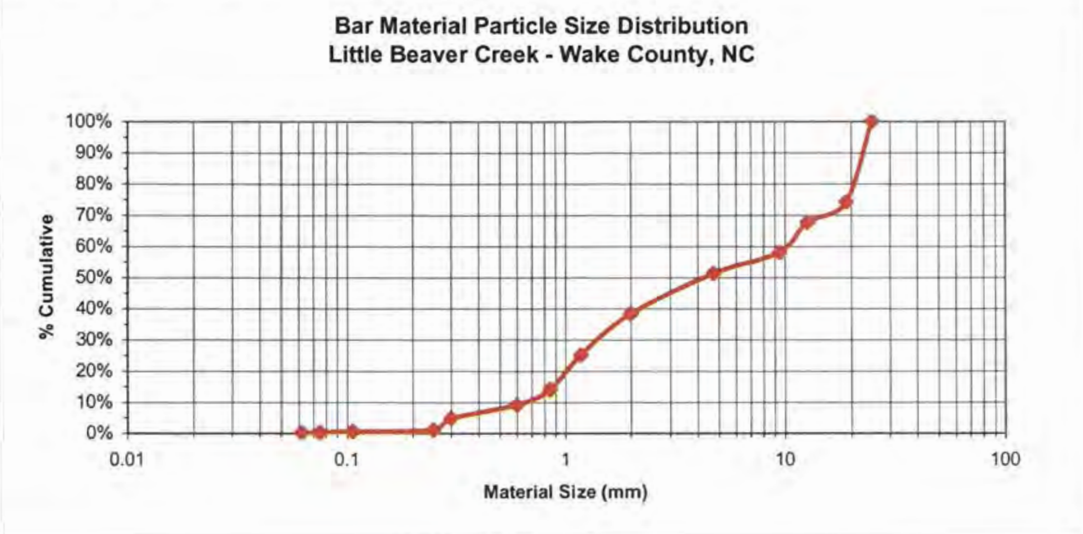
Little Beaver Creek, Wake County

Riffle Subpavement Sample
Little Beaver Creek- Main Stream

Sieve Size (mm)	0.062	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)	0.81	0.74	0.76	0.81	0.82	0.87	0.95	1.91	1.3	2.27	2.42	2.46	2.56	2.57
Sample Weight (lbs)	0.81	0.74	0.77	0.82	1.29	2.24	3.32	3.69	2.95	5.26	4.02	5.42	3.87	3.8
Net Sample Weight(lbs)	0.01	0	0.01	0.01	0.47	1.37	2.37	1.78	1.65	2.99	1.6	2.96	1.31	4.1
%	0%	0%	0%	0%	2%	7%	11%	9%	8%	14%	8%	14%	6%	20%
% Cumulative	0%	0%	0%	0%	2%	9%	21%	29%	37%	52%	59%	74%	80%	100%
D50 Subpavement	3 mm													
D50 Riffle Pavement	16 mm													

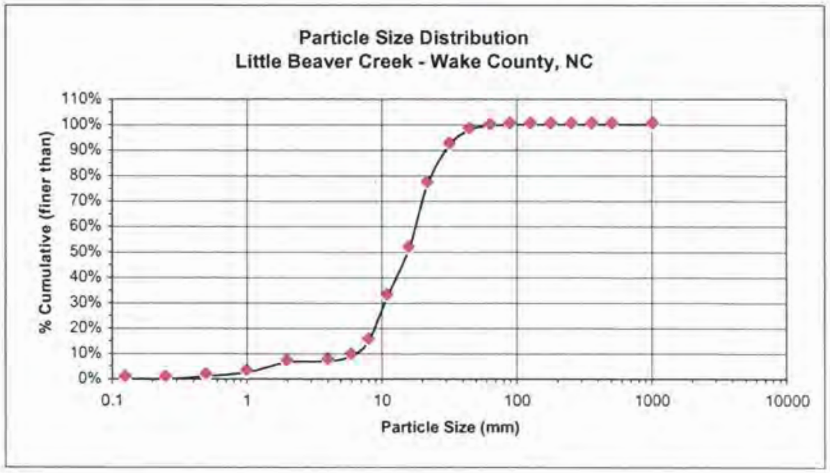
	LP1	LP2
dia	72	60
weight	1.69	1.18

TOTAL
20.63 lbs



Little Beaver Creek, Wake County

Riffle Pavement Sample							
Site: Little Beaver Creek					3/25/2002		
Party: Ben Goetz, Jan Patterson					Little Beaver Creek		
					Particle Count		
Inches	Particle	Millimeter		Riffle	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0	0	0%	0%
	Very Fine	.062 - .125	S	0	0	0%	0%
	Fine	.125 - .25	A	0	0	0%	0%
	Medium	.25 - .50	N	2	2	1%	1%
	Coarse	.50 - 1.0	D	3	3	1%	2%
.04 -.08	Very Coarse	1.0 - 2.0	S	8	8	4%	6%
.08 - .16	Very Fine	2.0 - 4.0		1	1	0%	7%
.16 - .22	Fine	4.0 - 5.7	G	4	4	2%	9%
.22 - .31	Fine	5.7 - 8.0	R	12	12	6%	15%
.31 - .44	Medium	8.0 - 11.3	A	35	35	17%	32%
.44 - .63	Medium	11.3 - 16.0	V	38	38	19%	51%
.63 - .89	Coarse	16.0 - 22.6	E	51	51	25%	77%
.89 - 1.26	Coarse	22.6 - 32.0	L	31	31	15%	92%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S	12	12	6%	98%
1.77 - 2.5	Very Coarse	45.0 - 64.0		3	3	1%	100%
2.5 - 3.5	Small	64 - 90	C	1	1	0%	100%
3.5 - 5.0	Small	90 - 128	O	0	0	0%	100%
5.0 - 7.1	Large	128 - 180	B	0	0	0%	100%
7.1 - 10.1	Large	180 - 256	L	0	0	0%	100%
10.1 - 14.3	Small	256 - 362	B	0	0	0%	100%
14.3 - 20	Small	362 - 512	L	0	0	0%	100%
20 - 40	Medium	512 - 1024	D	0	0	0%	100%
40 - 80	Lrg- Very Lrg	1024 - 2048	R	0	0	0%	100%
	Bedrock		BDRK	0	0	0%	100%
			Totals	**201**	**201**	**100%**	**100%**



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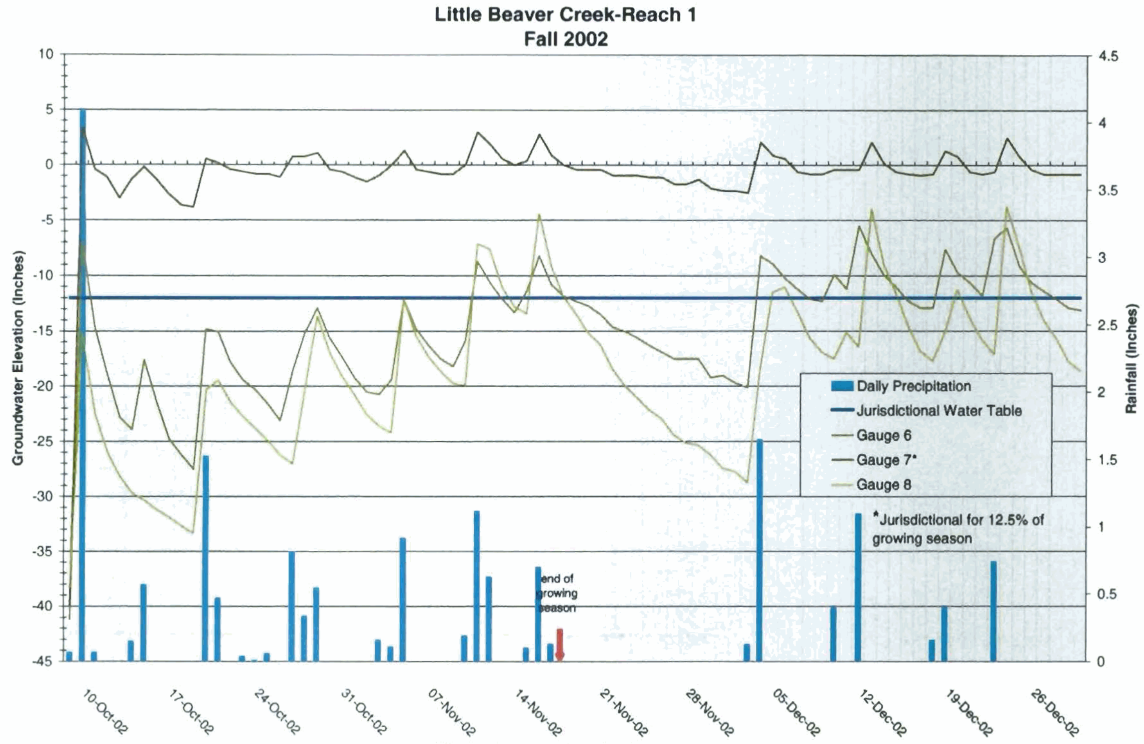
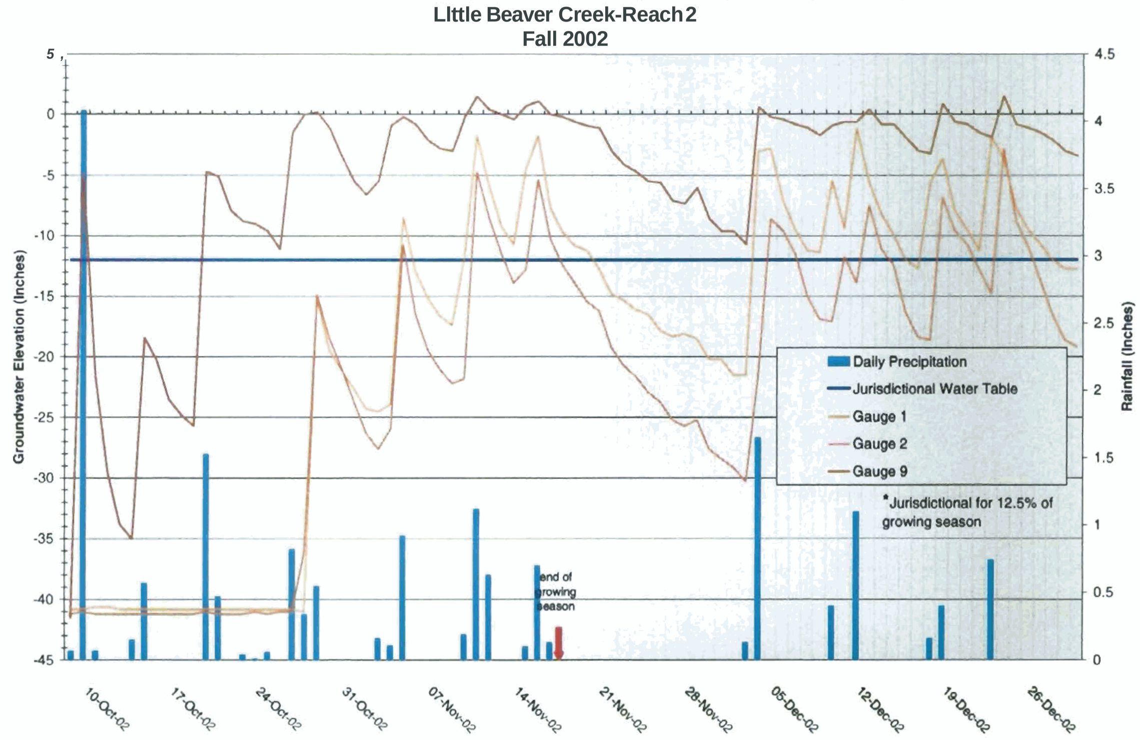
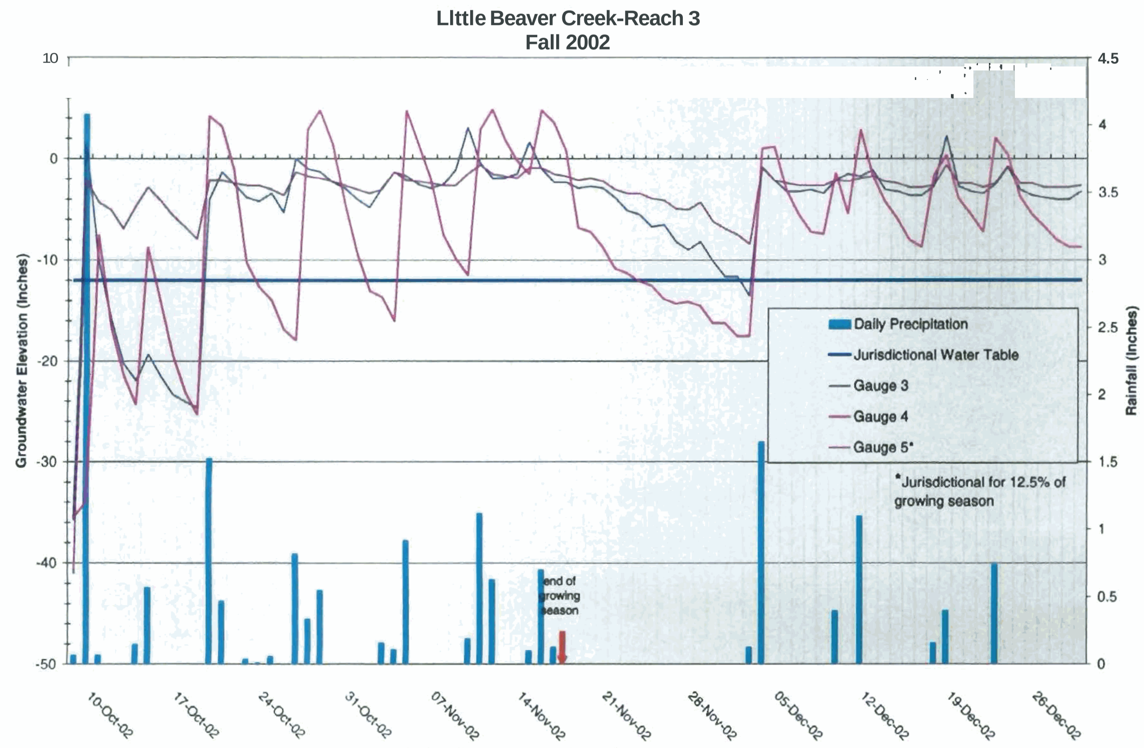
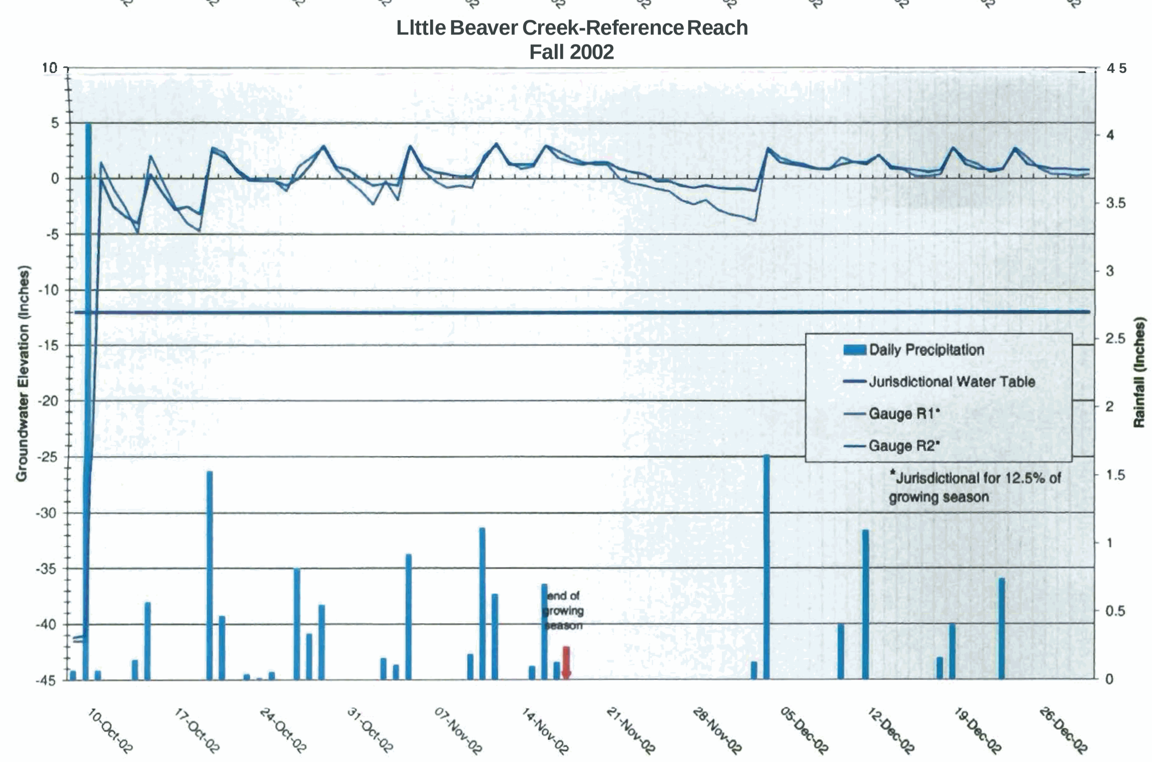








2002 Total Precipitation = 48.46 inches
30-Year Normal Range = 41.38-48.20 inches
30-Year Normal Average = 45.41inches
Growing Season = 228 days, 3/26-11/10

Data from State Climate Office
Raleigh 4 SW WETS Station.

N.C. Wetlands Restoration Program
NCDENR_DWQ

APPENDIX C
Hydrographs

Little Beaver Creek
Wake County, North Carolina

State of North Carolina
Department of Environment
and Natural Resources
Raleigh Regional Office

Michael F. Easley, Governor
William G. (Bill) Ross, Secretary
Alan W. Klimek, P.E., Director

NCDENR
NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

October 2, 2002

Cherri Smith
NCDENR/DWQ
Wetland Restoration Program
1619 Mail Service Center
Raleigh, N.C. 27699-1619

Subject: Little Beaver Creek
Wetland, Stream, and Buffer
Reference and Restoration Reaches
Cape Fear River Basin
Wake County

Dear Ms. Smith:

This letter is being sent to you in response to your request for written verification relative to the suitability of the subject reaches. As per our site visit, conducted September 6, 2002, the reference reach appears to be a relatively stable channel and suitable for use in developing a restoration design.

The proposed stream and wetland restoration plan for the impacted reach located on the Olive Farm must meet the minimum criteria for acceptance. Please be reminded that when conducting morphological evaluations and measurements, the length of the reference reach must be at least two (2) full meander wavelengths, approximately five to six riffle pools, or twenty bankfull channel widths.

If you should have any questions, please do not hesitate to contact me. (919-571-4700).

Sincerely,

Steve Mitchell
Environmental Scientist

Cc: Ben Goetz/Earth Tech
CO/Todd St. John
RRO

Little Beaver
Creek Reference
Wake County

Field Crew:	Ben Goetz, Jane Almon
River Basin:	Cape Fear
Watershed:	Little Beaver Creek
Reach:	Fairfield Lots
DA:	0.30 sq mi (189 ac)
Date:	7/25/2002
Station:	1+12
Feature:	CS #1, Pool

STATION (FEET)	HI (FEET)	FS (FEET)	ELEVATION (FEET)	NOTES
0+00.0	105.23	5.23	100.00	
0+06.0	105.23	5.23	100.00	
0+10.0	105.23	5.36	99.87	TERRACE
0+11.0	105.23	5.49	99.74	
0+12.0	105.23	5.90	99.33	
0+13.0	105.23	6.92	98.31	
0+14.0	10523	7.20	98.03	LBKF
0+15.0	105.23	7.52	97.71	
W16.0	10523	7.28	97.95	
0+18.0	105.23	7.20	98.03	
0+20.0	105.23	7.15	98.08	TOB
0+22.0	105.23	7.44	97.79	
0+23.0	105.23	7.89	97.34	
0+23.7	105.23	10.02	95.21	
0+25.0	105.23	10.20	95.03	
0+25.8	105.23	10.33	94.90	TW
0+27.0	105.23	10.18	95.05	
0+28.0	105.23	9.90	95.33	
0+28.0	105.23	8.18	97.05	
0+29.0	105.23	7.69	97.54	
0+31.0	105.23	7.31	97.92	TOB
0+34.0	105.23	7.57	97.66	
0+35.5	105.23	7.68	97.55	
0+37.5	105.23	7.82	97.61	
0+39.0	105.23	7.20	98.03	RBKF
0+40.0	105.23	6.86	98.37	
0+41.0	105.23	6.53	98.70	
0+42.0	105.23	6.45	98.78	TERRACE

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	1.0	0.3	0.2
	1.0	0.1	0.2
	2.0	0.0	0.1
	2.0	0.0	0.0
	2.0	0.2	0.2
	1.0	0.7	0.5
	0.7	2.8	1.2
	1.3	3.0	3.8
	0.8	3.1	2.5
	1.2	3.0	3.7
	1.0	2.7	2.8
	0.0	1.0	0.0
	1.0	0.5	0.7
	2.0	0.1	0.6
	3.0	0.4	0.7
	1.5	0.5	0.6
	2.0	0.4	0.9
	1.5	0.0	0.3
TOTALS	25.0		18.9

SUMMARY DATA (BANKFULL)

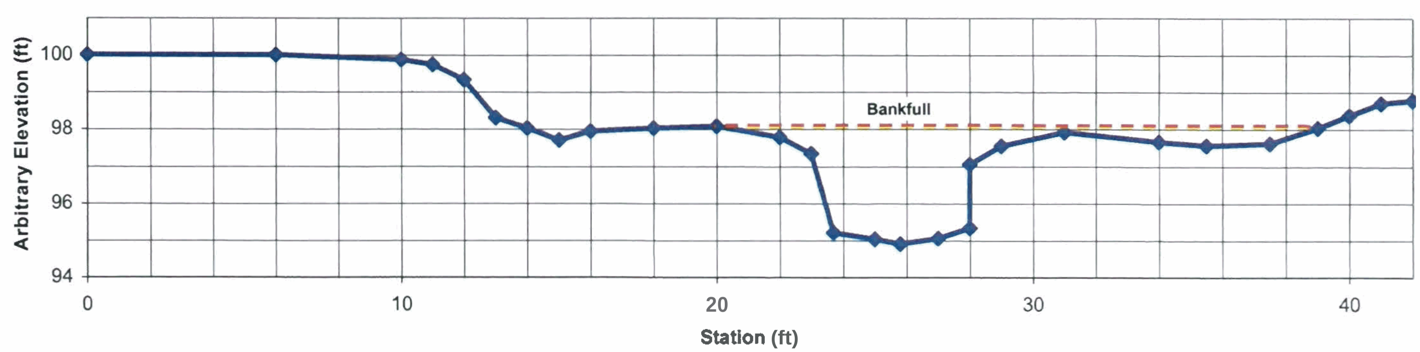
A(BKF)	18.9
W(BKF)	19.0
Max d	3.1
Mean d	1.0

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	1	1	very low
Root Depth/Bank Ht	1	1	very low
Root Density (%)	79	2	low
Bank Angle (Degrees)	60	3.9	low
Surface Protection (%)	79	2	low
Bank Materials	sand	5	
		14.9	low

Photo of CS#1, pool looking in the downstream direction.

Cross Section #1, Pool



Little Beaver
Creek Reference
Wake County

Field Crew:	Ben Goetz, Jane Almon
River Basin:	Cape Fear
Watershed:	Little Beaver Creek
Reach:	Fairfield Lots
DA:	0.30 sq mi (189 ac)
Date:	7/25/2002
Station:	1+60
Feature:	CS #2, Riffle

STATION (FEET)	HI (FEET)	FS (FEET)	ELEVATION (FEET)	NOTES
0+00.0	105.98	5.98	100.00	
0+07.0	105.98	5.84	100.14	
0+11.0	105.98	6.00	99.98	TERRACE
w12.0	105.98	6.18	99.80	
0+13.0	105.98	6.55	99.43	
0+14.0	105.98	7.54	98.44	
0+15.0	105.98	7.72	98.26	
0+17.0	105.98	7.67	98.31	
w19.0	105.98	7.59	98.39	
0+21.0	105.98	7.52	98.46	
w22.0	105.98	7.72	9826	LBKF
0+23.0	105.98	7.95	98.03	
0+23.5	105.98	9.08	96.90	
0+23.8	105.98	9.50	96.43	
0+25.0	105.98	9.71	9627	TW
0+27.0	105.98	9.50	96.43	
0+28.5	105.98	9.33	96.65	
0+28.7	105.98	8.38	97.60	
0+29.7	105.98	7.73	9825	
0+31.5	105.98	7.53	98.45	
0+34.0	105.98	7.72	9826	
0+36.0	105.98	7.97	98.01	
0+37.0	105.98	8.31	97.67	
0+40.5	105.98	7.94	98.04	
0+41.0	105.98	7.72	98.26	RBKF
0+43.0	105.98	7.00	98.98	
0+47.0	105.98	8.69	9929	TERRACE
0+60.0	105.96	7.31	98.67	

BANKFUU
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	1.0	0.2	0.1
	0.5	1.4	0.4
	0.3	1.8	0.5
	1.2	2.0	2.3
	2.0	1.8	3.8
	1.5	1.6	2.5
	0.2	0.7	0.2
	1.0	0.0	0.3
	2.0	0.3	0.3
	1.0	0.6	0.4
	3.5	0.2	1.4
	0.5	0.0	0.1
TOTALS	14.7		12.3

SUMMARY DATA (BANKFULL)

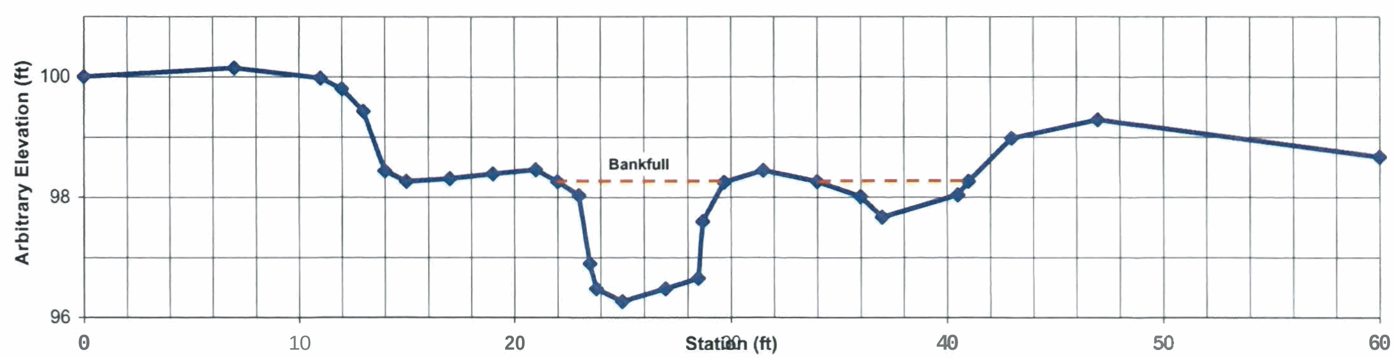
A(BKF)	12.3	W(FPA)	200
W(BKF)	14.7	Slope	n/a
Max d	2.0	Sinuosity	1.5
Mean d	0.8	Area= A	
W/D	17.6	Width= W	
Entrenchment	13.6	Depth= D	
Stream Type	C5	Bankfull= BKF	
Area from Rural Regional Curve			9.7

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bonk Ht/Bkf Ht	1	1	very low
Root Depth/Bank Ht	1	1	very low
Root Density (%)	79	2	low
Bank Angle (Degrees)	60	3.9	low
Surface Protection (%)	79	2	low
Bank Materials	sand	5	

Photo of CS#2, riffle looking in the downstream direction.

Cross Section #2, Riffle



Little Beaver
Creek Reference
Wake County

Field Crew:	Ben Goetz, Jane Almon
River Basin:	Cape Fear
Watershed:	Little Beaver Creek
Reach:	Fairfield Lots
DA:	0.30 sq mi (189 ac)
Date:	7/25/2002
Station:	2+21
Feature:	CS #3, Riffle

STATION (Feet)	HI (Feet)	FS (Feet)	ELEVATION (Feet)	NOTES
0+00.0	103.48	3.48	100.00	
0+11.0	103.48	3.63	99.85	TERRACE
0+13.0	103.48	4.16	99.32	
0+14.0	103.48	4.65	98.83	LBKF
0+15.0	103.48	5.00	98.48	
0+17.0	103.48	4.98	98.50	
0+19.0	103.48	4.72	98.83	
0+23.0	103.48	4.63	98.85	
0+26.0	103.48	4.52	98.96	
0+29.0	103.48	4.67	98.81	LTOB
0+30.0	103.48	4.96	98.52	
0+31.0	103.48	5.40	98.08	
0+31.5	103.48	6.07	97.41	
0+33.0	103.48	6.54	96.94	
0+35.0	103.48	6.64	96.84	TW
0+35.8	103.48	6.42	97.06	
0+36.5	103.48	6.20	97.28	
0+37.0	103.48	5.19	98.29	
0+38.0	103.48	4.65	98.83	RBKF
0+41.0	103.48	4.54	98.94	
0+43.0	103.48	4.05	99.43	
0+50.0	103.48	4.20	99.28	

BANKFULL
Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.0
	1.0	0.3	0.2
	2.0	0.3	0.7
	2.0	0.0	0.3
	1.0	0.3	0.2
	1.0	0.8	0.5
	0.5	1.4	0.5
	1.5	1.9	2.5
	2.0	2.0	3.9
	0.8	1.8	1.5
	0.7	1.6	1.2
	0.5	0.5	0.5
	1.0	0.0	0.3
TOTALS	14.0		12.2

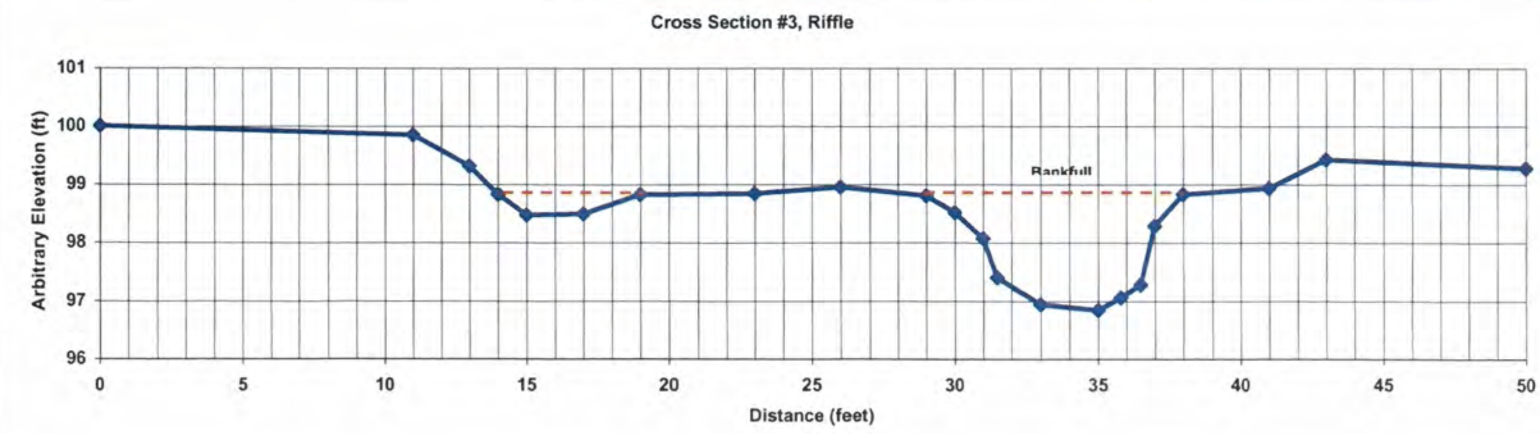
SUMMARY DATA (BANKFULL)

A(BKF)	12.2	W(FPA)	125
W(BKF)	14.0	Slope	0.0025
Max d	2.0	Sinuosity	1.5
Mean d	0.9	Area= A	
W/D	16.0	Width= W	
Entrenchment	8.9	Depth= D	
Stream Type	C5	Bankfull= BKF	
Area from Rural Regional Curve			9.7

Bank Erosion Hazard Index (BEHI)

Criteria	Value	Index	Bank Erosion Potential
Bank Ht/Bkf Ht	1	1	very low
Root Depth/Bank Ht	1	1	very low
Root Density (%)	79	2	low
Bank Angle (Degrees)	21	2	low
Surface Protection (%)	79	2	low
Bank Materials	sand	5	
		13	low

Photo of CS#3, riffle looking in the downstream direction.



Little Beaver
Creek Reference
Wake County

LONGITUDINAL PROFILE

River Basin:	Cape Fear
Watershed:	Little Beaver Creek
Stream Reach:	Little Beaver Creek, Fairfield Lots
DA (sq mi):	0.30 sq.mi.
Date:	########

REF PT	BS	HI	FS	ELEV	NOTES
BM (AM)	4.92	104.92		100.00	SS MH
BM (AM)		104.92	4.92	100.00	Error=0.00
BM (PM)	1.68	101.68		100.00	
BM (PM)		101.68	1.68	100.00	Error=0.00

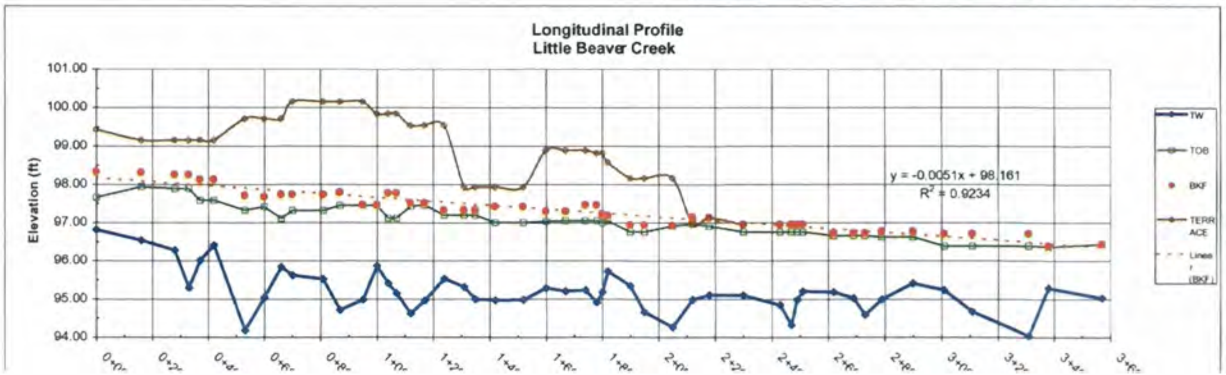
PATTERN DATA FOR LITTLE BEAVER CREEK

Curve	Chord L	Mid	Radius of C	Beltwidth	Wavelength
1	19	3.4	15		
2	14	2.5	11	14	
3	18	2.3	19		50
4	16	3.3	11	20	52
5	16	2.8	16	21	46
6	20	4.0	15	20	67
7	17	3.3	13	14	47
8	18	5.0	11	5	
9	20	4.8	13	13	
10	19	5.5	11		
11	25	5.8	16	17	
		Avg	14	16	52
		Min	11	5	46
		Max	19	21	67

Station	REF PT	HI	TW(FS)	TW	TOB(FS)	TOB	TER(FS)	TERRACE	BKF(FS)	BKF	Notes	P-P	Pool Length	Max Pool Depth	Pool Slope	Riffle Length	Riffle Slope
0+00.0	BM (AM)	104.92	8.11	96.81	7.26	97.66	5.50	99.42	6.60	98.32	Head of Riffle					16.0	1.75
0+16.0	BM (AM)	104.92	8.39	96.53	6.98	97.94	5.77	99.15	6.62	98.30	Head of Run						
0+28.0	BM (AM)	104.92	8.65	96.27	7.03	97.89	5.77	99.15	6.68	98.24	Head of Pool						
0+33.0	BM (AM)	104.92	9.63	95.29	7.03	97.89	5.77	99.15	6.68	98.24	Max Pool			2.95			
0+37.0	BM (AM)	104.92	8.92	96.00	7.33	97.59	5.77	99.15	6.80	98.12	Head of Glide		9.0		3.00		
0+42.0	BM (AM)	104.92	8.51	96.41	7.33	97.59	5.77	99.15	6.80	98.12	Head of Pool	14.0					
0+53.0	BM (AM)	104.92	10.74	94.18	7.59	97.33	5.21	99.71	7.22	97.70	Max Pool			3.52			
0+60.0	BM (AM)	104.92	9.88	95.04	7.50	97.42	5.21	99.71	7.26	97.66	Head of Glide		18.0		0.00		
0+66.0	BM (AM)	104.92	9.08	95.84	7.81	97.11	5.21	99.71	7.20	97.72	Head of Riffle					4.0	5.50
0+70.0	BM (AM)	104.92	9.30	95.62	7.60	97.32	4.77	100.15	7.20	97.72	Head of Run						
0+81.0	BM (AM)	104.92	9.40	95.52	7.60	97.32	4.77	100.15	7.20	97.72	Head of Pool	30.0					
0+87.0	BM (AM)	104.92	10.21	94.71	7.47	97.45	4.77	100.15	7.14	97.78	Max Pool			3.07			
0+95.0	BM (AM)	104.92	9.94	94.98	7.47	97.45	4.77	100.15	7.47	97.45	Head of Glide		14.0		3.86		
1+00.0	BM (AM)	104.92	9.06	95.86	7.47	97.45	5.08	99.84	7.47	97.45	Head of Riffle					4.0	11.25
1+04.0	BM (AM)	104.92	9.51	95.41	7.79	97.13	5.08	99.84	7.16	97.76	Head of Run						
1+07.0	BM (AM)	104.92	9.77	95.15	7.79	97.13	5.08	99.84	7.16	97.76	Head of Pool	26.0					
1+12.0	BM (AM)	104.92	10.30	94.62	7.48	97.44	5.38	99.54	7.41	97.51	Max Pool			2.89			
1+17.0	BM (AM)	104.92	9.96	94.96	7.45	97.47	5.38	99.54	7.41	97.51	Head of Glide		10.0		1.90		
1+24.0	BM (AM)	104.92	9.39	95.53	7.72	97.20	5.38	99.54	7.60	97.32	Head of Riffle					7.0	3.00
1+31.0	BM (AM)	104.92	9.60	95.32	7.72	97.20	6.99	97.93	7.60	97.32	Head of Run						
1+35.0	BM (AM)	104.92	9.92	95.00	7.72	97.20	6.99	97.93	7.60	97.32	Head of Pool	28.0					
1+42.0	BM (AM)	104.92	9.95	94.97	7.91	97.01	6.99	97.93	7.51	97.41	Max Pool			2.44			
1+52.0	BM (AM)	104.92	9.94	94.98	7.91	97.01	6.99	97.93	7.51	97.41	Head of Glide		17.0		0.12		
1+60.0	BM (AM)	104.92	9.63	95.29	7.88	97.04	6.03	98.89	7.63	97.29	Head of Riffle					7.0	1.14
1+67.0	BM (AM)	104.92	9.71	95.21	7.86	97.06	6.03	98.89	7.63	97.29	Head of Run						
1+74.0	BM (AM)	104.92	9.69	95.23	7.86	97.06	6.03	98.89	7.47	97.45	Head of Pool	39.0					
1+78.0	BM (AM)	104.92	10.01	94.91	7.86	97.06	6.10	98.82	7.47	97.45	Max Pool			2.54			
1+80.0	BM (AM)	104.92	9.73	95.19	7.92	97.00	6.10	98.82	7.70	97.22	Head of Glide		6.0		0.67		
1+82.0	BM (PM)	101.68	5.95	95.73	4.63	97.05	3.10	98.58	4.50	97.18	Head of Riffle					8.0	4.75
1+90.0	BM (PM)	101.68	6.33	95.35	4.91	96.77	3.51	98.17	4.75	96.93	Head of Run						
1+95.0	BM (PM)	101.68	7.02	94.66	4.91	96.77	3.51	98.17	4.75	96.93	Head of Pool	21.0					
2+05.0	BM (PM)	101.68	7.41	94.27	4.76	96.92	3.51	98.17	4.76	96.92	Max Pool			2.65			
2+12.0	BM (PM)	101.68	6.69	94.99	4.54	96.98	3.51	96.98	4.54	97.14	Head of Glide		17.0		-1.94		
2+18.0	BM (PM)	101.68	6.57	95.11	4.76	96.92	4.55	97.13	4.55	97.13	Head of Riffle					12.0	0.08
2+30.0	BM (PM)	101.68	6.58	95.10	4.92	96.76	4.74	96.94	4.74	96.94	Head of Run						
2+43.0	BM (PM)	101.68	6.83	94.85	4.92	96.76			4.74	96.94	Head of Pool	48.0					
2+47.0	BM (PM)	101.68	7.35	94.33	4.92	96.76			4.74	96.94	Max Pool			2.61			
2+49.0	BM (PM)	101.68	6.70	94.98	4.92	96.76			4.74	96.94	Head of Glide		6.0		-2.17		
2+51.0	BM (PM)	101.68	6.48	95.20	4.92	96.76			4.74	96.94	Head of Riffle					11.0	0.18
2+62.0	BM (PM)	101.68	6.50	95.18	5.02	96.66			4.96	96.72	Head of Run						
2+69.0	BM (PM)	101.68	6.66	95.02	5.02	96.66			4.96	96.72	Head of Pool	26.0					
2+73.0	BM (PM)	101.68	7.09	94.59	5.02	96.66			4.96	96.72	Max Pool			2.13			
2+79.0	BM (PM)	101.68	6.69	94.99	5.06	96.62			4.92	96.76	Head of Glide		10.0		0.30		
2+90.0	BM (PM)	101.68	6.27	95.41	5.06	96.62			4.92	96.76	Head of Riffle					11.0	1.64
3+01.0	BM (PM)	101.68	6.45	95.23	5.29	96.39			4.98	96.70	Head of Run						
3+11.0	BM (PM)	101.68	7.01	94.67	5.29	96.39			4.98	96.70	Head of Pool	32.0					
3+31.0	BM (PM)	101.68	7.65	94.03	5.29	96.39			4.98	96.70	Max Pool			2.67			
3+38.0	BM (PM)	101.68	6.40	95.28	5.32	96.36			5.30	96.38	Head of Glide		27.0		-2.26		
3+57.0	BM (PM)	101.68	6.66	95.02	5.25	96.43			5.25	96.43	Head of Riffle						

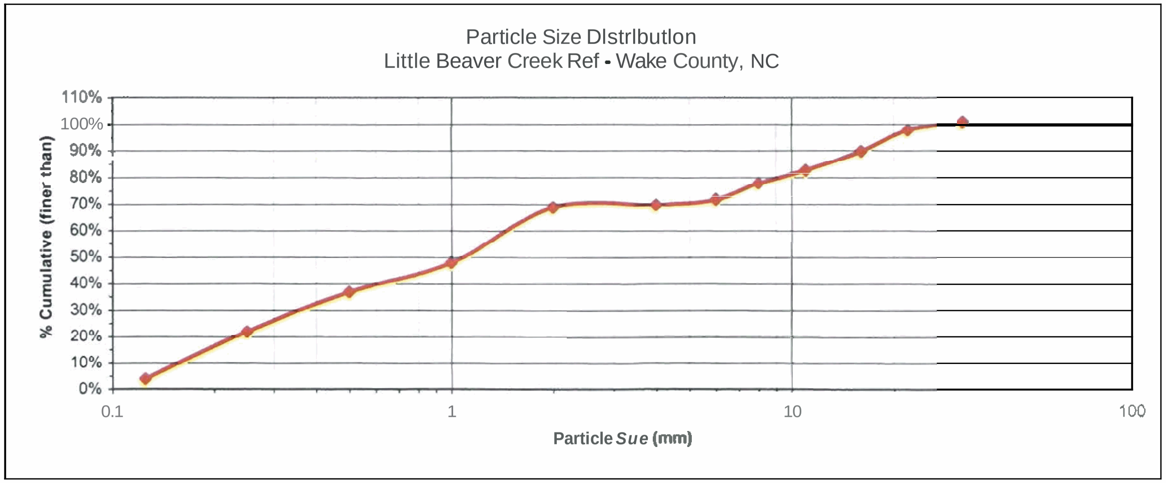
	P-P	Pool Length	Max Pool Depth	Pool Slope	Riffle Length	Riffle Slope
max	48	27	3.52	3.8571	16	11.2500
min	14	6	2.13	-2.2593	4	0.0833
avg	30	13	2.75	1.7750	9	3.2549
Max ratio	3.36	1.89	0.25	7.29	1.12	21.25
Min ratio	0.98	0.42	0.15	-4.27	0.28	0.16
avg ratio	2.12	0.94	0.19	3.35	0.62	6.15

BKF SLOPE 0.529 0.00529



Little Beaver Creek Reference Wake County

PEBBLE COUNT											
Site: Little Beaver Creek Ref								7/25/2002			
Party: Ben Goetz, Jane Almon								Little Beaver Creek Ref			
					Particle Count						
Inches	Particle	Millimeter		Riie	Pool	Riffle	Pool	Total No.	Item %	% Cumulative
	Silt/Clay	< 0.062	S/C	0	0	0	0	0	0%	0%
	Very Fine	.062 - .125	S	2	0	1	0	3	3%	3%
	Fine	.125 - .25	A	5	2	7	4	18	18%	21%
	Medium	.25 - .50	N	2	9	0	4	15	15%	36%
	Coarse	.50 - 1.0	D	3	4	0	4	11	11%	47%
.04 -.08	Very Coarse	1.0 - 2.0	S	4	5	11	1	21	21%	68%
.08 - .16	Very Fine	2.0 - 4.0		1	0	0	0	1	1%	69%
.16 - .22	Fine	4.0 - 5.7	G	0	1	0	1	2	2%	71%
.22 - .31	Fine	5.7 - 8.0	R	0	1	4	1	6	6%	77%
.31 - .44	Medium	8.0 - 11.3	A	2	0	2	1	5	5%	82%
.44 - .63	Medium	11.3 - 16.0	V	1	0	0	6	7	7%	89%
.63 - .89	Coarse	16.0 - 22.6	E	3	2	0	3	8	8%	97%
.89 - 1.26	Coarse	22.6 - 32.0	L	2	1	0	0	3	3%	100%
1.26 - 1.77	Very Coarse	32.0 - 45.0	S							
1.77 - 2.5	Very Coarse	45.0 - 64.0								
2.5 - 3.5	Small	64 - 90	C							
3.5 - 5.0	Small	90 - 128	O							
5.0 - 7.1	Large	128 - 180	B							
7.1 - 10.1	Large	180 - 256	L							
10.1 - 14.3	Small	256 - 362	B							
14.3 - 20	Small	362 - 512	L							
20 - 40	Medium	512 - 1024	D							
40 - 80	Lrg- Very Lrg	1024 - 2048	R							
	Bedrock		BDRK							
			Totals	25	25	25	25	100	100%	100%



REFERENCE REACH SURVEY
Stream Name: Richland Creek
Location:
Purpose: Longitudinal Profile and Cross-section measurements for Graduate Work
Date: [illegible]
Crew: Dan Clinton, Jim Patterson, Mike O'Rourke, Amy Dorsey, Amanda Todd
Ending Point LAT/LONG:
Watershed Area: 1 sq. mile STREAM TYPE: C4

LONGITUDINAL PROFILE
(Using Level)

Bench Mark #1= 100 ft.

BS = 6.82	HI = 106.82	BM1 is nail at base of hemlock	
TP1 BS= 6.52	TP1 HI= 110.73	TP1 FS= 2.61	TP1 El.= 104.21
TP2 BS= 5.46	TP2 HI= 113.17	TP2 FS= 3.02	TP2 El.= 107.71
TP3 BS= 2.41	TP3 HI= 108.93	TP3 FS= 6.65	TP3 El.= 106.52
TP4 BS= 4.51	TP4 HI= 109.34	TP4 FS= 4.1	TP4 El.= 104.83
TP5 BS= 2.13	TP5 HI= 105.05	TP5 FS= 6.42	TP5 El.= 102.92

FS to BM= 5.05 BM El.= 100.00
ERROR= 0.00

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

Distance	Thawl Wag (FS)	Thawl Wag Elev.	Water Surface (FS)	Water Surface Elev.	LBKF (FS)	BKF Elev.	RBKF (FS)	BKF Elev.	IB (FS)	IB Elev.	LTOB (FS)	LTOB Elev.	RTOB (FS)	RTOB Elev.	Notes	Mid Feature Location	Feature
2.5	9.3	103.9	9.09	104.08	8.3	104.9	8.3	104.9							TR	5.8	R
9.0	9.5	103.7	9.18	103.99			8.0	105.2	8.5	104.67					TP	23.8	P
18.0	10.1	103.1	9.22	103.95			8.2	105.0									
28.0	10.6	102.6	9.22	103.95		113.2	8.0	105.2							MP		
38.5	9.4	103.8	9.19	103.98	8.1	105.1			8.7	104.47					TR	42.3	R
46.0	10.2	103.0	9.50	103.67	8.2	105.0									TP	61.0	P
58.0	11.0	102.2	9.45	103.72					8.2	104.97	6.1	107.07	7.5	105.67	MP		
76.0	10.4	102.8	9.45	103.72	8.2	105.0									TG	80.3	G
84.5	9.7	103.5	9.44	103.73	8.3	104.9	8.2	105.0	8.8	104.37	6.7	106.47			TR	93.5	R
102.5	10.2	103.0	9.89	103.28	8.7	104.5					8.1	105.07			Trun	112.3	Run
122.0	10.2	103.0	10.05	103.12			8.8	104.4							TR	129.0	R
136.0	6.7	102.2	6.36	102.57			5.1	103.8	5.7	103.23			2.9	106.03	TP Now using TP3 HI	156.8	P
145.0	7.1	101.8	6.35	102.58	5.0	103.9									MP		
148.5	7.9	101.0	6.32	102.61	5.0	103.9											
159.0	7.0	101.9	6.41	102.52	5.2	103.7											
165.0	8.1	100.8	6.43	102.50			5.2	103.7					4.6	104.33			
175.0	7.7	101.2	6.41	102.52			5.2	103.7									
177.5	7.7	101.2	6.42	102.51			5.3	103.6							TG	183.8	G
190.0	6.6	102.3	6.42	102.51	5.0	103.9				108.93	5	103.93			TR	198.0	R
206.0	7.2	101.7	7.04	101.89	5.8	103.1									Trun	218.5	Run
231.0	7.4	101.5	7.20	101.73	6.0	102.9			6.6	102.33					TR	242.0	R
249.0	8.6	100.3	8.24	100.69	7.0	101.9									TP	252.5	P
253.0	9.1	99.8	8.23	100.70	7.0	101.9									MP		
256.0	8.5	100.4	8.22	100.71	7.0	101.9									TR		R

SLOPE & LENGTH OF FEATURES CALCULATIONS

Number	Length	Elevation Change	Slope
Riffles			
1	6.5	0.1	0.0138
2	7.5	0.3	0.0413
3	18.0	0.5	0.0250
4	14.0	0.6	0.0393
5	16.0	0.6	0.0388
6			
7			
8			
9			
10			
	12.4	Mean	0.0316
	14.0	Median	0.0388
	6.5	Min	0.0138
	18.0	Max	0.0393
Pools			
1	29.5	0.0	0.0003
2	30.0	0.0	0.0000
3	41.5	0.1	0.0014
4	7.0	0.0	0.0000
5			
6			
7			
8			
9			
10			
	27.0	Mean	0.00045
	29.8	Median	0.000
	7.0	Min	0.0014
	41.5	Max	0.0003
Glides			
1	8.5	0.0	0.0000
2	12.5	0.0	0.0000
3			
4			
5			
6			
7			
8			
9			
10			
	10.5	Mean	0.0000
	10.5	Median	0.0000
	8.5	Min	0.0000
	12.5	Max	0.0000
Runs			
1	19.5	0.2	0.0082
2	25.0	0.2	0.0064
3			
4			
5			
6			
7			
8			
9			
10			
	22.3	Mean	0.0073
	22.3	Median	0.0073
	19.5	Min	0.0064
	25.0	Max	0.0082

Number	Spacing (mid to mid)
Riffles to Riffle	
1	36.5
2	51.3
3	35.5
4	44.0
5	
6	
7	
8	
9	
10	
Mean	36.5
Median	36.5
Min	35.5
Max	51.3
Pool to Pool (mid to mid)	
1	37.3
2	95.8
3	95.8
4	
5	
6	
7	
8	
9	
10	
Mean	76.3
Median	95.8
Min	37.3
Max	95.8
Riffle to Pool (mid to mid)	
1	18.0
2	18.8
3	27.8
4	10.5
5	
6	
7	
8	
9	
10	
Mean	18.8
Median	18.4
Min	10.5
Max	27.8

X_SECTION MEASUREMENTS
Riffle X-Section #1
Location : 2+66
HI= 100 (arbitrary used depth off rod)

Distance	FS	Elev	Notes	Depth from BKF	Width	Area
0	4	96.0	LBKF	0.0	0.0	0.0
2	4.2	95.8		0.2	2.0	0.2
2.6	4.3	95.7	LIB	0.3	0.6	0.2
3.2	5	95.0	LEW	1.0	0.6	0.4
4	5.1	94.9		1.1	0.8	0.8
6	5.1	94.9		1.1	2.0	2.2
8	5.1	94.9		1.1	2.0	2.2
10	5.3	94.7		1.3	2.0	2.4
12	5.3	94.7		1.3	2.0	2.6
12.8	5.4	94.6	TW	1.4	0.8	1.1
14.4	5.1	94.9	REW	1.1	1.6	2.0
15.4	4.4	95.6		0.4	1.0	0.8
16.2	4	96.0	RBKF	0.0	0.8	0.2

sum: 15.0 sq. ft.

[illegible]

Riffle X-Section #2
Location : 7+54
HI= 100 (arb.)

Distance	FS	Elevation	Notes	Depth from BKF	Width	Area
0.0	4.1	95.9	LBKF	0.0	0.0	0.0
2.0	4.7	95.3	LIB	0.6	2.0	0.6
3.0	5.6	94.4	LEW	1.5	1.0	1.1
4.0	5.6	94.4		1.5	1.0	1.5
4.8	5.6	94.4	TW	1.5	0.8	1.2
6.0	5.3	94.7		1.2	1.2	1.6
8.0	5.2	94.8		1.1	2.0	2.3
10.0	5.4	94.6		1.3	2.0	2.4
12.0	5.5	94.5		1.4	2.0	2.7
12.8	5.3	94.7	REW	1.2	0.8	1.0
13.6	4.5	95.5		0.4	0.8	0.6
15.0	4.2	95.8		0.1	1.4	0.4
16.7	4.1	95.9	RBKF	0.0	1.7	0.1

sum: 15.5 sq. ft.

[illegible]

Pool X-Section #1
Location : 0+46
HI= 100 (arb.)

Distance	FS	Elev	Notes	Depth from BKF	Width	Area
0.2	5.5	94.5	LTOB			
2.5	6.3	93.7				
4.5	7.5	92.5				
5.1	7.7	92.3				
5.4	8.0	92.0	LBKF	0.0	0.0	0.0
6.0	9.3	90.7	LEW	1.3	0.6	0.4
6.3	9.6	90.4		1.6	0.3	0.4
7.0	9.7	90.3		1.7	0.7	1.2
8.4	9.4	90.6		1.4	1.4	2.2
8.7	9.7	90.3		1.7	0.3	0.5
9.6	10.5	89.5	TW	2.5	0.9	1.9
11.2	10.5	89.5		2.5	1.6	4.0
13.6	10.1	89.9		2.1	2.4	5.5
14.7	9.7	90.3		1.7	1.1	2.1
15.6	9.4	90.6	REW	1.4	0.9	1.4
16.2	8.4	91.6		0.4	0.6	0.5
16.5	8.0	92.0	RBKF	0.0	0.3	0.0
17.1	7.5	92.5				
17.4	7.3	92.7				
18.5	7.0	93.0				
21.0	6.8	93.2	RTOB			

sum: 20.1 sq. ft.

BKF Width = **11.1**
Area = **20.1**
Max. depth = **2.5**
Mean Depth= **1.8**
Width/Depth Ratio= **6.1**

X-Section Summary Sheet

Riffle X-Section

	Mean	Median	Maximum	Minimum
BKF Width =	16.5	16.5	16.7	16.2
Area =	15.2	15.2	15.5	15
Max. depth =	1.5	1.5	1.5	1.4
FPW =	51.5	51.5	53.0	50
ER =	3.1	3.1	3.3	3
Mean Depth=	0.9	0.9	0.9	0.9
Width/Depth Ratio=	17.8	17.8	18.0	17.5

Sinuosity=	1.2
Water Surface Slope=	0.0133

Stream Type =	C4

Pool X-Section

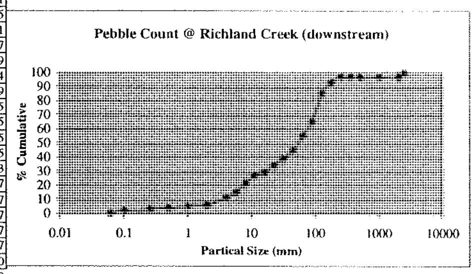
BKF Width =	11.1
Area =	20.1
Max. depth =	2.5
Mean Depth=	1.8
Width/Depth Ratio=	6.1

REFERENCE REACH SURVEY		
Stream Name:	Richland Creek	
Location:		
Purpose: Longitudinal Profile and Cross-section measurements for Graduate Work		
Date:	5/25/1999	
Crew: Dan Clinton, Jan Patterson, Mike O'Rourke, Amy Dorney, Amanda Todd		
Ending Point LAT/LONG:		
Watershed Area: 1 sq. miles		STREAM TYPE: C4

Pebble Count

Site: Richland Creek (downstream)
Date: 5/25/1999
Party: Amanda Todd, Amy Dorney, & Mike O'Rourke

	Particle	Size(mm)	Total #	% Cum.
	Silt/Clay	<0.062	0	0
SAND	Very Fine	0.062-0.125	2	2
	Fine	0.125-0.25	1	3
	Medium	0.25-0.50	1	4
	Course	0.50-1.0	1	5
	Very Course	1.0-2.0	1	6
GRAVEL	Very Fine	2-4	5	11
	Fine	4-5.7	4	15
	Fine	5.7-8	6	21
	Medium	8-11.3	6	27
	Medium	11.3-16	2	29
	Course	16-22.6	5	34
	Course	22.6-32	5	39
	Very Course	32-45	6	45
	Very Course	45-64	10	55
COBB	Small	64-90	10	65
	Small	90-128	20	85
	Large	128-180	8	93
	Large	180-256	4	97
BOULD	Small	256-362	0	97
	Small	362-512	0	97
	Medium	512-1024	0	97
	Large-Vry Lrg	1024-2048	0	97
	Bedrock	>2048	3	100
			100	100



0.06
0.1
0.25
0.5
1
2
4
5.7
8
11.3
16
22.6
32
45
64
90
128
180
256
362
512
1024
2048
2500

D16: 6 mm
D50 45 mm
D84: 125 mm
*all numbers extrapolated from data

Meander Geometry Data

Site: Richland Creek (downstream)
Date: 5/25/1999
Party: Amanda Todd, Amy Dorney, Mike O'Rourke, Jan Patterson, & Dan Clinton

RADIUS OF CURVATURE

Meander	Mid-Ordinate(M)	Cord Length(C)	Rad. Of Curvature
1	0.9	10	14.3
2	1.1	15	26.1
3	8	28	16.3
		Mean	19
		Median	16
		Max	26
		Min	14

Meander Wavelength

1	90	ft.
2	94	ft.
Mean	92	ft.
Median	92	ft.
Max	94	ft.
Min	90	ft.

Belt Width

1	29	ft.
2	25	ft.
3	40	ft.
Mean	31	ft.
Median	29	ft.
Max	40	ft.
Min	25	ft.

Valley Length 217 ft.

REFERENCE REACH Summary Data

REFERENCE REACH SURVEY	
Stream Name:	Richland Creek
Location:	
Purpose: Longitudinal Profile and Cross-section measurements for Graduate Work	
Date:	[illegible]
Crew: Dan Clinton, Jan Patterson, Mike O'Rourke, Amy Dorsey, Amanda Todd	
Ending Point LAT/LONG:	
Watershed Area: (sq. mile)	STREAM TYPE: C4

Channel Dimensions

	Mean	Median	Min	Max
Max. Riffle Depth(drmax)(ft.):	1.5	1.5	1.4	1.5
Riffle Width(Wr)(ft.):	16.5	16.5	16.2	16.7
Riffle X-Sect. Area(Ar)(ft^2):	15.2	15.2	15.0	15.5
Riffle Mean Bankfull Depth(dmbkf):	0.9	0.9	0.9	0.9

Max. Pool Depth(dpmax)(ft.):	2.5
Pool Width(Wp)(ft.):	11.1
Pool X-Sect. Area(Ap)(ft.):	20.1

	Mean	Median	Min	Max	
Ratio: Max. Pool Depth/Max. Riffle Depth(dpmax/drmax):	1.72	1.72	1.79	1.67	
Ratio: Pool Width/Riffle Width(Wp/Wr):	0.67	0.67	0.69	0.66	
Ratio: Pool Area/Riffle Area(Ap/Ar):	1.32	1.32	1.34	1.29	
Ratio: Max. Pool Depth/Mean Bankfull Depth(dpmax/dbkf):	2.70	2.70	2.78	2.78	
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):	19	16	14	26	ft.
Radius of Curvature(Rc):	92	92	90	94	ft.
Beltwidth(Wblt):	31	29	25	40	ft.

	Mean	Median	Min	Max
Meander Width Ratio(MWR=Wblt/Wbkf):	1.90	1.76	1.54	2.40
RATIO: Radius of Curvature/Bankfull Width(Rc/Wbkf):	5.59	5.59	5.56	5.63
RATIO: Meander Wavelength/Bankfull Width(Lm/Wbkf):	1.15	0.99	0.88	1.56

Channel Profile

	Mean	Median	Min	Max	
Valley Slope:	0.0136	ft./ft			
Water Surface Slope:	0.0133	ft./ft			
Riffle Slope:	0.0316	0.0388	0.01	0.0393	ft./ft
Pool Slope:	0.0004	0.0002	0.0014	0.0003	ft./ft
Run Slope:	0.0073	0.0073	0.006	0.0082	ft./ft
Glide Slope:	0.0000	0.0000	0.00	0.0000	ft./ft
Riffle Length:	12.4	14.0	6.5	18.0	ft.
Pool Length:	27.0	29.8	7.0	41.5	ft.
Run Length:	22.3	22.3	19.5	25.0	ft.
Glide Length:	10.5	10.5	8.5	12.5	ft.
Riffle to Riffle Spacing:	36.5	36.5	35.5	51.3	ft.
Pool to Pool Spacing:	76.3	95.8	37.3	95.8	ft.
Riffle to Pool Spacing:	18.8	18.4	10.5	27.8	ft.

	Mean	Median	Min	Max
RATIO: Riffle Slope/ Water Surface Slope:	2.38	2.91	1.04	2.96
RATIO: Pool Slope/Water Surface Slope:	0.03	0.01	0.11	0.03
RATIO: Run Slope/Water Surface Slope:	0.55	0.55	0.48	0.62
RATIO: Glide Slope/ Water Surface Slope:	0.00	0.00	0.00	0.00
RATIO: Max. Riffle Depth/Mean Bankfull Depth:	1.57			
RATIO: Max.Pool Depth/Mean Bankfull Depth:	2.70			
RATIO: Max. Run Depth/Mean Bankfull Depth:	n/a			
RATIO: Max. Glide Depth/Mean Bankfull Depth:	n/a			
RATIO: Riffle Length/Bankfull Width:	0.75	0.85	0.40	1.09
RATIO: Pool Length/Bankfull Width:	1.64	1.81	0.43	2.52
RATIO: Run Length/Bankfull Width:	1.35	1.35	1.19	1.52
RATIO: Glide Length/Bankfull Width:	0.64	0.64	0.52	0.76
RATIO: Riffle to Riffle Spacing/Bankfull Width:	2.22	2.22	2.16	3.12
RATIO: Pool to Pool Spacing/Bankfull Width:	4.64	5.82	2.26	5.82
RATIO: Riffle to Pool Spacing/Bankfull Width:	1.14	1.12	0.64	1.69

D84:	100	mm Stretch
dmbkf:	282	mm
dmbkf/D84:	2.82	
u/n* :	5.7	Reference: Rosgen Reference Reach Field Book
Mannings 'n'	0.04	"

HEC-RAS Plan: LBC EC River: Little Beaver Cr Reach: Reach 1

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)	Power Chan (lb/ft s)
Reach 1	50	48.00	291.60	292.81	292.81	293.14	0.027711	4.56	10.53	16.39	1.00	1.09	4.99
Reach 1	50	118.00	291.60	293.36	293.36	293.84	0.025180	5.51	21.42	23.32	1.01	1.42	7.83
Reach 1	50	163.00	291.60	293.62	293.62	294.15	0.024118	5.86	27.83	26.77	1.01	1.54	9.02
Reach 1	50	252.00	291.60	294.06	294.06	294.65	0.018501	6.19	42.41	44.48	0.93	1.57	9.70
Reach 1	49	48.00	290.70	291.85		291.90	0.004416	1.95	24.69	36.18	0.41	0.19	0.38
Reach 1	49	118.00	290.70	292.33		292.43	0.004985	2.65	47.07	57.09	0.46	0.32	0.84
Reach 1	49	163.00	290.70	292.55		292.68	0.005028	2.91	61.02	67.50	0.47	0.36	1.06
Reach 1	49	252.00	290.70	292.88		293.04	0.005223	3.32	86.46	85.25	0.50	0.45	1.48
Reach 1	48	48.00	289.80	290.98	290.85	291.13	0.016954	3.15	15.23	28.59	0.76	0.56	1.75
Reach 1	48	118.00	289.80	291.48	291.29	291.67	0.013315	3.49	33.85	45.61	0.71	0.61	2.13
Reach 1	48	163.00	289.80	291.66	291.47	291.89	0.014719	3.82	42.70	54.20	0.76	0.72	2.74
Reach 1	48	252.00	289.80	291.96	291.76	292.22	0.014775	4.15	60.78	68.49	0.78	0.81	3.37
Reach 1	47	48.00	287.40	288.62	288.62	289.06	0.026868	5.29	9.08	10.67	1.01	1.36	7.17
Reach 1	47	118.00	287.40	289.50	289.50	289.97	0.023275	5.49	21.89	28.36	0.96	1.38	7.59
Reach 1	47	163.00	287.40	289.83	289.83	290.25	0.019377	5.28	34.25	46.72	0.89	1.25	6.61
Reach 1	47	252.00	287.40	290.17	290.17	290.61	0.018461	5.64	52.59	62.18	0.89	1.36	7.68
Reach 1	46	48.00	286.40	287.82		287.84	0.004599	1.44	39.56	90.62	0.37	0.12	0.18
Reach 1	46	118.00	286.40	288.56		288.58	0.000949	1.11	124.00	128.11	0.19	0.06	0.06
Reach 1	46	163.00	286.40	288.89		288.90	0.000747	1.14	168.16	143.41	0.17	0.06	0.06
Reach 1	46	252.00	286.40	289.39		289.41	0.000611	1.20	245.66	164.06	0.16	0.06	0.07
Reach 1	45	48.00	285.80	287.69		287.71	0.000641	1.02	52.25	62.72	0.17	0.05	0.05
Reach 1	45	118.00	285.80	288.49		288.51	0.000564	1.23	112.89	88.35	0.17	0.06	0.07
Reach 1	45	163.00	285.80	288.82		288.84	0.000555	1.36	143.48	96.51	0.17	0.07	0.09
Reach 1	45	252.00	285.80	289.32		289.35	0.000554	1.58	194.81	107.13	0.18	0.08	0.13
Reach 1	44	48.00	284.90	287.42		287.55	0.005004	2.87	17.49	19.28	0.43	0.36	1.02
Reach 1	44	118.00	284.90	288.11		288.35	0.006706	4.08	35.05	31.97	0.52	0.65	2.66
Reach 1	44	163.00	284.90	288.40		288.67	0.007441	4.58	44.94	37.55	0.55	0.79	3.64
Reach 1	44	252.00	284.90	288.82		289.17	0.008747	5.38	64.00	53.71	0.60	1.05	5.67
Reach 1	43	48.00	284.90	286.18	286.18	286.61	0.023645	5.29	9.39	13.22	0.95	1.31	6.95
Reach 1	43	118.00	284.90	286.94	286.94	287.36	0.016016	5.72	27.08	34.99	0.83	1.34	7.67
Reach 1	43	163.00	284.90	287.19	287.19	287.64	0.015760	6.06	37.33	44.55	0.83	1.46	8.85
Reach 1	43	252.00	284.90	287.55	287.55	288.03	0.016080	6.63	55.33	57.38	0.85	1.67	11.10
Reach 1	42	48.00	282.80	285.32		285.37	0.006676	2.36	27.13	45.35	0.42	0.29	0.67
Reach 1	42	118.00	282.80	286.00		286.05	0.003995	2.36	64.42	65.97	0.34	0.25	0.60
Reach 1	42	163.00	282.80	286.26		286.32	0.003953	2.49	84.00	82.82	0.34	0.27	0.68
Reach 1	42	252.00	282.80	286.61		286.69	0.004106	2.73	116.90	103.86	0.36	0.31	0.86
Reach 1	41	48.00	282.50	284.54		284.68	0.005650	3.05	16.73	15.86	0.48	0.40	1.23
Reach 1	41	118.00	282.50	285.21		285.45	0.007394	4.23	36.57	48.57	0.57	0.70	2.98
Reach 1	41	163.00	282.50	285.53		285.76	0.006374	4.29	56.52	73.19	0.54	0.69	2.96
Reach 1	41	252.00	282.50	286.07		286.23	0.004121	4.00	103.11	101.38	0.45	0.56	2.23
Reach 1	40	85.00	281.80	283.87		284.00	0.009805	3.28	30.14	35.47	0.59	0.52	1.69
Reach 1	40	208.00	281.80	284.82		284.94	0.004814	3.23	82.37	76.89	0.46	0.42	1.36
Reach 1	40	286.00	281.80	285.21		285.32	0.003958	3.39	115.92	97.30	0.43	0.43	1.47
Reach 1	40	442.00	281.80	285.80		285.91	0.003148	3.61	179.69	120.10	0.40	0.45	1.61
Reach 1	39	85.00	281.00	283.73		283.76	0.001096	1.45	58.49	43.76	0.22	0.09	0.13
Reach 1	39	208.00	281.00	284.70		284.76	0.000989	1.92	118.28	81.53	0.23	0.13	0.25
Reach 1	39	286.00	281.00	285.09		285.16	0.001002	2.16	154.36	120.36	0.24	0.16	0.34
Reach 1	39	442.00	281.00	285.69		285.76	0.000956	2.42	245.94	174.39	0.24	0.18	0.44
Reach 1	38	85.00	281.20	283.54		283.61	0.002125	2.19	39.82	29.41	0.32	0.19	0.42
Reach 1	38	208.00	281.20	284.45		284.60	0.002617	3.17	70.30	39.04	0.37	0.35	1.11
Reach 1	38	286.00	281.20	284.78		284.98	0.003063	3.75	84.16	45.91	0.41	0.47	1.77
Reach 1	38	442.00	281.20	285.25		285.57	0.003899	4.74	109.84	68.08	0.48	0.71	3.37
Reach 1	37	85.00	281.20	283.43		283.46	0.001029	1.34	63.50	52.12	0.21	0.08	0.10
Reach 1	37	208.00	281.20	284.39		284.44	0.000926	1.79	116.78	61.67	0.22	0.12	0.21
Reach 1	37	286.00	281.20	284.72		284.79	0.001047	2.11	138.91	70.31	0.24	0.15	0.32
Reach 1	37	442.00	281.20	285.21		285.32	0.001308	2.66	176.02	84.06	0.28	0.23	0.61
Reach 1	36	85.00	279.50	283.32	282.12	283.35	0.001317	1.72	60.21	50.71	0.24	0.12	0.20
Reach 1	36	208.00	279.50	284.28		284.33	0.001339	2.11	120.51	74.71	0.25	0.16	0.34
Reach 1	36	286.00	279.50	284.60		284.67	0.001487	2.44	146.02	82.94	0.27	0.21	0.50
Reach 1	36	442.00	279.50	285.07		285.17	0.001833	3.03	185.61	88.51	0.31	0.30	0.92
Reach 1	35	85.00	280.20	282.82	282.36	283.04	0.008158	3.73	22.77	17.68	0.58	0.60	2.23
Reach 1	35	208.00	280.20	283.78	283.33	284.02	0.007373	4.12	59.94	61.19	0.58	0.67	2.78
Reach 1	35	286.00	280.20	284.11	283.69	284.35	0.006618	4.31	84.26	90.33	0.56	0.70	3.03
Reach 1	35	442.00	280.20	284.52	284.13	284.80	0.006495	4.88	128.39	130.10	0.58	0.84	4.12
Reach 1	34	85.00	279.20	281.22		281.76	0.021221	5.88	14.46	11.11	0.91	1.50	8.82
Reach 1	34	208.00	279.20	282.27	282.27	282.84	0.020148	6.17	36.02	33.54	0.92	1.59	9.82
Reach 1	34	286.00	279.20	282.56	282.56	283.23	0.020693	6.77	46.56	40.57	0.96	1.84	12.48
Reach 1	34	442.00	279.20	283.14	283.14	283.79	0.016173	6.87	76.70	62.36	0.88	1.77	12.18
Reach 1	33	85.00	279.00	281.37		281.39	0.000726	1.33	73.60	57.54	0.19	0.07	0.09
Reach 1	33	208.00	279.00	282.06		282.12	0.001265	2.05	116.76	66.90	0.25	0.15	0.31

HEC-RAS Plan: LBC EC River: Little Beaver Cr Reach: Reach 1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Power Chan
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/ft s)
Reach 1	33	286.00	279.00	282.33		282.41	0.001605	2.44	134.87	70.23	0.29	0.21	0.52
Reach 1	33	442.00	279.00	282.73		282.85	0.002239	3.11	163.91	75.26	0.35	0.33	1.03
Reach 1	32	85.00	278.70	281.22		281.28	0.002592	2.03	48.45	59.33	0.33	0.18	0.37
Reach 1	32	208.00	278.70	281.84		281.93	0.003290	2.68	95.00	91.33	0.39	0.29	0.78
Reach 1	32	286.00	278.70	282.06		282.18	0.003865	3.04	116.83	107.15	0.43	0.36	1.11
Reach 1	32	442.00	278.70	282.40		282.55	0.004673	3.57	156.17	129.03	0.48	0.49	1.73
Reach 1	31	85.00	278.90	280.43	280.43	280.72	0.020915	4.56	21.94	38.67	0.88	1.02	4.66
Reach 1	31	208.00	278.90	280.98		281.28	0.020986	4.90	51.40	72.85	0.90	1.14	5.58
Reach 1	31	286.00	278.90	281.29		281.52	0.015519	4.40	77.96	100.61	0.78	0.90	3.96
Reach 1	31	442.00	278.90	281.70		281.91	0.010743	4.29	124.56	126.13	0.68	0.79	3.37
Reach 1	30	85.00	277.80	279.54	279.10	279.61	0.004006	2.59	44.19	50.77	0.40	0.29	0.75
Reach 1	30	208.00	277.80	280.19	279.55	280.31	0.004641	3.38	81.71	64.76	0.44	0.45	1.51
Reach 1	30	286.00	277.80	280.47	279.76	280.61	0.005162	3.80	100.40	72.56	0.48	0.55	2.08
Reach 1	30	442.00	277.80	280.92		281.11	0.005541	4.33	135.53	82.56	0.50	0.68	2.94
Reach 1	29	85.00	276.70	278.66		278.89	0.017945	4.02	22.69	34.21	0.81	0.81	3.26
Reach 1	29	208.00	276.70	279.30		279.59	0.013785	4.49	51.32	54.77	0.76	0.90	4.04
Reach 1	29	286.00	276.70	279.67		279.93	0.010417	4.34	73.22	65.31	0.68	0.80	3.46
Reach 1	29	442.00	276.70	280.22		280.48	0.007978	4.39	112.97	81.21	0.62	0.76	3.32
Reach 1	28	85.00	276.70	278.67		278.68	0.000352	0.71	120.01	116.12	0.12	0.02	0.02
Reach 1	28	208.00	276.70	279.32		279.34	0.000457	1.03	201.99	135.59	0.15	0.04	0.04
Reach 1	28	286.00	276.70	279.67		279.69	0.000461	1.14	250.40	144.93	0.15	0.05	0.06
Reach 1	28	442.00	276.70	280.22		280.25	0.000463	1.32	336.67	165.26	0.16	0.06	0.08
Reach 1	27	130.00	276.60	278.18	278.18	278.51	0.020068	4.68	29.32	57.06	0.89	1.05	4.91
Reach 1	27	320.00	276.60	278.99		279.18	0.010951	3.72	95.71	110.11	0.67	0.64	2.38
Reach 1	27	440.00	276.60	279.40		279.55	0.006604	3.27	145.78	130.34	0.54	0.47	1.52
Reach 1	27	680.00	276.60	279.99		280.13	0.004176	3.17	231.32	157.21	0.45	0.40	1.26
Reach 1	26	130.00	274.60	277.97		277.99	0.000601	1.07	128.43	116.39	0.16	0.05	0.05
Reach 1	26	320.00	274.60	278.97		279.00	0.000466	1.37	259.39	140.91	0.16	0.07	0.09
Reach 1	26	440.00	274.60	279.36		279.39	0.000503	1.58	315.28	151.58	0.17	0.08	0.13
Reach 1	26	680.00	274.60	279.92		279.97	0.000594	1.95	406.60	174.29	0.19	0.12	0.23
Reach 1	26	130.00	275.00	277.13	277.13	277.73	0.023667	6.24	20.82	17.21	1.00	1.69	10.53
Reach 1	25	320.00	275.00	278.18	278.18	278.79	0.019046	6.32	52.70	54.19	0.94	1.63	10.30
Reach 1	25	440.00	275.00	278.57	278.57	279.19	0.014405	6.48	78.78	79.92	0.85	1.57	10.19
Reach 1	25	680.00	275.00	279.06	279.06	279.74	0.012627	7.11	122.31	99.32	0.83	1.75	12.44
Reach 1	24	130.00	273.60	275.55		275.73	0.008102	3.48	37.33	34.71	0.59	0.54	1.87
Reach 1	24	320.00	273.60	276.44		276.74	0.007460	4.40	72.70	44.66	0.61	0.75	3.29
Reach 1	24	440.00	273.60	276.82		277.19	0.007533	4.85	90.66	48.43	0.63	0.87	4.21
Reach 1	24	680.00	273.60	277.43		277.91	0.007804	5.56	122.35	55.09	0.65	1.07	5.97
Reach 1	23	130.00	272.80	275.17		275.24	0.002413	2.26	64.25	56.82	0.34	0.21	0.47
Reach 1	23	320.00	272.80	276.15		276.26	0.002166	2.87	129.35	78.42	0.34	0.29	0.83
Reach 1	23	440.00	272.80	276.56		276.69	0.002163	3.22	163.14	86.64	0.35	0.34	1.10
Reach 1	23	680.00	272.80	277.22		277.40	0.002179	3.76	225.64	109.75	0.37	0.43	1.63
Reach 1	22	130.00	271.50	274.70		274.90	0.004619	3.66	40.84	37.00	0.43	0.50	1.84
Reach 1	22	320.00	271.50	275.45		275.85	0.007981	5.60	75.24	56.36	0.57	1.09	6.12
Reach 1	22	440.00	271.50	275.74		276.25	0.009472	6.50	92.90	64.10	0.63	1.42	9.25
Reach 1	22	680.00	271.50	276.33		276.94	0.010244	7.54	144.30	132.56	0.68	1.82	13.71
Reach 1	21	130.00	271.90	274.03		274.23	0.008525	3.64	38.41	55.55	0.61	0.58	2.12
Reach 1	21	320.00	271.90	275.07		275.19	0.003803	3.13	130.48	119.50	0.43	0.38	1.19
Reach 1	21	440.00	271.90	275.57		275.67	0.002361	2.95	195.50	136.55	0.36	0.31	0.91
Reach 1	21	680.00	271.90	276.34		276.43	0.001580	2.97	308.03	157.72	0.31	0.28	0.83
Reach 1	20	130.00	270.90	273.61	272.69	273.72	0.003976	2.67	48.70	38.40	0.42	0.30	0.81
Reach 1	20	320.00	270.90	274.73	273.63	274.90	0.002893	3.37	98.52	54.20	0.39	0.40	1.34
Reach 1	20	440.00	270.90	275.25	273.94	275.45	0.002628	3.68	131.37	72.18	0.39	0.44	1.63
Reach 1	20	680.00	270.90	276.00	274.50	276.25	0.002514	4.22	190.64	85.64	0.39	0.53	2.25
Reach 1	19	130.00	270.50	272.75		273.08	0.010088	4.58	28.40	20.16	0.68	0.86	3.92
Reach 1	19	320.00	270.50	273.61		274.28	0.014395	6.55	49.99	31.20	0.85	1.60	10.49
Reach 1	19	440.00	270.50	273.89	273.89	274.81	0.018146	7.74	59.12	35.35	0.97	2.18	16.87
Reach 1	19	680.00	270.50	274.63	274.63	275.63	0.016301	8.24	89.19	46.26	0.94	2.33	19.18
Reach 1	18	130.00	270.00	272.89		272.90	0.000269	0.97	173.73	99.44	0.11	0.03	0.03
Reach 1	18	320.00	270.00	273.94		273.96	0.000415	1.46	313.26	170.63	0.15	0.07	0.10
Reach 1	18	440.00	270.00	274.36		274.39	0.000429	1.63	389.24	184.67	0.15	0.08	0.13
Reach 1	18	680.00	270.00	275.04		275.07	0.000458	1.89	519.25	202.44	0.16	0.11	0.20
Reach 1	17	130.00	269.60	272.68		272.82	0.003502	3.03	42.87	25.65	0.41	0.35	1.07
Reach 1	17	320.00	269.60	273.56		273.83	0.005041	4.32	88.70	75.29	0.52	0.66	2.86
Reach 1	17	440.00	269.60	273.98		274.26	0.004766	4.53	123.79	90.40	0.51	0.70	3.16
Reach 1	17	680.00	269.60	274.68	273.93	274.94	0.004076	4.63	194.44	110.87	0.48	0.69	3.21
Reach 1	16	130.00	270.60	271.75	271.75	272.17	0.025589	5.15	25.24	31.08	1.01	1.29	6.64
Reach 1	16	320.00	270.60	272.71	272.45	273.15	0.012836	5.35	59.80	41.31	0.78	1.15	6.15
Reach 1	16	440.00	270.60	273.06		273.59	0.012775	5.89	74.72	44.51	0.80	1.32	7.80
Reach 1	16	680.00	270.60	273.69		274.34	0.011846	6.47	105.10	51.32	0.80	1.50	9.69

HEC-RAS Plan: LBC EC River: Little Beaver Cr Reach: Reach 1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Power Chan
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/ft s)
Reach 1	15	130.00	268.00	270.76		270.95	0.004778	3.54	36.71	21.72	0.48	0.48	1.71
Reach 1	15	320.00	268.00	272.13		272.32	0.004188	3.75	104.55	83.10	0.46	0.51	1.91
Reach 1	15	440.00	268.00	272.74		272.88	0.002959	3.37	158.54	93.67	0.40	0.40	1.34
Reach 1	15	680.00	268.00	273.59		273.73	0.002048	3.44	251.11	126.42	0.35	0.37	1.29
Reach 1	14	130.00	267.10	270.51		270.61	0.002355	2.58	50.45	27.21	0.33	0.25	0.65
Reach 1	14	320.00	267.10	271.81		271.99	0.002875	3.46	92.58	37.86	0.39	0.41	1.42
Reach 1	14	440.00	267.10	272.35		272.58	0.003098	3.85	114.40	42.31	0.41	0.49	1.89
Reach 1	14	680.00	267.10	273.15		273.46	0.003393	4.52	151.50	52.37	0.44	0.64	2.89
Reach 1	13	130.00	267.00	270.06		270.27	0.005866	3.70	35.09	22.68	0.52	0.54	2.02
Reach 1	13	320.00	267.00	271.22		271.58	0.006527	4.82	66.42	31.38	0.58	0.83	3.99
Reach 1	13	440.00	267.00	271.68		272.13	0.007156	5.38	81.79	35.11	0.62	1.00	5.38
Reach 1	13	680.00	267.00	272.30		272.96	0.008110	6.52	104.93	40.62	0.68	1.38	8.99
Reach 1	12	130.00	266.30	269.90		269.96	0.001429	1.96	66.39	38.66	0.26	0.15	0.29
Reach 1	12	320.00	266.30	271.10		271.21	0.001673	2.66	120.52	51.61	0.30	0.24	0.64
Reach 1	12	440.00	266.30	271.59		271.73	0.001707	3.03	147.05	58.47	0.31	0.30	0.90
Reach 1	12	680.00	266.30	272.24		272.46	0.002014	3.77	188.28	67.89	0.35	0.43	1.62
Reach 1	11	130.00	266.00	269.81		269.85	0.000960	1.59	81.61	48.90	0.22	0.10	0.16
Reach 1	11	320.00	266.00	271.00		271.07	0.001133	2.14	149.59	69.23	0.25	0.16	0.34
Reach 1	11	440.00	266.00	271.49		271.58	0.001110	2.41	189.36	96.56	0.25	0.19	0.45
Reach 1	11	680.00	266.00	272.15		272.27	0.001200	2.89	264.54	125.43	0.27	0.25	0.73
Reach 1	10	130.00	266.10	269.74		269.77	0.000589	1.33	97.47	53.54	0.17	0.07	0.09
Reach 1	10	320.00	266.10	270.91		270.96	0.000867	1.81	177.22	82.77	0.22	0.11	0.21
Reach 1	10	440.00	266.10	271.39		271.45	0.000962	2.00	219.55	94.89	0.23	0.14	0.28
Reach 1	10	680.00	266.10	272.05		272.14	0.001010	2.39	287.77	112.27	0.25	0.18	0.43
Reach 1	9	130.00	265.80	269.68		269.71	0.000450	1.28	102.55	55.08	0.15	0.06	0.08
Reach 1	9	320.00	265.80	270.83		270.88	0.000666	1.91	182.39	83.54	0.20	0.12	0.22
Reach 1	9	440.00	265.80	271.29		271.36	0.000755	2.21	222.63	90.57	0.21	0.15	0.33
Reach 1	9	680.00	265.80	271.93		272.04	0.000983	2.77	297.93	146.33	0.25	0.23	0.63
Reach 1	8	130.00	264.70	269.62		269.66	0.000576	1.67	92.53	44.27	0.17	0.09	0.15
Reach 1	8	320.00	264.70	270.73		270.81	0.000922	2.55	171.32	116.41	0.23	0.20	0.50
Reach 1	8	440.00	264.70	271.19		271.28	0.000993	2.85	233.13	155.88	0.24	0.24	0.67
Reach 1	8	680.00	264.70	271.83		271.95	0.001150	3.37	348.83	228.15	0.27	0.31	1.06
Reach 1	7	130.00	265.60	269.38	268.10	269.53	0.002948	3.08	43.83	29.61	0.37	0.35	1.07
Reach 1	7	320.00	265.60	270.26	269.33	270.58	0.005179	4.74	81.11	54.75	0.51	0.76	3.61
Reach 1	7	440.00	265.60	270.64	269.98	271.02	0.005975	5.35	103.47	65.59	0.56	0.95	5.07
Reach 1	7	680.00	265.60	271.20	270.71	271.65	0.006887	6.09	153.97	130.84	0.61	1.20	7.28
Reach 1	6	130.00	267.00	268.50	268.50	268.80	0.023548	5.16	32.07	48.49	0.96	1.26	6.52
Reach 1	6	320.00	267.00	269.02	269.02	269.47	0.026173	6.27	62.88	66.62	1.05	1.74	10.91
Reach 1	6	440.00	267.00	269.23	269.23	269.78	0.027250	6.81	77.23	70.01	1.09	1.99	13.58
Reach 1	6	680.00	267.00	269.62	269.62	270.29	0.026347	7.43	105.73	76.92	1.10	2.25	16.69
Reach 1	5	130.00	264.00	266.25		266.41	0.005249	3.22	42.47	35.71	0.49	0.43	1.39
Reach 1	5	320.00	264.00	267.54		267.72	0.003452	3.50	99.04	52.11	0.42	0.44	1.53
Reach 1	5	440.00	264.00	268.09		268.29	0.003244	3.69	129.57	59.68	0.42	0.47	1.73
Reach 1	5	680.00	264.00	268.88		269.12	0.003322	4.16	183.45	78.29	0.44	0.56	2.33
Reach 1	4	130.00	263.20	265.97		266.08	0.002412	2.70	50.71	34.99	0.34	0.27	0.73
Reach 1	4	320.00	263.20	267.30		267.45	0.002352	3.29	117.71	67.53	0.35	0.36	1.19
Reach 1	4	440.00	263.20	267.87		268.03	0.002285	3.42	160.04	82.12	0.35	0.38	1.30
Reach 1	4	680.00	263.20	268.70		268.85	0.002171	3.58	242.32	111.74	0.34	0.40	1.44
Reach 1	3	130.00	262.30	265.74	265.09	266.00	0.007509	4.07	31.95	20.72	0.58	0.67	2.71
Reach 1	3	320.00	262.30	266.96	266.21	267.35	0.007506	5.03	63.68	30.47	0.61	0.91	4.59
Reach 1	3	440.00	262.30	267.46	266.67	267.92	0.007500	5.49	82.27	44.29	0.63	1.05	5.74
Reach 1	3	680.00	262.30	268.17	267.48	268.74	0.007500	6.21	120.16	68.23	0.65	1.26	7.80

HEC-RAS Plan: LBC PC River: Little Beaver Cr Reach: Reach 1

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Power Chan
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/ft s)
Reach 1	50	48.00	290.00	292.21		292.32	0.004210	2.68	18.92	23.26	0.43	0.31	0.83
Reach 1	50	118.00	290.00	292.81		293.02	0.005391	3.95	36.12	31.87	0.51	0.59	2.32
Reach 1	50	163.00	290.00	293.02		293.32	0.006540	4.69	43.13	33.80	0.58	0.80	3.73
Reach 1	50	252.00	290.00	293.35		293.80	0.008424	5.88	54.83	37.04	0.67	1.19	6.99
Reach 1	49	48.00	289.60	291.49		291.70	0.011580	3.69	13.03	14.03	0.67	0.64	2.36
Reach 1	49	118.00	289.60	292.03		292.33	0.010812	4.77	32.80	49.89	0.70	0.93	4.41
Reach 1	49	163.00	289.60	292.27		292.58	0.009749	5.02	45.71	57.08	0.68	0.97	4.89
Reach 1	49	252.00	289.60	292.66		292.97	0.008440	5.36	70.00	68.96	0.66	1.04	5.55
Reach 1	48	48.00	288.60	290.63	290.23	290.79	0.007341	3.16	15.84	38.08	0.55	0.45	1.44
Reach 1	48	118.00	288.60	291.09	290.95	291.35	0.009075	4.48	34.15	42.10	0.65	0.81	3.62
Reach 1	48	163.00	288.60	291.27	291.16	291.60	0.010211	5.14	42.02	43.66	0.70	1.02	5.24
Reach 1	48	252.00	288.60	291.60	291.46	292.02	0.010868	5.97	57.20	47.47	0.74	1.30	7.77
Reach 1	47	48.00	287.30	288.94	288.94	289.33	0.028453	4.99	9.62	12.96	1.02	1.26	6.30
Reach 1	47	118.00	287.30	289.69	289.69	290.09	0.014220	5.35	27.08	42.54	0.80	1.18	6.30
Reach 1	47	163.00	287.30	289.94	289.94	290.35	0.012447	5.60	39.73	54.21	0.77	1.22	6.85
Reach 1	47	252.00	287.30	290.27	290.27	290.73	0.012289	6.27	59.39	66.95	0.79	1.44	9.05
Reach 1	46	48.00	286.80	288.96		288.96	0.000080	0.36	148.16	152.14	0.06	0.01	0.00
Reach 1	46	118.00	286.80	289.42		289.43	0.000169	0.65	222.24	166.49	0.09	0.02	0.01
Reach 1	46	163.00	286.80	289.64		289.65	0.000212	0.79	259.34	173.39	0.10	0.02	0.02
Reach 1	46	252.00	286.80	290.01		290.02	0.000277	1.02	327.48	208.66	0.12	0.04	0.04
Reach 1	45	48.00	286.70	288.84		288.93	0.004106	2.53	28.21	97.19	0.42	0.28	0.71
Reach 1	45	118.00	286.70	289.32		289.38	0.002667	2.57	77.36	107.20	0.35	0.26	0.67
Reach 1	45	163.00	286.70	289.53		289.60	0.002500	2.70	100.33	111.45	0.35	0.27	0.74
Reach 1	45	252.00	286.70	289.88		289.95	0.002336	2.92	139.83	118.41	0.35	0.30	0.89
Reach 1	44	48.00	286.10	287.94		288.18	0.013440	3.88	12.37	13.78	0.72	0.72	2.78
Reach 1	44	118.00	286.10	288.45	288.45	288.80	0.013497	5.12	30.54	48.67	0.77	1.09	5.58
Reach 1	44	163.00	286.10	288.65	288.65	289.04	0.013185	5.56	41.22	56.43	0.78	1.22	6.80
Reach 1	44	252.00	286.10	288.92	288.92	289.40	0.014519	6.47	57.33	64.84	0.84	1.58	10.20
Reach 1	43	48.00	285.20	287.07	286.81	287.28	0.010858	3.61	13.28	13.95	0.65	0.61	2.21
Reach 1	43	118.00	285.20	287.53	287.53	287.78	0.010635	4.56	39.79	80.39	0.69	0.86	3.94
Reach 1	43	163.00	285.20	287.67	287.67	287.95	0.011495	5.06	51.29	84.72	0.72	1.03	5.20
Reach 1	43	252.00	285.20	287.87	287.87	288.22	0.013396	5.93	68.70	90.06	0.80	1.35	8.04
Reach 1	42	48.00	284.20	285.58	285.45	285.73	0.018553	3.27	15.59	25.94	0.78	0.60	1.97
Reach 1	42	118.00	284.20	286.16	285.86	286.37	0.013591	4.13	32.89	36.05	0.74	0.79	3.27
Reach 1	42	163.00	284.20	286.42		286.58	0.009985	4.12	58.60	114.62	0.65	0.73	3.01
Reach 1	42	252.00	284.20	286.84		286.95	0.005320	3.66	110.58	130.50	0.50	0.52	1.91
Reach 1	41	48.00	283.00	285.05		285.10	0.003225	2.11	26.21	39.07	0.36	0.20	0.43
Reach 1	41	118.00	283.00	285.67		285.77	0.003436	2.98	55.14	54.17	0.40	0.34	1.02
Reach 1	41	163.00	283.00	285.97		286.08	0.003290	3.24	72.09	60.97	0.41	0.39	1.25
Reach 1	41	252.00	283.00	286.47		286.59	0.002967	3.58	106.02	74.67	0.40	0.44	1.56
Reach 1	40	85.00	282.70	284.91		284.93	0.001151	1.39	74.21	88.53	0.22	0.08	0.12
Reach 1	40	208.00	282.70	285.49		285.53	0.001692	2.18	131.55	105.94	0.29	0.18	0.39
Reach 1	40	286.00	282.70	285.78		285.83	0.001805	2.49	163.48	113.73	0.30	0.22	0.56
Reach 1	40	442.00	282.70	286.29		286.35	0.001799	2.88	224.48	126.05	0.31	0.28	0.80
Reach 1	39	85.00	282.00	284.41		284.54	0.005288	3.24	39.69	98.20	0.49	0.43	1.40
Reach 1	39	208.00	282.00	285.05		285.14	0.003018	3.16	110.26	118.57	0.39	0.36	1.14
Reach 1	39	286.00	282.00	285.41		285.49	0.002219	3.02	153.31	120.91	0.35	0.31	0.95
Reach 1	39	442.00	282.00	285.97		286.05	0.001732	3.07	222.53	124.37	0.32	0.30	0.93
Reach 1	38	85.00	281.50	284.10		284.18	0.002739	2.50	58.15	126.49	0.36	0.25	0.62
Reach 1	38	208.00	281.50	284.93		284.96	0.001024	2.04	172.10	154.90	0.23	0.14	0.29
Reach 1	38	286.00	281.50	285.32		285.35	0.000816	2.01	236.36	175.06	0.21	0.13	0.27
Reach 1	38	442.00	281.50	285.90		285.93	0.000701	2.12	347.28	205.47	0.20	0.14	0.29
Reach 1	37	85.00	281.20	283.12	283.12	283.62	0.025457	5.68	14.97	15.29	1.01	1.49	8.46
Reach 1	37	208.00	281.20	284.02	284.02	284.69	0.015571	6.73	35.09	32.05	0.88	1.70	11.44
Reach 1	37	286.00	281.20	284.41	284.41	285.11	0.013396	7.10	48.86	36.86	0.84	1.77	12.59
Reach 1	37	442.00	281.20	285.04	285.04	285.73	0.010565	7.44	82.78	76.78	0.78	1.79	13.33
Reach 1	36	85.00	280.50	282.55		282.58	0.001215	1.31	69.61	58.14	0.22	0.08	0.10
Reach 1	36	208.00	280.50	283.30		283.35	0.001555	2.08	121.61	83.60	0.28	0.16	0.34
Reach 1	36	286.00	280.50	283.63		283.69	0.001710	2.44	150.47	93.99	0.30	0.21	0.52
Reach 1	36	442.00	280.50	284.09		284.18	0.002019	3.03	196.32	102.97	0.33	0.31	0.93
Reach 1	35	85.00	280.00	282.43		282.48	0.001962	1.95	51.91	46.64	0.30	0.16	0.31
Reach 1	35	208.00	280.00	283.12		283.22	0.002779	3.05	92.85	71.72	0.38	0.34	1.03
Reach 1	35	286.00	280.00	283.41		283.53	0.003239	3.60	115.23	85.28	0.42	0.45	1.62
Reach 1	35	442.00	280.00	283.82		284.00	0.003889	4.40	154.64	104.74	0.47	0.64	2.80
Reach 1	34	85.00	280.00	282.00		282.13	0.007928	3.27	32.14	40.13	0.57	0.49	1.59
Reach 1	34	208.00	280.00	282.56	282.24	282.77	0.008741	4.46	64.34	75.73	0.64	0.79	3.54
Reach 1	34	286.00	280.00	282.80	282.48	283.04	0.008826	4.93	83.97	90.11	0.66	0.93	4.57
Reach 1	34	442.00	280.00	283.15	282.84	283.45	0.008989	5.64	120.08	108.74	0.68	1.14	6.40
Reach 1	33	85.00	279.80	281.42	281.06	281.49	0.007137	2.40	41.38	61.04	0.51	0.30	0.71
Reach 1	33	208.00	279.80	281.92	281.46	282.05	0.008339	3.44	76.07	79.84	0.59	0.53	1.83

HEC-RAS Plan: LBC PC River: Little Beaver Cr. Reach: Reach 1 (Continued)

Reach	River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Power Chan
		(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)		(lb/sq ft)	(lb/ft s)
Reach 1	33	286.00	279.80	282.14	281.64	282.29	0.008801	3.94	94.41	91.37	0.62	0.66	2.61
Reach 1	33	442.00	279.80	282.48	281.96	282.68	0.008940	4.66	128.62	108.19	0.65	0.85	3.98
Reach 1	32	85.00	278.60	279.90	279.79	280.11	0.024354	3.48	23.41	36.70	0.89	0.71	2.45
Reach 1	32	208.00	278.60	280.52		280.76	0.015754	4.42	53.33	65.64	0.79	0.91	4.01
Reach 1	32	286.00	278.60	280.79		281.04	0.013804	4.67	72.04	72.43	0.76	0.95	4.44
Reach 1	32	442.00	278.60	281.21		281.49	0.012249	5.40	109.65	96.97	0.76	1.15	6.22
Reach 1	31	85.00	277.10	279.41		279.46	0.002604	2.11	52.81	59.33	0.33	0.19	0.40
Reach 1	31	208.00	277.10	280.11		280.18	0.002513	2.80	109.31	110.96	0.35	0.29	0.81
Reach 1	31	286.00	277.10	280.43		280.51	0.002310	2.97	149.30	150.69	0.35	0.31	0.92
Reach 1	31	442.00	277.10	281.01		281.07	0.001620	2.90	257.52	198.16	0.30	0.27	0.79
Reach 1	30	85.00	276.90	279.08		279.21	0.006532	3.24	32.78	53.42	0.53	0.46	1.48
Reach 1	30	208.00	276.90	279.81		279.96	0.004749	3.82	86.74	93.61	0.49	0.54	2.06
Reach 1	30	286.00	276.90	280.22		280.33	0.003188	3.56	124.99	97.76	0.41	0.44	1.56
Reach 1	30	442.00	276.90	280.83		280.95	0.002340	3.57	187.33	104.84	0.37	0.41	1.46
Reach 1	29	85.00	276.70	278.82		278.85	0.002062	1.77	60.02	62.63	0.29	0.14	0.25
Reach 1	29	208.00	276.70	279.62		279.67	0.001692	2.30	129.00	103.70	0.29	0.19	0.45
Reach 1	29	286.00	276.70	280.08		280.12	0.001340	2.35	178.67	114.31	0.27	0.19	0.45
Reach 1	29	442.00	276.70	280.72		280.78	0.001130	2.54	256.79	126.21	0.26	0.20	0.52
Reach 1	28	85.00	276.20	277.97	277.97	278.36	0.026631	5.32	17.74	22.41	1.01	1.37	7.27
Reach 1	28	208.00	276.20	278.98		279.33	0.010395	5.33	49.62	46.94	0.71	1.08	5.78
Reach 1	28	286.00	276.20	279.65		279.89	0.005268	4.71	92.40	99.93	0.53	0.76	3.58
Reach 1	28	442.00	276.20	280.51		280.63	0.002356	3.85	214.82	172.94	0.38	0.46	1.77
Reach 1	27	85.00	274.70	277.91		277.92	0.000326	1.08	121.58	104.68	0.13	0.04	0.04
Reach 1	27	208.00	274.70	279.16		279.17	0.000215	1.19	289.25	161.68	0.11	0.04	0.05
Reach 1	27	286.00	274.70	279.76		279.77	0.000190	1.25	399.06	204.20	0.11	0.04	0.06
Reach 1	27	442.00	274.70	280.54		280.56	0.000174	1.34	574.27	235.09	0.11	0.05	0.07
Reach 1	26	130.00	274.70	277.48		277.78	0.007274	4.46	32.39	30.67	0.59	0.76	3.38
Reach 1	26	320.00	274.70	278.88		279.08	0.003007	4.24	121.28	100.84	0.42	0.56	2.39
Reach 1	26	440.00	274.70	279.58		279.70	0.001800	3.75	212.60	146.19	0.34	0.41	1.54
Reach 1	26	680.00	274.70	280.40		280.50	0.001295	3.62	342.66	172.10	0.30	0.36	1.30
Reach 1	25	130.00	274.20	277.44		277.62	0.003533	3.47	39.55	23.22	0.42	0.43	1.51
Reach 1	25	320.00	274.20	278.58		278.97	0.004394	5.19	71.97	36.31	0.51	0.84	4.35
Reach 1	25	440.00	274.20	279.14		279.60	0.004477	5.82	94.59	51.40	0.53	1.00	5.82
Reach 1	25	680.00	274.20	279.86		280.40	0.004651	6.66	163.99	133.17	0.55	1.24	8.26
Reach 1	24	130.00	273.90	277.28		277.35	0.001845	2.41	66.69	46.25	0.30	0.21	0.52
Reach 1	24	320.00	273.90	278.53		278.65	0.001623	3.14	132.67	58.99	0.31	0.31	0.97
Reach 1	24	440.00	273.90	279.10		279.25	0.001794	3.68	169.25	79.01	0.33	0.40	1.47
Reach 1	24	680.00	273.90	279.77		280.00	0.002392	4.73	245.84	143.66	0.39	0.63	2.97
Reach 1	23	130.00	273.80	277.10		277.18	0.001897	2.41	65.34	45.17	0.31	0.22	0.52
Reach 1	23	320.00	273.80	278.38		278.50	0.001663	3.17	155.32	107.23	0.31	0.31	1.00
Reach 1	23	440.00	273.80	279.00		279.10	0.001282	3.13	229.59	134.27	0.28	0.29	0.91
Reach 1	23	680.00	273.80	279.69		279.80	0.001293	3.52	333.18	168.27	0.29	0.34	1.21
Reach 1	22	130.00	273.70	276.06	276.06	276.66	0.024043	6.24	20.84	17.71	1.01	1.69	10.55
Reach 1	22	320.00	273.70	277.05	277.05	278.02	0.019643	7.87	40.87	22.16	0.99	2.28	17.94
Reach 1	22	440.00	273.70	277.53	277.53	278.69	0.017726	8.65	51.86	24.85	0.98	2.56	22.15
Reach 1	22	680.00	273.70	278.82	278.82	279.49	0.006990	7.21	144.65	129.01	0.66	1.54	11.14
Reach 1	21	130.00	272.20	274.28		274.40	0.008620	3.16	47.18	63.96	0.58	0.47	1.49
Reach 1	21	320.00	272.20	275.35		275.44	0.003645	2.84	140.71	106.22	0.41	0.32	0.92
Reach 1	21	440.00	272.20	275.82		275.90	0.002866	2.47	193.77	121.13	0.36	0.25	0.61
Reach 1	21	680.00	272.20	276.53		276.61	0.002209	2.55	287.90	140.35	0.33	0.24	0.62
Reach 1	20	130.00	270.40	273.33	272.76	273.58	0.007213	4.02	32.35	21.30	0.57	0.65	2.60
Reach 1	20	320.00	270.40	274.37	273.76	274.86	0.008743	5.62	57.86	37.75	0.67	1.12	6.31
Reach 1	20	440.00	270.40	274.84	274.25	275.40	0.008158	6.12	80.12	53.46	0.67	1.26	7.69
Reach 1	20	680.00	270.40	275.44	275.14	276.16	0.008430	7.14	115.68	64.15	0.70	1.60	11.40
Reach 1	19	130.00	269.20	271.72		272.21	0.017008	5.65	23.00	17.32	0.86	1.34	7.56
Reach 1	19	320.00	269.20	273.19		273.72	0.008945	5.95	58.43	34.42	0.68	1.23	7.31
Reach 1	19	440.00	269.20	273.77		274.34	0.008244	6.28	83.55	58.67	0.66	1.31	8.20
Reach 1	19	680.00	269.20	274.84		275.24	0.005040	5.71	164.04	111.97	0.53	1.00	5.72
Reach 1	18	130.00	267.70	271.61		271.69	0.001598	2.27	57.21	28.71	0.28	0.19	0.43
Reach 1	18	320.00	267.70	273.08		273.21	0.001952	2.88	111.08	45.73	0.33	0.28	0.82
Reach 1	18	440.00	267.70	273.69		273.85	0.001884	3.15	139.81	48.78	0.33	0.32	1.01
Reach 1	18	680.00	267.70	274.68		274.88	0.001779	3.56	192.25	57.32	0.33	0.38	1.35
Reach 1	17	130.00	267.40	271.47		271.56	0.001364	2.32	56.07	23.81	0.27	0.19	0.43
Reach 1	17	320.00	267.40	272.83		273.02	0.002100	3.48	92.07	29.20	0.34	0.38	1.33
Reach 1	17	440.00	267.40	273.39		273.64	0.002510	4.04	108.87	31.39	0.38	0.50	2.03
Reach 1	17	680.00	267.40	274.27		274.65	0.003135	4.92	138.14	34.90	0.44	0.71	3.51
Reach 1	16	130.00	267.30	271.42		271.47	0.000743	1.84	95.51	73.34	0.20	0.11	0.21
Reach 1	16	320.00	267.30	272.85		272.90	0.000598	2.21	247.82	164.01	0.19	0.14	0.31
Reach 1	16	440.00	267.30	273.46		273.50	0.000476	2.16	355.25	182.16	0.18	0.13	0.28
Reach 1	16	680.00	267.30	274.44		274.48	0.000365	2.15	541.62	199.92	0.16	0.12	0.26

HEC-RAS Plan: LBC PC River: Little Beaver Cr. Reach: Reach 1 (Continued)

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl	Shear Chan (lb/sq ft)	Power Chan (lb/ft s)
Reach 1	15	130.00	267.10	271.32		271.39	0.001151	2.18	59.67	24.48	0.25	0.16	0.36
Reach 1	15	320.00	267.10	272.66		272.83	0.001678	3.29	104.33	51.78	0.31	0.33	1.09
Reach 1	15	440.00	267.10	273.22		273.43	0.001766	3.73	137.28	66.36	0.33	0.41	1.52
Reach 1	15	680.00	267.10	274.17		274.41	0.001680	4.20	216.36	107.69	0.33	0.48	2.02
Reach 1	14	130.00	267.00	271.19		271.26	0.001073	2.17	62.39	32.25	0.24	0.16	0.35
Reach 1	14	320.00	267.00	272.49		272.64	0.001419	3.29	111.26	43.20	0.30	0.32	1.05
Reach 1	14	440.00	267.00	273.03		273.23	0.001610	3.82	135.70	47.37	0.32	0.41	1.58
Reach 1	14	680.00	267.00	273.91		274.20	0.001859	4.64	180.75	55.01	0.36	0.57	2.66
Reach 1	13	130.00	268.00	270.77		271.00	0.007114	3.87	33.59	23.38	0.57	0.61	2.36
Reach 1	13	320.00	268.00	272.23		272.41	0.003205	3.76	113.77	99.67	0.42	0.48	1.80
Reach 1	13	440.00	268.00	272.88		273.02	0.001915	3.39	181.16	105.76	0.33	0.36	1.22
Reach 1	13	680.00	268.00	273.86		273.98	0.001245	3.27	295.17	125.64	0.28	0.31	1.00
Reach 1	12	130.00	267.50	270.42		270.57	0.003722	3.09	42.10	24.84	0.42	0.37	1.14
Reach 1	12	320.00	267.50	271.91		272.13	0.003748	3.69	86.63	39.32	0.44	0.48	1.79
Reach 1	12	440.00	267.50	272.58		272.81	0.003123	3.88	113.42	41.34	0.41	0.50	1.93
Reach 1	12	680.00	267.50	273.51		273.81	0.002999	4.42	158.62	63.09	0.42	0.60	2.65
Reach 1	11	130.00	266.70	269.89		270.10	0.004952	3.70	35.18	19.19	0.48	0.52	1.92
Reach 1	11	320.00	266.70	271.22		271.62	0.005625	5.09	62.89	22.68	0.54	0.87	4.41
Reach 1	11	440.00	266.70	271.83		272.33	0.005767	5.68	78.93	33.16	0.56	1.03	5.83
Reach 1	11	680.00	266.70	272.64	271.49	273.31	0.006461	6.71	111.25	44.36	0.61	1.36	9.11
Reach 1	10	130.00	266.40	269.42		269.64	0.005479	3.82	34.06	18.77	0.50	0.56	2.14
Reach 1	10	320.00	266.40	270.54		271.04	0.007620	5.67	56.46	21.13	0.61	1.10	6.23
Reach 1	10	440.00	266.40	271.05		271.71	0.008223	6.53	68.79	37.61	0.65	1.38	9.04
Reach 1	10	680.00	266.40	271.95		272.70	0.007215	7.23	113.41	58.00	0.63	1.56	11.28
Reach 1	9	130.00	266.00	269.13		269.24	0.002612	2.63	52.09	38.35	0.36	0.27	0.70
Reach 1	9	320.00	266.00	270.42		270.58	0.001946	3.32	112.02	54.57	0.34	0.35	1.17
Reach 1	9	440.00	266.00	271.06		271.23	0.001734	3.57	150.76	80.09	0.33	0.38	1.35
Reach 1	9	680.00	266.00	272.07		272.24	0.001420	3.81	253.54	117.58	0.31	0.40	1.51
Reach 1	8	130.00	265.70	268.61		268.86	0.006987	4.05	32.12	20.29	0.57	0.65	2.63
Reach 1	8	320.00	265.70	269.75		270.24	0.007791	5.61	57.05	23.35	0.63	1.09	6.10
Reach 1	8	440.00	265.70	270.28		270.89	0.008251	6.31	69.78	24.77	0.66	1.32	8.30
Reach 1	8	680.00	265.70	271.09		271.92	0.008254	7.40	99.68	51.77	0.69	1.67	12.39
Reach 1	7	130.00	265.40	268.43		268.47	0.001318	2.00	81.23	53.54	0.26	0.15	0.30
Reach 1	7	320.00	265.40	269.73		269.81	0.001134	2.64	160.77	68.17	0.26	0.22	0.57
Reach 1	7	440.00	265.40	270.33		270.42	0.001140	2.96	205.19	81.86	0.27	0.26	0.76
Reach 1	7	680.00	265.40	271.29		271.40	0.001121	3.41	297.43	108.13	0.28	0.32	1.08
Reach 1	6	130.00	265.00	268.16		268.29	0.003132	2.99	46.96	33.44	0.39	0.34	1.01
Reach 1	6	320.00	265.00	269.44		269.65	0.002567	3.86	99.04	47.96	0.38	0.47	1.81
Reach 1	6	440.00	265.00	270.01		270.26	0.002564	4.31	128.81	64.34	0.40	0.55	2.39
Reach 1	6	680.00	265.00	271.01		271.25	0.002099	4.57	215.44	114.59	0.37	0.58	2.63
Reach 1	5	130.00	264.60	267.65	266.92	267.85	0.004948	3.64	35.76	20.87	0.48	0.51	1.85
Reach 1	5	320.00	264.60	268.77	267.86	269.22	0.005599	5.39	61.29	24.47	0.56	0.94	5.09
Reach 1	5	440.00	264.60	269.10	268.36	269.77	0.007345	6.63	69.52	28.84	0.65	1.38	9.13
Reach 1	5	680.00	264.60	269.55	269.27	270.71	0.010875	8.80	85.58	42.35	0.81	2.33	20.48
Reach 1	4	130.00	264.00	266.33	266.33	266.95	0.024035	6.34	20.51	16.88	1.01	1.73	10.98
Reach 1	4	320.00	264.00	267.42	267.42	268.34	0.017108	7.74	43.40	31.26	0.93	2.15	16.60
Reach 1	4	440.00	264.00	268.04	268.04	268.89	0.012094	7.71	68.80	49.90	0.82	1.96	15.08
Reach 1	4	680.00	264.00	268.76	268.76	269.66	0.010278	8.31	111.94	68.36	0.79	2.10	17.46
Reach 1	3	130.00	263.30	266.08		266.15	0.002479	2.48	65.58	51.50	0.34	0.24	0.60
Reach 1	3	320.00	263.30	267.24		267.34	0.002062	3.22	136.19	71.06	0.34	0.34	1.09
Reach 1	3	440.00	263.30	267.79		267.91	0.001918	3.50	177.98	80.42	0.34	0.38	1.32
Reach 1	3	680.00	263.30	268.68		268.82	0.001788	3.95	257.62	101.17	0.34	0.44	1.75
Reach 1	2	130.00	262.60	265.46	264.97	265.70	0.007500	3.97	32.76	23.69	0.59	0.64	2.55
Reach 1	2	320.00	262.60	266.44	265.88	266.92	0.007502	5.63	60.55	32.83	0.64	1.09	6.11
Reach 1	2	440.00	262.60	266.90	266.34	267.49	0.007514	6.33	76.35	35.81	0.66	1.29	8.20
Reach 1	2	680.00	262.60	267.64	267.10	268.41	0.007508	7.37	109.21	53.19	0.68	1.63	11.99