# UT TAR RIVER
# FRANKLIN COUNTY
# RESTORATION PLAN
# 2003

# TABLE OF CONTENTS

## LIST OF TABLES



## LIST OF FIGURES



## LIST OF APPENDICES

# 1.0 INTRODUCTION

The North Carolina Wetlands Restoration Program (NCWRP) has identified an Unnamed Tributary to the Tar River (UT Tar River) as a potential stream restoration site. The Unnamed Tributary to the Tar River is located in the southeastern section of the town of Louisburg in Franklin County, North Carolina (Figure 1). The project site begins at NC Highway 39 and flows for approximately 1,700 ft. towards the northeast between Burnette Road and the Green Hill Country Club, Inc. The North Carolina Division of Water Quality (NCDWQ) has not classified this stream; therefore, it has not been assigned a NCDWQ Stream Index Number.

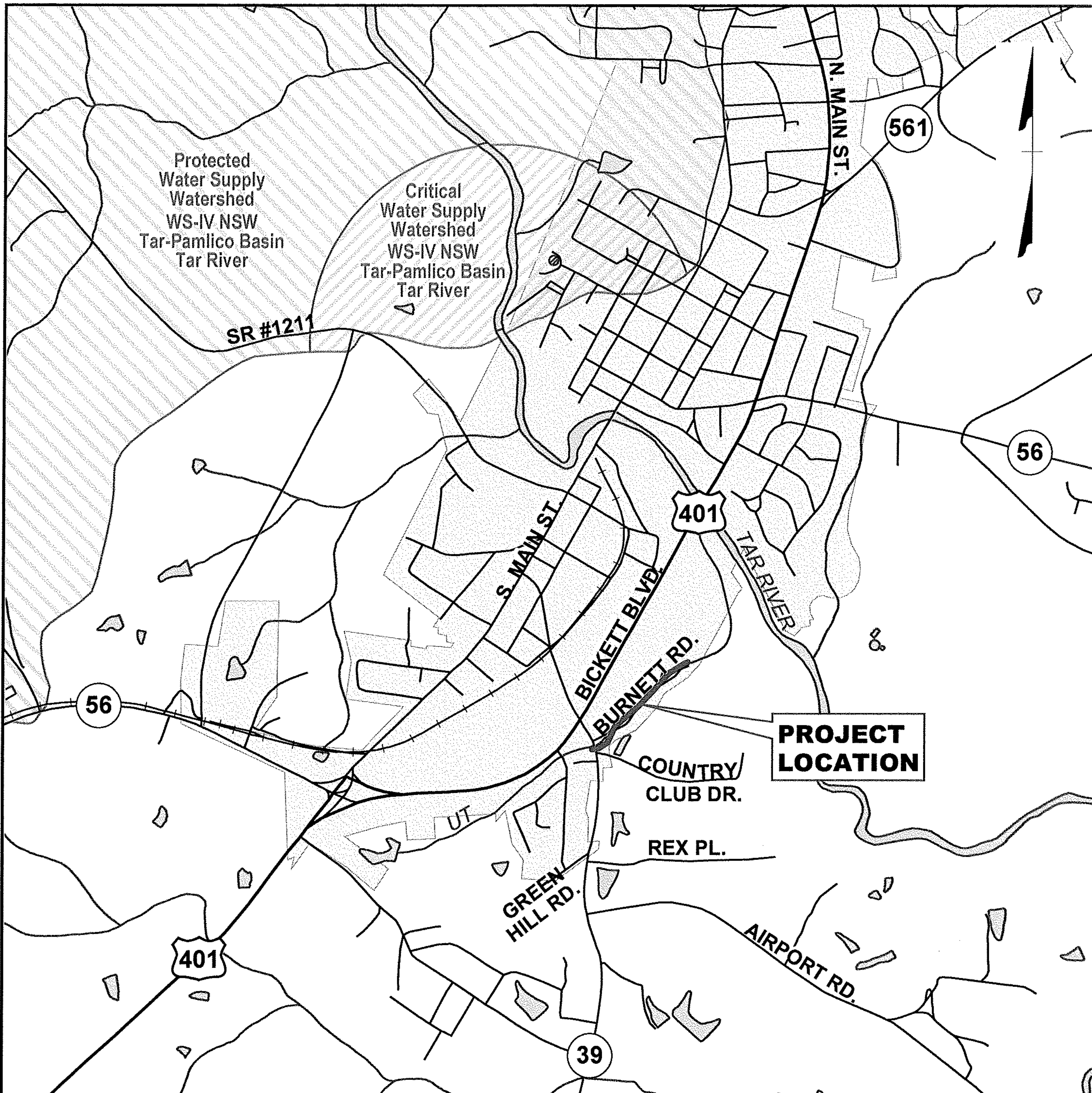
The town manager of Louisburg, C. L. Gobble, first identified the UT Tar River as a potential restoration site. His main concern is the streambank erosion that is undercutting Burnette Road. The lack of vegetation on the banks is one of the main causes of degradation along with past alterations of the stream course. Recent utility work by the town has caused additional channel instability. Typical of many urban streams, the UT Tar River channel is an oversized gully. The town has placed riprap in the channel in some areas to prevent undercutting. There is one tributary and one small drainage that enter the UT Tar River on the right bank from the golf course. Appendix A contains a photo log for the site depicting existing conditions of the stream.

Vegetation throughout the majority of the site is minimal due to channel degradation and other disturbances. Since there is a road adjacent to the left bank, there is no vegetation on this bank and very little on the right bank. There is a treed buffer between the stream and the golf course that members of the golf course have expressed interest in saving. The combination of extreme streambank erosion, lack of vegetation, and a signed conservation easement make this an excellent potential restoration site.

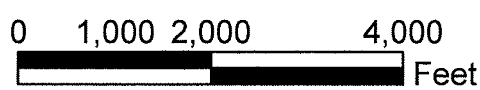
Restoration requires determining how far the stream has departed from its natural stability and then establishing the stable form of the stream under the current hydrologic conditions within the drainage area. The proposed restoration will construct a stable meander geometry, modify channel cross-sections,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

- Form a stable channel with the proper dimension, pattern, and profile.
- Establish a floodplain along the stream channel.
- Place natural material structures in the stream to improve stability and enhance aquatic habitat.
- Stabilize streambanks with herbaceous and woody vegetation.
- Restore/enhance the streams riparian zone.

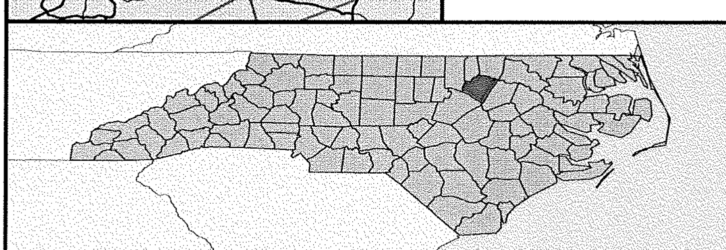
K:\654701\GIS\f1_locmap.mxd








N.C. Wetlands Restoration Program
NCDENR DWQ



# FIGURE 1
# PROJECT LOCATION MAP

Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

## 1.1 PROJECT DESCRIPTION

The UT Tar River project site is located in the town of Louisburg in Franklin County, North Carolina (Figure 1). Louisburg is located approximately 25 miles north of Raleigh along NC Highway 401. WRP previously obtained a conservation easement on the project from the Town of Louisburg and the Green Hill Country Club, Inc. UT Tar River flows from the southwest to the northeast. The project reach is bound on the west by NC Highway 39, Burnette Road along the left bank, and the country club along the right bank. The project ends at the northeastern extent of the conservation easement where the stream will tie into the old channel located on property owned by Raymond E. Burnette, et al. One small tributary and a small drainage flows off of the country club property and into the conservation easement before entering the UT Tar River from the right bank.

## 1.2 GOALS AND OBJECTIVES

This project has the following goals and objectives:

1. 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.
2. Improve water quality and reduce further property loss by stabilizing eroding streambanks.
3. Reconnect the stream to its floodplain and/or establish a new floodplain at a lower elevation.
4. Improve aquatic habitat with the use of natural material stabilization structures such as root wads, cross-vanes, woody debris, and a riparian buffer.
5. Provide aesthetic value, wildlife habitat, and bank stability through the creation of a riparian zone.
6. Stabilize and enhance the tributary and small drainage that enters the site.

## 1.3 STREAM SURVEY METHODOLOGY

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

Earth Tech contracted with 4D Site Solutions, Inc. to conduct a topographic survey of the restoration site in February 2003. 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 stream survey of the property was conducted to better evaluate the drainage properties of the area surrounding the restoration site on February 19, 2003. County Natural Resources Conservation Service (NRCS) Staff provided historic aerial photographs of the site to help assess the watershed's history. A windshield survey was also conducted to determine the existing conditions within the watershed.

During the site visit, three 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. Due to recent channel disturbances, a bankfull feature was not reliably identified in the field. Cross-sectional area was calculated using the best estimate of the bankfull feature identified in the field. See Appendix B for a copy of the existing condition survey for the UT Tar River.

### 1.3.1 Stream Delineation Criteria - Classification

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

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

The Rosgen Stream Classification System is based on five criteria: width/depth ratio, entrenchment ratio, slope, sinuosity, and channel materials. The cross-sections were classified using this system based on the few bankfull features present in the existing channel.

### 1.3.2 Bankfull Verification

The foundation of Dave Rosgen's classification system is the concept of bankfull stage, which is the point of incipient flooding. The classification depends 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; and
- Staining of rocks.

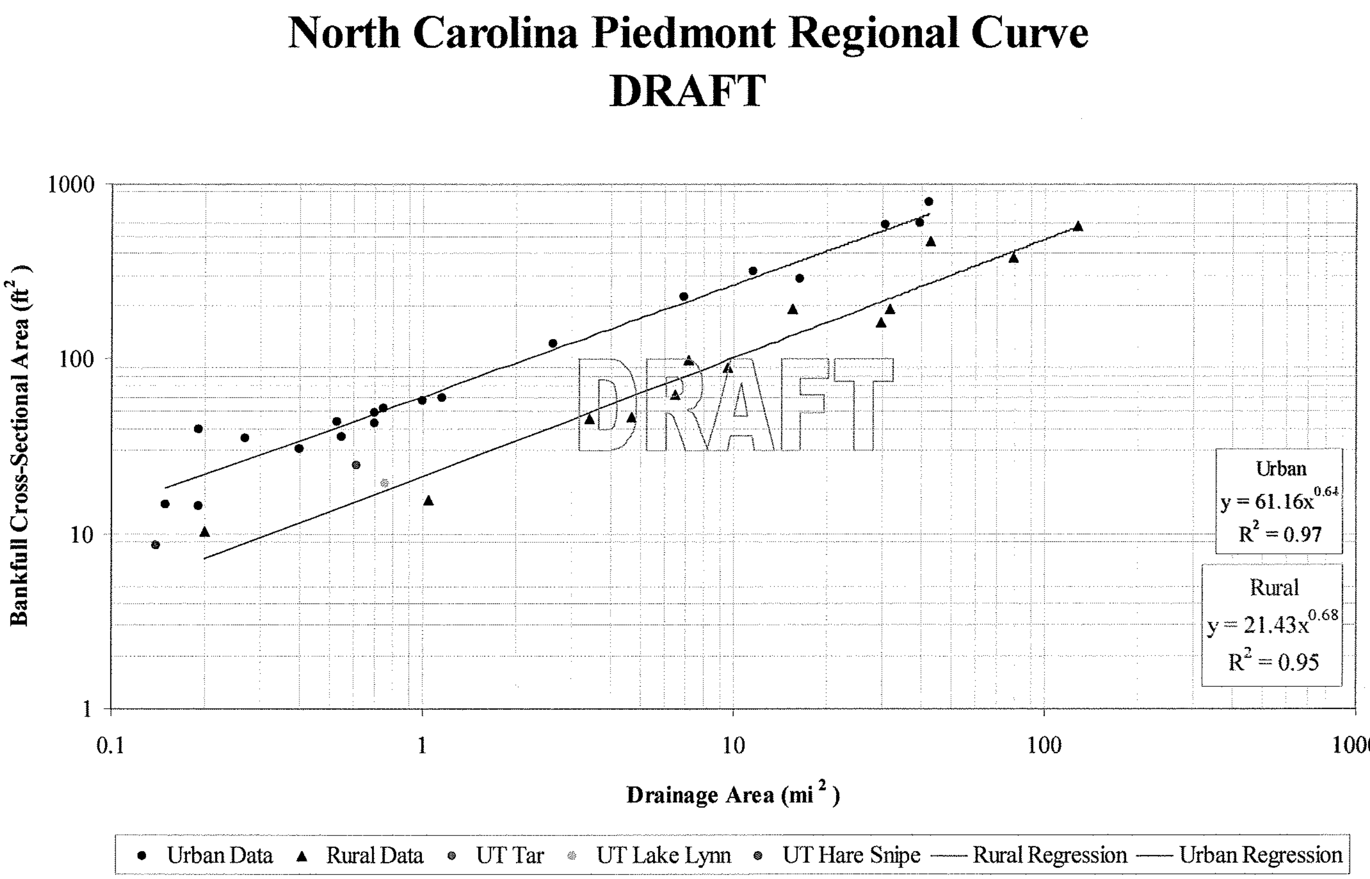
The most dominant bankfull indicators along the UT to Tar were breaks in slope on the channel banks in the upper section and the top of bank in the lower section.

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

In ungaged areas, Dave Rosgen recommends verifying bankfull with the development of regional curves. The regional curves normally plot bankfull discharge ($Q_{bkf}$), cross-sectional area, width, and depth as a function of drainage area. The cross-sectional areas of UT Tar River and the reference reach site used for this report are plotted on the Rural and Urban, Piedmont Regional Curve of North Carolina developed by the North Carolina State University (NCSU) Water Quality Group, 2000 (Figure 2).

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 UT to Tar River plots between the urban and rural trend lines on the NC Piedmont Regional Curve at 24.5 square feet. Arcadis G & M, Inc. conducted the Feasibility Study on this stream and concluded that the bankfull cross-sectional area was 17.7 square feet on average, which falls on the rural trend line. The bankfull cross-sectional area for the design channel was determined from evaluating the North Carolina regional curve relationships and comparing them to the existing cross-sectional area. There are 39 acres in the headwaters of the stream that have planned development within the next year, which also played into the final cross-sectional area. HEC-RAS will be used to verify the design cross-sectional area for the project and estimate in-channel shear stress. This assessment will not be conducted until the design phase of the project.

K:\65470\GIS\f2_regcurv.mxd




N.C. Wetlands Restoration Program
NCDENR DWQ

**FIGURE 2**
**NORTH CAROLINA REGIONAL CURVE**
Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

# 2.0 EXISTING CONDITIONS

## 2.1 WATERSHED

### 2.1.1 General Description of the Watershed

UT Tar River, an intermittent stream, is located within the Piedmont Physiographic Province of the Tar River Basin (USGS Cataloging Unit 03020101). The watershed is located to the southeastern section of the Town of Louisburg in Franklin County, North Carolina. The headwaters of the project originate approximately 1.2 miles to the southwest of the restoration site at the dam of a small pond. From the headwaters, the UT Tar River flows for approximately 2 miles before entering the Tar River. Several small drainages enter UT Tar River along its extent, most via culverts under Hwy. 401.

The watershed for UT Tar River is approximately 0.61 square miles (394 Acres)(Figure 3). The watershed is oriented southwest to northeast. The topography of the watershed is gently sloping with relatively flat, narrow floodplains. Land surface elevations range from approximately 210 to 300 feet above mean sea level. There is a 38.7-acre site in the headwaters that is currently planned for development into outparcels. Areas of hydric soils are common along the flat, narrow drainageways of this watershed. Intact wetland communities are present within the watershed; however, many of them have been disturbed through development activities, and/or invaded by exotic species.

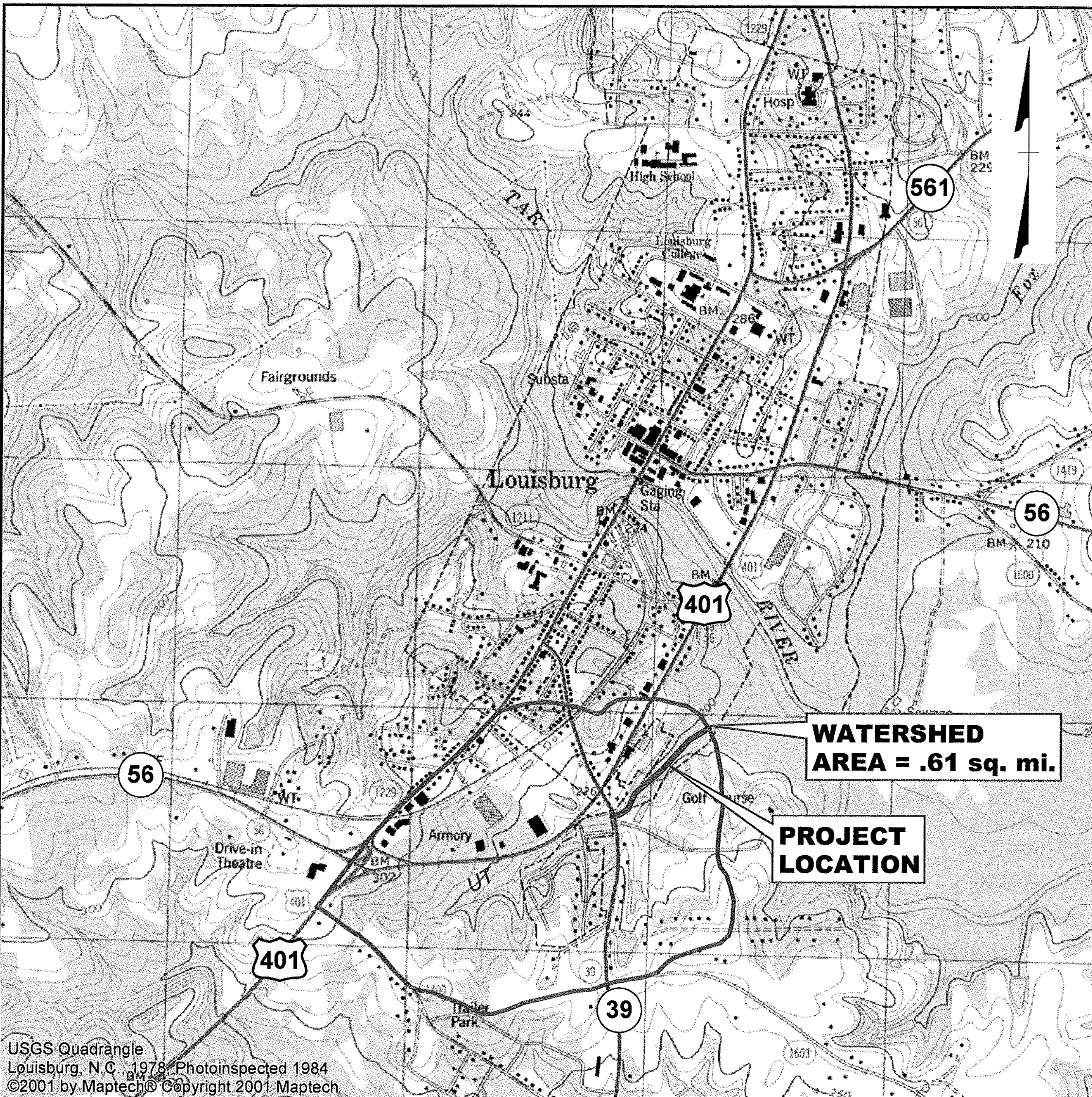
### 2.1.2 Surface Waters Classification

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. The UT Tar River has not been indexed by DWQ, so it can be assigned the same rating as its receiving stream (the Tar River). Therefore, the UT is classified as a *Class WS-V NSW* water body (NCDENR, 2003). *Class WS-V* waters are waters protected as water supplies that are generally upstream of and draining to *Class WS-IV* waters. No categorical restrictions on watershed development or treated wastewater discharges shall be required; suitable for all Class C uses. (*Class C* waters are freshwaters protected for secondary recreation, fishing, and aquatic life including propagation and survival, and wildlife.) The NSW classification is for waters that need additional nutrient management strategies for both point and non-point source pollution.

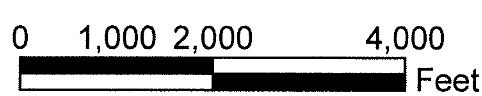
### 2.1.3 Soils of the Watershed

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 composition of the soils in the watershed assists in understanding the anticipated bedload and sediment transport capacity of the stream.

K:\65470\GIS\f3_wshed.mxd








N.C. Wetlands Restoration Program
NCDENR DWQ

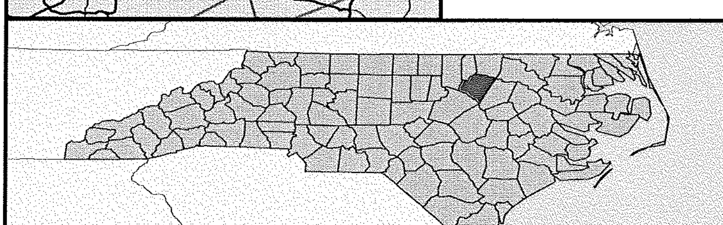


**FIGURE 3**
**WATERSHED MAP**

Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

Soils in most areas within the watershed consist primarily of sandy loam soils listed below. Soils information was obtained from draft maps and descriptions provided by the Franklin County NRCS office. The provisional map units are Chewacla and Wehadkee soils with 0 to 3% slopes, Wedowee sandy loam with 2 to 15% slopes, Wedowee-Urban land-Udorthents complex with 2 to 10% slopes, and Helena sandy loam soils with 2 to 6% slopes.

Chewacla and Wehadkee soils occur primarily on the floodplains within the watershed. Soils in upland areas within the watershed consist of all the other soil types listed above. Urban land composes about 20% of the total soils in the watershed.

Wedowee sandy loam soils are mapped in upland areas mainly in the southeastern portion of the watershed. These soils are typically found on side slopes in the Piedmont, and their thickness, drainage class, and permeability vary according to their slope. Surface runoff is moderate to rapid. These soils formed in residuum weathered from felsic crystalline rock. The seasonal high water table remains below 6 feet.

Helena sandy loam soils with 2 to 6% slopes are typically found in depressions, broad ridges, and heads of drainageways in the Piedmont. These soils are very deep, moderately well drained, and have slow permeability. Runoff is medium to rapid. These soils are formed in residuum weathered from a mixture of felsic, intermediate, or mafic igneous or high-grade metamorphic rock. The seasonal high water table remains at 1.5 to 2.5 feet below the ground surface.

Wedowee-Urban land-Udorthents complex, and Chewacla and Wehadkee soils are discussed in Section 2.2.3.

### 2.1.4 Land Use of the Watershed

Land use within the watershed is predominately commercial, forested, and residential. Evaluation of a USGS topographic map reveals that approximately 23% of the watershed is residential, roadways, and businesses, and 77% is forested, undeveloped areas.

Analysis of historic aerials dating as far back as 1938 reveal that the watershed has changed. In 1938, land use within the watershed was primarily agricultural, but by 1973, land used was almost entirely urban. It is difficult to discern the historical changes to the UT, although it appears that in 1938, the stream took a more direct path to the Tar River, flowing almost due east from the project site.

Based on conversations with town officials, the UT has been recently re-routed away from its original stream channel at the downstream end of the project area. This channel modification was conducted to avoid crossing a sewer service road while sewer and water utility upgrades were completed this year. Additional modifications to the stream are evident at the upstream end of the UT where road fill for both NC Highway 39 and Burnette Road has artificially narrowed the available floodplain and entrenched the stream channel.

According to a personal communication (Gobble, March 5, 2003), there are several parcels of land in the headwaters of the watershed that have planned development. The land, owned by Robert and Diane G. Schaaf, consists of approximately 7 parcels with about 38.7 acres of land. With the exception of about 1.2 acres that is zoned as Office/Institutional (O/I), the parcels are zoned as Highway Business (B2). The majority of this land is currently in the planning process to be developed into commercial outparcels due to its proximity to US Highway 401 (Bickett Boulevard). These parcels constitute approximately 10% of the watershed area. If this land is completely built out with impervious surfaces without on-site stormwater controls, then the storm flows delivered to the project site will be increased with a shorter time of concentration.

There is also an undeveloped 36.6-acre parcel with road frontage on Fox Park Road (SR 1700) in the headwaters of the watershed. Currently, there are no plans for development of this parcel, but it is zoned Agricultural-Residential (AR).

## 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 project site begins at NC Highway 39 and flows for approximately 1,700 ft. before exiting the conservation easement and an additional 2,600-2,800 ft. before terminating at the Tar River. The project is located on Town of Louisburg and Green Hill Country Club, Inc. properties. It flows northeast through a narrow floodplain while alongside Burnette Road and then through a larger floodplain (>120 ft. wide) after Burnette Road terminates. The majority of the floodplain in the lower portion of the conservation easement contains hydric soils, but no jurisdictional wetlands. Channel sinuosity for the entire reach is 1.07, with long straight stretches. High banks and areas of severe bank erosion can be found throughout the project reach due to high in-stream shear stress and lack of streambank vegetation. The treed buffer, within the conservation easement (along the right bank), ranges from about 15-90 ft. wide, but does not lie adjacent to the streambank due to a former sewer line that ran between the stream and the buffer.

The causes of impairment throughout the restoration site are:

- Road embankments adjacent to the streambanks;
- Previous channelization along the reach;
- Removal of riparian vegetation;
- Sedimentation; and
- Recent channel modifications due to utility work.

Dense rooting vegetation along the streambanks is extremely sparse for large lengths of stream. Additional degradation has resulted from historic channelization of the stream to allow for roads, utilities, and other development. The upstream portion of the UT Tar River is deeply incised partly due to the road embankments. The small tributary that enters the stream has headcut up approximately 100 ft. from the UT Tar River.

### 2.2.2 Existing Stream Characteristics

Field surveys of the existing stream channels and surrounding floodplains were conducted on February 19, 2003 to determine the potential for stream restoration on-site. The stream measurements are critical to the classification and assessment of the existing stream type. These measurements provide data to classify the stream using the Rosgen classification method, Levels I and II (Rosgen 1996). Appendix B contains the existing conditions data.

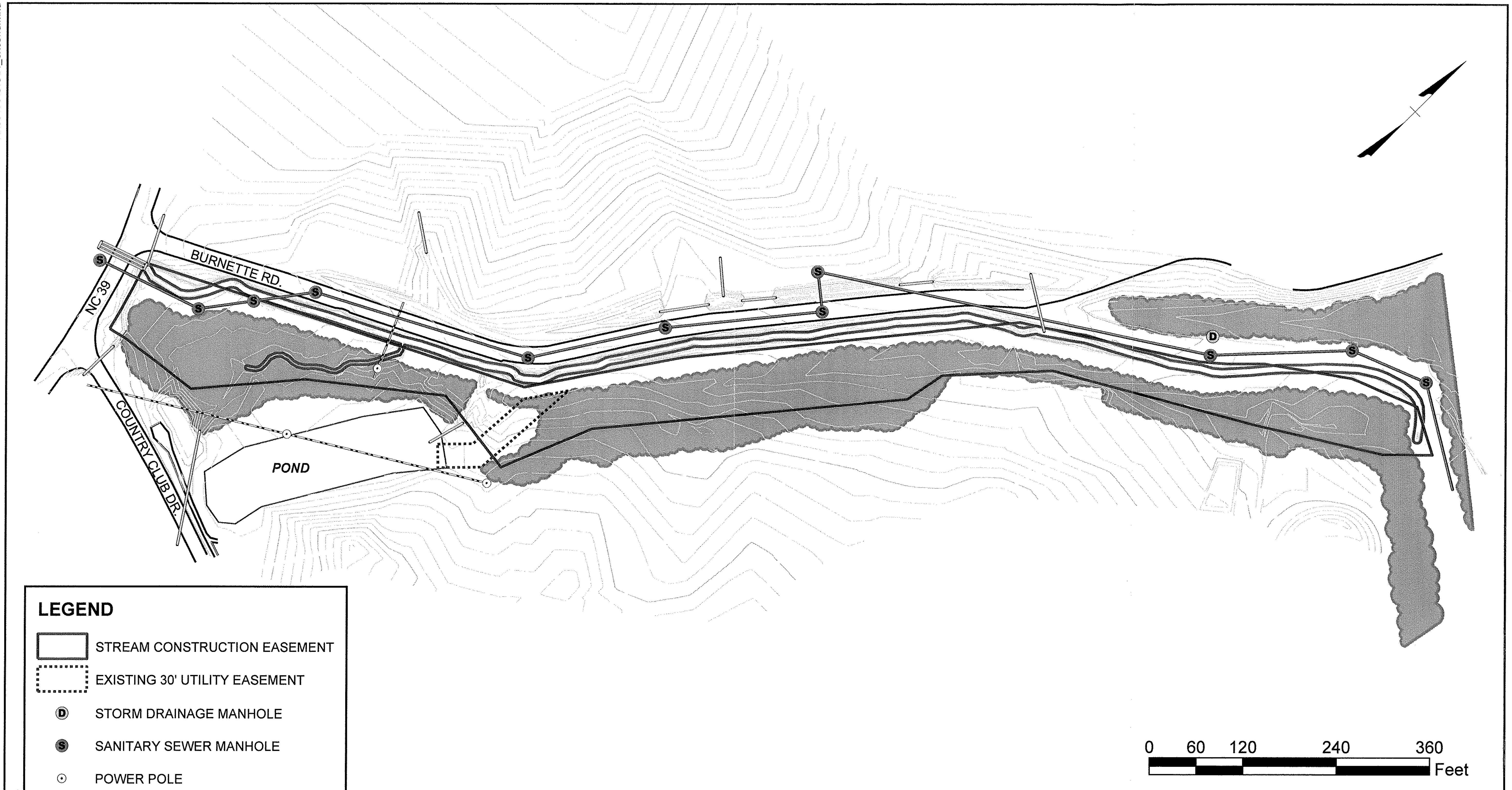
Photographs of the site were taken and are provided in Appendix A. The channel can be typically described as a channel being held in place with riprap to prevent it from undercutting Burnette Road (Figure 4). Although the channel is deeply incised, it is currently attempting to meander to establish a stable dimension, pattern, and profile with a floodplain. Streambank erosion dominates the site resulting from the combination of pattern modifications and lack of streambank vegetation. An erosion assessment was not conducted but banks were actively eroding during the site visit without human impact. Recent rains, sandy soils, and the lack of vegetation have left unprotected soil on the streambanks vulnerable to erosion.

A tributary enters the UT Tar River about 350 ft. downstream of NC Highway 39. This stream flows from of the adjacent golf course and has a 0.11 square mile (69-acre) drainage area. Within the conservation easement, this stream flows for approximately 250 ft. before entering the UT Tar River. There are several spoil piles along the right bank of the tributary, possibly from the construction of the golf course. The channel does not show signs of having been dredged in the past. The last 100 ft. of this channel is severely incised due to the current bed elevation of the UT Tar River.

A small drainage swale also enters the UT Tar River about 120 ft. downstream of the tributary from the golf course. It appears to flow only during storm events. The drainage swale is not currently vegetated due to recent disturbances from utility relocation. Therefore, it is transporting sediment into the UT Tar River during storms.

Riffle bankfull widths for UT Tar River range from 10.2 to 13.8 ft. with a mean depth of 2.0 ft. The cross-sectional areas for these riffles range from 20.8 to 28.1 $ft^2$. The predominant stream type is a degraded E5. Since the first pebble count was taken so close to the completion of the sewer construction, a second one was taken about one month later. Both pebble counts showed that the D50 is coarse sand; however, the bed had coarsened up slightly in the second pebble count. These pebble counts along with all of the data for the existing channel are included in Appendix B. The UT Tar River has the following average characteristics based on the two riffles surveyed:

K:\65470\GIS\f4_excond.mxd




N.C. Wetlands Restoration Program
NCDENR DWQ

**FIGURE 4**
**EXISTING CONDITIONS**

Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

| | |
|---|---|
| Bankfull Width: | 12.0 feet |
| Cross-sectional Area: | 24.5 square feet |
| Mean Depth: | 2.0 feet |
| Maximum Depth: | 3.1 feet |
| Average Water Surface Slope: | 0.0068 feet/feet |
| Entrenchment Ratio: | 2.2 |
| Sinuosity: | 1.07 |
| Bank Height Ratio (longitudinal profile) | 1.0-2.9 |
| Bank Erosion Potential | Extreme |

### 2.2.3 Soils of the Restoration Site

According to the draft maps and descriptions provided by the Franklin County NRCS office, soils adjacent to the UT Tar River within the restoration site are mapped as Chewacla and Wehadkee soils with 0 to 3% slopes, Wedowee sandy loam with 6 to 10% slopes, and Wedowee-Urban land-Udorthents complex with 2 to 10% slopes (Figure 5). Investigation of the soils adjacent to the stream indicates that all three soils appear to be present, although Chewacla soils dominate the site.

Chewacla and Wehadkee soils with 0 to 3% slopes are nearly level, very deep and somewhat poorly drained soils found on floodplains on the Piedmont. This soil has moderate permeability and surface runoff is slow in bare and unprotected areas. These soils formed in recent alluvium derived from metamorphic and igneous rocks. This map unit may also contain some (up to 30%) inclusions of Wehadkee soils. From November through April, the water table in Chewacla soils may remain 0.5 to 1.5 feet below the ground surface. In Wehadkee soils, the water table may remain within 1 foot of the ground surface from November through May. Chewacla and Wehadkee soils are both listed as hydric soils by the NRCS.

Wedowee-Urban land-Udorthents soils with 2 to 10% slopes are mapped along the northwest side of the project area. Thirty percent of this map unit is composed of Urban soils, which are the main soil types of this complex encountered on the project site. These soils are typically found in areas of urban development and have been significantly altered. Permeability of these soils is generally low, due to compaction or paving, and runoff is generally rapid. The depth to the seasonal high water table is highly variable.

Soil textures encountered include sandy loams and sandy clay loams. Significant amounts of gravel were noted in some horizons at some locations. Gravel was more common in the portion of the project nearest Burnette Road. In this area, the stream is eroding into the roadbed, exposing compacted fill material, including clay and gravel. Along the entire southeast side of the stream, and along the lower third of the project area along each side of the UT Tar River, hydric soils were encountered near the outer limits of the easement, however, no jurisdictional wetlands will be impacted by this project.

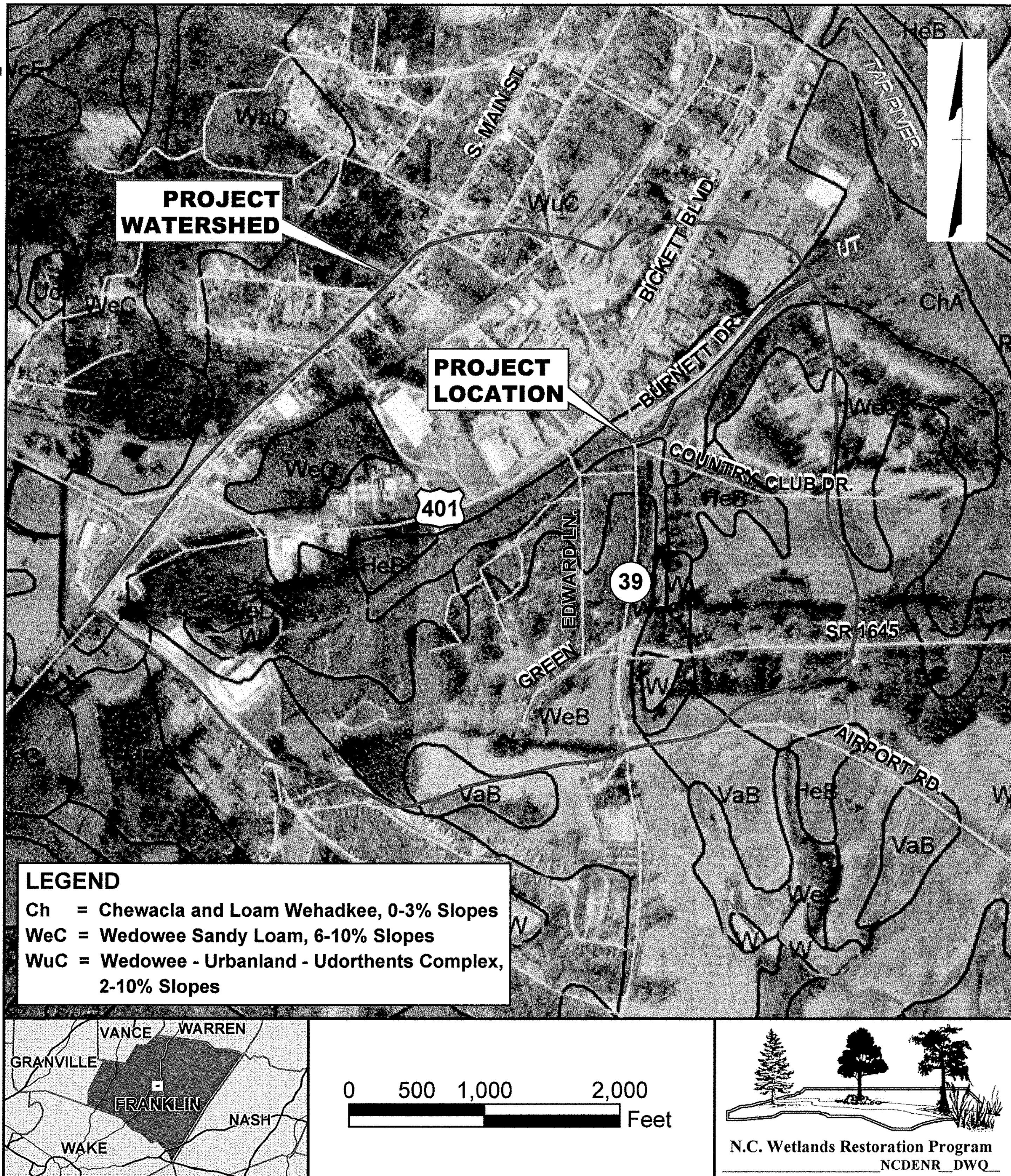



**FIGURE 5**
**SOILS**

Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

### 2.2.4 Terrestrial Plant Communities

The following sections describe the existing plant communities on and adjacent to the restoration site (Figure 4). For purposes of this project, two plant communities are described: a Disturbed Community and a Floodplain Community. Nomenclature follows Radford, et al. (1968). Maintenance of the road, sewer easement, and golf course has severely impacted the vegetation of the project site.

#### 2.2.4.1 Disturbed Community

This community has recently been impacted by human disturbance and includes maintained roadside shoulders and a city sewer right-of-way. It is kept in a low-growing, early successional state. Along the majority of the northwest side of the stream, little to no vegetation exists due to the severely eroded streambanks adjacent to Burnette Road and a gravel road. Maintenance of the gravel road near the downstream segment of the project site has caused the most recent disturbance to the community.

A sewer right-of-way is present along the southeast side of the stream, and is maintained by regular mowing. This area is dominated by herbaceous vegetation including: fescue grass (*Festuca* sp.), chickweed (*Stellaria media*), ground ivy (*Glechoma hederacea*), English plantain (*Plantago lanceolata*), common plantain (*Plantago major*), and pokeweed (*Phytolaca americana*). A few plants are present at the base of the streambanks including: soft rush (*Juncus effusus*), various sedges (*Carex* spp.), and scattered Chinese privet (*Ligustrum sinense*).

Along the periphery of this community, many invasive species common to waste places can be found. These include multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), goldenrod (*Solidago* sp.), greenbriar (*Smilax* sp.), poison ivy (*Toxicodendron radicans*), blackberry (*Rubus* sp.), bindweed (*Convulvus* sp.), and Chinese privet

#### 2.2.4.2 Floodplain Forest Community

A floodplain forest community is present along the southeast side of the project site. This community has also been impacted by maintenance activities, but not as severely as other areas within the project site. Mature trees present here include: box elder (*Acer negundo*), red maple (*Acer rubrum*), American sycamore (*Platanus occidentalis*), river birch (*Betula nigra*), loblolly pine (*Pinus taeda*), southern red oak (*Quercus falcata*), tulip poplar (*Liriodendron tulipifera*), and slippery elm (*Ulmus rubra*). The understory varies in density, due to maintenance activities, but is dominated by red cedar (*Juniperus virginiana*), Chinese privet, sweet gum (*Liquidambar styraciflua*), poison ivy, Japanese honeysuckle, and grapevine (*Vitis* sp.).

Hydric soils are scattered throughout this community, however no jurisdictional wetlands were noted. In these areas, sweetbay (*Magnolia virginiana*) is present, in addition to sweetgum, river birch, and red maple.

### 2.2.5 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*) were observed along the streambanks, and in the adjacent areas. A variety of birds were seen in the trees and shrubs surrounding the stream channel including: blue jay (*Cyanocitta cristata*), eastern bluebird (*Sialia sialis*), American goldfinch (*Carduelis tristis*), tufted titmouse (*Parus bicolor*), northern cardinal (*Cardinalis cardinalis*), house sparrow (*Passer domesticus*), white-throated sparrow (*Zonotricha albicollis*), American crow (*Corvus brachyrhynchos*), Carolina wren (*Thryothorus ludovicianus*), Carolina chickadee (*Parus caolinensis*), white-breasted nuthatch (*Sitta carolinensis*), downy woodpecker (*Picoides pubescens*), American robin (*Turdus migratorius*), European starling (*Sturnus vulgaris*), and song sparrow (*Melospiza melodia*).

The USFWS lists three species under federal protection and five federal species of concern (FSC) for Franklin County as of March 2002 (USFWS 2002). These species are listed in Table 1.

**Table 1. Federally Protected Species in Franklin County**

| Common Name | Scientific Name | Status | Habitat Present |
|---|---|---|---|
| Pinewoods shiner | *Lythrurus matutinus* | FSC | No |
| Dwarf wedgemussel | *Alasmodonta heterodon* | Endangered | No |
| Yellow lance | *Elliptio lanceolata* | FSC | No |
| Tar River spinymussel | *Elliptio steinstansana* | Endangered | No |
| Atlantic pigtoe | *Fusconaia masoni* | FSC | No |
| Yellow lampmussel | *Lampsilis cariosa* | FSC | No |
| Michaux's Sumac | *Rhus michauxii* | Endangered | No |

No Threatened, Endangered or Species of Federal Concern were observed; although, several are recorded at the NC National Heritage Program (NHP) 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.

The yellow lance, and the Atlantic pigtoe have each been recorded in the Tar River near the US Highway 401 bridge. Tim Savidge last observed the yellow lance on June 2, 1999, when fourteen live animals were found. John Alderman last observed the Atlantic pigtoe on June 5, 1990. Twelve live individuals were found on this date.

The confluence of Fox Creek and the Tar River lies 2,500 feet downstream from the confluence of the UT Tar River and the Tar River. Several federally listed species have been observed in Fox Creek where NC 56 bridges it. Atlantic pigtoe, yellow lance, and dwarf wedgemussel are all recorded by NHP as occurring at this site. No observation dates exist for the dwarf wedgemussel. John Alderman observed the yellow lance on April 11, 1996. Four live animals were found. John Alderman observed the Atlantic pigtoe on April 12, 1996, when one live animal was found.

# 3.0 REFERENCE REACHES

## 3.1 Unnamed Tributary to Lake Lynn

The Unnamed Tributary to Lake Lynn (UT Lake Lynn) is a first order stream flowing into Lake Lynn in North Raleigh (Figure 6). The stream is located adjacent to a trail in Lake Lynn Park off of Ray Road. The stream actually is an Unnamed Tributary to Hare Snipe Creek, but will be called UT Lake Lynn since the second reference reach is also an UT to Hare Snipe further downstream. The watershed area is approximately 489 acres (0.76 square miles) and encompasses several residential neighborhoods.

The watershed boundary to the east is NC 50 (Creedmoor Road), to the north Strickland Road, and then follows the ridgelines to the reference reach site. The watershed is predominately comprised of single-family residences with a few businesses along NC 50.

Approximately 250 ft. of this stream were surveyed on March 25, 2003 to obtain the morphological data. This length of channel was determined from the first cross-section that was taken (12.6 ft. wide) and falls at the lower range of the 20 to 30 bankfull width recommendation (Rosgen) for the length of a reference reach. The reference reach was stable below this location, however the 2 full wavelength rule was met and the survey was ended.

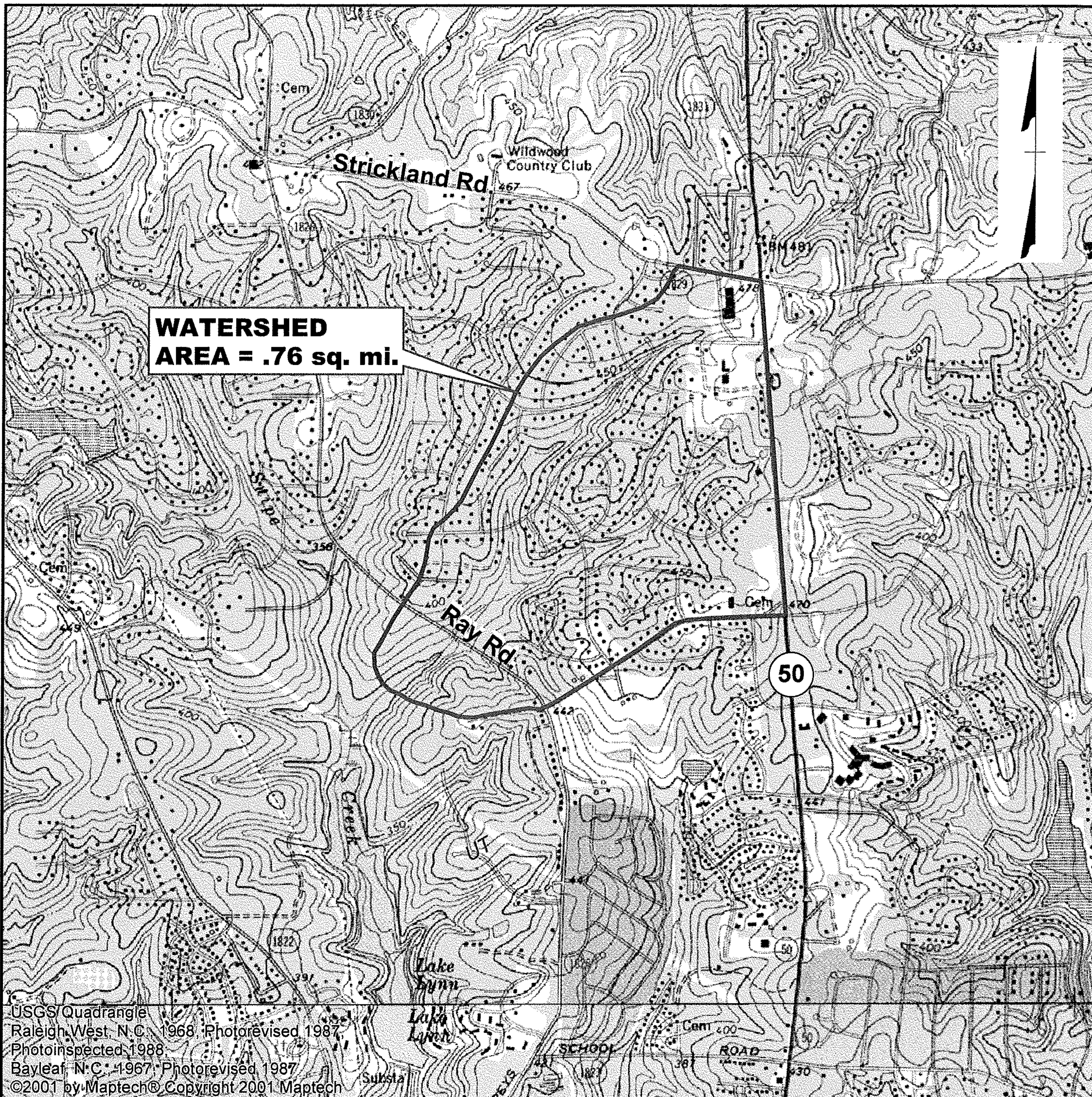
The streambed is composed of sand with small gravel in the riffle cross-sections. While the streambanks do not have an extensive buffer due to development and the adjacent trail, the streambanks are stable. Signs of recent overbank storm flows are evident by the amount of debris on the upstream side of trees in the floodplain. This reference classifies as a C5 stream type with a mean width-to-depth ratio of 13.0 and 1.25 sinuosity. The complete data set for this reference reach can be found in Appendix C or a summary can be found in Table 2.

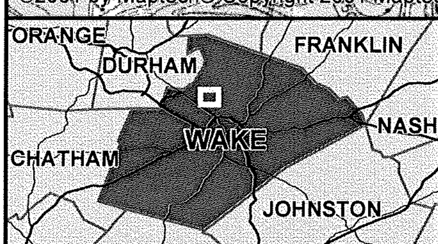
## 3.2 Unnamed Tributary to Hare Snipe Creek

The Unnamed Tributary to Hare Snipe Creek (UT Hare Snipe) is a first order stream flowing through the Brookhaven Subdivision in North Raleigh (Figure 7). The site is located in Brookhaven Nature Park near the intersection of US 70 (Glenwood Avenue) and NC Highway 50 (Creedmoor Road) adjacent to York School. The stream begins at a small pond and flows southwest for approximately 3,000 ft. before emptying into Hare Snipe Creek. The data for this reference reach can be found in Appendix D.

The section measured for reference was 155 ft. in length and classifies as a C4 stream type. This length of channel falls below the recommended 20 to 30 bankfull width recommendation (Rosgen) since the channel width ranged from 10.0 to 15.6 ft. wide. However, stable reference reaches in highly urbanized areas are difficult to locate and lengthy stable reference reaches are even more rare. This section of stream was the most stable reach located.

K:\65470\GIS\f6_rr-lakelynn.mxd




0 1,000 2,000 4,000
Feet

N.C. Wetlands Restoration Program
NCDENR DWQ

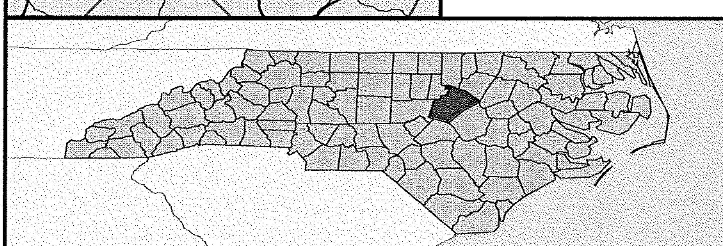


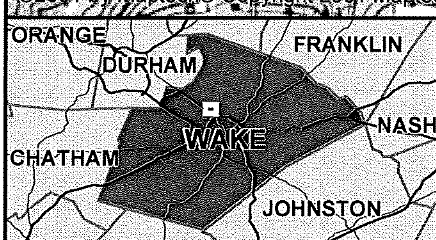
**FIGURE 6**
**UT TO LAKE LYNN - REFERENCE REACH**
**WATERSHED MAP**
Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

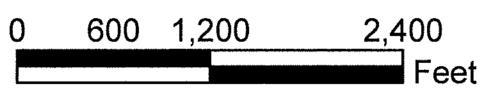
**Table 2. Morphological Characteristics**

| Variables | Unnamed Tributary to Tar River | Reference Reach-UT Lake Lynn | Reference Reach-Brookhaven | Proposed UT Tar River |
|---|---|---|---|---|
| Stream Type (Rosgen) | degraded E5 | C5 | C4 | C5 |
| Drainage Area (sq. mi.) | 0.61 | 0.74 | 0.14 | 0.61 |
| Bankfull Width ($W_{bkf}$, ft) | 10.2-13.8 | 12.6-19.1 | 10-15.6 | 18.0 |
| MEAN | 12.0 | 15.9 | 12.8 | |
| Bankfull Mean Depth ($d_{bkf}$, ft) | 2.0 | 1.22 | 0.55-0.76 | 1.38 |
| MEAN | 2.0 | 1.22 | 0.66 | |
| Width/depth Ratio ($W_{bkf}/d_{bkf}$) | 5.0-6.8 | 10.3-15.6 | 18.2-20.6 | 13.2 |
| MEAN | 5.9 | 13.0 | 19.4 | |
| Bankfull Cross-sectional Area ($A_{bkf}$ sq. ft.) | 20.8-28.1 | 15.4-23.4 | 5.5-11.8 | 24.5 |
| MEAN | 24.5 | 19.4 | 8.7 | |
| Bankfull Maximum Depth ($d_{max}$ ft) | 2.8-3.3 | 2.00-2.26 | 1.0-1.2 | 2.2 |
| MEAN | 3.1 | 2.13 | 1.1 | |
| Ratio Bankfull Maximum Depth to Mean Bankfull Depth ($d_{max}/d_{bkf}$) | 1.5 | 1.7 | 1.7 | 1.6 |
| Lowest Bank Height to Bankfull Maximum Depth Ratio | 0.33-0.97 | 1.0-1.8 | 1.0-2.8 | 1.0 |
| Width of Flood Prone Area ($W_{fpa}$ ft) | 40-55 | 68-126 | 29-33 | 40 |
| MEAN | 47.5 | 97 | 31 | |
| Entrenchment Ratio ($W_{fpa}/W_{bkf}$) | 3.9-4.0 | 5.4-6.6 | 1.9-3.3 | 2.2 |
| Meander Length ($L_m$ ft) | 265-470 | 42-59 | 47 | 59-84 |
| MEAN | 368 | 50 | 47 | 72 |
| Ratio of Meander Length to Bankfull Width ($L_m/W_{bkf}$) | 22.1-39.2 | 3.3-4.7 | 3.7 | 3.3-4.7 |
| MEAN | 30.6 | 4.0 | 3.7 | 4.0 |
| Radius of Curvature ($R_c$ ft) | 10-60 | 19-81 | 12-35 | 36-72 |
| MEAN | 27 | 36 | 24 | 54 |
| Ratio of Radius of Curvature to Bankfull Width ($R_c/W_{bkf}$) | 0.8-5.0 | 1.2-5.1 | 0.9-2.7 | 2.0-4.0 |
| MEAN | 2.2 | 2.3 | 1.9 | 3 |
| Belt Width ($W_{blt}$ ft) | 8-30 | 17-33 | 28-41 | 23-58 |
| MEAN | 16 | 24 | 35 | 40 |
| Meander Width Ratio ($W_{blt}/W_{bkf}$) | 0.7-2.5 | 1.3-2.6 | 2.2-3.2 | 1.3-3.2 |
| MEAN | 1.4 | 1.9 | 2.7 | 2.3 |
| Sinuosity (Stream Length/Valley Length, k - ft/ft) | 1.07 | 1.25 | 1.70 | 1.25 |
| Valley Slope ($S_{valley}$) ft/ft | 0.0179 | 0.0215 | 0.052 | 0.0179 |
| Average Water Surface Slope ($S_{avg}$) | 0.0068 | 0.0050 | 0.0161 | 0.0042 |
| Pool Slope ($S_{pool}$) | 0.000-0.0120 | 0.0000-0.0048 | 0-0.0031 | 0.0000-0.0048 |
| MEAN | 0.0047 | 0.0019 | 0.0010 | |
| Ratio of Pool Slope to Average Slope ($S_{pool}/S_{avg}$) | 0.69 (0.0-1.8) | 0.39 (0.0-0.95) | 0.06 (0.0-0.19) | 0.0-0.95 |
| Riffle Slope ($S_{riff}$ ft/ft) | 0.0018-0.0171 | 0.0085-0.0213 | 0.0304-0.075 | 0.0085-0.0333 |
| MEAN | 0.0115 | 0.0144 | 0.0462 | |
| Ratio of Riffle Slope to Average Slope ($S_{riff}/S_{avg}$) | 0.26-2.5 | 1.7-4.3 | 1.9-4.7 | 1.7-4.7 |
| MEAN | 1.7 | 2.9 | 2.9 | |
| Maximum Pool Depth ($d_{pool}$ ft) | 1.75-3.10 | 2.3-2.6 | 1.9-2.2 | 2.9 |
| Ratio of pool depth to mean bankfull depth ($d_{pool}/d_{bkf}$) | 2.7 | 2.0 | 3.1 | 2.1 |
| Pool Width ($W_{pool}$ ft) | 18.5 | 12.9 | 8.4-11.3 | 18.0 |
| Ratio of Pool Width to Bankfull Width ($W_{pool}/W_{bkf}$) | 1.5 | 0.8 | 0.8 | 1.0 |
| Pool to Pool Spacing (P-P ft) | 33-379 | 32-75 | 38-48 | 32-75 |
| MEAN | 226 | 47 | 43 | |
| Ratio of P-P to Bankfull Width (P-P/$W_{bkf}$) | 2.8-31.6 | 2.0-4.7 | 3.0-3.8 | 2.0-4.7 |
| MEAN | 18.8 | 3.0 | 3.4 | |

*Rosgen recommends keeping the Rc/Wbkf >2.0 for stability.

K:\165470\GIS\f7_haresnp.mxd


N.C. Wetlands Restoration Program
NCDENR DWQ

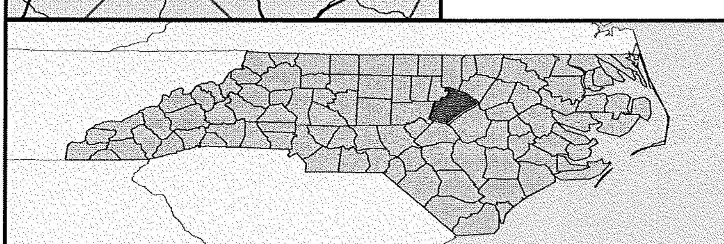


**FIGURE 7**
**UT TO HARE SNIPE - REFERENCE REACH**
**WATERSHED MAP**

Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

This urban watershed is approximately 90 acres (0.14 square mile) and encompasses the Brookhaven Subdivision as well as York School, several industrial buildings, and large tracts of undeveloped land. The watershed is oval in shape and includes the small tributary and pond. It is bounded to the east by NC Highway 50 and generally follows the topographic ridgelines to complete the watershed boundary.

The majority of the development within this watershed has been established for over 20 years and only in the extreme northern part of the watershed is there evidence of recent development. Portions of the stream and surrounding woods have been incorporated into Brookhaven Nature Park. Both the park and the neighborhood lend stability to the stream and watershed, as no new impervious surfaces have recently been built adjacent to the stream.

# 4.0 STREAM CHANNEL DESIGN

This restoration will classify as a Priority 2 restoration (Rosgen, 1997). A more sinuous channel will be cut at the existing bed elevation and a floodplain will be excavated to handle large storm events. The floodplain will be re-established to fit within the conservation easement that was determined prior to the design. The proposed stream restoration will restore a stable meander pattern, modify channel cross-section, restore bedform, improve sediment transport capacity, enhance habitat, and re-establish a floodplain for the stream.

The design was based upon Dave Rosgen's natural channel design methodology. As described in Section 3.0, UT Lake Lynn and UT Hare Snipe Creek were utilized as reference reaches on which the morphological characteristics were measured to determine a range of values for the stable dimension, pattern, and profile of the proposed channel. The existing, reference, and proposed morphological characteristics are shown in Table 2.

Two tributaries/drainages enter the UT Tar River within the project limits. The design will incorporate these features and will allow for a stable tie-in with the UT Tar River. There will be no formal design of these two features other than structures at the tie-in with the main channel.

Burnette Road will not be impacted by the construction of this project. It is Earth Tech's understanding that the Town will be paving the road after construction is complete on the stream restoration. However, the dirt path that the Town uses to access the sewer lift station may be relocated slightly from its current alignment. A culvert will be designed and installed as a part of this restoration to allow the Town to continue to access the lift station.

A conceptual design was developed from the range of values listed in Table 2. This stream restoration project will restore approximately 2,040 linear feet of UT Tar River, as measured along the proposed thalweg. The plan view of the proposed restoration design can be seen in Figure 8.

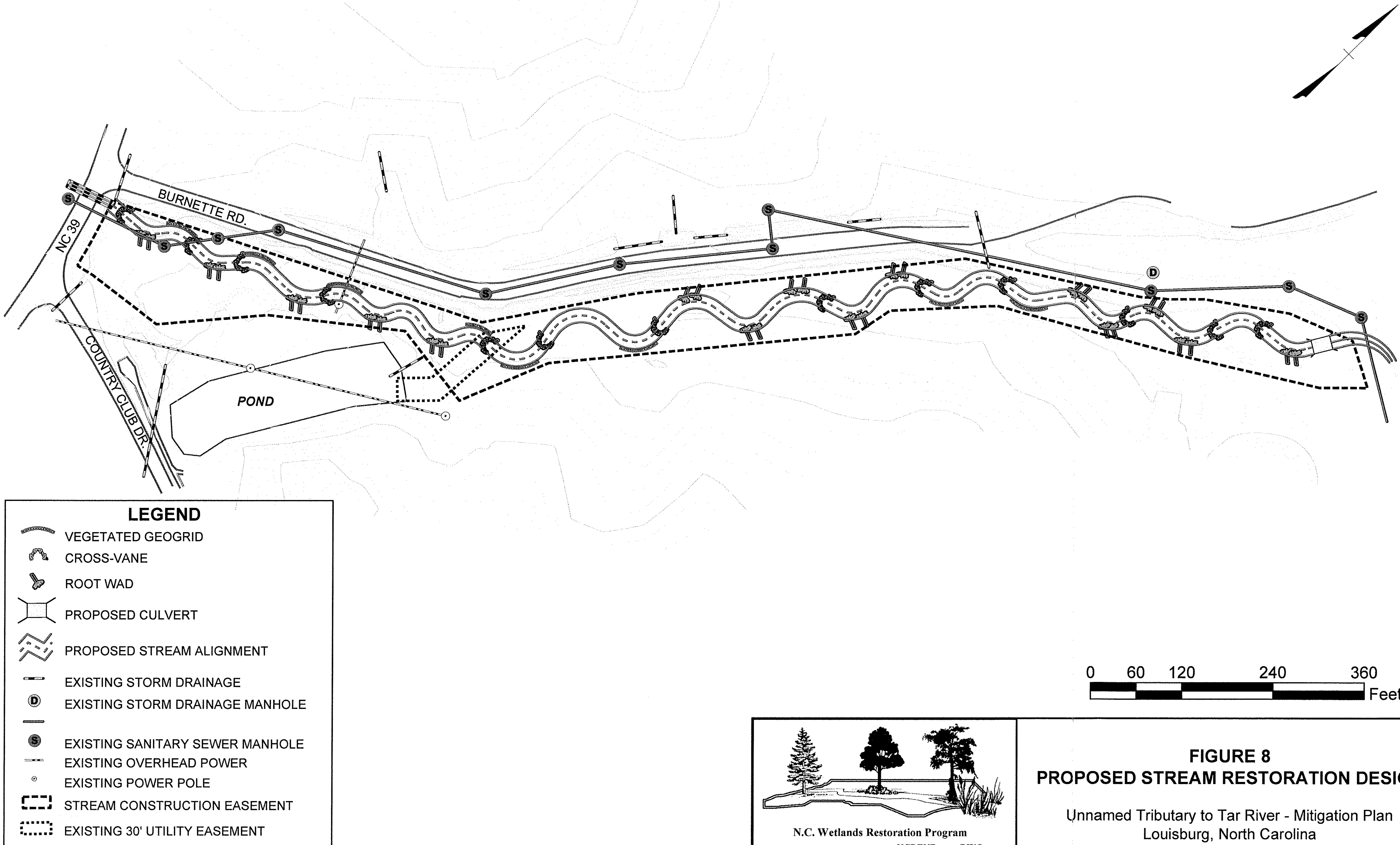



**FIGURE 8**
**PROPOSED STREAM RESTORATION DESIGN**

Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

K:\65470\GIS\f8_pcond.mxd

## 4.1 RESTORATION TECHNIQUES

Stream dimension, pattern, and profile will be adjusted so the new stream channel can maintain stability while transporting its water and sediment load. The Priority 2 restoration will involve modifying the existing channel at its existing elevation to create a stable channel (Figure 8).

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

A culvert will be designed towards the end of the project (Figure 8). This culvert will allow the Town of Louisburg to access the lift station immediately below the restoration site. This culvert will be designed to best fit the proposed channel.

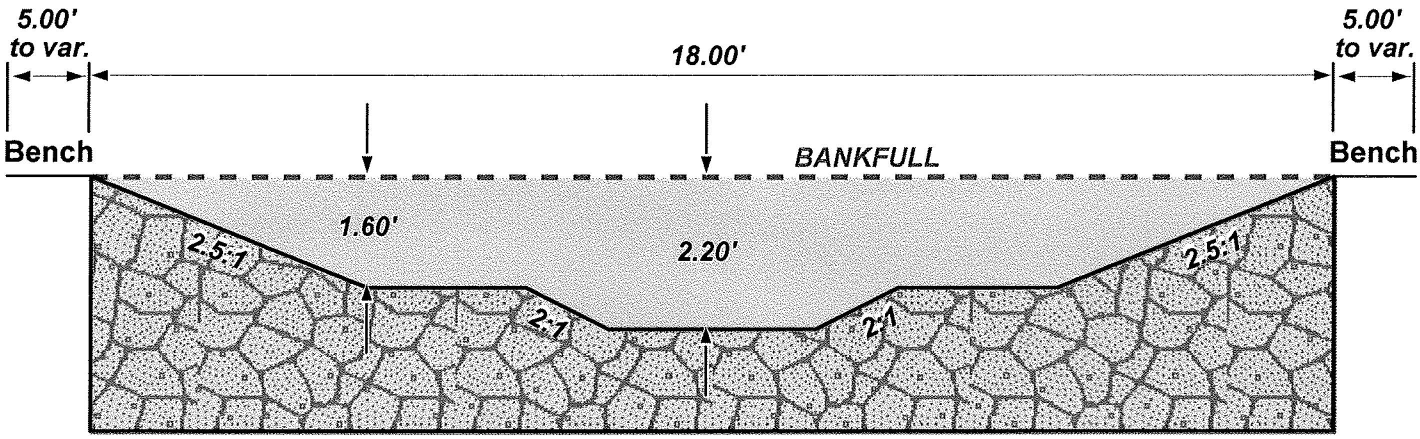
### 4.1.1 Dimension

The present bankfull channel width for UT Tar River ranges from 10.2 to 13.8 ft. with a cross-sectional area ranging from 20.8 to 28.1 $ft^2$. The design channel will be constructed to bankfull target dimensions that are based on a combination of existing conditions, HEC RAS modeling, and regional curve information. Typical cross-sections can be seen in Figure 9.

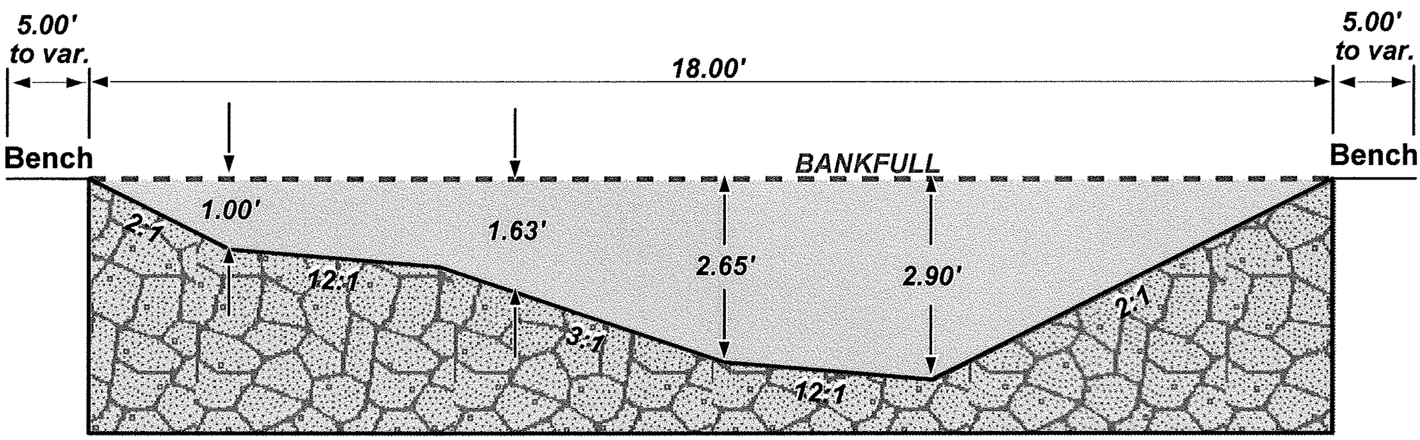
A design width of 18.0 ft. for the UT Tar River will be applied to the proposed reach. This width was back calculated from the cross-sectional area taken from the existing conditions and a width-to-depth ratio of 13.2 from the reference reaches. These characteristics will provide a stream channel that classifies as a C-type channel for the UT Tar River according to the Rosgen classification system.

The existing channel, with bank height ratio's ranges from 1.0 to 2.9, will have benches cut at the bankfull elevation so that the entrenchment ratio for the channel is a 2.2 at a minimum, where the conservation easement allows. With the proposed channel cross-section, a total of 13.2 feet of benches (minimum) are necessary to obtain an entrenchment ratio appropriated for a C-type channel. The bench width on the outside of the meanders will be 5 feet wide with the remainder of the floodplain benches being cut along the inside meanders. Benches in excess of 13.2 feet (combined left and right bank) will be obtained where the conservation easement and utility constraints allow to increase the entrenchment ratio beyond a minimum of 2.2. Unlike the existing channel, the proposed channel will be able to access a floodplain and effectively transport the sediment load.

The proposed channel will be sized to accommodate the existing watershed characteristics. A floodplain will be built adjacent to the proposed channel to accommodate additional stormwater input from future development in the headwaters.




**TYPICAL RIFFLE CROSS-SECTION**




**TYPICAL POOL CROSS-SECTION**

N.C. Wetlands Restoration Program
NCDENR DWQ

# FIGURE 9
# TYPICAL CROSS-SECTIONS

Unnamed Tributary to Tar River - Mitigation Plan
Louisburg, North Carolina

K:\654701GIS\f9_xsec.mxd

### 4.1.2 Pattern

The existing pattern of the UT Tar River can be described as long straight reaches followed by sparse meanders. The current sinuosity in the UT Tar River is 1.07. Design sinuosity for the UT Tar River is 1.25. Existing pattern measurements were taken from the topographic mapping. The proposed pattern is limited in a few places due to a narrow conservation easement and utility crossings. Minor modifications to the pattern may be necessary during the design process to ensure that the bankfull channel, floodplain benches, and slope to existing ground are contained within the conservation easement. Therefore, the sinuosity may be decreased to some extent.

A stable pattern will be achieved by introducing meanders into the stream with appropriate radius of curvatures and lengths based on reference reach data and existing constraints. Introduction of these meanders will improve habitat while lowering slope and shear stress.

### 4.1.3 Bedform

The existing bedform along the UT Tar River is in poor condition. Long, straight sections of the channel consist of predominantly run bedform features. Many of the riffles in the upper 800 feet of stream have been formed through riprap installed in the channel by the Town of Louisburg. The design channel will incorporate riffles and pools to provide bedform common to C5 stream types with sand substrate. Pools will be located in the outside of meander bends with riffles in the inflection points between meanders. Riffles in the UT Tar River will have a mean depth of 1.38 ft. and a thalweg depth of 2.2 ft. while the pools will be deeper with a maximum depth of 2.9 ft. The profile will be set during the design phase of the project, once all parties involved agree upon a final alignment.

The existing pool-to-pool spacing is impaired in areas due to past channelization and recent additions of riprap to the channel. Existing pool-to-pool spacing on the UT Tar River is 33 to 379. The proposed spacing is 36 to 90 ft. for the UT Tar River, which is within the range of 2 and 5 bankfull widths as determined from the reference reach data. To accomplish this, pools will be realigned or constructed such that they will be located in the outside of the meander bends. Bedform will also be addressed through the strategic placement of natural material structures such as cross vanes, root wads, and large woody debris. Modifications to the bedform will provide stability and habitat to the channel.

### 4.1.5 Riparian Areas

A riparian zone will be created around the new proposed stream channel to enhance both aquatic and terrestrial habitat as well as stabilize the stream channel. The riparian zone will extend from the top of bank to the conservation easement boundaries (Figure 8). These areas will be planted with appropriate riparian vegetation as described in Section 5.0 Habitat Restoration.

## 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 bedload and wash load. Wash load is normally composed of fine sands, silts and clay and transported in suspension at a rate that is determined by availability and not hydraulically controlled. Bedload is transported by rolling, sliding, or hopping (saltating) along the bed. At higher discharges, some portion of the bedload can be suspended, especially if there is a sand component in the bedload. Bed material transport rates are essentially controlled by the size and nature of the bed material and hydraulic conditions (Hey 1997).

Critical dimensionless shear stress can be calculated for gravel and cobble bed streams using sediment entrainment calculations. However, the bed material of UT Tar River classifies as sand. All particles in a sand bed channel have the potential to become mobilized during bankfull events.

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

$$\tau = \gamma R s$$

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

Hydraulic radius is calculated by:

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

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

Thus,

$$R = \frac{24.92 ft^2}{18.90 ft} = 1.32 ft$$

Wetted perimeter and cross-sectional area were measured off of a CADD file of the typical riffle cross-section drawn to scale.

Therefore,

$$\tau = (62.4 \frac{lb}{ft^3})(1.32 ft)(0.0042 \frac{ft}{ft}) = 0.35 lb / ft^2$$

The critical shear stress for the proposed channel has to be sufficient to move the $D_{84}$ of the riffle bed material, which is 8 mm (fine gravel) for UT Tar River. Based on a shear stress of 0.35 lb/ft$^2$, Shield's Curve predicts that this stream can move a particle that is, on average, greater than 28 mm (coarse gravel). Since the $D_{84}$ was 8 mm for UT Tar River and Shield's Curve predicts, on average, a 28 mm, the proposed stream has the competency to move its bedload. Rosgen has also generated a curve that piggybacks Shields Curve (Appendix B). Rosgen recommends using this curve when the critical shear stress falls below 1.0 lb/ft$^2$ and Shield's Curve above 1.0 lb/ft$^2$. This curve predicts that an 80 mm particle will be moved based on the critical shear stress of 0.35 lb/ft$^2$. The largest particle measured during the pebble count was between 23 to 32 mm, which corresponds with the largest particle found in the subsurface of the streambed in a riffle (28 mm). These particles would be moved as predicted by either curve as shown in the figure in Appendix A.

## 4.3 FLOODING ANALYSIS

Approximately the lower 650 feet of this restoration site are located in the 100-year floodplain of the Tar River and is, therefore, mapped in FEMA zone AE. This zone is defined as an area of 100-year floodplains determined by detailed methods. This designation is for the Tar River and not the Unnamed Tributary to the Tar River since the drainage area of the UT is only 0.61 square miles to the end of the project and the drainage area of the Tar River is 427 square miles. In addition, modifications are allowed within a floodplain (Zone AE) but are not permitted in a floodway (Zone AEFW). The floodway of the Tar River will not be affected by this project.

The Priority 2 restoration of the stream will leave the stream's existing profile elevations essentially the same. A new floodplain will be established so that the active stream (UT Tar River) will be able to access it during larger storm events. Considering the type of restoration it is assumed that for smaller events the water surface elevations along the stream shall remain the same or decrease slightly. During storms where the stream accesses the newly established floodplain, the new water surface elevations are expected to be lower than the existing water surface elevations for storms of the same magnitude. The restoration will create neither positive nor negative water surface elevation changes during the larger storm events (greater than 10-year). During these events, portions of the UT Tar River are drowned out due to the backwater effects of the Tar River. HEC-RAS will be used to analyze both existing and proposed conditions once the design is completed. Shear stress and flood stages will be compared between the two conditions to evaluate the design.

The USGS Method for estimating the magnitude and frequency of flood frequency in small urban basins was used to estimate the 2, 5, 10, 25, 50, and 100-year peak discharges (Table 3) for the project site on UT Tar River. The storm flows for each event are as follows:

**Table 3. Urban Recurrence Interval Discharges**

| UT Tar (Drainage Area=0.61 mi$^2$) | | |
|---|---|---|
| $Q_2$ = 200 cfs | $Q_5$ = 340 cfs | $Q_{10}$ = 445 cfs |
| $Q_{25}$ = 660 cfs | $Q_{50}$ = 760 cfs | $Q_{100}$ = 855 cfs |

HEC-RAS, version 3.0, will be used to compute a flooding analysis for the existing and proposed conditions during the design phase of the project. This analysis will ensure that the project will not raise existing floodwater limits and will determine whether personal or public property is at risk of damage.

## 4.4 STRUCTURES

Several different structures made of natural materials will be installed along the UT Tar River. These structures include cross vanes, root wads, and vegetated geogrids. Natural materials such as boulders, logs, root wads, and vegetation cuttings will be used to create these structures from both off-site and on-site sources.

### 4.4.1 Cross Vane

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

### 4.4.2 Root Wads

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

### 4.4.3 Vegetated Geogrids

Vegetated geogrids may be used in some outside meanders to protect public infrastructure such as utilities or Burnette Road where root wads are not deemed suitable due to space limitations. Vegetated geogrids are built off of a hardened structure, such as a gabion basket or rock toe. The lifts are created by wrapping soil fill material in a geotextile fabric with live cuttings placed in-between individual lifts. They will be used to create a vegetative stabilization once roots are established and are very useful fore very steep sites where space is limited. They provide soil reinforcement and aquatic habitat. Unlike a typical retaining wall, the wall effect of this structure disappears once the overhanging vegetation is established.

# 5.0 HABITAT RESTORATION

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

## 5.1 Vegetation

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

In the newly restored stream channel, the establishment of vegetation is vital to stabilizing the stream banks and the riparian zone around the restored channel. Revegetation efforts on this project will emulate natural vegetation communities found along relatively undisturbed stream corridors. To quickly establish a dense root mass along the channel bank, a native grass mixture will be planted on the streambanks. Shrubs, vines, and live stakes will be planted 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 out to the extents of the conservation easement.

In addition to planting to stabilize the newly excavated stream banks, a characteristic floodplain forest community will be reestablished in the 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. 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. Using native materials also helps to avoid contaminating the gene pool of the surrounding vegetation with non-adapted ecotypes. 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/Low Mountain Alluvial Forest described by Schafale and Weakley (1990). Recommended plantings are listed in the following sections.

## 5.2 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 (*Lonicera japonica*), Chinese privet (*Ligustrum sinense*), and fescue (*Festuca* sp.) are abundant in the proposed stream restoration areas. Careful site preparation is critical to providing conditions favorable to the establishment of target species.

All planting areas should be ripped on contour to 12 inches where current construction has caused compaction. A 2-inch layer of organic matter and other soil amendments should be incorporated into the soil surface by disking. Addition of organic matter 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 these communities. 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.

Lime and fertilizer may be necessary due to the amount of cut that will be required to create a floodplain at a lower elevation. Addition of nitrogen fertilizers 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 need to be incorporated into the soil for the greatest benefit.

## 5.3 Streambank Vegetation

There are no suitable salvageable plants along the stream banks. As a result, a mixture of seeds, lives takes, bare root nursery stock, and containerized shrubs will be utilized to stabilize the banks. Proposed species to be planted are included in Table 4.

## 5.2 Riparian Buffers

A riparian buffer will be established in the floodplain of the proposed stream channel. A combination of balled and burlapped (B&B) and bare-root seedlings of canopy and subcanopy tree species will be planted on 9-foot centers for a planting density of 440 trees/acre of the finest quality 1/0 seedlings. It is recommended that the bare-root seedlings be at least 12 to 18 inches in height. Understory plantings may be a combination of salvaged plants, container stock, and seeds. Proposed species to be planted in these areas are included in Table 4.

**Table 4. Proposed Plant Species List**

| | | |
|---|---|---|
| **Trees** | | |
| Black walnut | *Juglans nigra* | FACU |
| Blackgum | *Nyssa sylvatica* | FAC |
| Green ash | *Fraxinus pennsylvanica* | FACW |
| Ironwood | *Carpinus caroliniana* | FAC |
| Water Oak | *Quercus nigra* | FAC |
| Willow Oak | *Quercus phellos* | FACW- |
| Cherrybark Oak | *Quercus pagodaefolia* | FAC+ |
| River birch | *Betula nigra* | FACW |
| Serviceberry | *Amelanchier arborea* | FACWU |
| Sycamore | *Platanus occidentalis* | FACW- |
| **Shrubs** | | |
| Elder berry | *Sambucus canadensis* | FACW- |
| Spice bush | *Lindera benzoin* | FACW |
| Tag alder | *Alnus serrulata* | FACW+ |
| Wax Myrtle | *Myrica cerifera* | FAC+ |
| Possumhaw | *Viburnum nudum* | FACW+ |
| **Herbs- Permanent seed mixture** | | |
| **Graminoids** | | |
| Bluestem | *Andropogon glomeratus* | FACW+ |
| Deertongue | *Panicum clandestinum* | FACW |
| Little blue stem | *Schizachyrium scoparium* | FACU |
| Longleaf spikegrass | *Chasmanthium sessiliflorum* | FAC+ |

| | | |
|---|---|---|
| River oats | *Chasmanthium latifolium* | FAC- |
| Sedges | *Carex crinata* | FACW+ |
| Sedges | *Carex lurida* | OBL |
| Tussock sedge | *Carex stricta* | OBL |
| Virginia wildrye | *Elymus virginicus* | FAC |
| **Other herbaceous vegetation** | | |
| Coral honeysuckle | *Lonicera sempervirens* | |
| Cut-leaved coneflower | *Rudbeckia laciniata* | FACW |
| New York Ironweed | *Vernonia noveboracensis* | FACW+ |
| Wrinkle leaved goldenrod | *Solidago rugosa* | FAC |
| **Live stakes** | | |
| Silky dogwood | *Cornus amomum* | FACW+ |
| Silky willow | *Salix sericea* | OBL |

### 5.3 Temporary Seeding

A temporary seed mixture will be applied to all disturbed areas immediately after construction activities have completed. This temporary seed mixture will provide erosion control until permanent seed can become established. Multiple applications of the temporary seed mixtures may be required. The composition of this temporary seeding mixture will vary depending on the timing of construction and may include the following:

**Winter Mix**
Winter Rye (*Secale cereale*)
Barley (*Horedum sp.)*

**Summer Mix**
Japanese Millet *(Echinochloa esculenta*)
Browntop Millet (*Panicum ramosum)*
Pearl Millet (*Pennisetum glacum*)

## 6.0 MONITORING

### 6.1 STREAM CHANNEL

Monitoring of the stability of the channel is recommended to occur after the first growing season and should continue annually for a period of 5 years. Monitoring practices may include, but are not limited to the practices listed in Table 5. The purpose of monitoring is to determine bank stability, bed stability, morphological stability, and overall channel stability. Table 5, below, can be used for selecting monitoring practices.

**Table 5. Stream Monitoring Practices**

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

## 6.2 VEGETATION

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

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

In preparation for the quantitative sampling, belt transects will be established perpendicular to the channel to encompass both the stream channel and riparian buffer. Plots will be evenly distributed throughout the site. For each plot, species composition and density will be reported. Photo points will be taken within each zone. Monitoring will take place once each year for five years.

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

# 7.0 REFERENCES

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

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

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

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

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

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

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

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

NCDENR. "Water Quality Stream Classifications for Streams in North Carolina." *Water Quality Section.* http://h2o.enr.state.nc.us/wqhome.html (12 March 2002).

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

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

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

United States Department of Agriculture – Natural Resources Conservation Service September 1998. "Soil Survey of Franklin County, North Carolina." http://www.mo14.nc.nrcs.usda.gov/Publishd%20Soil%20Surveys/frank-cd.pdf

United States Fish and Wildlife Service. "Endangered Species/ Section 7 Program in North Carolina." *North Carolina Ecological Services.* (22 March 2001)

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

Webster, W.D., J.F. Parnell, and W.C. Biggs, Jr. 1985. *Mammals of the Carolinas, Virginia, and Maryland.* The University of North Carolina Press, Chapel Hill, North Carolina.

# Photo Log

Unnamed Tributary to the Tar River
Franklin County, North Carolina

1. Beginning of project looking upstream at culvert under NC 39.

2. Looking downstream from NC 39 at first 100 ft of existing channel. Notice high vertical banks on right bank and bar on left bank.

3. Looking downstream. Burnette Road lies adjacent to the left bank. White building in distance is the Food Lion/Wal Mart complex.

4. View of stream where Burnette Road and town maintained dirt access path to sewer lift station intersect.

5. Riffle Cross Section. Town dirt access path lies between the treeline on the left and the left streambank.

6. Raw streambanks about 100 ft upstream of end of project.

7. Former location of channel where proposed restoration will tie in.

8. Hydric soils outside of conservation easement on Burnette, et. al property behind Food Lion/Wal Mart complex.

| | |
|---|---|
| **Field Crew:** | Heather Renninger, Jan Patterson |
| **River Basin:** | Tar River Basin |
| **Stream Reach:** | UT Tar |
| **Date:** | 2/19/2003 |
| **Feature:** | Pool, Station 0+60 |

| STATION (Feet) | HI (Feet) | FS (Feet) | ELEVATION (Feet) | NOTES |
|---|---|---|---|---|
| 0+08.0 | 103.94 | 0.4 | 103.54 | |
| 0+10.5 | 103.94 | 1.05 | 102.89 | |
| 0+13.5 | 103.94 | 2.53 | 101.41 | |
| 0+15.4 | 103.94 | 4.04 | 99.90 | |
| 0+17.3 | 103.94 | 5.43 | 98.51 | LBKF |
| 0+17.5 | 103.94 | 5.51 | 98.43 | |
| 0+21.6 | 103.94 | 5.87 | 98.07 | |
| 0+24.3 | 103.94 | 6.20 | 97.74 | |
| 0+27.7 | 103.94 | 5.55 | 98.39 | |
| 0+31.7 | 103.94 | 6.60 | 97.34 | LEW/WS |
| 0+33.5 | 103.94 | 7.41 | 96.53 | TW |
| 0+35.8 | 103.94 | 5.43 | 98.51 | RBKF |
| 0+38.0 | 103.94 | 3.64 | 100.30 | |
| 0+53.0 | 103.94 | 1.56 | 102.38 | RTOB |
| 0+59.0 | 103.94 | 2.90 | 101.04 | |

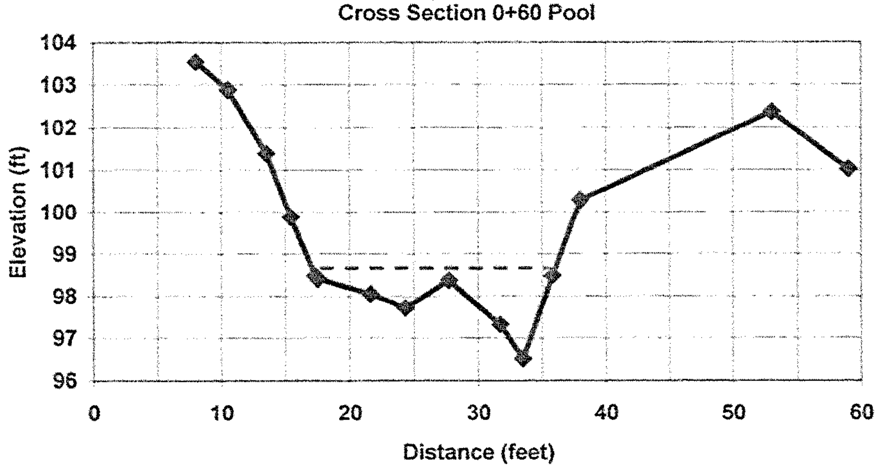
**BANKFULL**
**Hydraulic Geometry**

| | Width (Feet) | Depth (Feet) | Area (Sq. Ft.) |
|---|---|---|---|
| | 0.0 | 0.0 | 0.0 |
| | 0.2 | 0.1 | 0.0 |
| | 4.1 | 0.4 | 1.1 |
| | 2.7 | 0.8 | 1.6 |
| | 3.4 | 0.1 | 1.5 |
| | 4.0 | 1.2 | 2.6 |
| | 1.8 | 2.0 | 2.8 |
| | 2.3 | 0.0 | 2.3 |
| TOTALS | 18.5 | | 11.9 |

| SUMMARY DATA (TOB) | |
|---|---|
| A(BKF) | 11.9 |
| W(BKF) | 18.5 |
| Max d | 2.0 |
| Mean d | 0.6 |

Pool Cross-Section 0+60

UT Tar River
Cross Section 0+60 Pool




**BEHI:**

| CRITERIA | VALUE | INDEX | |
|---|---|---|---|
| Bank/BKF Ht | 3.0 | 10 | |
| Root Depth/Bank Ht | 0.09 | 8.6 | |
| Root Density | <5 | 10 | |
| Bank Angle | 80 | 5.9 | |
| Surface Protection | <10 | 10.0 | |
| Bank Materials | Sand | 10 | |
| | | 54.5 | Extreme |

| | |
|---|---|
| Field Crew: | Heather Renninger, Jan Patterson |
| River Basin: | Tar River Basin |
| Stream Reach: | UT Tar |
| Date: | 2/19/2003 |
| Feature: | Riffle, Station 8+12 |

| STATION (Feet) | HI (Feet) | FS (Feet) | ELEVATION (Feet) | NOTES |
|---|---|---|---|---|
| 0+00.0 | 99.16 | 3.57 | 95.59 | |
| 0+02.0 | 99.16 | 3.98 | 95.18 | LTOB |
| 0+04.1 | 99.16 | 4.83 | 94.33 | |
| 0+06.8 | 99.16 | 6.82 | 92.34 | LBKF |
| 0+07.4 | 99.16 | 7.37 | 91.79 | |
| 0+08.6 | 99.16 | 8.55 | 90.61 | |
| 0+09.0 | 99.16 | 8.41 | 90.75 | |
| 0+10.4 | 99.16 | 9.68 | 89.48 | LEW/WS |
| 0+13.0 | 99.16 | 10.07 | 89.09 | TW |
| 0+14.7 | 99.16 | 9.76 | 89.40 | R edge bank |
| 0+15.0 | 99.16 | 8.41 | 90.75 | |
| 0+17.0 | 99.16 | 6.82 | 92.34 | RBKF |
| 0+20.0 | 99.16 | 5.44 | 93.72 | RTOB |
| 0+26.0 | 99.16 | 4.39 | 94.77 | |
| 0+36.0 | 99.16 | 3.70 | 95.46 | |
| 0+47.0 | 99.16 | 3.31 | 95.85 | |

**BANKFULL**
**Hydraulic Geometry**

| | Width (Feet) | Depth (Feet) | Area (Sq. Ft.) |
|---|---|---|---|
| | 0 | 0 | 0 |
| | 0.6 | 0.6 | 0.2 |
| | 1.2 | 1.7 | 1.4 |
| | 0.4 | 1.6 | 0.7 |
| | 1.4 | 2.9 | 3.1 |
| | 2.6 | 3.3 | 7.9 |
| | 1.7 | 2.9 | 5.3 |
| | 0.3 | 1.6 | 0.7 |
| | 2.0 | 0.0 | 1.6 |
| TOTALS | 10.2 | | 20.8 |

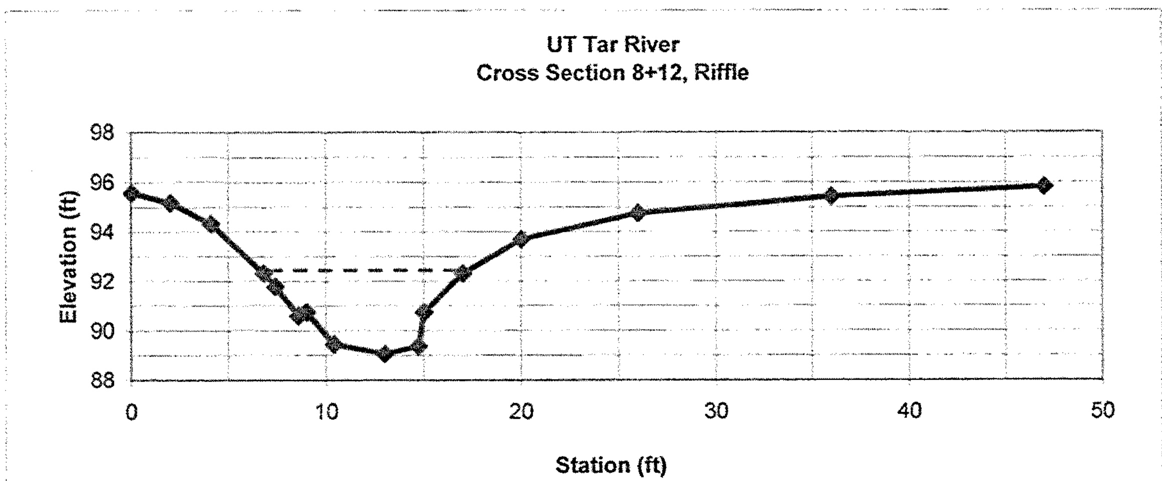
**SUMMARY DATA (BANKFULL)**

| | | |
|---|---|---|
| A(BKF) | 20.8 | |
| W(BKF) | 10.2 | |
| Max d | 3.3 | |
| Mean d | 2.0 | Area= A |
| W/D | 5.0 | Width= W |
| Entrenchment Ratio | 3.9 | Depth= D |
| Stream Type | degraded E | Bankfull= BKF |

Riffle Cross-Section 8+12

**BEHI:**

| CRITERIA | VALUE | INDEX | |
|---|---|---|---|
| Bank/BKF Ht | 1.5 | 5.9 | |
| Root Depth/Bank Ht | 0.12 | 8.2 | |
| Root Density | <5 | 10 | |
| Bank Angle | 75 | 5.4 | |
| Surface Protection | <10 | 10.0 | |
| Bank Materials | Sand | 10 | |
| | | 49.5 | Extreme |



| | |
|---|---|
| **Field Crew:** | Heather Renninger, Jan Patterson |
| **River Basin:** | Tar River Basin |
| **Stream Reach:** | UT Tar |
| **Date:** | 2/19/2003 |
| **Feature:** | Riffle, Station 13+09 |

| STATION (Feet) | HI (Feet) | FS (Feet) | ELEVATION (Feet) | NOTES |
|---|---|---|---|---|
| 0+00.0 | 95.75 | 5.00 | 90.75 | edge dirt road |
| 0+08.0 | 95.75 | 5.03 | 90.72 | |
| 0+16.0 | 95.75 | 4.87 | 90.88 | edge dirt road |
| 0+20.2 | 95.75 | 6.02 | 89.73 | LBKF |
| 0+21.4 | 95.75 | 8.47 | 87.28 | |
| 0+23.2 | 95.75 | 8.43 | 87.32 | LEW/WS |
| 0+27.5 | 95.75 | 8.79 | 86.96 | TW |
| 0+30.3 | 95.75 | 8.43 | 87.32 | REW/WS |
| 0+31.6 | 95.75 | 7.22 | 88.53 | |
| 0+33.9 | 95.75 | 6.15 | 89.60 | |
| 0+34.0 | 95.75 | 6.02 | 89.73 | RBKF |
| 0+36.0 | 95.75 | 4.24 | 91.51 | RTOB |
| 0+38.0 | 95.75 | 4.09 | 91.66 | |
| 0+46.0 | 95.75 | 4.33 | 91.42 | |
| 0+55.0 | 95.75 | 4.46 | 91.29 | Woodline |

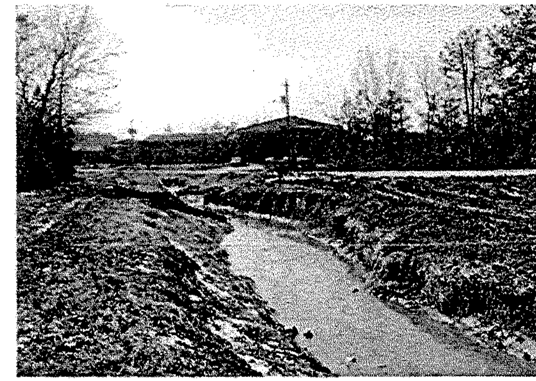
**BANKFULL**
**Hydraulic Geometry**

| | Width (Feet) | Depth (Feet) | Area (Sq. Ft.) |
|---|---|---|---|
| | 0.0 | 0.0 | 0.0 |
| | 1.2 | 2.5 | 1.5 |
| | 1.8 | 2.4 | 4.4 |
| | 4.3 | 2.8 | 11.1 |
| | 2.8 | 2.4 | 7.3 |
| | 1.3 | 1.2 | 2.3 |
| | 2.3 | 0.1 | 1.5 |
| | 0.1 | 0.0 | 0.0 |
| TOTALS | 13.8 | | 28.1 |

**SUMMARY DATA (BANKFULL)**

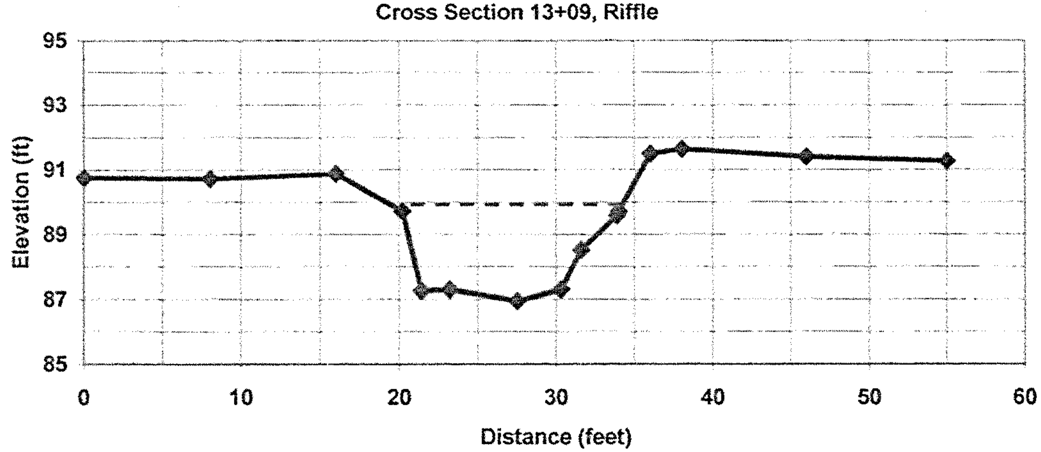
| | | |
|---|---|---|
| A(BKF) | 28.1 | |
| W(BKF) | 13.8 | |
| Max d | 2.8 | |
| Mean d | 2.0 | Area= A |
| W/D | 6.8 | Width= W |
| Entrenchment Ratio | 4.0 | Depth= D |
| Stream Type | degraded E | Bankfull= BKF |

Riffle Cross-Section 13+09

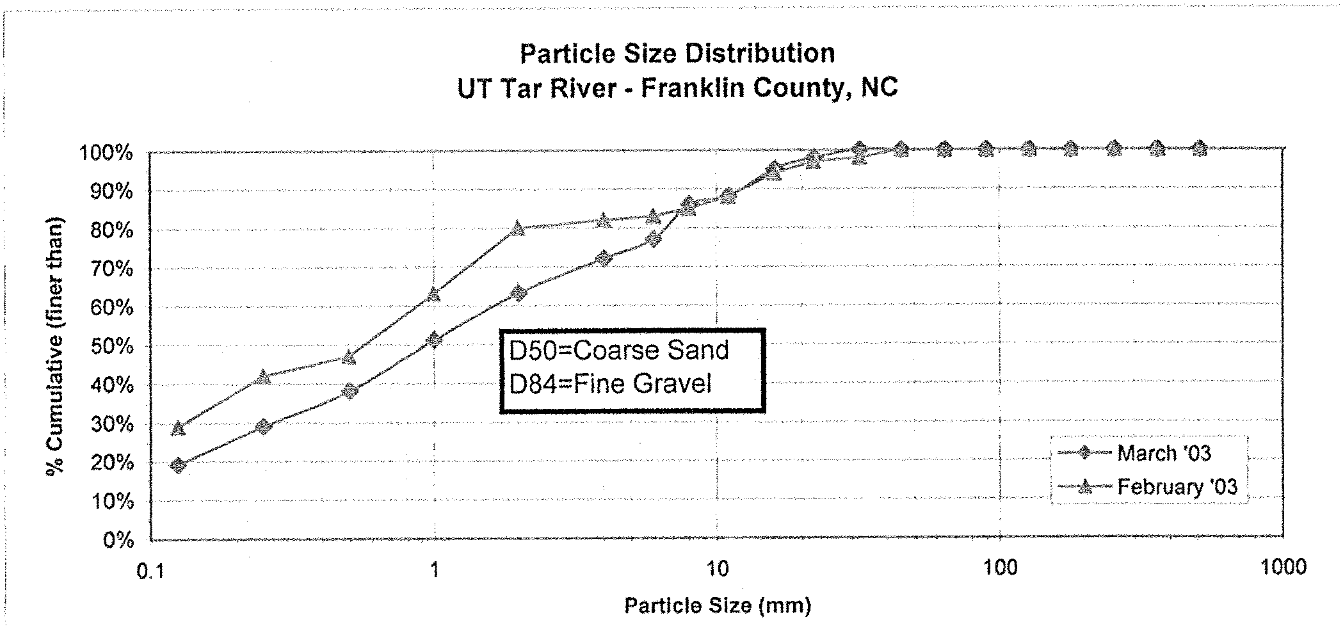


**BEHI:**

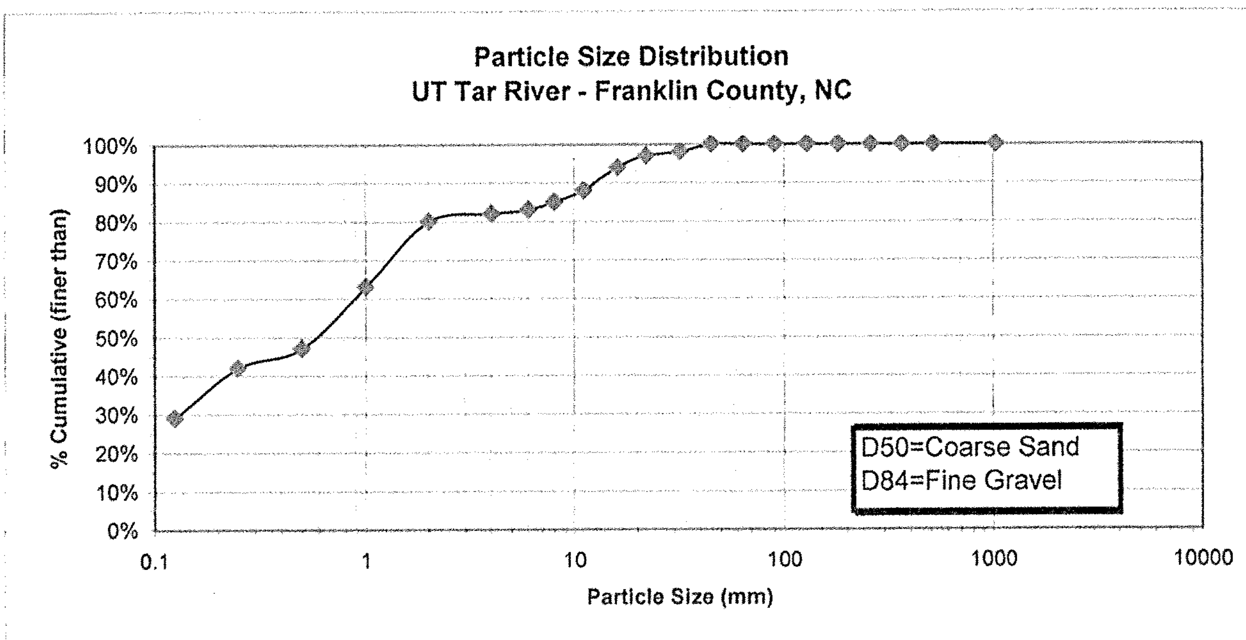
| CRITERIA | VALUE | INDEX | |
|---|---|---|---|
| Bank/BKF Ht | 1.0 | 1 | |
| Root Depth/Bank Ht | 0.21 | 7.1 | |
| Root Density | <5 | 10 | |
| Bank Angle | 110 | 8.7 | |
| Surface Protection | <10 | 10.0 | |
| Bank Materials | Sand | 10 | |
| | | 46.8 | Extreme |



| PEBBLE COUNT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Site: Unnamed Tributary to Tar River | | | | | | 3/19/2003 | | |
| Party: Jan Patterson | | | | | | Reach: NC 39 to 1700' | | |
| | | | | Particle Counts | | | | |
| Inches | Particle | Millimeter | | Pool | Riffle | Total No. | Item % | % Cumulative |
| | Silt/Clay | < 0.062 | S/C | 3 | 4 | 7 | 7% | 7% |
| | Very Fine | .062 - .125 | S | 6 | 6 | 12 | 12% | 19% |
| | Fine | .125 - .25 | A | 4 | 6 | 10 | 10% | 29% |
| | Medium | .25 - .50 | N | 2 | 7 | 9 | 9% | 38% |
| | Coarse | .50 - 1.0 | D | 2 | 11 | 13 | 13% | 51% |
| .04 -.08 | Very Coarse | 1.0 - 2.0 | S | 2 | 10 | 12 | 12% | 63% |
| .08 - .16 | Very Fine | 2.0 - 4.0 | | 1 | 8 | 9 | 9% | 72% |
| .16 - .22 | Fine | 4.0 - 5.7 | G | | 5 | 5 | 5% | 77% |
| .22 - .31 | Fine | 5.7 - 8.0 | R | | 9 | 9 | 9% | 86% |
| .31 - .44 | Medium | 8.0 - 11.3 | A | | 2 | 2 | 2% | 88% |
| .44 - .63 | Medium | 11.3 - 16.0 | V | | 7 | 7 | 7% | 95% |
| .63 - .89 | Coarse | 16.0 - 22.6 | E | | 3 | 3 | 3% | 98% |
| .89 - 1.26 | Coarse | 22.6 - 32.0 | L | | 2 | 2 | 2% | 100% |
| 1.26 - 1.77 | Very Coarse | 32.0 - 45.0 | S | | | 0 | 0% | 100% |
| 1.77 - 2.5 | Very Coarse | 45.0 - 64.0 | | | | 0 | 0% | 100% |
| 2.5 - 3.5 | Small | 64 - 90 | C | | | 0 | 0% | 100% |
| 3.5 - 5.0 | Small | 90 - 128 | O | | | 0 | 0% | 100% |
| 5.0 - 7.1 | Large | 128 - 180 | B | | | 0 | 0% | 100% |
| 7.1 - 10.1 | Large | 180 - 256 | L | | | 0 | 0% | 100% |
| 10.1 - 14.3 | Small | 256 - 362 | B | | | 0 | 0% | 100% |
| 14.3 - 20 | Small | 362 - 512 | L | | | 0 | 0% | 100% |
| 20 - 40 | Medium | 512 - 1024 | D | | | 0 | 0% | 100% |
| 40 - 80 | Lrg- Very Lrg | 1024 - 2048 | R | | | 0 | 0% | 100% |
| | Bedrock | | BDRK | | | 0 | 0% | 100% |
| | | | **Totals** | **20** | **80** | **100** | **100%** | **100%** |



| PEBBLE COUNT | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Site: Unnamed Tributary to Tar River | | | | | | 2/19/2003 | | | |
| Party: Heather Renninger, Jan Patterson | | | | | | Reach: NC 39 to 1700' | | | |
| | | | | Particle Counts | | | | | |
| Inches | Particle | Millimeter | | Pool | Riffle | Total No. | Item % | % Cumulative |
| | Silt/Clay | < 0.062 | S/C | 3 | 13 | 16 | 16% | 16% |
| | Very Fine | .062 - .125 | S | 6 | 7 | 13 | 13% | 29% |
| | Fine | .125 - .25 | A | 4 | 9 | 13 | 13% | 42% |
| | Medium | .25 - .50 | N | 2 | 3 | 5 | 5% | 47% |
| | Coarse | .50 - 1.0 | D | 2 | 14 | 16 | 16% | 63% |
| .04 -.08 | Very Coarse | 1.0 - 2.0 | S | 2 | 15 | 17 | 17% | 80% |
| .08 - .16 | Very Fine | 2.0 - 4.0 | | 1 | 1 | 2 | 2% | 82% |
| .16 - .22 | Fine | 4.0 - 5.7 | G | | 1 | 1 | 1% | 83% |
| .22 - .31 | Fine | 5.7 - 8.0 | R | | 2 | 2 | 2% | 85% |
| .31 - .44 | Medium | 8.0 - 11.3 | A | | 3 | 3 | 3% | 88% |
| .44 - .63 | Medium | 11.3 - 16.0 | V | | 6 | 6 | 6% | 94% |
| .63 - .89 | Coarse | 16.0 - 22.6 | E | | 3 | 3 | 3% | 97% |
| .89 - 1.26 | Coarse | 22.6 - 32.0 | L | | 1 | 1 | 1% | 98% |
| 1.26 - 1.77 | Very Coarse | 32.0 - 45.0 | S | | 2 | 2 | 2% | 100% |
| 1.77 - 2.5 | Very Coarse | 45.0 - 64.0 | | | | 0 | 0% | 100% |
| 2.5 - 3.5 | Small | 64 - 90 | C | | | 0 | 0% | 100% |
| 3.5 - 5.0 | Small | 90 - 128 | O | | | 0 | 0% | 100% |
| 5.0 - 7.1 | Large | 128 - 180 | B | | | 0 | 0% | 100% |
| 7.1 - 10.1 | Large | 180 - 256 | L | | | 0 | 0% | 100% |
| 10.1 - 14.3 | Small | 256 - 362 | B | | | 0 | 0% | 100% |
| 14.3 - 20 | Small | 362 - 512 | L | | | 0 | 0% | 100% |
| 20 - 40 | Medium | 512 - 1024 | D | | | 0 | 0% | 100% |
| 40 - 80 | Lrg- Very Lrg | 1024 - 2048 | R | | | 0 | 0% | 100% |
| | Bedrock | | BDRK | | | 0 | 0% | 100% |
| | | | Totals | 20 | 80 | 100 | 100% | 100% |



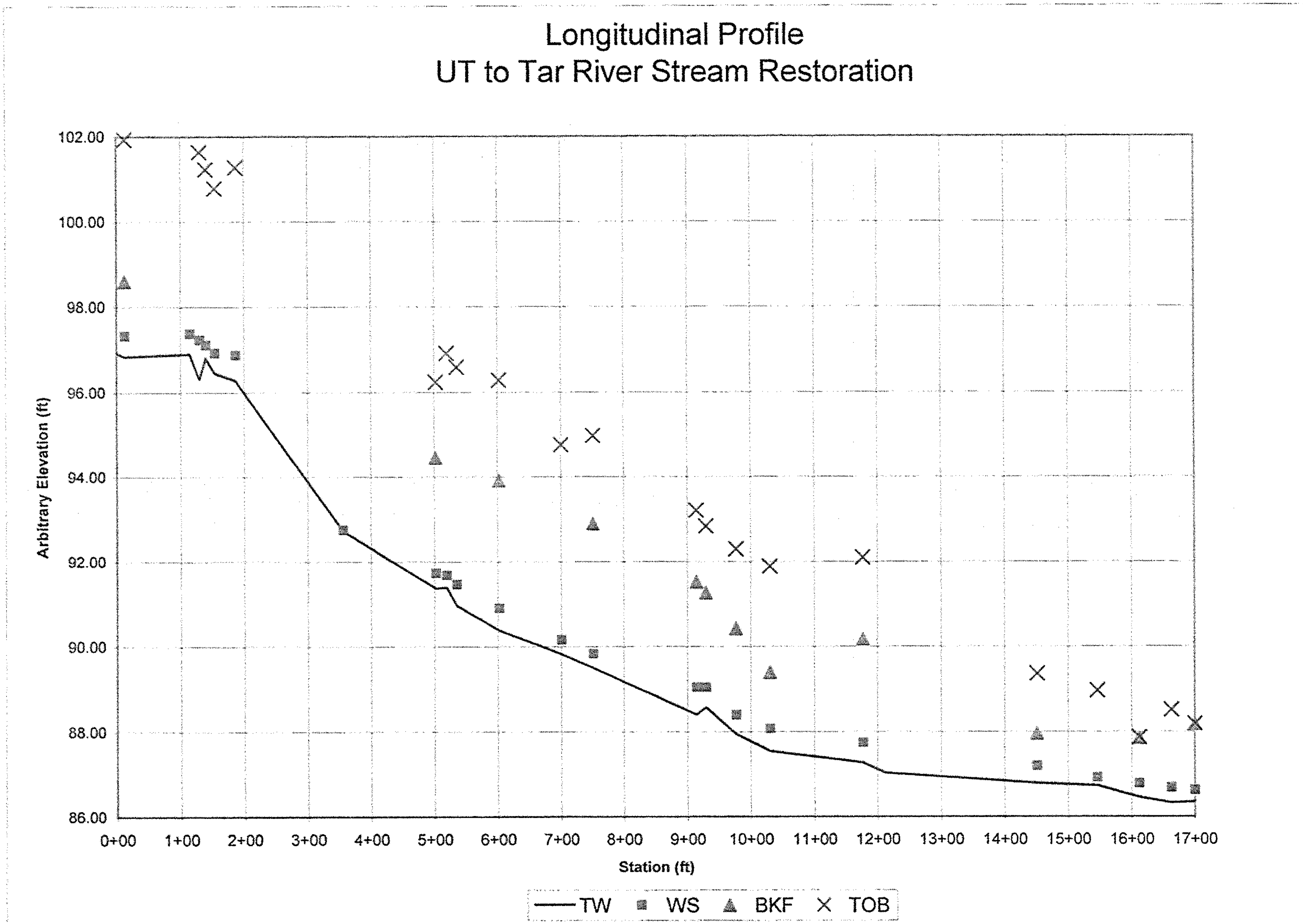
| | |
|---|---|
| **Field Crew:** | Heather Renninger, Jan Patterson |
| **River Basin:** | Tar River Basin |
| **Stream Reach:** | UT Tar below NC 39 |
| **Draiange Area:** | 0.75 sq. mi. |
| **Date:** | 2/19/2003 |
| **Description:** | LONGITUDINAL PROFILE |

| STA | BS | HI | FS | ELEV | NOTE |
|---|---|---|---|---|---|
| TBM #1 | 3.94 | 103.94 | | 100.00 | Tree Stump |
| TP #1 | 2.74 | 99.16 | 7.52 | 96.42 | riprap |
| TP #2 | 3.00 | 95.75 | 6.41 | 92.75 | fire hydrant |

| Station | TW (FS) | TW | WS (FS) | WS | BKF (FS) | BKF | TOB (FS) | TOB | Notes | HI | Bk Ht/Bkf Ht. | P-P | Pool Length | Max Pool Depth | Pool Slope | Riffle Length | Riffle Slope |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0+00.0 | 7.03 | 96.91 | | | | | | | Culvert @ NC 39 | 103.94 | | | | | | | |
| 0+12.0 | 7.11 | 96.83 | 6.61 | 97.33 | 5.36 | 98.58 | 2.00 | 101.94 | Top Pool | 103.94 | 2.92 | | 102 | 1.75 | 0.0000 | | |
| 1+14.0 | 7.05 | 96.89 | 6.56 | 97.38 | | | 1.72 | 102.22 | Top Riffle | 103.94 | | | | | | 15 | 0.0093 |
| 1+29.0 | 7.64 | 96.30 | 6.70 | 97.24 | | | 2.30 | 101.64 | Top Pool | 103.94 | | 117 | 10 | | 0.0120 | | |
| 1+39.0 | 7.14 | 96.80 | 6.82 | 97.12 | | | 2.71 | 101.23 | Top Riffle-riprap | 103.94 | | | | | | 14 | 0.0171 |
| 1+53.0 | 7.50 | 96.44 | 7.01 | 96.93 | | | 3.16 | 100.78 | Top Run | 103.94 | | | | | | | |
| 1+86.0 | 7.67 | 96.27 | 7.06 | 96.88 | | | 2.66 | 101.28 | Top Riffle-riprap | 103.94 | | | | | | 316 | 0.0131 |
| 3+55.0 | 11.23 | 92.71 | 11.21 | 92.73 | | | | | Tributary-Run | 103.94 | | | | | | | |
| 5+02.0 | 12.59 | 91.35 | 12.23 | 91.71 | 9.50 | 94.44 | 7.70 | 96.24 | Top Pool | 103.94 | 1.58 | 373 | 17 | 3.09 | 0.0029 | | |
| 5+19.0 | 12.57 | 91.37 | 12.28 | 91.66 | | | 7.02 | 96.92 | Top Riffle | 103.94 | | | | | | 16 | 0.0137 |
| 5+35.0 | 13.00 | 90.94 | 12.50 | 91.44 | | | 7.35 | 96.59 | Top Pool | 103.94 | | 33 | 67 | | 0.0084 | | |
| 6+02.0 | 13.57 | 90.37 | 13.06 | 90.88 | 10.05 | 93.89 | 7.65 | 96.29 | Top Run | 103.94 | 1.68 | | | | | | |
| 7+00.0 | 14.13 | 89.81 | 13.79 | 90.15 | | | 9.18 | 94.76 | Run | 103.94 | | | | | | | |
| 7+51.0 | 9.68 | 89.48 | 9.34 | 89.82 | 6.29 | 92.87 | 4.18 | 94.98 | Run | 99.16 | 1.62 | | | | | | |
| 9+14.0 | 10.77 | 88.39 | 10.14 | 89.02 | 7.67 | 91.49 | 5.96 | 93.20 | Top Pool | 99.16 | 1.55 | 379 | 15 | 3.10 | 0.0000 | | |
| 9+29.0 | 10.60 | 88.56 | 10.14 | 89.02 | 7.92 | 91.24 | 6.34 | 92.82 | Top Riffle | 99.16 | 1.59 | | | | | 48 | 0.0135 |
| 9+77.0 | 11.23 | 87.93 | 10.79 | 88.37 | 8.75 | 90.41 | 6.88 | 92.28 | Top Run | 99.16 | 1.75 | | | | | | |
| 10+30.0 | 11.63 | 87.53 | 11.11 | 88.05 | 9.79 | 89.37 | 7.29 | 91.87 | Run | 99.16 | 2.36 | | | | | | |
| 11+77.0 | 11.91 | 87.25 | 11.44 | 87.72 | 9.00 | 90.16 | 7.08 | 92.08 | Run | 99.16 | 1.66 | | | | | | |
| 12+12.0 | 9.43 | 87.01 | | | | | | | Culvert @ Plaza Entrance | 95.75 | | | | | | | |
| 14+51.0 | 8.98 | 86.77 | 8.59 | 87.16 | 7.81 | 87.94 | 6.41 | 89.34 | Run | 95.75 | 2.20 | | | | | | |
| 15+46.0 | 9.04 | 86.71 | 8.86 | 86.89 | | | 6.81 | 88.94 | Run | 95.75 | | | | | | | |
| 16+12.0 | 9.31 | 86.44 | 9.00 | 86.75 | 7.91 | 87.84 | 7.91 | 87.84 | Top Riffle | 95.75 | 1.00 | | | | | 88 | 0.0018 |
| 16+63.0 | 9.44 | 86.31 | 9.10 | 86.65 | | | 7.26 | 88.49 | Riffle | 95.75 | | | | | | | |
| 17+00.0 | 9.42 | 86.33 | 9.16 | 86.59 | 7.59 | 88.16 | 7.59 | 88.16 | Riffle | 95.75 | 1.00 | | | | | | |
| | | | | | | | | | | 95.75 | | | | | | | |
| | 7.54 | 88.21 | | | | | | | Manhole @ tie-in | 95.75 | | | | | | | |
| | 11.67 | 84.08 | 9.39 | 86.36 | | | | | Old Channel ds 15' | 95.75 | | | | | | | |
| | 9.73 | 86.02 | 9.39 | 86.36 | | | | | Old Channel ds 15' | 95.75 | | | | | | | |
| 4+67.0 | | | | | | | | | drainage | | | | | | | | |

| | |
|---|---|
| tw slope | 0.0067 |
| ws slope | 0.0068 |
| BKF W (ft)= | 12.0 |
| BKF D (ft)= | 2.0 |
| BKF Max D (ft)= | 3.0 |

| | Bk Ht/Bkf Ht. | P-P | Pool Length | Max Pool Depth | Pool Slope | Riffle Length | Riffle Slope |
|---|---|---|---|---|---|---|---|
| min | 1.00 | 33 | 10 | 1.75 | 0.0000 | 14 | 0.0018 |
| max | 2.92 | 379 | 102 | 3.10 | 0.0120 | 316 | 0.0171 |
| avg | 1.74 | 226 | 42 | 2.65 | 0.0047 | 83 | 0.0115 |
| Min ratio | 0.33 | 2.8 | | 0.86 | 0.0000 | | 0.2673 |
| Max ratio | 0.97 | 31.6 | | 1.52 | 1.7639 | | 2.5198 |
| avg ratio | 0.58 | 18.8 | | 1.30 | 0.6849 | | 1.6835 |

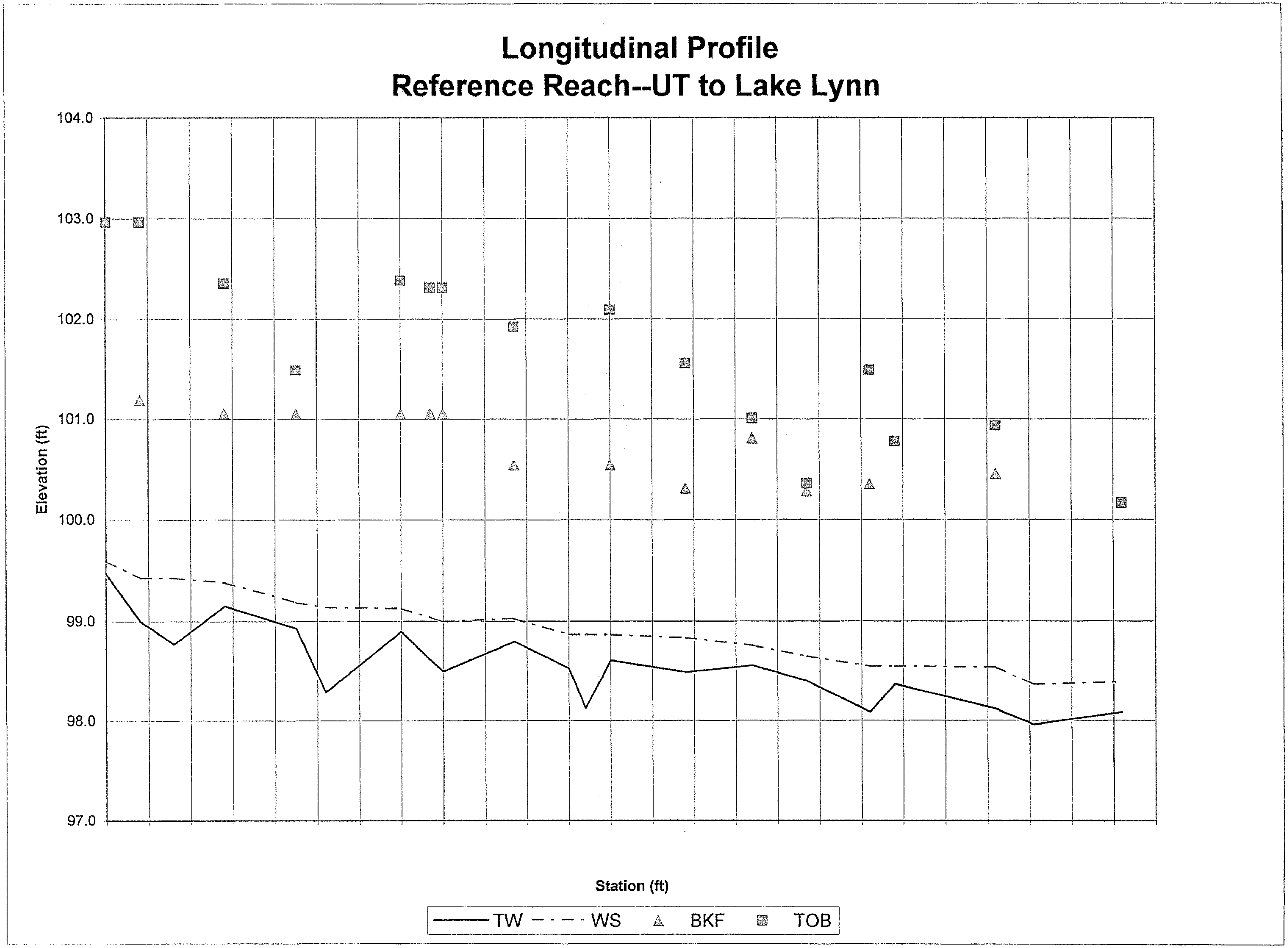

Longitudinal Profile
UT to Tar River Stream Restoration
102.00
100.00
98.00
96.00
94.00
92.00
90.00
88.00
86.00
Arbitrary Elevation (ft)
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
Station (ft)
TW
WS
BKF
TOB

## PATTERN MEASUREMENTS

| | Radius of Curvature | Ratio | Meander Length | Ratio | Belt Width | Ratio |
|---|---|---|---|---|---|---|
| | 40 | 3.33 | 470 | 39.2 | 30 | 2.5 |
| | 15 | 1.25 | | | | |
| | 10 | 0.83 | 265 | 22.1 | 11 | 0.9 |
| | 25 | 2.08 | | | | |
| | 10 | 0.83 | | | | |
| | 10 | 0.83 | | | 8 | 0.7 |
| | 15 | 1.25 | | | | |
| | 60 | 5.00 | | | | |
| | 55 | 4.58 | | | | |
| average | 27 | 2.2 | 368 | 30.6 | 16 | 1.4 |
| min | 10 | 0.8 | 265 | 22.1 | 8 | 0.7 |
| max | 60 | 5.0 | 470 | 39.2 | 30 | 2.5 |

Radius of Curvature, Meander Length, and Belt Width measured from topographic mapping.

BKF W (ft) 12.0


Longitudinal Profile
Reference Reach--UT to Lake Lynn
104.0
103.0
102.0
101.0
100.0
99.0
98.0
97.0
Elevation (ft)
Station (ft)
TW
WS
BKF
TOB

| LONGITUDINAL PROFILE | |
|---|---|
| River Basin: | Neuse |
| Watershed: | Lake Lynn |
| Stream Reach: | Reference Reach–UT Lake Lynn |
| DA (sq mi): | 0.74 |
| Date: | 3/25/2003 |

| REF PT | BS | HI | FS | ELEV | NOTES |
|---|---|---|---|---|---|
| BM | 6.78 | 106.78 | | 100.00 | |
| BM | | | 6.78 | 100.00 | |

| Station | REF PT | HI | TW(FS) | TW | WS(FS) | WS | BKF(FS) | BKF | TOB(FS) | TOB | Notes | | Bk Ht/Bkf Ht. | P-P | Pool Length | Max Pool Depth | Pool Slope | Riffle Length | Riffle Slope | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0+00.0 | BM | 106.78 | 7.32 | 99.46 | 7.19 | 99.59 | | | 3.82 | 102.96 | Head of Riffle | | | | | | | 8.0 | 0.0213 | |
| 0+08.0 | BM | 106.78 | 7.79 | 98.99 | 7.36 | 99.42 | 5.60 | 101.18 | 3.82 | 102.96 | Head of Pool | 2.19 | 1.8 | 37.0 | 20.0 | | 0.0020 | | | |
| 0+16.0 | BM | 106.78 | 8.02 | 98.76 | 7.36 | 99.42 | | | | | Max Pool | | | | | | | | | |
| 0+28.0 | BM | 106.78 | 7.64 | 99.14 | 7.40 | 99.38 | 5.74 | 101.04 | 4.43 | 102.35 | Head of Riffle | 1.90 | 1.7 | | | | | 17.0 | 0.0118 | |
| 0+45.0 | BM | 106.78 | 7.86 | 98.92 | 7.60 | 99.18 | 5.74 | 101.04 | 5.30 | 101.48 | Head of Pool | 2.12 | 1.2 | 32.0 | 25.0 | | 0.0024 | | | |
| 0+52.0 | BM | 106.78 | 8.50 | 98.28 | 7.65 | 99.13 | | | | | Max Pool | | | | | | | | | |
| 0+70.0 | BM | 106.78 | 7.89 | 98.89 | 7.66 | 99.12 | 5.74 | 101.04 | 4.40 | 102.38 | Head of Riffle | 2.15 | 1.6 | | | | | 7.0 | 0.0129 | |
| 0+77.0 | BM | 106.78 | 8.18 | 98.60 | 7.75 | 99.03 | 5.74 | 101.04 | 4.47 | 102.31 | Head of Pool | 2.44 | 1.5 | 33.0 | 20.0 | | 0.0005 | | | |
| 0+80.0 | BM | 106.78 | 8.29 | 98.49 | 7.79 | 98.99 | 5.74 | 101.04 | 4.47 | 102.31 | Max Pool | 2.55 | 1.5 | | | 2.55 | | | | |
| 0+97.0 | BM | 106.78 | 7.99 | 98.79 | 7.76 | 99.02 | 6.25 | 100.53 | 4.86 | 101.92 | Head of Riffle | 1.74 | 1.8 | | | | | 13.0 | 0.0123 | |
| 1+10.0 | BM | 106.78 | 8.26 | 98.52 | 7.93 | 98.86 | | | | | Head of Pool | | | 57.0 | 10.0 | | 0.0000 | | | |
| 1+14.0 | BM | 106.78 | 8.66 | 98.12 | 7.92 | 98.86 | | | | | Max Pool | | | | | | | | | |
| 1+20.0 | BM | 106.78 | 8.18 | 98.60 | 7.92 | 98.86 | 6.25 | 100.53 | 4.69 | 102.09 | Head of Run | 1.93 | 1.8 | | | | | | | |
| 1+38.0 | BM | 106.78 | 8.30 | 98.48 | 7.95 | 98.83 | 6.48 | 100.30 | 5.23 | 101.55 | Intermediate | 1.82 | 1.7 | | | | | | | |
| 1+54.0 | BM | 106.78 | 8.23 | 98.55 | 8.03 | 98.75 | 5.98 | 100.80 | 5.78 | 101.00 | Head of Riffle | 2.25 | 1.1 | | | | | 13.0 | 0.0085 | |
| 1+67.0 | BM | 106.78 | 8.39 | 98.39 | 8.14 | 98.64 | 6.51 | 100.27 | 6.43 | 100.35 | Head of Pool | 1.88 | 1.0 | 75.0 | 21.0 | | 0.0048 | | | |
| 1+82.0 | BM | 106.78 | 8.70 | 98.08 | 8.24 | 98.54 | 6.44 | 100.34 | 5.30 | 101.48 | Max Pool | 2.26 | 1.5 | | | 2.26 | | | | |
| 1+88.0 | BM | 106.78 | 8.42 | 98.36 | 8.24 | 98.54 | | | 6.01 | 100.77 | Head of Run | | | | | | | | | |
| 2+12.0 | BM | 106.78 | 8.67 | 98.11 | 8.25 | 98.53 | 6.34 | 100.44 | 5.85 | 100.93 | Head of Riffle | 2.33 | 1.2 | | | | | 9.0 | 0.0200 | |
| 2+21.0 | BM | 106.78 | 8.83 | 97.95 | 8.43 | 98.35 | | | | | Head of Run | | | | | | | | | |
| 2+42.0 | BM | 106.78 | 8.70 | 98.08 | 8.40 | 98.38 | 6.62 | 100.16 | 6.62 | 100.16 | Head of Pool | 2.08 | 1.0 | | | | | | | |
| 2+49.0 | Aerial Sewer Xing | | | | | | | | | | | | | | | | | | | |
| Average WS Slope | 0.0050 | | | | | | | | | | Max | | 1.8 | 75.0 | 25.0 | 2.6 | 0.0048 | 17.0 | 0.0213 | Max |
| | | | | | | | | | | | Min | | 1.0 | 32.0 | 10.0 | 2.3 | 0.0000 | 7.0 | 0.0085 | Min |
| | | | | | | | | | | | Avg | | 1.5 | 46.8 | 19.2 | 2.4 | 0.0019 | 11.2 | 0.0144 | Avg |
| | | | | | | | | | | | Max ratio | | | 4.7 | | | 0.95 | | 4.3 | Max ratio |
| | | | | | | | | | | | Min ratio | | | 2.0 | | | 0.00 | | 1.7 | Min ratio |
| | | | | | | | | | | | Avg ratio | | | 3.0 | | | 0.39 | | 2.9 | Avg ratio |

| | |
|---|---|
| Crew: | Jan Patterson, Heather Renninger, Amanda Todd |
| River Basin: | Neuse |
| Watershed: | Lake Lynn |
| Stream Reach: | UT Lake Lynn |
| DA (sq mi): | 0.74 |
| Date: | 3/25/2003 |
| Station: | 0+30 |
| Feature: | Riffle |

| STATION | HI (Feet) | FS (Feet) | ELEVATION (Feet) | NOTES |
|---|---|---|---|---|
| 0.0 | 106.78 | 4.66 | 102.12 | |
| 7.0 | 106.78 | 4.29 | 102.49 | edge path |
| 20.0 | 106.78 | 4.41 | 102.37 | edge path |
| 30.5 | 106.78 | 4.40 | 102.38 | LTOB |
| 32.0 | 106.78 | 5.74 | 101.04 | LBKF |
| 33.0 | 106.78 | 5.98 | 100.80 | |
| 34.0 | 106.78 | 6.42 | 100.36 | |
| 34.2 | 106.78 | 6.65 | 100.13 | |
| 34.7 | 106.78 | 7.26 | 99.52 | |
| 35.3 | 106.78 | 7.43 | 99.35 | LEW/WS |
| 36.5 | 106.78 | 7.74 | 99.04 | TW |
| 37.0 | 106.78 | 7.63 | 99.15 | |
| 38.5 | 106.78 | 7.56 | 99.22 | |
| 39.5 | 106.78 | 7.42 | 99.36 | REW |
| 41.0 | 106.78 | 7.19 | 99.59 | |
| 42.0 | 106.78 | 6.82 | 99.96 | |
| 43.7 | 106.78 | 6.42 | 100.36 | |
| 44.6 | 106.78 | 5.74 | 101.04 | RBKF |
| 45.2 | 106.78 | 5.26 | 101.52 | |
| 46.4 | 106.78 | 4.90 | 101.88 | |
| 47.0 | 106.78 | 4.63 | 102.15 | |
| 48.0 | 106.78 | 4.45 | 102.33 | RTOB |
| 53.5 | 106.78 | 4.44 | 102.34 | |
| 61.0 | 106.78 | 4.25 | 102.53 | |
| 68.0 | 106.78 | 4.68 | 102.10 | |

Hydraulic Geometry

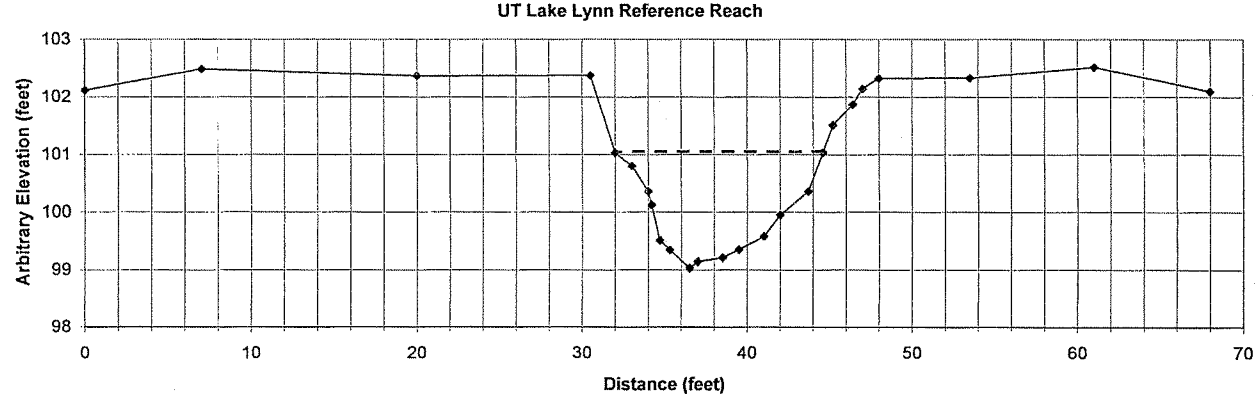
| Width (Feet) | Depth (Feet) | Area (Sq. Ft.) |
|---|---|---|
| 0.0 | 0.00 | 0.0 |
| 1.0 | 0.24 | 0.1 |
| 1.0 | 0.68 | 0.5 |
| 0.2 | 0.91 | 0.2 |
| 0.5 | 1.52 | 0.6 |
| 0.6 | 1.69 | 1.0 |
| 1.2 | 2.00 | 2.2 |
| 0.5 | 1.89 | 1.0 |
| 1.5 | 1.82 | 2.8 |
| 1.0 | 1.68 | 1.8 |
| 1.5 | 1.45 | 2.3 |
| 1.0 | 1.08 | 1.3 |
| 1.7 | 0.68 | 1.5 |
| 0.9 | 0.00 | 0.3 |
| 12.6 | | 15.4 |

<u>Summary Data</u>

| | |
|---|---|
| Area | 15.4 |
| Width | 12.6 |
| Max d | 2.00 |
| Mean d | 1.23 |
| W/D | 10.3 |
| FPA Width | 68 |
| ER | 5.4 |
| Stream Type | C5 |

**BEHI:**

| CRITERIA | VALUE | INDEX | |
|---|---|---|---|
| Bank/BKF Ht | 1.6 | 1.9 | |
| Root Depth/BKF Ht | 1.0 | 1 | |
| Root Density | 55 | 3.9 | |
| Bank Angle | 34 | 2.6 | |
| Surface Protection | 55 | 3.9 | |
| Bank Materials | sand | 5 | |
| TOTAL | | 18.3 | Low |



| | |
|---|---|
| Crew: | Jan Patterson, Heather Renninger, Amanda Todd |
| River Basin: | Neuse |
| Watershed: | Lake Lynn |
| Stream Reach: | UT Lake Lynn |
| DA (sq mi): | 0.74 |
| Date: | 3/25/2003 |
| Station: | 1+57 |
| Feature: | Riffle |

| STATION | HI (Feet) | FS (Feet) | ELEVATION (Feet) | NOTES |
|---|---|---|---|---|
| 0.0 | 106.78 | 3.50 | 103.28 | Old Road Bed/Berm |
| 42.0 | 106.78 | 5.07 | 101.71 | edge path |
| 42.0 | 106.78 | 4.60 | 102.18 | edge path |
| 58.0 | 106.78 | 4.68 | 102.10 | |
| 64.0 | 106.78 | 5.06 | 101.72 | |
| 70.0 | 106.78 | 5.16 | 101.62 | |
| 77.0 | 106.78 | 5.19 | 101.59 | |
| 83.0 | 106.78 | 5.19 | 101.59 | |
| 88.0 | 106.78 | 5.52 | 101.26 | |
| 93.5 | 106.78 | 5.98 | 100.80 | LBKF |
| 95.5 | 106.78 | 6.69 | 100.09 | |
| 97.0 | 106.78 | 7.71 | 99.07 | |
| 99.3 | 106.78 | 8.02 | 98.76 | LEW/WS |
| 100.3 | 106.78 | 8.22 | 98.56 | |
| 101.0 | 106.78 | 8.24 | 98.54 | TW |
| 101.8 | 106.78 | 8.23 | 98.55 | |
| 102.5 | 106.78 | 8.02 | 98.76 | REW |
| 105.6 | 106.78 | 7.44 | 99.34 | |
| 107.0 | 106.78 | 7.05 | 99.73 | |
| 109.1 | 106.78 | 6.45 | 100.33 | |
| 110.2 | 106.78 | 6.20 | 100.58 | |
| 112.6 | 106.78 | 5.98 | 100.80 | RBKF |
| 118.0 | 106.78 | 5.78 | 101.00 | RTOB |
| 126.0 | 106.78 | 5.70 | 101.08 | |

Hydraulic Geometry

| Width (Feet) | Depth (Feet) | Area (Sq. Ft.) |
|---|---|---|
| 0.0 | 0.00 | 0.0 |
| 2.0 | 0.71 | 0.7 |
| 1.5 | 1.73 | 1.8 |
| 2.3 | 2.04 | 4.3 |
| 1.0 | 2.24 | 2.1 |
| 0.7 | 2.26 | 1.6 |
| 0.8 | 2.25 | 1.8 |
| 0.7 | 2.04 | 1.5 |
| 3.1 | 1.46 | 5.4 |
| 1.4 | 1.07 | 1.8 |
| 2.1 | 0.47 | 1.6 |
| 1.1 | 0.22 | 0.4 |
| 2.4 | 0.00 | 0.3 |
| 19.1 | | 23.4 |

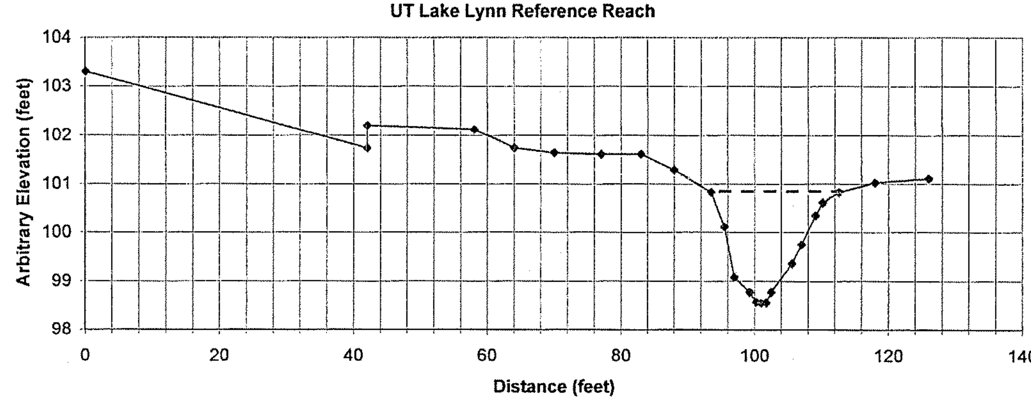
Summary Data

| | |
|---|---|
| Area | 23.4 |
| Width | 19.1 |
| Max d | 2.26 |
| Mean d | 1.22 |
| W/D | 15.6 |
| FPA Width | 126 |
| ER | 6.6 |
| Stream Type | C5 |

BEHI:

| CRITERIA | VALUE | INDEX | |
|---|---|---|---|
| Bank/BKF Ht | 1.09 | 1.8 | |
| Root Depth/BKF Ht | 1.0 | 1 | |
| Root Density | 29 | 6 | |
| Bank Angle | 32 | 2.5 | |
| Surface Protection | 30 | 5.9 | |
| Bank Materials | sand | 5 | |
| TOTAL | | 22.2 | Moderate |

Riffle Cross Section
Station 1+57
UT Lake Lynn Reference Reach



| | |
|---|---|
| **Crew:** | Jan Patterson, Heather Renninger, Amanda Todd |
| **River Basin:** | Neuse |
| **Watershed:** | Lake Lynn |
| **Stream Reach:** | UT Lake Lynn |
| **DA (sq mi):** | 0.74 |
| **Date:** | 3/25/2003 |
| **Station:** | 1+82 |
| **Feature:** | Pool |

| STATION | HI (Feet) | FS (Feet) | ELEVATION (Feet) | NOTES |
|---|---|---|---|---|
| 0.0 | 106.78 | 5.76 | 101.02 | |
| 3.4 | 106.78 | 5.30 | 101.48 | LTOB |
| 5.1 | 106.78 | 6.00 | 100.78 | |
| 5.6 | 106.78 | 6.43 | 100.35 | LBKF |
| 5.7 | 106.78 | 7.35 | 99.43 | |
| 6.0 | 106.78 | 8.59 | 98.19 | LEW |
| 7.2 | 106.78 | 8.70 | 98.08 | TW |
| 8.5 | 106.78 | 8.55 | 98.23 | |
| 10.3 | 106.78 | 8.40 | 98.38 | |
| 12.0 | 106.78 | 8.50 | 98.28 | |
| 13.2 | 106.78 | 8.24 | 98.54 | REW |
| 14.2 | 106.78 | 7.92 | 98.86 | |
| 15.2 | 106.78 | 7.45 | 99.33 | |
| 16.0 | 106.78 | 7.34 | 99.44 | |
| 18.5 | 106.78 | 6.43 | 100.35 | RBKF/RTOB |
| 23.0 | 106.78 | 6.28 | 100.50 | |
| 31.0 | 106.78 | 5.16 | 101.62 | |

**Hydraulic Geometry**

| Width (Feet) | Depth (Feet) | Area (Sq. Ft.) |
|---|---|---|
| 0.0 | 0.00 | 0.0 |
| 0.1 | 0.92 | 0.0 |
| 0.3 | 2.16 | 0.5 |
| 1.2 | 2.27 | 2.7 |
| 1.3 | 2.12 | 2.9 |
| 1.8 | 1.97 | 3.7 |
| 1.7 | 2.07 | 3.4 |
| 1.2 | 1.81 | 2.3 |
| 1.0 | 1.49 | 1.6 |
| 1.0 | 1.02 | 1.3 |
| 0.8 | 0.91 | 0.8 |
| 2.5 | 0.00 | 1.1 |
| 12.9 | | 20.3 |

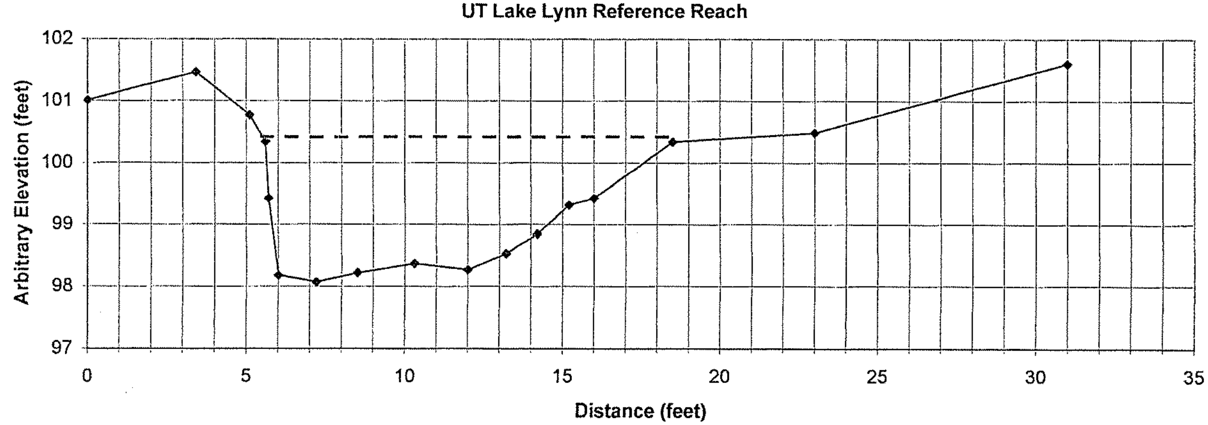
**Summary Data**

| | |
|---|---|
| Area | 20.3 |
| Width | 12.9 |
| Max d | 2.27 |
| Mean d | 1.57 |

**BEHI:**

| CRITERIA | VALUE | INDEX | |
|---|---|---|---|
| Bank/BKF Ht | 1.0 | 1 | |
| Root Depth/BKF Ht | 1.0 | 1 | |
| Root Density | 55 | 3.9 | |
| Bank Angle | 55 | 3.7 | |
| Surface Protection | 65 | 3.1 | |
| Bank Materials | sand | 5 | |
| TOTAL | | 17.7 | Low |

**Pool Cross Section**
**Station 1+82**
**UT Lake Lynn Reference Reach**



## PATTERN MEASUREMENTS
**UT Lake Lynn Reference Reach**

**Radius of Curvature**

| Chord Length | Mid Ordinate | Radius of Curvature | Rc/Bkf W |
|---|---|---|---|
| 18 | 1.9 | 22.3 | 1.4 |
| 30 | 1.4 | 81.1 | 5.1 |
| 26 | 4.5 | 21.0 | 1.3 |
| 23 | 3.9 | 18.9 | 1.2 |
| | ave | 35.8 | 2.3 |
| | min | 18.9 | 1.2 |
| | max | 81.1 | 5.1 |

**Bankfull Width=**

| | |
|---|---|
| US | 12.6 |
| DS | 19.1 |
| AVE | 15.9 |

**Meander Wavelength**

| | Meander Wavelength (ft) | Lm/Bkf W |
|---|---|---|
| | 42 | 3.3 |
| | 44 | 3.5 |
| | 59 | 4.7 |
| | 56 | 4.4 |
| ave | 50.3 | 4.0 |
| min | 42.0 | 3.3 |
| max | 59.0 | 4.7 |

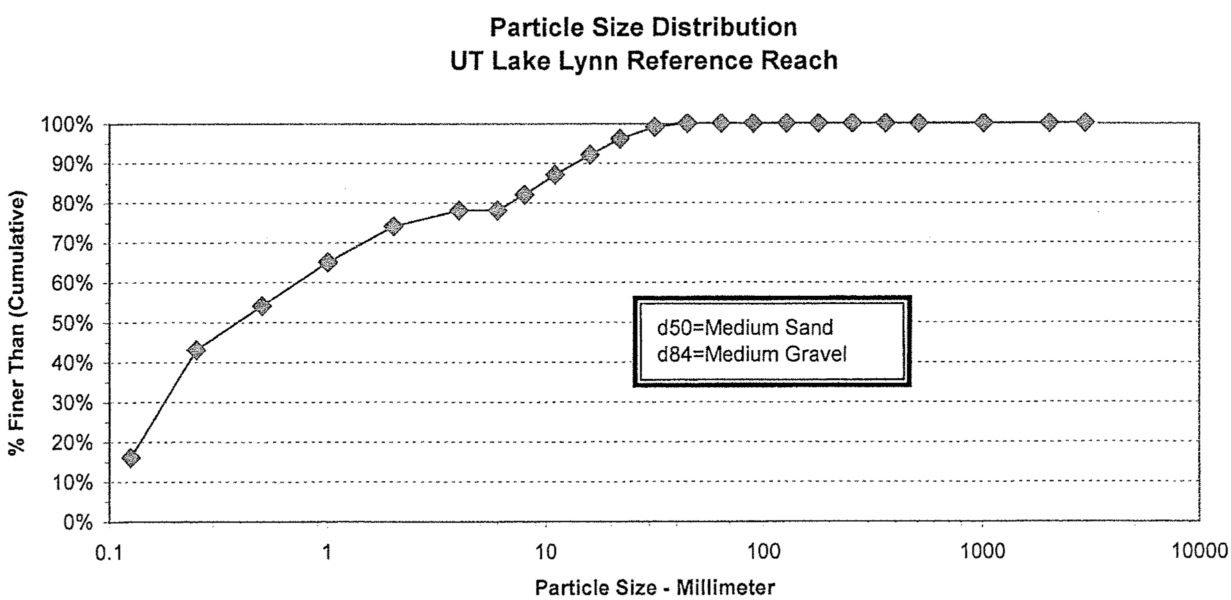
**Meander Width Ratio**

| | Belt Width (ft) | Meander Width Ratio |
|---|---|---|
| | 33 | 2.6 |
| | 23 | 1.8 |
| | 22 | 1.7 |
| | 17 | 1.3 |
| | 23 | 1.8 |
| ave | 23.6 | 1.9 |
| min | 17.0 | 1.3 |
| max | 33.0 | 2.6 |

**Sinuosity**

Sinuosity = $\frac{\text{Stream Length}}{\text{Valley Length}} = \frac{212}{170}$ 1.25

| PEBBLE COUNT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Site: Lake Lynn, Raleigh, NC | | | | | | | | Date: 3/25/03 |
| Party: J. Patterson, A. Todd, H. Renninger | | | | | Reach: | UT Lake Lynn | | |
| Notes: | Sand channel with gravel riffles | | | | | | | |
| Inches | Particle | Millimeter | | Particle Count | | Total No. | Item % | % Cumulative |
| | Silt/Clay | < 0.062 | S/C | 2 | 2 | 4 | 4% | 4% |
| | Very Fine | .062 - .125 | S | 5 | 7 | 12 | 12% | 16% |
| | Fine | .125 - .25 | A | 12 | 15 | 27 | 27% | 43% |
| | Medium | .25 - .50 | N | 4 | 7 | 11 | 11% | 54% |
| | Coarse | .50 - 1.0 | D | 3 | 8 | 11 | 11% | 65% |
| .04 -.08 | Very Coarse | 1.0 - 2.0 | | 5 | 4 | 9 | 9% | 74% |
| .08 - .16 | Very Fine | 2.0 - 4.0 | | 1 | 3 | 4 | 4% | 78% |
| .16 - .22 | Fine | 4.0 - 5.7 | G | | | 0 | 0% | 78% |
| .22 - .31 | Fine | 5.7 - 8.0 | R | 3 | 1 | 4 | 4% | 82% |
| .31 - .44 | Medium | 8.0 - 11.3 | A | 4 | 1 | 5 | 5% | 87% |
| .44 - .63 | Medium | 11.3 - 16.0 | V | 4 | 1 | 5 | 5% | 92% |
| .63 - .89 | Coarse | 16.0 - 22.6 | E | 3 | 1 | 4 | 4% | 96% |
| .89 - 1.26 | Coarse | 22.6 - 32.0 | L | 3 | | 3 | 3% | 99% |
| 1.26 - 1.77 | Very Coarse | 32.0 - 45.0 | | 1 | | 1 | 1% | 100% |
| 1.77 - 2.5 | Very Coarse | 45.0 - 64.0 | | | | 0 | 0% | 100% |
| 2.5 - 3.5 | Small | 64 - 90 | C | | | 0 | 0% | 100% |
| 3.5 - 5.0 | Small | 90 - 128 | O | | | 0 | 0% | 100% |
| 5.0 - 7.1 | Large | 128 - 180 | B | | | 0 | 0% | 100% |
| 7.1 - 10.1 | Large | 180 - 256 | L | | | 0 | 0% | 100% |
| 10.1 - 14.3 | Small | 256 - 362 | B | | | 0 | 0% | 100% |
| 14.3 - 20 | Small | 362 - 512 | L | | | 0 | 0% | 100% |
| 20 - 40 | Medium | 512 - 1024 | D | | | 0 | 0% | 100% |
| 40 - 80 | Lrg- Very Lrg | 1024 - 2048 | R | | | 0 | 0% | 100% |
| | Bedrock | | BDRK | | | 0 | 0% | 100% |
| | | | **Totals** | **50** | **50** | **100** | **100%** | **100%** |



# Longitudinal Profile
# Brookhaven Reference Reach

| | |
|---|---|
| Basin: | Neuse |
| Watershed: | Crabtree |
| Reach: | Brookhaven |
| Date: | 8/15/98 |
| Crew: | Will, Greg, Jim, Karen, Ron, and Lynn |
| Purpose: | Site Characterization - reference reach |

Longitudinal Profile

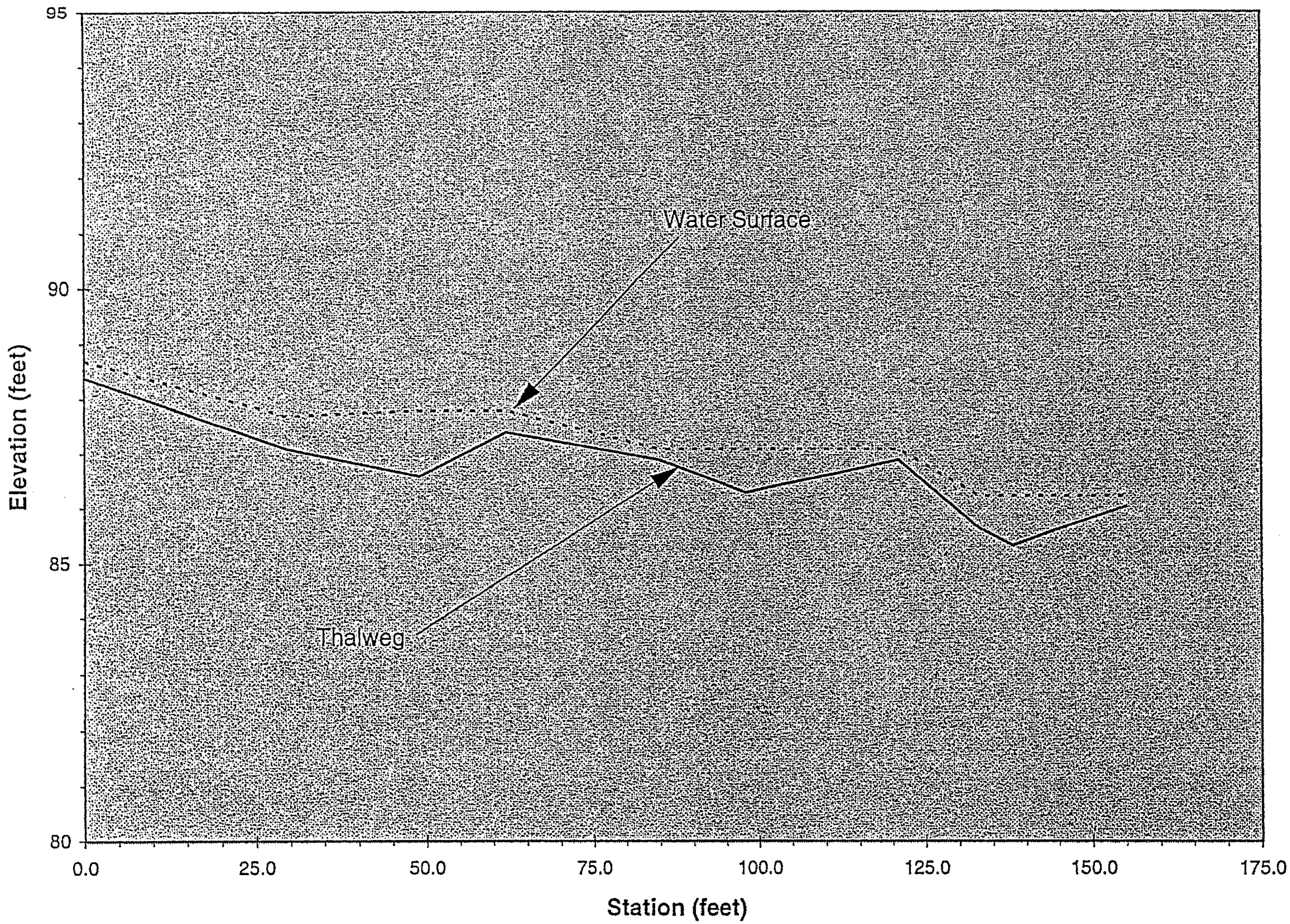
| Station | Elevation-thalweg | Elevation-water surface |
|---|---|---|
| 0 | 88.4 | 88.7 |
| 30 | 87.1 | 87.7 |
| 49 | 86.6 | 87.8 |
| 62 | 87.4 | 87.8 |
| 85 | 86.9 | 87.1 |
| 98 | 86.3 | 87.1 |
| 121 | 86.9 | 87.1 |
| 133 | 85.6 | 86.2 |
| 138 | 85.3 | 86.2 |
| 155 | 86.0 | 86.2 |

| | |
|---|---|
| **Water Surface Slope** | **0.016** |
| Stream Length | 155 |
| Valley Length | 91 |
| **Sinuosity** | **1.7** |

**Channel Pattern:**

| | |
|---|---|
| Meander Length | 47 feet |
| Belt Width | 28 - 41 feet |
| Radius of Curvature | 12 - 35 feet |

Longitudinal Profile
Brookhaven Reference Reach



## Cross Section - Station 0+12.5 (Riffle)
## Brookhaven Reference Reach

Basin: Neuse
Watershed: Crabtree
Reach: Brookhaven
Date: 8/15/98
Crew: Will, Greg, Jim, Karen, Ron, and Lynn
Purpose: Site Characterization - reference reach

Permanent Cross Section 0+12.5

| Station | HI Feet | FS Feet | Elevation Feet | NOTES |
|---|---|---|---|---|
| 0.0 | 93.99 | 1.5 | 92.5 | |
| 0.1 | | 2.0 | 92.0 | |
| 1.5 | | 2.5 | 91.5 | |
| 2.1 | | 3.2 | 90.8 | |
| 2.2 | | 4.3 | 89.7 | |
| 2.3 | | 4.5 | 89.5 | |
| **2.8** | | **4.9** | **89.1** | LBKF |
| **3.5** | | **5.2** | **88.8** | |
| **4.1** | | **5.3** | **88.7** | |
| **4.5** | | **5.5** | **88.5** | |
| **5.5** | | **5.6** | **88.4** | |
| **5.6** | | **5.6** | **88.4** | |
| **6.0** | | **5.7** | **88.3** | |
| **6.7** | | **5.7** | **88.3** | |
| **7.6** | | **5.7** | **88.3** | |
| **8.4** | | **5.6** | **88.4** | |
| **8.7** | | **5.8** | **88.2** | |
| **9.1** | | **5.9** | **88.1** | TW |
| **9.5** | | **5.7** | **88.3** | |
| **9.9** | | **5.5** | **88.5** | REW |
| **10.6** | | **5.4** | **88.6** | |
| **11.5** | | **5.1** | **88.9** | |
| **12.0** | | **5.0** | **89.0** | |
| **12.8** | | **4.9** | **89.1** | RBKF |
| 14.3 | | 4.6 | 89.4 | |
| 15.8 | | 4.3 | 89.7 | |
| 18.0 | | 4.1 | 89.9 | |

**BKF Hydraulic Geometry**

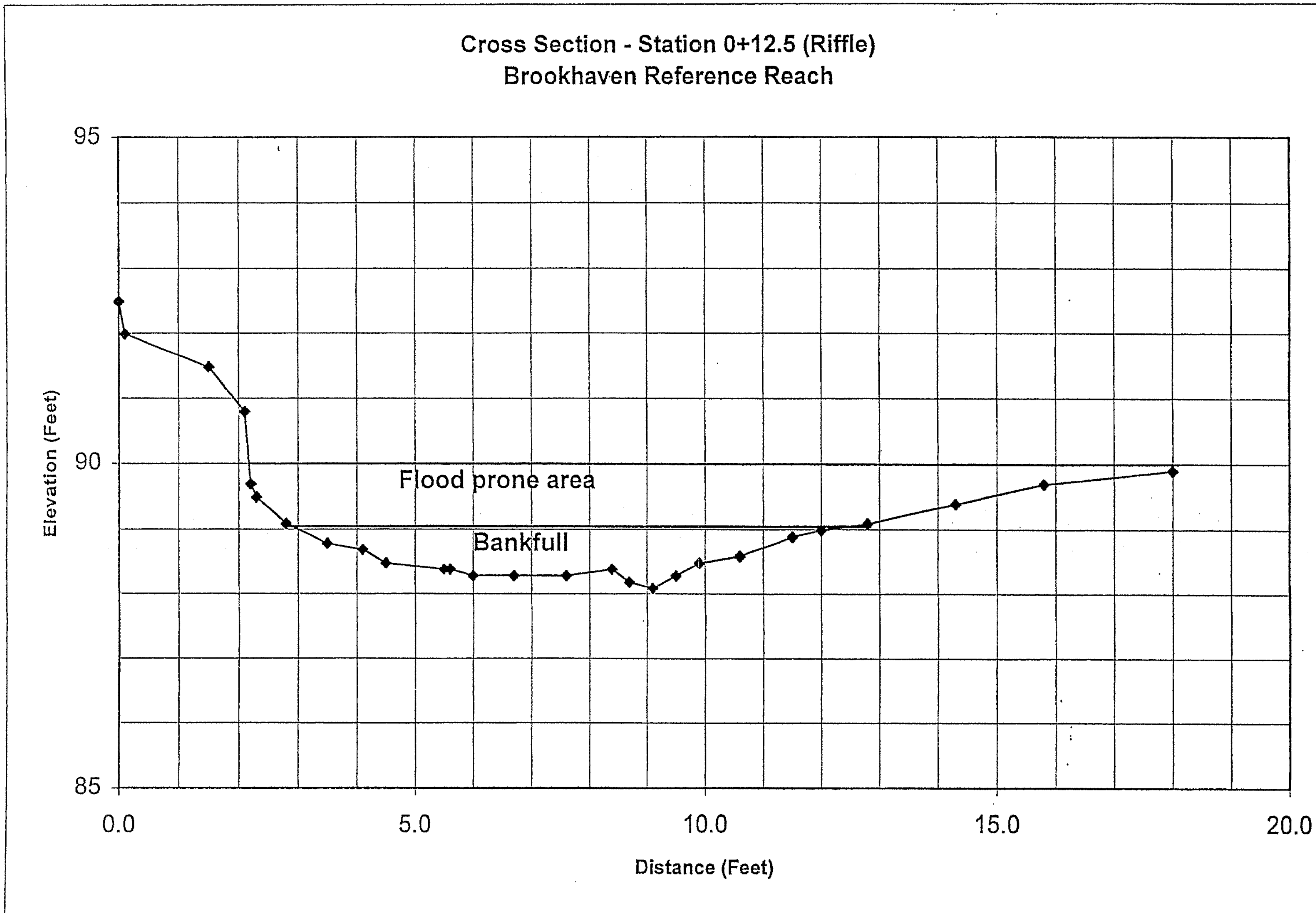
| Width Feet | Depth Feet | Area Sq. Ft. |
|---|---|---|
| 0 | 0.0 | 0.0 |
| 0.7 | 0.3 | 0.1 |
| 0.6 | 0.4 | 0.2 |
| 0.4 | 0.6 | 0.2 |
| 1 | 0.7 | 0.6 |
| 0.1 | 0.7 | 0.1 |
| 0.4 | 0.8 | 0.3 |
| 0.7 | 0.8 | 0.6 |
| 0.9 | 0.8 | 0.7 |
| 0.8 | 0.7 | 0.6 |
| 0.3 | 0.9 | 0.2 |
| 0.4 | 1.0 | 0.4 |
| 0.4 | 0.8 | 0.4 |
| 0.4 | 0.6 | 0.3 |
| 0.7 | 0.5 | 0.4 |
| 0.9 | 0.2 | 0.3 |
| 0.5 | 0.1 | 0.1 |
| 0.8 | 0.0 | 0.0 |
| 10 | | 5.5 |

Regional Curve (Rural)

| | |
|---|---|
| Watershed Size (sq mi) | 0.14 |
| Bkf A (Regional Curve) | 4.5 |
| Bkf W (Regional Curve) | 6.5 |
| Bkf D (Regional Curve) | 0.7 |

Summary Data

| | |
|---|---|
| BKF A | 5.5 |
| BKF W | 10 |
| Max d | 1.0 |
| Mean d | 0.55 |
| W/D Ratio | 18.2 |
| FP W | 33 |
| ER | 3.3 |
| Str Type | C4 |


Cross Section - Station 0+12.5 (Riffle)
Brookhaven Reference Reach
95
90
85
Elevation (Feet)
Flood prone area
Bankfull
0.0
5.0
10.0
15.0
20.0
Distance (Feet)

## Cross Section - Station 0+49 (Pool)
## Brookhaven Reference Reach

| | |
|---|---|
| Basin: | Neuse |
| Watershed: | Crabtree |
| Reach: | Brookhaven |
| Date: | 8/15/98 |
| Crew: | Will, Greg, Jim, Karen, Ron, and Lynn |
| Purpose: | Site Characterization - reference reach |

**Permanent Cross Section 0+49**

| Station | HI Feet | FS Feet | Elevation Feet | NOTES |
|---|---|---|---|---|
| 0 | 93.99 | 2 | 92.0 | LTOP |
| **0.65** | | **5.1** | **88.9** | **LBKF** |
| **1.3** | | **7.3** | **86.7** | **Undercut bank** |
| **2.3** | | **7.3** | **86.7** | **TW** |
| **3** | | **7.2** | **86.8** | |
| **4.8** | | **6.5** | **87.5** | |
| **5.7** | | **6.2** | **87.8** | **REW** |
| **7.6** | | **5.5** | **88.5** | |
| **8** | | **5.4** | **88.6** | |
| **9** | | **5.1** | **88.9** | **RBKF** |
| 10.8 | | 4.9 | 89.1 | |
| 13.4 | | 4.7 | 89.3 | |
| 15 | | 4.4 | 89.6 | |
| 16.8 | | 4.1 | 89.9 | |

**BKF Hydraulic Geometry**

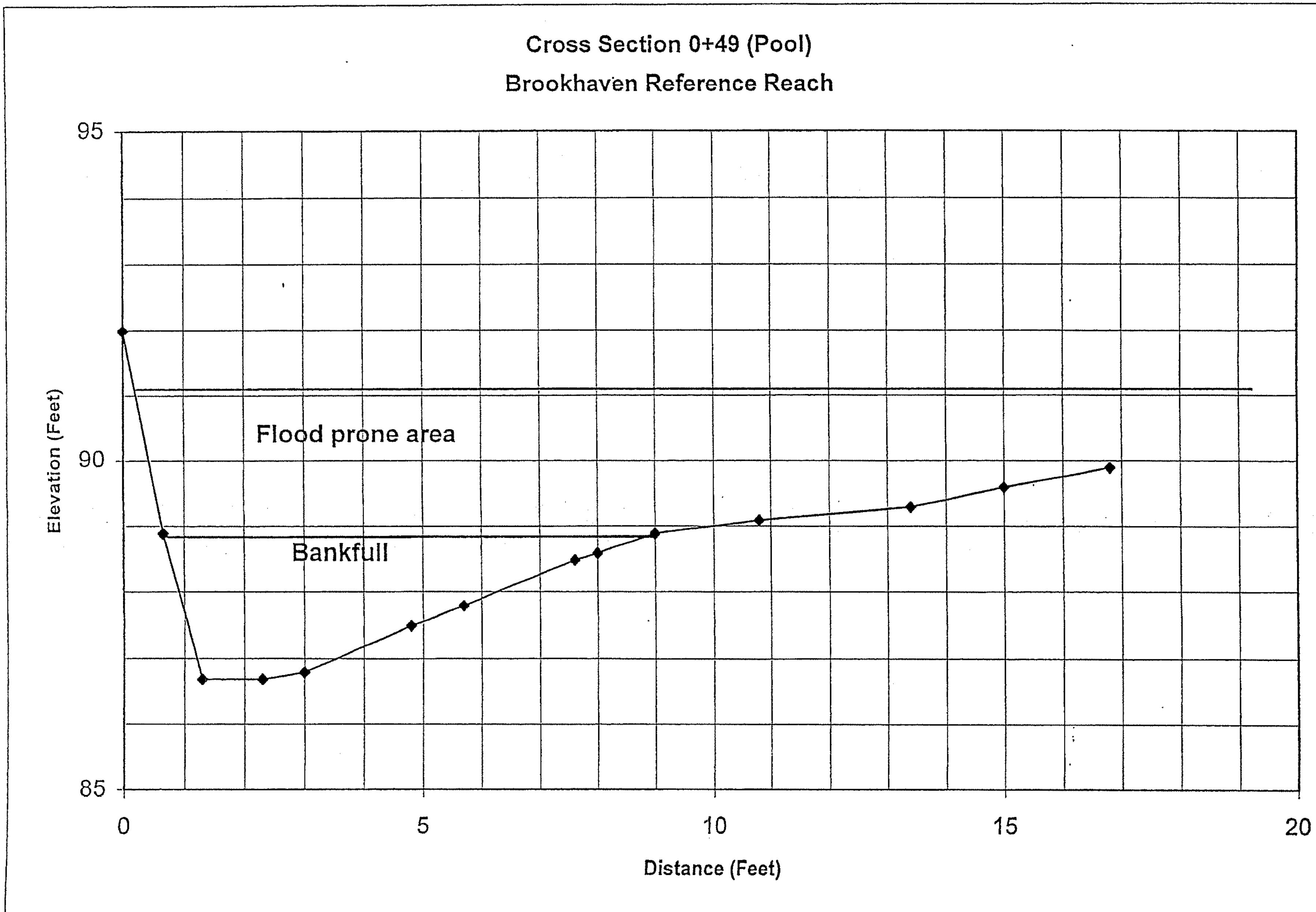
| Width Feet | Depth Feet | Area Sq. Ft. |
|---|---|---|
| 0 | 0 | 0 |
| 0.65 | 2.2 | 0.7 |
| 1 | 2.2 | 2.2 |
| 0.7 | 2.1 | 1.5 |
| 1.8 | 1.4 | 3.2 |
| 0.9 | 1.1 | 1.1 |
| 1.9 | 0.4 | 1.4 |
| 0.4 | 0.3 | 0.1 |
| 1 | 0 | 0.2 |
| 8.35 | | 10.4 |

**Regional Curve (Rural)**

| | |
|---|---|
| Watershed Size (sq mi) | 0.14 |
| Bkf A (Regional Curve) | 4.5 |
| Bkf W (Regional Curve) | 6.5 |
| Bkf D (Regional Curve) | 0.7 |

**Summary Data**

| | |
|---|---|
| BKF A | 10.4 |
| BKF W | 8.35 |
| Max d | 2.2 |
| Mean d | 1.2 |
| W/D Ratio | 6.7 |
| FP W | |
| ER | >2.2 |


Cross Section 0+49 (Pool)
Brookhaven Reference Reach
Elevation (Feet)
95
90
85
0
5
10
15
20
Distance (Feet)
Flood prone area
Bankfull

# Cross Section - Station 0+97 (Pool)
# Brookhaven Reference Reach

| | |
|---|---|
| Basin: | Neuse |
| Watershed: | Crabtree |
| Reach: | Brookhaven |
| Date: | 8/15/98 |
| Crew: | Will, Greg, Jim, Karen, Ron, and Lynn |
| Purpose: | Site Characterization - reference reach |

**Permanent Cross Section 0+97**

| Station | HI Feet | FS Feet | Elevation Feet | NOTES |
|---|---|---|---|---|
| 0 | 91.94 | 1.9 | 90.0 | |
| 4.5 | | 3.5 | 88.4 | |
| **6.8** | | **3.8** | **88.1** | LBKF |
| **10** | | **4.3** | **87.6** | |
| **11.4** | | **4.9** | **87.0** | |
| **12.6** | | **5.4** | **86.5** | |
| **14.4** | | **5.7** | **86.2** | |
| **17.2** | | **4.9** | **87.0** | REW |
| **17.9** | | **4.3** | **87.6** | |
| **18.1** | | **3.8** | **88.1** | RBKF |
| 18.9 | | 1.3 | 90.6 | RTOB |

**BKF Hydraulic Geometry**

| Width Feet | Depth Feet | Area Sq. Ft. |
|---|---|---|
| 0 | 0 | 0.0 |
| 3.2 | 0.5 | 0.8 |
| 1.4 | 1.1 | 1.1 |
| 1.2 | 1.6 | 1.6 |
| 1.8 | 1.9 | 3.2 |
| 2.8 | 1.1 | 4.2 |
| 0.7 | 0.5 | 0.6 |
| 0.2 | 0 | 0.1 |
| 11.3 | | 11.5 |

**Regional Curve (Rural)**

| | |
|---|---|
| Watershed Size (sq mi) | 0.14 |
| Bkf A (Regional Curve) | 4.5 |
| Bkf W (Regional Curve) | 6.5 |
| Bkf D (Regional Curve) | 0.7 |

**Summary Data**

| | |
|---|---|
| BKF A | 11.5 |
| BKF W | 11.3 |
| Max d | 1.9 |
| Mean d | 1.0 |
| W/D Ratio | 11.1 |
| FP W | |
| ER | >2.2 |

# Cross Section - Station 0+97 (Pool)
## Brookhaven Reference Reach

Basin: Neuse
Watershed: Crabtree
Reach: Brookhaven
Date: 8/15/98
Crew: Will, Greg, Jim, Karen, Ron, and Lynn
Purpose: Site Characterization - reference reach

**Permanent Cross Section 0+97**

| Station | HI Feet | FS Feet | Elevation Feet | NOTES |
|---|---|---|---|---|
| 0 | 91.94 | 1.9 | 90.0 | |
| 4.5 | | 3.5 | 88.4 | |
| **6.8** | | **3.8** | **88.1** | **LBKF** |
| **10** | | **4.3** | **87.6** | |
| **11.4** | | **4.9** | **87.0** | |
| **12.6** | | **5.4** | **86.5** | |
| **14.4** | | **5.7** | **86.2** | **TW** |
| **17.2** | | **4.9** | **87.0** | **REW** |
| **17.9** | | **4.3** | **87.6** | |
| **18.1** | | **3.8** | **88.1** | **RBKF** |
| 18.9 | | 1.3 | 90.6 | RTOB |

**BKF Hydraulic Geometry**

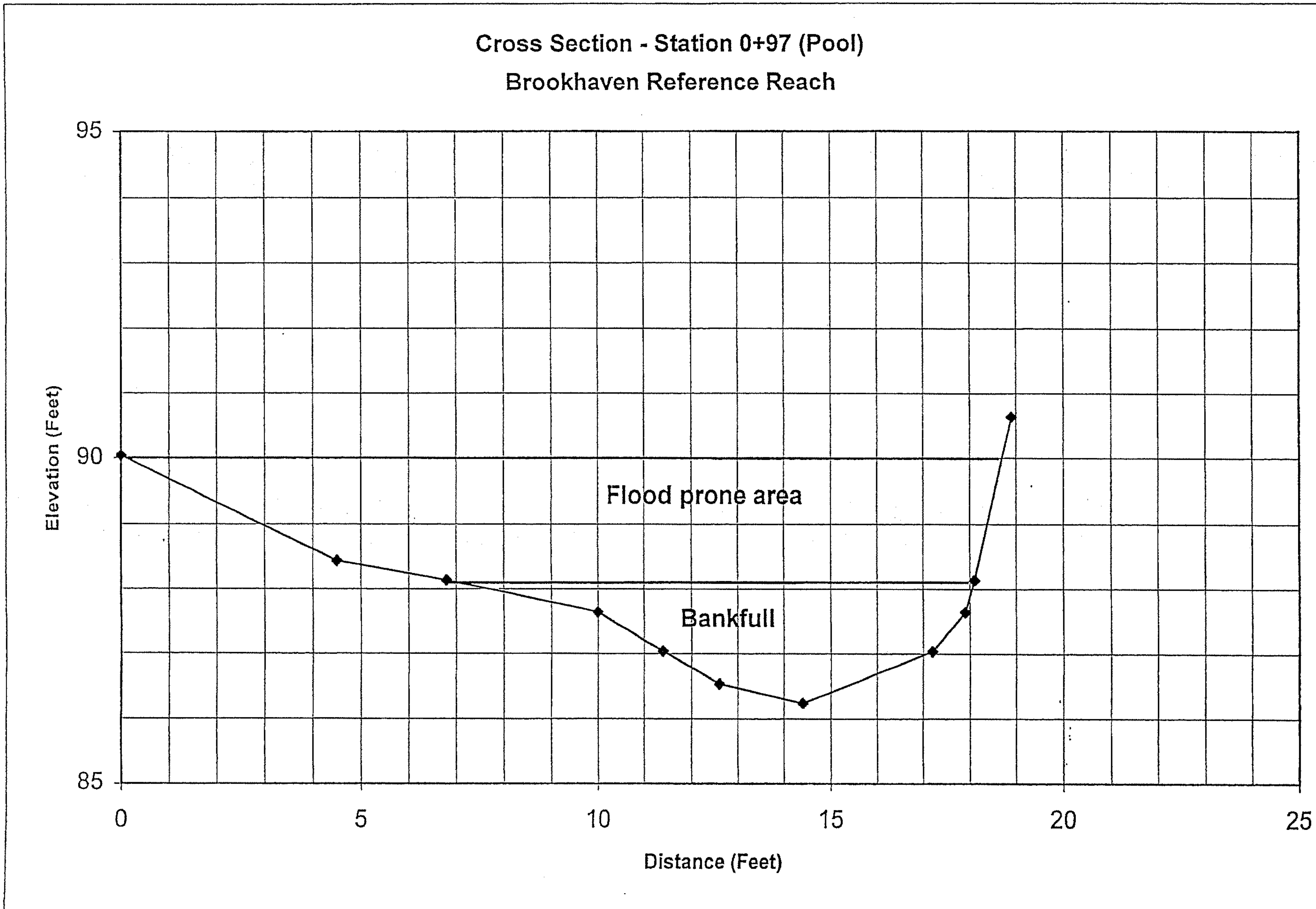
| Width Feet | Depth Feet | Area Sq. Ft. |
|---|---|---|
| 0 | 0 | 0.0 |
| 3.2 | 0.5 | 0.8 |
| 1.4 | 1.1 | 1.1 |
| 1.2 | 1.6 | 1.6 |
| 1.8 | 1.9 | 3.2 |
| 2.8 | 1.1 | 4.2 |
| 0.7 | 0.5 | 0.6 |
| 0.2 | 0 | 0.1 |
| 11.3 | | 11.5 |

**Regional Curve (Rural)**

| | |
|---|---|
| Watershed Size (sq mi) | 0.14 |
| Bkf A (Regional Curve) | 4.5 |
| Bkf W (Regional Curve) | 6.5 |
| Bkf D (Regional Curve) | 0.7 |

**Summary Data**

| | |
|---|---|
| BKF A | 11.5 |
| BKF W | 11.3 |
| Max d | 1.9 |
| Mean d | 1.0 |
| W/D Ratio | 11.1 |
| FP W | 19 |
| ER | 1.7 |


Cross Section - Station 0+97 (Pool)
Brookhaven Reference Reach
Elevation (Feet)
95
90
85
Flood prone area
Bankfull
0
5
10
15
20
25
Distance (Feet)

# Cross Section - Station 1+24 (Riffle)
## Brookhaven Reference Reach

Basin: Neuse
Watershed: Crabtree
Reach: Brookhaven
Date: 8/15/98
Crew: Will, Greg, Jim, Karen, Ron, and Lynn
Purpose: Site Characterization - reference reach

**Permanent Cross Section 1+24**

| Station | HI Feet | FS Feet | Elevation Feet | NOTES |
|---|---|---|---|---|
| 0 | 95.47 | 4.8 | 90.7 | LTOB |
| 3.3 | | 6.6 | 88.9 | |
| 9.4 | | 7 | 88.5 | |
| **12.9** | | **7.4** | **88.1** | LBKF |
| **16.8** | | **7.8** | **87.7** | |
| **17.1** | | **8.3** | **87.2** | |
| **19.8** | | **8.2** | **87.3** | |
| **21.8** | | **8.5** | **87.0** | LEW |
| **23.6** | | **8.6** | **86.9** | TW |
| **26.6** | | **8.5** | **87.0** | REW |
| **28** | | **7.8** | **87.7** | |
| **28.5** | | **7.4** | **88.1** | RBKF |
| 29.8 | | 5.3 | 90.2 | RTOB |

**BKF Hydraulic Geometry**

| Width Feet | Depth Feet | Area Sq. Ft. |
|---|---|---|
| 0 | 0 | 0.0 |
| 3.9 | 0.4 | 0.8 |
| 0.3 | 0.9 | 0.2 |
| 2.7 | 0.8 | 2.3 |
| 2 | 1.1 | 1.9 |
| 1.8 | 1.2 | 2.1 |
| 3 | 1.1 | 3.5 |
| 1.4 | 0.4 | 1.1 |
| 0.5 | 0 | 0.1 |
| 15.6 | | 11.8 |

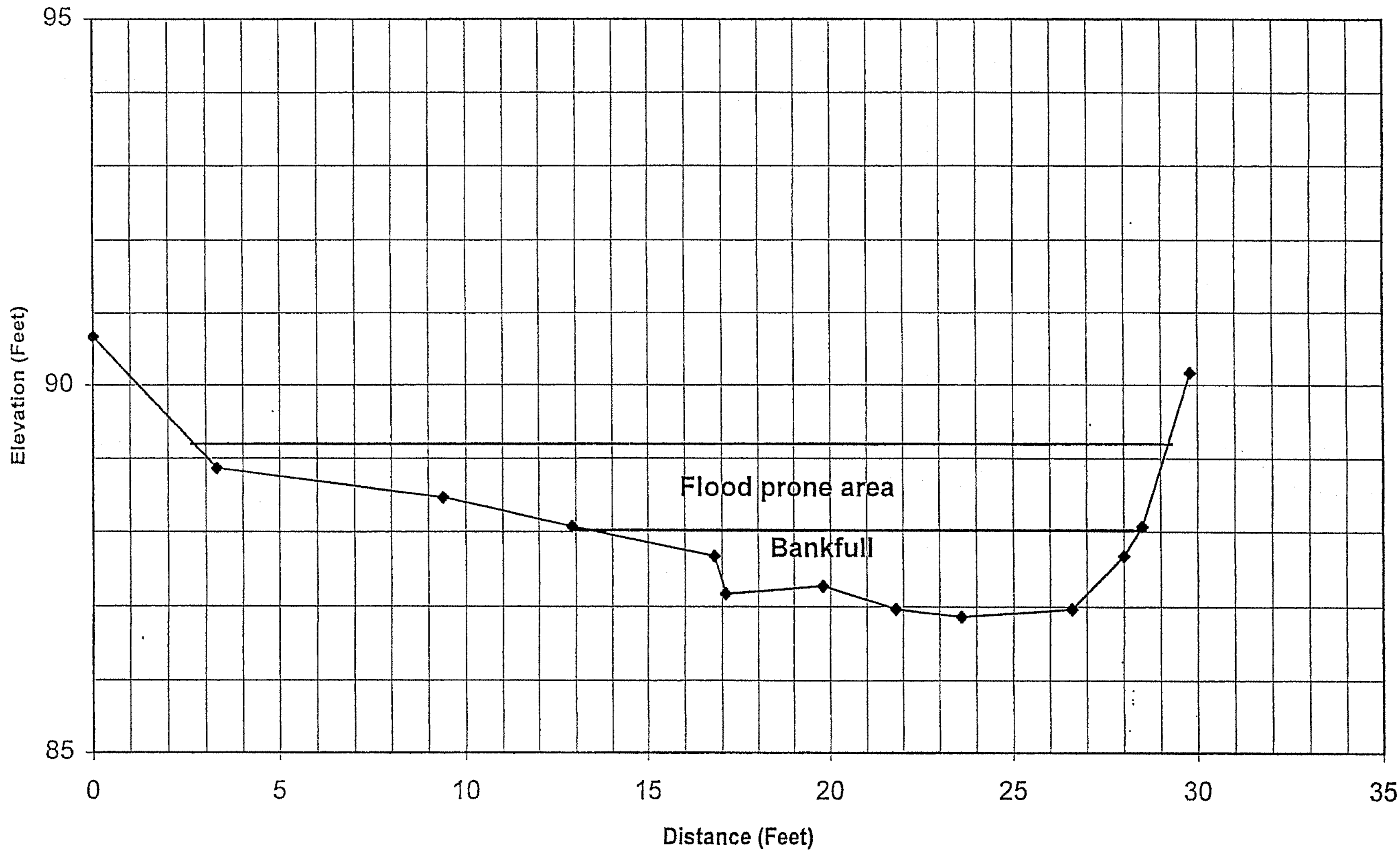
**Regional Curve (Rural)**

| | |
|---|---|
| Watershed Size (sq mi) | 0.14 |
| Bkf A (Regional Curve) | 4.5 |
| Bkf W (Regional Curve) | 6.5 |
| Bkf D (Regional Curve) | 0.7 |

**Summary Data**

| | |
|---|---|
| BKF A | 11.8 |
| BKF W | 15.6 |
| Max d | 1.2 |
| Mean d | 0.8 |
| W/D Ratio | 20.6 |
| FP W | 29 |
| ER | 1.9 |
| Str Type | C4 |

Cross Section - Station 1+24 (Riffle)
Brookhaven Reference Reach



Pebble Count
Brookhaven Reference Reach

| PEBBLE COUNT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Site: Brookhaven Nature Park | | | | | Date: 8/15/98 | | | |
| Party: Jim Buck, Karen Hall, Gregg Jennings, Will Harman | | | | | Reach: Trib - Hare Snipe Creek | | | |
| | | | | Particle Counts | | | | |
| Inches | Particle | Millimeter | | Riffles | Pools | Total No. | Item % | % Cumulative |
| | Silt/Clay | < 0.062 | S/C | 0 | 4 | 4 | 4% | 4% |
| | Very Fine | .062 - .125 | S | 1 | 0 | 1 | 1% | 5% |
| | Fine | .125 - .25 | A | 2 | 1 | 3 | 3% | 8% |
| | Medium | .25 - .50 | N | 0 | 4 | 4 | 4% | 12% |
| | Coarse | .50 - 1.0 | D | 0 | 7 | 7 | 7% | 19% |
| .04 -.08 | Very Coarse | 1.0 - 2.0 | S | 5 | 2 | 7 | 7% | 26% |
| .08 - .16 | Very Fine | 2.0 - 4.0 | | 2 | 6 | 8 | 8% | 34% |
| .16 - .22 | Fine | 4.0 - 5.7 | G | 0 | 5 | 5 | 5% | 39% |
| .22 - .31 | Fine | 5.7 - 8.0 | R | 2 | 2 | 4 | 4% | 43% |
| .31 - .44 | Medium | 8.0 - 11.3 | A | 1 | 2 | 3 | 3% | 46% |
| .44 - .63 | Medium | 11.3 - 16.0 | V | 2 | 2 | 4 | 4% | 50% |
| .63 - .89 | Coarse | 16.0 - 22.6 | E | 4 | 4 | 8 | 8% | 58% |
| .89 - 1.26 | Coarse | 22.6 - 32.0 | L | 4 | 3 | 7 | 7% | 65% |
| 1.26 - 1.77 | Very Coarse | 32.0 - 45.0 | S | 2 | 8 | 10 | 10% | 75% |
| 1.77 - 2.5 | Very Coarse | 45.0 - 64.0 | | 4 | 2 | 6 | 6% | 81% |
| 2.5 - 3.5 | Small | 64 - 90 | C | 7 | 5 | 12 | 12% | 93% |
| 3.5 - 5.0 | Small | 90 - 128 | O | 4 | 1 | 5 | 5% | 98% |
| 5.0 - 7.1 | Large | 128 - 180 | B | 0 | 1 | 1 | 1% | 99% |
| 7.1 - 10.1 | Large | 180 - 256 | L | 0 | 0 | 0 | 0% | 99% |
| 10.1 - 14.3 | Small | 256 - 362 | B | 0 | 0 | 0 | 0% | 99% |
| 14.3 - 20 | Small | 362 - 512 | L | 0 | 0 | 0 | 0% | 99% |
| 20 - 40 | Medium | 512 - 1024 | D | 0 | 0 | 0 | 0% | 99% |
| 40 - 80 | Lrg- Very Lrg | 1024 - 2048 | R | 0 | 0 | 0 | 0% | 99% |
| | Bedrock | | BDRK | 0 | 1 | 1 | 1% | 100% |
| | | | **Totals** | **40** | **60** | **100** | **100%** | **100%** |