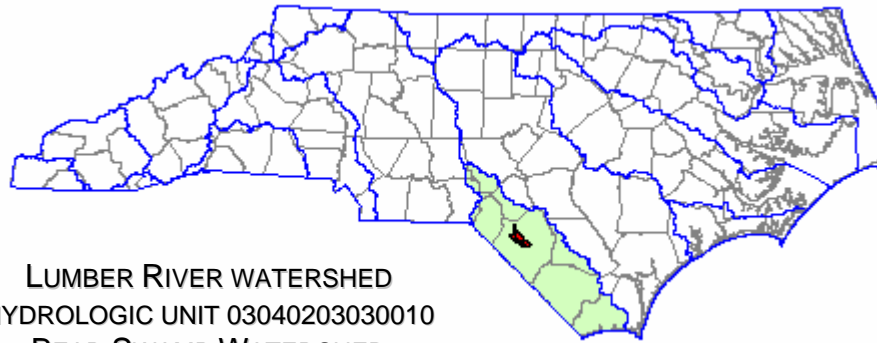


# LUMBER RIVER TECHNICAL WATERSHED ASSESSMENT WATERSHED MANAGEMENT PLAN



LUMBER RIVER WATERSHED  
HYDROLOGIC UNIT 03040203030010  
BEAR SWAMP WATERSHED  
HYDROLOGIC UNIT 03040203050010  
ROBESON COUNTY, NORTH CAROLINA



Ecosystem Enhancement Program  
1619 Mail Service Center  
Raleigh, NC 27603



A **tyco** International Ltd. Company

Earth Tech of North Carolina, Inc.  
701 Corporate Center Drive, Suite 475  
Raleigh, NC 27607

February 2006



## **Table of Contents**

1.0 INTRODUCTION .....	1
1.1 Management Context.....	1
1.2 Summary of Initial Watershed Characterization .....	4
1.3 Summary of Critical Area Analysis .....	6
2.0 GOALS AND OBJECTIVES.....	9
3.0 PRACTICES FOR ACHIEVING OBJECTIVES .....	11
3.1 Management settings .....	11
3.1.1 Croplands .....	11
3.1.2 Livestock Operations .....	12
3.1.3 Urban Areas .....	13
3.2 Management Targets .....	14
3.2.1 Sediment.....	14
3.2.2 Nitrogen and Phosphorus .....	16
3.2.3 Stormwater .....	16
3.3 Management Practices.....	18
3.3.1 Stream Restoration.....	18
3.3.2 Wetland Restoration.....	21
3.3.3 Croplands Management Practices .....	23
3.3.4 Livestock Operations Management Practices .....	26
3.3.5 Urban Area Management Practices.....	27
3.3.6 Land Use Ordinances .....	31
4.0 IMPLEMENTATION OF MANAGEMENT PLAN .....	35
4.1 Project Types .....	35
4.2 Potential Projects .....	38
5.0 RESOURCES FOR IMPLEMENTATION.....	61
6.0 TIME FACTORS.....	73
7.0 MONITORING AND EVALUATION.....	74
7.1 Monitoring Criteria.....	74
7.2 DWQ Monitoring .....	75
7.3 EEP Monitoring.....	76
7.4 BMPs .....	77
8.0 BIBLIOGRAPHY.....	79
9.0 GIS Metadata.....	83

**Tables**

Table 1. General Practices for Achieving Management Objectives .....	10
Table 2. Management Practices and Their Appropriate Settings and Targets.....	11
Table 3. Estimated Potential Sediment Export Rates for Various Land Uses.....	15
Table 4. Criteria for Conventional Mitigation Types .....	23
Table 5. Reductions in Field Surface Runoff.....	24
Table 6. Agricultural BMP Efficiencies. ....	26
Table 7. Pollutant Reduction Efficiencies and Costs of BMPs. ....	28
Table 8. Summary of Project Potential .....	36
Table 9. Prioritized Potential Projects .....	39
Table 10. Technical Resources .....	63
Table 11. Potential Funding Sources .....	67
Table 12. Maintenance Requirements.....	78
Table 13. GIS Metadata .....	83

**Figures**

Figure 1. Vicinity Map.....	2
Figure 2. Priority Subwatersheds.....	5
Figure 3. Potential Project Locations.....	37
Figure 4. Subwatershed 2.....	47
Figure 5. Subwatershed 4.....	49
Figure 6. Subwatershed 5.....	51
Figure 7. Subwatershed 6.....	53
Figure 8. Subwatershed 7.....	55
Figure 9. Subwatershed 9 (North).....	57
Figure 10. Subwatershed 9 (South).....	59

**Exhibits**

Exhibit 1. Agricultural fields with no buffer (left) or narrow buffer (right).....	12
Exhibit 2. Unrestricted cattle access to stream. ....	12
Exhibit 3. Pasture with inadequate buffers. ....	13
Exhibit 4. Typical urban ditch. ....	13
Exhibit 5. Sedimentation resulting from channel maintenance. ....	15
Exhibit 6. Channel Incision Ratio (bank height/bankfull height).....	18
Exhibit 7. Cross vane (left) and root wad (right).....	19
Exhibit 8. Stream restoration methods (NC Stream Restoration Institute .....	19
Exhibit 9. Close proximity of agricultural fields and residences to streams. ....	20
Exhibit 10. Conservation tillage. ....	23
Exhibit 11. Grassed waterway. ....	24
Exhibit 12. Flashboard risers with raised water level (left) and free drainage (right).....	25
Exhibit 13. Cattle exclusion and stream crossing .....	26

Exhibit 14. Erosion related to overgrazing. ....	27
Exhibit 15. Detention pond. ....	28
Exhibit 16. Bioretention areas.....	29
Exhibit 17. Level Spreaders in Orange County, NC and Umstead Park, Raleigh, NC. ....	30
Exhibit 18. Stormwater wetland. ....	30
Exhibit 19. Rain barrel. ....	31
Exhibit 20. Typical drainage district stream with maintenance road.....	35

## **Appendices**

Appendix A. Watershed Functions

Appendix B. Current Mitigation Criteria

Appendix C. Center for Watershed Protection Design Principles

*Lumber River/Bear Swamp  
Watershed Management Plan*

---

## 1.0 INTRODUCTION

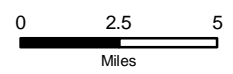
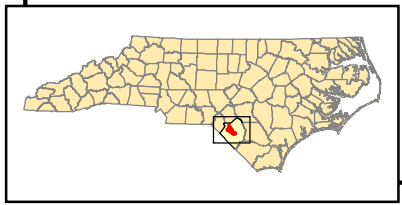
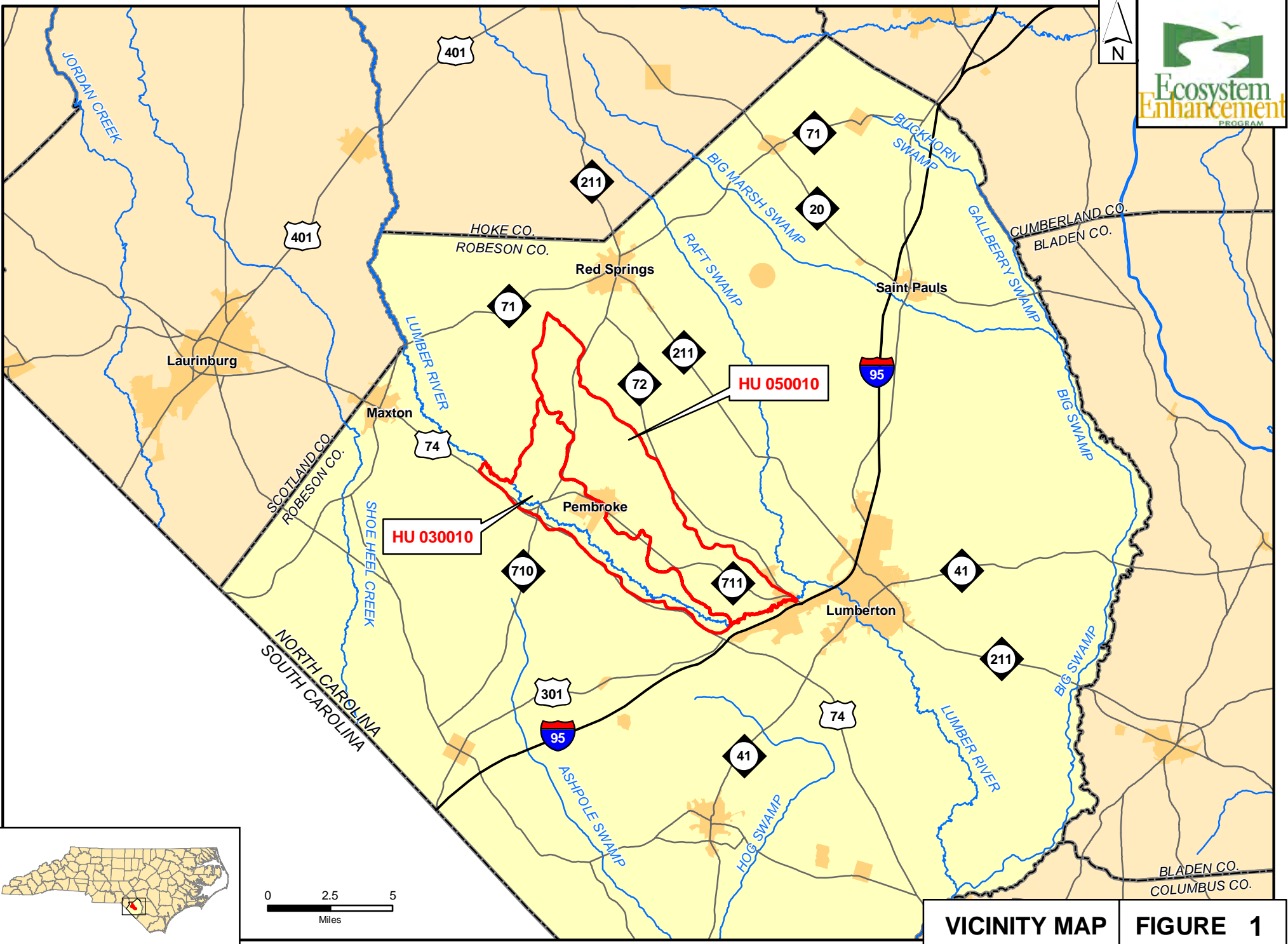
This *Watershed Management Plan* for the Lumber River/Bear Swamp (LRBS) watersheds is the product of a multi-phase study conducted for the Ecosystem Enhancement Program (EEP) of the North Carolina Department of Environment and Natural Resources. The watersheds (HU 03040203030010 and HU 03040203050010), which are within the Lumber River Basin of North Carolina, include the town of Pembroke and surrounding areas (**Figure 1**, page 2). They are among several watersheds across the state selected by EEP for a comprehensive planning effort to investigate sources of pollution and degradation in a local watershed (14-digit hydrologic unit) and to recommend comprehensive strategies for improving or maintaining water quality and other watershed functions. These local watershed plans also serve to identify potential stream and wetland restoration projects to help meet the future compensatory mitigation needs of the North Carolina Department of Transportation (NCDOT). The mitigation needs are based on the estimated impacts resulting from implementation of the NCDOT Transportation Improvement Plan. At the time this project was scoped, projected needs were for stream and riverine wetland mitigation. It is EEP's hope and intention that the watershed management plans will be used by local stakeholders as a framework for linking EEP restoration projects with other watershed improvement projects initiated at the local level. In the LRBS watersheds, the management plan is written in way that should provide guidance for local stakeholders such as county and municipal officials, natural resource professionals, and community leaders to identify the areas of greatest need, what types of projects are needed, who are the potential collaborators, what are the funding sources, and where to obtain more detailed information and technical assistance for project implementation.

This approach to local watershed planning includes new methods of watershed assessment that focus on ecological functions of the watershed. The phases of the planning process include characterizing the watershed, identifying types and locations of degraded ecological function, and developing a plan that provides specific solutions for protecting, maintaining, or restoring ecological function. These activities are documented in two preliminary reports, the *Initial Watershed Characterization* (Earth Tech, 2004) and the *Critical Area Analysis* (Earth Tech, 2005), which provided the framework for development of this *Watershed Management Plan*.

### 1.1 Management Context

Based on the findings of the preliminary reports, management strategies were developed for dealing with the sources of functional degradation of most concern in the watershed. In accordance with guidance provided by the Watershed Needs Assessment Team (NCDENR *et al.*, 2003), the *Watershed Management Plan* is directed toward restoring and maintaining three main watershed functions:

- **Water quality** - the ability of the water to support aquatic life and other designated uses, such as drinking water or recreation.
- **Stable hydrology** - the occurrence, distribution, and movement of water in a way that supports other watershed functions.
- **Habitat** - the physical, chemical, and biological characteristics necessary for an organism's viability.



**VICINITY MAP** **FIGURE 1**

A more detailed explanation of watershed functions and the indicators that signal their degradation was provided in Section 3.0 of the *Initial Watershed Characterization* and Section 2.2 of the *Critical Area Analysis*. These concepts are summarized in Tables A-1 and A-2 included in **Appendix A** of this document.

Functional degradation occurs through a chain of events initiated by some change in land or stream corridor use (*e.g.*, conversion from forest to agriculture) or through some specific human activity (*e.g.*, direct wastewater discharge to a stream). Resulting changes in hydraulics, morphology, or other factors precipitate changes in functions such as the maintenance of habitat diversity, maintenance of sediment regime, and water storage. These functional degradations may result in numerous direct and indirect effects, such as changes in stream morphology that perpetuate erosion and down-cutting of the stream, changes in fish populations, and even lowering the water table. In short, watershed processes are highly interrelated and effects can reach far beyond the initial stressor in both space and time.

The purpose of a watershed management plan, therefore, is to recommend specific management actions that achieve a balance in these interrelationships, thereby protecting, maintaining, or restoring key watershed functions. There are eight commonly employed strategies for protection and maintenance of watershed function. The first four strategies listed below are all strategies that fall under the purview of local, state, or federal agencies.

- Riparian buffer restoration
- Erosion and sediment control practices
- Stormwater management
- Regulation of non-stormwater discharges

The remaining four strategies are more suited to local initiatives, either private or governmental.

- Land use planning
- Land conservation
- Better site design and low-impact development practices
- Watershed stewardship programs

Technical and funding support may be available for the implementation of these strategies. Possible sources of technical support and funding for these recommended watershed projects and management actions are presented in **Tables 9** and **10** in Section 5.0 of this Plan.

Restoration of watershed function may be accomplished by bioengineering and natural channel design techniques for stream and wetland restoration, which may be eligible for funding by the EEP and other state and federal agencies. **Appendix B** describes activities that can qualify as compensatory mitigation for environmental impacts and could be eligible for EEP funding. Specific potential watershed restoration projects were identified in the *Critical Area Analysis* and presented again in Section 5.0 of this document.

In collaboration with researchers from East Carolina University and EEP, Earth Tech conducted a GIS analysis and field sampling in the watersheds, resulting in two preliminary reports. Brief summaries of the purpose and findings of the reports leading up to this watershed management plan are given below, followed by sections on specific management recommendations to protect, maintain, or restore ecological functions in selected subwatersheds.

## **1.2 Summary of Initial Watershed Characterization**

The *Initial Watershed Characterization* was a compilation of existing published data in Geographic Information Systems (GIS) and other databases regarding land use, water quality, ecosystem functions, current management measures, and existing restoration and protection needs. The current conditions and functional status of the watersheds were evaluated and stressors were identified. The watershed evaluation included visual observation of the watershed and analysis of existing data. Subwatersheds were identified and classified for future field studies and monitoring. Extensive field studies were not included in this phase of the watershed evaluation.

This report addressed three main watershed functions -- Water Quality, Hydrology, and Habitat. The analysis was limited to data currently available in GIS or other databases. Indicators were developed for each of the functions and values were used to rank the subwatersheds in terms of functional capacity. Examples of some functional indicators used in the analysis include length of stream protected by a forested buffer (water quality, habitat), total area of wetlands (hydrology), and total area of forested land cover (habitat).

The LRBS watershed was divided into 11 subwatersheds (**Figure 2**, page 5) and a ranking system was developed to classify the subwatersheds by functional status. The functional degradation concerns identified through this analysis were summarized as follows:

- Lack of forested riparian buffers
- Fragmentation and loss of terrestrial habitat and wetlands through clearing and draining for agricultural lands
- Conversion of agricultural lands to residential/commercial uses (increased impervious surface)
- Loss of in-stream habitat as a result of channelization




The subwatershed (SW) functional status classification results from the Initial Watershed Characterization were as follows:

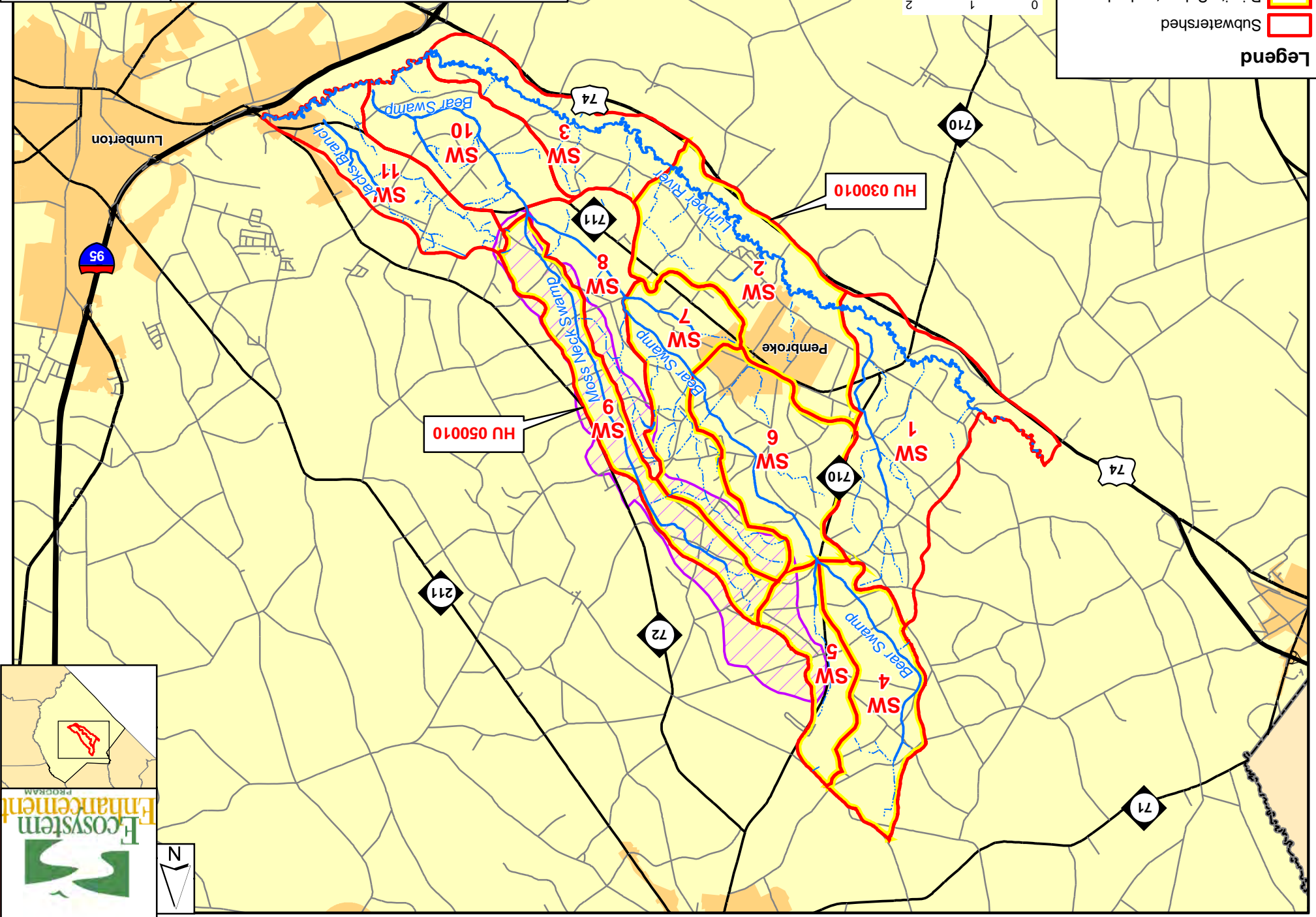
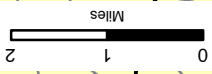
- High - SWs 03 and 10
- Medium - SWs 01, 02, 07, 08, 11
- Low - SWs 04, 05, 06, 09

The SWs with Low functional status were targeted as Critical Areas for the detailed functional assessment described in the Methods section. SWs 02 and 07 in the Medium category were also targeted so that all SWs draining the town of Pembroke would be included in the assessment. This decision was based on the assumption that the extent of impervious surface was likely to

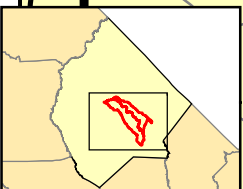
**PRIORITY SUB\_WATERSHEDS**  
**FIGURE 2**

**Legend**

-  Moss Neck Drainage District
-  Priority Subwatershed
-  Subwatershed



**Ecosystem Enhancement**  
PROGRAM



increase over time in the Pembroke area and management strategies should include the town as a whole. **Figure 2** (page 5) shows the targeted subwatersheds.

### **1.3 Summary of Critical Area Analysis**

The Critical Area Analysis Report summarized the data and findings of the water quality and biological monitoring and field assessment activities in the six Critical Area subwatersheds of the Lumber River and Bear Swamp HUs. See **Figure 2** (page 5) in this document for subwatershed locations. The *Critical Area Analysis* was designed with the goal of further elucidating the specific causes of functional degradation in the watershed.

A field analysis was performed in the Critical Area subwatersheds using methodology developed by East Carolina University (2005) to rank stream and riparian condition of a channel reach compared to an unaltered reference reach. A series of functional degradation indicators are rated compared to the reference system and scored to represent the stream and riparian condition for a stream reach.

Composite function scores indicated that 73% of the randomly sampled locations in the subwatershed were considered Altered or Severely Altered. This indicates that although the selected subwatersheds are predominantly rural, they have been subjected to extensive alterations. The three most prominent degradation conditions found were deep channelization, sedimentation, and narrow riparian zones.

Subwatershed 9, which includes most of the Moss Neck Swamp drainage district, scored in the Severely Altered category (0-29). The main alteration throughout the drainage district, channelization, directly affects the channel-riparian zone connection, which is used as an indicator of all three ecological functions (hydrology, water quality, habitat) in both areas. The extremely low average for this indicator in SW 9 (CRZC=6), therefore, had the most influence on the Composite Function Score.

Subwatersheds 2, 4, 5, and 7 scored in the Altered category (30-59). The lowest individual indicator score for these subwatersheds varied, which may be attributed to the variety of land uses found in these subwatersheds. Subwatershed 5 includes Little Bear Swamp, a headwater tributary of Bear Swamp. It is partially within the Moss Neck drainage district. The indicator that scored the lowest was Habitat Quality. Both sample reaches lacked a forested buffer on one or both banks. Subwatershed 2, which includes tributaries to the Lumber River, also lacks forested buffer on the majority of sample reaches. The indicator that scored the lowest was also Habitat Quality. Subwatershed 7 includes a well-forested mid-reach of Bear Swamp, largely non-forested tributaries to Bear Swamp that fall within the drainage district, and Watering Hole Swamp. The lowest indicator score for this subwatershed was Sediment Regime. This may be a reflection of the watershed position, downstream of a predominantly agricultural landscape. Subwatershed 4 includes the Bear Swamp headwaters, which are channelized but, in general, are adequately buffered. The lowest indicator score was Channel-Riparian Zone Connection.

Subwatershed 6 scored in the Somewhat Altered category (60-89). It includes a middle reach of Bear Swamp that is well-forested. There are also two tributaries, one of which drains the Town

of Pembroke. The lowest indicator score was Sediment Regime, which again may reflect the position of the subwatershed downstream of agricultural areas, as well as the position of one of the tributaries in an urban area with little bank protection.

The data collected from these detailed assessments were used to identify where functional deficiencies were the greatest and where implementation of watershed improvements such as stream or wetland restoration and best management practices (BMPs) would have the greatest impact on water quality and watershed functions.

The condition scores were used to classify the projects by functional status and potential restoration project suitability. Potential project areas were identified in three screenings. The first screening identified areas with a minimum of 1500-linear feet of stream, 5 or fewer landowners, and one or more of the following indicators of functional degradation from the ECU methodology:

- Channelized stream (CZRC)
- Inputs from field or roadside ditches (PAS)
- Forested buffer less than 50 feet wide on one or both banks (HQRZ)
- Little or no instream woody debris (IWS)
- Cattle access to stream (PAS)

A second screening included sites similar to those above but are currently mapped as intermittent rather than perennial. A third level of screening identified areas with commercial or residential development (potential stormwater problems) and/or areas with ditch networks (potential pollution problems) that were not associated with areas identified in the first two screenings. Twenty-nine sites were identified from the three screenings and prioritized into four groups. The potential project prioritization results from the Critical Area Analysis were as follows:

***Priority 1-Conventional Group:*** These sites are suitable for conventional stream and wetland restoration under current EEP and regulatory agency guidelines. Three sites in Subwatersheds 4, 5, and 7 were classified in this restoration group.

***Priority 2-Intermittent Group:*** Sites in this group have the same characteristics as the Priority 1 group, except that the streams are mapped as intermittent on USGS 7.5" quadrangles. These sites were identified in case intermittent streams become eligible for mitigation credit. Four sites in Subwatersheds 2 and 7 were classified in this restoration group.

***Priority 3-Drainage District Group:*** This group of sites was identified in the same manner as the Priority 1 and 2 groups, but were set apart because they fall within the Moss Neck Drainage District. Negotiations with the Drainage District commissioners and regulatory agencies will be necessary for restoration work on these projects. Eleven sites in Subwatersheds 7 and 9 were classified in this restoration group.

***Priority 4-Ditch/Stormwater BMP Group:*** These sites were identified as having a ditch or network of ditches leading to a stream, and/or a concentrated area of impervious surface draining to a stream, as in a commercial or residential area. Agricultural or roadway ditch BMPs and/or

stormwater BMP retrofits are recommended in these potential project areas to reduce sediment and pollution inputs and decrease runoff. Eleven sites in Subwatersheds 2, 4, 5, 6, and 7 were classified in this restoration group.

Traditional restoration projects could be implemented to correct degradation factors on Priority Groups 1 through 3 although compensatory mitigation may not be possible on Groups 2 and 3. Priority Group 4 projects are best suited to local entities that wish to implement best management practices to improve water quality or prevent watershed development from causing further degradation of water quality and other watershed functions.

## 2.0 GOALS AND OBJECTIVES

Simply stated, the goals of this *Watershed Management Plan* are **to identify ways to improve watershed functions and protect against future degradation and loss of watershed functions**. The achievement of these goals depends upon the selection of appropriate objectives that address the specific functional deficiencies of the watershed. Following selection of appropriate objectives, specific practices can be identified to meet the objectives. Successful implementation of the various practices is vital to protecting, maintaining, and restoring watershed health. It requires a well-coordinated, long-term effort with multi-agency collaboration and stakeholder involvement throughout the process.

Four factors were identified in the *Initial Watershed Characterization* and confirmed in the *Critical Area Analysis* as contributing to functional degradation in the LRBS subwatersheds. These factors are as follows:

- Lack of riparian buffers
- Fragmentation and loss of terrestrial habitat diversity by clearing and drainage activities
- Increasing impervious surface area
- Loss of in-stream habitat by channelization

Objectives that directly address these functional degradation factors are listed below.

- Improve water quality where it is degraded by pollutant inputs
- Improve terrestrial habitat diversity
- Improve terrestrial habitat connectivity
- Reduce impacts of present and future impervious surface
- Improve in-stream habitat
- Improve functions degraded by loss of channel-riparian zone connection
- Protect against future threats

These objectives are specific, measurable, achievable actions that can protect, maintain, or restore watershed functions. In general, they can be related back to one or more specific indicators of degradation as defined and discussed in the *Critical Area Analysis*. See Table 1 in the *Critical Area Analysis* for the relationship of indicators to function, and *Critical Area Analysis* Table 10 for the relationship of remedial actions to degraded functions. **Table 1** puts these concepts into the context of this management plan, and relates the specific objectives for the LRBS watersheds to the selected management practices that can protect, maintain, or restore function in these watersheds.

**Table 1. General Practices for Achieving Management Objectives**

<b>PRACTICES</b>								
<b>OBJECTIVES</b>		Riparian Buffer Restoration	Sediment Reduction BMPs*	Nutrient Reduction BMPs	Stormwater BMPs	Stream Restoration	Wetland Restoration	Land Use Ordinances
	Improve water quality	<b>X</b>	<b>X</b>	<b>X</b>	<b>X</b>		<b>X</b>	<b>X</b>
	Improve terrestrial habitat diversity	<b>X</b>					<b>X</b>	
	Improve terrestrial habitat connectivity	<b>X</b>					<b>X</b>	<b>X</b>
	Reduce impacts of impervious surface	<b>X</b>			<b>X</b>			<b>X</b>
	Improve in-stream habitat	<b>X</b>	<b>X</b>			<b>X</b>		
	Improve functions degraded by loss of channel-riparian zone connection					<b>X</b>		
	Protect against future threats							<b>X</b>

\*Best Management Practices

### 3.0 PRACTICES FOR ACHIEVING OBJECTIVES

The following sections describe the specific practices in each general category selected for use in the LRBS watersheds. Details about the application of these practices, such as where they are used, their specific purpose, effectiveness, and costs are provided.

#### 3.1 Management settings

The developed land use types in the six LRBS subwatersheds on which this plan is focused are primarily croplands, livestock operations, and urban areas. Each land use type exhibits particular types of functional degradation. Specialized management techniques have been developed that are best suited for one setting or another, although there is some overlap in the techniques used. **Table 2** below lists the various practices selected for use in the LRBS watersheds and shows the typical setting or land use type for which they are used. The land use types are described following the table. The table also shows the target, or measurable element, that the various practices are designed to manage. More details on the targets follow in Section 3.2.

**Table 2. Management Practices and Their Appropriate Settings and Targets**

Management Practice	Management Setting			Management Target		
	Cropland	Livestock	Urban	Sediment	Nitrogen & Phosphorus	Storm-water
Conservation Tillage	X			X		
Grassed Waterways	X			X		
Field Borders	X			X	X	
Livestock Exclusion		X		X	X	
Water Control Structures	X				X	
Fertilizer Management	X				X	
Riparian Buffers	X	X	X	X	X	X
Bioretention			X		X	X
Wet Retention/Detention			X			X
Level Spreaders	X		X		X	X
Constructed Wetlands		X	X	X	X	X
Rainwater Collection			X			X

##### 3.1.1 Croplands

Croplands account for 13,200 acres or 73 % of the land area in the six Critical Area subwatersheds. Based on field observations, the main crop is soybeans. Corn, cotton, and

tobacco are grown to a lesser extent. Typical degradation factors associated with row crops are excess sediment and nutrient inputs to streams from soil erosion and fertilizer runoff. When fields are cleared all the way to the stream banks (**Exhibit 1**), the very narrow or complete absence of wooded buffers contribute to habitat fragmentation and loss of diversity in both plant and animal communities.

**Exhibit 1. Agricultural fields with no buffer (left) or narrow buffer (right).**



### **3.1.2 Livestock Operations**

There are very few livestock operations in the Critical Area subwatersheds. However, the two cattle operations that were observed in Subwatershed 7 allow unrestricted access of the cattle to streams (**Exhibit 2**) in the pastures and stream buffers are very narrow or completely absent (**Exhibit 3**, page 13). The degradation factors are the same as for row crops, but result from different causes. The trampling of the banks causes instability and erosion, which leads to excess sediment inputs. If pastures are not well-managed and are overgrazed, upland erosion can also add to sediment inputs. Excess nutrient inputs result from fecal contamination rather than fertilizer.

**Exhibit 2. Unrestricted cattle access to stream.**



**Exhibit 3. Pasture with inadequate buffers.**



### **3.1.3 Urban Areas**

The Town of Pembroke constitutes the only urban area in the Critical Area subwatersheds. It covers about 1,300 acres in Subwatersheds 2, 6, and 7. Urban areas are characterized by a much higher percentage of impervious surface area than rural or suburban areas. The density of road networks, buildings, and parking lots is greater per unit area, leaving less native soil area available for the infiltration of rainwater. In addition, storm drain systems may be present which can very quickly convey large amounts of pollutant-laden water to streams (**Exhibit 4**). Sediment, nutrients, and hydrologic factors are all causes of functional degradation associated with stormwater in urban areas.

**Exhibit 4. Typical urban ditch.**



## **3.2 Management Targets**

Management targets are measurable elements that can be used to quantify the level of functional degradation. Management practices are designed to remove or modify these targets, and monitoring of the targets is used to set success criteria and determine the level of functional improvement achieved by the practices. The following sections discuss sediment, the nutrients nitrogen and phosphorus, and stormwater as the management targets of most concern in the Lumber River/ Bear Swamp Critical Area subwatersheds.

### **3.2.1 Sediment**

Sediment originating from land being used for urban and residential development, agricultural fields, and forestry can be transported in rainwater runoff to streams and be deposited on the channel bed and banks. Excessive amounts of sediment on stream beds can cover woody debris and void spaces in coarse channel substrate, and thereby destroy or degrade the in-stream habitat for aquatic insects and fish. In addition, phosphorus, metals, pesticides and other pollutants readily attach to sediment particles and thus are transported and stored with the sediment. Excess sediment was reflected in the functional indicator scores from the field sampling. See Tables 5 and 6 of the *Critical Area Analysis* (Earth Tech, 2005).

Sediment export from road building and development activities is regulated by the NC Sedimentation Pollution Control Act of 1973. The NC Division of Land Resources enforces the provisions of the Act across the state, except where local entities have been granted control. Neither Pembroke nor Robeson County are included in the Delegated Local Programs that are responsible for their own sediment and erosion control regulations and enforcement (NCDENR., 2005a). While agricultural and forestry activities are exempt from this act, there are state and federal programs involving incentives for reducing sediment export from these land uses.

The Lumber River and Bear Swamp basins have significant areas of agricultural land, which often is subject to accelerated erosion (**Table 3**, page 15); however, sedimentation does not appear to be a significant problem as benthic macroinvertebrate communities are healthy and diverse as indicated by a bioclassification of excellent and relatively high habitat scores reported in the basinwide water quality plan. Further, in its report dated March 2005, DWQ concluded from more recently conducted monitoring that the water quality of Bear Swamp was not particularly degraded, with the exception of Jack's Branch and Watering Hole Swamp. This is consistent with field observations that indicated isolated areas of possible water quality problems as outlined in the Critical Area Analysis. Further, monitoring of Jack's Branch documented total residue (suspended solids or sediment) concentrations as high as 78 milligrams per liter (mg/L) and a turbidity of 50 nephelometric turbidity units (ntu) in one sample. The state water quality standard for residue in waters other than trout waters or Primary Nursery Areas is 20 mg/L. The state standard for turbidity is 50 ntu.

**Table 3. Estimated Potential Sediment Export Rates for Various Land Uses.**

Land Use	Export (ton/ac-yr)	Source
<b>Forest</b>		
Mature, undisturbed	0.1-0.4	Hill (1991)
Clear cut harvesting	2-32	SCS (1977)
Select harvesting	0.01-0.02	USEPA (1993)
Forest roads	6.8-33.7	USEPA (1993)
<b>Pasture</b>		
Light to moderate grazing	0.1-0.7	Line <i>et al.</i> (2002)
Heavy grazing	1.3-17	Line <i>et al.</i> (2000)
<b>Cropland</b>		
High residue	3-5	Mud Creek WRC (2003)
Low residue	5-20	Mud Creek WRC (2003)
<b>Urban</b>		
Construction	25	Line <i>et al.</i> (2002)
Completed	1-6	Line <i>et al.</i> (2002)
<b>Highways</b>		
Construction	2-21	Line, unpublished
Completed	0.1-1.0	Wu <i>et al.</i> (2002)
<b>Unimproved roads/driveways</b>	35	SCS (1977)
<b>Streambank Erosion</b>		
Slight	50	SCS (1977)
Moderate	150	SCS (1977)

**Exhibit 5. Sedimentation resulting from channel maintenance.**

The elevated suspended sediment concentration in Jack's Branch was likely associated with a golf course upstream of the monitoring site. The development of forest and agricultural land into residential, industrial, and commercial areas is a relatively minor activity in the watershed at this time. However, these types of development can create potential sediment sources during construction and increase runoff volumes and rates that can destabilize streams and cause long-term channel erosion. Bank maintenance activities may be the more significant source of sediment in the study area at this time (**Exhibit 5**). Enforcement of sediment and erosion control laws and developing land in a way that minimizes stormwater runoff are needed to minimize



sedimentation in the basin. The soils of the basin are relatively porous, so stormwater practices that maximize the amount of rain that soaks into the ground would be appropriate. Some of these practices include bioretention areas or rain gardens, grass strips, and grassed swales.

### ***3.2.2 Nitrogen and Phosphorus***

The largest potential source of nitrogen and phosphorus in the basin is from fertilizer application on cropland. Ideally, fertilizer application rates would match the nitrogen and phosphorus uptake of the crop; however, fertilizer is generally applied only at or near the time of planting, which creates the potential for export from the field if erosive events occur before uptake. Also, fertilizer rates are determined for relatively high yields and if growing conditions are not good, some of the fertilizer will not be used by the crop. Other sources of nitrogen and phosphorus in the basin include animal pastures and urban areas. Whereas the area of these land uses is relatively small, significant amounts of nutrients can originate from them and severely impact smaller streams. Excess nitrogen and phosphorus in slow moving waters can cause algal blooms, which can ultimately reduce dissolved oxygen levels, thereby killing fish. The DWQ report of March 2005 concluded that low dissolved oxygen was the primary cause of poor water quality in Jack's Branch and that low dissolved oxygen may also be a problem in the Bear Swamp.

There are about 2,000 acres of pasture and hay land in the Critical Area subwatersheds, so minimizing sediment export from these areas is a consideration. Nutrients and pollutants such as nitrogen and phosphorus readily adhere to sediment and can create additional problems when the nutrient laden sediment is transported to streams. As an example, there is a pasture in Watering Hole Swamp where cattle have unlimited access to a stream channel, which has caused the channel to be incised and widened. Minimizing sediment yield from this and similar pastures involves maintaining vegetation and protecting waterways. Because pastures consist mostly of close-growing grasses, they are protected from erosion; however, trampling of stream banks, overgrazing, and heavy use around feeding areas can reduce or eliminate grasses and increase erosion.

Nitrogen and phosphorus concentrations were relatively low within the basin suggesting good water quality with the possible exception of the Jack's Branch and Watering Hole Swamp tributaries. Nitrate-nitrogen concentrations were also elevated in Mill Branch and Upper Bear Swamp. The movement of nitrogen from cropland fields to streams can be reduced by implementing nutrient management strategies, establishing riparian buffers, and installing water control structures.

### ***3.2.3 Stormwater***

Although there are relatively few industrial, commercial, or large residential areas in the basin, urban stormwater can be a significant source of pollutants. Developing forests and farms into urban and residential land creates areas of impervious surface that prevent precipitation from soaking into the ground. Consequently, this increases the amount of precipitation that runs over the land surface and becomes stormwater runoff. To convey the increased runoff quickly and safely to streams, stormwater systems with pipes, ditches, and channels are built. The combination of the increased volumes and rapid conveyance of stormwater creates short-term

bursts of water to streams, which often results in erosion of the channel bed and banks. The short duration bursts of stormwater also cause stress on aquatic insects and fish by washing rocks, submerged logs, and other structures downstream and burying habitat under fine sediments. In addition to its physical effects, stormwater can also carry nitrogen, phosphorus, metals, and toxic organic pollutants washed from developed areas such as parking lots, industrial plants, roads, and residential subdivisions.

There are both federal and state programs, administered by the NC Division of Water Quality, that determine when stormwater controls are required by law (NCDENR, 2005b). See **Tables 9** and **10** in Section 5.0 for additional information. The federal rules primarily apply to large industrial facilities and to municipalities of at least 50,000 people (40CFR 122.32). The state rules focus on new development and construction activities in sensitive watersheds. There are no facilities in the LRBS watersheds that fall under the federal stormwater rules through the National Pollution Discharge Elimination System (NPDES). Pembroke, the only municipality in the LRBS watershed, does not currently fall under the Phase II stormwater rules, although the rules are expected to be modified to eventually include smaller municipalities (NCDENR, 2005b).

The NPDES stormwater management program regulates point source discharges of stormwater from specific activities that have been identified as having significant pollution potential. Pollutants on impervious surfaces associated with the facility may wash off during significant rain events and reach surface waters through storm drains. Two general stormwater permits have been issued in the LRBS Critical Area subwatersheds. See Table 10 in the *Initial Watershed Characterization* for details. (Earth Tech, 2004).

In subwatersheds where stormwater discharges are a concern, a review of NPDES permits, local ordinances, and inspection schedules would be the first course of action. If a pollution source is identified and regulatory action is not sufficient to promote compliance, a targeted program of education and incentives may be useful. Owners of facilities similar to the facilities of the offending discharger (*e.g.*, all gas station owners) could be identified through trade associations or other means and provided with information regarding the impacts of non-compliance, *e.g.*, fish kills, endangerment of human health, increased costs for additional inspections, or aesthetic concerns. Incentives may be offered such as certification and recognition programs or on-site technical assistance.

The prevention and regulation of stormwater discharge falls mainly under the purview of specific state regulatory agencies and local governments. Funds for implementation of educational or assistance programs similar to those described in the preceding paragraphs are unlikely to be funded by EEP, given current regulatory guidance regarding what constitutes mitigation for permitted impacts. However, grass-roots campaigns financed by grants or local benefactors may be effective. See **Table 9** in Section 5.0 for information on funding programs.

Stormwater management BMPs are installed in urban and residential areas to control peak and cumulative runoff rates as well as sediment, nitrogen, phosphorus, metals, and other pollutants. There are a wide range of stormwater BMPs and each must be designed to the specific site

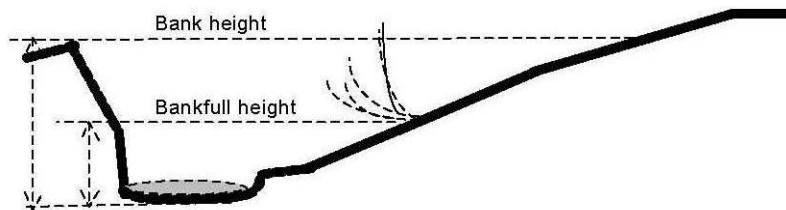
conditions for maximum effectiveness. Structural and preventive stormwater BMPs appropriate for use in the LRBS watersheds are discussed in Section 3.3.5.

### **3.3 Management Practices**

The following sections discuss the various management practices appropriate to the settings in the LRBS watersheds. Stream and wetland restoration are discussed separately because they can be applied in all three of the settings and can affect all three of the management targets discussed above.

#### **3.3.1 Stream Restoration**

Incised channels indicating accelerated stream channel erosion were observed at several sites in the basin as documented in previous reports. Channel incision is measured by calculating the ratio of bank height to bankfull height (**Exhibit 6**). For the purposes of this assessment, a channel was considered incised if the ratio was greater than 2.5 (ECU, 2005). A variety of practices and techniques are available for controlling erosion of stream channels, from simply revegetating the banks to raising the streambed elevation or moving the channel to its original position in the floodplain.



**Exhibit 6. Channel Incision Ratio (bank height/bankfull height)**

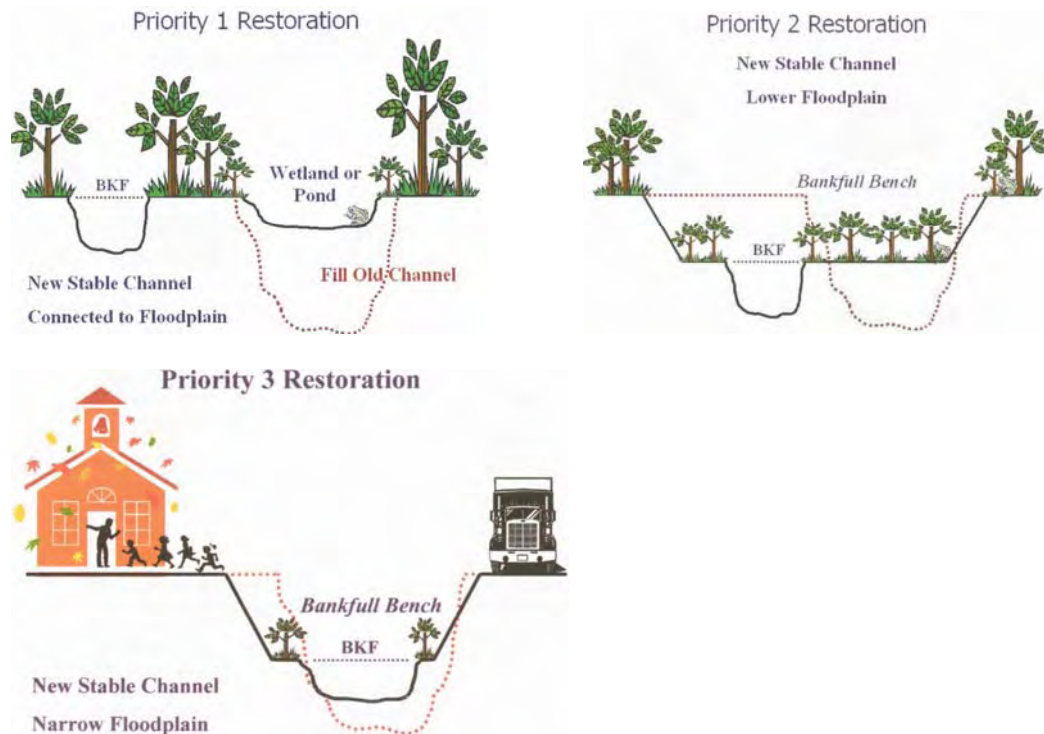
Where streambank vegetation has been impacted by livestock or other forms of disturbance, removing the stressors and replanting the banks is often enough to stabilize the streambanks. Where streams have been channelized or development has occurred in the watershed or along the banks, more drastic measures such as reconstructing the channel may be required to achieve and maintain a natural, stable stream pattern. Channel reach restoration has been classified into four groups (Priority 1 through 4) by Rosgen (1996), depending upon the degree of alteration. Significant alterations to the stream channel may require the use of rock vanes, cross vanes, J hooks, root wads (**Exhibit 7**, page 19) or other structures to direct water flow to stable parts of the stream channel. These structures may have the added benefit of providing habitat for aquatic insects and certain fish species.

Exhibit 7. Cross vane (left) and root wad (right).



Incised stream channels are common in the study area as a result of channel straightening, loss of riparian buffers, and changes in watershed land use and sediment supply. These streams make good candidates for stream restoration projects because of their unstable nature and poor function. Four basic methods are used to restore incised stream channels (**Exhibit 8**). These are establishment of the bankfull stage at the historical floodplain elevation (Priority 1); creation of a new floodplain and stream pattern with the stream bed remaining at the present elevation (Priority II); widening the floodplain at the existing bankfull elevation (Priority III); and the stabilization of the existing streambanks in place (Priority IV) (Rosgen, 1996). The criteria for categorizing levels of stream restoration for compensatory mitigation in North Carolina are slightly different. See **Table 4** (page 23).

Exhibit 8. Stream restoration methods (NC Stream Restoration Institute)



Stabilization of stream channels can be accomplished by the use of natural structures such as root wads, logs, and rocks to control the grade of the channel and protect the banks. Rock, log, and rootwad structures force the flow of water away from streambanks and armor a streambank. All of these structures can provide habitat for fish and other aquatic animals. Root wads and logs also add woody debris to the stream, supplying nutrients and detritus to aquatic organisms in the food chain. Re-establishment of streamside and riparian vegetation also assists in streambank stabilization, water quality improvement, enhancing habitat, and providing a means for floodwater velocity to be attenuated (Doll *et al.*, 2003).

Indicators of degraded stream condition as discussed in the ECU Report would show improvement as a result of the stream restoration techniques described above. Re-establishment of riparian buffers and the implementation of root wads and logs to divert flow and reduce shear will aid stream bank stability, reduce the transport of pollutants and sediment in the stream, and increase the in-stream woody structure in streams, thereby increasing habitat for aquatic organisms. Reestablishing the channel-riparian zone connection by elevating the streambed to allow overbank flooding or the creation or widening of a floodplain at an existing elevation can provide numerous benefits to the hydrology, biogeochemistry, and habitat of streams and riparian zones. An accessible floodplain also provides temporary storage of water in overbank conditions and reduces potential stream erosion. The filtering mechanisms of the riparian zone can also improve the water quality by the removal of sediment and pollutants and assimilation of these substances by riparian plant species.

Standard methods used in stream restoration are not widely applicable in the LRBS watershed because of drainage issues, development of historic floodplains, and the very low gradient, swampy character of the stream systems. In the LRBS watershed, channels are deeply incised but often occur in close proximity to active agricultural fields and residential areas (**Exhibit 9**).

**Exhibit 9. Close proximity of agricultural fields and residences to streams.**



In most cases Priority I restoration is not feasible in this watershed. Restoring natural channel geometry so that a stream can access its historic floodplain would result in flooding of contemporary land uses (development, agriculture) that have encroached upon the floodplain.

Priorities II and III are more appropriate for this watershed because there would be no change of flooding potential along these streams (Doll *et al.*, 2003). There may be cases, however, where Priority IV restoration is the only option because of the land use constraints preventing the increase of floodplain or riparian width. Some innovative approaches that restore many functions without causing flooding to existing infrastructure are being developed for areas with drainage ditching. Modification of existing drainage ditches using natural channel design concepts (based on Priorities II-IV), interconnection of modified ditches with networks of constructed stormwater wetlands, and construction of in-stream wetlands can improve water quality, habitat, and hydrologic function without reducing drainage capacity necessary for current land use needs. (Evans *et al.*, 2004)

Implementation of stream restoration projects may be funded by a variety of state and local agencies dependent on the degree of degradation. In North Carolina the Ecosystem Enhancement Program pays around \$219.00 per linear foot for stream restoration costs (EEP, 2005). Actual costs can be higher in some situations such as a restoration project in an urbanized area or one that requires the maintenance of livestock or vehicle crossings.

Costs for riparian buffer restoration are estimated using the standard 10' by 10' planting of 436 trees per acre, which will provide an estimated density of 320 trees at maturity and is the required density for riparian plantings (USACE, 2003). Trees planted at this density will cost an estimated \$283-\$436 per acre to restore riparian wetland vegetation. Plantings (live stakes) along streambanks cost on average \$0.33 per linear foot of stream. Total riparian buffer restoration costs as estimated by EEP are \$0.96 per square foot.

### **3.3.2 Wetland Restoration**

Wetland loss has been significant in the United States since colonization. Major losses are the result of draining, dredging, filling, and hydrologic modifications of wetlands for conversion to agricultural or other developed land uses. Wetlands are important ecosystems and provide a number of benefits to human society. Wetlands provide habitat for populations of numerous species that provide uses to humans. Wetlands also play an important role in storm abatement and flood mitigation, aquifer recharge, and water quality improvement (Mitsch and Gosselink, 1993). A connection between the wetlands in riparian zones and streams plays an important role in filtering sediment and pollutants and providing temporary storage of water during overbank flow, thereby limiting erosion and the pollution and sediment load in the stream. Much of the beneficial characteristics of the riparian zone are dependent on the habitat quality and the maintenance of the channel-riparian zone connection.

Wetlands also have the ability to intercept and store storm runoff thereby reducing runoff peaks to slower discharges over longer periods of time. An example of the negative effect wetland destruction can cause in storm abatement is demonstrated by the bottomland forests along the Mississippi River. These forests stored the equivalent of about 60 days of river discharge before European settlement and presently storage capacity is now only about 12 days due to the reduction of forests (Mitsch and Gosselink, 1993).

An additional well-known benefit riparian wetlands provide is the removal of significant amounts of nitrogen and phosphorus from runoff. Peterjohn and Correll (1984) found that a 50 meter wide riparian forest in an agricultural watershed near the Chesapeake Bay in Maryland removed an estimated 89 percent of the nitrogen and 80 percent of the phosphorus that entered it from upland runoff, groundwater, and bulk precipitation. Jacobs and Gilliam (1985) suggested that riparian buffer strips less than 16 meters in width in North Carolina were effective in denitrifying a substantial portion of nitrates in agricultural subsurface salvage water before it reached the adjacent stream. These studies and others demonstrate that riparian wetlands can be effective in removing and modifying nutrients and sediments from agricultural runoff before it reaches a stream or river.

Restoration has become an important tool in slowing or reversing the loss of wetlands and degradation of wetland functions. Restoration usually entails the rehabilitation of wetlands that may be degraded or hydrologically altered, but may also refer to the reestablishment of wetland vegetation. Techniques that may be utilized to restore hydrologic function include removal of fill dirt in filled wetlands, removal of hydrologic impediments to restore surface or subsurface flow, and plugging or filling of drainage ditches that have lowered the water table to the extent that an area no longer exhibits wetland function. Restoration of bankfull flow and floodplain access will also help restore hydrology to riparian wetlands. These methods can begin the process of restoring function and habitat to degraded wetlands.

However, in the LRBS watershed, draining and floodplain encroachment have been so extensive that full wetland restoration is not feasible in most cases because of the significant potential for hydrologic trespass into agricultural or residential areas. Restoration options are greater in agricultural areas than residential areas. Wetland enhancement may be a more feasible option than restoration in many cases in the LRBS watershed. Enhancement is the manipulation of the physical, chemical, or biological characteristics of a wetland to heighten, intensify, or improve specific functions (USACE, 2005). Vegetation plantings may enhance wetland habitats, and it may also be possible to partially restore wetland hydrology to some areas to provide an improvement in wetland habitat and function without introducing hydrologic trespass.

Long term success of any wetland restoration project is dependent upon restoring and managing the appropriate hydrology. Wetland hydrology determines abiotic factors such as water availability, nutrient availability, aerobic or anaerobic soil conditions, soil particle size and composition, and related factors such as water depth, water chemistry, and water velocity. Hydrology also modifies or controls the composition of both the plant and animal community. Saturation and loss of oxygen found in the hydric soils of wetland systems allow these soils to develop anaerobic conditions that favor hydrophytic vegetation (Hammer, 1992). If the proper hydrologic conditions are restored, the chemical and biological conditions will respond accordingly (Mitsch and Gosselink, 1993).

Ultimately, wetland restoration is determined on a regulatory basis and is typically undertaken as mitigation for development projects. This in turn focuses the funding for restoration or enhancement projects to areas where development is occurring. In North Carolina, the Ecosystem Enhancement Program oversees wetland restoration and enhancement projects for compensatory mitigation for NCDOT impacts to wetlands. Costs for restoration can be high,

exemplified by the fact that EEP pays \$26,246.00 per acre for wetland restoration costs (EEP, 2005).

**Table 4** below shows some of the practices used in restoration projects and the types of credits for which they would qualify.

**Table 4. Criteria for Conventional Mitigation Types**

Mitigation Credit Category	Buffer Restoration	Dimension Restoration	Pattern Restoration	Profile Restoration	Wetland Vegetation Restoration	Wetland Hydrology Restoration
Stream Restoration	X	X	X	X		
Stream Enhancement I	X	X		X		
Stream Enhancement II	X	X				
Wetland Restoration					X	X
Wetland Enhancement*					X	X

\*Restoration of just one or the other of these criteria is sufficient for enhancement

### 3.3.3 Croplands Management Practices

The typically flat land and coarse soils such as Norfolk and Goldsboro loamy sand help to minimize potential erosion in the agricultural areas of the LRBS watershed. However, practices such as conservation tillage, grassed waterways, and field borders are still recommended for all row crop fields to minimize erosion.

**Conservation tillage (Exhibit 10)** involves a range of practices that leave plant residues on or near the soil surface to reduce the erosive effects of rainfall and runoff.

**Exhibit 10. Conservation tillage.**



**Grassed waterways (Exhibit 11)** are channels planted and maintained in close-growing grasses that safely convey concentrated flow off of a field. These waterways are usually made where runoff concentrates such as swales or hollows.

**Exhibit 11. Grassed waterway.**



**Field borders** are relatively narrow (10-30 feet wide) strips of grass planted around the edge of the field to filter sediment and other pollutants out of runoff as it leaves the field. The effectiveness of each of these BMPs varies with site conditions; however, each has been shown to be effective at reducing erosion and sediment export when implemented appropriately. Field borders have the additional benefit of reducing nitrogen and phosphorus loss from cropland to streams. Information and assistance in implementing the cropland BMPs is readily available from the local office of the NC Cooperative Extension Service, Natural Resources Conservation Service, or the Soil and Water Conservation District.

**Nutrient management** involves applying nitrogen fertilizer at the optimum time, rate, and manner as to fit crop needs and use. Even when this is done, unusual climatic conditions can cause the movement of some nitrogen to the near surface groundwater or surface water system.

**Wooded and grassed riparian buffers** of as little as 10 feet in width established between nitrogen sources and streams have been shown to reduce concentrations of nitrogen in surface and groundwater (**Table 5**). Although buffers are effective at reducing nitrogen, phosphorus, and sediment, their implementation usually removes land from production, which may be unacceptable. However, buffers enhance wildlife habitat and often improve aquatic habitat.

**Table 5. Reductions in Field Surface Runoff.**

Buffer Type	Width (feet)	Reductions in Concentration (%)		
		Sediment	Nitrogen	Phosphorus
Grass	15	61	4	29
Grass	30	75	23	24
Forest	62	90	74	70

(Lowrance *et al.*, 1995)

**Installing and properly managing water control structures** in drainage ditches (**Exhibit 12**) can also reduce nitrogen and phosphorus export from agricultural lands where these inputs are high, such as from corn, cotton, and tobacco fields. Nutrient export is less of a problem with soybean fields because soybeans are a legume, hence they require little, if any, nitrogen fertilization. Water control structures, such as a flashboard riser (**Exhibit 12**), installed in the drainage ditch are designed to raise or lower the water height as needed to either store water in the field or promote rapid drainage from the field. This practice is particularly suited to this basin where drainage ditches are so extensive and nutrient removal through wetland construction and restoration is often not desirable because it removes valuable land from agricultural and residential uses.

**Exhibit 12. Flashboard risers with raised water level (left) and free drainage (right).**



Controlling the drainage in this way can reduce outflow of water by 20-30% on average (Osmond *et al.*, 2002) depending on soil type, rainfall, type of drainage system, and management. Along with a decrease in outflow, an associated decrease in nitrogen and phosphorus export from the field also occurs. Numerous field studies have documented an average reduction of 9 lb/ac-yr or 45% in nitrogen export from fields in the Coastal Plain of North Carolina. In addition to outflow reduction, the goal of controlled drainage is to maintain the water levels or water table close to the land surface for longer periods of time which promotes denitrification within the soil profile. Denitrification, the process by which nitrogen in various forms (ammonia, ammonium, nitrate, nitrite) is converted to nitrogen gas and released to the atmosphere, has been shown to reduce nitrogen concentrations by 10-20% under controlled drainage (Osmond *et al.*, 2002). Controlled drainage has also been shown to reduce phosphorus export from fields by roughly 35% (Osmond *et al.*, 2002). The mechanism for the decreased export has not been documented, but it likely results from a combination of increased crop uptake, enhanced sediment deposition, and reduced discharge.

An added benefit of controlled drainage is that it can also enhance productivity by keeping water in the field during periods of low rainfall, thereby improving the growing conditions of the field. Also, controlled drainage is a practice with significant water quality benefits with no loss in

productive land. Controlled drainage does require somewhat more labor and management; however, the benefits to the landowner and the environment appear to outweigh these inputs.

### **3.3.4 Livestock Operations Management Practices**

**Installing livestock exclusion fencing (Exhibit 13)** prevents continuous livestock access to streambank areas. It is typically installed along most streams at a distance of 35-50 feet from the top of the streambank and at 15 feet along small streams, thereby allowing revegetation and stabilization of the sensitive streambanks and reducing streambank erosion.

**Exhibit 13. Cattle exclusion and stream crossing.**



The revegetation process can be enhanced and the water quality benefits improved by planting appropriate riparian vegetation in the excluded corridor. Technical and financial assistance in implementing these BMPs on pastures can be obtained from the local Soil and Water Conservation District, NC Cooperative Extension, or USDA NRCS office.

Exclusion and revegetation also are effective at reducing nitrogen, phosphorus, and fecal coliform bacteria inputs to streams (**Table 6**). Another benefit to excluding livestock from streams is to reduce the chance of young animals being caught in the mire or standing water of a stream bottom, or leg injuries from navigating steep stream banks.

**Table 6. Agricultural BMP Efficiencies.**

<b>BMP</b>	<b>Pollutant Reductions (%)</b>				<b>Source</b>
	<b>TSS</b>	<b>TN</b>	<b>TP</b>	<b>FC</b>	
Livestock exclusion-heavy usage	81	70	58	66	Line <i>et al.</i> , 2000
Livestock exclusion-light usage	40	NA	NA	NA	Owens <i>et al.</i> , 1996
Row crop BMPs	87	NA	NA	NA	Hill, 1991

Notes: TSS-total suspended solids or sediment; TN-total nitrogen; TP-total phosphorus; FC-fecal coliform bacteria. Livestock usage is considered heavy when remaining ground cover is less than 30%

Along with fencing, providing alternate sources of water and stable stream crossings are often necessary to make the pasture useable. Erosion associated with overgrazing (**Exhibit 14**) and heavy use areas can be addressed by dividing the pasture into sections and rotating livestock from one area to another, thereby maximizing the growth of grass and soil cover. This practice allows time for revegetating feeding areas that have been denuded by trampling. Detailed design standards for the above mentioned BMPs can be found at the national NRCS website: <http://www.nrcs.usda.gov/technical/Standards/nhcp.html>.

**Exhibit 14. Erosion related to overgrazing.**



### **3.3.5 Urban Area Management Practices**

Stormwater management practices or BMPs are installed in urban and residential areas to reduce peak and cumulative runoff volumes and sediment, nitrogen, phosphorus, metals, and other pollutant exports from developed sites. There are many varieties of stormwater BMPs, and each must be designed to the specific site conditions for maximum effectiveness. Commonly implemented structural BMPs that have been shown to be effective at treating runoff from industrial, commercial, and residential areas include wet retention/detention ponds, bioretention areas, level spreader-vegetated strips, constructed wetlands, and rainwater collection systems. Preventive measures include appropriate application and timing of lawn fertilizer and use of low-input (fertilizer, pesticides, water) landscaping. **Table 7** (page 28) shows the efficiency and costs of some of these management practices.

**Table 7. Pollutant Reduction Efficiencies and Costs of BMPs.**

Site	BMP	Drainage Area (acres)	Pollutant Reductions (%)			Construction Cost	Maintenance Cost (20 years)
			TSS	TN	TP		
1	Bioretention	4	77 <sup>2</sup>	45 <sup>1</sup>	71 <sup>1</sup>	\$45,900 <sup>1</sup>	\$5,250 <sup>1</sup>
2	Bioretention	3	77 <sup>2</sup>	45 <sup>1</sup>	71 <sup>1</sup>	\$33,600 <sup>1</sup>	\$4,060 <sup>1</sup>
3	Rainwater collection system	4	NA	NA	NA	NA	NA
4	Level spreader	4	82 <sup>2</sup>	62 <sup>2</sup>	48 <sup>2</sup>	\$8,000 <sup>2</sup>	\$1,000 <sup>2</sup>
5	Wetland	10	61 <sup>1</sup>	22 <sup>1</sup>	33 <sup>1</sup>	\$11,740 <sup>1</sup>	\$6,403 <sup>1</sup>

<sup>1</sup> Wossink and Hunt (2003).

<sup>2</sup> Unpublished data collected by Line (2005).

**Wet retention/detention ponds (Exhibit 15)** or basins are designed to retain a small permanent pool of water to enhance pollutant removal while having the capacity to temporarily retain a much larger volume of runoff that is released over several days. An important function of these ponds is the retention and slow release of water, which helps to reduce peak runoff volumes and subsequent downstream flooding and stream channel erosion. The retention of water also facilitates settling of sediment and associated pollutants in the pond, thereby treating the runoff.



**Exhibit 15. Detention pond.**

**Bioretention areas (Exhibit 16, page 29)** are designed to retain and treat a smaller volume of runoff from a smaller catchment area than retention ponds. They are less effective at reducing peak runoff rates. The typical bioretention area has a small depression on the ground surface where runoff ponds up to 9 inches before it flows over a yard inlet and into the storm drain system. Runoff that does not leave via the overflow, soaks through a surface mulch or vegetation, and then through 2-4 feet of a sandy soil material, often imported or mixed on-site, to an underdrain before exiting back into the storm drain system. As water soaks through the soil, sediment and associated pollutants are filtered leaving treated water to reenter the storm drains. The vegetation on the surface of the bioretention areas can be an array of water tolerant plants and thus provide an aesthetically pleasing addition to urban areas.

**Exhibit 16. Bioretention areas.**



**Level spreaders** (Exhibit 17, page 30) divert the runoff from channels or storm drains and spread it out over a larger, vegetated area. Although urban areas contain large amounts of impervious surface, there are often patches of vegetation left, especially along streams. Many of these areas can provide effective treatment of urban runoff. Typically, runoff is conveyed through the vegetated area by a storm drain or channel, which severely limits the treatment capability of the vegetation. The diversion can be as simple as a relatively small (<1 foot deep and <3 feet wide) channel constructed mostly on the contour in the existing soil with the end of the channel blocked. Stormwater runs into and fills the channel until the water spills over the downslope edge of the diversion in a thin uniform sheet. Spreading the water over a large area causes more water to soak into the soil where it can be used by the vegetation or percolate to the groundwater, thereby decreasing runoff volume and peak discharge. The level spreader-vegetated strip is generally not effective at peak runoff rate reductions for larger storms because there is limited storage of stormwater. Nitrogen and phosphorus in the runoff that soaks into the ground is used by the vegetation which prevents it from entering nearby streams. The vegetation can be anything from weeds to ornamental plants as long as adequate ground cover is maintained to prevent erosion. This practice is very effective at reducing nitrogen and phosphorus in stormwater if the rate and volume of runoff are relatively low. Because of the relatively flat topography in this basin, locations where this practice would be suitable are likely very limited.

**Exhibit 17. Level Spreaders in Orange County, NC and Umstead Park, Raleigh, NC.**



**Exhibit 18. Stormwater wetland.**



**Constructed stormwater wetlands (Exhibit 18)** are similar to wet retention ponds except they are much shallower (water depth 1-1.5 feet) and more heavily vegetated with wetland plants. The shallow water depth limits the amount of retention of the wetland and hence its effectiveness at reducing peak runoff rates and runoff total volume. Wetlands often have varying water depths throughout to facilitate treatment of stormwater via several different natural processes and the growth of an array of wetland plants. As stormwater flows

through the treatment wetland, pollutant removal occurs through settling of sediment, adsorption to plants, and plant uptake. Constructed stormwater wetlands can be very effective at reducing both peak runoff rates as well as nutrient levels, if properly designed. Additional benefits of constructed wetlands can include wildlife habitat and aesthetic value.

**Exhibit 19. Rain barrel.**



**Rainwater collection systems**, also called cisterns or rainbarrels (**Exhibit 19**), store roof runoff in above or underground storage structures and then release this water sometime after the rainfall event has ended. The stored water can be used to irrigate grass or ornamental plants or dumped into the storm drain system. Reductions in peak and overall discharge volume depend on the capacity of the storage structures and how the stored water is released. For example, if the water is simply stored to the end of the rainstorm and then released into the storm drain system, the peak flow rate will be reduced, but overall runoff volume will not. Because rainwater has been shown to contain 1.0 mg/L of total nitrogen (Line *et al.*, 2002), reductions in nitrogen export from the site during a rain event can also be achieved if the rainwater is stored for later use or release. Reductions in other pollutants such as metals that originate from roofs can also be significant. A

variation of rainwater collection is to plant vegetation on the roof thereby creating a green roof that will retain and use rainwater consequently reducing roof runoff.

**Preventive stormwater measures** involve actions taken to limit the amount of stormwater pollutants generated. These can include the use of plants with low water, nutrient, and pest management requirements in the landscape; sweeping paved surfaces following fertilizer application; selecting the type, amount, and timing of fertilizer application to match plant needs; limiting the use of fertilizer as de-icing agents, and proper handling and disposal of pet wastes. These practices often have minimal effects on an individual home or business basis, but can have a significant effect if widely adopted.

There are both federal and state programs, administered by the NC Division of Water Quality, that determine when stormwater controls are required by law. The federal rules primarily apply to industrial facilities and municipalities of around 50,000 people, while the state rules focus on new development and construction activities in sensitive watersheds.

### **3.3.6 Land Use Ordinances**

The Robeson County Zoning Ordinance includes a Watershed Protection Plan (WPP). It is found in Article VII of the ordinance, and was adopted in June 1998. The WPP establishes a two-tier protection system for regulating land within the watershed. Critical Area means the area within a WS-IV water supply watershed adjacent to a water supply intake or reservoir where risk associated with pollution is greater than from the remaining portions of the watershed. The Critical Area is defined as extending either 1/2 mile from the normal pool elevation of the reservoir in which the intake is located or to the ridge line of the watershed (whichever comes first); or 1/2 mile upstream from and draining to the intake. Protected Area is the area adjoining and upstream of the Critical Area of a WS-IV water supply watershed.

These two watershed designations regulate development density and impervious surface area, and prohibit certain non-residential uses that may negatively impact the watershed. A small percentage of county land, along the Lumber River, is considered Critical Area under the Watershed Protection Ordinance (Michelle Frizzell, personal communication, 2005).

The County's Zoning Ordinance incorporates the WPP, and establishes zoning districts, use regulations, conditional uses, and procedures and standards for changes and amendments, as well as enforcement. The zoning regulations help guide the growth and development of land in the county. Official zoning maps that designate the seven zoning districts within the county accompany the ordinance.

The zoning ordinance designates an Open Space zoning district that is established primarily for flood control, future roadways, public recreation, community facilities and protection of natural or man-made water bodies, forests, and other open space uses. The intent of this district is to encourage the preservation and continued use of land for conservation purposes. Residential, commercial, industrial and other uses that would interfere with preservation of open space are prohibited.

The County issues approximately 100 zoning permits per month for primarily residential development, of which about 30% are residential subdivisions. About ten percent of the development occurring within the County is commercial or industrial development. The County does not maintain records of zoning variances.

Robeson County has not adopted a land use or comprehensive plan. Several stakeholder meetings for the development of watershed plans, and planning by the Lumber River Basin Consortium call for both regional and local land use plans to improve watershed management. Land use planning can help communities define a community vision and establish policies that guide land use decisions and encourage quality and sustainable growth, as well as balance economic viability with quality of life issues.

The NCDENR Division of Water Quality is currently developing a Universal Stormwater Management Program that provides an option for participation by local governments (NCDENR, 2005c). The requirements of the Universal Stormwater Program would override other stormwater requirements that may apply. This program is intended to simplify existing rules and provide better protection to state water resources. This program is currently under review by the Environmental Management Commission and a model ordinance will be available by summer of 2006. It will allow local governments to adopt and implement a simplified stormwater program in their jurisdiction. The link to this program is: <http://h2o.enr.state.nc.us/su/usmp.htm>

There are many land use and zoning principles that can be employed by local governments to enhance the communities' ability to accommodate new growth while protecting natural resources and water quality. Land use planning tools can help communities assess land resources and develop strategies to achieve their long-term goals. The following list describes some techniques that can be used:

- **Watershed Based Zoning** is a land use planning process using subwatershed boundaries as the basis for future land use decisions. Watershed based zoning involves defining watershed conditions, measuring current and potential future impervious cover, classifying subwatersheds based on the amount of future imperviousness, and modifying land use plans and zoning to shift the location and density of future development to the appropriate subwatershed that is targeted for development.
- **Low Impact Development (LID)** is a stormwater management approach to site planning that is intended to result in a development that mimics a site's predevelopment hydrology by using design techniques that infiltrate, filter, store, evaporate, and detain runoff close to its source. Techniques are based on the premise that stormwater should not be conveyed to and managed in large, costly end-of-pipe facilities located at the bottom of drainage areas. Instead, LID addresses stormwater through small, cost-effective landscape features located at the lot level. LID provisions have been incorporated into some land development regulations, particularly in Maryland.
- **Smart growth** is defined as development that serves the economy, the community, and environment. It typically promotes mixed use development, preservation of open space, compact building design, walkable neighborhoods, directing development towards existing development, transportation options, providing predictable development decisions, and community participation.

As more development occurs within the subwatersheds, non-point source discharges from impervious surfaces will increase. These impacts can be mitigated by improved site plan design, and through the use of clustering provisions for subdivisions and open space protection provisions the County is currently implementing. These provisions can be reviewed, along with the existing zoning code to help assess the effect on water quality over time.

The Center for Watershed Protection has developed twenty-two model development principles that provide design guidance for economically viable, yet environmentally sensitive development (Center for Watershed Protection, 2005). The Center developed a project that is intended to provide planners, developers, and local officials with benchmarks to investigate where existing ordinances may be modified to reduce impervious cover, conserve natural areas, and prevent stormwater pollution. These development principles are not national design standards. Instead, they identify areas where existing codes and standards can be changed to better protect streams, lakes and wetlands at the local level.

These standards can be reviewed by local watershed advocacy groups, local governments, planners or other stakeholders for possible inclusion in plans and ordinance, or considered and modified to fit local conditions. The development principles are divided into the three following areas:

- Residential Streets and Parking Lots (Habitat for Cars)
- Lot Development (Habitat for People)
- Conservation of Natural Areas (Habitat for Nature)

Each principle is presented as a simplified design objective. Actual techniques for achieving the principle should be based on local conditions. The complete list of principles is included as **Appendix C**.

The Lumber River Basin Consortium developed a Clean Water Action Plan, and a Strategic Plan. The consortium is a multi-stakeholders organization that includes local governments, business, industry, environmental groups, the agriculture community, federal/state agencies, and research institutions. The Consortium's goal is to help with water resource issues, and to assist in watershed conservation and stewardship activities. Land Use Planning, along with surface water education, sediment/erosion control, and stormwater control were issues that were raised during Education Workshops sessions.

The Lumber River Council of Governments (COG) is currently implementing a debris removal project along approximately 64 miles of the Lumber River. The Lumber River State Park is managing the \$133,000 project awarded by DENR's Water Resources Division. The COG also received a grant award from the Division of Water Quality to develop a storm water education program for interested local governments in the Lumber River Watershed. The stormwater education project will provide workshops and technical assistance to local governments in developing stormwater ordinances.

## 4.0 IMPLEMENTATION OF MANAGEMENT PLAN

A number of watershed management recommendations have been made in the preceding sections. The implementation of these recommendations can only be achieved through the coordination and cooperation of multiple stakeholders according to the program mission and goals of each stakeholder. In this section, specific project types and locations as identified in the *Critical Area Analysis* are discussed. The main stakeholders and their potential contributions to implementation are discussed in Section 5.0.

### 4.1 Project Types

In the *Critical Area Analysis*, four project types were identified. The priority ranking for these project types indicates the suitability of the projects from EEP's program mission perspective and is not related to the Rosgen nomenclature for stream restoration.

**Priority 1-Conventional Group:** These sites are suitable for conventional stream and wetland restoration under current EEP and regulatory agency guidelines.

**Priority 2-Intermittent Group:** Sites in this group have the same characteristics as the Priority 1 group, except that the streams are mapped as intermittent on USGS 7.5" topographic quadrangles. If the Priority I sites do not meet the needs of the EEP mitigation program, it is recommended that perennial/intermittent determinations be made on the stream segments in this group. If a segment is found to be perennial based on field classification, then the site would meet the criteria for conventional mitigation.

**Priority 3-Drainage District Group:** This group of sites was identified in the same manner as the Priority 1 and 2 groups, but were set apart because they fall within the Moss Neck Drainage District. The stream segments are all channelized and most lack an adequate woody riparian buffer on one or both banks as a result of regular clearing (**Exhibit 20**).

**Exhibit 20. Typical drainage district stream with maintenance road.**



Some Priority 3 sites have ditch inputs from agricultural fields. Assuming cooperation from the drainage district and agency approval, it may be possible to obtain mitigation credit for a combination of agricultural BMPs related to the ditches, buffer enhancement on at least one bank, and stream channel modifications, water control structures, or some other technique to improve habitat, hydrologic, and water quality functions without creating adverse conditions on adjacent farm fields.

**Priority 4-Ditch/Stormwater BMP Group:** These sites were identified as having a ditch or network of ditches leading to a stream, and/or a concentrated area of impervious surface draining to a stream, as in a commercial or residential area. Agricultural or roadway ditch BMPs and/or stormwater BMP retrofits are recommended in these potential project areas to reduce sediment and pollution inputs and decrease runoff. Currently, BMPs alone are not eligible for mitigation credit, so implementation would fall to some entity other than EEP. Also, some of these areas encompass large numbers of parcels and are more suitable for initiatives at the local level.

**Table 8** below summarizes the number of projects and potential length or acreage in each project group. **Figure 3** (page 37) shows the potential project locations throughout the watershed.

**Table 8. Summary of Project Potential**

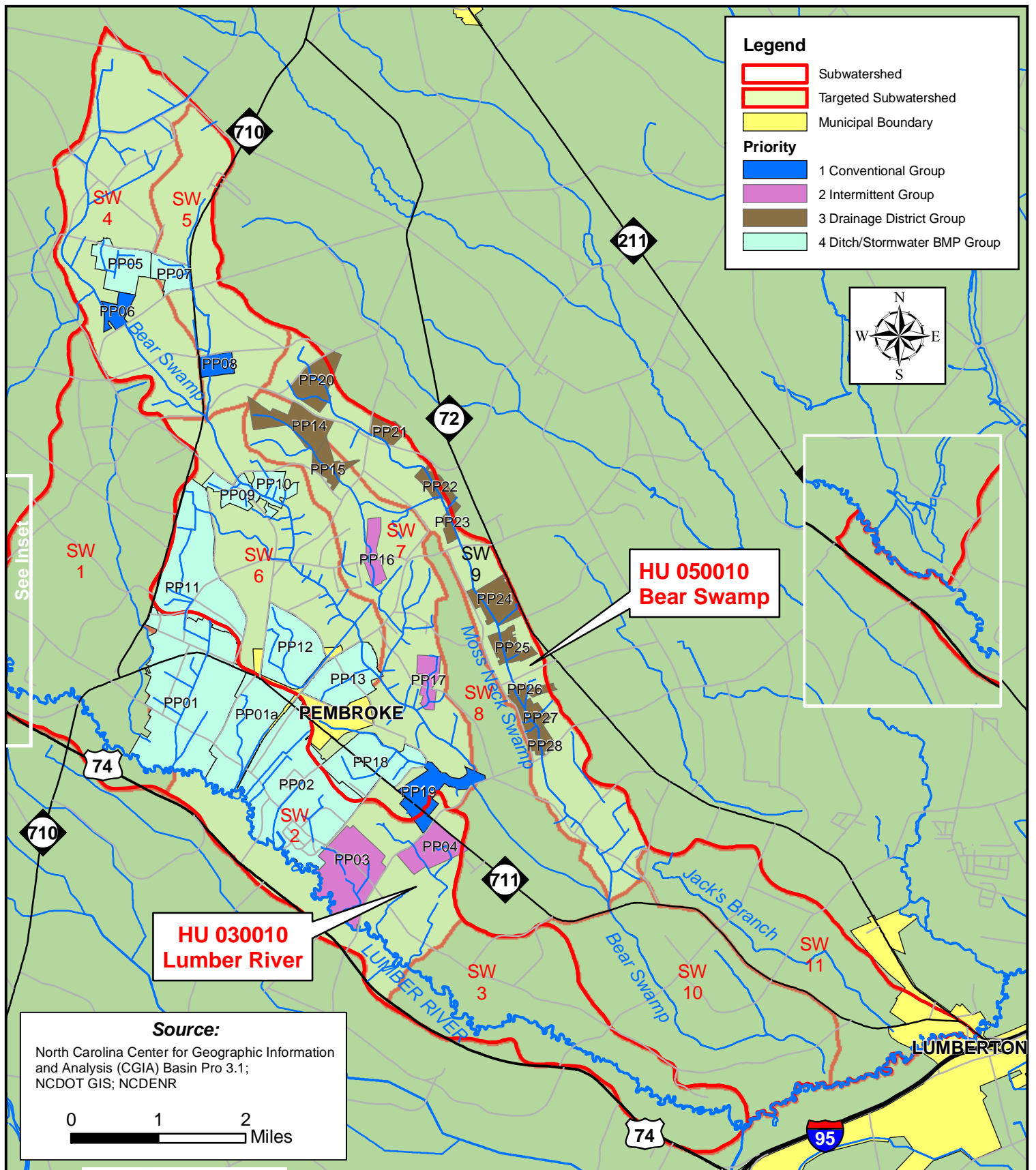
<b>Project Groups</b>	<b># of Projects</b>	<b>Total Stream Length (linear feet)</b>	<b>Total Wetland Area (acres)</b>
1-Conventional	3	6,000	25 <sup>1</sup>
2-Intermittent	4	16,500	
3-Drainage District	11	30,000	
4-Ditch/Stormwater BMPs	11	93,000 <sup>2</sup>	

<sup>1</sup>Wetland projects on two sites only, pending verification of hydric soils.

<sup>2</sup>Footage includes ditches, and perennial and intermittent streams affected by ditch inputs and stormwater

The groups are prioritized here according to current rules governing EEP compensatory mitigation credits, but the ideal would be for various stakeholders to work simultaneously to implement the parts of the watershed management plan that are most appropriate to their mission. Although the appropriate implementer for each project group is easy to define based on the practices that each implementer is able to execute, the various project types are distributed throughout the six subwatersheds. Therefore, the management plan lends itself to simultaneous, well-coordinated execution of projects on a watershed level rather than working subwatershed by subwatershed.

The Town of Pembroke occupies parts of Subwatersheds 2 (Lumber River), 6, and 7 (Bear Swamp). In addition to the urban areas with extensive impervious surface, these subwatersheds also have areas of wide, forested buffers along the main drainages, large areas of row crops, and extensive ditch systems. SW7 is the only subwatershed where livestock operations were observed. The majority of projects in these subwatersheds are in Groups 2 and 4, although the best potential project (PP) in the Conventional group (PP19) does occur in Subwatershed 7 at the



**FIGURE 3**  
**POTENTIAL PROJECT LOCATIONS**  
 Lumber River Local Watershed Plan  
 Watershed Management Plan  
 HU 030010 & HU 050010  
 Robeson County, North Carolina

downstream end of Watering Hole Swamp. Aside from PP19, which could be designed and implemented by EEP, watershed management activities in this area should focus on education and on implementation of stormwater and ditch BMPs. These activities are most appropriately handled by advocacy groups and local governments. Subwatersheds 2 and 6 are at or near the 10% threshold of impervious surface (Schueler, 2004), beyond which water quality can be expected to degrade. It is expected that impervious surface in these subwatersheds will increase, so stormwater and pollutant management education for private landowners, businesses, and LID education for developers is recommended.

The Moss Neck Drainage District covers all of Subwatershed 9 and a small part of the headwaters of Subwatershed 7. This area is all rural and the majority of potential projects are in Group 3. Implementation of these projects could be handled by EEP in collaboration with the NRCS, if negotiations with the Drainage District commissioners and the regulatory agencies are successful. If the commissioners are unwilling to allow the types of activities that would improve or restore function along Moss Neck Swamp and its tributaries to levels at which the regulatory agencies would award mitigation credits, then EEP would not be able to implement these projects according to its mission. In that case, it is recommended that the NRCS take the lead in this area to educate landowners and implement BMPs to the extent allowed by the Drainage District.

Subwatersheds 4 and 5 occupy the headwater region of Bear Swamp. This area is characterized by a relatively dry hydrologic regime compared to the rest of the watershed. The predominant land use is row crops, and the holdings are relatively small, often resulting in high numbers of landowners along a given stream reach. Only 2 potential projects in the Conventional group were identified in this area. Both could be implemented by EEP for mitigation credit. In addition, two projects from Group 4 were identified, both involving agricultural BMPs which could be implemented with assistance from NRCS.

## **4.2 Potential Projects**

**Table 9** (page 39) lists the potential projects by group, along with the recommended management practices and implementer for each project. Refer back to Section 3.3 of this report for details on the individual practices. The individual site narratives that follow the table describe the conditions of the project area and the remedial strategies that may be used to correct the deficiencies found in the project area. **Figures 4 through 10** (pages 47-59) show the location of the Potential Projects in each of the targeted subwatersheds.

*Lumber River/Bear Swamp  
Watershed Management Plan*

**Table 9. Prioritized Potential Projects**

Project Number	Figure Number	Stream Status	Stream Length	No. of Parcels	No. of Owners	Stream Name	Subwatershed No.	Stream Restoration	Stream Enhancement	Buffer Restoration	Buffer Enhancement	Agricultural BMPs	TyLvsstkBMP	Stormwater BMPs	Wetland Restoration	Group	Priority	Implementing Agency
PP06	4	PER	1670	5	5	Bear Swamp	4				X					C	1	EEP
PP08	5	PER	1280	1	1	Little Bear Swamp	5	X		X						C	1	EEP
PP19	7	PER	3050	6	4	Ditch to, and Watering Hole Sw	7	X		X		X	X		X	C	1	EEP,NRCS
PP03	3	INT	8000	2	1	UT to Lumber River	2	X		X		X			X	Int	2	EEP,NRCS
PP04	3	INT	1510	2	2	UT Lumber River	2	X		X	X	X				Int	2	EEP,NRCS
PP16	7	INT	2610	3	3	UT to Bear Swamp	7	X		X		X	X			Int	2	EEP,NRCS
PP17	7	INT	4378	5	5	UT to Bear Swamp	7	X			X					Int	2	EEP,NRCS
PP14	7	INT	4360	2	2	UT to Bear Swamp	7	X			X					DD	3	EEP,NRCS
PP15	7	INT	2500	5	5	UT to Bear Swamp	7	X			X					DD	3	EEP,NRCS
PP20	8	INT	4830	1	1	Moss Neck Swamp	9		X							DD	3	NRCS
PP21	8	PER	1280	1	1	Moss Neck Swamp	9		X		X					DD	3	EEP,NRCS
PP22	8	PER	2340	5	5	Moss Neck Swamp	9		X		X					DD	3	EEP,NRCS
PP23	8	PER	1740	4	4	Moss Neck Swamp	9		X		X					DD	3	EEP,NRCS
PP24	9	PER	3890	4	4	Moss Neck Swamp	9		X		X	X				DD	3	EEP,NRCS
PP25	9	PER	1670	5	5	Moss Neck Swamp	9		X		X	X				DD	3	EEP,NRCS
PP26	9	PER	2540	5	5	Moss Neck Swamp	9		X		X	X				DD	3	EEP,NRCS
PP27	9	PER	2530	5	5	Moss Neck Swamp	9		X		X	X				DD	3	EEP,NRCS
PP28	9	PER	1940	4	3	Moss Neck Swamp	9		X		X					DD	3	EEP,NRCS
PP01	3	PER	19450	>5	>5	Lumber River	2					X		X		Di	4	NRCS, Local
PP02	3	PER	16870	>5	>5	Lumber River	2					X		X		Di	4	NRCS, Local
PP01a	3	INT	10300	>5	>5	UT Lumber River	2					X		X		Di	4	NRCS, Local
PP05	4	DIT	6340	>5	>5	Ditch Bear Swamp	4					X				Di	4	NRCS
PP07	5	INT	3190	>5	>5	Ditch Little Bear Swamp	5					X				Di	4	NRCS
PP11	6	INT	11960	>5	>5	Ditch to UT Bear Swamp	6					X		X		Di	4	NRCS, Local
PP09	6	PER	3540	>5	>5	Bear Swamp	6					X				Di	4	NRCS
PP10	6	PER	1880	5	5	Bear Swamp	6					X				Di	4	NRCS
PP18	7	PER	6398	>5	>5	Ditch to, and Watering Hole Sw	7					X				Di	4	NRCS
PP12	6	INT	9800	>5	>5	Ditch and UT Bear Swamp	6							X		Sto	4	NRCS, Local
PP13	6	PER	3760	>5	>5	Ditch to, and Bear Swamp	6							X		Sto	4	NRCS, Local

PER-perennial; INT-intermittent; DIT-ditch; UT-unnamed tributary

**Potential Project 01 (PP01)** is located along the Lumber River in SW02. PP01 was selected based on the presence of a ditch network that drains agricultural fields and low-density residential areas. Project possibilities include agricultural and stormwater BMPs. There were no sample sites within this project area.

**Potential Project 01a (PP01a)** is downstream of PP01 and was selected for the same reasons and project possibilities.

**Potential Project 02 (PP02)** is downstream of PP01a and also encompasses a large area of agricultural fields and low-density residential development. A ditch network drains this area and empties directly into the Lumber River. The river itself is well-buffered with a mixture of swamp forest and mixed forest approximately 25-50 years old.

Native and exotic species are found in the buffer. Native species include bald cypress (*Taxodium distichum*), red maple (*Acer rubrum*), swamp black gum (*Nyssa biflora*) and smartweeds (*Polygonum* sp.) along the wetland edges. Exotic species are present in this buffer and include Japanese honeysuckle (*Lonicera japonica*), Chinese privet (*Ligustrum sinense*), and multiflora rose (*Rosa multiflora*). Wetlands are present in some locations along the river.

Project possibilities include agricultural and stormwater BMPs.

**Potential Project 03 (PP03)** is immediately downstream of PP02 and includes an unnamed tributary and a ditch that run through an agricultural field, draining to the Lumber River. The ditch and unnamed tributary (UT) lack adequate buffers, although a thin line of shrubs are growing in or along the channel. The UT is downstream from at least one roadside ditch lacking an associated detention basin and is backed up by a clogged culvert. The channel incision ratio is between 2.0 and 2.2 indicating the channel is severely incised.

Exotic species are present along the stream and include chinaberry (*Melia azedarach*) and multiflora rose.

There appear to be no hydrologic constraints, so wetland restoration may be possible in this area if hydric soils are determined to be present. Other project possibilities include stream and buffer restoration for the UT and agricultural BMPs for the ditch and fields.

The UT is currently mapped as intermittent, so project potential may hinge on that classification.

**Potential Project 04 (PP04)** is a segment of an unnamed tributary to the Lumber River and is located in SW02. It is currently mapped as intermittent. The tributary passes through an agricultural field in this area. The buffer is variable and ranges from absent to greater than 50 feet along this stretch. Where forested, the buffer is generally composed of relatively young trees between 10 and 25 years of age. The channel incision ratio is approximately 1.5 indicating the channel is moderately incised. An unmapped ditch also appears to be present perpendicular to the right bank of the UT. A mapped ditch originates in the floodplain of the left bank and empties into the UT just downstream of the project area.

Native and exotic species are found in the buffer. Native species include red maple, sweetgum (*Liquidambar styraciflua*), swamp black gum, sweetbay (*Magnolia virginiana*), ti-ti (*Cyrilla racemiflora*), loblolly pine (*Pinus taeda*), and giant cane (*Arundinaria gigantea*). The primary exotic species found in the project area is Japanese honeysuckle.

Project possibilities in this area include stream restoration (if UT is found to be perennial), buffer restoration and enhancement, and agricultural BMPs.

**Potential Project 05 (PP05)** is located north of Bear Swamp in SW04. It contains a network of drainage ditches through agricultural fields. Project possibilities include agricultural BMPs to reduce sediment and nutrient inputs from the ditches to Bear Swamp.

**Potential Project 06 (PP06)** is located on Bear Swamp and is immediately south of PP05 in SW04. It was selected based on its similarities in land use to other sampled potential project areas visible on aerial photography. Buffer enhancement is recommended along this reach.

**Potential Project 07 (PP07)** is located along an unnamed tributary of Bear Swamp in SW05. It was selected for the presence of ditches draining agricultural fields. Agricultural BMPs to reduce sediment and nutrient inputs from the ditches to the UT are recommended.

**Potential Project 08 (PP08)** includes a small segment of an unnamed perennial tributary to Bear Swamp in SW05. This tributary passes through an agricultural field. No buffer is present. The mean channel incision ratio is 2.5 for the tributary, indicating the channel is severely incised.

Project possibilities include buffer restoration and stream restoration, although probably not full hydrologic restoration.

**Potential Project 09 (PP09)** includes two ditches that empty into a relatively high-quality segment of Bear Swamp in SW06. The ditches appear mainly to drain agricultural fields.

The riparian buffer along Bear Swamp in this area is young to mature forest extending greater than 50 feet from the stream edge. Native and exotic species are present in the buffer although native species predominate. Native species include red maple, swamp black gum, tulip poplar (*Liriodendron tulipifera*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), sweet bay, ti-ti, and Virginia willow (*Itea virginica*). The exotic species present include Chinese privet and wart-removing herb (*Murdannia keisak*). Of the two, Chinese privet was far more common.

Agricultural BMPs to reduce sediment and nutrient inputs from the ditches to Bear Swamp are recommended.

**Potential Project 10 (PP10)** adjoins PP09 on the east side of Bear Swamp. It also contains a ditch that drains an agricultural field and empties into Bear Swamp. Agricultural BMPs to reduce sediment and nutrient inputs from the ditch to Bear Swamp are recommended.

**Potential Project 11 (PP11)** is a large area along the western border of SW06 that drains to a long, north-south ditch network. This system crosses into SW02 and PP01, eventually emptying

into the Lumber River. The ditches drain agricultural fields, small forest fragments, and scattered residential lots.

Agricultural and stormwater BMPs are recommended to reduce sediment, nutrient, and runoff inputs from the ditches to the Lumber River.

**Potential Project 12 (PP12)** includes an unnamed tributary to Bear Swamp in SW06 between the railroad tracks and N. Odum Dr. The tributary is currently mapped as intermittent. Land use in this area is a mixture of high and low density residential development, small agricultural fields, and forest fragments. Buffers along this tributary are primarily grass and typically 25 feet or less in width. A ditch feeding into the tributary is also present and transports pollutants and sediment to the stream.

The buffers are composed of primarily herbaceous species and exotic vegetation. Maintained grass lawns are the primary vegetation type with some native vegetation present such as rushes (*Juncus* sp.). Exotic species are present in the riparian area and include mimosa (*Albizia julibrissin*), Japanese honeysuckle, and multiflora rose.

Restoration of the tributary is not a viable option because of the high number of landowners in this area as well as physical constraints. Primarily stormwater BMPs are recommended, although some buffer enhancement may be possible.

**Potential Project 13 (PP13)** is on the east side of the railroad tracks and across from PP12. This project area includes a reach of Bear Swamp and a ditch feeding into Bear Swamp. Land use includes residential development and agricultural fields. The buffer along this segment of Bear Swamp is greater than 25 feet in width. It is composed of mature swamp forest and includes the following native species: bald cypress, swamp black gum, loblolly pine, red maple, tulip poplar, and swamp chestnut oak (*Quercus michauxii*). Exotics present in the buffer include Chinese privet and bamboo (*Phyllostachys* sp.).

Agricultural BMPs to reduce sediment and nutrient inputs from the ditch to Bear Swamp are recommended. Bear Swamp is in good condition in this area and is not in need of stream restoration or enhancement.

**Potential Project 14 (PP14)** encompasses a headwater stretch of an unnamed tributary to Bear Swamp in SW07. Streams and ditches are maintained by the Moss Neck Drainage District in this area. This site and all those in the Moss Neck Drainage District were selected because of the deeply incised stream channels and lack of forested buffers along one or both sides of the selected reach. These sites also meet the criteria for minimum reach length and number of landowners (five or fewer).

The UT, currently mapped as intermittent, flows through agricultural fields and forested stands. The riparian buffer in the forested stands is greater than 50 feet in width and is predominantly young or successional forest. The buffer is primarily a mixed pine-hardwood forest composed of loblolly pine, red maple, water oak, red bay (*Persea borbonia*), sweet pepperbush (*Clethra*

*alnifolia*), and horse sugar (*Symplocos tinctoria*). No exotic species were documented in this area.

Stream restoration opportunities in this reach are limited to Priority II-IV restoration, in-stream wetlands, or other innovative techniques which may restore in-stream habitat and certain hydrologic functions without causing adverse impacts to adjacent farmlands. Buffer enhancement may be possible as well. Coordination with the Moss Neck Drainage District is essential to develop a solution for improving water quality and aquatic habitat in the district.

**Potential Project 15 (PP15)** is downstream of PP14 to the southeast on the same intermittent UT to Bear Swamp and is in the Moss Neck Drainage District. The channel has a channel incision ratio of 5.9 and is severely incised. The buffers are much narrower along this reach, and Japanese honeysuckle is present in low densities.

Project possibilities are the same as for PP14.

**Potential Project 16 (PP16)** is downstream of PP15 on the same UT to Bear Swamp in SW07. It is outside the Moss Neck Drainage District. This reach flows through an agricultural field and the buffer, consisting of young forest, is generally less than 10 feet wide. The channel incision ratio is approximately 2.8 indicating the channel is severely incised.

Buffer vegetation is composed of native and exotic species. Native species in the buffer include sweetgum, black willow, sweetbay, red maple, and loblolly pine. Exotic species encountered include wart-removing herb.

Although this reach is not within the drainage district, hydrologic constraints still exist because of the proximity of some residential structures and farm outbuildings to the stream. The project possibilities are the same as for a drainage district site, with the potential for full 50-foot buffer restoration. Agricultural and livestock BMPs are also recommended.

**Potential Project 17 (PP17)** is similar to PP16 and includes reaches of two unnamed tributaries to Bear Swamp in SW07. Both tributaries flow through agricultural fields. The buffer along these tributaries is one tree wide or absent entirely. The channel incision ratio on the larger tributary is 4.4 indicating a severely incised channel. The small amount of buffer vegetation present is primarily grasses and other perennial herbaceous species.

Although this reach is not within the drainage district, hydrologic constraints still exist because of the proximity of some structures to the stream. The project possibilities are the same as for a drainage district site, with the potential for full 50-foot buffer restoration.

**Potential Project 18 (PP18)** includes two ditches that drain to Watering Hole Swamp in SW07. The ditches drain low density residential areas and agricultural areas. Watering Hole Swamp has a 25-50 foot buffer in this area. The channel incision ratio for the tributary is 2.0 indicating the channel is severely incised.

The tributary buffer is a mixture of native and non-native species. Cover type is primarily shrubs or herbaceous/grassy areas. Native species observed along the tributary include black willow and bald cypress. Non-native species were common in the riparian zone and include Japanese honeysuckle, Chinese privet, and kudzu (*Pueraria lobata*).

Although Watering Hole Swamp is obviously channelized in this area, the number of landowners is high. Project possibilities are most likely limited to agricultural BMPs to lessen the impact of the ditches.

**Potential Project 19 (PP19)** is downstream of PP18 on Watering Hole Swamp, and includes a ditch. This reach of Watering Hole Swamp runs through a cow pasture. Cattle have complete access to the channel and there is no buffer along the channel except at the far downstream end where Watering Hole Swamp joins Bear Swamp. The channel incision ratio was estimated to be 1.5 in this area and there is one agricultural ditch that drains into the tributary.

This site appears to have excellent stream and wetland restoration potential. It lies in a wide, shallow valley that appears to allow for full restoration of stream dimension, pattern, and profile as well as riverine wetland hydrology. Wetland restoration may be possible within the full width of the valley. If the cattle operation is maintained, livestock BMPs and 50-foot forested buffers would be recommended. Agricultural BMPs implemented along the ditch would also be recommended.

### **Potential Projects 20-28**

These sites all occur along Moss Neck Swamp in the Moss Neck Swamp Drainage District. The stream has been deeply channelized and widened and is regularly cleared of woody debris. The left bank is regularly mowed and devoid of trees. Buffer width varies along the right bank. A dirt access road parallels the swamp along the top of the left bank for its entire length. All sites in the Moss Neck Drainage District were selected because of the deeply incised stream channels and lack of forested buffers along one or both sides of the selected reach. These sites also meet the criteria for minimum length and maximum number of landowners. Coordination with the Moss Neck Drainage District is essential to develop a solution for improving habitat and water quality in the district.

**Potential Project 20 (PP20)** includes two unnamed tributaries that join in this project area to form the headwaters of Moss Neck Swamp in SW09. They are currently mapped as intermittent.

The buffer is narrow to absent at the head of each stream. A dirt road parallels the channel for the entire length of Moss Neck Swamp right at the top of the left bank. Where intact, the buffer of the northernmost channel is typically young forest that is extremely variable in width, ranging from 10 to 90 feet wide. The southernmost channel has riparian buffers that are primarily a mixture of successional forest and residential or agricultural plantings. The northern most channel has a channel incision ratio of 4 and the southernmost channel has a ratio of 2.8. These ratios indicate that both channels are severely incised.

This project area is adjacent to a portion of the Moss Neck Savanna Significant Natural Heritage Area (Moss Neck SNHA). Moss Neck Savanna SNHA is an upland pine savanna and is potential habitat for red-cockaded woodpecker (*Picoides borealis*) and Michaux's sumac (*Rhus michauxii*).

Because of the drainage district, stream restoration opportunities in this reach are limited to Priority II-IV restoration, in-stream wetlands, or other innovative techniques which may restore in-stream habitat and certain hydrologic functions without causing adverse impacts to adjacent farmlands. Buffer enhancement may be possible as well.

**Potential Project 21 (PP21)** is located along Moss Neck Swamp immediately downstream and adjacent to Moss Neck Savanna SNHA. Moss Neck Swamp has a narrow buffer in this area and is surrounded by low density residential and agricultural areas. The riparian buffer typically ranges from 10 feet to approximately 100 feet in width. The buffer, where intact, is primarily young forest. The channel incision ratio is variable and ranges from 2.2 to 4.9 indicating a severely incised channel. Exotic vegetation is present in the riparian buffers and includes wart-removing herb, Chinese privet, Japanese honeysuckle, and tree-of-heaven (*Ailanthus altissima*).

Because of the drainage district, stream restoration opportunities in this reach are limited to Priority II-IV restoration, in-stream wetlands, or other innovative techniques which may restore in-stream habitat and certain hydrologic functions without causing adverse impacts to adjacent farmlands. Buffer enhancement may be possible as well.

**Potential Project 22 (PP22)** is located on Moss Neck Swamp and was selected based on its similarities on aerial photography (1998, 1:12,000) to other sampled PPAs. Project possibilities are the same as for all sites in the Moss Neck Drainage District.

**Potential Project 23 (PP23)** is located on Moss Neck Swamp and was selected based on its similarities on aerial photography to other sampled PPAs. Project possibilities are assumed to be the same as for all sites in the Moss Neck Drainage District.

**Potential Project 24 (PP24)** is along Moss Neck Swamp downstream of PP23. A segment of Moss Neck Swamp and a drainage ditch are included in this project area. The eastern side of Moss Neck Swamp has a sizeable buffer (over 50 feet) while the buffer along the western side has been reduced significantly to less than 50 feet in some cases.

Riparian buffers in this area are a mixture of native and non-native vegetation. Native species include loblolly pine, sweetgum, black cherry, red maple, water oak, and red bay. Exotic species are also present in this project area and include wart-removing herb and wisteria (*Wisteria floribunda*).

Because of the drainage district, stream restoration opportunities in this reach are limited to Priority II-IV restoration, in-stream wetlands, or other innovative techniques which may restore in-stream habitat and certain hydrologic functions without causing adverse impacts to adjacent farmlands. Buffer enhancement may be possible as well. Agricultural BMPs are also recommended for the ditch.

**Potential Project 25 (PP25)** is located along Moss Neck Swamp downstream of PP24. It includes a segment of Moss Neck Swamp and a drainage ditch feeding into Moss Neck Swamp. Buffers along Moss Neck Swamp are very narrow or nonexistent in this area. Buffers are generally young or successional forest where present and less than 50 feet wide in many cases. There is no buffer between the drainage ditch and the agricultural fields it drains.

Vegetation in the riparian buffer is a mixture of native and non-native species. Native species include black willow, black cherry, sweetgum, ti-ti, and red maple. Non-native species include tree-of-heaven, Chinese privet, multiflora rose, and wart-removing herb.

Because of the drainage district, stream restoration opportunities in this reach are limited to Priority II-IV restoration, in-stream wetlands, or other innovative techniques which may restore in-stream habitat and certain hydrologic functions without causing adverse impacts to adjacent farmlands. Buffer enhancement may be possible as well. Agricultural BMPs are also recommended for the ditch.

**Potential Project 26 (PP26)** is located along Moss Neck Swamp downstream of PP25. It includes a segment of Moss Neck Swamp and a drainage ditch feeding into Moss Neck Swamp. Buffers along Moss Neck Swamp are somewhat narrow in this area. Buffer types are generally mature forest where present and usually no more than 10 feet in width. Vegetation in the riparian buffer is a mixture of native species, including white oak, sweetgum, and red maple. There is no buffer between the drainage ditch and the agricultural fields it drains.

Because of the drainage district, stream restoration opportunities in this reach are limited to Priority II-IV restoration, in-stream wetlands, or other innovative techniques which may restore in-stream habitat and certain hydrologic functions without causing adverse impacts to adjacent farmlands. Buffer enhancement may be possible as well. Agricultural BMPs are also recommended for the ditch.

**Potential Project 27 (PP27)** is located on Moss Neck Swamp downstream of PP26 and was selected based on its similarities on aerial photography to other sampled PPAs. Project possibilities are assumed to be the same as for all sites in the Moss Neck Drainage District.

**Potential Project 28 (PP28)** is located on Moss Neck Swamp downstream from PP27. This segment of Moss Neck Swamp has buffers typically greater than 75 feet wide in most places. In some areas the buffer exceeds 200 feet in width.

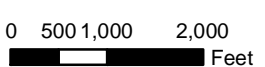
The buffer along Moss Neck Swamp is a mixture of native and non-native species. Native species include sweetgum, tulip poplar, willow oak, red maple, American holly (*Ilex opaca*), and horse sugar. Japanese privet is an exotic that has been found in the riparian buffer in this area.

Because of the drainage district, stream restoration opportunities in this reach are limited to Priority II-IV restoration, in-stream wetlands, or other innovative techniques which may restore in-stream habitat and certain hydrologic functions without causing adverse impacts to adjacent farmlands. Buffer enhancement may be possible as well.



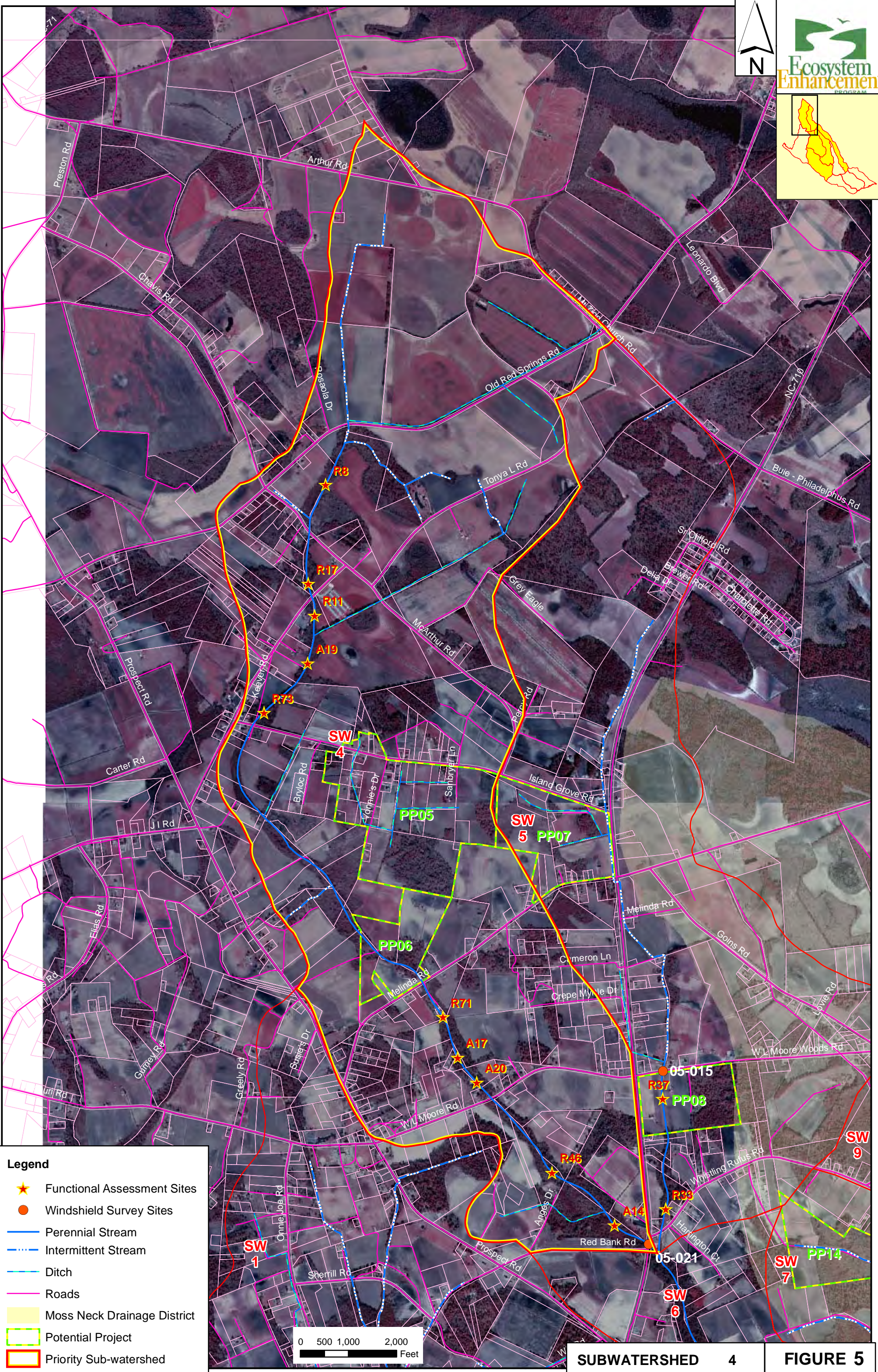
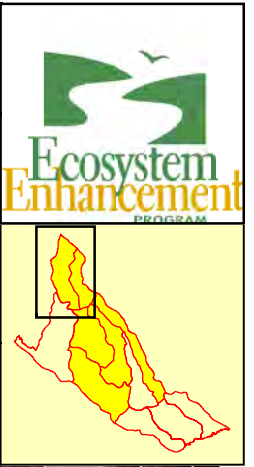
**Legend**

- ★ Functional Assessment Sites
- Windshield Survey Sites
- Perennial Stream
- - - Intermittent Stream
- Ditch
- Roads
- Moss Neck Drainage District
- Potential Project
- Priority Sub-watershed



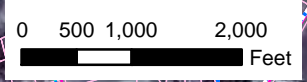
**SUBWATERSHED 2** **FIGURE 4**



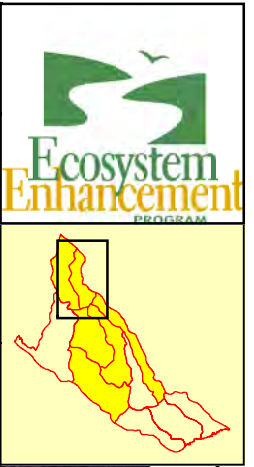


**Legend**

- ★ Functional Assessment Sites
- Windshield Survey Sites
- Perennial Stream
- - - Intermittent Stream
- Ditch
- Roads
- Moss Neck Drainage District
- Potential Project
- Priority Sub-watershed

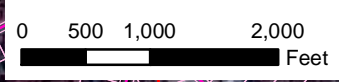






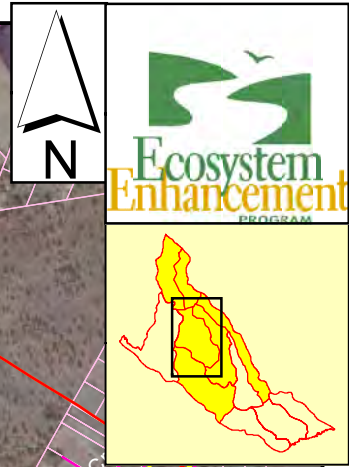
**Legend**

- ★ Functional Assessment Sites
- Windshield Survey Sites
- Perennial Stream
- - - Intermittent Stream
- - - Ditch
- Roads
- Yellow shaded area Moss Neck Drainage District
- Green outlined area Potential Project
- Red outlined area Priority Sub-watershed



**SUBWATERSHED 5** **FIGURE 6**





**Legend**

- ★ Functional Assessment Sites
- Windshield Survey Sites
- Perennial Stream
- - - Intermittent Stream
- - - Ditch
- Roads
- Yellow box Moss Neck Drainage District
- Green box Potential Project
- Red box Priority Sub-watershed

0 500 1,000 2,000 Feet

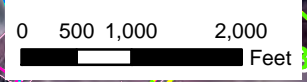
**SUBWATERSHED 6** **FIGURE 7**



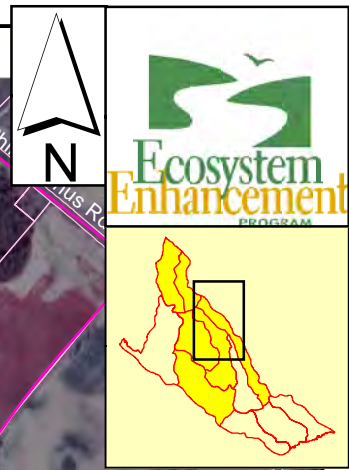


**Legend**

- ★ Functional Assessment Sites
- Windshield Survey Sites
- Perennial Stream
- - - Intermittent Stream
- Ditch
- Roads
- Moss Neck Drainage District
- Potential Project
- Priority Sub-watershed

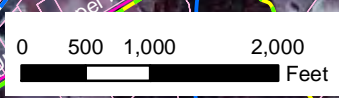






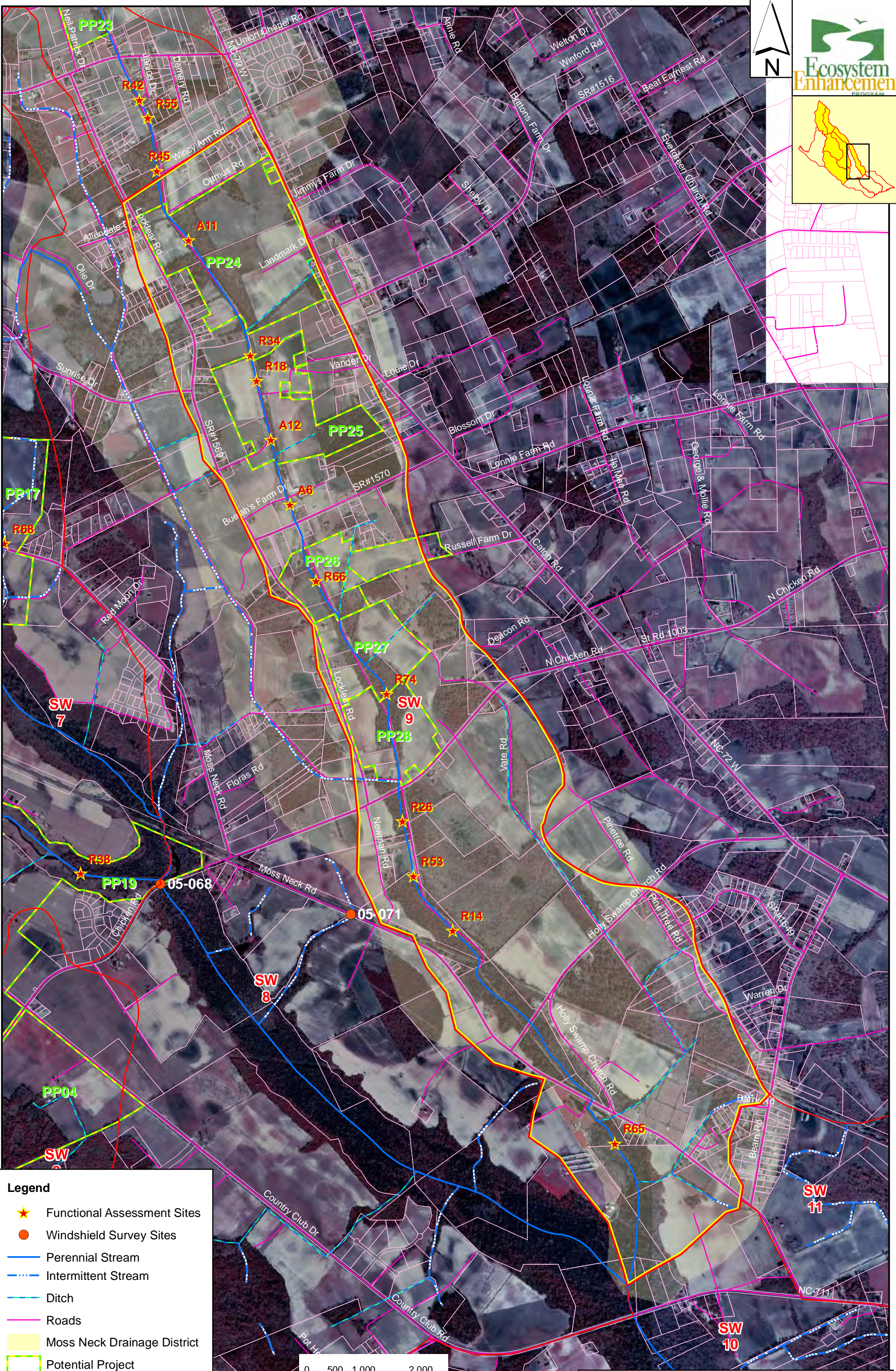
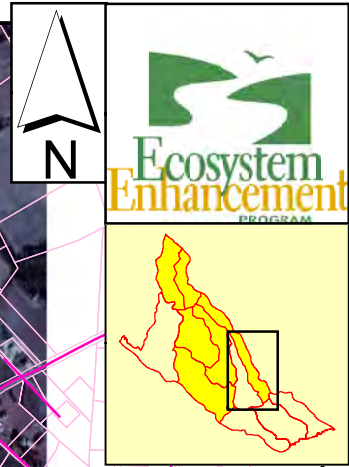
**Legend**

- ★ Functional Assessment Sites
- Windshield Survey Sites
- Perennial Stream
- - - Intermittent Stream
- Ditch
- Roads
- Moss Neck Drainage District
- Potential Project
- Priority Sub-watershed



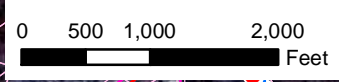
**SUBWATERSHED 9 (North) FIGURE 9**





**Legend**

- ★ Functional Assessment Sites
- Windshield Survey Sites
- Perennial Stream
- - - Intermittent Stream
- Ditch
- Roads
- Moss Neck Drainage District
- Potential Project
- Priority Sub-watershed



**SUBWATERSHED 9 (South) FIGURE 10**



## **5.0 RESOURCES FOR IMPLEMENTATION**

Identification of a lead person or agency with the time, budget, and commitment to coordinate implementation of the *Watershed Management Plan* is critical to the success of the plan. Across the state, these duties and responsibilities have been discharged by a variety of entities. City or county watershed management departments, non-profit watershed protection groups, cooperative extension agents, and NRCS personnel are all appropriate to lead and coordinate the effort. A number of interest groups currently operate in Robeson County and inclusion and coordination of these groups may prove fruitful. Some of the groups which may have missions and goals that overlap with the Watershed Management Plan are the Lumber River Council of Governments, the Lumber River Basin Consortium, the Lumber River Conservancy, and the North Carolina Coastal Land Trust. A compilation of technical resources and potential funding sources available to assist with the design and funding of the various projects in this *Watershed Management Plan* can be found in **Tables 10** and **11** at the end of this section.

The technical assistance needed to implement the recommended functional improvement measures is readily available. The Robeson Soil and Water Conservation District and local USDA NRCS offices are well-positioned to design and install livestock exclusion fencing and associated alternate watering systems. The NC Agricultural Cost Share and Environmental Quality Improvement Program (EQIP) cost share rates for BMPs are designed to cover 50-75% of the total cost of the practice. Conservation District or NRCS personnel can also oversee stream restoration projects on smaller streams. Full-scale restoration and stabilization of larger streams can be contracted to consulting firms specializing in this practice. The cost of stream restoration varies considerably based on site conditions, but has generally ranged from \$70 to as much as \$200 per foot. Funding for stream and wetland restoration, including fencing and watering systems, is available through EEP.

Standard stormwater BMP design and installation is typically handled by consulting engineers or municipal engineering departments. Funding to offset the cost of these BMPs is available through state 319 grants, Clean Water Management Trust Fund (CWMTF) grants, or stormwater utility fees if such a program is initiated by local municipalities. Grant-funded demonstration projects conducted by universities are also a possibility.

Bioretention areas, level spreaders, rainwater harvesting, and, to a lesser extent, constructed stormwater wetlands are not as common as some traditional stormwater BMPs such as detention ponds, and therefore design and installation guidelines are not as well developed. In particular, design guidelines for the bioretention and level spreader BMPs are still being developed by researchers; hence, not only should the practices be designed by a knowledgeable practicing engineer, but they should also be reviewed by researcher(s) familiar with the practices. Financial assistance could be provided from the 319 program, the CWMTF, or other sources.

Like technical assistance, much of the informational and educational support for collaborative watershed management can be conducted by personnel of the Conservation District, NRCS, and the NC Cooperative Extension Service or through a watershed group or coordinator. Providing information to personnel in these agencies would be the best way of disseminating it to rural

landowners. The NC Division of Land Resources, in addition to administering and enforcing the State Sediment and Erosion Control regulations, can provide training programs to those involved in land clearing activities on proper techniques and practices for minimizing sediment pollution.

Extensive use of rain barrels and other urban stormwater management practices would require a relatively intensive educational program. One-page flyers in utility bills, public service announcements on radio, and newspaper articles have been shown to be successful means of disseminating information on a widespread basis. Local conservation organizations, master gardeners, and municipal employees may also develop workshops and demonstration projects for neighborhoods and business associations. Several successful models for these types of programs exist across the state. The Town of Cary, for example, has arranged for a volume discount from a rain barrel manufacturer and makes them available to residents at periodic truckload sales. This award-winning program provides information and educational opportunities on water quality, water supply, and water conservation topics through monthly utility bill inserts, regular workshops, and a neighborhood block leader program.

**Table 10. Technical Resources**

<b>Management Practice</b>	<b>Program</b>	<b>Links</b>	<b>Level</b>
<i>Agricultural (livestock and cropland) BMPs</i>	USDA-NRCS, Nutrient and Pest Management	<a href="http://www.wsi.nrcs.usda.gov/products/nutrient.html">http://www.wsi.nrcs.usda.gov/products/nutrient.html</a>	Federal
	USDA-NRCS, Conservation Buffers	<a href="http://www.wsi.nrcs.usda.gov/products/buffers.html">http://www.wsi.nrcs.usda.gov/products/buffers.html</a>	Federal
	NC Cooperative Extension Service	<a href="http://www.ces.ncsu.edu/">http://www.ces.ncsu.edu/</a>	State
	NC Division of Soil and Water Conservation	<a href="http://www.enr.state.nc.us/DSWC/">http://www.enr.state.nc.us/DSWC/</a>	State
	NCSU Department of Soil Science	<a href="http://www.soil.ncsu.edu/programs/wasteman/">http://www.soil.ncsu.edu/programs/wasteman/</a>	State
<i>Forestry BMPs</i>	NC DENR, Division of Forest Resources	<a href="http://www.dfr.state.nc.us">http://www.dfr.state.nc.us</a>	State
	NC Forestry Association	<a href="http://www.ncforestry.org/docs/Landowners/regulations/mgmt_practices.htm">http://www.ncforestry.org/docs/Landowners/regulations/mgmt_practices.htm</a>	State
	NC Forest Nursery Program	<a href="http://www.dfr.state.nc.us/starting/starting_seedlingprogram.htm">http://www.dfr.state.nc.us/starting/starting_seedlingprogram.htm</a>	State
<i>Roadway BMPs</i>	NC Department of Transportation, Division of Highways	<a href="http://www.doh.dot.state.nc.us/operations/BMP_manual/">http://www.doh.dot.state.nc.us/operations/BMP_manual/</a>	State
<i>Residential BMPs</i>	Center for Watershed Protection	<a href="http://www.cwp.org/">http://www.cwp.org/</a>	National

**Table 10. Continued**

<b>Management Practice</b>	<b>Program</b>	<b>Links</b>	<b>Level</b>
<i>Planning Ordinances</i>	NC League of Municipalities	<a href="http://www.nclm.org">http://www.nclm.org</a>	State
	NC Institute of Government	<a href="http://www.iog.unc.edu/organizations/planning">www.iog.unc.edu/organizations/planning</a>	State
<i>Low Impact Development</i>	EPA's Smart Growth Initiatives	<a href="http://www.epa.gov/livability/sginitiatives.htm">http://www.epa.gov/livability/sginitiatives.htm</a>	Federal
	Low Impact Development Center	<a href="http://www.lid-stormwater.net">http://www.lid-stormwater.net</a>	National
	Prince George's County, MD Department of Environmental Resources, Low Impact Design Strategies	<a href="http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/low-impact.asp?nivel=foldmenu(7)">http://www.goprincegeorgescounty.com/Government/AgencyIndex/DER/ESD/low-impact.asp?nivel=foldmenu(7)</a>	County
	Town of Huntersville, NC – Water Quality Ordinance for LID.	<a href="http://www.co.mecklenburg.nc.us/Departments/luesa/water+and+land+resources/programs/water+quality/huntersville+ordinance/home.asp">http://www.co.mecklenburg.nc.us/Departments/luesa/water+and+land+resources/programs/water+quality/huntersville+ordinance/home.asp</a>	Town
<i>Public Education</i>	USEPA Public Education & Outreach on Storm Water Impacts	<a href="http://cfpub.epa.gov/npdes/stormwatermonth.cfm">http://cfpub.epa.gov/npdes/stormwatermonth.cfm</a>	Federal
	NC Division of Water Quality Stormwater Unit	<a href="http://h2o.enr.state.nc.us/su/Manuals_Factsheets.htm">http://h2o.enr.state.nc.us/su/Manuals_Factsheets.htm</a>	State
	Charlotte/Mecklenburg Stormwater Services	<a href="http://www.charmeck.org/Departments/Stormwater+-+City/Pollution+Prevention/Home.htm">http://www.charmeck.org/Departments/Stormwater+-+City/Pollution+Prevention/Home.htm</a>	County
	Town of Chapel Hill Stormwater Management Program	<a href="http://www.townofchapelhill.org/index.asp?NID=74">http://www.townofchapelhill.org/index.asp?NID=74</a>	Town

**Table 10. Continued**

<b>Management Practice</b>	<b>Program</b>	<b>Links</b>	<b>Level</b>
<i>Public Education</i>	Town of Cary Stormwater program	<a href="http://www.townofcary.org/depts/dsdept/engineering/engproj/stormwater/stormwatermain.htm">http://www.townofcary.org/depts/dsdept/engineering/engproj/stormwater/stormwatermain.htm</a>	Town
<i>Water Quality</i>	Center for Watershed Protection	<a href="http://www.cwp.org/">http://www.cwp.org/</a>	National
	NC Division of Water Quality	<a href="http://h2o.enr.state.nc.us/">http://h2o.enr.state.nc.us/</a>	State
<i>Stream Watch</i>	Delaware Nature Society – Delaware Stream Watch	<a href="http://www.delawarenaturesociety.org/streamwatch.html">http://www.delawarenaturesociety.org/streamwatch.html</a>	State
	Ellerbe Creek Stream Watch Association	<a href="http://www.ellerbecreek.org/streamwatch.htm">http://www.ellerbecreek.org/streamwatch.htm</a>	Local
	NC DENR Office of Environmental Education – Stream Watch	<a href="http://www.ee.enr.state.nc.us/edresources/denrprograms/streamwatch.htm">http://www.ee.enr.state.nc.us/edresources/denrprograms/streamwatch.htm</a>	State
<i>Stream Restoration</i>	North Carolina Stream Restoration Institute, NCSU Department of Agricultural and Biological Engineering	<a href="http://www.bae.ncsu.edu/programs/extension/wqg/sri/">http://www.bae.ncsu.edu/programs/extension/wqg/sri/</a>	Region
	US EPA’s River Corridor and Wetland Restoration	<a href="http://www.epa.gov/owow/wetlands/restore/">http://www.epa.gov/owow/wetlands/restore/</a>	Federal
	USDA Forest Service	<a href="http://www.stream.fs.fed.us/">http://www.stream.fs.fed.us/</a>	Federal
	NC Ecosystem Enhancement Program	<a href="http://www.nceep.net/">http://www.nceep.net/</a>	State
<i>Stream Restoration</i>	USDA-NRCS	<a href="http://www.wsi.nrcs.usda.gov/products/stream.html">http://www.wsi.nrcs.usda.gov/products/stream.html</a>	Federal

**Table 10. Continued**

<b>Management Practice</b>	<b>Program</b>	<b>Links</b>	<b>Level</b>
<i>Watershed Conservation</i>	Lumber River Conservancy	<a href="http://www.ctnc.org/landtrusts/lumber.htm">http://www.ctnc.org/landtrusts/lumber.htm</a>	Region
	Sandhills Area Land Trust	<a href="http://www.sandhillslandtrust.org/">http://www.sandhillslandtrust.org/</a>	Region
	North Carolina Coastal Land Trust	<a href="http://www.coastallandtrust.org">http://www.coastallandtrust.org</a>	Region
<i>Stormwater BMPs</i>	Center for Watershed Protection, Stormwater Manager's Resource Center	<a href="http://www.stormwatercenter.net">http://www.stormwatercenter.net</a>	Region
	NCSU Biological & Agricultural Engineering	<a href="http://www.bae.ncsu.edu/bae">http://www.bae.ncsu.edu/bae</a>	Region
	EPA, Post-Construction Stormwater Management in New Development & Redevelopment	<a href="http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm">http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm</a>	Federal
	International Stormwater Best Management Practices (BMP) Database	<a href="http://www.bmpdatabase.org">http://www.bmpdatabase.org</a>	Federal
	NCDENR BMP Manual	<a href="http://h2o.enr.state.nc.us/su/PDF_Files/SW_Documents/BMP_Manual.PDF">http://h2o.enr.state.nc.us/su/PDF_Files/SW_Documents/BMP_Manual.PDF</a>	State

*Lumber River/Bear Swamp  
Watershed Management Plan*

**Table 11. Potential Funding Sources**

<b>Agency/Source</b>	<b>Program Name</b>	<b>Description</b>	<b>Dollar Value FY 2005</b>	<b>Webpage</b>
Bureau of Land Management, U.S. Fish and Wildlife Service, and USDA Forest Service	Bring Back the Natives Grant Program	Provides funds to restore damaged or degraded riverine habitats and their native aquatic species through watershed restoration and improved land management.	\$1.1 million	<a href="http://www.nfwf.org/programs/bbn.cfm">http://www.nfwf.org/programs/bbn.cfm</a>
Corporation for National and Community Service	Learn and Serve America Program	Provides students and youth with opportunities to serve America by connecting community service with academic learning, personal growth, and civic responsibility. Typical projects address local needs in the areas of education, the environment, and other human needs.	\$500,000	<a href="http://www.learnandserve.org">http://www.learnandserve.org</a>
EPA	Drinking Water State Revolving Fund (DWSRF)	To help protect public drinking water supply	\$14.5 million	<a href="http://www.epa.gov/safewater/dwsrf/index.html">http://www.epa.gov/safewater/dwsrf/index.html</a>
EPA	Five-Star Restoration Program	Funds for community-based wetland and riparian restoration projects with a preference given on-the-ground habitat restoration and projects that involve larger watersheds.	\$500,000	<a href="http://www.epa.gov/owow/wetlands/restore/5star/">http://www.epa.gov/owow/wetlands/restore/5star/</a>
EPA	Nonpoint Source Implementation Grants (319 Program)	Provides formula grants to implement nonpoint source projects and programs in accordance with section 319 of the Clean Water Act (CWA) such as BMP's. Nonpoint source pollution reduction projects can be used to protect source water areas and the general quality of water resources in a watershed.	\$207 million	<a href="http://h2o.enr.state.nc.us/nps/Section 319 Grant Program.htm">http://h2o.enr.state.nc.us/nps/Section 319 Grant Program.htm</a>

*Lumber River/Bear Swamp  
Watershed Management Plan*

**Table 11. Continued**

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
EPA	<u>Water Quality Cooperative Agreements</u>	These EPA grants are provided to help states, Indian tribes, interstate agencies, and other public or nonprofit organizations develop, implement, and demonstrate innovative approaches relating to the causes, effects, extent, prevention, reduction, and elimination of water pollution. This includes watershed approaches for combined sewer overflow, sanitary sewer overflows, and storm water discharge problems, pretreatment and sludge (biosolids) program activities, decentralized systems, and alternative ways to measure the effectiveness of point source programs.	\$19 million (estimated)	<a href="http://www.epa.gov/owm/cwfinance/waterquality.htm">http://www.epa.gov/owm/cwfinance/waterquality.htm</a>
National Fish and Wildlife Foundation	National Fish and Wildlife Foundation General Matching Grants	Conservation grants awarded to projects that: (1) address priority actions promoting fish and wildlife conservation and the habitats on which they depend; (2) work proactively to involve other conservation and community interests; (3) leverage available funding; and (4) evaluate project outcomes.	\$4 million	<a href="http://www.nfwf.org/guidelines.cfm">http://www.nfwf.org/guidelines.cfm</a>
National Fish and Wildlife Foundation	Southern Rivers Conservation	Projects are funded that help to restore and enhance riparian and riverine habitat in twelve southeastern states including North Carolina. Projects fall into one of the three categories: (1) Stream Restoration (Restore Our Southern Rivers), (2) Freshwater Mussel Conservation, and (3) Southeastern Imperiled Fishes Management.	Not yet Available	<a href="http://www.nfwf.org/programs/ROSR.cfm">http://www.nfwf.org/programs/ROSR.cfm</a>
NCDENR	Clean Water Management Trust Fund (CWMTF)	The Clean Water Management Trust Fund makes grants to local governments, state agencies and conservation non-profits to help finance projects that specifically address water pollution problems, including repair of waste treatment equipment, riparian protection easements, restoration of degraded lands, and stormwater control.	\$100 million	<a href="http://www.cwmtf.net/">http://www.cwmtf.net/</a>

*Lumber River/Bear Swamp  
Watershed Management Plan*

**Table 11. Continued**

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
NCDENR	Ecosystem Enhancement Program	Program that combines previous stream, buffer, and wetland restoration and or enhancement work from NCDOT and an existing NCDENR program to offset unavoidable environmental impacts from transportation-infrastructure improvements.		<a href="http://www.nceep.net/">http://www.nceep.net/</a>
NCDENR	NC Ag Cost Share Program	Reduce agriculture nonpoint pollution and improve the water quality in North Carolina	Local SWCD determines	<a href="http://www.enr.state.nc.us/DSWC/pages/agcostshareprogram.html">http://www.enr.state.nc.us/DSWC/pages/agcostshareprogram.html</a>
NCDENR	North Carolina Parks and Recreation Trust	To improve or establish public parks	\$500,000 maximum per grant	<a href="http://www.partf.net/">http://www.partf.net/</a>
NCDENR-SWCD	Robeson County Soil and Water Department	To conserve, improve and sustain soil and water for future generations to come		<a href="http://www.co.robeson.nc.us/departments/soilandwater/">http://www.co.robeson.nc.us/departments/soilandwater/</a>
State of NC	Natural Heritage Trust Fund (NHP)	To acquire and protect the state's ecological diversity and cultural heritage and to inventory the natural areas of the state.	\$12 million/year	<a href="http://ils.unc.edu/parkproject/heritage/nhtf.html">http://ils.unc.edu/parkproject/heritage/nhtf.html</a>
U.S. Department of Commerce Economic Development Administration, Public Works Division	Public Works and Development Facilities Program	This program provides assistance to help distressed communities attract new industry, encourage business expansion, diversify local economies, and generate long-term, private sector jobs. Specific activities may include demolition, renovation, and construction of public facilities; provision of water or sewer infrastructure; or the development of stormwater control mechanisms (e.g., a retention pond) as part of an industrial park or other eligible project.	\$164 million	<a href="http://www.eda.gov/InvestmentsGrants/Investments.xml">http://www.eda.gov/InvestmentsGrants/Investments.xml</a>

*Lumber River/Bear Swamp  
Watershed Management Plan*

**Table 11. Continued**

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
U.S. Department of Transportation	Transportation Equity Act for the 21st Century Funding Programs (TEA-21)	Funds numerous transportation programs to improve the nation's transportation infrastructure, enhance economic growth, and protect the environment. Funds include those for transportation enhancement projects, which can include acquisition of conservation and scenic easements and the mitigation of highway stormwater runoff water quality, as well as scenic beautification, pedestrian and bicycle trails, archaeological planning, and historic preservation. These varied project types can be used to protect source water areas during construction of transportation corridors.	\$5.06 billion (National highway system), \$5.9 billion (Surface transportation program).	<a href="http://www.fhwa.dot.gov/tea21/">http://www.fhwa.dot.gov/tea21/</a>
U.S. Fish and Wildlife Service	Private Stewardship Grants Program	Provides grants and other assistance on a competitive basis to individuals and groups engaged in private conservation efforts that benefit species listed or proposed as endangered or threatened under the Endangered Species Act of 1973, as amended, candidate species, or other at-risk species on private lands within the United States. Examples of the types of projects that may be funded include managing nonnative competitors, restoring streams that support imperiled species, fencing to exclude animals from sensitive habitats, and planting native vegetation to restore a rare plant community.	\$6.9 million	<a href="http://www.fws.gov/endangered/grants/private%5Fstewardship/">http://www.fws.gov/endangered/grants/private%5Fstewardship/</a>
U.S. Fish and Wildlife Service	State Wildlife Grant Program (Non-Tribal)	Provides grants for wildlife conservation. The SWG program provides funds to help develop and implement programs that benefit wildlife and their habitat, including species that are not hunted or fished.	\$63 million	<a href="http://12.46.245.173/pls/portal30/CATALOG.PROGRAM_TEXT_RPT.SHOW?p_arg_names=prog_nbr&amp;p_arg_values=15.634">http://12.46.245.173/pls/portal30/CATALOG.PROGRAM_TEXT_RPT.SHOW?p_arg_names=prog_nbr&amp;p_arg_values=15.634</a>

*Lumber River/Bear Swamp  
Watershed Management Plan*

**Table 11. Continued**

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
USDA	Watershed Processes and Water Resources Program	The program sponsors research that address two areas: (1) Understanding fundamental processes controlling a) source areas and flow pathways of water, b) the transport and fate of water, sediment, nutrients, dissolved matter, and organisms (including water-borne pathogens), within forest, rangeland, and agricultural environments as influenced by watershed characteristics and contaminant origin, and c) water quality. (2) Developing appropriate technology and management practices for improving the effective use of water (consumptive and non-consumptive) and protecting or improving water quality for agricultural and forestry production, including the evaluation of management policies that affect the quantity and quality of water resources.	\$4.3 million	<a href="http://www.csrees.usda.gov/funding/rfas/nri_rfa.html">http://www.csrees.usda.gov/funding/rfas/nri_rfa.html</a>
USDA-Farm Agency Service	Conservation Reserve Program	CRP is a voluntary program that offers long-term rental payments and cost-share assistance to establish long-term, resource-conserving cover on environmentally sensitive cropland or, in some cases, marginal pastureland.	\$1.95 billion	<a href="http://www.fsa.usda.gov/dafp/cepd/crp.htm">http://www.fsa.usda.gov/dafp/cepd/crp.htm</a>
USDA-Forest Service	Cooperative Forestry Assistance Programs	Through its Forest Legacy Program (FLP), the USDA Forest Service supports state efforts to protect environmentally sensitive forest lands. The program helps fund the acquisition of forest land or partial interests in privately owned forest lands. It encourages and supports the acquisition of conservation easements..	Not yet Available	<a href="http://www.fs.fed.us/spf/coop/flp.htm">www.fs.fed.us/spf/coop/flp.htm</a>
USDA-Natural Resource Conservation Service	Environmental Quality Incentives Program	Established to provide a voluntary conservation program for farmers and ranchers to address significant natural resource needs and objectives. It provides technical, financial, and educational assistance.	\$992 million	<a href="http://www.nrcs.usda.gov/programs/eqip/">http://www.nrcs.usda.gov/programs/eqip/</a>
USDA-NRCS	Conservation Reserve Program (CRP) Continuous	To protect soil, water, wildlife, and to improve water quality	\$50,000 a year per person	<a href="http://www.nrcs.usda.gov/programs/crp/">http://www.nrcs.usda.gov/programs/crp/</a>

*Lumber River/Bear Swamp  
Watershed Management Plan*

**Table 11. Continued**

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
USDA-NRCS	Wetlands Reserve Program	Provides landowners with financial incentives to restore and protect wetlands in exchange for retiring marginal agricultural land on a volunteer basis. To participate in the program landowners may sell a conservation easement or enter into a cost-share restoration agreement	154,500 acres nationwide.	<a href="http://www.nrcs.usda.gov/programs/wrp/">http://www.nrcs.usda.gov/programs/wrp/</a>
USDA-NRCS	Wildlife Habitat Incentives Program (WHIP)	Develop and enhance wildlife habitat	\$10,000 (higher amounts for special projects)	<a href="http://www.nrcs.usda.gov/programs/whip/">http://www.nrcs.usda.gov/programs/whip/</a>
USDA NRCS	Watershed Protection and Flood Prevention Program	This program provides technical and financial assistance to address water resource and related economic problems on a watershed basis. Projects related to watershed protection, flood mitigation, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, agricultural water conservation, and public recreation are eligible for assistance. Technical and financial assistance is also available for planning new watershed surveys.	\$75 million	<a href="http://www.nrcs.usda.gov/programs/watershed/">http://www.nrcs.usda.gov/programs/watershed/</a>

Source: <http://cfpub.epa.gov/fedfund/>

## **6.0 TIME FACTORS**

Implementation of the Watershed Management Plan is dependent on a number of factors such as the availability of local leaders and resource agency personnel to further customize the plan and set schedules and milestones according to local priorities. Other factors include grant funding cycles, state and local budget priorities, and complexity of design and construction of the various practices. Even after the implementation of the plan, the quality of water resources often takes several years to improve significantly as the various projects stabilize.

The Clean Water Management Trust Fund is a major grantor to municipalities and conservation organizations seeking to restore and protect surface water quality. Grant applications are accepted for projects such as improvements to wastewater treatment & collection systems; stormwater management; repair of septic tanks and removal of straightpipes; wetlands, riparian buffer and stream restoration; acquisition of buffers, floodplains, wetlands, and greenways; and agricultural best management practices. Applications are received twice a year, on June 1 and December 1.

The USEPA Clean Water Act Section 319(h) funds are administered by DWQ. These funds are available for non-point source pollution management, including stormwater control. Types of projects funded include demonstration of innovative BMPs, water quality monitoring and modeling, environmental education and technology transfer, and restoration of waters impaired due to NPS pollution. Grant applications are received once a year, usually around the end of May.

Other potential grantors, such as private foundations, may be considered as well. Funding cycles vary, and would have to be investigated on an individual basis.

Once projects are defined and funding is obtained, designers and contractors can provide timeline estimates for individual projects. For a typical stream or wetland restoration project funded through EEP, the design and permitting process usually takes about one year. Construction may take from 2-6 months depending on the size of the project, and planting of the project would be restricted to the winter dormant season. Typically stormwater BMPs do not require permits. Design may take 2-4 weeks, and construction may take 1-2 months. The contact persons for EEP projects in the LRBS basin are listed below:

Eastern Project Manager  
Tracy Morris  
[Tracy.morris@ncmail.net](mailto:Tracy.morris@ncmail.net)  
919-715-1658

Watershed Planner  
Zack Mondry  
[Zackary.mondry@ncmail.net](mailto:Zackary.mondry@ncmail.net)  
919-715-6933

Ecosystem Enhancement Program  
2728 Capital Blvd., Suite 1H 103  
Raleigh, NC 27606

Mailing address:  
1652 Mail Service Center  
Raleigh, NC 27699-1652

## **7.0 MONITORING AND EVALUATION**

The type and intensity of monitoring conducted on the watershed improvement projects recommended in this plan depends on which entity implements the project, as well as on budget constraints. Projects implemented for mitigation credit by EEP would be subject to established performance criteria and would be monitored by EEP or contractors to EEP. Other projects may be implemented locally or in collaboration with universities or other agencies and monitoring plans would be developed according to program needs or particular research interests.

### **7.1 Monitoring Criteria**

There are many ways of monitoring water quality from simple observation by residents of how clear a river or lake looks to an intensive monitoring program with automated monitoring equipment. Residents can become involved with volunteer monitoring programs through the local Cooperative Extension Service or with the state's Stream Watch program ([http://www.ncwater.org/Education\\_and\\_Technical\\_Assistance/Stream\\_Watch/](http://www.ncwater.org/Education_and_Technical_Assistance/Stream_Watch/)). More intensive monitoring can be conducted by the NC Division of Water Quality, the U.S. Geological Survey, or Universities such as NC State University. This would involve establishing monitoring stations at strategic locations in the watershed to monitor flow and collect samples based on flows.

If the purpose of the monitoring is to evaluate the effectiveness of management measures, many factors must be considered in developing a monitoring plan including the configuration of sites, discharge monitoring methods, sample analysis parameters, frequency of monitoring, covariates, data analysis, and quality assurance. Monitoring sites can be configured in an upstream-downstream, paired watershed, or single downstream station manner. Generally, upstream-downstream or inflow-outflow configurations are used for evaluating single practices and either the paired watershed or single downstream station are used to compare drainage areas before and after implementation. The suitability of the drainage system also affects the configuration, in that discharge can only be monitored at a location where it collects and then enters a stable, well-defined channel. This requirement makes monitoring at some locations impossible. In addition, accurate measurement of pollutant loads resulting from nonpoint source pollution, which is the dominant type of pollution in the LRBS basin, must include monitoring of a significant proportion of the storm events occurring during the year. Because the topography and soils of the basin combine to minimize surface runoff, storm event monitoring would likely involve fewer storms than in the Piedmont or Mountains of North Carolina, but it is still needed, especially on smaller streams.

The minimum duration of monitoring is dependent on the configuration of sites and the frequency of rain events in the area. Pre- and post-implementation monitoring periods should be determined based on an analysis of the number of significant rain events occurring in the area and how many storms or data points are needed to adequately evaluate the measures. Evaluation of a single or combination of BMPs generally requires monitoring at least 15 storm events, but this will need to be determined based on specific site conditions (Spooner and Line, 1993). Highly variable runoff or pollutant export conditions may require monitoring of additional storm events. If several measures or BMPs are implemented in a larger drainage area, then often at least 1.5 years of monitoring prior to the implementation of the measures and 2 years after the

implementation is required for an adequate evaluation of the measures (Spooner and Line, 1993; Gale *et al.*, 1993).

A monitoring plan should also include recommended discharge monitoring methods. The likelihood of debris in runoff, sediment concentration, range of expected peak discharge rates, and type of runoff conveyance system affect the selection of flow monitoring methods. Debris in runoff reduces the accuracy of some flow control devices. The range of peak discharge rates should be computed from the predicted rainfall amounts, the drainage area, and land use. This range should be used to determine the type of discharge monitoring employed and, if a flow control structure is used, the size of the structure.

Sample collection frequency and number should be based on how many data points are needed to adequately characterize the hydrology of the drainage area. The plan should include a recommended minimum number of monitored storm events needed to characterize runoff and pollutant export from the drainage areas. Sample analysis parameters should be determined based on the sources of pollutants and the expected effectiveness of the practice(s). Only USEPA approved sample analysis methods should be used (USEPA, 2002; USEPA, 1997).

Monitoring of covariates such as rainfall, construction stage and activity, impervious surfaces, vegetation, and irrigation are important in interpreting monitoring results; therefore, the plan should include ways to do this, which may need to be updated as conditions change.

The plan should also include a Quality Assurance Project Plan, which should cover components such as chain-of-custody, equipment blanks, sample handling and preservation, duplicate samples (duplicates sent to certified lab), and laboratory sensitivity checks. Corrective measures should also be discussed if inadequate quality is documented.

The monitoring plan should also include expected data management and analysis methods as this is an important part of any monitoring effort. Statistical analysis of monitoring data using methods such as analysis of covariance and regression is often necessary to properly interpret the monitoring results.

Costs of monitoring should be considered a part of the cost of implementing any project. The desired level of intensity should be determined in the planning and design stage. Appropriate personnel should be identified to conduct the monitoring according to the requirements of the entity implementing the project.

## **7.2 DWQ Monitoring**

Long-term ambient monitoring stations within the watershed will continue to be sampled every 5 years by DWQ as documented in the Critical Area Analysis Report. Results are reported in the Basinwide Assessment Reports prepared by the Environmental Sciences Section and are posted on the DWQ website at <http://h2o.enr.state.nc.us/esb/Basinwide/> (NCDENR, 2002). If additional monitoring is desired, a request can be submitted to DWQ. Tissue sampling of fish taken from the Lumber River has led to a fish consumption advisory due to elevated levels of Mercury; hence, continued tissue sampling is recommended, especially for the Lumber River.

Future routine monitoring at established DWQ stations in the LRBS Basin should take into consideration any watershed improvement projects that have been implemented since the last sampling event.

### **7.3 EEP Monitoring**

One of the primary long-term goals of the Ecosystem Enhance Program is to demonstrate measurable functional improvement at the watershed scale. This will be realized through strategic watershed planning and monitoring designed to characterize functional improvement. However, the watershed scale at which functional improvement can be reliably documented and the proportion of the watershed that must be treated with nonpoint source controls to affect an improvement, given the size and degree of impairment, is currently the subject of research. Documentation of an in-stream improvement in water quality, habitat, or biotic indices resulting from the implementation of a strategic system of nonpoint source controls can be further complicated by stressor reserves within the watershed that can mask any immediate decrease in stressors for some time. As a result, EEP guidelines for implementation of watershed plans that use various combinations of natural systems restoration and stormwater BMPs are in a state of development at this time. However, there are many good references that discuss the factors that should be considered in the development of a monitoring plan (USEPA, 1997; USEPA, 2002). If watershed status and trends permit, these can be utilized to facilitate protocol development.

Monitoring guidance at the project level is available for BMPs and natural systems restoration, but with functional aspects of the latter still under development. For EEP stream and wetland restoration projects, a monitoring report template has been developed that provides a monitoring inventory. A copy of this template document entitled “Content, Format and Data Requirements for EEP Monitoring Reports” can be found at <http://www.nceep.net/>. Standard monitoring components of most EEP stream restoration projects have traditionally centered on those related to the physical and geomorphic stability, sediment transport, bedform/instream habitat, and riparian vegetative success. These still represent the core of stream restoration monitoring and typically involve 5 annual measurements after the measurement of the As-built condition. These parameters are measured and characterized through surveying techniques detailed in various references (Rosgen, 1996; USACE, 2003) and involve measuring the stream’s dimension (cross-section), pattern (plan-view geometry) and profile (longitudinal and facet slopes). The need for any one of these geomorphic stability parameters is determined by the extent of the restoration. For example, stream restoration projects that simply modify the stream cross-section will typically only require the measurement of that geomorphic parameter (dimension). One cross section is typically established for every 500 feet of project channel, depending upon channel width, and the entire project extent is typically assessed for pattern parameters.

Additional mandatory components that are now being added include Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) assessments (Rosgen, 1996) for the entire project extent before and at least 3 times after construction in order to assess the pre-and post-bank stability/sediment export. In addition, for projects that reconnect a stream to its floodplain, it will soon become a requirement to calculate the extent or volume of the newly created floodplain storage serving as an indicator of functional uplift and hydrologic functional assessment. Other

will soon become a requirement to calculate the extent or volume of the newly created floodplain storage serving as an indicator of functional uplift and hydrologic functional assessment. Other indicator parameters currently being evaluated for restoration success/effectiveness include macrobenthic community metrics, fish populations, formal habitat assessments, and other functional indicators such as leaf litter processing rates. Inclusion of these parameters should be considered carefully in terms of assessing project success due to watershed influences and require control sites up and downstream of a project site both prior to and after restoration.

The EEP monitoring protocol also requires photomonitoring of stream restoration projects. This is a useful tool for tracking the success of projects over time. When implemented according to specific guidelines and protocols, qualitative as well as quantitative data can be obtained (Lucey and Barraclough, 2001).

The aforementioned EEP monitoring template includes required elements of wetland restoration projects as well. Wetland restoration projects are monitored for hydrological function based on minimum hydroperiods and vegetative success (Environmental Laboratory, 1987). The latter for wetlands and stream riparian areas have historically been evaluated using stem-count criteria with a year-5 minimum of 260 stems per acre. New vegetative success criteria are being developed as a result of research that has been initiated with a consortium of academic researchers designed to provide more ecologically targeted and relevant criteria.

#### **7.4 BMPs**

Performance measurement at the project level for BMPs has received a great deal of attention over the last 2 decades (USEPA, 1997; USEPA, 2002; Strecker, 1998; USDOT, July 2005) and typically involves the measurement of flow/discharge and a suite of pollutants that these NPS treatment measures are designed to remove. Solids (TSS), oxygen demand (BOD, COD, TOC), nutrients (NO<sub>x</sub>, TN, TP, SRP), metals, and pathogens represent the dominant water quality parameters evaluated in relation to BMPs. To a large extent monitoring strategies and pollutants of interest will be watershed dependent, but the aforementioned references provide guidance on the development of effective monitoring strategies.

In addition to the technical monitoring, a system of regular progress reporting to local stakeholders should be developed. Newsletters, newspaper articles, and/or radio or television stories should keep the stakeholders informed of both short-term accomplishments and long-term goals.

Monitoring also must include an evaluation of the structural and functional integrity of the BMP over time. **Table 12** (page 78) lists the types and frequencies of maintenance required on the various BMPs and restoration types. Refer to **Table 7** (page 28) for cost data from published research for some of the BMPs. Generally, the only costs involved are labor and materials as needed.

**Table 12. Maintenance Requirements**

<b>Practice</b>	<b>Maintenance Requirements</b>	<b>Frequency of Maintenance</b>
Stream restoration*	None if properly built	
Wetland restoration*	Sediment removal, cleaning of outlet structure, vegetation upkeep	As needed, inspection at least 2x per year
Conservation tillage	None	NA
Grassed waterways	Mowing or reseeding, sediment removal	As needed
Field borders	Mowing or reseeding, sediment removal	As needed
Nutrient management	None	NA
Wooded and grassed buffers	Vegetation maintenance	NA
Water control structures	Clean outlet structure, replace boards**	As needed, inspection at least 2x per year
Livestock exclusion fencing	Fence maintenance	As needed, inspection at least 2x per year
Wet ret/det ponds	Sediment removal, cleaning of outlet structure, vegetation upkeep	As needed, inspection at least 2x per year
Bioretention areas	Replacement of soil material if clogged, possible flushing of drain pipes, clean high flow outlet structure, landscape vegetation maintenance	As needed, inspection at least 2x per year
Level spreaders	Occasion sediment removal, repair of the level lip, removal of woody vegetation	As needed, inspection at least 2x per year
Stormwater wetlands	Sediment removal, cleaning of outlet structure, vegetation upkeep	As needed, inspection at least 2x per year
Rainwater collection systems	Maintain pipes and fittings	As needed, inspection at least 2x per year

\*Maintenance not required beyond 5-year monitoring period. Voluntary maintenance could include invasive species management, replacement of vegetation, erosion control or repair in case of stream structure failure.

\*\* For maximum water quality effectiveness the water table height (*i.e.*, height of the boards) should be managed as described in Evans *et al.*, (1991).

## **8.0 BIBLIOGRAPHY**

Center for Watershed Protection. October 25, 2005. <http://www.cwp.org>.

Doll, B.A., G.L. Grabow, K.R. Hall, J. Halley, W.A. Harman, G.D. Jennings, and D.E. Wise. 2003. *Stream Restoration, A Natural Channel Design Handbook*. North Carolina Stream Restoration Institute and North Carolina Sea Grant.

Earth Tech. 2004. "Lumber River Technical Watershed Assessment: Initial Watershed Characterization." Prepared for NCDENR Ecosystem Enhancement Program, Raleigh, NC.

Earth Tech. 2005. "Lumber River Technical Watershed Assessment: Critical Area Analysis." Prepared for NCDENR Ecosystem Enhancement Program, Raleigh, NC.

Ecosystem Enhancement Program. October 25, 2005. "EEP Schedule of Fees." <http://www.nceep.net/pages/fee.htm>.

East Carolina University. 2005. "Applying Ecological Assessments to Planning Stream Restoration in Coastal Plain North Carolina." Report to the Ecosystem Enhancement Program, NCDENR.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1, U.S. Army Engineer Waterways Experiment Station. Vicksburg, MS.

Evans, R.O., R.D. Hinson, R. Johnson, M. Doxey, K.L. Bass, and J.T. Smith. 2004. "Innovative Approaches for Coastal Plain Agricultural Ditches." Proceedings from the 2004 North Carolina Stream Restoration Institute Stream Restoration Conference in Winston Salem, NC.

Evans, R.O., J.W. Gilliam, and R.W. Skaggs. 1991. Controlled Drainage Management Guidelines for Improving Water Quality. AG-443. NC Agricultural Extension Service, Raleigh, NC.

Gale, J.A., D.E. Line, D.L. Osmond, S.W. Coffey, J. Spooner, J.A. Arnold, T.J. Hoban, and R.C. Wimberley. 1993. Evaluation of the Experimental Rural Clean Water Program. EPA-841-R-93-005. U.S. Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds. Washington, D.C.

Hammer, D.A. 1992. *Creating Freshwater Wetlands*. Lewis Publishers, Inc. Chelsea, MI.

Hill, C.L. 1991. Effects of Land-Management Practices on Sediment Yields in Northeastern Guilford County, NC. Water Resources Investigations Report 90-4127. U.S. Geological Survey. Raleigh, NC.

- Jacobs, T.C. and J.W. Gilliam. 1985. Riparian losses of nitrate from agricultural drainage waters. *J. Environmental Quality* 14:472-478.
- Line, D.E. 2005. Evaluating BMPs for Treating Stormwater and Wastewater From NCDOT's Highways, Industrial Facilities, and Borrow Pits: Final Reports. NC Department of Transportation. Raleigh, NC.
- Line, D.E., N.M. White, D.L. Osmond, G.D. Jennings, and C.B. Mojonnier. 2002. Pollutant Export from Various Land Uses in the Upper Neuse River Basin. *Water Environment Research* 74(1):100-108.
- Line, D.E., W.A. Harman, G.D. Jennings, E.J. Thompson, and D.L. Osmond. 2000. Nonpoint-Source Pollutant Load Reductions Associated with Livestock Exclusion. *J. Environmental Quality* 29(6):1882-1890.
- Low Impact Development Center. October 25, 2005. <http://www.lowimpactdevelopment.org>.
- Lowrance, R., L.S. Altier, J.D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J.W. Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W. Lucas, and A.H. Todd. 1995. Water Quality Functions of Riparian Forest Buffer Systems in the Chesapeake Bay Watershed. U.S. Environmental Protection Agency, Washington, D.C. EPA 903-R-95-004/CBP/TRS 134/95.
- Lucey, W.P. and C.L. Barraclough. 2001. *A User Guide to Photopoint Monitoring Techniques for Riparian Areas-Field Test Edition*. Aqua-Tex Scientific Consulting Ltd. Kimberley, B.C., Canada.
- Mitsch, W.J. and J.G. Gosselink. 1993. *Wetlands*. 2nd ed. Van Nostrand Reinhold. New York, NY.
- NCDENR. 2005a. "Local Erosion and Sediment Control Ordinances." Division of Land Resources, Raleigh, NC. <http://www.dlr.enr.state.nc.us/pages/sedimentlocalprograms.html> Accessed June 2005.
- NCDENR. 2005b. "NPDES Phase II Stormwater Program." Division of Water Quality, Stormwater Unit. [http://h2o.enr.state.nc.us/su/NPDES\\_Phase\\_II\\_Stormwater\\_Program.htm](http://h2o.enr.state.nc.us/su/NPDES_Phase_II_Stormwater_Program.htm). Accessed June 2005.
- NCDENR. 2005c. "Universal Stormwater Management Program." Division of Water Quality. <http://h2o.enr.state.nc.us/su/usmp.htm>. accessed October 2005.
- NCDENR. 2002. *Lumber River Basinwide Assessment Report*. Division of Water Quality, Environmental Sciences Section, Raleigh, NC. <http://h2o.enr.state.nc.us/esb/Basinwide/>

- NCDENR, NC Department of Transportation, and US Army Corps of Engineers. 2003. "Report from the Watershed Needs Assessment Team to the Mitigation Coordination Group." <http://www.nceep.net/news/reports/WNAT%20Mit%20Group%20Final.pdf>
- Osmond, D.L., J.W. Gilliam, and R.O. Evans. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. North Carolina Agricultural Research Service Technical Bulletin 318. NC State University, Raleigh, NC.
- Peterjohn, W.T. and Correll, D.L. 1984. Nutrient dynamics in an agricultural watershed: Observations on the role of a riparian forest. *Ecology* 65:1466-1475.
- Rosgen, D. 1996. *Applied River Morphology*. Wildland Hydrology. Pagosa Springs, CO.
- SCS. 1977. Erosion and Sediment Inventory for North Carolina. USDA, Natural Resources Conservation Service. Raleigh, NC.
- Schueler, T. 2004. *Urban Subwatershed Restoration Manual No. 1: An Integrated Framework to Restore Small Urban Watersheds, Version 1.0*, in Center for Watershed Protection Urban Subwatershed Restoration Manual Series. Office of Water Management, U.S. Environmental Protection Agency, Washington, DC.
- Spooner, J. and D.E. Line. 1993. Effective Monitoring Strategies for Demonstrating Water Quality Changes from Nonpoint Source Controls on a Watershed Scale. *Water Science and Technology* 28(3-5):143-148.
- Strecker, E.W. 1998. *Considerations and Approaches for Monitoring the Effectiveness of Urban BMPs*. Woodward-Clyde, Portland Oregon.
- USACE. October 24, 2005. Wilmington District. <http://www.SAW.usace.army.mil/WETLANDS/Mitigation/definitions.html>.
- USACE. 2003. *Stream Mitigation Guidelines*. USACE, USEPA, NC Wildlife Resources Commission, NCDENR Division of Water Quality.
- USDOT. Federal Highway Administration Stormwater Best Management Practices in an Ultra-Urban Setting. <http://www.fhwa.dot.gov/environment/ultraurb/> accessed July 2005.
- USEPA. October 25, 2005. "Smart Growth." <http://www.epa.gov/smartgrowth/topics/topics.htm>
- USEPA. 2002. Chapter 5 - Sampling Effort and Collection Methods In: *Stormwater Effects Handbook: A Toolbox for Watershed Managers, Scientists, and Engineers* 929 pp. CRC Press, LLC. <http://www.epa.gov/clariton/clhtml/pubtitleOW.html>
- USEPA. 1997. Chapter 2 – Developing a Monitoring Plan In: *Monitoring Guidance for Determining the Effectiveness of Nonpoint Source Controls*. USEPA #841B96004. <http://www.epa.gov/ednrmrl/publish/book/handbook/>

- USEPA. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA 840-B-92-001. U.S. Environmental Agency, Office of Water. Washington, D.C.
- Wossink, A. and W.F. Hunt. 2003. The Economics of Structural Stormwater BMPs in North Carolina. Water Resources Research Institute Report no. 344. University of North Carolina. Raleigh, NC.
- Wu, J.S., C.J. Allan, W.L. Saunders, and J.B. Evett. 1998. Characterization and Pollutant Loading Estimation for Highway Runoff. *J. Environmental Engineering* 124(7):584-592.

9.0 GIS METADATA

Table 13 describes the data files and update processes used to produce the figures in this document.

Table 13. GIS Metadata

FILE	GEO_TYPE	PATH	FIGURE01_VicMap	FIGURE02_WatershedMap	FIGURE03_PotentialProjectLocations	FUGURES04-09(WMP_SubWatersheds)	SOURCE1	SOURCE 2	CREATED FROM	DESCRIPTION	ADDED FIELDS	CREATION/UPDATE PROCESSES
lumberbear_hu.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\Shapef	X	X	X		WRP			Boundary for HU 030010 (Lumber River) and HU 050010 (Bear Swamp)	SUBSHED_N	Populated <b>SUBSHED_N</b> with appropriate HU name (Bear Swamp or Lumber River)
countybnd.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X	X	X	X	BasinPro 3.1			Statewide county boundaries	None	None
interstate highway.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X				NCDOT GIS			Interstate highways within Robeson County	None	None
primary roads.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X				BasinPro 3.1			Statewide primary roads	None	None
major rivers.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X		X		BasinPro 3.1			Statewide major rivers	None	None
hydromaj.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X	X	X		BasinPro 3.1			Statewide major hydrography	None	None
municipalbnd.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\BasinPro\State	X	X	X		BasinPro 3.1			Statewide municipal boundaries	None	None
roads_robe.shp	Line	Q:\69796\GIS\Spatial\NAD83m\NCDOT\Infr		X	X		NCDOT GIS			Roades within Robeson County	None	None
LBHU_SW.shp	Polygon	Q:\69796\GIS\Atlas\shapefiles		X	X	X	Earth Tech	WRP	LRHU_SW	HU 030010 and HU 050010 divided into 9 sub-HUs; sub-HUs categorized as priority or non-priority	None	Added and populated <b>Priority</b> field regarding Subsheds. Created from <b>LRHU_SW.shp</b>

Lumber River/Bear Swamp  
Watershed Management Plan

FILE	GEO_TYPE	PATH	FIGURE01_VicMap	FIGURE02_WatershedMap	FIGURE03_PotentialProjectLocations	FUGURES04-09(WMP_SubWatersheds)	SOURCE1	SOURCE 2	CREATED FROM	DESCRIPTION	ADDED FIELDS	CREATION/UPDATE PROCESSES
LRHU_SW.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\Shapef					Earth Tech	WRP		HU 030010 and HU 050010 divided into 9 sub-HUs	SUBSHED_N; SUBSHED_ID; Area_m; Area_ac; Area_mi	Created by delimiting HU 030010 and HU 050010 divided into 9 sub-HUs. Populated <b>SUBSHED_N</b> with appropriate HU name (Bear Swamp or Lumber River); populated <b>SUBSHED_ID</b> with an number 1-9 which identifies the polygon as one of the 9 sub-HUs; populated Area_m by calculating area of polygons in sq meters; populated Area_ac by calculating area of polygons in acres; populated Area_mi by calculating area of polygons in sq miles.
Streams.shp	Line	Q:\69796\GIS\Atlas\shapefiles		X		X	Earth Tech	WRP	hydro_03_in.shp	Hydrography coverage file (arc)	None	Created from <b>hydro_03_in.shp</b> . Modified stream and ditch segment locations based on aerial photography. See raster images listed below.
Streams_ECU.shp	Line	Q:\69796\GIS\atlas			X		ECU			Hydrography		
hydro_03_in.shp	Line	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef					WRP			Hydrography coverage file (arc)	None	None
DrainageDistricts.shp	Polygon	Q:\69796\GIS\Atlas\shapefiles		X		X	Earth Tech	source here	Moss Neck drainage district map	Moss Neck drainage district (polygon)	DistName	Digitized from mossneck.tif; <b>DistName</b> populated with Moss Neck drainage district
hydro_03_pl.shp	Polygon	Q:\69796\GIS\Spatial\NAD83m\WRP\Shapef					WRP			Hydrography coverage file (polygon)	None	None
lumber.shp	Line	Q:\69796\GIS\Spatial\NAD83m\BasinPro\LRBS HU			X		BasinPro 3.1			Hydrography shapefile for the Lumber watershed		
PotProj.shp	Polygon	Q:\69796\GIS\atlas\shapefiles			X	X	Earth Tech		PotProjParcels.shp	Polygons representing all parcels coinciding with potential projects	NUM_OWNERS, Priority	PotProjParcels dissolved.
FuncAssmtSites.shp	Point	Q:\69796\GIS\Atlas				X	Earth Tech	ECU		Functional Assessment Sites visited.	TYPE, STORDER, STREAM, HYDORDER, SUBWSNUM, ID	Points provided by ECU, see report text for methodology. Points included in this file are those that were actually visited in the field. Information added from field notes.
photolist.shp	Point	Q:\69796\GIS\Atlas\shapefiles				X	Earth Tech		streams.shp and dotroads.shp	Points representing photo locations.	PhSiteID, SiteIDHU, OBS, SITETYPE	Points generated using intersections of streams and roads, kept if sites accessible and photos actually taken.
ditches_sw.shp	Line	Q:\69796\GIS\spatial\nad83m\wrp\shapef				X	Earth Tech	BasinPro 3.1	streams.shp	Ditches in watershed.	subshed_n, subshed_id, length_m	Subset of streams, where minor1 = 414.

FILE	GEO_TYPE	PATH	FIGURE01_VicMap	FIGURE02_WatershedMap	FIGURE03_PotentialProjectLocations	FUGURES04-09(WMP_SubWatersheds)	SOURCE1	SOURCE 2	CREATED FROM	DESCRIPTION	ADDED FIELDS	CREATION/UPDATE PROCESSES
ZoomSW.shp	Polygon	Q:\69796\GIS\Atlas\shapefiles				X	Earth Tech			Index boxes for figure locations - dummy use only		
dotroads.shp	Line	Q:\69796\GIS\spatial\nad83f\shapef				X	NCDOT GIS			NCDOT roads for Robeson county		
Parcels_LRBS.shp	Polygon	Q:\69796\GIS\Atlas\shapefiles				X	Robeson Co.			Parcels in and around study area.	PotentProj, ProjNum	Added attributes if parcel contained potential project.
PotProjParcels.shp	Polygon	Q:\69796\GIS\Atlas\shapefiles				X	Robeson Co.		Parcels_LRB S.shp	Parcels coinciding with potential projects.	PotentProj, ProjNum	Subset of Parcels_LRBS.shp, where potential project exists.
pembro1.sid	raster image	Q:\69796\GIS\Spatial\NAD83m\Imagery\CIRs				X	NCCGIA	USGS		1998 Color Infared Digital Orthophoto Quadrangles		
nwlumb3.sid	raster image	Q:\69796\GIS\Spatial\NAD83m\Imagery\CIRs				X	NCCGIA	USGS		1998 Color Infared Digital Orthophoto Quadrangles		
pembro2.sid	raster image	Q:\69796\GIS\Spatial\NAD83m\Imagery\CIRs				X	NCCGIA	USGS		1998 Color Infared Digital Orthophoto Quadrangles		
pembro3.sid	raster image	Q:\69796\GIS\Spatial\NAD83m\Imagery\CIRs				X	NCCGIA	USGS		1998 Color Infared Digital Orthophoto Quadrangles		
pembro4.sid	raster image	Q:\69796\GIS\Spatial\NAD83m\Imagery\CIRs				X	NCCGIA	USGS		1998 Color Infared Digital Orthophoto Quadrangles		
redspr3.sid	raster image	Q:\69796\GIS\Spatial\NAD83m\Imagery\CIRs				X	NCCGIA	USGS		1998 Color Infared Digital Orthophoto Quadrangles		

**General Notes:**

Refer to Appendix A of the *Initial Watershed Characterization* for other files used in intermediate steps.

All files are projected in NAD 83, North Carolina, metric coordinates.

In column SOURCE1, Earth Tech is listed as primary source of data when a GIS file is created by Earth Tech or significantly modified by geoprocessing such as cutting/intersection. In cases where Earth Tech did not generate the original data, SOURCE2 is populated with the original source. In cases where additional fields were added, but no other modifications were performed, the original source is listed in SOURCE1.



## **APPENDIX A**



## APPENDIX A

**Table A-1. Watershed Functions** (NCDENR *et al.*, 2003)

### Water Quality Functions

<b>Sub-Function</b>	<b>Indicator</b>	<b>Description</b>
Elemental Cycling and Spiraling	Living biomass Detrital biomass Hydrologic alterations	Abiotic and biotic processes that convert elements from one form to another within the watershed. These processes include nutrient and elemental cycling, biogeochemical transformation, and export of dissolved organic constituents. Plants, water, and soil microbes drive these processes.
Removal and Transport	Presence of stream buffers Presence of ponds Channel sinuosity Channel incision	Removal and transport of nutrients, contaminants, sediment, and other elements or compounds from surface waters. Plants, water, soil microbes, and stream morphology drive these processes.
Retention	Soil surface texture Sub-soil texture Soil organic matter Stream buffers Wetland cover	The ability of the watershed to retain nutrients, contaminants, sediment, and other elements or compounds that are moving towards surface waters. Nutrients, contaminants, and other elements may be physically filtered from the system by binding to fine-textured clayey soils. Plants may also filter these substances as well as sediment.
Thermal Regulation	Shading of channel Forested buffer	Absorption, storage, and dissipation of thermal energy. Temperature and thermal energy regulate the rate at which abiotic and biotic processes occur. Vertebrate and invertebrate aquatic community composition varies according to the water temperature and the amount of solar irradiation reaching the surface water body.



## Hydrology Functions

Sub-Function	Indicator	Description
Sub-Surface Water Storage	Presence of certain geologic formations Soil type Climate Abundance of perennial streams and springs	Availability of water storage beneath the surface. This ability is driven by geologic formations, soil type, and climate. This sub-function is difficult to predict without detailed geologic maps or extensive well data. Abundance of perennial streams and springs may be a surrogate measure.
Moderation Of Groundwater Flow Or Discharge	Slope Land cover type Stream buffers	Capacity of a watershed to control the rate of groundwater flow from upgradient sources. This presumably refers to headwater perennial streams and springs.
Surface Water Flow Or Discharge	Channel sinuosity Channel incision Land cover type Available floodplain	Capacity of a watershed to moderate surface water flow and energy from upgradient sources. This is related to the ability of higher-order streams to handle surface runoff and receive waters discharged by tributaries.
Dynamic Surface Water Storage	Soil permeability Floodplain width Floodplain land cover Presence of wetlands	Capacity of a watershed to detain and absorb moving water from overbank flow for a short duration when flow is out of channel. This may also include overland flow from overbank and upland surface water inputs.
Long-Term Surface Water Storage	Microtopographic features Ponds or lakes Forest cover Soil organic matter Soil permeability	Capacity of a watershed to temporarily store (retain) surface water for long durations. It is associated with standing water not moving over the surface. Water sources may be overbank flow, overland flow, channelized flow from uplands, or direct precipitation. Water may be stored in microtopographic depressions and ponds, taken up by vegetation through evapotranspirative processes, or held in the soil.



## Habitat Functions

Sub-Function	Indicator	Description
Maintain Characteristic Plant Distribution and Abundance	Forested cover Presence of wetlands Presence of exotic invasive vegetation Number of natural community types	The sub-function of maintaining a characteristic plant distribution and abundance is difficult to define with no reference watershed. It is assumed that habitat function is enhanced by the presence of natural community cover and diverse, mature, and undisturbed plant communities.
Maintain Characteristic Animal Distribution and Abundance	Trapping, point counts, or other surveys Forested cover Forested patch size Corridors between patches Number of terrestrial and aquatic community types Pools, rootwads, undercut banks, <i>etc.</i> for fish cover Rocks, leafpacks, <i>etc.</i> for benthos colonization Variety of pools Well-defined riffle-pool sequence Prevalence of nuisance predation Presence of habitat specialists Availability of water	Ability of the watershed to sustain viable, diverse terrestrial and aquatic wildlife communities characteristic of the region. Assumptions are that more diverse natural cover types will result in more diverse communities, large patches of natural cover with many connections to other patches and to water sources are preferable, patches large enough to overcome edge effects are preferable, stable, well-shaded streams are preferable; and structurally complex habitats ( <i>e.g.</i> , self-sustaining, mixed-age forest stands and stable streams with a defined riffle-pool sequence and a variety of cover for aquatic species) are preferable.
Physical Habitat Characteristics	Stand age Number of terrestrial and aquatic community types Contiguity of communities	Ability of the watershed to maintain interspersed, connectivity, temporal dynamics and spatial structure of the physical habitat. It suggests a stable, self-sustaining landscape with minimal disturbance. The assumptions and indicators for plant and animal functions listed above also apply to this function.



**Table A-2. Relationship between indicators and function scores (East Carolina University, 2005).**

INDICATORS	STREAM CHANNEL			RIPARIAN ZONE		
	Hydrology	Biogeo-chemistry	Habitat	Hydrology	Biogeo-chemistry	Habitat
Riparian zone cover (RZC)				X	X	X
Near-stream cover (NSC)		X	X			
Instream woody structure (IWS)	X	X	X			
Sediment regime (SR)		X				
Channel-riparian zone connection (CRZC)	X	X	X	X	X	X
Pollution affecting stream (PAS)	X	X	X			
Factors affecting riparian zone (FARZ)				X	X	X
Habitat quality of riparian zone (HQRZ)						X
Stream bank stability (SBS)		X	X			
Function Score: Mean of all appropriate indicator scores for each function and location (stream vs. riparian zone).	Avg.	Avg.	Avg.	Avg.	Avg.	Avg.
	Mean Function Score for Stream Channel Condition			Mean Function Score for Riparian Zone Condition		
	Composite Function Score					



## **APPENDIX B**



## APPENDIX B

### Stream Mitigation

The following discussion and definitions about mitigation and stream restoration are a compilation of information primarily from the April 2003 Stream Mitigation Guidelines published by the USACE Wilmington District. The guidance was prepared by a workgroup consisting of representatives from U.S. Army Corps of Engineers (USACE), Wilmington District, North Carolina Division of Water Quality (DWQ), U.S. Environmental Protection Agency, Region IV (EPA), Natural Resources Conservation Service (NRCS) and the North Carolina Wildlife Resources Commission (WRC).

At one time, compensatory mitigation for impacts to all aquatic systems was in the form of wetland mitigation. However, wetland mitigation does not provide appropriate replacement of aquatic functions lost due to impacts to stream systems. Because of this, the USACE and DWQ began to require that compensatory mitigation for impacts to stream resources should be in the form of restoration and/or enhancement of degraded stream channels. Stream restoration and enhancement is defined as follows:

**Stream Restoration** - The process of converting an unstable, altered, or degraded stream corridor, including adjacent riparian zone (buffers) and flood-prone areas, to its natural stable condition considering recent and future watershed conditions. This process should be based on a reference condition/reach for the valley type and includes restoring the appropriate geomorphic dimension (cross-section), pattern (sinuosity), and profile (channel slopes), as well as reestablishing the biological and chemical integrity, including transport of the water and sediment produced by the stream's watershed in order to achieve dynamic equilibrium. Examples include adding a stable pattern, dimension and profile to a channelized stream; add pools and riffles with in-stream structures.

**Stream enhancement** - The process of implementing certain stream rehabilitation practices in order to improve water quality and/or ecological function. These practices are typically conducted on the stream bank or in the flood prone area. Enhancement activities may also include the placement of in-stream habitat structures. Examples include fencing out livestock; planting wooded buffers without stream or stream bank modifications; install habitat structures; daylighting channel without altering pattern, dimension and profile with planted buffer and instream structures.

**Stream/Buffer Preservation** – Protection of ecologically important streams, generally, in perpetuity through the implementation of appropriate legal and physical mechanisms. Preservation may include the protection of upland buffer areas adjacent to streams as necessary to ensure protection or enhancement of the overall stream. Preservation must protect both sides of the channel. Generally, stream preservation

should be in combination with restoration or enhancement activities. Under exceptional circumstances, preservation may stand alone where high value waters will be protected or ecologically important waters may be subject to development pressure. Stand-alone preservation may generally be most acceptable in mitigating impacts associated with nationwide and regional general permits. Preservation may be utilized for relatively undisturbed areas that require little or no enhancement activities other than protective measures.

## **FLEXIBLE STREAM MITIGATION**

In urban areas, traditional stream mitigation may not be possible due to multiple landowners, physical constraints, or hydraulic (flooding) concerns. The regulatory agencies recognize that innovative approaches to controlling storm water and pollutant removal may provide benefits to water quality and aquatic life where traditional mitigation (as defined above) is not possible, these concepts are considered Flexible Stream Mitigation.

Where innovative approaches are approved, typically the project proponent will be required to document the benefits of the mitigation through development of a Watershed Management Plan and then monitoring. The specific mitigation credit that is generated from these innovative approaches will be determined by the regulatory agencies on a case-by-case basis. Watershed mitigation is essentially a program to provide long-term improvement and protection of an urban watershed with a variety of best management practices (BMPs), installation of aquatic habitat structures, and measures for improving public access and enjoyment.

The most important consideration for BMP selection for the watershed approach is the ability of the BMP to remedy the problem(s) identified in the watershed or sub-watershed assessment. For instance, if the problem identified is excess nutrient loading, one might consider utilizing an extended detention wetland, which is considered to be one of the better BMPs for nutrient removal. Similarly, it may be inappropriate to consider a dry detention pond, which is less effective at removing nutrients than other BMPs. In any event, BMPs must be considered on a case-by-case basis.

## **APPENDIX C**



## Appendix C

### Center for Watershed Protection Better Site Design Principles [http://www.cwp.org/22\\_principles.htm](http://www.cwp.org/22_principles.htm)

#### **Residential Streets and Parking Lots (Habitat for Cars)**

1. Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.
2. Reduce the total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.
3. Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, the sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the right-of-way wherever feasible.
4. Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Alternative turnarounds should be considered.
5. Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.
6. The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible.
7. Parking codes should be revised to lower parking requirements where mass transit is available or enforceable shared parking arrangements are made.
8. Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spillover parking areas where possible.
9. Provide meaningful incentives to encourage structured and shared parking to make it more economically viable.
10. Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.

## **Lot Development (Habitat for People)**

11. Advocate open space design development incorporating smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.
12. Relax side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.
13. Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.
14. Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes together.
15. Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing both natural and recreational open space.
16. Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing rooftop runoff to the roadway and the stormwater conveyance system.

## **Conservation of Natural Areas (Habitat for Nature)**

17. Create a variable width, naturally vegetated buffer system along all perennial streams that also encompasses critical environmental features such as the 100-year floodplain, steep slopes and freshwater wetlands.
18. The riparian stream buffer should be preserved or restored with native vegetation. The buffer system should be maintained through the plan review delineation, construction, and post-development stages.
19. Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner.
20. Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas.

21. Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, stormwater credits, and by-right open space development should be encouraged to promote conservation of stream buffers, forests, meadows, and other areas of environmental value. In addition, off-site mitigation consistent with locally adopted watershed plans should be encouraged.

22. New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, sole-source aquifers, or sensitive areas.