Gills Creek Watershed Management Plan

Prepared for:

Richland County Stormwater Management
400 Powell Road
Columbia, SC 29203

Prepared by:

TETRA TECH
2110 Powers Ferry Road, Suite 202
Atlanta, GA 30339

and

BP Barber
Engineering • Experience • Excellence
128 Millport Circle, Suite 100
Greenville, SC 29607

Final Version

May 2009

Cover photo courtesy of Elliott Powell, GCWA

Table of Contents

List of Figures

List of Tables

(This page left intentionally blank.)

Executive Summary

The Gills Creek Watershed Association (GCWA) has, as part of a comprehensive commitment to the environment and community, established a goal and vision for the health and well being of the watershed and its citizens, as follows:

> *In 2017 the Gills Creek Watershed is a national model for watershed management and planning. Citizens are enjoying the bike and walking trails throughout the watershed and it serves as the basis for an environmental education curriculum for Richland County Schools. All new development is carefully studied for its impact on the watershed and many of the mistakes of the past have been corrected. The stream corridors have received special attention, accommodate diverse wildlife and natural flows and capacities have been restored. Water quality is much improved and best management practices are working. An example is that there has been no net loss of pervious surfaces, in fact, there has been a measurable reduction in impervious surfaces in the past 3 years. Current codes reflect strong support from the public and encourage "green" development. The watershed is litter free and sedimentation in the lakes has been drastically reduced. A task force composed of governmental representatives and citizens is a model for a coordinated approach to planning, regulation and development in an environmentally sensitive area.*

The Gills Creek Watershed Management Plan has been developed as a cooperative effort between the GCWA, Richland County, the City of Columbia, The University of South Carolina, SC Department of Health and Environmental Control (SCDHEC), Tetra Tech and BP Barber in order to provide a comprehensive framework for the achievement of the stated goals of the community. The report provided herein addresses current watershed conditions, including pollutant sources and types, development conditions, environmental conditions such as stream and buffer quality, and flooding concerns. These data were compiled through collection and analysis of existing watershed information and input from coordinating public and private entities. The information was then evaluated through a matrix analysis to determine the critical areas of concern within the watershed. These critical areas were deemed the most impaired, and as such, restoration within or upstream of these areas would provide the most cost-effective overall environmental benefit to the watershed. Further, the report presents an overall management plan and strategy for the watershed based on the critical area matrix. This plan has been provided based on current watershed conditions. Thusly, as implementation of the plan continues, and development within the watershed grows, this plan should be revisited and updated periodically to ensure that the plan still meets the overall goal and vision of the GCWA and its partners. The plan has been divided into eight (8) primary sections describing existing conditions, implementation and management scenarios, as detailed below.

Section 1 of the plan presents the overall purpose and organizational framework of the watershed management plan. A planning committee, formed by GCWA, will provide oversight of the overall plan. This committee will direct planning operations and public education and outreach efforts within the watershed. The overall implementation of the individual BMPs and restoration and preservation areas is described further in Section 8. Section 1 also identifies the primary stakeholders involved with the plan. This section, including the organizational chart, should be revised on an annual basis in case additional agencies become more actively involved in the management of the project. If non-profit organizations are recruited to play a larger roll in the implementation of the plan, it may be necessary to include them in the overall management structure.

Overall baseline data are presented in Section 2 of the plan. This includes discussions of the size, surface and groundwater water resources, and demographics within the watershed. This information is utilized as a foundation for identifying the areas of high existing and future population density and projected growth.

The demographic information provided herein is a key component to locating existing and future sources of water quality problems. Information on natural resources provides a foundation for understanding the ecological processes within the watershed and for identifying important resources for protection. Unique characteristics of the watershed include its seven endangered species and over 100 lakes and ponds.

Water quality standards, impairments, and available data are identified in Section 3 of the plan. This includes 303(d) listed waterbodies, existing and potential use designations for waterbodies within the watershed, and available data from USGS, state and local governments, and stakeholders. Impaired uses include recreation, aquatic life, and fish consumption, and these uses are impaired by bacteria, low dissolved oxygen, and elevated mercury concentrations within the watershed. This section also describes the sources of stakeholder data utilized in the assessment portion of the management plan. Stakeholder input was collected through a preliminary public meeting as well as a survey; the information collected included locations within the watershed, termed "hot spots," where severe sedimentation, trash build-up, and other problems have been observed. The photograph to the right, showing sedimentation in Lake Katherine, is an example of a hot spot identified by stakeholders (photo courtesy of Elliott Powell, GCWA). Public comments on the plan were received during a public meeting and two week comment period.

Section 4 identifies the potential pollution sources associated with the impairments and other problem areas identified in Section 3. While not all pollution sources identified in this section are actively contributing to the degradation of the Gills Creek watershed, the potential exists for these sources to become influential as development and demographic shifts occur. The primary pollution sources associated with watershed degradation in this plan are identified as urban/suburban runoff, streambank erosion, waterfowl, NPDES point sources, atmospheric deposition of Mercury, sanitary sewer overflows (SSOs), and a combination of industrial sources (hazardous materials facilities, brownfields, underground storage tanks, landfills, etc.).

A two-tiered approach to assessment of watershed concerns was developed and is described in Section 5. Tier I concerns include an overall assessment of watershed function. A review of stakeholder input, available data, and other information on the watershed was conducted and the following major watershed concerns were identified:

- Flooding: Flooding hazards exist that endanger human life and have caused or may cause property damage in the future.
- Sedimentation: Streams, lakes, and other waterbodies have and continue to receive excessive sediment loads during storm events, which reduce the aesthetic and recreational value of these water bodies and impact fish and other aquatic life.
- Trash: Streams and other waterbodies contain excessive amounts of trash which reduce the aesthetic and recreational value of the watershed, endanger wildlife, and threaten to clog infrastructure.

- Water Quality and Aquatic Ecosystems: Water quality degradation in streams and other waterbodies has impaired designated uses and threatens human health as well as aquatic life.
- Wildlife: Wildlife habitat has significantly declined, and some remaining wildlife habitat is currently unprotected.

A Tier I critical area matrix was developed to identify which subwatersheds within Gills Creek were most adversely affected by the above concerns. Once these subwatersheds were identified, a Tier II matrix was evaluated which identified the most applicable management strategies to be implemented in each subwatershed. The following management strategies were considered:

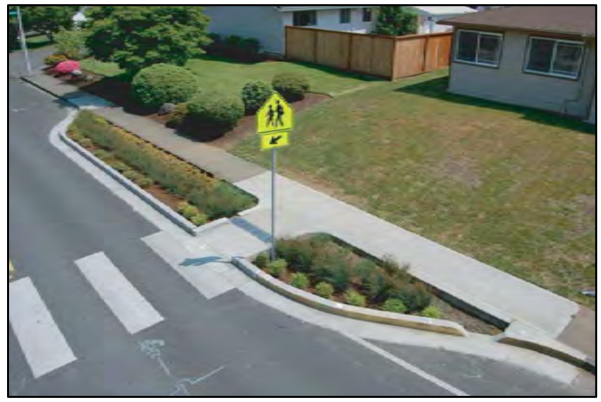
- Stormwater BMP Retrofits – Best Management Practices (BMPs), either structural or non-structural, that are implemented within existing development to reduce impacts from stormwater runoff.
- Stream and Riparian Buffer Restoration – Revegetation and/or restructuring of a stream channel, banks, and/or floodplain area to reduce high flows, downstream flooding, and erosion and to restore the biological and water quality functions of a stream.
- Preservation – Acquisition and permanent protection of undisturbed natural areas to protect wildlife habitat and downstream water quality.
- New Development Policies – Requirements or other policies to encourage control and treatment of stormwater runoff from new development to protect watershed functions, including water quality and aquatic habitat.
- Other Policies and Outreach – Programs implemented to educate watershed citizens and promote watershed protection efforts.

This section of the plan provides the most detailed analytical analysis of the watershed. As such, these matrices should be reevaluated regularly to determine their applicability based on newly collected data or visual information.

Section 6 reiterates the overall goals of the GCWA and Richland County as part of the overall watershed management plan. It defines the primary concerns of the citizenry and the long-term goals of the management plan. This is a critical component in the implementation of any management plan. While this plan does not provide the means to address and restore every water quality issue within the Gills Creek watershed, it serves as a guide to be used as a tool for implementation and achievement to the maximum extent practicable of the GCWA goals and objectives.

Based on the Tier II scoring and identification of subwatershed concerns, a two-scenario implementation approach is developed and described in Section 7. The two scenarios differ in the type of management and the area of water quality treatment. As a corollary to the difference in the scenario, the section also provides rough cost estimates for each scenario. While both scenarios provide water quality treatment and watershed restoration suitable for achieving the GCWA goals, it should be understood that Scenario 1 is the optimum treatment option for the watershed. This scenario recommends the following:

- BMP retrofits: 1270 acres of drainage area to be treated, estimated to cost between $26.4 million and $51.4 million.
- Trash management: 1330 acres of drainage area and one in-stream trash boom, estimated to cost between $0.4 and $0.6 million.
- Stream restoration: 25,000 feet, estimated to cost between $6.4 and $7.9 million.
- Riparian buffer restoration: 210 acres, estimated to cost between $2.7 and $4 million.
- Preservation: 4800 acres, estimated to cost between $30 and $104 million.



Scenario 2 includes similar management recommendations within smaller areas and at a reduced cost. New development policies (including the use of innovative design techniques) and public outreach and education are also recommended for both scenarios. A "green street" is shown in the photograph to the right, an example of BMP techniques recommended as part of the management scenarios.

While specific project sites are not identified in this report, locations and target areas are recommended within each subwatershed where projects should be focused, during implementation, in order to address watershed concerns. Targets have been identified based on treatment drainage area. These criteria should be followed during the site identification and construction portion of the implementation. Treatment effectiveness and pollutant removal efficiency are more critical in the overall restoration of the watershed as opposed to the overall number of BMPs implemented. Thus, the cost estimates may vary as new technology develops and site-specific BMPs are identified. This section provides a suite of BMP retrofit options and details the general stream restoration and preservation approach. Field data will need to be collected during implementation to further define site-specific restoration needs.

The total estimated costs for plan implementation are $68 to $169 million for Scenario 1 and $27 to $48 million for Scenario 2. To achieve implementation, this plan recommends a three-phase approach in which the following would occur:

- Phase I: Begin to implement Scenario 2 with small, neighborhood BMP retrofit projects (bioretention, rain barrels/cisterns, etc.) and riparian buffer restoration or preservation. Provide outreach, education, assistance to public on reducing watershed impacts. Conduct septic system inventory. Estimated cost: $1 million for Scenario 2; $155,000 per year for outreach; $10,000 to $100,000 for a septic system inventory.
- Phase II: Complete implementation of Scenario 2 when larger funding sources are available. Continue public outreach, education, and assistance efforts. Estimated cost: $26 to $47 million for Scenario 2 and $155,000 per year for outreach.
- Phase III: Implement the remaining management proposed in Scenario 2 that is not proposed in Scenario 1. Continue public outreach, education, and assistance efforts. $41 to $121 million for Scenarios 1 and 2; $155,000 per year for outreach.

The implementation of the watershed management plan is detailed in Section 8. This includes the management strategy for the implementation of the plan, acquisition and identification of funding sources, and a timeline for implementation. While this timeline is not identified as permanent and can shift based on property acquisition issues and economic factors, it provides a guideline of measureable goals to achieve watershed improvement that supports the GCWA mission. This section also outlines the necessary steps required for identification, data collection, design and installation of the BMPs, stream restoration and preservation areas discussed in this report. As part of any plan implementation, the most important component is effective and identifiable results. A monitoring program is outlined in this section to provide tangible results to the GCWA, Richland County, the City of Columbia and SCDHEC. This monitoring is crucial in identification of successful restoration activities and serves as a basis of justification for future implementation.

The Gills Creek Watershed Management Plan recommends the strategies critical to restoring watershed functions, addressing impairments, and protecting the natural resources of the Gills Creek watershed. The recommendations were developed through an evaluation of both existing data and stakeholder input and, therefore, provide a publically supported watershed management plan with a scientific foundation. The implementation of this plan will require coordinated efforts among GCWA, Richland County, City of Columbia, and other local governments and partners. Through careful attention to implementation recommendations herein as well as changing watershed conditions, the partners have an opportunity to begin a watershed management program that can ultimately succeed at restoring and protecting watershed functions.

Photo of Forest Lake courtesy of Elliott Powell, GCWA

(This page left intentionally blank.)

1.0 Introduction

1.1. Document Overview

This watershed management plan describes existing conditions in the Gills Creek watershed, establishes critical areas for restoration and preservation, and defines management strategies and an implementation program to meet goals set by Richland County and the Gills Creek Watershed Association (GCWA). Various watershed and planning studies and data collection efforts have been completed in the watershed by a number of agencies including the US Geological Survey (USGS), US Army Corps of Engineers (USACE), SC Department of Health and Environmental Control (SCDHEC), Academic Institutions, the City of Columbia, and Richland County. Existing data, information, and reports were used to prepare this watershed management plan.

Each section of this document is designed to provide a clear picture of the steps taken to establish an endpoint for the Gills Creek watershed to be a national example for restoration and preservation. Section 2 of this report describes existing conditions in the watershed. Section 3 describes data collected to quantify ecosystem conditions, including water quality, water quantity, and biological data. Section 4 presents a pollutant source assessment which identifies stressors in the watershed. Section 5 presents the link between data collected in the watershed and sources of pollutants, as described in other sections, through the identification of critical areas. Section 6 defines the goals and objectives that will be met through implementation of this watershed management plan. Sections 7 and 8 define management strategies and an implementation program, respectively, to meet the goals and objectives of this watershed management plan.

1.2. Watershed Management Plan Purpose and Process Used

1.2.1. Watershed Management Team

This watershed management plan is truly a collaborative effort. Richland County and the GCWA have established relationships with various federal, state, and local agencies, private entities, and watershed residents. This effort was accomplished with the participation from members of the GCWA. Contributors include the following:

- US Department of Agriculture – Natural Resources Conservation Service
- US Environmental Protection Agency
- SC Department of Health and Environmental Control
- SC Department of Natural Resources
- City of Columbia
- Yancey Environmental Solutions

Figure 1-1 provides an organizational chart for the major management efforts in the Gills Creek watershed.

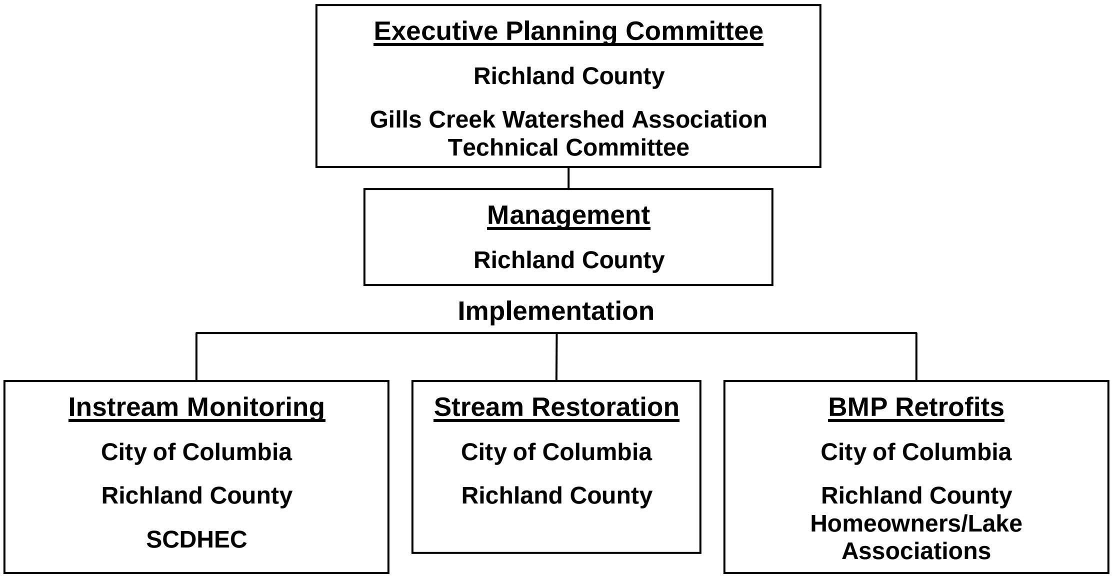


Figure 1-1. Organizational Chart

1.2.2. Public Participation

Public participation was critical in developing goals, objectives, and management strategies for implementation of this watershed management plan. Ultimately, the quality of implementation will depend on the involvement of residents in the Gills Creek watershed. In December 2007, the GCWA held a public meeting where stakeholders defined “hot spots” in the watershed where trash, flooding, sedimentation, and other activities have been seen. In October 2008, a survey was also conducted of residents by the GCWA’s outreach committee to determine critical areas in the watershed. Finally, a stakeholder meeting will be held to present the final watershed management plan. These efforts are described in more detail in Section 3.3.

The final stakeholder meeting was held on Thursday, April 30, 2009 as an opportunity for the public to provide comments on the completed WMP. Implementation will require involvement from residents and municipalities in the watershed. This public meeting offered an opportunity for stakeholders to voice their suggestions and concerns regarding management strategies used to implement this watershed management plan. A two-week comment period was provided following the meeting. Appendix E lists the comments received. The public comments focused on site-specific concerns within the watershed. The locations noted in these comments should be evaluated for potential project opportunities during implementation.

2.0 Watershed Description

2.1. WATERSHED BOUNDARY

The Gills Creek watershed includes seven 14-digit Hydrologic Unit Codes (HUCs) within one 11-digit HUC (03150110-030) and is located in Richland County, South Carolina. The watershed consists primarily of Gills Creek and its tributaries and waterbodies – Jackson Creek, Bynum Creek, Rose Creek, Mack Creek, Wildcat Creek, Carys Lake, and Spring Lake – which encompass over 70 miles of streams. The Gills Creek watershed covers 74.5 square miles (47,681 acres) including parts of Columbia, Forest Acres, and Fort Jackson, a U.S. Army basic combat training center. Originating near Sesquicentennial State Park, Gills Creek flows through the northeastern section of the City of Colombia and eventually drains into the Congaree River. The Congaree River is formed by the confluence of the Saluda and Broad Rivers within the City of Columbia between Richland, Calhoun, and Lexington Counties and flows into the Santee River, which ultimately discharges into the Atlantic Ocean.

2.2. HYDROLOGY

2.2.1. Surface Water Resources

The Gills Creek watershed contains over 70 miles of streams, beginning above Sesquicentennial State Park and eventually flowing into the Congaree River below Columbia. Table 2-1 displays streams within the Gills Creek watershed, providing the name and type of each waterbody and the respective stream lengths in miles. Figure 2-1 and Figure 2-2 provide the location of streams and impoundments, respectively.

Table 2-1. Hydrology of the Gills Creek Watershed

Waterbody	Length (Miles)
Alligator Lake	0.26
Bells Pond	0.15
Boyden Arbor Pond	0.57
Bruners Pond	0.24
Bynum Creek	0.76
Carys Lakes	0.95
Clark Pond	0.13
Drexel Lake	0.16
Eightmile Branch	0.78
Forest Lake	1.07
Gills Creek	4.56
Hughes Pond	0.35
Jackson Creek	0.78
Lake In The Woods	0.03
Lake Katherine	1.06
Lightwood Knot Branch	0.77
Little Jackson Creek	0.70

Waterbody	Length (Miles)
Lower Legion Lake	0.15
Mack Creek	0.60
Old Barstow Pond	0.09
Orphanage Branch	0.32
Pen Branch	0.76
Rockyford Lake	0.83
Rose Creek	0.80
Rowell Creek	0.59
Semmes Lake	0.34
Spring Lake	0.41
Upper Legion Lake	0.22
Wildcat Creek	0.99
Windsor Lake	1.33

There are over 100 impoundments within the watershed. The largest impoundments in the watershed are Windsor Lake, Rockyford Lake, Spring Lake, Forest Lake, Lake Katherine, Cary Lake, and Springwood Lake. Natural springs in the watershed were built up as local resorts in the 1800s. Today, the majority of large impoundments in the watershed are managed by home and lake owners associations. The recreational enjoyment and aesthetic value of water resources (including wetlands, lakes, and ponds) have brought a number of residents to the area.

2.2.2. Groundwater Resources

The Gills Creek watershed is within the Southeastern Coastal Plain aquifer system. Rocks within the Gills Creek watershed are composed of semiconsolidated sand aquifers which consist of semiconsolidated sand interbedded with silt, clay, and minor carbonate rocks. Semiconsolidated sand aquifers have a moderate to high hydraulic conductivity and porosity is intergranular. The varied depositional environments of these sediments have caused complex interbedding of fine and coarse grained materials.

Richland County Public Health Department is not aware of any residents that are using drinking water wells within the watershed (Robert Deyo, Richland County Public Health Department, personal communication to H. Fisher, November 2008). All jurisdictions in the watershed are using municipal drinking water systems.

2.2.3. Flood Plains

The hydrology of Gills Creek is influenced by the Congaree River floodplain, which intersects with the watershed. During large storm events, the lower portion of the watershed nearest the Congaree River is likely to receive some floodwaters from the river. The lower watershed in general is characterized by flat land and nearly all of the watershed drainage area south of State Highway 48 (Bluff Road) is within the 100-year floodplain. The floodplain narrows above State Highway 48 and, in the central and upper portions of the watershed, the widest floodplain areas coincide with the watershed's largest impoundments.

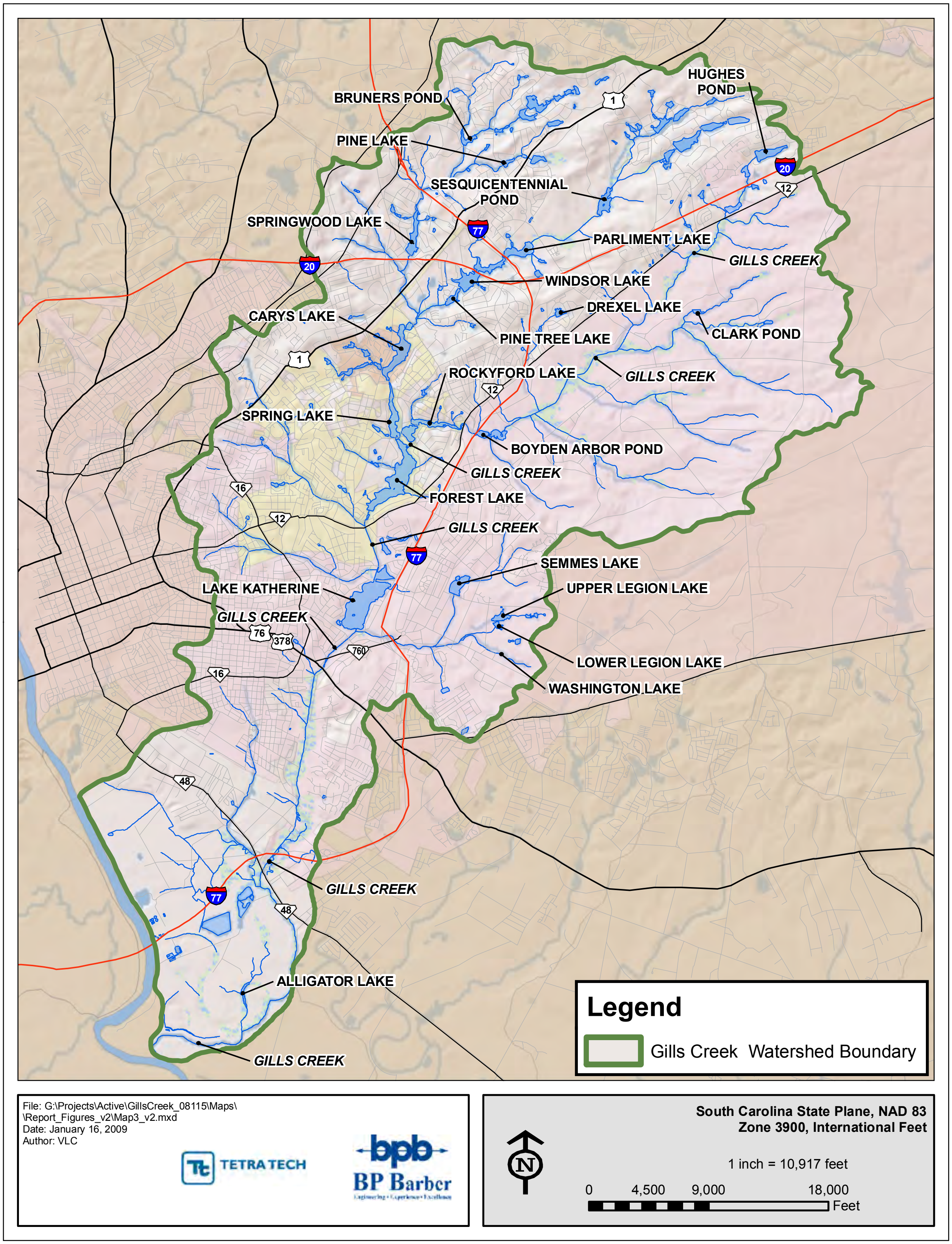


Figure 2-1. Gills Creek Watershed Streams and Tributaries

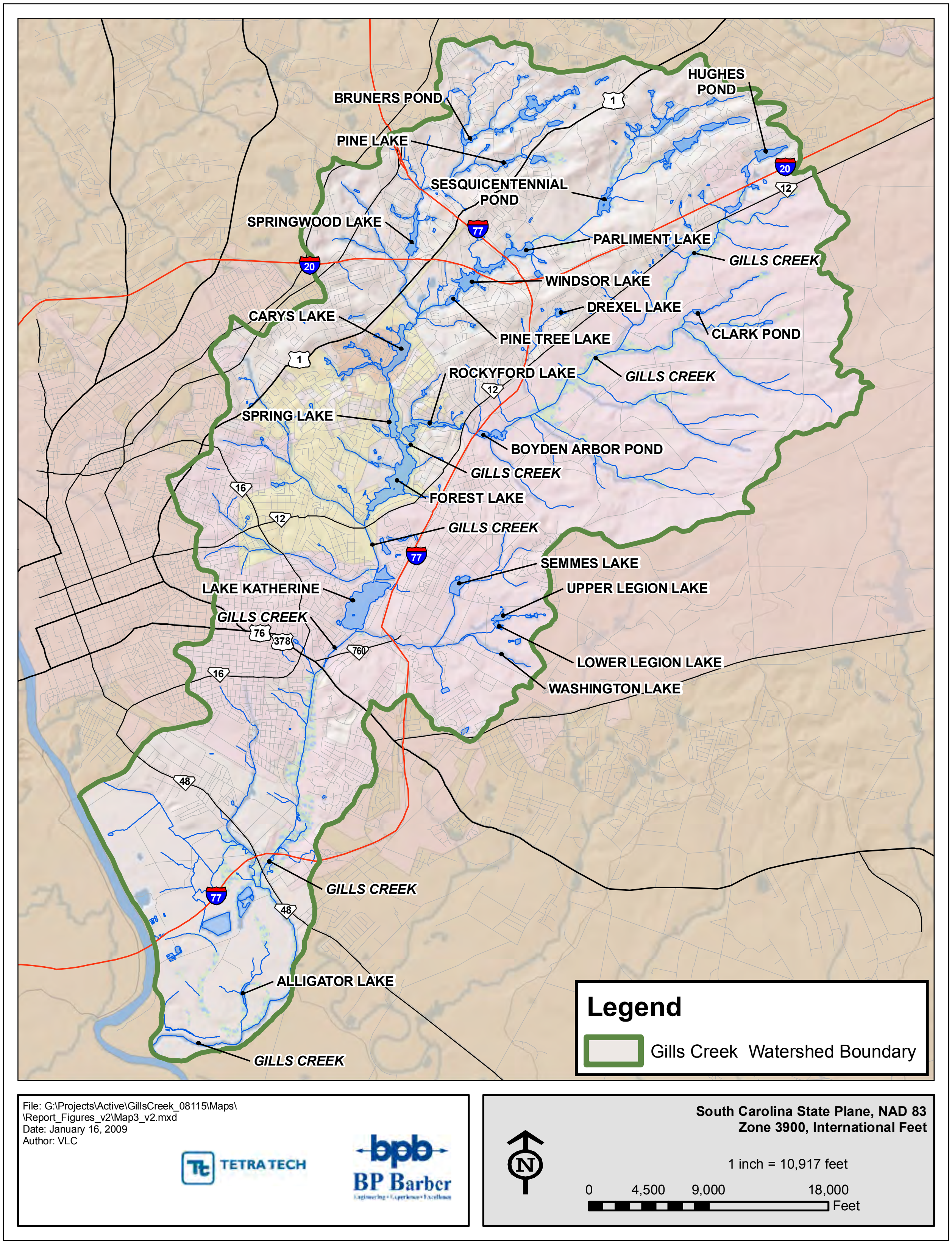


Figure 2-2. Gills Creek Watershed Impoundments and Other Waterbodies

2.3. CLIMATE/PRECIPITATION

Climate in the Richland County area is characterized by generally mild winters with an average temperature of 48 degrees Fahrenheit (^oF) and warm summers with an average temperature around 80 ^oF. The lowest recorded temperature in Richland County was -5 ^oF in January 1994 and the highest recorded temperature was 109 ^oF in June 1998. The highest daily rainfall was 7.3 inches on July 9, 1959, the wettest year recorded for Richland County. Annual average rainfall is approximately 47.7 inches with the majority of rainfall events occurring during the warmer months of April extending through September. Richland County can expect approximately 74 rain events per year with 15 events being one inch of rain or more. Highest average rainfall usually occurs during the month of August. Table 2-2 displays average total monthly rainfall data from January 1952 to December 2006 (DHEC, 1997).

Table 2-2. Average Total Monthly Rainfall Data (inches) from January 1972-December 2006 (Clemson, 2008)

Month	Total (inches)
January	4.1
February	3.6
March	4.4
April	2.8
May	3.2
June	4.3
July	4.9
August	4.6
September	4.0
October	2.9
November	2.9
December	3.3

2.4. TOPOGRAPHY/ELEVATION

Topography of the Gills Creek watershed can be easily defined by the two ecoregions located within the watershed, the Southern Piedmont, and the Coastal Plain. The Southern Piedmont is characterized by irregular plains and open hills with occasional tablelands. Elevations in the Southern Piedmont Ecoregion within the Gills Creek watershed can range from 65 to 600 feet. The Coastal Plain, which covers the southern most portion of the Gills Creek watershed, is characterized by low rolling hills, swamps, and marshes. The Coastal Plain, the largest Ecoregion in the state, is divided into the Upper Coastal Plain and the Lower Plain. The Upper Coastal Plain is then divided into the Aiken Plateau, the Richland Red Hills, and the High Hills of Santee. The Gills Creek watershed is within the Richland Red Hills division (DHEC, 1997). Table 2-3 shows elevation ranges at the HUC 14 Level.

Table 2-3. Elevation Ranges at the HUC 14 Levels for the Gills Creek Watershed

HUC 14	Watershed	Elevation Range (feet)	Ecoregion
03050110030010	Jackson Creek	180-600	Southern Piedmont
03050110030020	Little Jackson Creek	180-400	Southern Piedmont
03050110030030	Gills Creek-Bynum Creek	180-600	Southern Piedmont
03050110030040	Forest-Katherine Lakes	65-400	Southern Piedmont
03050110030050	East Columbia	65-325	Coastal Plain
03050110030060	Gills Creek	65-325	Coastal Plain
03050110030070	Wildcat Creek	65-325	Southern Piedmont

2.5. GEOLOGY AND SOILS

2.5.1. Geology

The near-surface geology of the Gills Creek watershed can be divided into four general lithologies: kaolinitic sands and clays of the Upper Cretaceous age Tuscaloosa Formation, laminated sands and red clays of the Tertiary age, clean sand dune deposits of the Post-Eocene age, and alluvial sand and gravel deposits of the Pleistocene and Holocene ages. The hilly terrain of the uplands is composed of the first three of these lithologies where they may be readily observed in road cuts, mines, ditches, and stream banks. The fourth lithology occurs as terrace and floodplain deposits along stream valleys, especially downstream of US-48 where Gills Creek crosses the Congaree River valley. Mineral resources utilized from these formations and deposits within and near the Gills Creek watershed include kaolin and sand for use in brick making, foundry work, and glass making (Johnson, 1961).

2.5.2. Soils

Soil types within or near the Gills Creek watershed in Richland County vary upon the location within the watershed. In the northeastern section of the watershed, the predominant soil types are Lakeland Soils which are gently sloping to steep soils and are found within the Southern Piedmont Ecoregion. Lakeland soils are excessively drained soils that are sandy throughout. Soils in the center portion of the watershed are predominately Pelion-Johnston-Vaucluse soils. These soils are also gently sloping to steep soils found within the Southern Piedmont Ecoregion and can be moderately well drained soils that have a sandy surface layer and a loamy subsoil, very poorly drained soils that are loamy throughout, and/or well drained soils that have a sandy surface layer and a fragipan in the loamy subsoil. In the southernmost part of the Gills Creek watershed, soils are nearly level to sloping soils found within the floodplains in the Coastal Plain Ecoregion. The three soil types in this area are Orangeburg-Norfolk-Marlboro, Persanti-Cantey-Goldsboro, and Congaree-Tawcaw-Chastain. Orangeburg-Norfolk-Marlboro soils are well drained soils that have a sandy or loamy surface layer and can have a loamy or clayey subsoil. Persanti-Cantey-Goldsboro soils are moderately well drained soils that have a loamy surface layer and a clayey or loamy subsoil and/or poorly drained soils that have a loamy surface layer and a clayey subsoil. The Congaree-Tawcaw-Chastain soils, which are nearly level soils on flood plains, are well drained to moderately well drained soils that are loamy throughout. These soils can also be somewhat poorly drained soils that have a loamy surface layer and a clayey subsoil.

2.6. ENDANGERED OR PROTECTED SPECIES

Table 2-4 displays rare, threatened, and endangered species of the Gills Creek watershed. Of the 81 listed species in the state of South Carolina, seven are located within the watershed boundary. The red-cockaded woodpecker is the only known fauna, or animal, on the Federal Endangered list in the watershed. Six of the species identified are plants. Of the plant species, two are listed as Federal Endangered/State Endangered and four are listed as of Concern at the state level. Table 2-5 shows the code meanings for all of the Rare, Threatened, and Endangered Species listed in Table 2-4. Figure 2-3 provides the approximate locations where these species have been observed. The locations are not labeled due to the sensitive nature of this information.

Table 2-4. Richland County Rare, Threatened, and Endangered Species Inventory List

Scientific Name	Common Name	Legal Status
Plants		
Hypericum adpressum	Creeping St. John's-Wort	RC
Lechea torreyi	Piedmont Pinweed	SC
Lobelia sp 1	Lobelia	SC
Lysimachia asperulifolia	Rough-Leaved Loosestrife	FE/SE
Sarracenia rubra	Sweet Pitcher-Plant	SC
Trepocarpus aethusae	Aethusa-Like Trepocarpus	SC
Animals		
Picoides borealis	Red-Cockaded Woodpecker	FE/SE

Table 2-5. Legal Status Codes for Rare, Threatened, and Endangered Species

FE	Federal Endangered
FT	Federal Threatened
PE	Proposed for Federal listing as Endangered
PT	Proposed for Federal listing as Threatened
C	Candidate for Federal Listing
NC	Of Concern, National (unofficial--plants only)
RC	Of Concern, Regional (unofficial--plants only)
SE	State Endangered (official state list--animals only)
ST	State Threatened (official state list--animals only)
SC	Of Concern, State
SX	State Extirpated

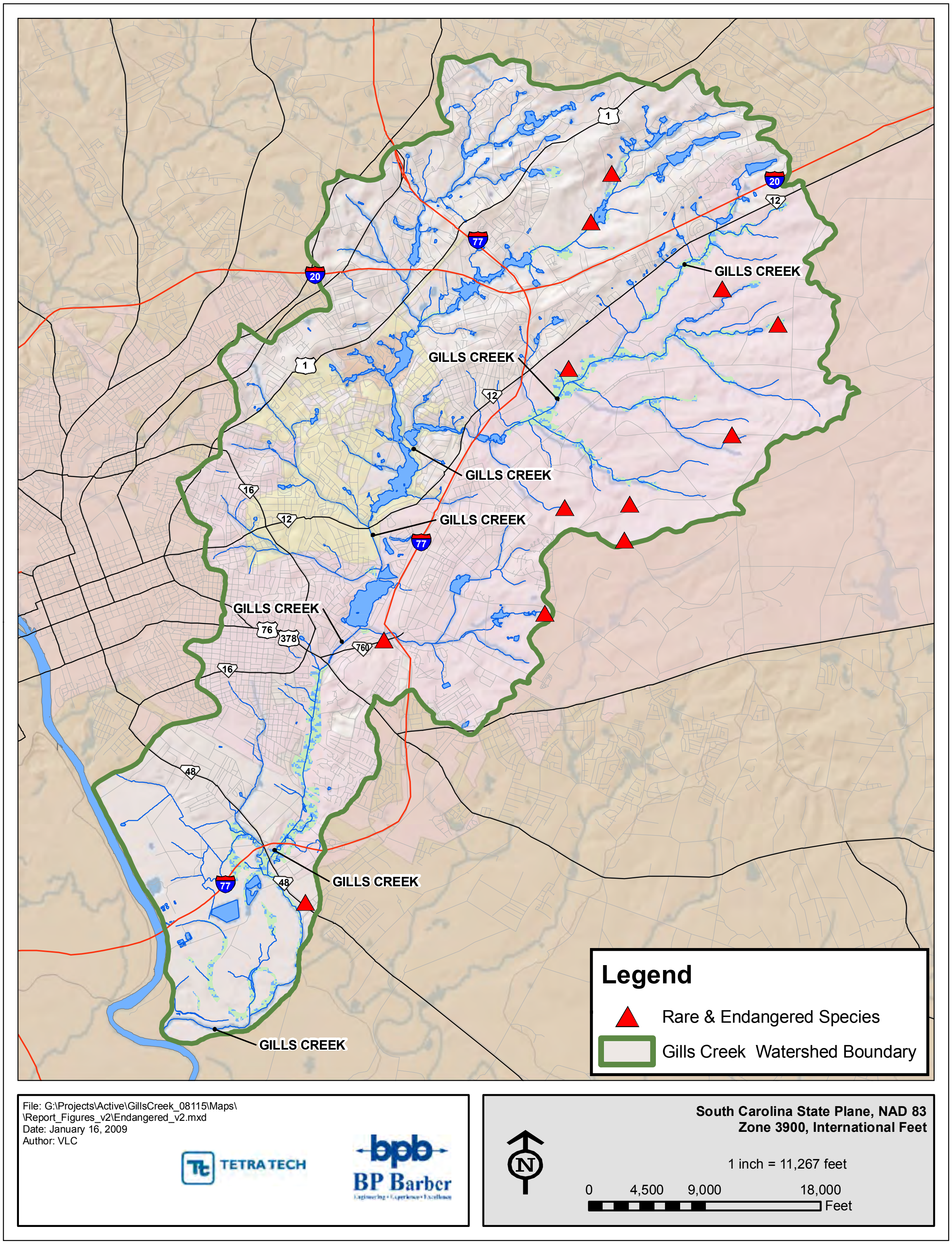


Figure 2-3. Rare, Threatened, and Endangered Species

2.7. CULTURAL RESOURCES

Cultural Resources include any natural or manmade sites, events, activities, or historic structures and can have a general social significance on the community. Cultural Resources can enhance community interaction as well as provide beneficial social outlets for the community. Richland County has a multitude of historic structures including churches, public facilities, sites, and homes that have significant historic value, along with 14 historic districts. Richland County recognizes 219 historic buildings, structures, and districts as historic places, and 141 of these are on the National Register of Historic Places. Sesquicentennial State Park, located within the Gills Creek watershed, is considered by Richland County to be a unique natural or scenic resource. Locations of significant cultural and archeological resources, including those eligible for the national register, have been found within Fort Jackson. Additional sites may exist outside of Fort Jackson (Chan Funk, archeologist, personal communication to H. Fisher, December 1, 2008).

The Gills Creek watershed's streams and lakes influenced initial settlement in the area by providing benefits for living such as drinking water supply, food source, transportation, and fertile flood plain soils for agricultural use. The Congaree Native Americans inhabited a large portion of the Gills Creek watershed. In 1740, Richard and Philip Jackson had plats recorded giving Jackson and Little Jackson Creek their names, and in 1732, the first recorded plats were certified. Gills Creek most likely received its name from James Gill, a settler who lived in this area sometime before the American Revolution. Agricultural production was highly prevalent in the Gills Creek watershed, and waters from the creek were used to power a number of mills in the area. Remnants of a cotton spinning mill at Forest Acres still stand and portray the importance of agricultural production in this region.

Local water resources were also used for recreational purposes. There are many natural springs in the Gills Creek watershed, and, during the 1800s, resorts near the natural springs were very popular attractions. Camp Johnson, formerly known as Lightwood Knot Springs near Parklane Road, was once a very popular public area which residents frequented during the summer months to enjoy the cool air near the springs. Other recreational amenities, such as bathing and fishing, were also available to the public at Dents Pond, now known as Forest Lake, before it was developed for residential property.

2.8. LAND USE AND LAND COVER

2.8.1. Historical Land Use

As of 1987, land use in the watershed was calculated by the South Carolina Department of Natural Resources as 49 percent urban, 8 percent agricultural, 1 percent scrub/shrub, 36 percent forested, 3 percent wetland, 3 percent water, and less than 1 percent barren. The population in 1987 was expected to have grown by 22 percent by 2015, and a large portion of the growth was expected to occur in the Richland Northeast area.

2.8.2. Current Land Use

Table 2-6 shows the 2001 National Land Cover Data (NLCD) coverage in square miles and by percent for the Gills Creek watershed. About 33 percent of the watershed is developed, and the remaining area is largely in forest or open space. Agriculture represents a small percentage of the watershed, at about 6 percent. Land use/ land cover are considered in more detail in Sections 4.0 and 5.0.

Table 2-6. Gills Creek Watershed Land Use/ Land Cover (USGS 2001 NLCD)

2001 NLCD	Area (mi^2)	Percent (%)
Open Water	1.8	2%
Open Space	12.3	17%
Development	24.7	33%
Barren	0.0	0%
Deciduous Forest	3.0	4%
Evergreen Forest	14.6	20%
Mixed Forest	1.3	2%
Shrubland	0.1	0%
Grassland	5.3	7%
Pasture and Hay	1.8	2%
Cropland	3.3	4%
Woody Wetland	6.1	8%
Emergent Wetland	0.2	0%
Watershed Total	74.5	

2.8.3. Future Land Use Considerations

New residential developments are currently being constructed in the upper portion of the watershed, and this type of development is likely to continue in the future. The largest area of developable land exists in the upper, northeastern portion of the watershed, which is owned by the U.S. Army's Fort Jackson. This land is within the City of Columbia's jurisdiction and is zoned R-1 (Figure 2-4), which is defined as single-family residential. However, as long as the land remains within Fort Jackson boundaries, the city zoning will not apply. The land is expected to remain in the existing land uses in the short-term, and it is difficult to predict what the land will be used for in the long-term (D. Allen, Fort Jackson Natural Resources, personal communication to H. Fisher, September 2008). At build out, if all developable land in the R-1 zoning district is converted to development (including the land within Fort Jackson), development would increase about 40 percent in area compared to 2001, and most of this development would occur in the undeveloped areas of Fort Jackson. This is a rough estimate of the potential increase of future development. Additional development may occur in other smaller zoning districts and less development may occur in the R-1 district if Fort Jackson maintains existing land uses or cluster developments are implemented which require open space preservation.

2.9. Political Boundaries/Relevant Authorities

2.9.1. Federal Lands

Fort Jackson, the largest and most active Initial Entry Training Center in the U.S. Army, is located northeast of Columbia and east of Gills Creek. Fort Jackson trains approximately 50 percent of all U.S. Army soldiers and 70 percent of the women entering the Army every year, approximately 50,000 individual soldiers in total per year. Fort Jackson is also home to the U.S. Army Soldier Support Institute, The U.S. Army Chaplains Center and School, and the Defense Academy for Credibility Assessment. Fort Jackson contains more than 100 ranges and field training sites and 1,160 buildings. Over 3,900 active duty soldiers and their family members live at Fort Jackson, encompassing approximately 18,000 people.

2.9.2. State Lands

Sesquicentennial State Park is located approximately 13 miles from Columbia, SC and is considered a green space in the Columbia suburbs. The headwaters to the Gills Creek watershed start directly above the park. Sesquicentennial State Park encompasses 2 square miles (1,419 acres) and was originally developed by the Civilian Conservation Corps (CCC), a New Deal Program created by President Franklin D. Roosevelt. Centennial Lake, a 30-acre lake located in the center of the park, provides access to activities such as fishing, swimming, and boating. Other amenities at Sesquicentennial State Park include picnic areas, camping areas, bird watching areas, biking trails, hiking trails, and nature trails. There are seventeen camp sites that accommodate RVs up to 35 feet, 14 pull-through sites, and 4 primitive camp sites. The park also contains a two-story log house dating back to the mid 1700s which is believed to be the oldest building standing in Richland County. The house was relocated to Sesquicentennial State Park in 1969 (DHEC, 1997).

2.9.3. Local Lands

The Gills Creek watershed is located entirely within Richland County. Columbia, South Carolina is the largest city in Richland County in the watershed, and Forest Acres is the second largest city located within the watershed, north of Columbia. Arcadia, the smallest city in the Gills Creek watershed, is located north of Forest Acres (Figure 2-5).

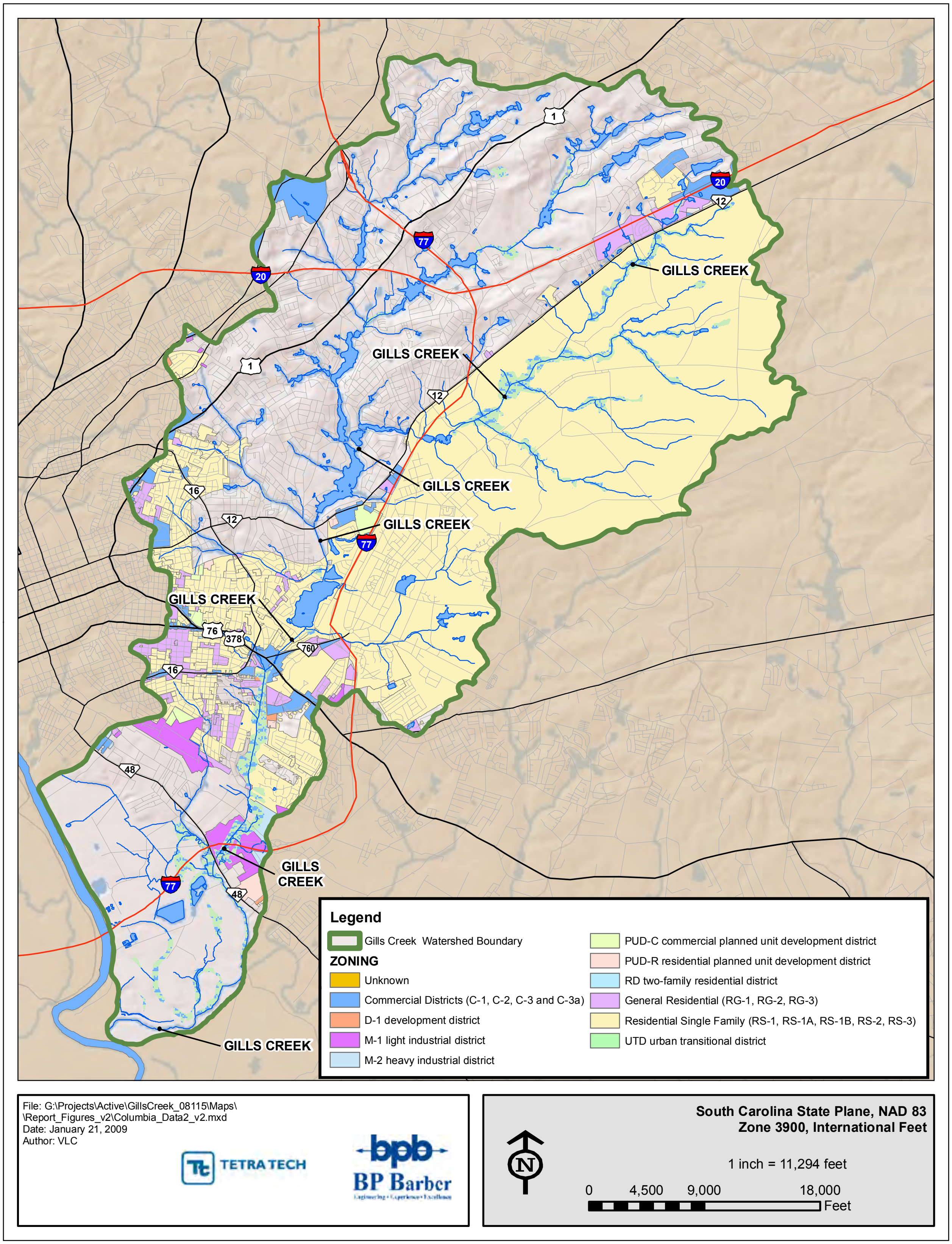


Figure 2-4. City of Columbia Zoning

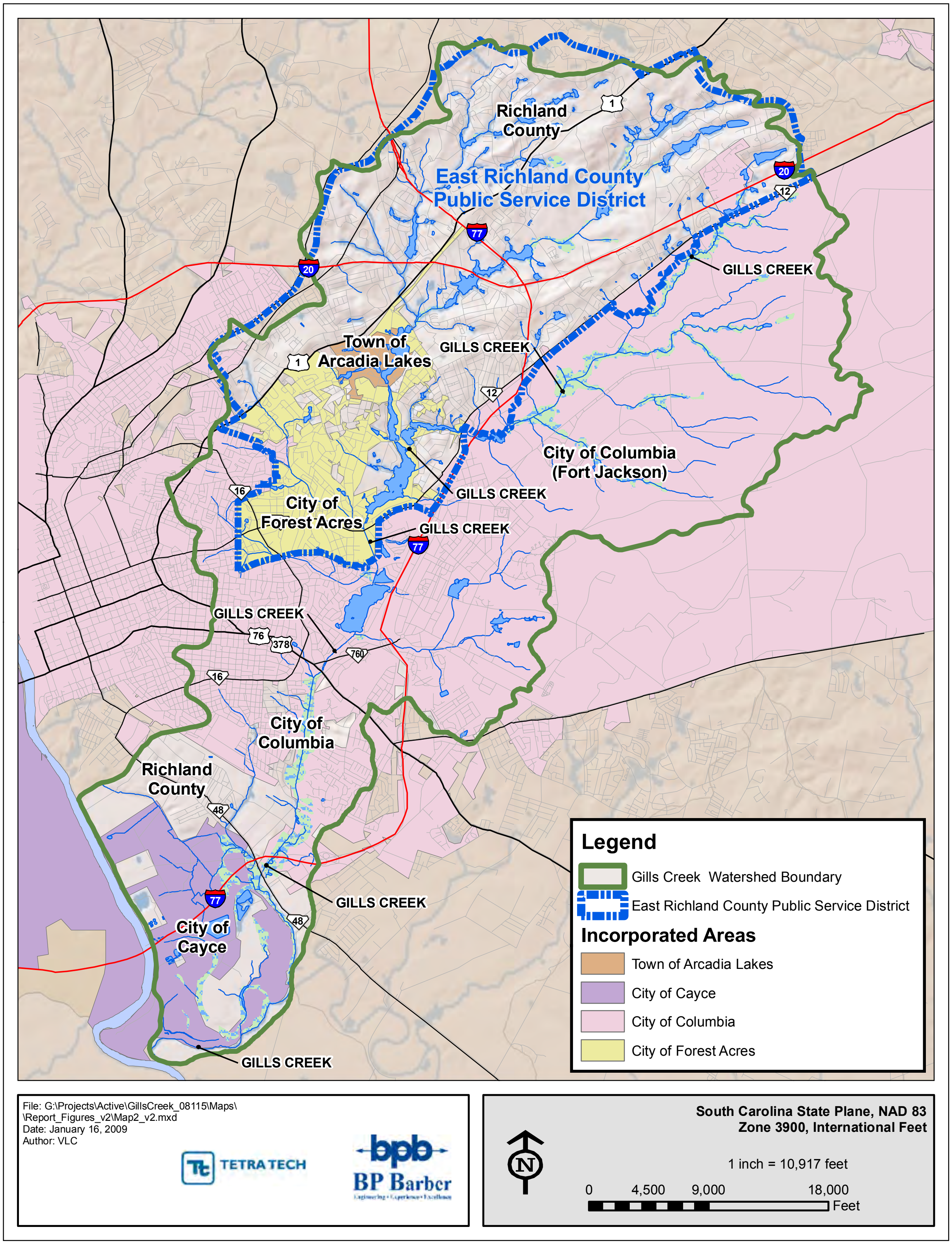


Figure 2-5. Political Boundaries

2.10. DEMOGRAPHIC CHARACTERISTICS

2.10.1. Population

Table 2-7 shows population data for 2000 and 2006 in Richland County and county land area provided by the U.S. Census Bureau. Between 2000 and 2006, it is estimated that the population of Richland County increased 8.6 percent. Columbia, Richland County's largest city and the County seat, experienced a 1 percent increase in population from April 2000 to July 2003. Table 2-8 shows population data for 2000 and 2003 in the city of Columbia. In 2000, individuals over the age of 25 who have received a high school diploma made up 85 percent of the population of Richland County and 33 percent of individuals in Richland County had received a Bachelor's degree or higher. In 2006, there were 149,833 housing units in Richland County. In 2000, the home ownership rate was 61 percent, and the median value of owner-occupied housing units was $98,700. Based on census tract GIS data, the estimated population of the Gills Creek watershed is 90,000 people, with an average density of 2 people per acre.

Table 2-7. Population Census Data for Richland County (US Census Bureau, 2006)

Richland County	
Population, 2000	320,677
Population, 2006*	348,226
% Change (2000-2006)	8.6%
Land Area 2000 *(square miles)*	756.41
Population Density 2000 *(persons/square mile)*	424.2

*2006 population is estimated. Population listed above is for all of Richland County.

Table 2-8. Population Census Data for the City of Columbia, South Carolina (US Census Bureau, 2006)

Columbia, South Carolina	
Population, 2000	116,278
Population, 2003*	117,357
% Change (2000-2003)	1.0%
Land Area 2000 *(square miles)*	125
Population Density 2000 *(persons/square mile)*	928.6

*2003 population is estimated.

3.0 Watershed Conditions

3.1. WATER QUALITY STANDARDS

3.1.1. Water-use Classification and Designated Uses

State water quality standards are determined based on the water-use classification for each waterbody. Water-use classifications are based on the desired uses of a waterbody and not necessarily the actual water quality. Classifications are used to determine NPDES permit limits. This also means that waterbodies can be reclassified if the desired or existing use justifies reclassification. The tributaries and lakes in the Gills Creek watershed are *Class FW* or *freshwater*.

> *Class FW are freshwaters that are suitable for primary and secondary contact recreation and as a source for drinking water supply, after conventional treatment, in accordance with the requirements of the Department. These waters are suitable for fishing, and the survival and propagation of a balanced indigenous aquatic community of fauna and flora. This class is also suitable for industrial and agricultural uses. (DHEC, 2008a)*

In addition to water-use classifications, the state has four "use support" designations.

1. Aquatic Life Use Support – based on the composition and functional integrity of the biological community.
2. Recreational Use Support – the degree to which a waterbody meets fecal coliform bacteria water quality standards. Waters that have fecal coliform excursions in greater than 25 percent of samples are considered nonsupporting of recreational uses.
3. Fish Consumption Use Support – a risk based approach is used to evaluate fish tissue data and to issue consumption advisories.
4. Drinking Water Use Support – nonattainment occurs when the median concentration (based on a minimum of three samples) for any pollutant exceeds the appropriate drinking water Maximum Contaminant Level (MCL).

Waterbodies that do not meet these designated uses are impaired and identified by the state in accordance with the Federal Clean Water Act Section 303(d), known as the "303(d) list." The state uses the 303(d) list to target waterbodies that need to be restored to meet water quality standards. Generally, the total maximum daily load (TMDL) is developed for waters identified on the 303(d) list. A TMDL is used to determine the amount of pollutants a waterbody can assimilate and still meet water quality standards. A TMDL must include both point and non-point sources of pollution and some margin of safety.

Waterbodies in the Gills Creek watershed identified on SCDHEC's 2006 303(d) list are shown in Figure 3-1, and listed in Table 3-1. Table 3-1 also presents the designated use that was not supported through surface water quality samples collected in the waterbody.

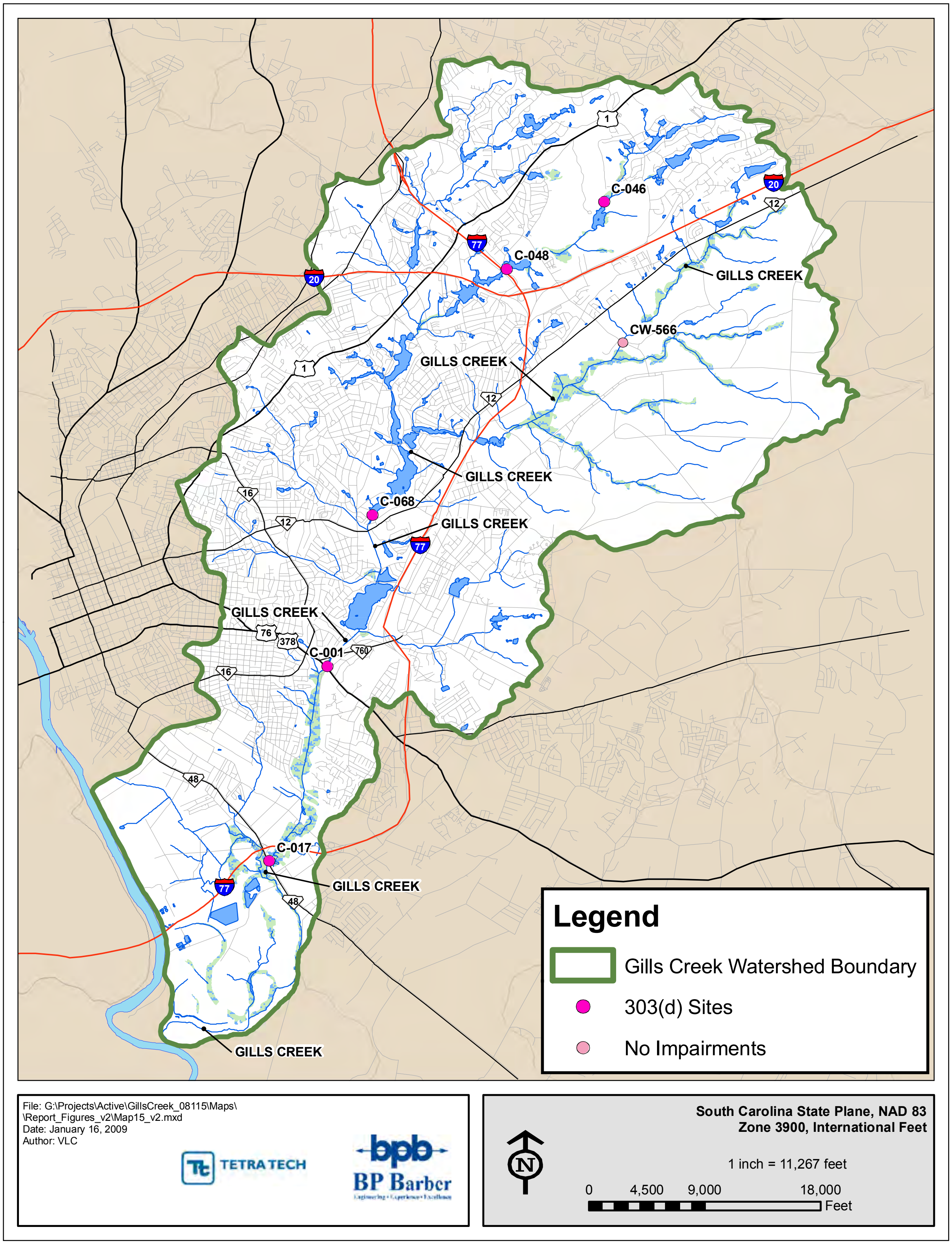


Figure 3-1. 303(d) Listed Streams

Table 3-1. 303(d) Listed Waterbodies

Station	Description of Station	Use	Cause
C-001	Gills Creek at US 76	Recreation	Fecal Coliform
C-017	Gills Creek at SC 48	Aquatic Life / Recreation	Dissolved Oxygen/ Fecal Coliform
C-046	Sesquicentennial Park Pond	Fish Consumption	Mercury
C-048	Windsor Lake Spillway on Windsor Lake Blvd.	Aquatic Life	Dissolved Oxygen
C-068	Forest Lake at Dam at Fort Jackson Water Intake	Fish Consumption	Mercury

3.1.2. Numeric and Narrative Criteria

Water quality standards for waters classified as freshwater are listed in Table 3-2.

Table 3-2. Freshwater Water Quality Standards in the State of South Carolina (DHEC, 2008a)

Parameter	Standard
Garbage, cinders, ashes, oils, sludge, or other refuse	None allowed
Treated wastes, toxic wastes, deleterious substances, colored or other wastes except those given in (a) above	None alone or in combination with other substances or wastes in sufficient amounts to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
Toxic pollutants	Varied as described in SC Reg 61 – 68.
Dissolved Oxygen	Daily average not less than 5.0 mg/l with a low of 4.0 mg/l
Fecal coliform	Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml.
pH	Between 6.0 and 8.5.

Parameter	Standard
Temperature	Free flowing waters shall not increase by 5 deg F above natural temperature conditions and shall not exceed a maximum of 90 deg F as the result of a discharge of heated liquids unless a site specific standard has been approved. These standards also apply to weekly average temperatures in lakes.
Turbidity *	Not to exceed 50 NTUs, provided existing uses are maintained
*Turbidity, Lakes only	Not to exceed 25 NTUs, provided existing uses are maintained

3.1.3. Antidegradation Rules

The SC Regulation 61 – 68, *Water Classifications and Standards*, details the State's antidegradation rules. Antidegradation rules provide a minimum loss of protection to all waters of the State and include conditions when water quality degradation is allowed. The State's antidegradation rules require existing uses be maintained and water quality be protected regardless of the waters classification. Conditions where water quality degradation is allowed that apply to the Gills Creek watershed include:

- Existing uses and water quality necessary to protect uses may be affected by instream modifications as long as the stream flows protect classified and existing uses and water quality supporting these classified uses is consistent with riparian rights to reasonable use of water.
- Water quality standards can be lowered if it benefits the people and economy of an area where water quality would remain adequate to fully protect existing and classified uses.
- Natural conditions cause a depression of dissolved oxygen (DO). (DHEC, 2008a).

3.2. AVAILABLE MONITORING/RESOURCE DATA

3.2.1. Water Quality Data

Several agencies monitor water quality in the Gills Creek watershed: SCDHEC, the U.S. Geological Survey (USGS), Richland County, and the City of Columbia. The SCDHEC monitors water quality to determine if waterbodies meet designated use standards. As previously described, waterbodies that do not meet water quality standards for their designated use are said to have *impaired uses* and listed on the state's 303(d) list of impaired waterbodies. The Gills Creek watershed was included in a national water quality monitoring effort by the USGS, National Assessment of Water Quality Assessment (NAWQA). The NAWQA monitoring program was designed to update Congress on the quality of US waters. Finally, both Richland County and the City of Columbia collect water quality for local management decisions and for compliance with their Municipal Separate Storm Sewer Systems (MS4) permits.

The following sections will describe data provided by each of these agencies.

SCDHEC has five water quality monitoring stations and one biological monitoring station in the Gills Creek watershed. SCDHEC originally began monitoring water quality in the watershed in the late 1960s. At that time, samples were collected nearly monthly at three stations for a ten year period. Data collection began again in 1999.

USGS collects water quality data at state highway SC 760, USGS 02169570. They have been collecting streamflows at this location for more than 40 years, as described in Section 4.2.2. Water quality monitoring has occurred intermittently since the station was installed. In the late 1990s, Gills Creek was sampled as part of a larger study, NAWQA, to investigate the quality of water in the entire country. Several site specific studies were written from this monitoring effort (Maluk, 1999).

Richland County has collected continuous data at locations throughout the County to meet the needs of their stormwater monitoring program. Water quality sampling of Gills Creek has occurred on an annual basis at three locations in 2007 and 2008. Sample analyses included BOD, dissolved oxygen, nutrients, metals, alkalinity, fecal coliform, suspended solids, and chlorophyll *a*.

City of Columbia conducted stormwater monitoring in 2001 and 2002. Water quality data were collected during storm events as part of their MS4 permit application.

Sesquicentennial State Park collects basic water quality data for Sesquicentennial Pond. A University of South Carolina (USC) graduate student is also conducting an aquatic species inventory in the pond and along the shoreline (S. Jensen, Sesquicentennial State Park, personal communication to H. Fisher, September 2008).

3.2.1.1. Impaired Uses and/or Water Quality Threats

The SCDHEC identifies impaired waterbodies by monitoring stations, Table 3-1. In the Gills Creek watershed, five monitoring stations have been identified as impaired and are currently on the 2008 303(d) list of impaired waterbodies (DHEC, 2008c).

3.2.2. Flow Data

The USGS has one continuous monitoring station on Gills Creek at Columbia, South Carolina, USGS 02169570, at state highway SC 760. The USGS has monitored continuous flow at this station since 1966. Figure 3-2 illustrates the continuous flow record on Gills Creek at Columbia (USGS 02169570).

Visually, streamflows in Gills Creek remain similar between the present day record and when the station began collecting data in 1966. According to the low-flow statistics, little change has occurred. Flows less than 10 cubic feet per second (cfs) occur in 6 percent of the total record. Since 1980 the number of daily average flows recorded less than 10 cfs has increased, but only slightly to 8 percent. In the last 18 years, since 1990, the percent of total daily average flows less than 10 cfs is 9 percent. Flows less than 100 cfs occur in 81 percent of the recorded historical flows. Since 1980, flows less than 100 cfs occur in 82 percent of the record and since 1990, in 83 percent of the record. Though these percentages suggest a slight increase in the occurrence of low flows on Gills Creek, the change over time is not significant.

Management decisions for water quality are often determined by the 7-day average lowest flow occurring in a 10-year period, referred to as the 7Q10. The 7Q10 analysis was conducted for 10-year periods, Figure 3-2. Historically, the lowest flows are similar to the 7Q10 for the entire period of record, 3.9 cfs. The period from 1966 – 1976 is exhibits exceptionally high flows with a 7Q10 of 11.1 cfs, nearly three times larger than the average.

Table 3-3. USGS 02169570 Statistics for 7day average lowest flow occurring in 10-year period

Period	7Q10 (cfs)
1966-1976	11.1
1976-1986	3.5
1986-1996	4.7
1996-2006	4.5
Period of Record	3.9

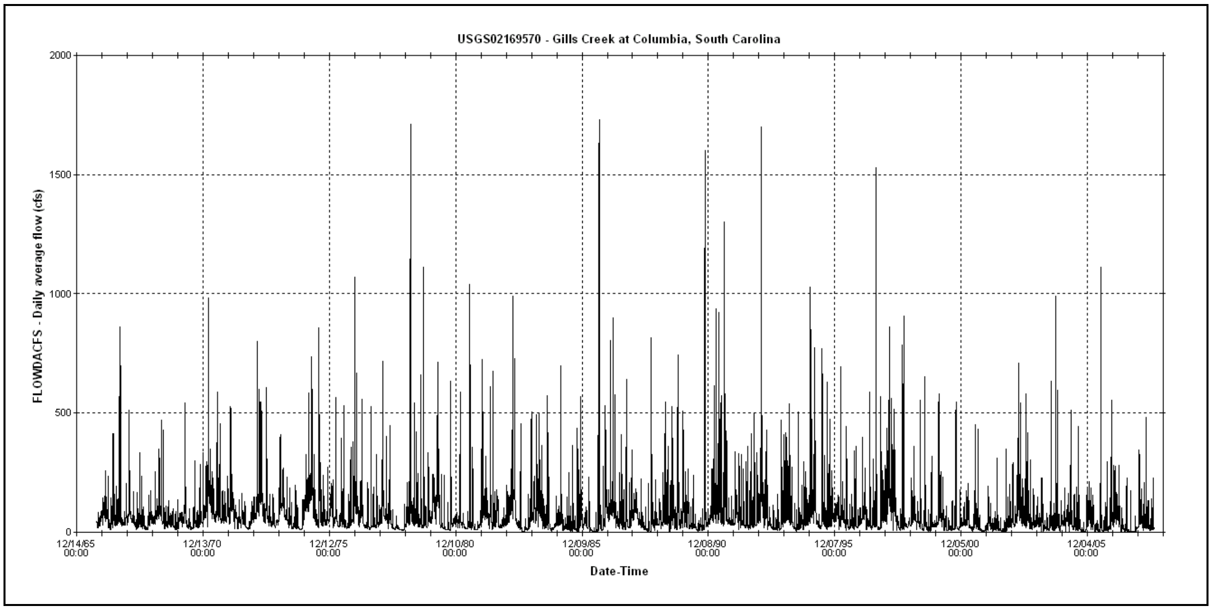


Figure 3-2. Streamflow on Gills Creek at (SC 760) Columbia, SC

The consistency in streamflow from 1966 to present is assumed to be because of the location of the station, nearly 900 feet downstream of Lake Katherine. Lake Katherine was built in the 1940s and 50s. The influence of changes in land use activity in the watershed are likely more visible upstream of Lake Katherine and downstream of the USGS station.

3.2.3. Biological Data

Biological data is very effective in understanding overall ecosystem health. Aquatic diversity and the number of macroinvertebrate and fish species can be used to assess long-term trends in water quality and physical habitat conditions. Generally, biological indicators require a period of time to establish, whereas water quality data represent a sample at a specific time.

3.2.3.1. Benthic Macroinvertebrates

Richland County is planning a macroinvertebrate data collection and SCHEC has collected macroinvertebrate data in the Gills Creek watershed. Macroinvertebrate counts were previously collected by SCDHEC at one location in the Gills Creek watershed, B-081, in 1995 and 1999. These counts resulted in bioclassification scores ranging from fair to good (Flora, 2008).

3.2.3.2. Fish

SCDHEC monitors fish throughout the state to provide fish consumption advisories to their citizens. Fish advisories have been issued for a series of lakes on Jackson Creek, Sesquicentennial Pond, Parliament Lake, Windsor Lake, Pine Tree Lake, and Carys Lake. Of these, Sesquicentennial Pond has been identified on the 303(d) list for impairment of fish consumption due to mercury. Downstream at the confluence of Gills and Jackson Creeks, Forest Lake has also been identified on the 303(d) list for impairment of fish consumption due to mercury.

3.2.3.3. Aquatic Nuisance Species

Studies done to identify aquatic nuisance species were not identified.

3.2.3.4. Migratory Patterns

Studies done to establish migratory patterns were not identified.

3.2.4. Stream Survey Data

Stream surveys conducted during stormwater inventories that would include a photographic record of the stream corridor were not identified.

3.3. STAKEHOLDER INPUT

3.3.1. Upfront Public Meeting

In December 2007, the GCWA hosted a public meeting at the Richland County Council Chambers. Nearly 100 stakeholders attended the meeting to learn about the efforts of the GCWA to protect the Gills Creek watershed. During this meeting, stakeholders were provided a survey used to identify specific areas that need to be protected in the watershed. Nine specific issues were commented on by 23 attendees. Trash, sediment, stormwater runoff, development, wildlife, flooding, clear cutting, restoring natural areas, and overflowing sewers were among the issues identified by stakeholders at the meeting. The location of some of these issues was identified on aerial maps. These have been included in identified hot spots for this Watershed Management Plan.

3.3.2. Stakeholder Survey

Tetra Tech helped the Gills Creek Watershed Outreach Committee develop and conduct a stakeholder survey to identify hot spots of concern in the watershed and gather information that would help evaluate pollutant sources and plan management. The survey was administered on-line, but some responses were collected in paper format from respondents that did not have access to the internet. The survey questions and results are provided in Appendix A. The response period was October 10 through November 7, 2008, and the survey was advertised through local websites and email. The Gills Creek Watershed Association also promoted the survey through phone calls to members and known watershed residents. The respondents' addresses were requested as part of the survey so that locations of concern within the watershed could be located.

The hot spots identified during the first stakeholder meeting occurred mostly upstream of the US-76 crossing of Gills Creek. It was likely that residents of the lower watershed were not represented adequately during the first public meeting. One purpose of the survey was to provide another opportunity for watershed residents to identify hot spots for flooding, trash, in-stream or in-lake sedimentation, and other concerns. These hotspots are not considered a comprehensive inventory for the watershed but as an indicator to be considered alongside more comprehensive data.

The number of survey responses was 67, representing 46 electronic and 21 paper submissions. The survey responses represented a greater portion of the watershed than the public meeting hot spots, and a number of responses were provided for locations downstream of US-76. Portions of the watershed not represented by stakeholder input (public meeting or survey) included the headwaters of Little Jackson Creek, Eightmile Branch, and Pen Branch, as well as the land downstream of State Route 48 (Bluff Road). A total of 17 responses did not have sufficient location information, and eight respondents gave locations outside of the watershed. Geolocated survey responses (50) on flooding, trash, and in-stream or in-lake sedimentation hot spots were used to identify critical areas of watershed concerns (Section 5.0). Additional hot spots in the lower watershed were identified in the field by Richland County Soil and Water Conservation District.

3.3.3. Final Public Meeting

The final stakeholder meeting was held on Thursday, April 30, 2009 at the Forest Acres Council Chambers, and 52 people attended the meting. This meeting was provided as an opportunity for the public to provide comments on the completed WMP. Implementation will require involvement from residents and municipalities in the watershed. This public meeting offered an opportunity for stakeholders to voice their suggestions and concerns regarding management strategies used to implement this watershed management plan. A two-week comment period was provided following the meeting. Appendix E lists the comments received. The public comments focused on site-specific concerns within the watershed. The locations noted in these comments should be evaluated for potential project opportunities during implementation.

4.0 Pollutant Source Assessment

Potential sources of pollutants are reviewed in the following section using available data and information. Sources of nutrients, sediment, metals, bacteria, and other pollutants are considered in relation to where these sources may occur in the watershed and the potential impacts they may have on water quality and aquatic life.

4.1. Nonpoint Sources

4.1.1. Agriculture

4.1.1.1. Livestock

Livestock production can lead to increased pollutant concentrations in downstream waterbodies. Where livestock have unlimited access to streams, animals may contribute fecal matter directly to streams and cause severe disturbance to stream banks. Runoff from livestock facilities (pasture, paddocks, manure storage areas, etc.) can introduce sediment, nutrients, bacteria, and toxins to surface waters.

Very few livestock operations are believed to exist in the watershed. Horse farms exist in the upper, northeastern portion of the watershed, and a few additional operations may exist throughout the less developed portions of the watershed (H. Caldwell, Richland County Soil and Water Conservation District, personal communication to H. Fisher, September 2008). All of these operations are expected to be small farms with low densities of livestock. Livestock operations may contribute some pollutant loading to the watershed but are not expected to be a major source.

4.1.1.2. Cropland

Nonpoint sources associated with agricultural crop production include nutrients, sediment, bacteria, and toxins. Sediment loading occurs through erosion of bare or disturbed soils. Nutrients in agricultural runoff originate from exposed soil as well as from applied fertilizers. Bacteria may originate from livestock manure applied to agricultural land. Toxins in agricultural runoff, including like pesticides, typically originate from chemical applications to cropland. Metals, which are potential toxins, may also be released in agricultural runoff, and these toxins may originate from fertilizer applications, both manure and mineral-based fertilizers.

About four percent of the watershed is maintained as cropland and about two percent is maintained for pasture or hay production. Most of the agricultural land is located in the lower portion of the watershed near the Congaree River. No known manure application sites exist in the watershed. Major crops grown include corn, soy, and hay (H. Caldwell, Richland County Soil and Water Conservation District, personal communication to H. Fisher, September 2008).

Runoff from agricultural land may be a source of sediment, nutrients, bacteria, and other pollutants in portions of the watershed. Toxins from chemical applications may contribute to declines in aquatic species populations in combination with other sources (urban/suburban runoff, point sources, and hazardous waste). Cropland is most likely to impact water quality and aquatic life in the lower portion of the watershed near the confluence of Gills Creek and the Congaree River.

4.1.2. Wildlife

Natural areas that support wildlife are generally considered to represent the natural, unimpacted state of the watershed, and wildlife feces are considered a background source of nutrients and bacteria in surface water. The watershed contains about 34 percent forest and wetland where wildlife is likely to exist. Most of the natural forest and wetland areas are located in the upper, northeast portion of the watershed.

Wildlife within these areas is likely to contribute some nutrient and bacteria loading to downstream waterbodies.

About two percent of the Gills Creek watershed (2.4 square miles) is in open water, and ponds and lakes encompass the majority of this area. This large area of open water is likely to attract waterfowl during migratory seasons and throughout the year, and waterfowl are likely to be a source of nutrients and bacteria in the Gills Creek watershed.

4.1.3. Septic Systems

Septic systems that are not properly maintained are a potential source of nutrients and bacteria to surface and ground water. Figure 4-1 shows that the entire watershed is served by municipal sewer systems. This indicates that new or recent development is likely to be served by municipal sewer systems and not septic systems. Older development may be served by septic systems or other onsite wastewater facilities. U.S. census data indicates that in 1990, onsite wastewater system density ranged from 3 to 1100 systems per square mile, as shown in Figure 4-2. Since the 1990 census, it is likely that septic systems in developing areas were replaced with sanitary sewers. Richland County Public Health Department is not aware of any septic systems within the watershed and believes the impact from any remnant septic systems would be minimal (Robert Deyo, Richland County Public Health Department, personal communication to H. Fisher, November 2008). Remnant septic systems are most likely to occur where the system density was highest in 1990. These areas can be approximated by census block groups in that had densities between 100 and 1100 systems per square mile in 1990. The stakeholder survey indicated that there is at least one remnant septic system in the lower portion of the watershed, between US-76 and SC-48 (Bluff Road).

4.1.4. Silviculture

Silviculture, which involves managing forests towards a particular goal, can have both positive and negative effects on water quality and aquatic habitat. When forest is managed to prevent catastrophic fires, a watershed is at less risk for high sediment loading that would occur after a catastrophic event. On a much smaller scale, fire prevention techniques may increase sediment loading due to removal of vegetation during prescribed burns or thinning. Timber harvesting can increase sediment loading from forested areas, and roads associated with timber harvesting tend to increase sediment loading to a greater degree than harvested areas themselves.

Forest, including shrubland, accounts for about 34 percent of the watershed. No known industrial timber harvesting operations exist within the watershed. Some private landowners may practice timber harvesting and other silviculture activities on a small scale. Large tracts of privately owned forest exist in the lower watershed near the Congaree River and in the upper, northeastern portion of the watershed.

The forest within Sesquicentennial Park represents about 7 percent of the forest in the watershed. Within the park, forest is managed to a minimal degree and is mostly left in its natural state. Damaged or diseased trees are periodically removed if they present a public safety hazard. Wildfires have occurred within the park, and according to park staff, these fires have burned slowly and were easily contained. No prescribed burns or thinning are currently performed on the park property (S. Jensen, Sesquicentennial State Park, personal communication to H. Fisher, September 2008). Silvicultural activities may contribute some sediment loading within the watershed, but these activities are unlikely to be a major source.

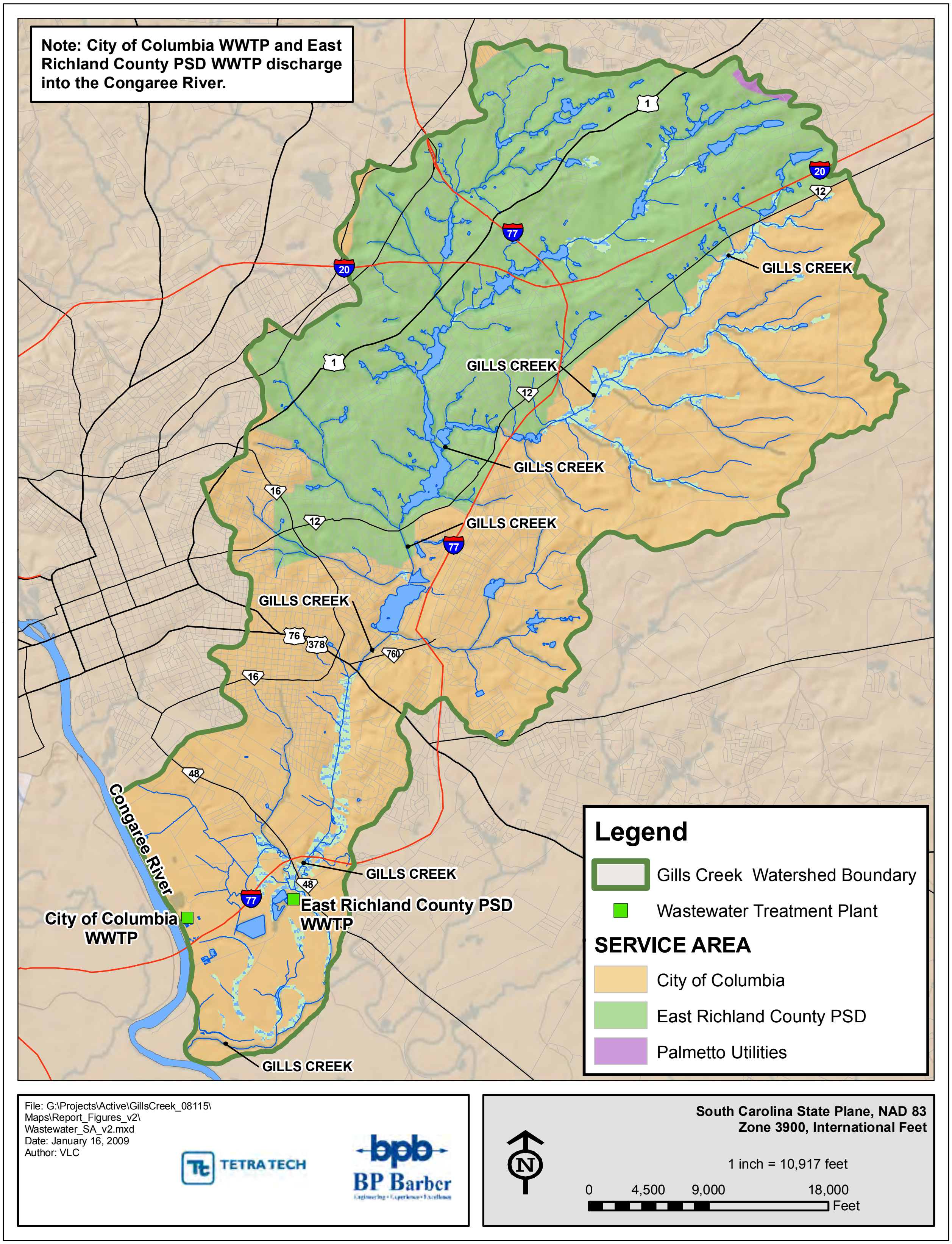


Figure 4-1. Municipal Sewer Service Districts

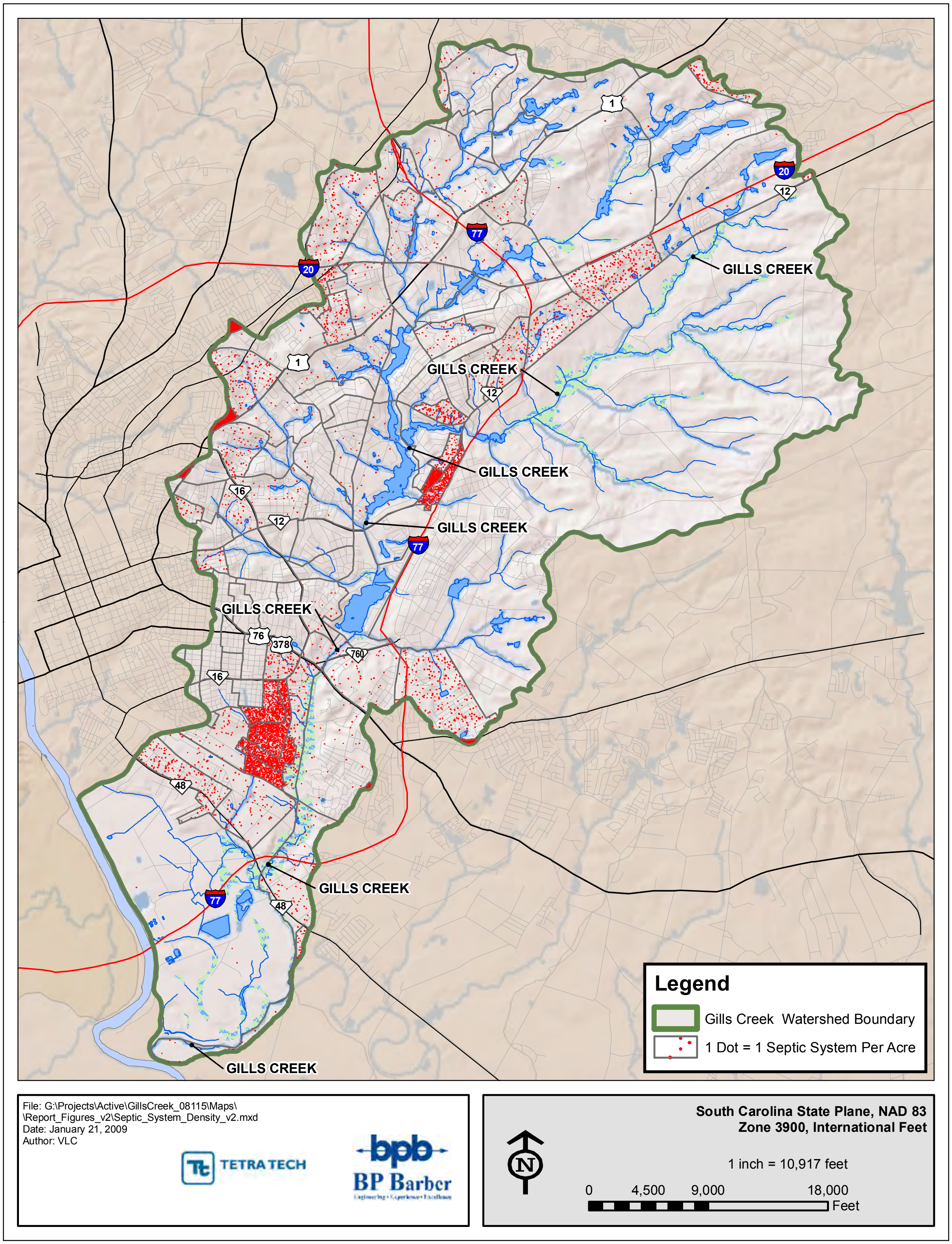


Figure 4-2. Septic System Density, 1990 Census

4.1.5. Urban/Suburban Runoff

Urban/Suburban runoff is similar to cropland runoff in that it includes nutrients, sediment, bacteria, and toxins. However, a major difference lies in how and when the runoff from urban and suburban landscapes is delivered to waterbodies. Urban/Suburban runoff is usually routed from impervious surfaces either directly to the waterbodies, or somewhere just upstream of the waterbodies. These different runoff characteristics threaten streams and other waterbodies from urban/suburban runoff in several different ways. The first, and potentially most influential threat, is from the increased stormwater discharges that are delivered directly to streams where both the volume and velocities of the flows are often drastically higher than runoff from undeveloped lands. Secondly, the increased overland flow that is often associated with urban/suburban impervious surfaces decreases the amount of stormwater that flows through subsurface processes from which groundwater is recharged thus leading to lower base flows. Thirdly, urban/suburban land uses can increase pollutant loads in stormwater runoff through erosion from disturbed areas (e.g., construction sites), build-up and wash-off of pollutants, illicit connections, and dumping into storm sewers. Another common threat from urban/suburban development is the increase in stream temperatures due to lack of shading as well as heated stormwater runoff from ponds and impervious areas. Finally, a decreased population and diversity of plants and animals is usually observed in urban/suburban areas due to the poor quality of habitat. All of these mechanisms can contribute to waterbody impairment, both from a human health and aquatic life perspective.

A significant portion of the Gills Creek watershed has been developed into suburban and urban lands (~24.7 mi^2). The amount of developed land within the watershed (33 percent) is approximately the same as undeveloped lands (34 percent). This development is scattered throughout most of the watershed—with the exception of Fort Jackson lands (mostly forested) and the lower portion of the watershed in cropland and pasture (City of Cayce)—and impacts from urban/suburban land are likely to occur throughout the watershed due to the sprawling nature of this development (Figure 4-3).

As mentioned earlier, imperviousness can play a large role in the pollutant loading from urban/suburban runoff. The average imperviousness within Gills Creek watershed is 17 percent (Figure 4-4). Although the average imperviousness of the watershed is relatively low compared to other developed watersheds, higher percentages are found within developed areas. Like urban/suburban development, impervious surfaces are dispersed throughout much of the watershed and are likely to be a source of pollutants and erosive flows in many stream reaches and other waterbodies. Additionally, hotspots were identified by stakeholders during the first public meeting where runoff has directly entered waterways and/or sediment was being delivered via stormwater infrastructure Figure 4-5. These hotspots should not be considered an exhaustive inventory of erosion, sedimentation, and stormwater concerns for the entire Gills Creek watershed but may serve as a sampling of some of the potential pollutant loading from urban/suburban lands, both during and after construction.

Runoff from urban/suburban land may be a source of sediment, nutrients, bacteria, and other pollutants in portions of the watershed. Fecal matter from pets and wildlife found in urban and suburban areas can contribute to the bacteria levels found in the waterways of Gills Creek watershed. Nutrients and toxins from chemical applications to lawns and landscaped areas may contribute to declines in aquatic species populations in combination with other sources (cropland runoff, point sources, and hazardous waste). Urban/Suburban lands are most likely impacting water quality and aquatic habitats throughout most of the upper watershed with the exception of the forested areas of Fort Jackson in the southeastern corner of the upper watershed. With the potential of land being continually developed into suburban and urban land uses, especially in the areas zoned as R1 within the City of Columbia's jurisdiction (see Section 2.8.3), it will be important to consider undeveloped areas as potential future pollutant sources.

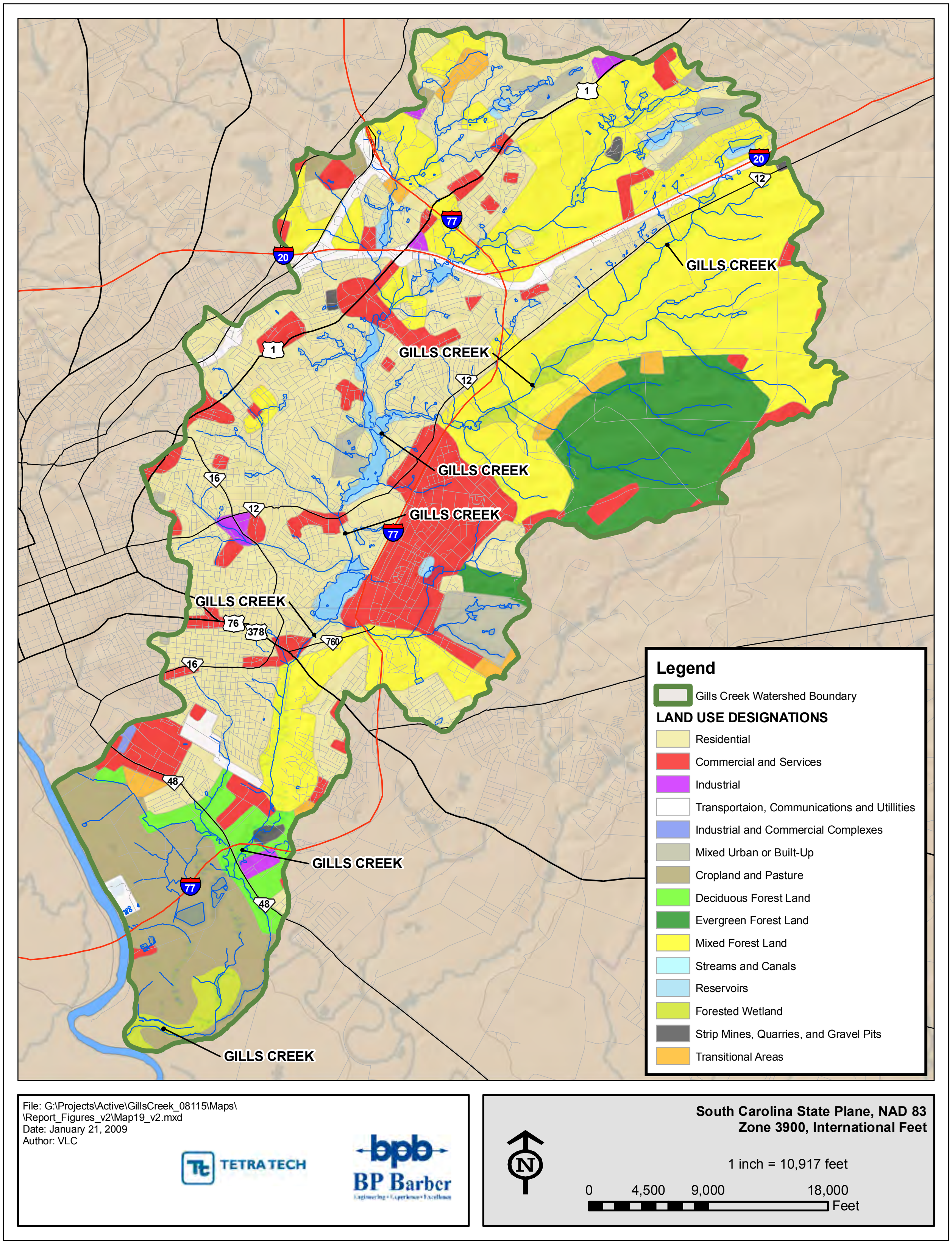


Figure 4-3. Land Use, Present

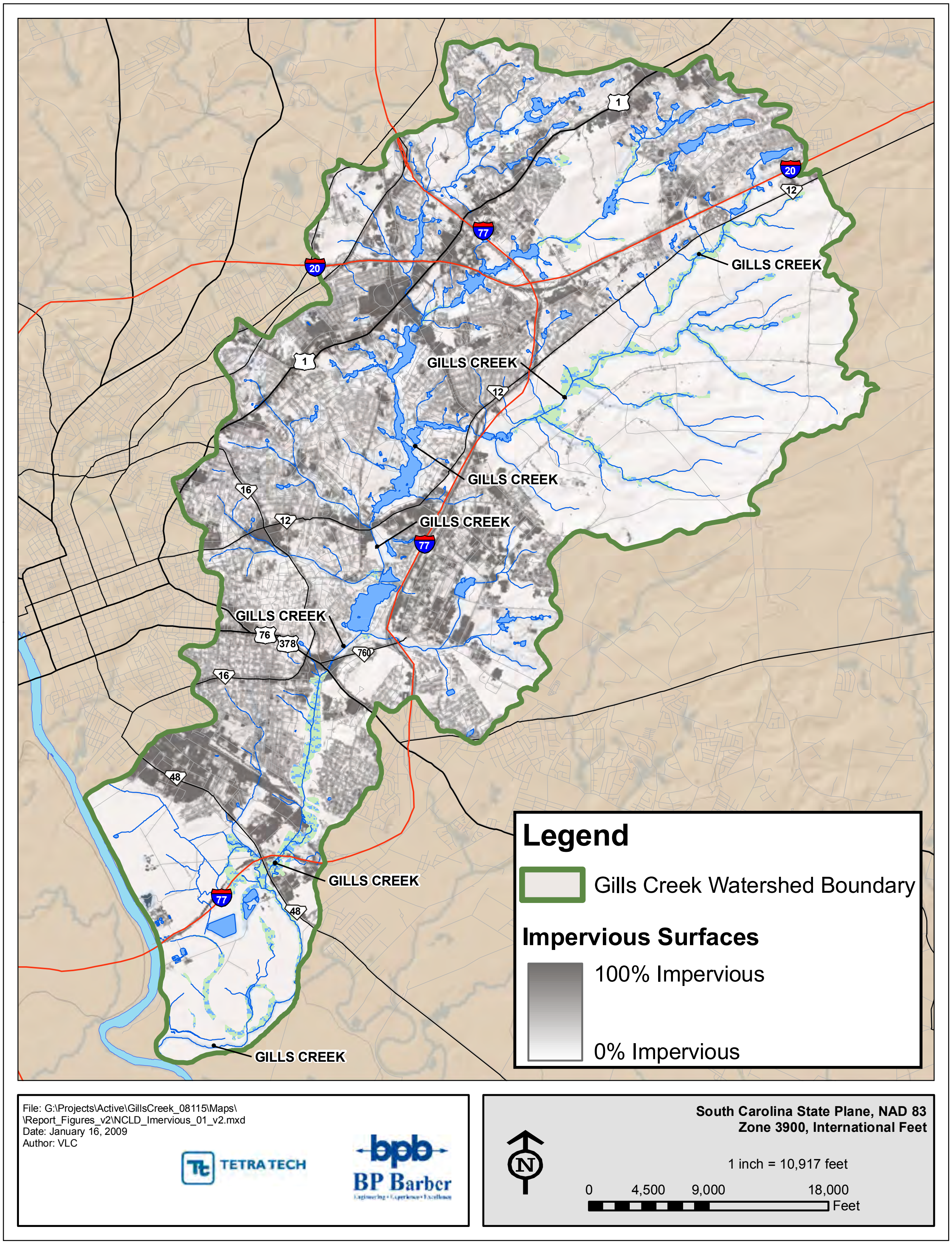


Figure 4-4. 2001 NLCD Percent Impervious Surface

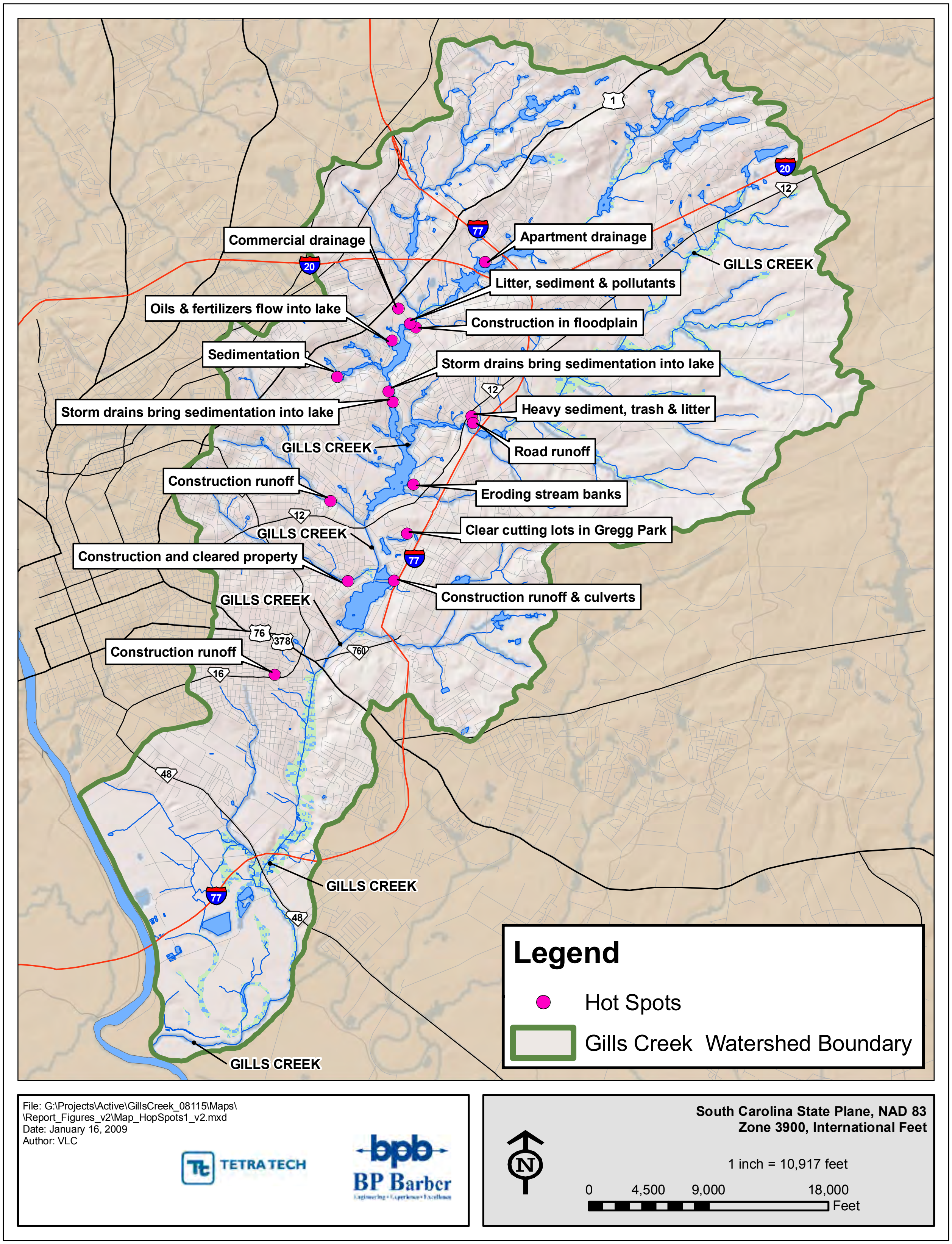


Figure 4-5. Erosion, Sedimentation, and Stormwater Hot Spots Identified by Stakeholders

4.1.6. Streambank Erosion

Modification of the hydrologic regime due to land development in a watershed can result in elevated volumes of stormwater runoff being delivered to creeks, streams, and waterbodies. These increased volumes and the quick delivery of these runoff events can lead to scour of stream channels, incision, and streambank erosion. Hydrologic scour of the streambed can also limit key microhabitats (e.g., leaf packs, sticks, and coarse substrate) for aquatic species. While it is difficult to delineate the different sources of sediment that is being delivered to streams (e.g., streambank erosion as opposed to upland sources such as construction sites), instream sedimentation and subsequent lack of microhabitat are, to some degree, a result of sediment input to streams from streambank erosion. Channel widening through streambank erosion can also exacerbate low flow conditions because channels become overly wide and shallow.

Ideally, the evaluation of streambank erosions risks in a watershed would be done through field observations using industry-standard methodologies (e.g., Bank Erosion Hazard Index (BEHI) as described by Rosgen (2001) or Channel Evolution Model as described by Simon (1989)). However, due to limited time and funds, the influence of streambank erosion was quantified throughout the Gills Creek watershed using a geospatial assessment that involved a statistical analysis of the Universal Soil Loss Equation (USLE) K-factor values (obtained from the USDA NRCS Soil Survey Geographic (SSURGO) Database) within 10 feet of all existing natural stream channels. While the USLE K-factor—having units of tons/acre—is a measure of the susceptibility of a soil to particle detachment and transport by rainfall (also with the assumption that the soil is cultivated, continuous fallow), it is the best available measure of a specific soil's susceptibility to streambank erosion for the Gills Creek watershed. Moreover, the K-factor values most likely underestimate the risks of streambank erosion because the erosive power of stream flows on (most likely) saturated streambank soils is presumed to be greater than that of rainfall. The sub-surface K-factor was used so that bank and channel erodibility was most closely reflected by the data.

To supplement the geospatial analysis, stakeholders identified hotspots from the first public meeting and identified areas where streambank erosion processes may be active (Figure 4-6). These hotspots should not be considered an exhaustive inventory of instream erosion concerns for the entire Gills Creek watershed but may serve as a sampling of some of the potential areas of streambank erosion found throughout the watershed.

The average sub-surface K-factor related to streambank erosion for the entire Gills Creek watershed ranges from 0.10 to 0.32 ton/acre, and the area weighted average is 0.26. Because the soils are most likely recently deposited alluvial sediments it is not surprising that areas with relatively high K-factor values are in the floodplain of the Congaree River that are within and surround the City of Cayce. However, there are numerous stretches of streams—of first and greater than first order—throughout the entire watershed that have a K-factor value greater than the watershed's weighted average of 0.26 tons/acre (Figure 4-7). The more erosive areas appear to be concentrated in the entire eastern side as well as the entire upper and lower portions of the watershed. The data indicate that the western, middle portion of the watershed may have the lowest risk for stream bank and channel erosion.

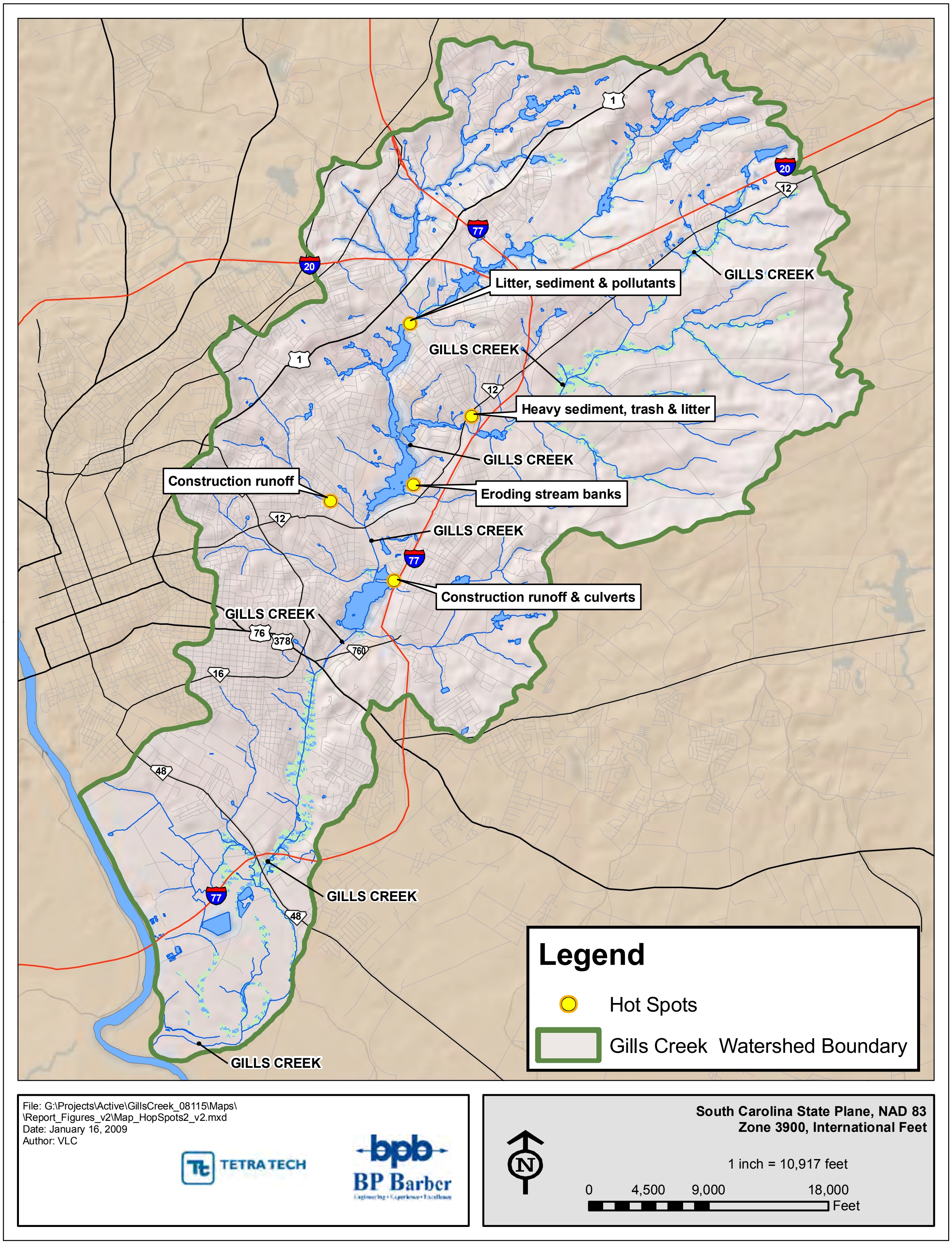


Figure 4-6. Instream Erosion Hot Spots Identified by Stakeholders

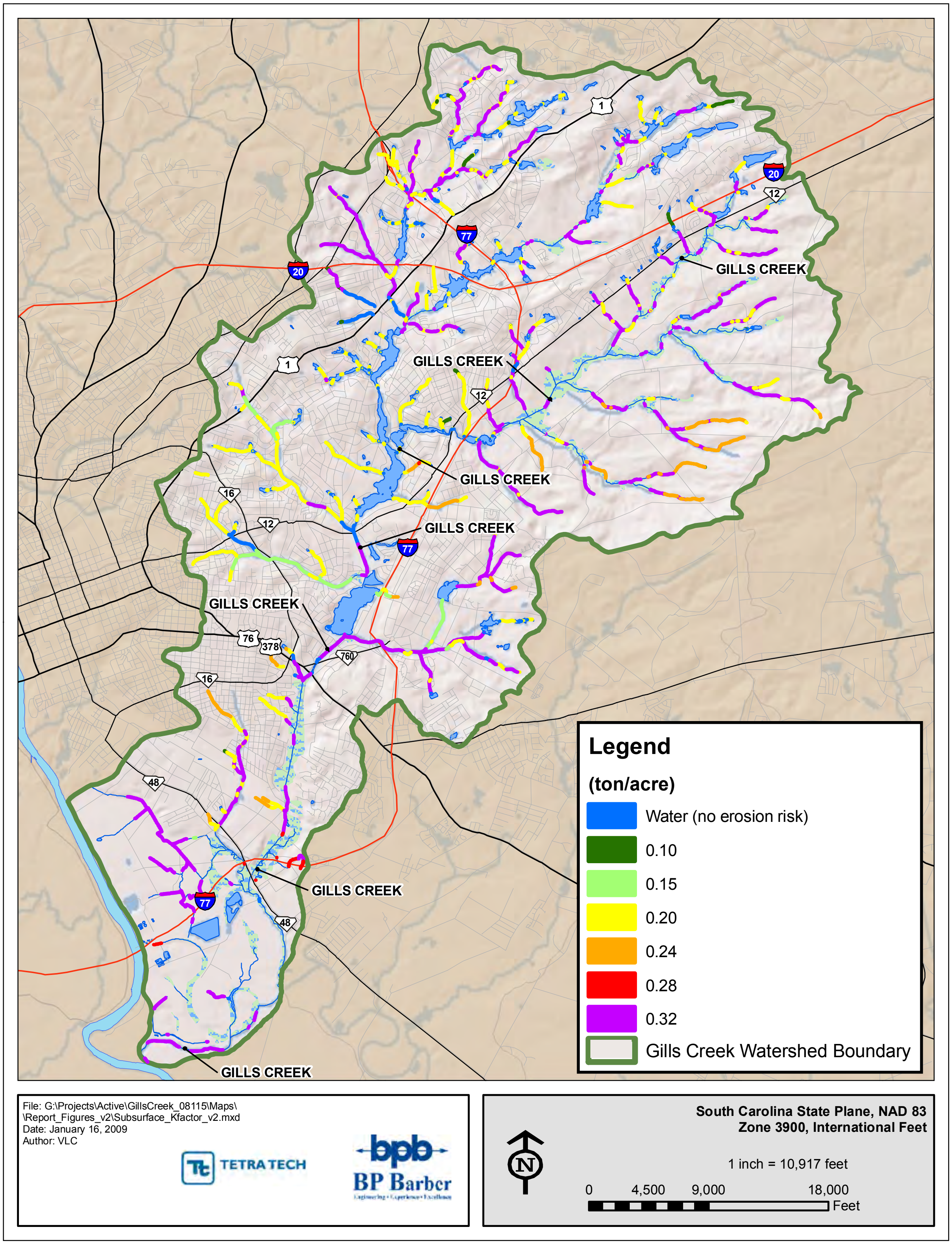


Figure 4-7. Sub-surface K-Factor within 10 feet of Streams

4.1.7. Atmospheric Deposition

Atmospheric deposition can be a source of pollutants that originate from air emissions within and outside the watershed. Pollutants in the atmosphere may originate from automobiles, power plants, incinerators, factories, and a number of other sources. The sources of pollutants may be located many miles from the receiving watershed. Deposition can occur during rain events (wet deposition) and between rain events (dry deposition). Atmospheric deposition is most commonly investigated as a source of nitrogen, sulfur, and mercury, which can degrade water quality and endanger public health and aquatic life.

Statistics for mercury deposition were generated from the 2002 results of the CMAQ-Hg modeling efforts, a regional mercury transport model developed by the US EPA as part of the U.S. Congestion Mitigation and Air Quality (CMAQ) Improvement Program. The following mercury deposition rates were estimated from the simulated data:

- Total Dry Mercury ranges from 19.3 $\mu g/m^2$ to 27.8 $\mu g/m^2$, with an average 24.8 $\mu g/m^2$
- Total Wet Mercury ranges from 12.9 $\mu g/m^2$ to 15.0 $\mu g/m^2$, with an average 13.8 $\mu g/m^2$
- Total Dry and Wet Mercury range from 32.8 $\mu g/m^2$ to 42.9 $\mu g/m^2$, with an average 38.6 $\mu g/m^2$

Estimated deposition rates are also available for nitrogen and sulfur from the USEPA Clean Air Status and Trends Network (CASTNET). The closest CASTNET monitoring station is located in Montgomery County, NC near the NC-SC border, and data from 1997 through 2007 are summarized in Table 4-1.

Table 4-1. Range and Average of CASTNET Deposition Rates for Nitrogen and Sulfur 1997-2007, excluding 1998 and 2004, for Site NC36 in Montgomery County, NC

	Nitrogen Deposition (kg/ha)			Sulfur Deposition (kg/ha)		
	Dry	Wet	Total	Dry	Wet	Total
Minimum	1.8	3.1	5.4	1.9	3.6	5.5
Average	2.2	4.5	6.6	2.3	5.0	7.3
Maximum	2.6	5.6	7.6	2.7	6.4	8.6

Mercury deposition is a source of high mercury concentrations in fish tissue and surface water, which have impaired streams and lakes in the watershed. Nitrogen deposition is likely to contribute to total nitrogen concentrations in the watershed, which can cause algal blooms and eutrophication, lead to lower dissolved oxygen, and impact aquatic life. Sulfur deposition is likely to contribute to reduced pH below natural conditions, which can also harm aquatic life. The entire watershed is expected to be affected by atmospheric deposition of these pollutants.

4.2. Point Sources

4.2.1. NPDES Permits

The National Pollutant Discharge Elimination System (NPDES) was developed by USEPA to regulate point source pollutant discharges to surface waters. In South Carolina, NPDES permitted dischargers must comply with discharge limitations that are set by DHEC to protect downstream waterbodies.

Figure 4-8 shows the locations of NPDES permitted facilities, with both active and inactive permits. Four NPDES permitted facilities are active dischargers to surface waters in the watershed. Two of these discharges are stormwater outlets from diked oil storage facilities within Fort Jackson. The NPDES facility in the upper part of the watershed (SC0046264) discharges concentrations of organic chemicals. The active facility in the lower portion of the watershed (SCG250180), which is an industrial facility, is a minor discharger of cooling water.

The NPDES discharges may contribute to declines in aquatic species populations in combination with other sources of potential toxins (stormwater runoff, agriculture, and hazardous waste), but are not expected to be significant pollutant sources in the watershed.

4.2.1.1. Phase I and II Stormwater Permits

Urban areas designated by USEPA and DHEC as significant dischargers of stormwater runoff can represent a significant source of sediment, nutrients, bacteria, metals, other dissolved substances, and erosive stream flows. Stormwater is addressed generally under Section 4.1.5, but it is also important to consider where significant sources of stormwater are identified by the federal and state governments.

DHEC Bureau of Water requires jurisdictions with significant urban area to develop municipal stormwater management programs as part of EPA's Phase I and II stormwater requirements. The jurisdictions are termed Municipal Separate Storm Sewer Systems (MS4s). Within the Gills Creek watershed, the following jurisdictions are MS4s: Richland County, the City of Columbia, the Town of Arcadia Lakes, the City of Cayce, and the City of Forest Acres. Of these jurisdictions, Richland County and the City of Columbia are designated medium MS4s and are required to address more elements under their stormwater programs than the other jurisdictions, which are designated as small MS4s. Medium MS4s are also required to develop an individual stormwater permit, whereas small MS4s can choose to discharge under the state's general permit.

As noted in Section 4.1.5, stormwater runoff is likely to be a significant nonpoint pollutant source in the watershed. Stormwater runoff is likely to contain high concentrations of nutrients and sediment, and may also be a significant source of fertilizer and pesticides from golf courses, lawns, and other landscaping. Metals and other toxic substances in stormwater runoff can endanger aquatic life downstream of urbanized areas. Pet waste in residential areas is likely to be a significant source of bacteria within MS4s as well. The MS4 urbanized area in the watershed is shown in Figure 4-9 and encompasses a majority of the watershed, excluding the lower portion near the Congaree River and the upper, northeastern portion.

4.2.1.2. CAFO Permits

Concentrated Animal Feeding Operations (CAFOs) are livestock operations that raise animals in confined facilities. These facilities are permitted by USEPA, and DHEC regulates these and smaller facilities with stricter standards than the minimum USEPA requirements. According to the most recent information available from DHEC, no permitted animal feeding operations are located within the watershed.

4.3. HAZARDOUS WASTE

4.3.1. CERCLA Sites

The USEPA identifies uncontrolled or abandoned sites that contain hazardous waste under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). These sites are commonly referred to as Superfund sites. According to the most recent information available from the USEPA, no CERCLA, or Superfund, sites exist within the watershed.

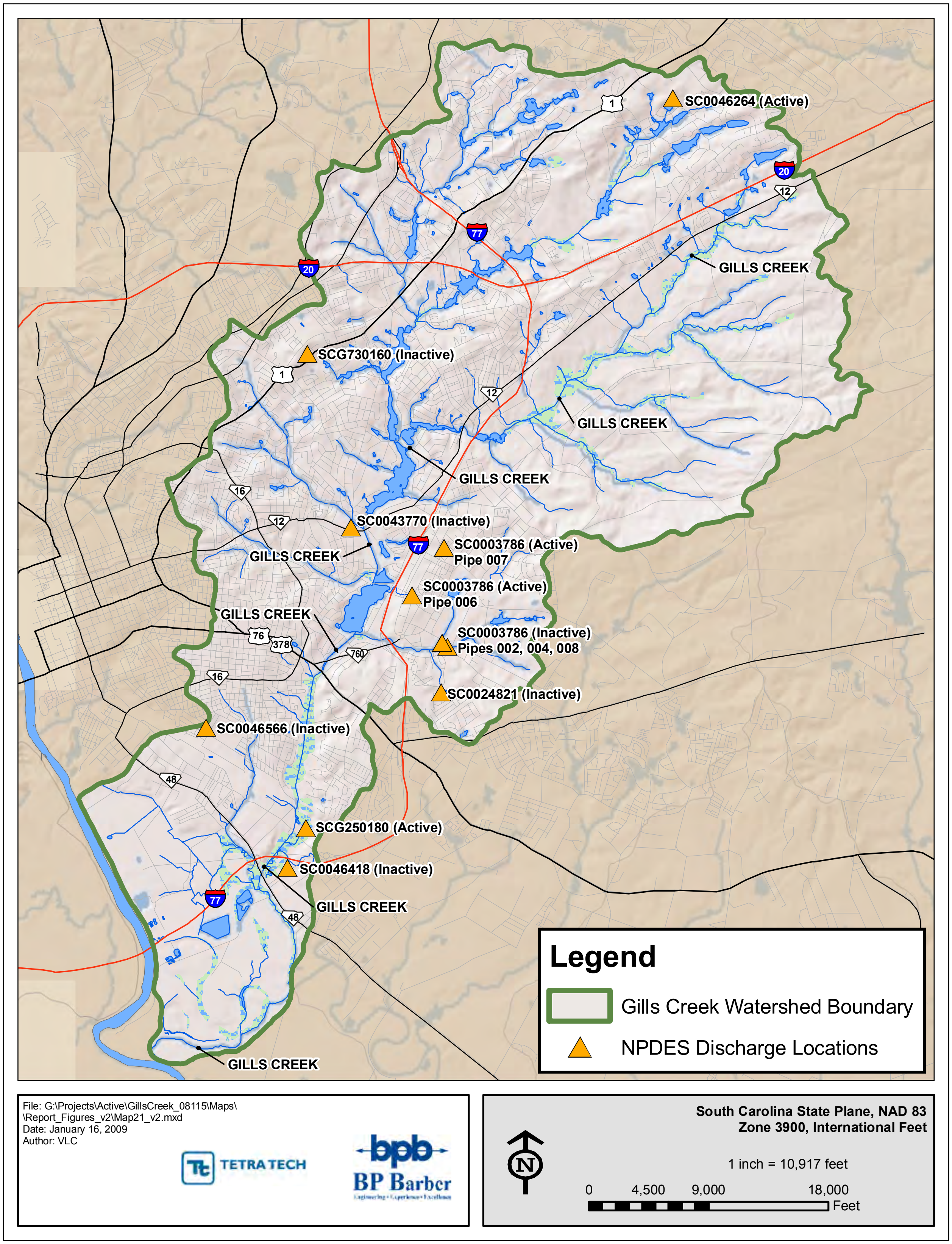


Figure 4-8. NPDES Permitted Facilities

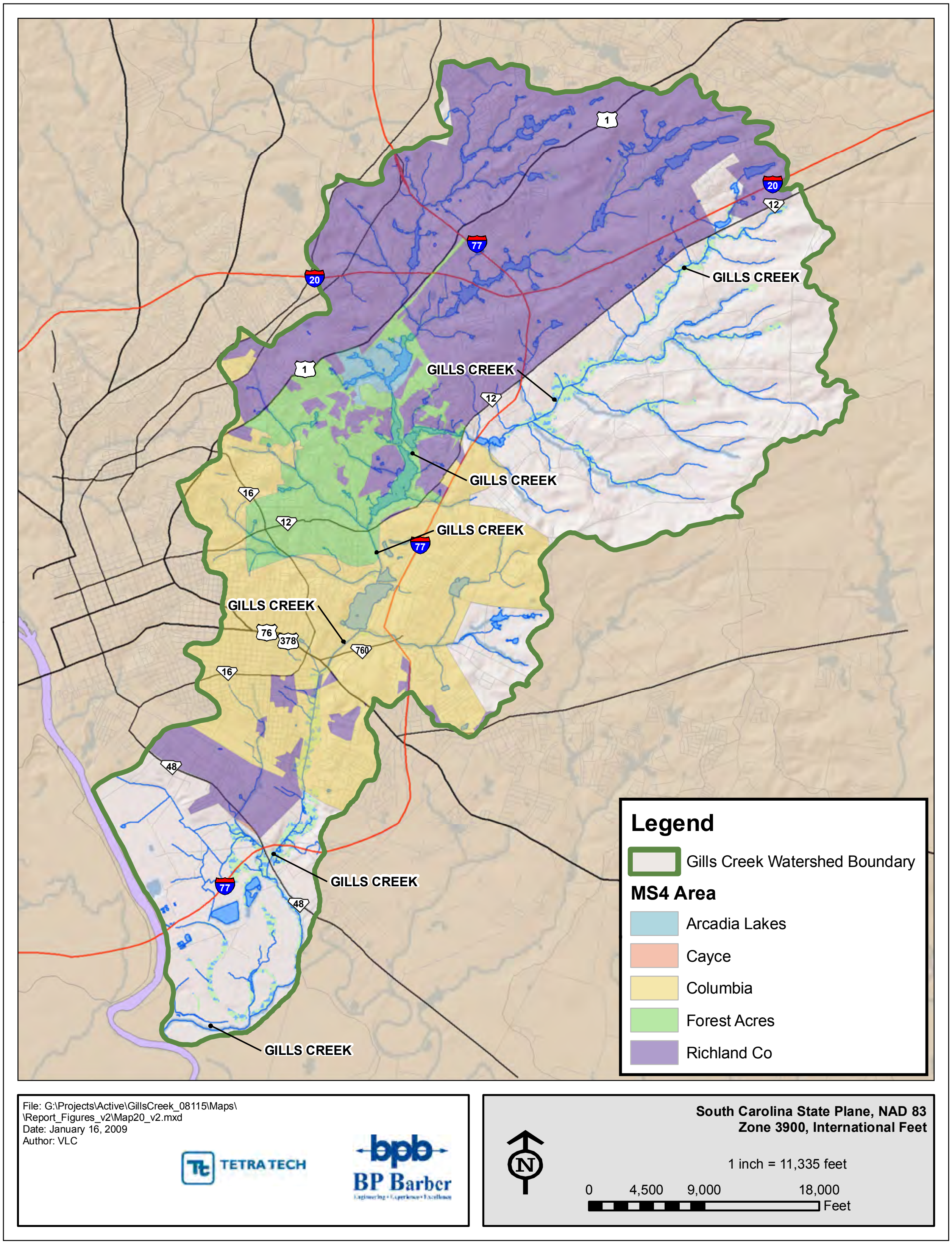


Figure 4-9. MS4 Urbanized Area

4.3.2. RCRA Sites

Under the Resource Conservation and Recovery Act (RCRA), USEPA identifies locations where hazardous wastes must be managed to protect against risks to human health. Improper handling and disposal of hazardous substances could result in contamination of surface waters.

The Gills Creek watershed contains six RCRA sites as shown in Figure 4-10. Three of these sites are designated as Treatment, Storage, and Disposal sites; these facilities are permitted to treat, store, and dispose of hazardous wastes. Disposal of hazardous wastes may occur at these permitted sites or may occur outside of the watershed and some of these facilities may be incinerators. The watershed also contains two RCRA sites designated as Large Quantity Generators; these facilities produce relatively large quantities of waste, are allowed to store hazardous waste for 90 days, and cannot dispose of hazardous materials onsite.

Toxic substance releases are reported annually by industrial facilities, some of which may not be regulated under RCRA. Three RCRA sites have reported toxic releases to the EPA, and 14 non-RCRA facilities have reported toxic releases to the EPA. All but three of these releases were reported in the lower portion of the watershed near and along State Route 48 (Bluff Road). For those RCRA facilities that have not reported releases, no known releases occurred at these sites; however, small releases may occur as a result of stormwater runoff.

4.3.3. Brownfields

Brownfields are sites where redevelopment may cause the release of hazardous substances or other pollutants. Locations for brownfields could not be obtained during this assessment. Brownfields are likely to exist within the watershed and may be concentrated in the older, industrial area along State Route 48 and in the vicinity of airport.

4.3.4. Underground Storage Tanks

Underground Storage Tanks (USTs) can be another potential source of toxic releases to soil and ground water. Within the Gills Creek watershed, 266 USTs are known to exist (Figure 4-11). The highest densities of USTs occur within dense urban areas and within Fort Jackson. Among the 266 USTs in the watershed, 128 of these (about 50 percent) are known to be leaking. The leaking tanks are not concentrated in one portion of the watershed and have a similar geographic distribution as the non-leaking tanks. Leaks in these USTs could be contaminating soils and groundwater and may be impacting nearby streams and aquatic communities within the watershed.

4.4. OTHER POTENTIAL POLLUTANT SOURCES

4.4.1. SSOs and CSOs

Sanitary Sewer Overflows (SSOs) and Combined Sewer Overflows (CSOs) are sources of sediment, nutrients, bacteria, and toxins during storm events. These overflows are caused when surface water enters sewer systems beyond their designed flow capacity, causing the sewers to overflow and release raw sewage. During these events, the released sewage may enter nearby waterbodies and cause an acute increase in pollutant concentrations. SSOs involve sewers that are exclusively used to transport sanitary wastewater, whereas CSOs involve sewers that receive both stormwater runoff and sanitary wastewater.

Figure 4-12 shows where SSOs have occurred in the Gills Creek watershed and where releases have reached surface water. Additional SSOs may have occurred in the watershed but could not be geolocated due to insufficient information. The overflows do not appear to be concentrated in a single portion of the watershed. The locations that cause the most pollution to surface waters are likely those that occur directly adjacent to waterbodies, like the locations directly upstream of Lake Katherine. DHEC is not aware of any CSOs in the watershed and does not expect that any CSOs have occurred (G. Trofatter, DHEC Bureau of Water, personal communication to H. Fisher, September 2008).

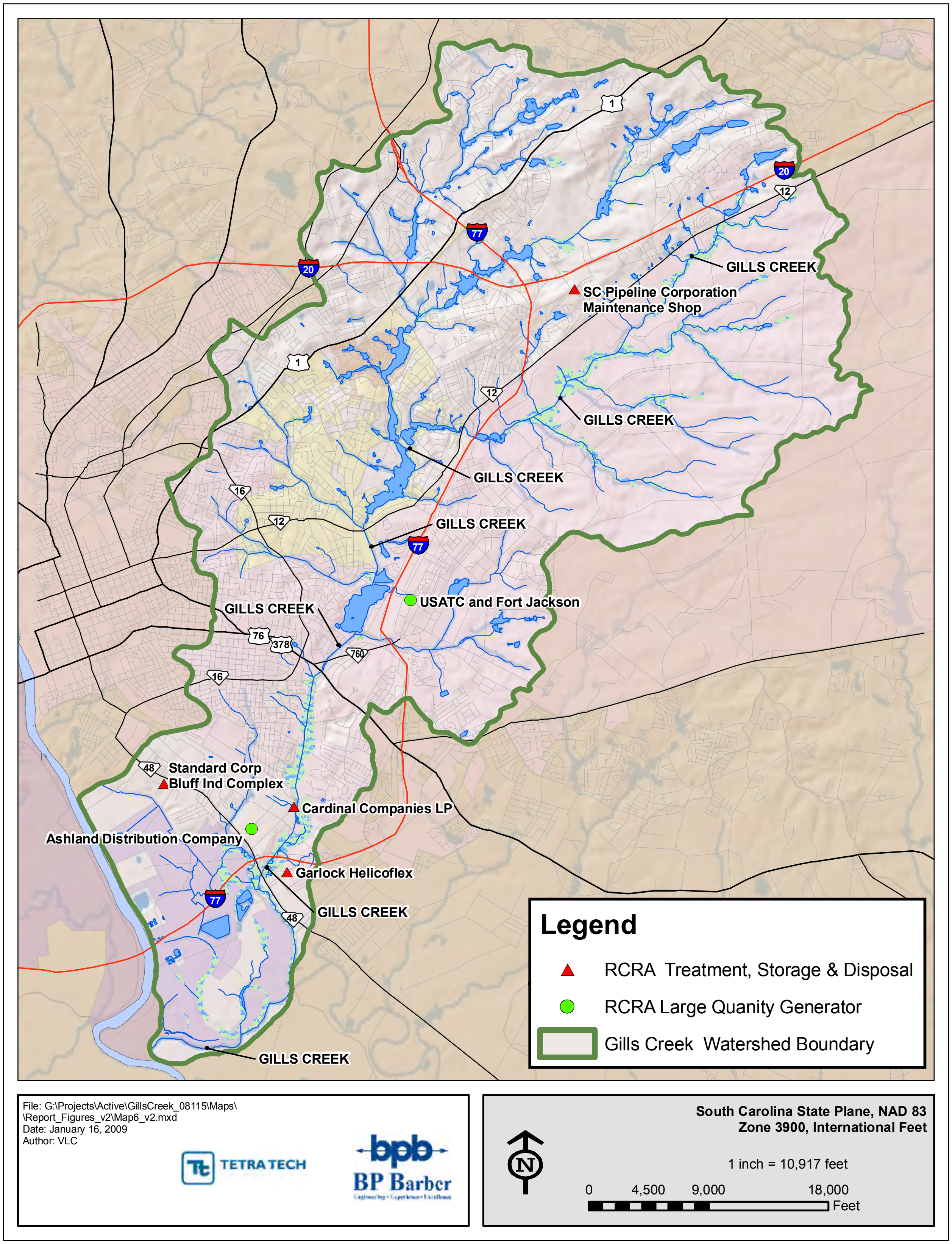


Figure 4-10. RCRA Sites

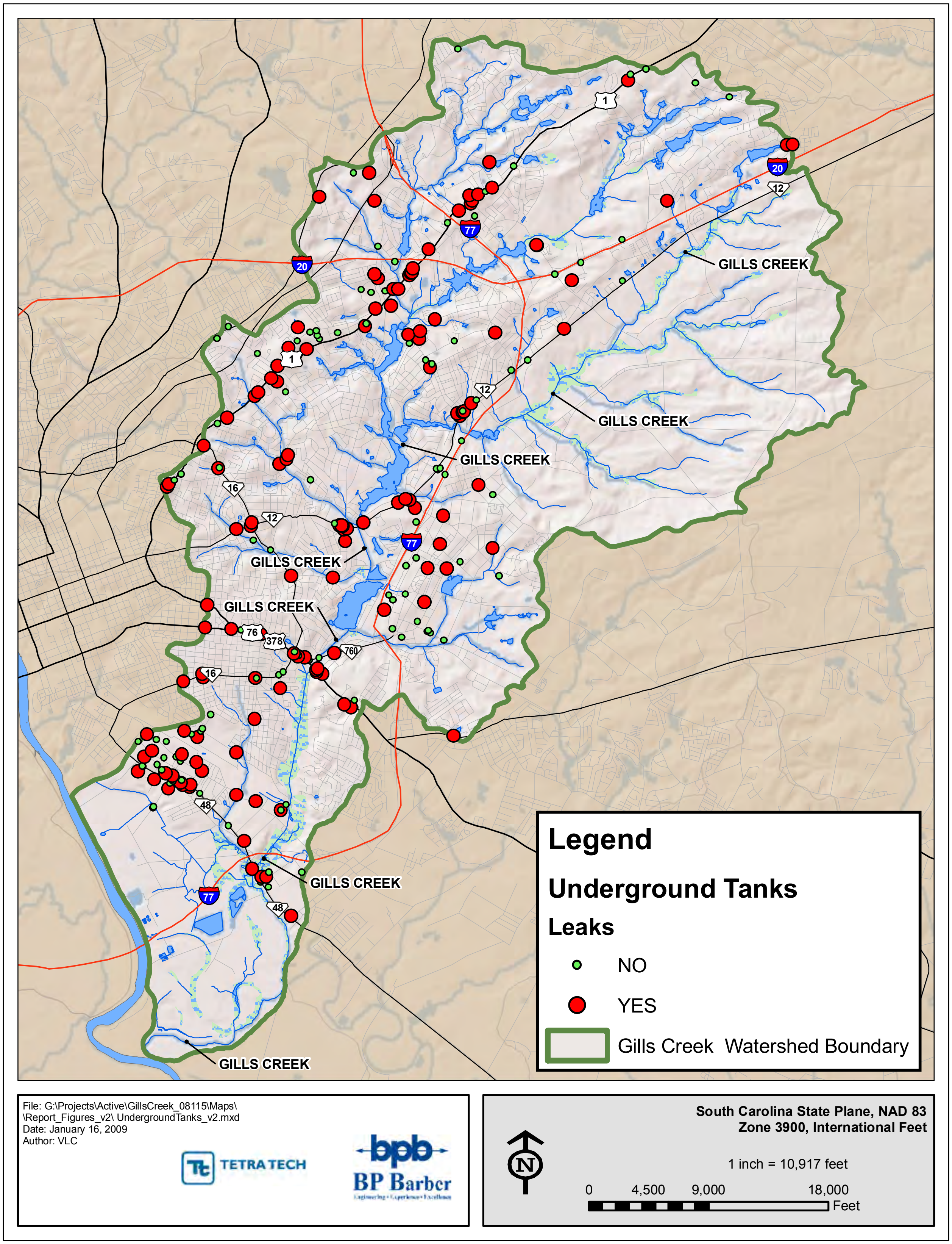


Figure 4-11. Underground Storage Tanks (USTs)

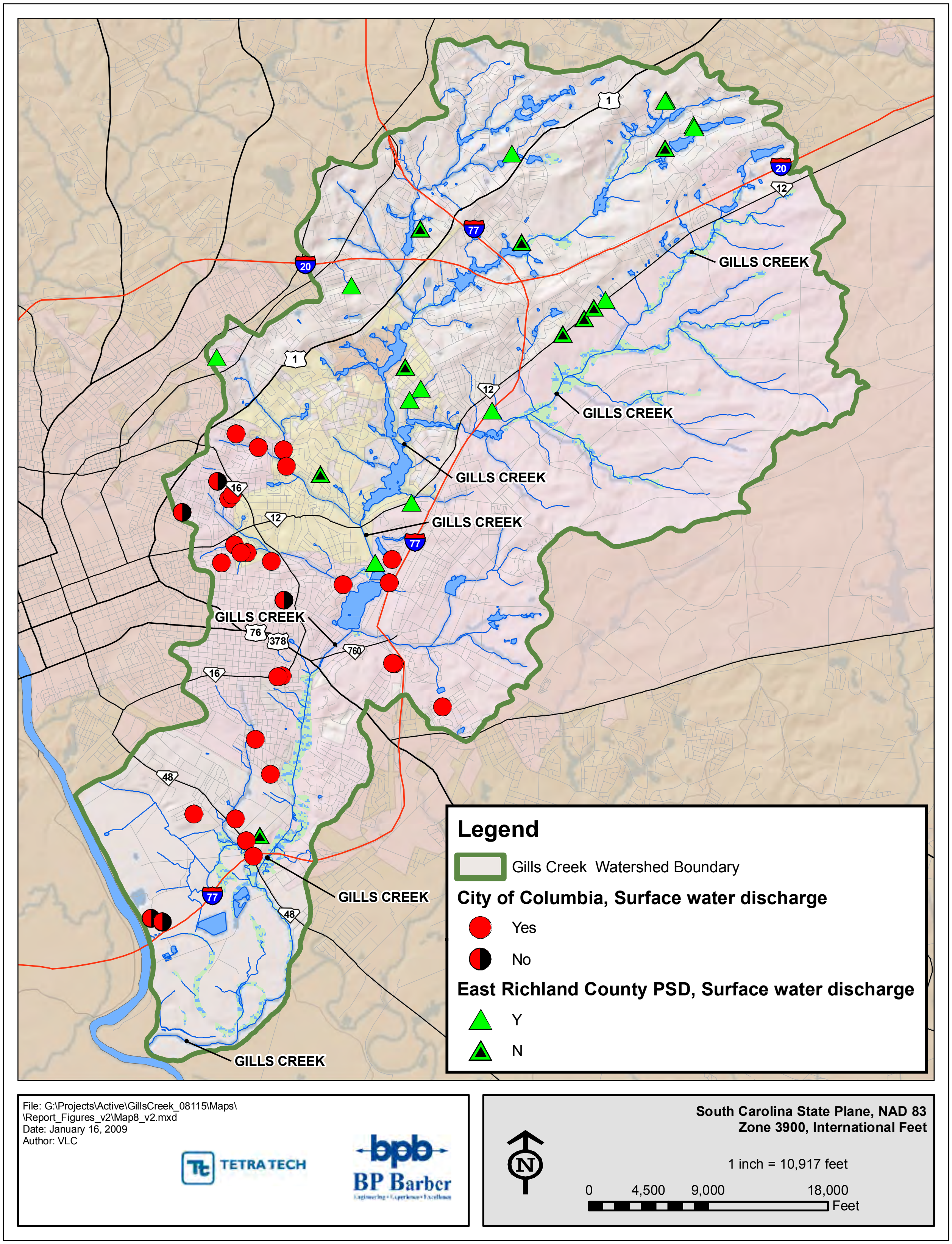


Figure 4-12. SSOs and CSOs

4.4.2. Landfills

Landfills, mainly municipal and industrial, have been known to leach a number of pollutants into ground water, including nutrients, heavy metals, and other substances. If streams are connected to ground water near landfills, contaminated ground water could degrade water quality and endanger aquatic communities. Landfills are required by the USEPA to implement leaching controls and to monitor groundwater contamination.

Six landfills exist in the watershed (Figure 4-13). Two inactive landfills are located in the central portion of the watershed along the western ridgeline. These landfills contain construction and demolition waste. Among the two active landfills located in the lower portion of the watershed (near Interstate 77), one is used to dispose of industrial waste (ash, cardboard, paper, wood, fillers, resin, and crushed 55-gallon drums), and one is a City of Columbia composting facility. Two inactive landfills are located in the lower portion of the watershed: one municipal landfill and one industrial landfill.

The inactive construction and demolition waste landfills are not expected to have a significant impact on groundwater or downstream waterbodies. The greatest impacts to groundwater from landfills likely occur in the lower reaches of Gills Creek, downstream of the inactive municipal landfill and the three inactive/active industrial landfills. Leaching from these landfills, in combination with other sources of pollutants (hazardous waste sites, urban/suburban runoff, etc.), may have some impact on aquatic communities in Gills Creek. Sources related to hazardous waste and industry, in general, appear to be concentrated in the lower portion of the watershed near the intersection of Interstate 77 and State Highway 48 (Bluff Road). Although one single source may not have a significant impact, the cumulative impact of these sources may be leading to degradation in Gills Creek.

4.4.3. Pesticides

Pesticides have been mentioned above as potential watershed contaminants that originate from a number of land uses including agricultural, commercial, and residential areas. When herbicides are applied to streams or stream banks to control weed growth, pesticides may enter streams and lakes directly. Runoff from land where pesticides have been applied will carry pesticides into surface waters. Pesticides may also enter streams via ground water. Since a number of sources are responsible for pesticide contamination, it is useful to consider how all sources impact contamination in the Gills Creek watershed.

Maluk (1999), a USGS study, sampled 16 sites throughout the watershed over a 4-day low-flow period in 1996. The following pesticides were most commonly detected:

- Tebuthiuron – an herbicide which is used to control weeds in non-cropland areas, right-of-ways, and industrial sites.
- Diazinon – an insecticide which is used to control a variety of insects in residential areas, home gardens, and farms.
- Atrazine – an herbicide which is used on weeds in cropland and industrial areas.

In each of the 13 detections of Diazinon in the watershed, the pesticide exceeded the chronic criteria for the protection of aquatic life. Two other pesticides, dieldrin and carbaryl, were not the most common detected but were also detected at concentrations that exceed chronic criteria for aquatic life. Carbaryl, an insecticide, is currently used on a variety of land uses, including crops, forests, lawns, poultry, livestock, and pets. The USEPA banned dieldrin from use in 1987, but this insecticide breaks down slowly and may be found in both surface and groundwater. Maluk (1999) also found that as the number of pesticides detected at a location increased, the percent of urban land use increased.

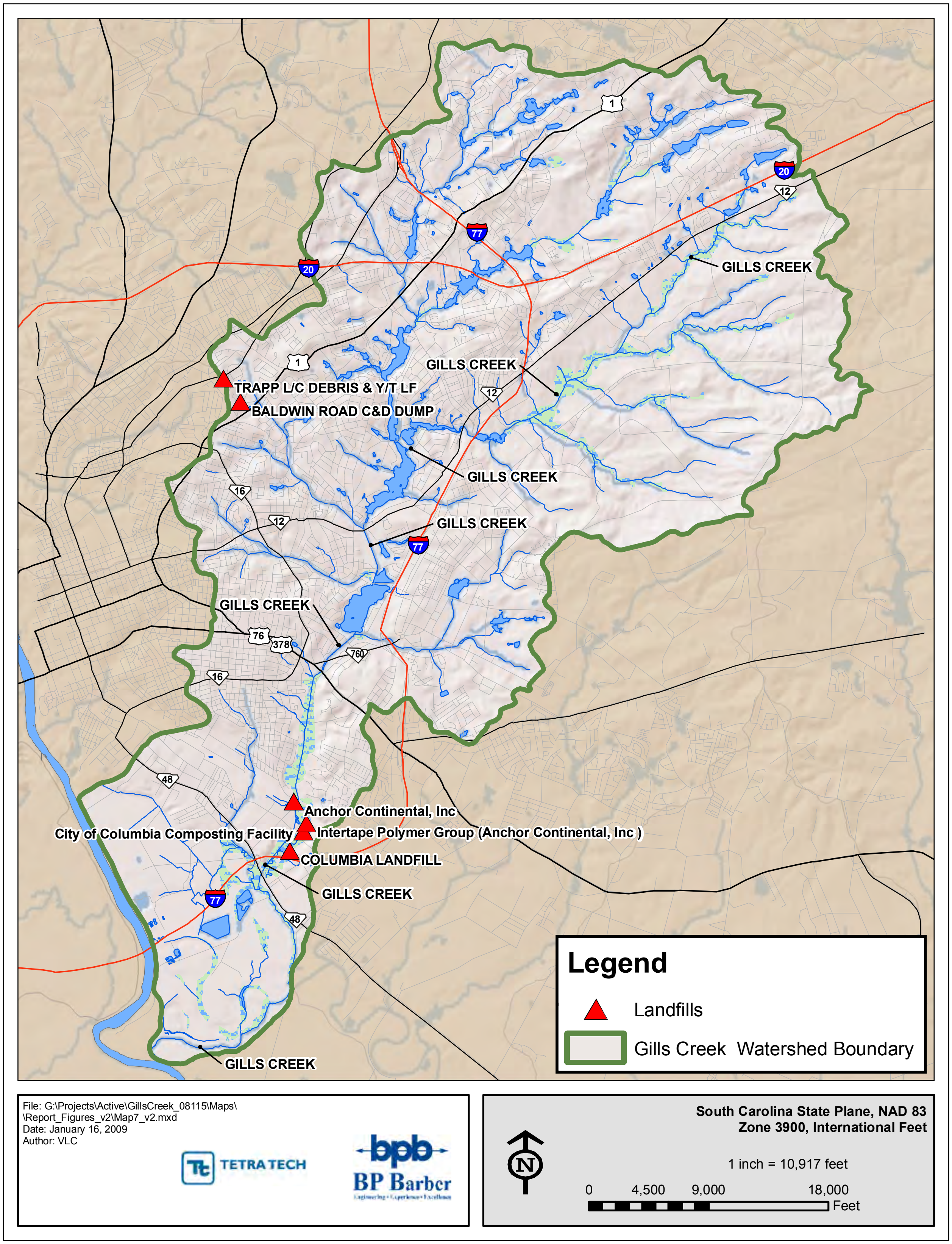


Figure 4-13. Landfills

The Maluk study suggests that the largest source of pesticides may be residential and industrial areas, since the most commonly detected pesticides are applied to these land uses. Agricultural areas are still a concern for pesticides given that both diazinon and atrazine are used on farms. The largest pesticide load is likely to originate from the portions of the watershed with the highest percentage of urban land.

4.5. POLLUTANT SOURCE OVERVIEW

Table 4-2 summarizes the significant pollutant sources identified in the watershed according to the pollutant source assessment and lists the pollutants of concern and the affected area for each significant source. Urban/suburban runoff is likely to be the largest source of nutrients and sediment in the watershed since urban/suburban land is a dominant land use in the watershed. Although it is not listed as a significant source, atmospheric nitrogen deposition is a likely source of nitrogen loading from urban and suburban land. Atmospheric mercury deposition is likely to be a significant source of mercury in the watershed. Waterfowl and SSOs are likely to have an impact on pollutant concentrations, especially for bacteria, downstream of where these sources occur. Although a single hazardous materials source is unlikely to pose significant concern, the concentration of abandoned and existing industrial uses near State Route 48 (Bluff Road) may be posing a cumulative impact on aquatic life downstream.

Table 4-2. Significant Pollutant Sources Identified in the Gills Creek Watershed

Significant Source	Pollutant(s) of Concern	Affected Area
Urban/suburban runoff, and Streambank Erosion, including MS4 Urban Areas	Nutrients, sediment, bacteria, and metals, pesticides, and other toxins.	Most of the watershed except for the northeastern portion within Fort Jackson; if future development occurs here, this area will be affected as well. Streams within the lowest portion of the watershed, although mostly undeveloped, are likely to be affected by upstream development.
Waterfowl	Bacteria	Within and downstream of lakes and other impoundments.
Atmospheric deposition of Mercury	Mercury	Entire watershed.
Combination of industrial sources (RCRA, brownfields, USTs, landfills, etc.)	Toxins	Lower portion of the watershed near and downstream of State Route 48 (Bluff Road).
SSOs	Nutrients, sediment, bacteria, and metals and other toxins.	Downstream of SSOs that reach surface waters.

NPDES point sources, atmospheric sulfur deposition, crops, and livestock are not likely to be significant sources of impairment or degradation but may be contributing to impacts in combination with more significant sources. Pollutant loading from silvicultural activities and wildlife (other than waterfowl) is expected to be minimal.

5.0 Identification of Critical Areas

The purpose of the critical areas identification is to select areas within the watershed where particular concerns exist and to identify management measures that would address those particular concerns. Management may be considered throughout the watershed, but the critical areas provide a tool for focusing management where it is most needed. Tetra Tech applied a two-tiered approach to selecting critical areas in the Gills Creek watershed:

- Tier I. Critical Areas for Watershed Concerns
- Tier II. Critical Areas for Management Opportunities

Under Tier I, watershed concerns are conditions in the watershed that indicate significant loss of watershed function, and these concerns represent endpoints of watershed processes. Pollutant sources and intermediate stressors interact to cause these endpoints; however, the watershed concerns focus on the endpoints themselves. For example, a watershed concern may be declining fish populations, which could be caused by multiple stressors, including toxicity and low dissolved oxygen. These stressors, in turn, could be caused by multiple pollutant sources. The Tier I Critical Areas are selected based on where the endpoints occur. Sources and stressors are considered under Tier II, when critical areas for management opportunities are identified. Management opportunities include any measures that would address watershed concerns.

The 16 subwatersheds delineated by CDM for the Gills Creek watershed HSPF model were used as the unit of comparison for the critical areas. To ensure that the entire watershed was included in the analysis, Tetra Tech added one additional subwatershed, for a total of 17 subwatersheds considered. The subwatersheds were given identification codes based on stream names. Appendix B provides a look-up table that matches these codes to the HSPF identification codes so that the critical areas can be linked to model input and results in future analyses.

The critical areas were selected using indicators based on available data. The indicator data were translated into scores that represented comparable conditions across the different indicators. Metrics, or measurements, of the indicators were defined and simple rules were developed to score subwatersheds based on the metrics. For each indicator, scores of 0, 0.5, and 1 were awarded according to a selected threshold for each metric. A score of 1 represents the greatest impacts or worst conditions, and a score of 0 represents the least impacts or best conditions. The scoring rules, metrics, and scores are provided in Appendix C.

Scores were totaled for each subwatershed, and subwatersheds with the highest scores were selected as critical areas. For some indicators, several subwatersheds tied for the highest score for each category, and, therefore, multiple subwatersheds were selected as critical areas for some categories. Appendix C reports the resulting scores for both tiers. A spreadsheet tool was developed so that once improvement occurs in critical areas, the next highest ranking subwatersheds can be identified for management. The tool also allows the scoring to be updated based on new data.

5.1. Tier I Critical Areas for Watershed Concerns

Tetra Tech reviewed stakeholder input, available data, and other information on the watershed, and identified the following major watershed concerns:

- Flooding: Flooding hazards exist that endanger human life and have caused or may cause property damage in the future.

- Sedimentation: Streams, lakes, and other waterbodies have and continue to receive excessive sediment loads during storm events, which reduce the aesthetic and recreational value of these water bodies and impact fish and other aquatic life.
- Trash: Streams and other waterbodies contain excessive amounts of trash which reduce the aesthetic and recreational value of the watershed, endanger wildlife, and threaten to clog infrastructure.
- Water Quality and Aquatic Ecosystems: Water quality degradation in streams and other waterbodies has impaired designated uses and threatens human health as well as aquatic life.
- Wildlife: Wildlife habitat has significantly declined, and some remaining wildlife habitat is currently unprotected.

Table 5-1 lists the indicators used to evaluate the magnitude of watershed concerns in each subwatershed. Using the scoring rules outlined in Appendix C, Tetra Tech identified subwatersheds within the Gills Creek watershed as priorities for addressing watershed concerns.

Table 5-1. Tier I Watershed Concern Indicators

Watershed Concern	Indicator
Flooding	Stakeholder Hot Spots -- Flooding
	Building within FEMA 100-Year Floodplain
Sedimentation	Stakeholder Hot Spots – In-stream and In-lake Sediment
Trash	Stakeholder Hot Spots -- Trash
Water Quality and Aquatic Ecosystems	303(d) Listed Waterbody
	Fish Use Advisory
Wildlife	Percent forest and wetlands in subwatershed (protected and unprotected)
	Percent forest and wetlands in riparian zone (protected and unprotected)
	Observations of threatened and endangered species

The scoring rules in Appendix C provide a description of all data and assumptions used, but a few assumptions are of particular importance. The riparian zone was defined as land within 100 feet of perennial streams, within 50 feet of intermittent streams, and within 50 feet of lakes and ponds. Several of the indicators depend on the hot spots identified by stakeholders during the first public meeting and stakeholder survey. A few additional hot spots were identified by Richland County in the field. The survey responses provided information on the magnitude or frequency of an impact, whereas the public meeting hot spots only provided the location of a problem. To incorporate both into the scoring, Tetra Tech assumed that the public meeting hot spots represented the highest level of severity as defined in the survey. Many of the numeric indicators, both in Tier I and Tier II, are scored based on statistical quartiles representing the 25th, 50th, 75th, and 100th percentile of values across subwatersheds.

Subwatersheds with the greatest concerns (highest scores) were selected as Tier I Critical Areas. The scores indicate where management should occur first; once the greatest concerns are addressed, the county can use the rankings to manage remaining concerns. Table 5-2 presents the scores for each watershed concern, with critical areas indicated in bold. Figure 5-1 illustrates the location of the Tier I Critical Areas. The following sections discuss how the scores reflect the potential opportunities for management within each critical area.

Table 5-2. Tier I Scores and Selected Critical Areas (in bold)

SW ID	Flooding	Sedimentation	Trash	Water Quality and Aquatic Ecosystems	Wildlife	Total
EM-01	1.0	0.5	0.0	0.0	**3.0**	4.5
GC-01	0.0	0.5	0.5	0.0	0.0	1.0
GC-02	0.0	**1.0**	0.0	0.0	0.0	1.0
GC-03	1.0	0.5	**1.0**	0.0	2.5	5.0
GC-04	1.0	0.0	0.5	**2.0**	**3.0**	6.5
GC-05	1.5	**1.0**	**1.0**	0.0	2.5	6.0
GC-06	**2.0**	0.5	0.5	1.0	0.0	4.0
GC-07	**2.0**	**1.0**	**1.0**	1.0	2.0	**7.0**
GC-08	1.0	0.0	0.0	0.0	1.0	2.0
GC-09	0.5	0.0	0.0	0.0	0.5	1.0
JC-01	0.5	0.0	0.0	**2.0**	0.5	3.0
JC-02	0.0	0.0	0.0	1.0	0.0	1.0
JC-03	0.5	0.0	0.5	**2.0**	1.5	4.5
JC-04	1.5	**1.0**	**1.0**	1.0	2.5	**7.0**
LJ-01	1.0	0.0	0.0	0.0	1.0	2.0
LJ-02	0.5	0.0	0.0	0.0	1.0	1.5
LJ-03	1.0	**1.0**	**1.0**	0.0	2.5	5.5

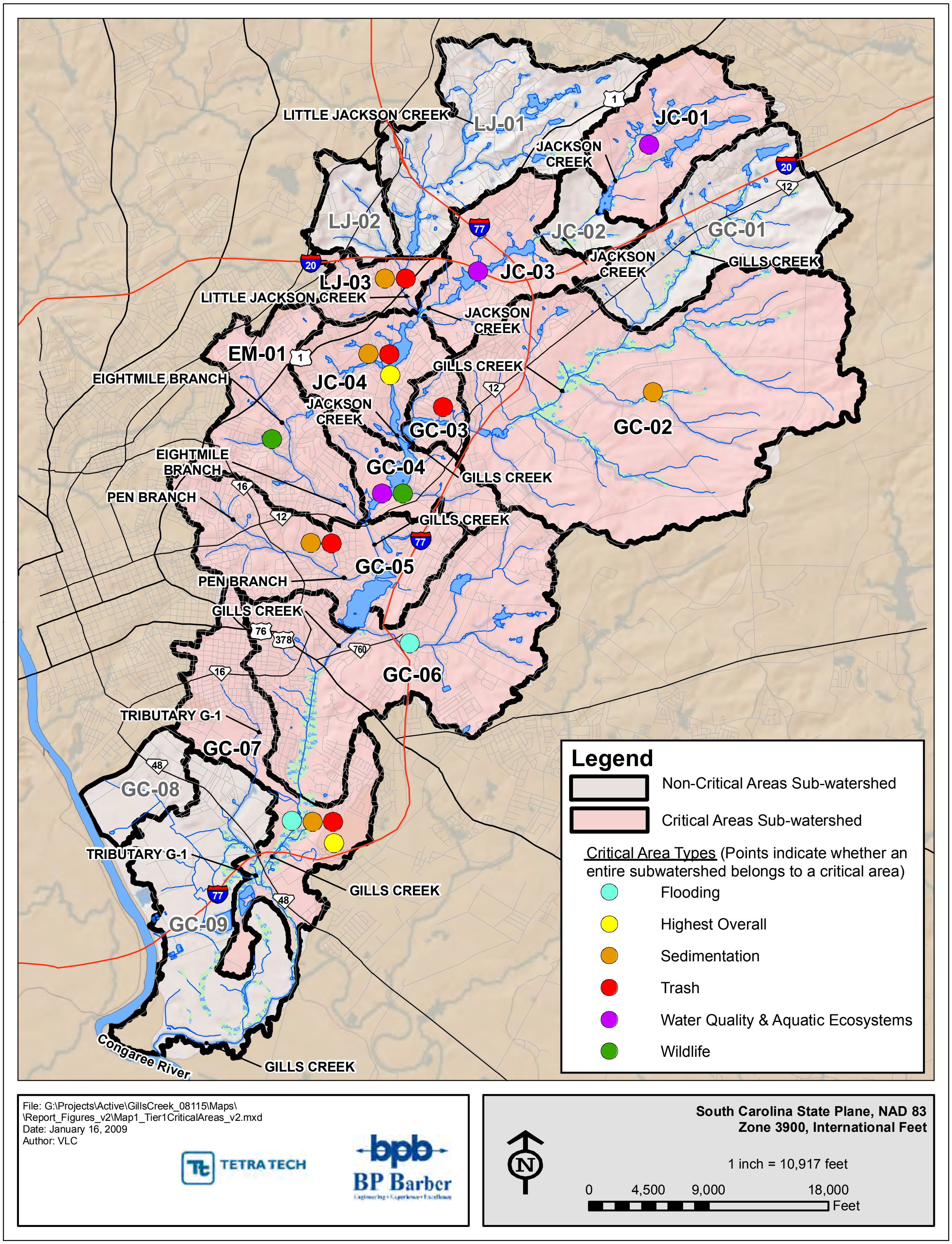


Figure 5-1. Tier I Critical Areas – Watershed Concerns

Flooding

Subwatersheds GC-06 and GC-07 were selected as the critical areas for flooding. When Tetra Tech reviewed FEMA 100-year floodplain maps and locations of development (using 2001 land use), GC-06 and GC-07 were among the subwatersheds with the greatest development intersecting the floodplain. According to stakeholder survey results, in GC-06 residents in at least one home cannot leave their neighborhood due to flooding between two and five times per year, and in GC-07 flooding occurs within at least one home between two and five times per year. Also in GC-06, homes have experienced ponding in yards at a similar frequency, and stakeholders noted a flooding hot spot in this subwatershed during the first public meeting.

Sedimentation

The critical areas for instream or inlake sedimentation were selected as subwatersheds. GC-02, GC-05, GC-07, JC-04, and LJ-03 using stakeholder recommended hot spots and severity ratings. Hot spots for sedimentation were noted in these subwatersheds either during the public meeting, in survey responses, or both. Considering all hot spots, these subwatersheds received the highest average rating for sedimentation severity. Waterbodies affected include Carys Lake, Eight Mile Branch, and Gills Creek. LJ-03 was selected due to one survey response, which indicated high sedimentation in an unnamed stream. This subwatershed should be investigated during plan implementation to determine if either 1) a localized sediment problem is occurring or 2) a larger, subwatershed-wide problem is occurring.

Trash

Subwatersheds GC-03, GC-05, GC-07, JC-04, and LJ-03 were selected as critical areas for trash. Like sedimentation, stakeholder input was the only indicator used to select these critical areas. Hot spots for trash were noted in these subwatersheds either during the public meeting, in survey responses, or both. Considering all hot spots, these subwatersheds received the highest average rating for trash severity. Affected waterbodies include Little Jackson Creek, Carys Lake, Lightwood Knot Branch, Rockyford Lake, Gills Creek, Pen Branch, Lake Katherine, and Tributary G-1. The number of affected waterbodies and critical areas indicates that trash loading is widespread throughout the watershed.

Water Quality and Aquatic Ecosystems

Subwatersheds selected as critical areas for water quality and aquatic ecosystems were GC-04, JC-01, and JC-03. These subwatersheds each contain a 303(d)-listed waterbody as well as a waterbody with a fish use advisory.

The selected critical areas contain mercury and dissolved oxygen impairments. In GC-04 and JC-01, Forest Lake and Sesquicentennial Park Pond, respectively, are listed as impaired due to mercury. In JC-03, Windsor Lake is listed for impairment of aquatic life due to low dissolved oxygen. The critical areas selected do not include GC-06 and GC-07, which have fecal coliform and dissolved oxygen impairments. As explained below, GC-07 is one of the two highest-scoring overall critical areas, partially due to water quality impairments as well as its flooding, sedimentation, and trash impacts. Management to address impairments in GC-07 is likely to occur upstream of both GC-06 and GC-07, which would help address both impairments. For this reason, it does not appear necessary to consider GC-06 and GC-07 as water quality critical areas.

In the Gills Creek watershed, waterbodies with fish use advisories for mercury are Sesquicentennial Park Pond (JC-01), Windsor Lake (JC-03), Carys Lake (JC-04), and Forest Lake (GC-04). GC-04 was not selected as a critical area because it does not contain a 303(d)-listed waterbody. No other fish use advisories have currently been issued for parameters other than mercury in the Gills Creek watershed.

Wildlife

Subwatersheds EM-01 and GC-04 were selected as critical areas for wildlife. Since high scores represent worst conditions, these subwatersheds are expected to have experienced the greatest loss of wildlife habitat and biodiversity. EM-01 and GC-04 are in the lowest quartile for percent area in forest and wetlands, both within the riparian zone (34 and 37 percent respectively) and the entire subwatershed (10 and 17 percent respectively). They have more forest and wetland than several subwatersheds, but they received the highest scores because they have no threatened or endangered species occurrences.

Preservation and restoration within EM-01 and GC-04 would not provide an efficient means of regaining lost habitat because impacts within these subwatersheds are so severe. However, the Tier II critical areas for preservation and restoration will help determine how a combination of management within and adjacent to these subwatersheds could most efficiently protect and restore wildlife habitat.

Overall Critical Areas

When Tier I scores are summed across all watershed concerns, subwatersheds GC-07 and JC-04 have the highest scores. These subwatersheds were selected as the overall critical areas where the greatest management needs exist.

Subwatershed JC-04 received the highest scores for sedimentation and trash. This subwatershed also received relatively high scores for flooding, water quality and aquatic ecosystems, and wildlife concerns. A fish use advisory, due to mercury, has been issued for Carys Lake in this subwatershed.

Subwatershed GC-07 received the highest scores for flooding, sedimentation, and trash as well as relatively high scores for water quality and aquatic ecosystems and wildlife. Within this subwatershed, Gills Creek is on the 303(d) list for fecal coliform and dissolved oxygen impairments.

Impacts in subwatersheds JC-04 and GC-07 are likely to originate from numerous sources, and management should be coordinated so that concerns are addressed effectively. Management opportunities that address more than one source or stressor may provide the most effective means of addressing the impacts in these subwatersheds.

5.2. TIER II CRITICAL AREAS FOR MANAGEMENT OPPORTUNITIES

The Tier II critical areas represent subwatersheds where management would likely address downstream watershed concerns, including the critical areas identified in Tier I. The following categories of management opportunities were considered:

- Stormwater BMP Retrofits – Best Management Practices (BMPs), either structural or non-structural, that are implemented within existing development to reduce impacts from stormwater runoff.
- Stream and Riparian Buffer Restoration – Revegetation and/or restructuring of a stream channel, banks, and/or floodplain area to reduce high flows, downstream flooding, and erosion and to restore the biological and water quality functions of a stream.
- Preservation – Acquisition and permanent protection of undisturbed natural areas to protect wildlife habitat and downstream water quality.
- New Development Policies – Requirements or other policies to encourage control and treatment of stormwater runoff from new development to protect watershed functions, including water quality and aquatic habitat.
- Other Policies and Outreach – Programs implemented to educate watershed citizens and promote watershed protection efforts.

Table 5-3 lists the indicators used to evaluate management opportunity within a subwatershed. The indicators represent likely causes of watershed concerns or other conditions that may indicate the presence of management opportunities. The Tier I Critical Areas were used as indicators for each of the management opportunities. A subwatershed's score for these indicators depends on the location of the

Tier I Critical Areas relative to that subwatershed (within, downstream, upstream, or adjacent). The critical areas used for each management opportunity are shown in parentheses in Table 5-3. Stakeholder hot spots relating to sources and stressors were also used as indicators. The remaining indicators were based on available geographic data.

Table 5-3. Tier II Management Opportunity Indicators

Management Opportunity	Indicator
BMP Retrofits	Upstream or within Tier I Critical Area (Flooding, Water Quality and Aquatic Ecosystems)
	Impervious (%)
	Impervious (%) in Riparian Zone
	Developed (%)
	Hot Spots – Post-Construction
	High Score in Restoration (within SW or upstream)
Trash	Upstream or within Tier I Critical Area (Trash)
Stream and Riparian Buffer Restoration	Upstream or within Tier I Critical Area (Sedimentation and Water Quality and Aquatic Ecosystems)
	Percent Forest and Wetlands in Riparian Zone (protected and unprotected)
	Hot Spots – Bank Erosion
	Subsurface K-factor within 10-ft of Stream
	Impervious surface within 10-ft of Stream
	Stormwater Outfalls per Stream Mile
Preservation	Within or Adjacent to Tier I Critical Area (Wildlife)
	Percent Forest and Wetlands in SW (unprotected)
	Percent Forest and Wetlands in Riparian Zone (unprotected)
New Development Policies	Upstream or within Tier I Critical Area (Any)
	Hot Spots – Construction
	Percent Forest and Wetlands in SW (unprotected)
	Percent Forest and Wetlands in Riparian Zone (unprotected)
	Surface K-factor in SW
	Average % Slope
	Population Trend to 2018
Other Policies and Outreach	Upstream or within Tier I Critical Area (Any)
	Upstream of Multiple Watershed Concerns

Using the scoring rules outlined in Appendix C, Tetra Tech selected subwatersheds as Tier II Critical Areas where successful management opportunities are likely to restore and protect watershed functions in the Tier I critical areas. Table 5-4 presents the scores for each management category, with critical areas indicated in bold. Figure 5-2 illustrates the location of the Tier II Critical Areas. The following sections discuss how the scores reflect the potential opportunities for management within each critical area.

Table 5-4. Tier II Scores and Selected Critical Areas (in bold)

SW ID	BMP Retrofits	Trash	Stream and Riparian Buffer Restoration	Preservation	New Development Policies	Other Policies and Outreach
EM-01	**5.0**	**1.0**	**4.0**	1.0	3.0	**1.5**
GC-01	2.5	**1.0**	2.0	0.0	1.5	**1.5**
GC-02	3.5	**1.0**	1.5	1.0	3.5	**1.5**
GC-03	4.5	**1.0**	3.0	**2.0**	2.5	**1.5**
GC-04	**4.5**	**1.0**	**4.0**	**2.0**	4.0	**1.5**
GC-05	4.0	**1.0**	3.5	1.0	3.0	**1.5**
GC-06	3.5	**1.0**	2.5	1.0	3.5	**1.5**
GC-07	4.0	**1.0**	3.0	1.0	3.5	**1.5**
GC-08	1.0	0.0	1.0	**2.0**	3.0	0.0
GC-09	0.0	0.0	1.0	**2.0**	3.0	0.0
JC-01	3.0	**1.0**	2.0	0.0	3.0	**1.5**
JC-02	1.0	**1.0**	2.0	0.0	3.0	**1.5**
JC-03	5.0	**1.0**	2.5	**2.0**	3.5	**1.5**
JC-04	5.5	**1.0**	3.5	**2.0**	4.5	**1.5**
LJ-01	4.5	**1.0**	2.5	**2.0**	4.0	**1.5**
LJ-02	3.5	**1.0**	2.0	**2.0**	**5.0**	**1.5**
LJ-03	**6.0**	**1.0**	**4.0**	0.0	2.0	**1.5**

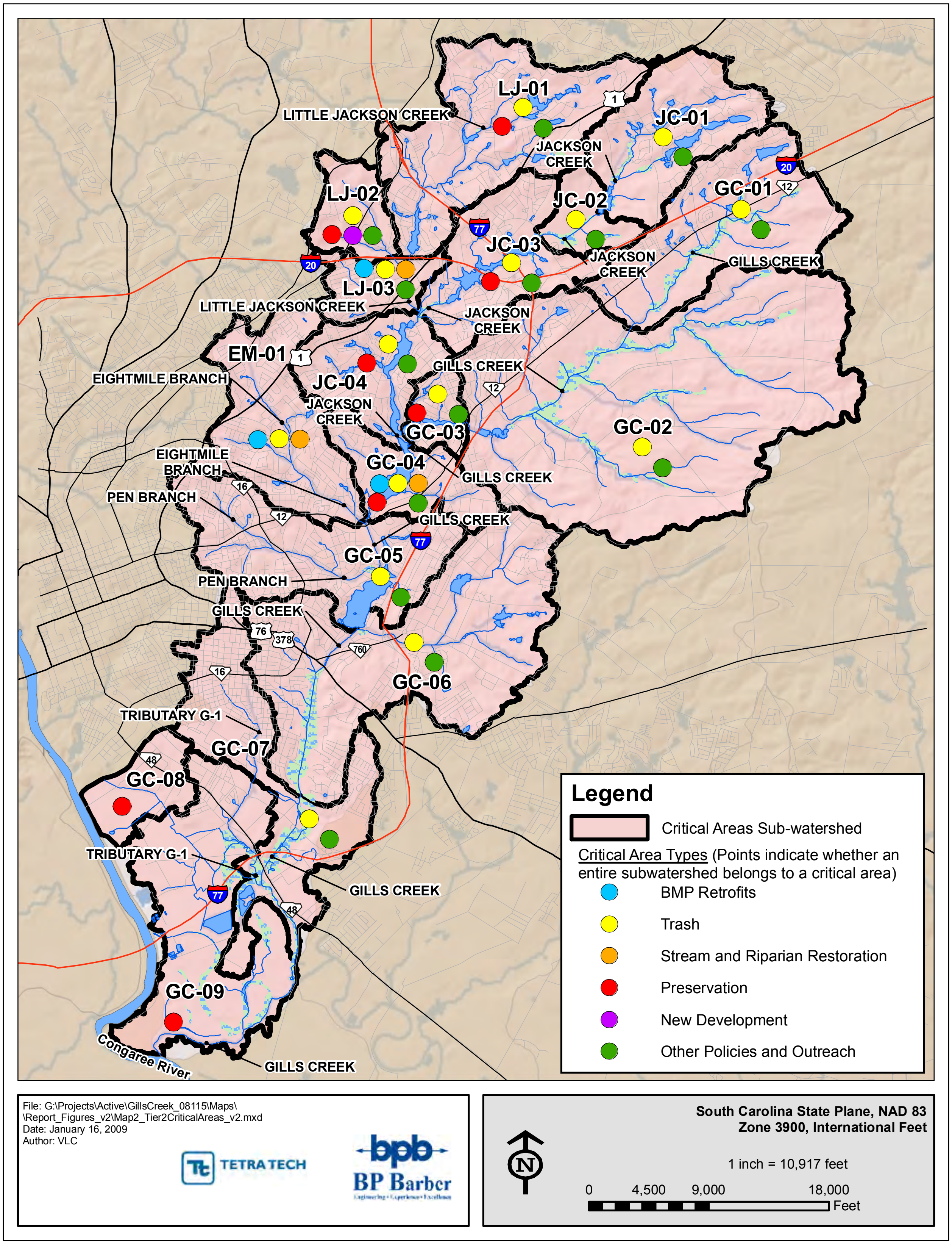


Figure 5-2. Tier II Critical Areas – Management Opportunities

BMP Retrofits

Subwatershed LJ-03 was selected as a critical area for BMP retrofit implementation. This subwatershed is upstream of GC-04, which is one of three critical areas for water quality and aquatic ecosystems. LJ-03 is highly developed and is likely to contain numerous opportunities to control and treat stormwater with BMP retrofits. This subwatershed is 89 percent developed and has the highest percentage of impervious surface, both by total area (46 percent) and within the riparian zone (44 percent). LJ-03 contains stakeholder recommended hot spots with post-construction impacts. This subwatershed also received the highest score for restoration opportunity and is upstream of subwatersheds with high scores for restoration opportunity. BMP retrofits within this subwatershed would not only address existing impacts but would also help protect and enhance stream restoration projects downstream.

Following review of this analysis by Richland County and BP Barber, subwatersheds EM-01 and GC-04 were added as critical areas for BMP retrofits. These critical areas were added so that BMP retrofits could be implemented in concert with stream restoration, which is recommended below for these subwatersheds. The BMP retrofits will reduce the erosivity of flows entering stream restoration reaches and achieve a more successful restoration of stream ecosystem functions.

Trash

All subwatersheds except GC-08 and GC-09 were selected as critical areas for trash. As noted above, the only indicator available for measuring trash impacts was whether a subwatershed is upstream of the Tier I Critical Areas for trash. The stakeholder hot spots and survey data indicated that trash impacts are widespread throughout the watershed, and management would need to be focused throughout developed areas to effectively reduce these impacts.

Stream and Riparian Buffer Restoration

EM-01, GC-04, and LJ-03 were selected as critical areas for stream and riparian buffer restoration. These subwatersheds are upstream of Tier I Critical Areas for Sedimentation and Water Quality and Aquatic Ecosystems. LJ-03 contains the least forest and wetlands in the riparian zone (9 percent) and has the greatest impervious surface within 10 feet of streams (40 percent). EM-01 is more disturbed in the riparian zone than most subwatersheds and has one of the highest counts of stormwater outfalls (7 per mile). Riparian areas in GC-04 are moderately disturbed, and streambank erosion has been observed by stakeholders in this subwatershed. All three subwatersheds are likely to contain promising stream and riparian buffer restoration opportunities. None of the highest scoring subwatersheds had highly erodible soils within 10 feet of streams (K-factor), but the disturbance within these subwatersheds indicates that stream impacts are likely to have occurred regardless of soil erodibility.

Preservation

The subwatersheds selected as critical areas for preservation are GC-03, GC-04, GC-08, GC-09, JC-03, JC-04, LJ-01, and LJ-02. These subwatersheds have the greatest percent unprotected forest and wetlands within the watershed, ranging from 19 to 35 percent, and most of these subwatersheds have the highest percent unprotected forest and wetlands within the riparian zone as well, ranging from 32 to 72 percent. Several of these subwatersheds are adjacent to Tier I wildlife critical areas where habitat has been severely impacted. Although not considered in the scoring, preservation within most of these subwatersheds would help address multiple watershed concerns.

New Development Policies

Subwatershed LJ-02 was selected as a critical area for new development policies. Although other subwatersheds should be considered for new development policies, this subwatershed is likely to present a significant opportunity to reduce the impact of new development in the future. This subwatershed had the highest average slope and moderately high densities of unprotected forest and wetlands (23 percent in the subwatershed and 40 percent in the riparian zone). LJ-02 is also among the subwatersheds with the lowest population density. All of these characteristics indicate that LJ-02 is likely to experience significant new development in the future, and that the land disturbance and impervious surface associated with development is likely to increase watershed impacts.

Other Policies and Outreach

All subwatersheds except for GC-08 and GC-09 were selected as critical areas for other policies and outreach. The multiple impacts in GC-07 were a major factor in this selection, since most of the watershed is upstream of this area. Most of the watershed's population lives within or upstream of GC-07, and therefore it would be appropriate to focus outreach efforts within the most populated subwatersheds. However, people are living within GC-08 and GC-09 near State Route 48 (Bluff Road). These communities were not represented in the stakeholder survey, and outreach should be conducted in these areas as well.

Factors Not Considered

The critical areas prioritize portions of the watershed where management will, for the most part, target urban/suburban runoff and streambank erosion. These sources were among the significant sources of impacts identified in the source assessment. However, the source assessment also identified the following significant sources:

- Waterfowl
- NPDES Point Sources
- Atmospheric deposition of Mercury
- Combination of industrial sources (RCRA, brownfields, USTs, landfills, etc.)
- SSOs

Septic Systems will also be considered since remnant systems may be a source of bacteria and nutrients. Management scenarios will consider measures that will target these sources and help to address watershed concerns.

(This page left intentionally blank.)

6.0 Watershed Goals and Objectives

The Gills Creek Watershed Association has set a vision.

> *In 2018, the Gills Creek Watershed is a national model for watershed management and planning. Citizens are enjoying the biking and walking trails throughout the watershed and it serves as the basis for an environmental education curriculum for Richland County Schools. All new development is carefully studied for its impact on the watershed and many of the mistakes of the past have been corrected. The stream corridors have received special attention, accommodate diverse wildlife and natural flows and capacities have been restored. Water quality is much improved and best management practices are working. An example is that there has been no net loss of pervious surfaces. In fact, there has been a measureable reduction in impervious surfaces in the past 3 years. Current codes reflect strong support from the public and encourage "green" development. The watershed is litter free and sedimentation in the lakes has been drastically reduced. A task force composed of governmental representatives and citizens is a model for a coordinated approach to planning, regulation, and development in an environmentally sensitive area.*

A list of goals and objectives were established in a strategic plan to achieve this vision (GCWA, 2009). This watershed management plan takes this vision to the next level to establish specific goals and objectives to meet the vision described by the Gills Creek Watershed Association. The Gills Creek Watershed Association has already established the goal to *develop a comprehensive plan for the management of the Gills Creek watershed*. Objectives set in their vision to meet this goal include:

- Gills Creek watershed will be a national model for watershed management and planning by 2018.
- Citizens will enjoy biking and walking trails throughout the watershed.
- Gills Creek watershed serves as a tool for environmental education in Richland County Schools.
- Stream corridors accommodate diverse wildlife.
- Stream hydrology has been restored.
- Water quality is improved and standards are met.
- No net loss of pervious surface.
- Impervious surface area is reduced.
- County and City codes reflect support of low impact development.

As defined by the US Army Corps of Engineers, objectives in planning are statements that describe the results you want to get by solving the problems and taking advantage of the opportunities (USACE, 2000). Understanding the problems identified by stakeholders as previously described (Section 5.1) and the Gills Creek Watershed Association's vision for the watershed, the following opportunities were identified:

- Remove trash from waterbodies.
- Reduce the impacts of stormwater to decrease flooding and sedimentation and improve water quality.
- Stabilize degrading stream channels and unstable stream banks to decrease sedimentation and improve wildlife habitat and water quality.
- Meet water quality standards for fecal coliform.
- Meet water quality standards for dissolved oxygen.

- Protect wildlife habitat in riparian zones.

In planning, there are constraints that must be considered in establishing management scenarios. Constraints identified for this project include:

- The ability to update ordinances.
- Funding for outreach and implementation.
- Available land for new stormwater management features.

The constraints identified in the Gills Creek watershed are consistent with other urban watersheds. These constraints were considered throughout the development of this watershed management plan. Management strategies were prioritized to maximize the County's ability to improve the ecosystem health of the Gills Creek watershed without being limited by these constraints.

6.1. MANAGEMENT OBJECTIVES

Management objectives incorporate the watershed goals but focus on specific processes that can be managed, such as riparian conditions and trash in waterbodies (EPA, 2008). After review of existing data, objectives were established to meet the opportunities available in the watershed.

- Implement stream buffers throughout the watershed.
- Stop floatable trash from filling waterbodies in the Gills Creek watershed by keeping trash in trash cans and out of stormdrains.
- Reduce the impacts of stormwater flooding by improving stormwater volume controls and retrofitting inadequate confining structures (culverts and bridges).
- Stabilize degrading stream channels and unstable stream banks to decrease sedimentation and improve wildlife habitat and water quality.
- Reduce bacteria loads from domesticated pets and leaking or inadequate septic tanks.
- Reduce nutrients from fertilizers.
- Purchase lands for preservation in areas near the Congaree River and in Little Jackson and Jackson Creeks.

Using the Tier II Critical Areas as guidance, management strategies were developed that would meet these objectives. Section 7.0 describes these management strategies and how priority locations for management were identified.

7.0 Identification of Management Strategies

7.1. Existing Management Strategies

Management strategies were developed to meet the goals and objectives established for the watershed and address the identified critical areas. Prior to developing the management strategies, watershed management strategies currently being used in the watershed were reviewed as building blocks for the WMP management strategies. Currently, Richland County, the City of Columbia, and the Gills Creek Watershed Association are leading management efforts in the watershed, including stormwater regulations, incentives for developers, and public outreach.

Richland County stormwater regulations include requirements for developers to prepare and implement erosion and sediment control plans. In general, the county requires developers to use best management practices (BMPs) to minimize degradation of water quality. All temporary and permanent stormwater BMPs must be designed and constructed either 1) to remove 80 percent of total suspended solids or 2) to achieve 0.5 ML/L peak settleable solids concentration, whichever is less. The regulations also require that stormwater runoff from a constructed development not exceed the pre-development discharge rate of the 2-year, 24-hour storm up to the 10, 25, or 50-year, 24-hour storm, depending on the area of the development (Richland County, 2001). Under the Richland County Green Development Code, developers can receive density bonuses by using innovative watershed protection practices like low impact development (LID). According to Richland County and the City of Columbia, a number of stormwater control devices, including numerous detention ponds, have been constructed in the watershed. Older stormwater ponds in the watershed are likely to need maintenance, repair, and/or retrofitting.

Several watershed management projects are being implemented within or near the watershed. The City of Columbia is involved with daylighting[1] a stream reach in Martin Luther King, Jr. Park in downtown Columbia. Innovative stormwater BMPs, including permeable pavement and two rain gardens (see Section 7.2.1 for definitions) are being constructed on a commercial site north of the Gills Creek watershed, near I-77. Wetland protection, restoration, and enhancement projects are being implemented throughout the county through the US Department of Agriculture's (USDA's) Wetlands Reserve Program. Within the Gills Creek watershed, a restoration project is underway to address an erosion problem on Windsor Lake Beach along Windsor Lake Boulevard. These activities provide a baseline for selecting future management activities that would be successful in the watershed. The current and past activities have provided local government staff with experience in watershed management and have promoted public awareness with these practices.

Richland County also has experience maintaining stormwater best management practices, including innovative practices like rain gardens. The county has not yet maintained constructed wetlands and has limited experience with permeable pavement. The county's baseline experience in BMP maintenance is an important consideration for future management strategy recommendations.

Several outreach activities are ongoing within the watershed. The Gills Creek Watershed Association is a partnership of federal, state, local governments, private organizations, and individuals working to restore and protect the Gills Creek watershed. Their objectives, as described in Section 6.0, include educating the public on watershed protection practices. Richland County Conservation District educates homeowners on the benefits of rain barrels. These activities provide a baseline from which to launch more extensive outreach efforts.

[1] Daylighting is the process of converting an underground stream to an open, natural channel.

7.2. STRATEGIES NEEDED TO ACHIEVE GOALS

The Tier II Critical Areas analysis in Section 5.2 identified general management strategies to address watershed concerns in the Gills Creek watershed. These strategies were BMP retrofits, stream and buffer restoration, preservation, new development policies, outreach, and other policies. To develop management scenarios, these strategies were defined in more detail and areas were identified where management would best address watershed concerns. Two scenarios were developed in which Scenario 1 recommends an intensive suite strategies and Scenario 2 recommends a less costly proposal, focusing on the most critical management. Priority locations for management were focused in Tier II critical areas. The following sections define the recommended management strategies in more detail, describe each scenario, and provide information on costs and benefits.

7.2.1. Stormwater BMP Retrofits

Stormwater Best Management Practice (BMP) retrofits are implemented within existing development to reduce impacts from stormwater runoff. BMP Retrofits can be selected and designed to achieve a variety of water quality and hydrology benefits. This plan recommends a suite of BMP retrofits that would address the multiple concerns within the Gills Creek watershed. Pond retrofits and stormwater wetlands provide opportunities to reduce flow rates, which are currently eroding stream channels, while reducing sediment, nutrient, and bacteria loading to waterbodies. Smaller BMPs – including bioretention/rain gardens, vegetated filter strips, cisterns/rain barrels, and tree boxes – help treat pollutants at the source and promote natural, less erosive drainage pathways. Green roofs and permeable pavement directly reduce the impact of impervious surface by promoting evapotranspiration and infiltration of stormwater, respectively. Green streets integrate multiple strategies, including treating pollutants at the source and reducing impervious surface. Scenarios 1 and 2 recommend a combination of these BMPs to address watershed concerns relating to flooding, sedimentation, and water quality and aquatic ecosystems. The following sections describe each BMP in more detail.

Types of BMP Retrofits

Wet Detention Pond Retrofit

A wet detention pond maintains a permanent pool of water. This device stores stormwater runoff and reduces stormwater flow. The ponding of stormwater allows excess sediment to settle out of the water and encourages bacteria and algae to use excess nutrients. Shoreline plants and other aquatic vegetation may also remove nutrients, and portions of other pollutants may also be removed. Under typical designs, stormwater first enters a forebay, which is a small depression lined with rocks that slows the incoming stormwater flow and settles out larger particles. The outlet structure and emergency spillway control the rate of water draining out of the pond.

A wet detention pond retrofit can take several forms. Over time, wet detention ponds fill in with sediment and no longer remove pollutants effectively. Digging out the sediment and replanting vegetation surrounding the pond can restore the pond's ability to perform its functions. Improvements in outlet structures may also be beneficial. Wet Detention Pond Retrofits can also be installed in place of existing *Dry Detention Basins*, which are frequently used for peak flow and flood control, but provide little pollutant removal.

Stormwater Wetland

A stormwater wetland treats runoff through a series of shallow pools that support wetland plants. This device stores some stormwater runoff and reduces stormwater outflow. The detention of stormwater allows excess sediment to settle out of the water. The wetland conditions encourage bacteria and plants to use excess nutrients, and portions of other pollutants may also be removed. The permanent pool varies in depth, but is generally no deeper than 3 feet. An outlet structure controls the flow of water out of the wetland. Large stormwater wetlands may have a forebay, which is a small depression lined with rocks that slows the incoming stormwater flow and settles out larger soil particles. Stormwater Wetlands are similar to wet detention ponds, but wet detention ponds have deeper pools, fewer plants, and less surface area than stormwater wetlands.

Bioretention/Rain Gardens

Bioretention areas (also called rain gardens) are depressions filled with 2 to 4 feet of sandy soil and planted with drought and flood tolerant plants. Stormwater drains into the surface of the bioretention area and, as the water infiltrates through the sandy soil, the soil and plants remove a portion of pollutants (see photo to right). In areas with permeable soils, the water treated by the bioretention cell will infiltrate into the native soil. In areas that have soils with low permeability (typically clay-dominated soils), a gravel layer and underdrain pipe are placed below the sandy soil layer. Once the stormwater infiltrates through the treatment cell's sandy soil, it is drained out through the underdrain pipe. Bioretention areas are designed so that a particular depth of water can pond in the cell during a rain event. The storage depth of these areas vary from 6 to 12 inches depending local design standards. Sometimes a weir is included in the bioretention area to bypass excess water above the ponding depth; other installations allow excess water to filter onto adjacent pervious areas. Since bioretention areas use mulch and a variety of shrubs and small trees, they can be easily incorporated into existing landscaping.

Tree Boxes

Tree boxes are a special kind of bioretention cell designed to be used in heavily urbanized areas. In a typical installation, a large self-contained planter box is installed in the sidewalk adjacent to the street and a curb cut or other device directs runoff to the box's filter media (see photo to right). Tree boxes may be indistinguishable from other street trees to the untrained eye. Runoff filtered by the soil media is captured by an underdrain and conveyed to the stormwater sewer system. The boxes may also contain shrubbery and other vegetation in addition to trees to help take up water and pollutants from the soil media.

Permeable Pavement

Permeable pavement differs from conventional asphalt and concrete in that it allows for infiltration of water during a rainfall event. Permeable pavement types include permeable asphalt, permeable concrete, and paving stones interspersed with sandy soil or other porous fill. These types of pavement vary in vehicular traffic capacity. Grass parking lots, reinforced with plastic rings, are typically used for overflow parking while some permeable pavement can be designed to handle more frequent traffic.

Green Streets

Green streets are similar to bioretention in that they are designed as depressions to temporarily store and infiltrate stormwater runoff. They are generally located between the street and sidewalk and contain shrubs and other vegetation to slow runoff, take up pollutants, and improve soil infiltration (see photo to right). When properly designed and maintained, they can reduce peak flows and infiltrate and treat a large percentage of annual runoff. They can be integrated with new development, but are especially popular in some cities (such as Seattle, WA, and Portland, OR) as retrofit projects in urban areas. Municipalities have documented significant cost savings for controlling flooding and sewer overflow problems when compared to traditional engineering approaches.

Vegetated Filter Strip with Level Spreader

A vegetated filter strip is a flat strip of land planted with grass or other vegetation. Level spreaders are used with vegetated filter strips to distribute stormwater runoff and release the water as sheet flow onto the filter strip. When combined, these two devices reduce stormwater flow and remove a portion of sediment and pollutants from stormwater runoff.

Cisterns/Rain Barrels

Cisterns are tanks that hold rainwater for irrigation and other uses (see photo to right). The cistern pictured to the right can hold over 200 cubic feet of water. These BMPs can be pre-manufactured or constructed on-site. They also can be incorporated inconspicuously into the side of a building. Rain barrels typically hold less water than cisterns, about 8 cubic feet per rain barrel. If enough storage volume is provided and if water is reused frequently, they can be used to control stormwater runoff, reduce stormwater flow, and remove pollutants by preventing them from entering runoff.

Extensive Green Roof

Green roofs (photo to right) are grassy areas or gardens installed on a roof. Rainfall infiltrates into the soil of a green roof, and a net reduction of stormwater runoff is achieved as the plants and soil media facilitate the evaporation of collected rainfall. Green roofs vary in design depending on the type of vegetation and how the roof will be used. Extensive green roofs are simple, low maintenance designs that do not allow public access to the roof. They are generally constructed with a low weight soil media that readily soaks up rainfall. Special desert plants called sedums are frequently planted on extensive green roofs.

Photographs from the following sources: Bioretention: Mecklenburg County, NC; Cistern/Rain Barrels: Clemson University; Green Roof: U.S. General Services Administration; Stormwater Wetland: City of Charlotte, NC; Tree Box: Low Impact Development Center; Green Street: City of Portland, OR Bureau of Environmental Services.

Scenario Development

Areas within the Tier II BMP Retrofit Critical Areas (subwatersheds LJ-03, EM-01, and GC-04) were identified as priorities for BMP retrofits. Tetra Tech consulted past BMP retrofit programs, including Mecklenburg County's stormwater utility, and estimated that, due to lack of landowner interest or physical constraints, BMP retrofits can be successfully implemented to treat up to 10 percent of a given subwatershed. For Scenario 1, Tetra Tech added 5 percent as a safety factor and assumed that 15 percent of the critical areas could potentially be treated. If fewer opportunities are available during implementation, the funding could be used in other subwatersheds. Scenario 2 assumes that 10 percent of the critical areas will be treated.

To prioritize locations within the critical areas, Tetra Tech selected locations with the most concentrated impervious surface so that BMP retrofits would address the most severe impacts, both from a hydrologic and water quality perspective. The area of land identified represented 15 percent of critical areas in Scenario 1, and 10 percent of critical areas in Scenario 2.

Additional priority locations were selected to address concerns in the two overall Tier I Critical Areas JC-04 and GC-07. BMP retrofits recommended in LJ-03 (described above) will help address concerns in subwatershed JC-04; therefore, the additional priority locations were focused on subwatershed GC-07. Although conditions in this watershed are likely to be affected by LJ-03, EM-01, and GC-04, management downstream of Lake Katherine would most directly address concerns in GC-07. Therefore, highly concentrated areas of imperviousness were identified in subwatershed GC-06. These locations will help address flooding, sedimentation, and water quality and aquatic ecosystem concerns in subwatershed GC-07. For Scenario 1, the priority areas were a commercial area located on Gills Creek and dense development within Fort Jackson. For Scenario 2, the Fort Jackson locations were removed and only the commercial area was considered. Figure 7-1 displays the locations prioritized for BMP retrofits under Scenarios 1 and 2, including locations within Tier II critical areas and the additional locations in GC-06.

The recommended BMP retrofits above focus on areas with concentrated impervious surface and dense development. Although these retrofits will help address hot spots of pollutant loading and high stormwater flows, a well-rounded management plan also should consider dispersed sources and stressors. Six subwatersheds were selected as priorities for implementing small BMP retrofits in residential neighborhoods, including rain gardens, cisterns/rain barrels, and others as appropriate. These priority areas include the three Tier II critical areas (LJ-03, EM-01, and GC-04) and three additional subwatersheds (GC-05, GC-06, and GC-07) to address the more downstream portion of the watershed. Stormwater education and outreach should also be conducted in these subwatersheds, as described in more detail in Section 7.2.5. Figure 7-1 displays the subwatersheds prioritized for residential stormwater BMPs and outreach.

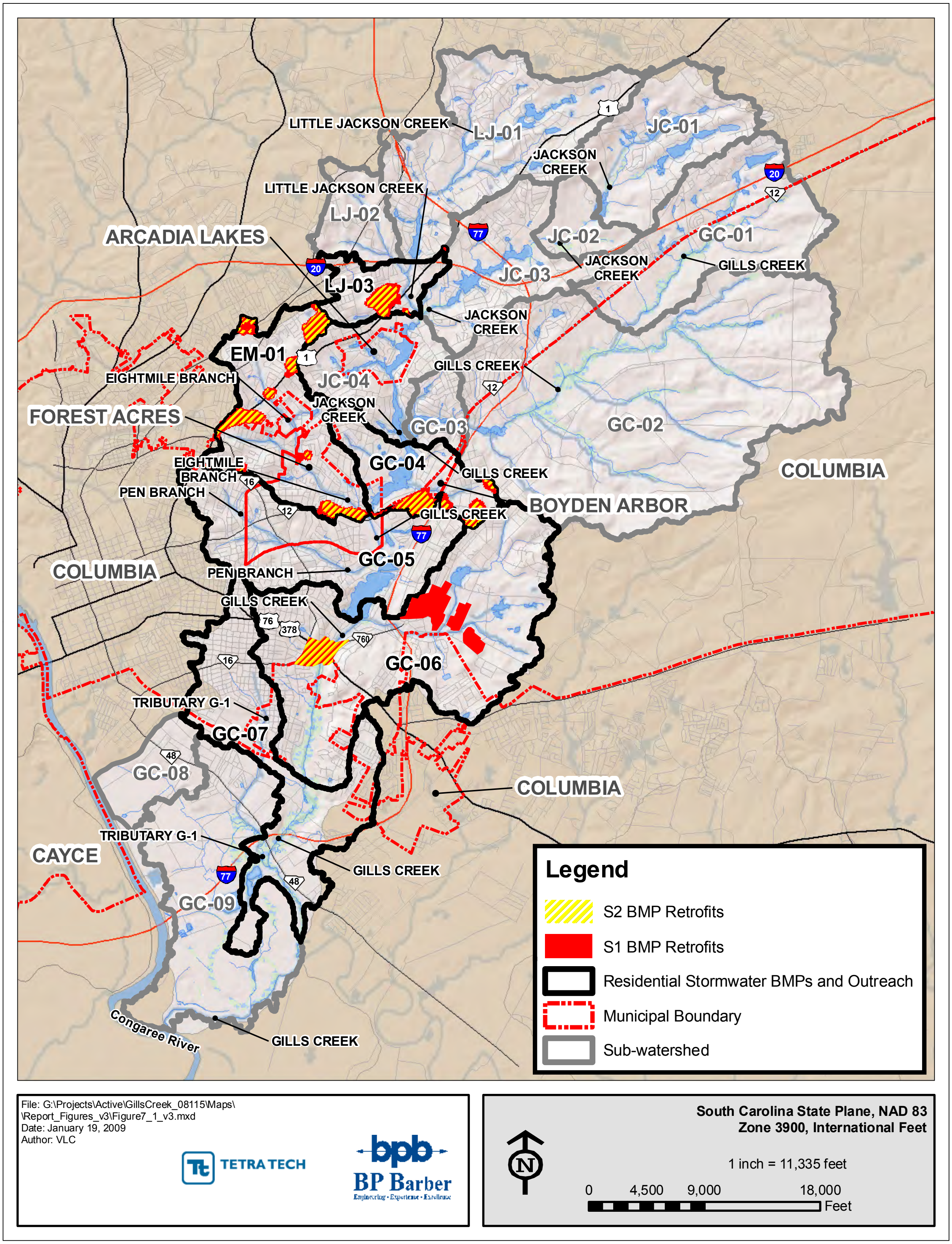


Figure 7-1. BMP Retrofit Priority Locations and Subwatersheds

The type of BMP most suitable for a given site will be determined during implementation of this plan. For the purposes of these scenarios, Tetra Tech developed recommended proportions of the BMPs to be applied to all priority locations, as shown in Table 7-1. The proportions were based on how well a BMP has been tested and used successfully in the watershed as well as in other communities in the southeast. The proportions also reflect cost-effectiveness and the ability to achieve a range of pollutant removal and flow/runoff reduction benefits. These proportions were applied to both scenarios. For subwatersheds selected for residential BMPs, an equal proportion of small BMP types (bioretention, cisterns/rain barrels, etc.) was assumed.

Table 7-1. Proportions of BMP Retrofit Type Applied to Recommended Priority Locations

Recommended BMPs	Percent of Target Drainage Area Treated
Wet Detention (retrofit existing ponds)	35%
Stormwater Wetland	25%
Bioretention/Rain Gardens	14%
Tree Boxes	5%
Green Streets	1%
Permeable Pavement	1%
Rain Barrels	5%
Cisterns	10%
Extensive Green Roofs	1%
Filter Strip and Level Spreader	4%

Table 7-2 displays the recommended drainage areas (DAs) for BMP retrofits within the Gills Creek watershed. The DAs represent the amount of area for which BMP retrofits would treat and control stormwater. The table also reports estimated ranges for upfront costs and percent pollutant removal for those areas. Additional benefits that could not be estimated are described qualitatively. Area weighted averages of the percent pollutant removal estimates are provided as a rough estimate of what can be achieved in the prioritized areas for sediment, phosphorus, nitrogen, and bacteria removal. Both the pollutant removal and cost estimates are provided as approximate, planning-level values; more accurate costs and benefits will depend on site-specific characteristics and should be determined during plan implementation.

The costs provided in Table 7-2 reflect costs to design, engineer, and construct BMP retrofits. Each retrofitted facility also will require inspection and maintenance in order to achieve the water quality and runoff/flow reduction benefits over the lifetime of the facility. Maintenance costs vary depending on what equipment is available and what entity (local government, landowner, homeowner, etc.) is performing the work. Appendix D provides a table of the major inspection and maintenance tasks for each type of retrofit.

Table 7-2. BMP Retrofit Costs and Benefits

Recommended BMPs	Scenario 1			Scenario 2			Percent Pollutant Load Removal				Description of other benefits (hydrology, trash removal, etc.)
	Target Drainage Area (acres)	Upfront Cost Low	Upfront Cost High	Target Drainage Area (acres)	Cost Low	Cost High	TSS	TN	TP	FC	
Wet Detention (retrofit existing ponds)[1]	380	$1.7M	$6.3M	210	$1.0M	$3.5M	20 - 28	15 - 25	13 - 37	18 - 42	Hydrology – peak flow reduction, downstream channel erosion protection. Trash removal, depending on outlet structure. Requires regular maintenance. Note that Wet Detention Retrofit may provide only modest gains compared to what is replaced.
Stormwater Wetland	270	$2.1M	$7.5M	150	$1.2M	$4.2M	61 - 86	22 - 55	33 - 76	78 - 88	Hydrology – peak flow reduction, downstream channel erosion protection, modest annual runoff reduction. Trash removal, depending on outlet structure. Requires regular maintenance.
Bioretention/ Rain Gardens	150	$5.1M	$6.3M	80	$2.7M	$3.4M	59 - 74	42 - 65	50 - 65	90+	Hydrology – large reduction in annual runoff volume, moderate reduction in peak flow. Trash removal – good, requires regular maintenance. Very good for metals/oil/grease removal.
Tree Boxes [2]	50	$1.2M	$3.7M	30	$0.7M	$2.2M	59 - 74	42 - 65	50 - 65	90+	Same as bioretention.

[1] Range assumes existing pond performing at the 25th percentile (poor),and retrofit pond performs between median (average) and 75th percentile (good).

[2] Assumed to perform like bioretention.

Recommended BMPs	Scenario 1			Scenario 2			Percent Pollutant Load Removal				Description of other benefits (hydrology, trash removal, etc.)
	Target Drainage Area (acres)	Upfront Cost Low	Upfront Cost High	Target Drainage Area (acres)	Cost Low	Cost High	TSS	TN	TP	FC	
Green Streets [1]	10	$1.8M	$2.4M	3	$0.5M	$0.7M	72 - 92	53 - 74	49 - 74	0	Hydrology – large reduction in annual runoff volume, moderate reduction in peak flow.
Permeable Pavement	5	$0.2M	$0.5M	3	$0.1M	$0.3M	0 - 50	0 - 30	0 - 40	0 - 50	Hydrology – good peak flow reduction. Performance tied to design and infiltration capacity of soils. Potential for moderate to good pollutant and annual runoff volume reduction.
Rain barrels	50	$3.3M	$4.5M	30	$2.0M	$2.7M	0 - 6	0 - 6	0 - 6	0 - 6	Hydrology – minimal annual volume reduction due to small volume/roof area ratio. Excellent as an educational/stakeholder involvement tool.
Cisterns	110	$2.2M	$3.0M	60	$1.2M	$1.6M	10 - 20	10 - 20	10 - 20	10 - 20	Hydrology – moderate annual volume reduction, provided water reuse occurs.
Extensive Green Roofs	5	$1.1M	$4.4M	3	$0.7M	$2.6M	0	0	0	Not known	Hydrology – good peak flow reduction, exceptional annual runoff volume reduction.

[1] Bacteria removal not reported in reviewed studies; however, any losses are likely offset by inputs from wildlife and pet waste.

Recommended BMPs	Scenario 1			Scenario 2			Percent Pollutant Load Removal				Description of other benefits (hydrology, trash removal, etc.)
	Target Drainage Area (acres)	Upfront Cost Low	Upfront Cost High	Target Drainage Area (acres)	Cost Low	Cost High	TSS	TN	TP	FC	
Filter Strip and Level Spreader [1]	40	$0.5M	$1.2M	20	$0.3M	$0.6M	81 - 87	55 - 76	50 - 70	0	Hydrology – good peak flow control and annual runoff volume reduction. Performance depends heavily on level spreader structure remaining completely level to maintain diffuse flow. Field evaluations demonstrate that failure is common; even small drops in structure elevation (fractions of an inch) can result in concentrated flow and active filter strip erosion.
Residential BMPs	200	$7.2M	$11.6	200	$7.2M	$11.6M	0 - 74	0 - 65	0 -90+	0 -90+	BMPs include bioretention/raingardens, tree boxes, and cisterns/rain barrels; benefits depend on BMP used.
Total	1270	$26.4M	$51.4M	789	$17.6M	$33.4M	44[2]	32	37	49	

Sources of cost estimates: Wossink and Hunt (2003), Low Impact Development Center (2008), USEPA (2008), previous Tetra Tech cost estimates for BMP retrofits in Charlotte, NC.

Sources of pollutant removal estimates: Bean, et al. (2007), Center for Watershed Protection (2007), Collins, et al. (2007), Hunt, et al. (2006), Hunt and Lord (2006), Moran, et al. (2003), Tetra Tech (2006), Tackett (2008), and Wossink and Hunt (2003).

[1] Few studies of bacteria in open channels or filter strips are available; most show export of bacteria.

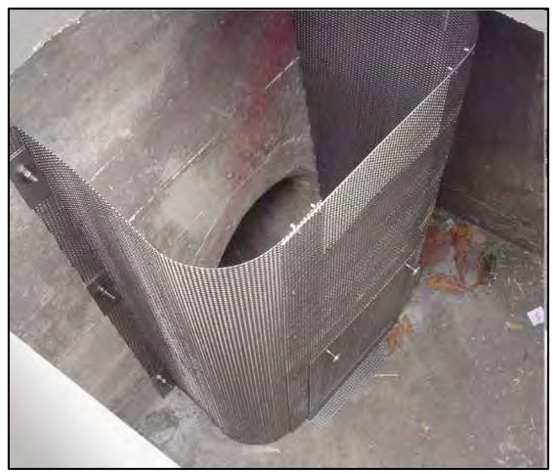
[2] Area-weighted percent pollutant removal for both scenarios..

7.2.2. Trash Management

Richland County staff and stakeholders have observed trash loading to streams and lakes throughout the watershed. The critical areas analysis confirmed that trash loading was widespread based on locations provided by stakeholders during Public Meeting #1 and the stakeholder survey. Fifteen subwatersheds were selected as critical areas for trash management because these subwatersheds were upstream of areas where significant trash loading has been observed. Trash can be released to waterbodies through a number of mechanisms, including but not limited to: improperly covered receptacles, wildlife tampering with trash bins, littering from moving vehicles, littering from parked cars in parking lots, and littering during recreational activities. A combination of outreach, enforcement, and stormwater collection is required to significantly reduce the amount of trash reaching waterbodies in the Gills Creek watershed. Retrofits to collect trash from stormwater are considered in this section; outreach and enforcement are discussed under Section 7.2.5.

BMP Retrofit Types Recommended for Trash

A variety of BMP retrofit options are available to collect trash from stormwater runoff and directly from waterbodies. Large-scale trash filters that span streams and use nets to remove trash from stream flow tend to be expensive to install and maintain and are generally geared towards removing trash before it reaches a large critical waterbody. The trash concerns for the Gills Creek watershed are more focused on trash accumulating within the streams and lakes throughout the watershed. Tetra Tech therefore determined that small-scale BMPs, which remove trash at or near the source, were more appropriate for the Gills Creek watershed.



Catch basin inserts, inlet screen covers, and trash booms are recommended as trash BMP retrofits for Scenarios 1 and 2. Catch basin inserts (top photo) are screens or filters inserted into a catch basins or stormwater inlets, which prevent trash from continuing through the stormwater conveyance system. Screen covers (bottom photo) are installed over the entrance to the catch basin or inlet, preventing trash from entering the conveyance system. Both of these devices are effective at removing trash from stormwater runoff including floatable and non-floatable trash. Trash build-up must be removed regularly, and design should consider that these devices can cause street flooding during storm events. If stormwater infrastructure is being newly constructed or replaced, devices that remove trash from multiple inlets (baffle boxes) may be more cost-effective than individual inserts or screen covers.

In addition to these BMPs, trash racks can also be installed on the outlet structures of stormwater BMPs. These racks cost $1,000 to $2,000, which is a fraction of the cost of the large scale BMP retrofits like stormwater wetlands. The racks could be installed on all BMP retrofits implemented through this plan as well as any BMPs installed through new development. Maintenances activities for these BMPs would need to include regular removal of trash. The cost of trash racks was not included in the scenario costs.

Stormwater is not the only source of trash loading to the watershed. Stakeholders have reported that motorists litter near or directly into waterbodies. To remove trash from these sources, in-stream or in-lake mechanisms are required. Low-cost trash booms can be installed in streams to remove floatable trash. These structures consist of a floating plastic boom perpendicular to stream flow that collects trash and debris. As with the stormwater BMPs, trash must be removed periodically from these devices.

Photographs from the following sources: Catch Basin Insert: City of Los Angeles Stormwater Program; Screen Cover: Gordon, M. and R. Zamist (2006).

Scenario Development

As noted above, fifteen Tier II Critical Areas were selected for trash management. These areas represent the majority of the watershed, and implementing and maintaining retrofits for trash removal in this entire area may not be cost-effective or practical for Richland County and other local governments. Tetra Tech selected five subwatersheds (LJ-03, JC-02, JC-03, JC-04, and GC-03) that were upstream of the most severely rated trash hot spots where retrofits may also benefit other trash hotspots downstream. Within these subwatersheds, priority locations were selected where trash loading from stormwater is likely to be highest. For Scenario 1, significant areas of high and medium density development were selected as well as parks and other recreational facilities. For Scenario 2, the selection was limited to significant areas of high density development. The selected areas are prioritized for either catch basin inserts or screen covers.

In addition to these areas, a trash boom is recommended along Gills Creek downstream of a large commercial area and upstream of several trash hot spots in the lower portion of the watershed (subwatershed GC-06). This device will help remove floatable trash from the commercial area stormwater runoff as well as from direct loading to Gills Creek from littering. BMP retrofits recommended for this commercial area will also help reduce trash loading if trash racks are used. To achieve significant reduction of trash loading, this device should be implemented along with extensive outreach, enforcement of littering fines, and improvement of city trash bin quality (to prevent wildlife tampering). One trash boom at this location is recommended for both scenarios. Figure 7-2 displays the locations prioritized for trash retrofit BMPs (inserts and screen covers) and the recommended trash boom under Scenarios 1 and 2.

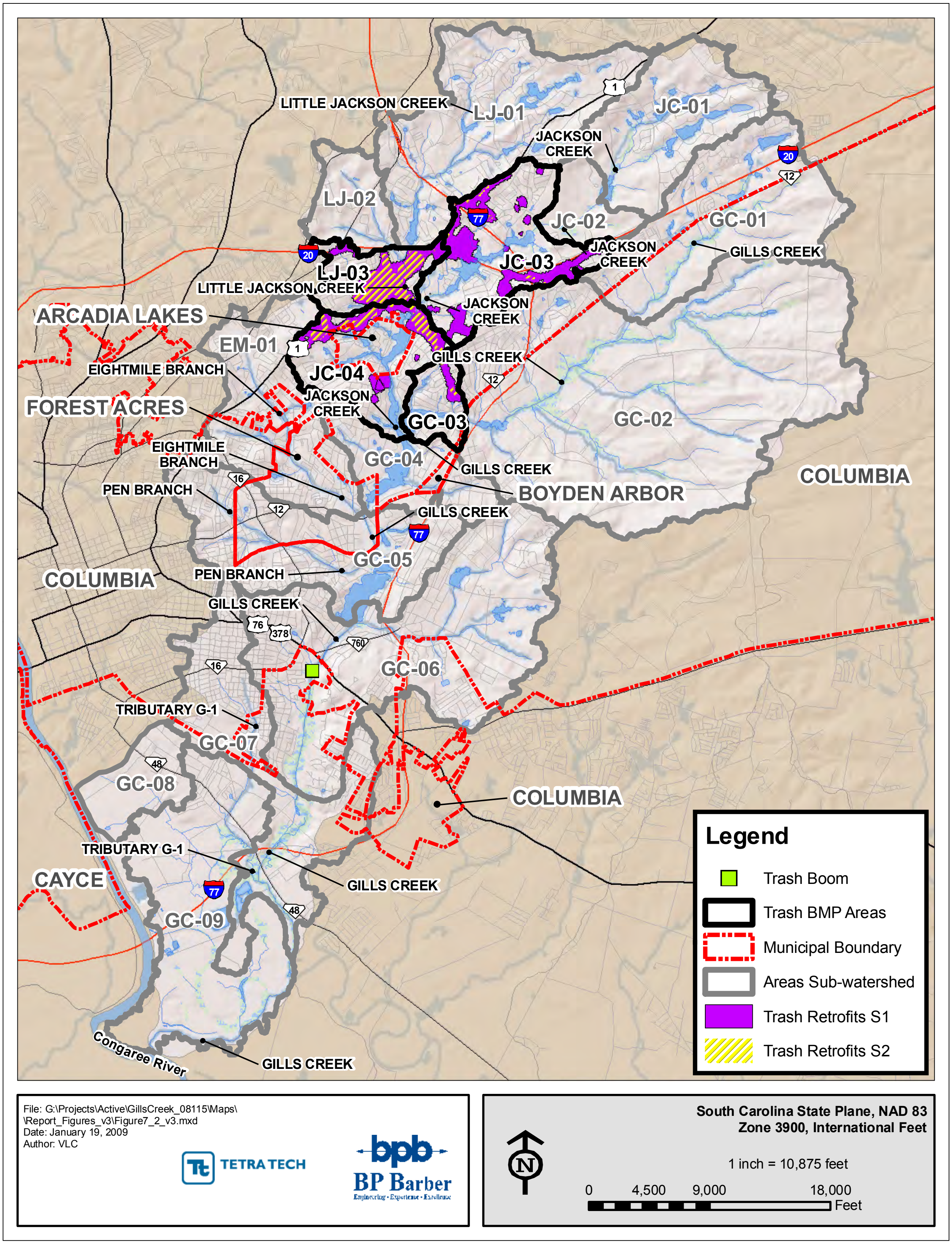


Figure 7-2. Trash Management Priority Locations

Table 7-3 displays the recommended drainage areas (DAs) for catch basin inserts or screen covers within the Gills Creek watershed for each scenario. The DAs represent the amount of area for which the retrofits would remove trash from stormwater. The recommended trash boom is also included in this table, and ranges of upfront cost and trash removal estimates are provided for both facility types. The costs provided in Table 7-3 reflect costs to design, engineer, and install the devices. Each facility will require regular trash removal to achieve the estimated reduction efficiencies and to prevent street or parking lot flooding. Trash removal and maintenance costs vary depending on what equipment is available and what entity (local government, contractor, landowner, etc.) is performing the work. Outreach, enforcement, and other policies will be essential to achieving significant reduction of trash loading from all sources; these recommended strategies are described in Section 7.2.5. Both the trash removal and cost estimates are provided as approximate, planning-level values. More accurate costs and benefits will depend on site-specific characteristics and should be determined during plan implementation.

Table 7-3. Trash Management Costs and Benefits

Recommended BMPs	Scenario 1			Scenario 2			Percent Trash Removal
	Target	Upfront Cost Low	Upfront Cost High	Target	Upfront Cost Low	Upfront Cost High	
Catch basin inserts or screen covers (DA acres)	1330	$1.3M	$1.8M	448	$0.4M	$0.6M	61 - 81
Trash booms (#)	1	$1,000	$2,000	1	$1,000	$2,000	12 – 20 [7]
Total	------	$1.3M	$1.8M	------	$0.4M	$0.6M	------

Sources of cost and removal estimates: Gordon, M. and R. Zamist (2006), Santa Clara Valley Urban Runoff Pollution Prevention Program (2007), Granite Environmental, Inc., personal communication to H. Fisher, September 23, 2008.

7.2.3. Stream and Riparian Buffer Restoration

Restoration of stream channels and riparian buffers are recommended in the Gills Creek watershed to address the watershed concerns of sedimentation and water quality and aquatic ecosystems. Although flooding is best addressed by BMP retrofits that control stormwater, restoration may also address flooding concerns as well. The benefits of stream restoration are best understood by considering watershed functions of unimpacted stream ecosystems, which include:

- Removal of suspended sediment through settling within floodplain areas
- Filtering of sediment, nutrients, and other pollutants as runoff flows through floodplain areas
- Reduction of instream nutrients that cause low dissolved oxygen and algal blooms
- Regulation of stormwater flows and flooding

Disturbance and development of watersheds impact stream ecosystems by increasing flows and pollutant loads beyond the natural capacity of these systems. BMP retrofits are recommended to protect streams from erosive flows from development and impervious surfaces, while enforcement of sediment and erosion control requirements is recommended to reduce excessive sediment loading to streams. Stream and riparian buffer restoration is recommended to restore the natural functions of stream ecosystems that have previously been impacted. Recommended restoration includes revegetation and/or restructuring of a stream channel, banks, and/or floodplain areas to reduce high flows, downstream flooding, and erosion

[7] Booms capture floatable trash only, which accounts for about 20 percent of all trash; this range reflects the percent of total trash removed.

and to restore the biological and water quality functions of streams. The following section describes the recommended types of restoration in more detail.

Types of Restoration Recommended

Daylighting

Some stream reaches within the Gills Creek watershed have been covered by parking lots or other structures or piped under a variety of land uses. These reaches may either be piped or buried as earthen channels. Piped streams are not likely to be actively eroding but may cause stream instability and channel/bank erosion downstream of their confluence with open channels, while buried earthen channels are likely to be actively eroding and contributing sediment to downstream reaches. Daylighting is a type of stream restoration that converts a buried stream to an open channel and seeks to restore the natural functions of a stream. When a stream is daylighted and restored, the natural functions of nutrient cycling can be enhanced and restored; these functions remove excessive dissolved nutrients that cause low dissolved oxygen. Restoration provides habitat for fish and other aquatic organisms, slows stream flow, and reduces erosion of downstream reaches. Daylighting buried earthen channels provides the additional benefit of reducing channel erosion within the stream reach. Once a stream is converted to an open channel, restoration strategies can be similar to those used for channel restoration, which is described below.

Channel Restoration

Open channels that have been receiving stormwater flow from development are likely experiencing bank and channel erosion beyond their natural capacities. Aquatic communities are likely degraded due to these impacts, and this erosion was identified in the source assessment as a potentially significant source of sediment loading (Section 4.1.6). Restoration strategies include:

- Producing more gradually sloping banks
- Reconnecting a stream to the floodplain
- Converting a stream from a straight to a meandering channel
- Restoration of riffles (shallow areas where flow passes over a gravel bed)
- Restoration of pools (deeper, more slow flowing areas)
- Rock or wood structures that promote natural stream flow patterns (see above photo)
- Revegetation of banks

Within urban streams, development may exist too close to stream reaches and limit restoration strategies to those that can be accomplished within the existing channel configuration. The design of stream restoration depends on a number of site-specific factors.

Photograph by Heather Fisher, Tetra Tech.

Riparian Buffer Restoration

Riparian habitat exists between stream channels and upland areas and typically intersects with the floodplain. Riparian buffer restoration involves restoring natural vegetation where riparian habitat has been previously impacted or destroyed. Riparian buffer restoration will provide an important management strategy, particularly when coupled with preservation, bioengineering, and BMP retrofit opportunities.

Riparian buffer restoration management measures, as considered in this management plan, would include restoration (i.e., planting) of riparian vegetation. Appropriate plant communities will need to be selected, and a planting plan should be developed for each site that identifies planting zones based on hydrology, soils, slopes and other factors) for the selected plant communities. Construction activities will involve invasive plant removal, grading, soil conditioning, planting, and soil stabilization. Maintenance and monitoring will be required to ensure success of the restoration.

Scenario Development

Three subwatersheds (EM-01, GC-04, and LJ-03) were selected as Tier II Critical Areas for stream and riparian buffer restoration. Within these subwatersheds, aerial photographs were used to identify opportunities for restoration. Intermittent and perennial stream reaches that were buried beneath surfaces and are relatively easy to remove, like grass or parking lots, were identified as daylighting opportunities. For some reaches, the type of channel was difficult to determine using aerial photographs; daylighting opportunities will need to be verified during implementation. Open channels, either intermittent or perennial, were prioritized for channel restoration. Areas within the riparian zone[8] were identified as riparian buffer restoration opportunities if they were significantly devoid of natural vegetation and were not already developed. Scenario 1 includes all three types of restoration opportunities, and Scenario 2 includes only channel and buffer restoration. Daylighting opportunities were removed from Scenario 2 to reduce costs and potential feasibility issues. Figure 7-3 displays the priority locations for daylighting, channel restoration, and buffer restoration for Scenarios 1 and 2.

[8] Consistent with earlier analysis, the riparian zone was defined as land within 100 feet of perennial streams, within 50 feet of intermittent streams, and within 50 feet of lakes and ponds.

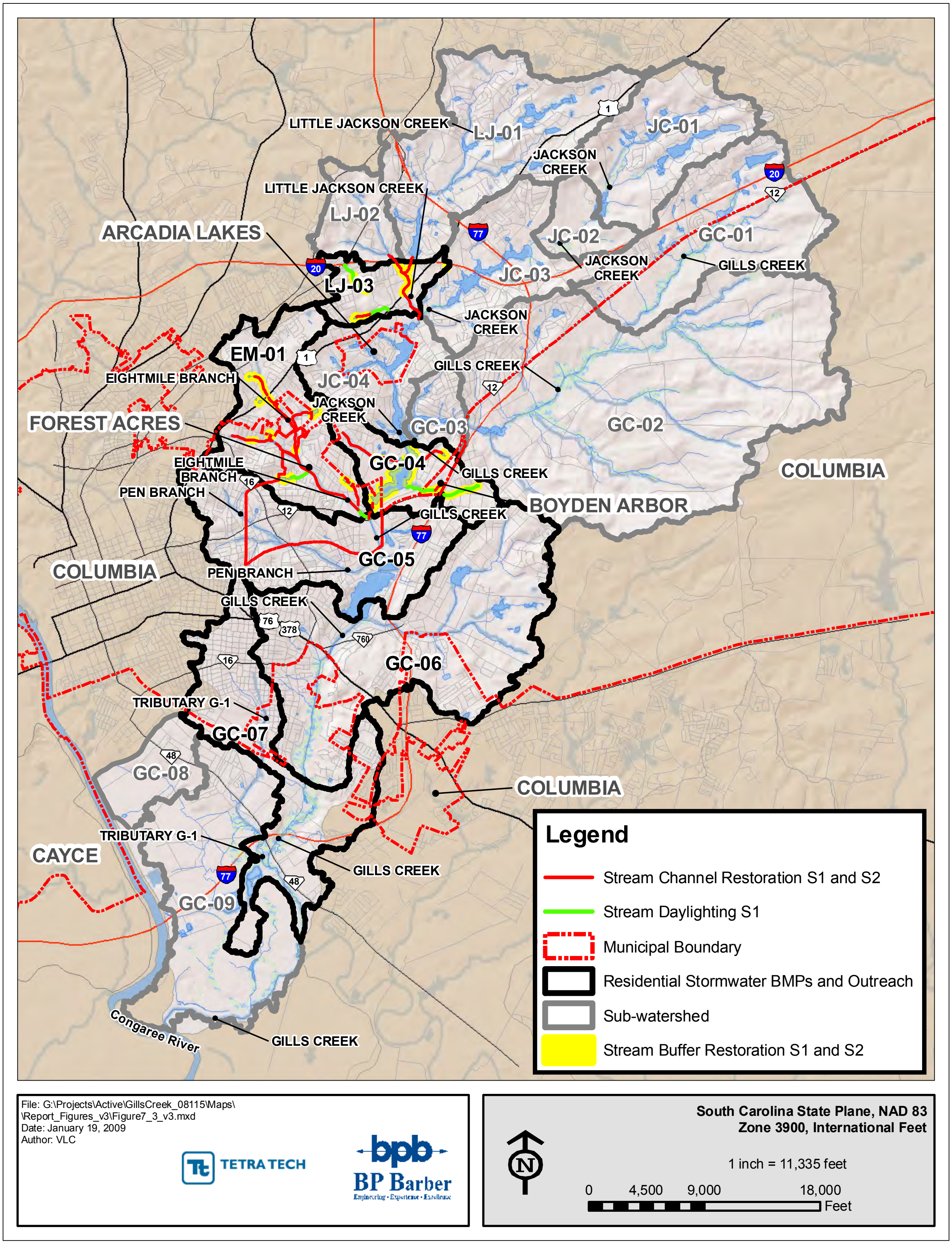


Figure 7-3. Stream and Riparian Buffer Restoration Priority Locations

Table 7-4 displays the recommended lengths of stream restoration reaches and drainages areas for buffer restoration. The buffer restoration drainage areas represent the area within approximately 150 feet of buffer restoration opportunities. Buffer restoration is estimated to provide the greatest pollutant removal benefits for runoff from land within 150 feet of the buffer. Beyond this distance, runoff can begin to form channels or concentrated flow that short circuits the pollutant removal functions of the buffer.

The costs provided in Table 7-4 reflect costs to design, engineer, construct, and purchase conservation easements for the recommended restoration. Monitoring of each restoration will be required in order to ensure successful restoration of ecosystem functions, and some repairs or revegetation may be necessary to maintain these functions.

Table 7-4 provides approximate pollutant removal estimates for channel restoration and riparian buffer restoration. Data on pollutant removal from daylighting were not available and could be highly variable depending on the condition of the buried stream. Daylighting and restoring streams that are buried without being piped would have both direct sediment and nutrient reduction benefits, while daylighting of piped streams might provide direct nutrient reduction benefits and only indirect sediment reduction benefits by reducing downstream erosion. Percent removal efficiencies for channel restoration in Table 7-4 refer to the reduction of instream sediment loading from bank and channel erosion. The removal efficiencies for riparian buffer restoration estimate the reduction in pollutant loading from the target drainage areas (150 feet from the restored riparian buffer). Both the pollutant removal and cost estimates are provided as approximate, planning-level values; more accurate costs and benefits will depend on site-specific characteristics and should be determined during plan implementation.

Table 7-4. Stream and Riparian Buffer Restoration Costs and Benefits

Recommended Restoration	Scenario 1			Scenario 2			Percent Pollutant Load Removal				Description of other benefits (hydrology, trash removal, etc.)
	Target Area or Length	Upfront Cost Low	Upfront Cost High	Target Area or Length	Upfront Cost Low	Upfront Cost High	TSS	TN	TP	FC	
Daylighting (feet) [1]	12,000	$3.1M	$3.8M	0	$0.0M	$0.0M	Not known	Not known	Not known	Not known	Hydrology – restoration of natural hydrology. Restoration of aquatic habitat.
Channel Restoration (feet) [2]	13,000	$3.3M	$4.1M	13,000	$3.3M	$4.1M	50 – 90[3]	Not known	Not known	Not known	Hydrology – restoration of natural hydrology. Restoration of aquatic habitat.
Riparian Buffer Restoration (50-foot; acres DA)	160	$2.1M	$3.2M	160	$2.1M	$3.2M	62	31	38	Not known	Restored wildlife habitat, increased flood retention, further pollutant loading reduction through conversion to forest from other land uses.
Riparian Buffer Restoration (100-foot; acres DA)	50	$0.6M	$0.8M	50	$0.6M	$0.8M	67	34	43	Not known	Enhanced wildlife habitat, flood retention, and additional pollutant loading reduction compared to 50-foot buffers.
Total	------	$9.8M	$11.9M	------	$6.7M	$8.1M	------	------	------	------	

Source of cost estimates: NCEEP (2007)

Sources of pollutant removal estimates: Desbonnet, et al. (1994), Jessup (2003), Schueler (1995), Tetra Tech (2005), Wenger (1999).

[1] Reduction in nutrients likely due to establishment of aquatic ecosystem and build up of organic matter. Sediment reduction is less likely but depends heavily on whether the buried stream and/or its outlet were a sediment source.

[2] Preliminary research suggests limited or no additional nutrient removal

[3] Percent pollutant removal refers to reduction of instream sediment sources and not reduction of delivered loads from upland areas. Stream restoration may provide additional sediment reduction benefits relating to the settling of delivered upland sediment loads.

7.2.4. Preservation and New Development Policies

The majority of natural areas within the watershed, outside Fort Jackson, have been disturbed or developed. The remaining land within riparian, or floodplain, areas provides natural pollutant removal and stream flow regulation, as described in the previous section. Natural areas outside of the riparian zone protect land from erosion and provide wildlife habitat, and if this land were developed, pollutant loading and runoff delivered to streams would increase. These impacts would be especially prominent in critical areas in the upper watershed where the highest slopes and erosion potentials were identified. The purpose of recommended preservation and new development policies is to reduce future impacts to existing natural areas.

Types of Preservation and New Development Policies

Preservation of natural areas involves the purchase of land in fee simple or through a conservation easement. A conservation easement typically costs 50 to 80 percent of the fee simple purchase price of land. The easement allows a property owner continued use of the property while preventing the removal or disturbance of natural vegetation. A fee simple purchase involves a complete transfer of property rights from the landowner to the party preserving the property.

New development policies include practices to minimize the impacts of development on existing natural areas. These practices can either be promoted or required by local governments. Richland County currently requires developers to manage the quality and quantity of stormwater runoff and encourages additional treatment and control through its Green Development Code. The county is also currently updating its stormwater and water quality regulations to provide additional watershed protection. Developers would be required to maintain undisturbed riparian buffers within 100 feet of perennial waterbodies and within 50 feet of intermittent waterbodies. The proposed regulations include an overlay district, whose boundaries are defined as the Gills Creek Floodway as shown on the FEMA Flood Insurance Rate Maps. Within this district, the proposed regulations would require that developers restrict peak discharges rates to half the pre-development rates for the 2, 5, 10 and 25-year storm events or to the downstream system capacity, whichever is less. The proposed regulations would also require all development in the Gills Creek watershed to treat runoff for water quality beyond what is currently required (Richland County, 2008).

The proposed regulations, if enacted, would reduce the impacts of new development in the Gills Creek watershed. New development regulations, both current and proposed, are often more successful when pilot projects demonstrate how the regulations can be implemented. New development strategies recommended as part of this plan considered how Richland County could work together with developers to implement pilot projects on new development.

Scenario recommendations considered two innovative development design strategies that can help address watershed concerns. The first strategy, Low Impact Development (LID), allows for development of a property while maintaining the essential site hydrologic functions (Coffman, 1999). LID accomplishes this by drawing on a suite of site planning concepts as well as structural and non-structural BMPs. The major LID design concepts are:

- Minimization of disturbed area: Delineate areas that can be permanently protected from disturbance to reduce the extent of clearing and grading required.
- Natural drainage design: Design the drainage and hydrology of the site to minimize stormwater runoff, to convey runoff through the site in a way that takes advantage of natural landscape features, and to modify drainage flow paths to promote longer travel times.
- Location of Best Management Practices (BMPs) near the pollutant source: Locate detention and water quality stormwater BMPs to treat runoff at the source.

- Reduction of impervious surface: Reduce total impervious area through alternative roadway layouts, narrower road sections, fewer on-street parking spaces, smaller rooftops, and alternative driveway configurations to minimize hydrologic impacts.
- Disconnection of impervious surfaces: Disconnect impervious surfaces from stormwater conveyances (e.g., directing roof drains to bioretention cells or conveying runoff from lawns and driveways through vegetated buffers).
- Optimal use of structural practices: Adjust the location, type, and/or configuration of structural practices to enhance overall site performance (e.g., use swales to convey and treat stormwater as opposed to simply conveying stormwater with underground storm drains).

The LID concepts offer guidance for how to design a site that minimizes pollutants in surface runoff and helps to preserve the natural hydrology of the site and receiving waters. The photograph to the right depicts an LID design with permeable pavement, disconnected impervious surface, and natural drainage design that incorporates landscaping. Not all LID strategies are appropriate for each site, and at times, a hybrid approach, incorporating LID and conventional designs, may provide the most cost-effective approach to reducing impact. The success of an LID design is determined by evaluating how similar a development's hydrology and pollutant loading are to predevelopment conditions.

Conservation design is related to LID and involves planning development to preserve natural, undisturbed forest, wetland, and other natural features. Strategies include clustering lots and buildings to reduce road lengths and disturbance to natural areas; prioritizing high quality habitat and other natural features to preserve; and designing the development so that residents and visitors benefit from the natural beauty, shade, and recreational opportunities of the preserved areas. The photograph below depicts a community in which natural areas have been preserved.

Opportunities to implement conservation design and LID can enhance the benefits of Richland County stormwater requirements (both current and pending future regulations) by controlling pollutants at the source, reducing overall land disturbance, and preserving natural areas. Within the remaining developable land in the watershed, Richland County and other local governments could work with developers to implement these strategies, providing incentives to developers under the County Green Development Code. The management scenarios consider how these efforts can be integrated with preservation, and where in the watershed would innovative development practices provide the greatest benefit.

Photographs by Heather Fisher, Tetra Tech.

Scenario Development

Eight subwatersheds were selected as Tier II Critical Areas for preservation. Unprotected natural areas, including undisturbed forest and wetlands, were identified as priority locations for preservation. Locations were defined as unprotected if they are not currently being maintained within city or state park boundaries. Natural areas within Fort Jackson were also considered protected because they are managed for wildlife habitat and are not currently planned for development [D. Allen, Fort Jackson Natural Resources, personal communication with H. Fisher, November 20, 2008]. Priority areas include extensive forested wetlands within the floodplain of the Congaree River. Development may occur on this land if developers obtain permits from the federal government. Permanent preservation of these wetland areas would prevent development and ensure that this wetland habitat remains undisturbed. For Scenario 1, all priority locations identified are recommended for preservation; for Scenario 2, priority locations were reduced to land within the riparian zone[1] only.

Subwatershed LJ-02 was selected as the Tier II Critical Area for new development policies. Priority locations were identified in this subwatershed for the promotion of innovative development techniques, like LID or conservation design, to reduce the impact of future development. Significant areas of undeveloped land were identified for this purpose. Since this land coincides with those identified for preservation in this subwatershed, Scenario 1 would involve pursuit of preservation of this land first. If landowners are not interested in preservation but want to develop the property, then a partnership between potential developers of this property would be pursued to demonstrate implementation of innovative practices on the property. Under Scenario 2, innovative development techniques would be pursued on this property in lieu of preservation. Figure 7-4 displays the priority locations for preservation and innovative practices for new development.

[1] Consistent with earlier analysis, the riparian zone was defined as land within 100 feet of perennial stream, within 50 feet of intermittent streams, and within 50 feet of lakes and ponds.

Figure 7-4. Preservation and New Development Priority Locations (This map was not included to due the sensitive nature of these locations.)

Table 7-5 displays the recommended drainages areas for preservation. The upland preservation drainage areas represent land that is outside riparian buffer areas. The riparian buffer preservation drainage areas represent the area within approximately 150 feet of these opportunities. Like riparian buffer restoration, buffer preservation is estimated to provide the greatest pollutant removal benefits for runoff from land within 150 feet of the buffer. Beyond this distance, runoff can begin to form channels or concentrated flow that short-circuits the pollutant removal functions of the buffer.

The costs provided in Table 7-5 reflect the upfront costs to purchase conservation easements for the recommended preservation. These are approximate costs based on recent, local land sales and actual costs could be higher or lower than these estimates. Preservation costs can vary widely based on property value and landowner willingness to sell. Funding will also need to be set aside to address any legal needs or land management over time.

Table 7-5 provides approximate pollutant removal estimates for riparian buffer preservation. Upland preservation benefits can vary widely depending on the type of land-use draining to the property as well as how the property would have been used without preservation; therefore, quantitative pollutant removal estimates could not be provided. The removal efficiencies for riparian buffer preservation estimate the reduction in pollutant loading from the target drainage areas (150 feet from the preserved riparian buffer).

The costs and benefits of innovative development strategies are difficult to predict without knowing the type of development planned for a property. Table 7-6 provides upfront costs and benefit information for a few examples of strategies that could be implemented within a new development.

The first two examples involve either the preservation or restoration of 50-foot and 100-foot riparian buffers within a new development. Riparian buffers on development properties may present no additional costs to a developer if the land is already forested. If riparian buffers require restoration, the costs could be significant in order to restore natural functions and achieve pollutant removal benefits. Like the previous riparian buffer estimates, the drainage area is limited to the land within 150 feet of the buffer.

The four remaining examples in Table 7-6 involve structural stormwater control and treatment for new development. Expected ranges in cost and pollutant removal benefits are provided for LID and conventional stormwater treatment. These ranges are provided for medium density residential development (about 30 percent impervious) and commercial areas (45 to 85 percent impervious) and are based on previous case studies developed by Tetra Tech for Mecklenburg County (Tetra Tech, 2005). As shown by the cost ranges, LID can be more expensive per acre of development than conventional development, but LID costs can also be similar to conventional costs depending on the strategies used. LID and conservation design also can reduce costs below conventional stormwater treatment by reducing grading, paving, and other construction costs. In addition to reducing costs, LID and conservation design may increase marketability and property value through enhanced aesthetics, recreational opportunities, and public interest in “green” strategies.

The reported costs do not include administrative or maintenance costs. As with any new technique, local governments may require additional staff time to review and negotiate development plans using LID or conservation design. Maintenance will be required for some LID strategies that involve landscaping or structural BMPs. Appendix D provides information on BMP maintenance requirements. Both the pollutant removal and cost estimates are provided as approximate, planning-level values. More accurate costs and benefits will depend on site-specific characteristics and should be determined during plan implementation.

Table 7-5. Upland and Riparian Buffer Preservation Costs and Benefits

Recommended Preservation	Scenario 1			Scenario 2			Percent Pollutant Load Removal				Description of other benefits (hydrology, trash removal, etc.)
	Target Drainage Area (acres)	Upfront Cost Low	Upfront Cost High	Target Drainage Area (acres)	Upfront Cost Low	Upfront Cost High	TSS	TN	TP	FC	
Upland	4000	$28.0M	$98.0M	0	$0.0M	$0.0M	Varies	Varies	Varies	Varies	Wildlife habitat, reduced pollutant loading compared to other land uses, preservation of natural hydrology.
50-foot Forested Buffer	500	$1.5M	$3.5M	500	$1.5M	$3.5M	62	31	38	Not known	Wildlife habitat, increased flood retention, and further pollutant loading reduction by preventing conversion to other land uses.
100-foot Forested Buffer	300	$0.9M	$2.1M	300	$0.9M	$2.1M	67	34	43	Not known	Enhanced wildlife habitat, flood retention, and additional pollutant loading reduction compared to 50-foot buffers.
Total	4800	$30.4M	$103.6M	800	$2.4M	$5.6M	------	------	------	------	

Source of cost estimates: NCEEP (2007)

Sources of pollutant removal estimates: Desbonnet, et al. (1994), Schueler (1995), Tetra Tech (2005), Wenger (1999).

Notes: Buffer performance varies widely in monitoring studies; however, there is a clear trend that most of the pollutant removal from surface runoff takes place in the first 50 feet of buffer. Wider buffers provide additional benefits beyond treatment of surface runoff:

- Enhanced denitrification (conversion of nitrate to inert nitrogen gas) of loads in subsurface and shallow groundwater flows entering the stream
- Enhanced nutrient uptake from shallow groundwater
- Reduced risk of vegetation loss and buffer failure
- Increased ability to handle changes in stream pattern and profile
- Forested land typically has lower loading rates than lawn, so an increase in forest buffer width decreases the load generated from land surface. The “reduction” in load by preventing forest conversion to lawn can be substantial. For instance, using loading rates estimated for the North Carolina Piedmont region, a buffer 50-ft wide by 1000 ft in length filters and removes 1.04 lbs/ac/yr of phosphorus, while also preventing 0.45 lb/ac/yr from entering runoff by preserving forest and preventing the same area from becoming lawn. If the buffer width is increased from 50 ft to 100 ft, the buffer filters and removes 1.16 lb/ac/yr, but now 0.90 lb/ac/yr are prevented from entering runoff by preserving the forest.

Table 7-6. New Development Regulations and Practices Costs and Benefits (Applies to Both Scenarios)

Strategy	Upfront Cost per Acre Drainage Area [13]		Percent Pollutant Load Removal				Description of other benefits (hydrology, trash removal, etc.)
	Low	High	TSS	TN	TP	FC	
50-foot Forested Riparian Buffer	$0	$12,000	62	31	38	Not known	Wildlife habitat, increased flood retention, and further pollutant loading reduction by preventing conversion to other land uses.
100-foot Forested Riparian Buffer	$0	$24,000	67	34	43	Not known	Enhanced wildlife habitat, flood retention, and additional pollutant loading reduction compared to 50-foot buffers.
Medium Density Residential: Conventional BMPs	$7,000	$10,000	65	25 – 30	40 – 45	70	Hydrology – peak flow reduction, downstream channel erosion protection. Trash removal, depending on outlet structure. Requires regular maintenance.
Medium Density Residential: LID BMPs	$7,000	$13,000	80 - 95	35 - 45	50 – 60	90+	Hydrology – peak flow reduction, downstream channel erosion protection. Increased infiltration and evapotranspiration compared to conventional BMPs; more closely mimics natural hydrograph. Trash removal, depending on outlet structure. Requires regular maintenance.
Commercial: Conventional BMPs	$13,000	$24,000	65	30	45 – 50	70	Hydrology – peak flow reduction, downstream channel erosion protection. Trash removal, depending on outlet structure. Requires regular maintenance.
Commercial: LID BMPs	$13,000	$45,000	85	45 - 50	60 – 70	90+	Hydrology – peak flow reduction, downstream channel erosion protection. Increased infiltration and evapotranspiration compared to conventional BMPs; more closely mimics natural hydrograph. Trash removal, depending on outlet structure. Requires regular maintenance.

Sources of cost estimates: NCEEP (2007), previous Tetra Tech LID and conventional stormwater case study comparisons.

Sources of pollutant removal estimates: Center for Watershed Protection (2007), Tetra Tech (2005).

[13] Buffer costs reflect potential that preserved buffers may enhance the value of a development and may not present a net cost to the developer. Cost range also reflects the potential need to restore previously disturbed forest within the buffer area.

7.2.5. Other Policies and Outreach

The ability to achieve the objectives established in this watershed management plan will require cooperation and action from citizens in the watershed. This section describes "Other Polices and Outreach" recommended for implementation that will be the foundation for improving the health of the Gills Creek watershed. As discussed in previous sections, these include:

Outreach:

- Littering outreach.
- Educational displays.
- Public education on good housekeeping practices.
- Other Polices:
- Stream buffer ordinance.
- Training on LID and Innovative Stormwater BMPs.
- Enhanced enforcement of sediment and erosion controls.
- Training on BMPs for the lawn care, pest control, and landscape industry.

The following section explains these strategies in more detail.

Types of Outreach and Other Policies

Littering Outreach

Keep the Midlands Beautiful has already established an anti-litter program with Richland County that should be used in efforts to implement this watershed management plan. In addition to the trash management measures described in Section 7.2.2, outreach efforts should include enforcement of littering fines, signs to remind residents not to litter, and improved city trash bins. City trash bins should be retrofitted to block wildlife from entering trash bins and dumping trash. Contracts with trash collection companies should also be updated to require the use of similar trash bins for residents.

Educational Displays

Demonstration projects of LID and stormwater BMPs can provide added value when an educational display is incorporated. Educational displays, or kiosks, incorporate information about the project, why it was implemented, and tips on how residents could incorporate aspects of the project on their property. These displays should be installed for each large BMP (pond retrofits, stormwater wetlands, etc.) and for small BMPs (bioretention, cisterns, etc.) on public properties or other highly visible locations.

Public Education on Good Housekeeping Practices

Public education using brochures, workshops and booths at community events should be considered for public education. These methods should be used to educate residents about good housekeeping practices and BMPs to decrease their impact on nonpoint sources of pollution. The survey conducted during development of this plan found that 11 percent of pet owners do not pick up pet waste during walks. This source of bacteria, if concentrated, can cause impairment of the State's water quality standards.

This material should educate residents of the watershed on 1) what a watershed is, 2) what nonpoint source pollution is, 3) why they should care (including the city and county ordinances and regulations), and 4) what they can do to help. Material should focus on picking up after pets, good practices for washing cars, minimizing fertilizer and pesticide use, decreasing stormwater runoff and using runoff in landscaping, and finally using vegetative buffers adjacent to waterbodies to improve water quality and stabilize stream banks.

During implementation of this management plan, steps should be taken to implement cisterns/rain barrels, bioretention, and other small-scale BMP retrofits in neighborhoods. These projects can be an opportunity to educate residents on features they can install at their homes.

Stream Buffer Ordinance

The County is currently working to establish stream buffer requirements for new in the Gills Creek watershed. As described in Section 7.2.4, stream buffers can protect water quality and stabilize stream banks.

Training on LID and Innovative Stormwater BMPs

In addition to educating residents of the watershed about what they can do to improve the health of Gills Creek, developers and municipal workers should also be aware of their impact on the health of the watershed. Trainings on LID and innovative stormwater BMPs should be held for developers and municipal workers. Workshops should provide training on 1) what a watershed is, 2) what nonpoint source pollution is, 3) why they should care, and 4) what they can do to help. Discussions should focus on informing attendees about LID and innovative stormwater BMPs that may be used as alternatives to current practices.

Enhanced Enforcement of Sediment and Erosion Controls

Ordinances can be difficult to implement when there is no enforcement. To properly enforce sediment and erosion control features in the Gills Creek watershed, it is recommended that the County hire additional staff to focus efforts on enforcement of sediment and erosion control construction measures in the Gills Creek watershed. Enforcement holds stakeholders accountable for improvements to their watershed. By maintaining sediment and erosion controls water quality will improve; overland sediment loads will decrease; and dissolved mercury should decrease. Enforcement can also be an opportunity for the County to earn income associated with violations.

Training on BMPs for the Lawn Care, Pest Control, and Landscape Industry

In addition to educating residents, developers, and municipal workers in the watershed about what they can do to improve the health of Gills Creek, those in landscaping and pest control should also be aware of their impact on the health of the watershed. These workshops should provide BMPs describing proper fertilization, pest control, irrigation, and cultural practices for landscape and pest control professionals. The material presented should describe the benefits of appropriate fertilizer rates, sources, and application methods to reduce potential pollution of waterbodies.

Scenario Development

Seven subwatersheds (LJ-03, JC-03, JC-04, EM-01, GC-04, GC-05, and GC-06) were selected for implementation of a combination of stream buffer restoration, stream channel restoration, trash retrofits, and BMP retrofits. Since these subwatersheds include the greatest concentration of impervious surface and disturbed land, efforts should be focused in these subwatersheds to educate stakeholders on good housekeeping methods and the benefits of BMPs. However, outreach should be conducted throughout the watershed and not limited to these priority subwatersheds. In both scenarios, "Other Policies and Outreach" should be used at various levels to promote good stewardship through both education and enforcement. The annual costs of this outreach are estimated in Table 7-7.

Table 7-7. Cost Estimates for Outreach and Other Policies

Recommended Other Policies and Outreach	Cost/Unit or Training	Annual Cost	Description
Littering Outreach	$1,000/ each	$7,000	Signs and trash can bins.
Educational Displays	$3,000/ display	$6,000	Feature and design costs.
Public education on good housekeeping practices	$3,000/ training	$30,000	Training and brochures to support outreach.
Training on LID and Innovative Stormwater BMPs	$10,000/ training	$40,000	Training and brochures to support outreach.
Enhanced enforcement of sediment and erosion controls.	$28,000 - $48,000/ annually	$32,000	Employee.
Training on BMPs for lawn care, pest control, and the landscape industry.	$10,000/ training	$40,000	Training and brochures to support outreach.
Total		$155,000	

Source of cost estimates: previous Tetra Tech experience.

7.2.6. Other Factors

The management scenarios identified portions of the watershed where management will, for the most part, target urban/suburban runoff and streambank erosion. These sources were among the significant sources of impacts identified in the source assessment. However, the source assessment also identified the following potentially significant sources:

- Waterfowl
- NPDES Point Sources
- Atmospheric deposition of Mercury
- Combination of industrial sources (RCRA, brownfields, USTs, landfills, etc.)
- SSOs
- Septic Systems

The following sections discuss management for these pollutant sources that will help address watershed concerns.

Waterfowl

As identified in the source assessment, waterfowl can be a significant source of bacteria and nutrients in waterbodies, and a number of management strategies are available to control their populations. It is generally desirable to have waterfowl habitat within a watershed ecosystem. Since the Gills Creek watershed has a large number of impoundments, the amount of waterfowl habitat in the watershed likely is greater than the watershed's natural capacity to cycle nutrients and maintain bacteria at levels safe for human health. GCWA, their partners, and concerned citizens can work towards reducing waterfowl populations on lakes at risk for nutrients and bacteria while maintaining healthy and diverse waterfowl populations. The following strategies can be used to discourage the use of waterbodies by waterfowl, particularly Canadian geese (French and Parkhurst, 2001):

- Install devices that repel waterfowl from a waterbody without causing harm to the birds or other wildlife (custom windmills, eagle-shaped kites, flashing lights, etc.)
- Reduce or eliminate fertilization and irrigation near waterbodies.
- Replace lawn areas along waterbodies with shrubs, yucca plants, or other vegetation that is less attractive to waterfowl.
- Build in trees, shrubs, rocks and other natural obstructions that provide habitat for predators.

These strategies should also be used to prevent BMP retrofits, especially pond retrofits and stormwater wetlands, from being accessed by waterfowl.

NPDES Point Sources

Three active permitted NPDES point sources exist within the watershed. When CDM developed a water quality HSPF model for the watershed, they did not identify any significant point sources relating to water quality (R. Wagner, CDM, personal communication to Ray Pittman (Thomas and Hutton Engineering) and Srinivas Valavala (Richland County), October 9, 2008). Dissolved Oxygen and Fecal Coliform TMDLs, which will be developed by DHEC, will further address whether these sources are contributing to impairments in the watershed.

Atmospheric Deposition of Mercury

DHEC is planning to develop Mercury TMDLs for Carys Lake and Sesquicentennial Park Pond as part of a larger effort for multiple waterbodies in the state. These TMDLs will identify sources and implementation actions to address the mercury impairments in the watershed. Dissolved mercury in waterbodies is tied to sediment loading from upstream waterbodies. Management practices that reduce sediment loading, especially those that reduce upland sediment loading, can help reduce dissolved mercury in downstream waterbodies. BMPs that control runoff and pollutants at the source (bioretention/rain gardens, tree boxes, green streets, etc.) are more likely to help reduce mercury loading than BMPs like wet ponds and stormwater wetlands, which may act as sources of dissolved mercury. Enforcement of erosion and sediment control requirements is the best management that can occur within the watershed to reduce dissolved mercury in Carys Lake and Sesquicentennial Park Pond.

Industrial Sources and Hazardous Materials

The large industrial facilities in the lower portion of the watershed are regulated by the federal government to protect human health. No implementation action is recommended as part of this plan; however, members of GCWA may be interested in monitoring the performance of these facilities through US EPA's Envirofacts website (www.epa.gov/enviro/).

The source assessment identified 128 Underground Storage Tanks (USTs) that are leaking in the watershed. Many additional undocumented USTs may exist in the watershed. If the leaking tanks present a risk to ground water quality, grants can be obtained to fund the proper removal of these tanks. If tanks are not removed properly, landowners may face high soil treatment costs if they intend to sell their property. Prior to any action, experts on USTs should be consulted to assess the risk of removing the tank versus leaving the tank in the ground. Some tanks may not present a risk unless removed.

Sanitary Sewer Overflows (SSOs)

The recommended BMP retrofits and restoration projects will help reduce stormwater volume and flow that causes sanitary sewer overflows (SSOs). Design of BMP retrofits should consider how stormwater can be controlled to address SSOs downstream. Sanitary sewer upgrades should also be considered to address SSOs, especially those shown in Figure 4-12 as having discharged to surface water. Development of FC TMDLs for Gills Creek may provide insight on the degree that SSOs contribute to bacteria impairments in the watershed.

Septic Systems

As discussed in Section 4.1.3, the entire watershed is served by municipal sewer systems. DHEC is not aware of any septic system use in the watershed. The stakeholder survey revealed that at least one remnant system exists and more may exist within areas with high septic system density during the 1990 census. A septic system inventory should be conducted during plan implementation to document where septic systems exist and are still being used in the watershed. The inventory should be conducted in cooperation with DHEC, Richland County Department of Environmental Health, and other appropriate partners. Inventory costs will vary depending on whether a consultant is hired and the type of information collected, and these costs would likely range between $10,000 and $100,000. Alternatively, information meetings could be conducted in neighborhoods that have a high likelihood of containing remnant systems. Citizens would be asked to self-report whether they are still using a septic system and information could be provided to them on system maintenance and conversion to municipal sewer systems.

7.3. MANAGEMENT SCENARIOS SUMMARY

Scenarios 1 and 2 were presented to the Gills Creek Executive Committee and Technical Team on January 6, 2009. These groups provided feedback on the scenarios, which was incorporated into the current scenarios outlined above. The groups recommended that both scenarios be implemented in a phased approach, with Scenario 2 implementation occurring in the short-term, and Scenario 1 implementation occurring over the long-term. A mechanism for raising funds, like a stormwater utility, would be needed to fully implement either scenario.

The total estimated costs for plan implementation are $68 to $169 million for Scenario 1 and $27 to $48 million for Scenario 2. The greatest difference in cost between the 2 scenarios is due to the inclusion of upland preservation in Scenario 1. To achieve implementation, this plan recommends a three-phase approach in which the following would occur:

- Phase I: Begin to implement Scenario 2 with small, neighborhood BMP retrofit projects (bioretention, rain barrels/cisterns, etc.) and riparian buffer restoration or preservation. Provide outreach, education, assistance to public on reducing watershed impacts. Conduct septic system inventory. Estimated cost: $1 million for Scenario 2; $155,000 per year for outreach; $10,000 to $100,000 for a septic system inventory.
- Phase II: Complete implementation of Scenario 2 when larger funding sources are available. Continue public outreach, education, and assistance efforts. Estimated cost: $26 to $47 million for Scenario 2 and $155,000 per year for outreach.
- Phase III: Implement the remaining management proposed in Scenario 2 that is not proposed in Scenario 1. Continue public outreach, education, and assistance efforts. $41 to $121 million for Scenarios 1 and 2; $155,000 per year for outreach.

Section 8.0 outlines the key implementation actions, partners, funding, schedule, technical assistance, and monitoring required to complete these phases in a reasonably expeditious period.

8.0 Watershed Plan Implementation

8.1. PHASED IMPLEMENTATION PLAN

When implementing a watershed management plan, there are several key factors that must be addressed prior to proceeding with on the ground installation. While maintaining the ultimate goal of implementing as many of the BMPs addressed in this plan, the primary focus of the plan is to improve water quality and increase both the aesthetics and functionality of the Gills Creek watershed. Thus, the factors discussed below should be considered as part of the implementation of the management plan.

Oversight of the implementation of the plan shall be provided by a combination of GCWA and County/City representatives. The City and County should designate one professional each to sit on a Watershed Implementation Committee formed through the GCWA. In addition, for further professional expertise, the Committee should include members of agencies and organization that could be key to the successful implementation of the plan, including, but not limited to: USC faculty or similar representative, professional engineers familiar with stormwater planning and stream restoration, landscape architects, developers and non-profit representation such as the Sierra Club, Nature Conservancy, Ducks Unlimited or the Center for Watershed Protection. Additional professionals may be included. However, it is recommended that the size of this Committee be limited to 10 to 12 individuals. The Committee will develop implementation scenarios and identify funding sources. Application for and acquisition of the funding is not limited to the Committee. The Committee's knowledge of the implementation sequencing shall be used to identify proper funding sources for the proposed implementation.

Costs and Funding

While private funding may exist through local conservancies, preservation groups, and City and County funds, the scope of the overall watershed plan will require additional financial sources. Several sources exist for this funding, including overall watershed improvement grants, innovation grants for LID implementation, and wetland and stream restoration grants. The sources for these grants include government entities and conservancy groups. Some examples of potential funding sources include Section 319 grants (upon the development of the TMDL for Gills Creek), State Revolving Funds, USDA's Environmental Quality Incentives Program and Conservation Reserve Program, and Community for a Renewed Environment (CARE) grants. The scope and value of these grants vary greatly with the improvement proposed. Therefore, it is important to gather additional analytical data. This data collection, addressed Section 8.5, will provide the basis for grant application and subsequent funding. Grant appropriateness is addressed further below in this section.

There are several additional sources of funding available for the implementation of the management plan. One such source is through the restoration of streams and wetlands through the U.S. Army Corps of Engineers (USACE) mitigation rule requirements. The USACE requires that all impacts to streams and wetlands be offset by the restoration or creation of wetlands and streams based on a predetermined mitigation ration. This is known as no net loss. The rule also requires that this mitigation take place within the same major eight digit HUC Code. Thus, any development within the Congaree HUC must be mitigated for within the basin. This provides opportunity for watershed restoration of impaired streams and wetlands at the total cost to the developer. As part of the implementation of the management plan, contact should be made with the local USACE mitigation representative to discuss areas in need of restoration as identified in the management scenarios.

Federal, State, Richland County, and Columbia City funding may also be available as part of their required NPDES program implementation.

Cost Value Assessment

Once funding sources have been identified as either liquid or potential, in the case of grants, the application of the funding should be distributed in order to provide the most effective watershed restoration approach. To make the most effective use of capital, the implementation of the plan should begin in the upstream subwatersheds identified in the management scenarios. It should also be focused on a combination of BMPs. For instance, the installation of LID technology should be used in combination with stream restoration or traditional BMP retrofits in order to maximize the improvement in the watershed. Spreading funding throughout the watershed in a type of piecemeal approach will not provide the overall desired restoration in the watershed. Due to the increased development and impervious cover throughout the watershed, localized focus shall provide a much more measurable improvement to the watershed. Also, as a corollary affect, the improvements to the watershed can be more closely monitored with this type of approach. Thus, field investigation should be implemented, as identified in Section 8.5, to further prioritize the areas of implementation outlined in Scenario 1. This should be used to most effectively utilize procured funding.

Implementation Schedule

Implementation of Phase 1 should begin as funding is available immediately following completion of this plan. Once financial considerations have been addressed, the management plan implementation should continue to proceed as a phased approach. This will provide the most cost-effective and environmentally beneficial development within the watershed. Unless otherwise determined, in order to achieve the goals set forth by Richland County and the GCWA, the initial plan should begin with the goal of fully implementing the Scenario 1 watershed restoration recommendations. While financial concerns may be a consideration at the current time, this is a long-term management plan and should be addressed as such. Funding sources do exist for phased implementation of the project and should not be considered a limitation for the plan.

As the plan begins implementation, several limiting factors and hindrances will inevitably develop that will change the overall look and scope of the management plan. These factors may include the inability to obtain necessary buffer easements or property for projects, lack of cooperation from business and private residents, and the identification of areas in need of restoration not previously identified. Therefore, it is important to understand the watershed management plan is a working document and should be amended periodically to meet the goals set forth in the plan.

Prior to implementing any BMP retrofit, restoration, or preservation projects, preliminary onsite investigations should be performed. While this management plan presents scenarios involving the implementation of specific BMPs, the actual location of the BMPs must be determined prior to beginning any preliminary design or planning. This investigation may be performed by the GCWA or other volunteer organizations but should be verified by qualified stormwater professionals, either from the County/City or a third party firm. Section 8.5 details the type of data that should be collected.

Phase I of the project should begin with the implementation of small-scale BMP retrofits and LID measures to address site-specific issues. These retrofits should be concentrated within the upper limits of the watershed within highly impervious areas as deemed high priority under Section 8.5, as well as those subwatersheds in the upper and lower portions of the watershed selected for neighborhood BMP retrofit projects. Neighborhood BMPs retrofits, as defined in this section, apply to both residential and commercial development. The BMPs to be implemented as part of Phase I include small BMP retrofit projects (bioretention, rain barrels/cisterns, etc.) and riparian buffer restoration or preservation. Ideally the first few retrofits should be implemented as "pilot" projects involving community groups and educational outreach. Horticulture societies and local homeowner associations should be used for less technical implementation such as planting and aesthetic beautification. Signage, created either through the County and City requirement under the NPDES program or by donations/sponsorships by local businesses, should be used to identify the retrofits and their purpose. A key component of a successful watershed restoration effort is community awareness and involvement. The routine maintenance of these facilities should be designated to local community groups, business owners, or local governments where applicable. Included in Phase I should be BMP retrofits, implementation of site-specific LID practices, and the acquisition and restoration of vegetative buffers. In the case of buffer acquisition/restoration, effort should be made, where practicable, to plat and record easements with the County or City. The secession of easements is preferable and may possibly be eligible for tax credits as conservation areas to the landowner. However, the purchase of easements may be necessary. There are many conservancy groups operating within South Carolina that may be of assistance in either the purchase or long-term maintenance of these conservation areas. As watershed planning is concerned, the simple adaptation of the Gills Creek Overlay District may not be sufficient in preserving and maintaining these buffer areas. However, the buffers to be acquired should be parceled out in that all buffers associated with other BMPs and stream restoration areas should be acquired during the implementation of that specific BMP. Phase I should also include education to developers on implementing LID BMPs in their development plans.

Once significant progress has been made under the first phase of implementation, as designated under Section 8.2, Phase II should include larger scale BMP and restoration efforts. This would include the development of stream and wetland restoration areas and the review and analysis for regional stormwater facilities. Regional stormwater facilities include dry ponds, wet ponds, and constructed wetland facilities that are designed and implemented to treat multiple parcels and larger drainage areas. During the Phase I implementation it may be determined that some areas designated as optimum for BMP retrofits may not be plausible for the reasons described above. Thus, it may be necessary to address the development of regional stormwater BMPs. These BMPs would be located on, or adjacent to, tributaries to Gills Creek. These could be used to treat larger areas for water quality, flooding, and peak flow attenuation. This phase should also include stream restoration, wetland restoration, and any dredging identified as necessary. While Phase II is a much more visible result to the community, it is important not to implement this phase until Phase I recommendations have been implemented in the designated subwatersheds. Restoration and sediment removal prior to controlling the culprit of increased discharge will only result in short-term repair and will likely lead to failure of the restoration work. As previously mentioned, this is a long-term effort and while funding sources may be identified and more readily available for these larger projects, the small projects, which include the neighborhood BMP retrofits, should be completed first.

As Phases I and II are implemented, it will become clear through the revision and reassessment of the overall management plan that some BMPs cannot be implemented or that future development has lead to other areas of concern. These areas, where possible, should be integrated into the overall two phase matrix. Due to the long-term approach of this program, neither Scenario 1 nor Scenario 2 may be able to be fully implemented. Most likely, the final development will by a hybrid of both Scenarios. Phase III of the program should be a reassessment of the overall management plan based on visual observations and empirical water quality data collected in the completed Phase I and Phase II areas.

As technology continues to develop in the areas of water quality treatment and BMP design, additional BMPs should be evaluated for future implementation within the watershed. It is important as this plan is implemented to collect data where possible to evaluate the success of each BMP installed. For instance, if trash collection methods upstream in the watershed are significantly reducing the trash load downstream, trash booms may not be necessary. Additionally, it may be noted that some BMPs may be more effective and desirable to the community. This should be noted and applied to future decision-making.

8.2. Interim Milestones

The schedule of implementation will be variable, based on funding sources and the ability to acquire property and approval of the retrofits. This plan provides an overall goal for implementation, but several key factors, including grant cycles, the economy, and design development timelines, may influence the ability to implement the plan as recommended. In addition, the schedule should be revisited annually to determine the practicality of the schedule and revisions based on changes to the overall plan.

The implementation schedule is based on Scenario 1. If the GCWA and the City/County determine that Scenario 1 is not feasible, the schedule may be adjusted based on revised treatment areas. However, to achieve the full goals of the GCWA, every effort should be made to implement as much of Scenario 1 as possible.

From data presented in Table 7-2 and Table 7-5, there are approximately 1,270 acres that can be treated through the implementation of BMPs and retrofits, and 4,800 acres of buffer that need to be acquired as part of this scenario. The **minimum** goals of the management plan should be as follows. If funding sources become available for additional work, the Phase I projects should be completed as soon as possible.

Years 1-3:

- Conduct education and outreach.
- Conduct septic system inventory.
- Investigate and pursue willing landowners for buffer preservation and restoration opportunities.
- Preliminary investigation for a minimum of 100 percent of the Phase I BMPs.
- Verification and BMP selection for a minimum of 60 percent of the BMPs.
- Design of BMPs to treat a minimum of 20 percent of the drainage area identified in Scenario 1.
- Implementation of a minimum of 5 BMPs per year following Year 1.
- A minimum of 2 "pilot" projects implemented in Year 1.
- Recordation of a minimum of 15 percent of buffer areas.
- Develop escrow account by the end of Year 3. This escrow account shall receive City/County funds and/or private fund as part of the funding for the management plan. These funds shall be used for long-term maintenance of the BMP facilities.

Years 3-6:

- Continue education and outreach.
- Investigate and pursue riparian buffer preservation and restoration opportunities.
- All preliminary investigation of Phase I BMPs complete.
- Complete verification and selection of remaining Phase I BMPs.
- Design of 50 percent of Phase I BMPs complete.
- Implementation of a minimum of BMPs to treat 50 percent of the watershed complete.
- Water quality monitoring of BMPs completed in Years 1-3 begun.

Years 6-10:

- Continue education and outreach.
- Design of 50 percent of Phase II projects.

- Construction of 30 percent of Phase II projects.
- Identification of additional Phase I and II projects not identified during initial investigation.

Years 10-20:

- Continue education and outreach.
- Complete construction of all Phase I and II projects. Re-evaluate management priorities and begin Phase III.
- Maintain permanent water quality monitoring stations on all major tributaries and Gills Creek.

8.3. MANAGEMENT SEQUENCING

The overall management plan implementation should be a coordinated effort through Richland County, the GCWA, and where applicable, the City of Columbia in the form of the Watershed Implementation Committee. The GCWA Committee should be the overall coordinating entity when determining the implementation phasing of the BMPs. With their resources to perform onsite investigations and community evaluations, the GCWA will provide recommendations on the proper areas to begin the implementation of the program. The City and County should be responsible for coordinating and reviewing design plans and provide technical review and oversight of the GCWA's proposed implementation sequence. With their overall mission and objectives outlined, the GCWA should be responsible for funding applications and financial management of privately acquired funds. The County and City hold the responsibility of determining the proper use and allocation of State funds as designated to their locality. Each BMP retrofit should be designed by a licensed professional and reviewed and approved by both the City/County and the GCWA prior to approval.

The first task of the Committee shall be to identify site locations for BMP retrofits (Phase I) as identified in Sections 7.2.1 and 7.2.2. These sites should be selected based on visual or empirical evidence of an adverse effect to the watershed. The identification of these sites should include a ranking matrix to prioritize the necessity of each retrofit. While this plan provides a recommended number of retrofits, the site identification should be extended as necessary to include as many potential sites as feasible. Site selection shall then be pared down based on matrix ranking to provide the most effective treatment. Multiple site selection is a critical step in the implementation of Phase I. Once sites have been identified, it will be the responsibility of the Committee, or designated City/County representative, to approach the property owner to determine their willingness to implement the project. Thus, through the course of the plan development, several sites will be ruled out due to lack of owner interest.

Also included in this first planning phase should be investigation as to the feasibility of obtaining buffer easements, as defined in Section 7.2.4. Preliminary contact should be made with property owners and conservation groups to determine the feasibility of obtaining the easements. Every attempt should be made to obtain contiguous buffer areas for more effective water quality treatment. Thus, if the buffer locations identified in this plan are not obtainable in such a manner that greater than 70 percent of the linear buffer footage parallel to the stream channels cannot be preserved, the Committee should revisit the buffer plan and evaluate alternative buffer possibilities. Where possible, these buffers should be obtained, surveyed and recorded as part of Phase I. This should be limited to buffer easements not associated with proposed stream restoration work. Due to construction activities, the recordation of easements within the restoration areas is difficult due to the necessity for future disturbance associated with the restoration itself. Therefore, all buffer preservation or restoration adjacent to stream restoration areas should be considered as part of Phase II of the project.

Once a final Phase I plan has been developed by the Committee, the implementation of this plan should commence with concentration on one subwatershed at a time. This approach will allow for quicker implementation of Phase II, the restoration and remaining preservation identified in Sections 7.2.3 and 7.2.4. Thus, upon completion of Phase I implementation within each subwatershed, the Committee should identify locations for restoration, preservation, and if necessary, regional stormwater facilities within each subwatershed. This identification should include the same matrix ranking as implemented in Phase I.

A third party professional should be consulted on an annual basis to ensure that the goals of the County and GCWA are being met and that the approach meets both technical and community-specified goals. As part of this review, the overall management plan should be revised to reflect specific site locations and BMPs either implemented or planned to be implemented. In addition, a BMP database should be developed identifying proposed and implemented BMP locations and their subwatersheds (treatment areas). This database should be updated with water quality data, once monitoring has been implemented.

Additional consultation may be required with legal representatives, particularly in the buffer acquisition and recordation phase of the project.

8.4. INDICATORS TO MEASURE PROGRESS

The Tier I Critical Areas analysis (Section 5.1) provides a foundation for measuring progress towards addressing the watershed concerns identified in this plan. The following indicators were used in this analysis:

- Stakeholder Hot Spots – Flooding
- Building within FEMA 100 –Year Floodplain
- Stakeholder Hot Spots – In-stream and In-lake Sediment
- Stakeholder Hot Spots – Trash
- 303(d) Listed Waterbody
- Fish Use Advisory
- Percent forest and wetlands in subwatershed (protected and unprotected)
- Percent forest and wetlands in riparian zone (protected and unprotected)
- Observations of threatened and endangered species

The datasets for these indicators should be updated after each implementation phase is completed, especially following Phase II. The scores can then be re-calculated and critical areas re-evaluated. This analysis will show what progress has been made in addressing watershed concerns and where watershed concerns still need to be addressed. The Tier II Critical Areas analysis can also be updated and rescored to measure progress and identify management opportunities, in light of the updated information. In addition to the indicators used above, monitoring data should also be used to measure progress. Section 8.7 outlines the recommended plan for monitoring.

8.5. TECHNICAL ASSISTANCE NEEDED

The implementation of this management plan is a multifaceted approach to restoring water quality within the Gills Creek watershed. As such, there is significant technical assistance that is necessary to fully complete the plan. Each BMP and restoration area should be designed and approved by a qualified professional. Plans shall be submitted to the City and/or County for approval. All State and Federal permits shall be required including USACE permits associated with working in a live watercourse. For the purpose of this section, it is assumed that the City/County and/or GCWA will take the steps to have the design complete and all permits approved prior to installation of any BMP reference herein. The following addresses potential technical work required to complete the design plans and the subsequent maintenance and oversight.

BMP and Trash Retrofits:

- The location of each potential BMP shall be identified by GPS and with photographs in each cardinal direction.
- Technical plans and specifications, including as-built survey, must be obtained for any existing structure to be retrofit. If plans are not available, a licensed surveyor shall be used to survey the location of all structures, local topography to an accuracy of 1-foot in elevation, and identification of any existing easements and utilities. If design plans are more than five years old, the site should be re-surveyed to ensure that settling and undocumented site changes have not adversely affected the BMP.
- Coordinate with property owner to obtain permission to proceed with retrofit design. This coordination should include legal documentation in the form of either a contract or option agreement signed by both the property owner and City/County. In coordination efforts, the City/County should operate as the legal representative on all documentation. This coordination shall also extend to all utility companies with lines and/or easements that will fall within the limits of construction activities.
- Detailed engineering modeling must be performed for any retrofit to ensure that the functional purpose of the BMP is not compromised.
- Design plans, including technical specifications suitable for contractor bidding, shall be completed. This includes obtaining all necessary State and Federal permits.
- Where the source of the funding is State, Federal or City/County funds, the City/County shall utilize their public procurement process unless the retrofit falls below the municipality's minimum threshold. If the funding is from a grant source obtained by the GCWA, they have the option of choosing a sole-source contractor or bidding the project.
- Professional construction oversight should be provided by either the design engineer or a qualified professional familiar with the installation of the specific BMP. Specifically, the success of LID measures depends greatly on the meticulous nature with which they are installed.
- The City/County shall provide signage for a minimum of 10 percent of the retrofits unless private entities choose to fund the signage. Signage is a valuable educational tool to the public and should be utilized in high-traffic areas.
- A designated entity should be appointed to provide long-term maintenance. This should be in the form of a contact or other legal document. "Adopt A…" programs are an acceptable form of maintenance. However, any individual tasked with maintaining the facility should go through training on the proper operation and maintenance of each facility. LID facilities, particularly, need routine maintenance beyond trash pickup, and monitors should be trained to notice when more detailed maintenance is required.

Stream and Riparian Buffer Restoration:

- Field survey of the stream channel to be restored. This survey should extend a minimum of 200 feet upstream and downstream of the restoration area. This survey work shall be supervised by a stream restoration design professional familiar with Natural Stream Channel Design techniques and the Rosgen stream classification system.
- GPS location and identification of all specimen trees within 100 feet with a diameter at breast height (dbh) greater than 6"

- Identification, both though GPS location and survey elevation, of all pipes, outfalls, and utilities within 100 feet or crossing the stream system.
- Identification of all easements within the project limits.
- Acquisition of platted buffers through either transfer of title or recordation prior to final restoration design.
- Detailed design of restoration including hydrologic and hydraulic analysis, reference reach data (where applicable), typical cross sections, longitudinal profile from the thalweg of the channel, structure design and details, and technical specifications suitable for contactor bidding. This should include all necessary permits.
- Professional construction oversight should be provided by either the design engineer or a qualified professional familiar with stream restoration construction. Where possible, the design engineer should provide the oversight.
- Permanent monitoring stations should be located along the stream to ensure the stability of the restoration. Typically, the USACE sets the distance interval for these stations. Monitoring includes an annual longitudinal and cross sectional survey, pebble count, and macroinvertebrate survey. As a rule, stream monitoring is usually required for a minimum of 10 years. Voluntary restoration may not have monitoring requirements associated with it depending on the USACE position. However, it is recommended that monitoring be performed for a minimum of three years to ensure that the restoration was successful. This monitoring needs to be performed by a trained professional familiar with the monitoring criteria. “Adopt A …” programs are acceptable and should be utilized for stream cleanup efforts but should not be used for technical monitoring.

Preservation Sites:

- Legal description of all areas, including existing easements, setbacks, and restrictions per deeded lot within the buffer area
- Aerial survey of forest coverage within proposed preservation area
- Boundary survey by a licensed surveyor
- Development of plat map by licensed professional
- Recordation of preservation areas with the City/County including legal conservation easement language
- A long-term steward should be designated through legal document to ensure that areas are preserved according to the easement language

8.6. INFORMATION/EDUCATION COMPONENT

Throughout the implementation of this watershed management plan it is essential that stakeholders are encouraged to participate in selecting, designing, and implementing the recommended strategies. The cooperation of local agencies with the Gills Creek Watershed Association and other nonprofit outreach organizations will decrease the cost of outreach and maximize the number of stakeholders that are aware of efforts to improve the health of the Gills Creek watershed. Information about the purpose of this plan and the management strategies should be presented to local businesses and residents through community organizations and neighborhood associations. Documentation of the plan should be available online at the Counties stormwater website and the Gills Creek Watershed Associations website. Hardcopies should also be made available at county and city offices for those without internet access. Newsletters sent through email to the Gills Creek Watershed Association stakeholder mailing list and as inserts with water and sewer bills can also be used to update stakeholders on the progress of implementing this plan.

8.7. MONITORING PLAN

The monitoring plan is designed to capture an existing baseline condition for the watershed and to monitor long-term trends in watershed health. The plan components include monitoring locations, parameters monitored, and frequency of monitoring. The purpose of the monitoring plan is to track progress in addressing watershed concerns and improving watershed conditions through plan implementation.

Proposed Monitoring Locations

To select the monitoring locations, the watershed was first divided into subwatershed groups based on major tributaries. Nine groups were formed based on drainage area and location within the Gills Creek watershed. Additionally, two more groups were formed; one representing the upper half of the watershed, and the other representing nearly the entire watershed (Table 8-1).

Table 8-1. Locations for Monitoring Plan Implementation

ID, Proposed Site	ID, Existing Site	Water Body	Location	Cognizant Party	Upstream Subwatersheds
	C-017	Gills Ck.	Bluff Rd / SC-48	DHEC	Upper 90% (all above GC-08 and GC-09)
GCMP-01		Tributary G-1	Bluff Rd / SC-48		Upper West GC-07
GCMP-02		Wildcat Ck.	Shady Lane		GC-06
GCMP-03		Pen Br.	Converse St.		GC-05
GCMP-04		Gills Ck.	Forest Dr.		Upper half (all above GC-05)
GCMP-05		Eightmile Br.	Willingham Dr.		EM-01
GCMP-06		Gills Ck.	Boyden Arbor Rd.		GC-01, GC-02
	CW-566	Gills Ck.	Park Rd.	DHEC	GC-02
GCMP-07		Bynum Ck.	Park Rd.		Upper GC-03
GCMP-08		L. Jackson Ck.	Trenholm Rd. Ext.		LJ-01, LJ-02, LJ-03
GCMP-09		Jackson Ck.	Oneil Ct.		JC-01, JC-02, JC-03
	C-068	Forest Lake	Dam at Fort Jackson water intake	DHEC	All above GC-05 except EM-01
	C-048	Windsor Lake	Spillway	DHEC	JC-01, JC-02, plus upper third of JC-03
	C-046	Sesquicentennial Pond	Sesquicentennial Park	DHEC	JC-01

ID, Proposed Site	ID, Existing Site	Water Body	Location	Cognizant Party	Upstream Subwatersheds
	C-001 and 02169570	Gills Ck.	Garners Ferry Rd / US-76	DHEC and USGS	All above GC-06 plus Wildcat Creek
	202-36B1-2	Outfall to trib of Eightmile Br.	10 Forest Trace Way	Richland County	Portion of north central EM-01
	202-35C4-1	Outfall to trib of Jackson Ck.	6616 Dare Circle	Richland County	Portion of north JC-04
	202-45B4-3	Outfall to trib of L. Jackson Ck.	26 Office Park Ct	Richland County	Portion of east central LJ-01

The existing DHEC and Richland County monitoring sites were reviewed to determine how well suited the locations are for capturing data representative of the subwatershed groups. Of the six DHEC locations:

- Two are co-located with proposed monitoring sites (C-017 and CW-566).
- Three are in ponds (C-046, C-048, and C-068).
- One is co-located with the USGS gaging station (C-001).

It is recommended that data collected by DHEC and USGS be used whenever possible to establish trends in water quality and changing conditions.

Each of the existing Richland County stormwater monitoring sites is located at a stormwater outfall. The area draining to each of these outfalls appears to be only a portion, perhaps 25 percent at most, of their respective 14 digit HUCs. Additionally, it is not known if the channel below the outfall is flowing during dry periods. Stormwater monitoring data from these sites may be useful in pinpointing the sources of pollutants within the subwatershed groups.

One monitoring location was selected within each of the subwatershed groups. The locations listed in Table 8-1 are at road/stream crossings near the downstream end of each group. The criteria for selecting a given crossing included:

- Being co-located with an existing DHEC site.
- Being far enough downstream to capture all minor tributaries.
- Far enough upstream of the confluence with the next subwatershed group to prevent any backwater influence during high flows.

These locations were derived from maps and aerial photographs and thus, are subject to change pending the outcome of ground truthing the locations for accessibility.

Since a subset of monitoring sites might need to be selected due to limited budgets, it is recommended that monitoring be done at sites relevant to where management is occurring in the watershed, and that existing DHEC monitoring stations be used if they are near and downstream of the management. Prior to installation of management features in a subwatershed, it is recommended that monitoring occur at the nearest feasible downstream location to quantify changes in the subwatershed. A location upstream may also need to be sampled when management features are not located in headwater subbasins. Once standards have been met or management has been in place for five years in a particular subwatershed, managers may consider discontinuing any non-DHEC monitoring stations monitoring for that subwatershed and using funding to monitor in areas targeted for on-going or future management.

Parameters Monitored

Water quality/chemistry parameters of concern in the Gills Creek watershed include nutrients, sediment, pathogens, and dissolved oxygen. Additional parameters include aquatic biological health, flow, and general visual observations (Table 8-2).

The five water quality parameters are temperature, dissolved oxygen, turbidity, pH, and conductivity. These data should be collected using DHEC approved methods and are commonly measured utilizing a handheld sonde. Temperature, pH, and conductivity serve as general indicators of water quality. Turbidity is a general indicator for levels of suspended solids. Dissolved oxygen levels are used to indicate meeting the aquatic life designated use when listing or delisting streams from the 303(d) list.

The water chemistry parameters include fecal coliform, nitrate-nitrite, total phosphorus, total suspended solids, and metals. These data should be collected using DHEC approved methods and laboratories. Several stream reaches have been placed on the 303(d) list for not meeting the designated uses of recreation, fish consumption, and supporting aquatic life, which are related to these parameters.

Table 8-2. Recommended Water Quality Parameters for Monitoring

Water Quality	Water Chemistry	Other
Temperature	Fecal Coliform	Benthic Macroinvertebrates
Dissolved Oxygen	Nitrite/Nitrate	Flow
Turbidity	Phosphorus	Visual Observations
pH	TSS	
Conductivity	Metals	

Benthic macroinvertebrate monitoring serves two functions. The presence of a particular species, either sensitive or insensitive to water quality, serves as an indicator of overall stream health. Additionally, benthic macroinvertebrates serve as moderate term indicators due to their life spans of typically several months to a year. This is in contrast to water grab samples which indicate the conditions at a particular instant in time. Again, these data should be collected using DHEC approved methods.

Flow measurements are necessary for calculating pollutant loads from grab sample concentrations. Alternatives for flow measurement include both high-cost-and-effort to low-cost-and-effort methods. Higher-cost methods entail installing electronic stream stage measuring devices at each location, then generating a stage/discharge rating curve by measuring flow throughout a large storm event. Lower-cost methods entail installing a staff gage on the bridge footing at each location. The stream stage and time of day are recorded when grab samples are collected. Flow can be loosely estimated by comparing the stage and drainage area to that of the USGS gaging station on Gills Creek. Additionally, if in the future a rating curve is developed for that site, then the historical stage and pollutant concentration data can be used to calculate historic pollutant loads without using the high cost method. The crest stage gage, a simple variation of the staff gage, is a low-cost alternative for recording peak stages during high flow events.

Visual Observations are qualitative assessments of factors that cannot be measured but may influence the water quality parameter values. Typically, these are transient influences that last for only several weeks, months or a year or two at most. Examples include but are not limited to: beaver dams, land development adjacent to the stream, waste material spills, etc.

Frequency of Monitoring

The suggested monitoring frequency is designed to capture water quality at both low and high flow conditions. The concentrations and load levels of various pollutants are often correlated to flow. For example, high temperatures and low dissolved oxygen are often related to low flow conditions whereas the highest concentrations of TSS and nutrients often occur during moderate flows shortly after the onset of rainfall. Frequency schedules and the period of monitoring are designed to capture baseline conditions and quantify changes following installation of management features (Table 8-3).

Table 8-3. Suggested Monitoring Frequency

Parameter	Frequency	Period
Benthic Macroinvertebrates	Once per year	One year before installation and 5 years after
Flow	Staff gage, during grab sampling	One year before installation and 3 years after
Visual Observations	Once per month, April through November, + 2 high flow events per year	One year before installation and 3 years after
Temperature	" "	" "
Dissolved Oxygen	" "	" "
Turbidity	" "	" "
pH	" "	" "
Conductivity	" "	" "
Fecal Coliform	" "	" "
Nitrite/Nitrate	" "	" "
Phosphorus	" "	" "
TSS	" "	" "
Metals	" "	" "

Pesticides and Other Toxins in Sediment

Stakeholder concerns have been raised regarding pesticide and other toxin contamination in the sediment of waterbodies in the Gills Creek watershed. Sediment monitoring within the watershed should continue, and experts on management of contaminated sediment should be consulted to provide further insight on the health risks of these contaminants and potential management solutions.

References

Bean, E.Z,, W.F. Hunt, D.A. Bidelspach. 2007. Evaluation of Four Permeable Pavement Sites in Eastern North Carolina for Runoff Reduction and Water Quality Impacts. Journal of Irrigation and Drainage Engineering. 133(6): 583-592.

Center for Watershed Protection. 2007. National Pollutant Removal Performance Database Version 3 (September 2007). Ellicott City, MD.

Clemson University. 2008. Sandhill Research and Education Center Rainfall Record. Columbia, SC. Clemson University Public Service. 2008.

Coffman, L. 1999. Low Impact Development Design Strategies, An Integrated Design Approach. Prepared by Tetra Tech for the Prince George's County Maryland Department of Environmental Resources Programs and Planning Division, Largo, MD.

Collins, K.A., W.F. Hunt, and J.M. Hathaway. 2007. Hydrologic and Water Quality Comparison of Four Types of Permeable Pavement and Standard Asphalt in Eastern North Carolina. North Carolina State University Biological and Agricultural Engineering Department. Prepared for Interlocking Concrete Pavement Institute.

CWP. 2008. The Stormwater Manager's Resource Center: Factsheets. The Center for Watershed Protection. Accessed September 2008. http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Infiltration%20Practice/Porous%20Pavement.htm

Desbonnet, A., P. Pogue, V. Lee, and N. Wolff. 1994. Vegetated buffers in the coastal zone: a summary review and bibliography. Coastal Resources Center. University of Rhode Island, RI.

DHEC. 2008b. MS4 – Municipal Separate Storm Sewer System. South Carolina Department of Health and Environmental Control. Accessed September 2008. http://www.scdhec.net/environment/water/swnsms4.htm#large

DHEC. 1997. The Gills Creek Watershed Project, An Urban Nonpoint Source Project: Richland County, S.C. February 1994 – September 1996. South Carolina Department of Health and Environmental Quality Bureau of Water, Water Quality Division.

DHEC. 2008a. *Document No. 3161 Department of Health and Environmental Control. Chapter 61 Statutory Authority: 1976 Code Section 48-1-10 et. seq. Regulation 61-68, Water Classifications and Standards*. South Carolina Department of Health and Environmental Control. April 2008.

DHEC. 2008c. 2008 303(d) list of impaired waters. South Carolina Department of Health and Environmental Control. Accessed July 2008. http://www.scdhec.gov/environment/water/tmdl/docs/tmdl_08-303d.pdf

French, L. and J. Parkhurst. 2001. Managing Wildlife Damage: Canada Goose (Branta canadensis). Virginia Cooperative Extension. Publication Number 420-203. http://www.ext.vt.edu/pubs/wildlife/420-203/420-203.html#L3

Flora, Joseph R.V, and Jonathan Goodall. 2008. *Sediment and Benthic Community Monitoring: A Concept Study for Richland County*. Department of Civil and Environmental Engineering, University of South Carolina, Columbia, SC.

GCWA. 2009. Gills Creek Watershed Association Website. Accessed January 2009. http://www.gillscreekwatershed.com/Documents/GillsCreekStrategicPlan.pdf

Gordon, M. and R. Zamist. 2006. Municipal Best Management Practices for Controlling Trash And Debris in Stormwater and Urban Runoff. California Coastal Commission and Algalita Marine Research Foundation. Accessed December 2008. Accessed September 2008. http://www.plasticdebris.org/Trash_BMPs_for_Munis.pdf

Hunt, W.F. and W.G. Lord. 2006. Bioretention Performance, Design, and Construction and Maintenance. E06-44609. North Carolina Cooperative Extension Service.

Hunt, W.F., A.R. Jarrett, J. T. Smith, and L. J. Sharkey. 2006. Evaluating Bioretention Hydrology and Nutrient Removal at Three Field Sites in North Carolina. ASCE Journal of Irrigation And Drainage Engineering. Vol 132, No. 6, Pg: 600-608.

Jessup, A. 2003. Sediment in Our Streams: Upland and Streambank Erosion in North Carolina. Conference Proceedings from the NC SRI Southeastern Regional Conference on Stream Restoration. June 21-24. Winston-Salem, NC.

Johnson, H.S., Jr. 1961. Fall Line Stratigraphy Northeast of Columbia, S.C. in Geologic Notes. Division of Geology, State Development Board, Columbia, South Carolina. Volume 5, Number 5, September-October 1961, pp11-13.

Low Impact Development Center. 2008. Urban Design Tools: Tree Box Filter, Costs. Accessed December 2008. http://www.lid-stormwater.net/treeboxfilter_costs.htm

Maluk, T. L. 1999. Pesticides and Bacteria in an Urban Stream – Gills Creek, Columbia, South Carolina. USGS Fact Sheet FS-131-98. US Geological Service, National Water-Quality Assessment Program.

Moran, A., W.F. Hunt, and G. Jennings. 2003. A North Carolina Field Study to Evaluate Greenroof Runoff Quantity, Runoff Quality, and Plant Growth. Paper Number: 032303 for the 2003 ASAE Annual International Meeting.

NCEEP. 2007. Ecosystem Enhancement Program, 2006-2007 Annual Report. Ecosystem Enhancement Program, NC Department of Environment and Natural Resources. Accessed October 2008. http://www.nceep.net/news/annualreport/2007/EEP_Annual_Report_2006_2007.pdf

Richland County. 2001. Richland County Stormwater Management Ordinance and Storm Drainage Design Standards. Accessed December 2008. http://www.richlandonline.com/departments/publicworks/storm.asp?Show=Regs

Richland County. 2008. Proposed Ordinance Changes, State of South Carolina County Council for Richland County; Chapter 26. Ordinance No. xx-09HR. Accessed December 2008. http://www.richlandonline.com/departments/publicworks/storm.asp

Rosgen, D.L. 2001. A Practical Method of Computing Streambank Erosion Rate. Wildland Hydrology. Pagosa Springs, CO.

Santa Clara Valley Urban Runoff Pollution Prevention Program. 2007. Trash BMP Toolbox. Accessed December 2008. http://scvurppp-w2k.com/trash_bmp_toolbox_2007.htm

Schueler, T. 1995. Site Planning for Urban Stream Protection. The Center for Watershed Protection. Silver Spring, MD.

Simon, A. 1989. A model of channel response in disturbed alluvial channels. Earth Surface Processes and Landforms 14: 11-26.

Tetra Tech, Inc. 2006. OWASA Site Evaluation Tool Model Documentation. Prepared for Orange Water and Sewer Authority, Orange County, NC.

Tetra Tech. 2005. Post-Construction Ordinance Development Phase I Report. Prepared by Tetra Tech, Inc. Prepared for Mecklenburg County Water Quality Program and Charlotte Storm Water Services. February 2005.

Tracy Tackett. 2008. "Planning for Sustainable Infrastructure". *Workshop B: Incorporating Green Infrastructure into Municipal Programs.* Watershed Environment Federation Sustainability 2008 Conference.

USACE. 2000. USACE ER 1105-2-100, Planning Guidance Notebook, April 22, 2000.

USEPA. 2008. Post-Construction Stormwater Management in New Development and Redevelopment. National Pollutant Discharge Elimination System, Office of Wastewater Management, US Environmental Protection Agency. Accessed September 2008. http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=min_measure&min_measure_id=5

Wenger, S. J. 1999. A review of the scientific literature on riparian buffer width, extent and vegetation. Athens: Institute of Ecology Office for Public Service and Out-reach, University of Georgia.

Wossink, A., and B. Hunt. 2003. The Economics of Structural Stormwater BMPs in North Carolina. N.C. WRRI Project 50260. Urban Water Consortium, Stormwater Group and Water Resources Research Institute of the University of North Carolina.

(This page left intentionally blank.)

Appendix A. Public Survey Results

Are you or any other person in your household a pet owner? If no, skip to question 5.

Yes	48%
No	44%
No Answer	8%

If you are a pet owner, please specify the type of pet(s) you own below.

Dog	16%
More than 1 Dog	8%
Cat	8%
More than 1 Cat	4%
Dog/Cat	6%
More than 1 Cat/Dog	4%
Cat and Other	2%
N/A	8%
No Pet	44%

Does your pet(s) eliminate waste outdoors? If so, do you pick up after your pet?

My pet does not eliminate outdoors	14%
Yes, pick up after pet	57%
Yes, but do not pick up after pet	11%
No, but other wildlife does	0%
Sometimes	7%
N/A	11%

Have you observed wildlife waste/feces in or near your yard?

Yes	38%
No	28%
No Answer	34%

What waterbody or bodies exist on or near your property or place of residence? (stream, river, ditch, lake, pond, etc.). If none apply, skip to question 12.

Creek	18%
Lake	26%
None	4%
Stream	6%
Pond	4%
River	2%
Sink Hole	2%
Unknown	2%
Lake/Pond	2%
Ditch/Creek	2%
Creek/Stormwater Ditch	2%
Ditch	2%
N/A	28%

If you know the name of the waterbody (Little Jackson Creek, Jackson Creek, Kilbourne Creek/Devils' Ditch, Gills Creek), please provide the name. If you do not know the name of the waterbody, simply state "a waterbody does exist."

Arcadia Lake	6%
Cary Lake	8%
Congaree River	2%
Cary Lake/Devils Ditch	2%
Devils Ditch/Gills Creek	2%
Forest Lake	2%
Gills Creek	8%
Ilex St. Di.	2%
Jackson Creek	4%
Kilbourne	4%
Lake Katharine	4%
Lower Rock	2%
Penn Branch	2%
Other	12%
Rowls Creek	2%
Upper Rockyford Lake	2%
Windsor Lake	4%
N/A	32%

How would you describe the land within 10 feet of the banks of the waterbody?

Bare rock/soil	2%
Mixture of trees and lawn	22%
Trees, woods, or forest	20%
Pavement	2%
Mixture of All of Above	6%
Other	22%
No Answer	26%

How would you describe the land within 100 feet of the banks of the waterbody?

Bare rock/soil	0%
Lawn	2%
Mixture of trees and lawn	12%
Trees, woods, or forest	26%
Pavement	2%
Other	16%
Mixture of all above	10%
Not located within 100 ft	4%
N/A	28%

What type of waste management (public sewer, septic tank, other) do you have? Please note any leaks or other problems you have with your waste management system.

City/Public Sewer	74%
Septic Tank	2%
No Answer	24%

How would rate the severity of sediment build-up in the waterbody on or near your property (0 being no sediment build-up, 1 being least severe and 5 being very severe)?

0	18%
1	8%
2	8%
3	16%
4	12%
5	18%
NA	20%

How would you rate the severity of trash build-up within or near the waterbody (0 being no trash, 1 being small amount of trash, and 5 being large amount of trash)?

0	14%
1	10%
2	16%
3	12%
4	12%
5	18%
NA	18%

How often has your property or your place of residence flooded within the last year?

Never	68%
Once	4%
Between two and five times	20%
Between six and ten times	2%
Greater than 10 times	2%
No Answer	4%

How would you rate the severity of flooding on your property or place of residence within the last year?

No flooding occurs	58%
Water ponds in low points of your yard	26%
You cannot drive out of neighborhood due to a flooded driveway or street, or other flooding	2%
Water is in your home	4%
Water is in your home and you cannot get out of the neighborhood	10%

Describe any concerns regarding storm drains on your street and/or storm drain pipes flowing into a waterbody near your home. This may include drains clogging and causing flooding or impacts to a waterbody downstream.

Water Quality	2%
Education	2%
Pollution-Other	6%
Sewer Discharge	2%
Other	12%
Flooding	2%
Trash/Litter	8%
General	2%
Sedimentation	8%
Lake Use	2%
Development	4%
N/A	32%
None	16%
Regulations	2%

(This page left intentionally blank.)

Appendix B. HSPF Subwatersheds

SW ID	HSPF ID	Acres
EM-01	GC_m1_t1	2660
GC-01	GC_m1_t2_3	3330
GC-02	GC_m1_t2_2	10171
GC-03	GC_m1_t2_1	550
GC-04	GC_m1_5	1360
GC-05	GC_m1_4	3189
GC-06	GC_m1_3	5994
GC-07	GC_m1_2	3362
GC-08	Added by Tetra Tech	941
GC-09	GC_m1_1	4110
JC-01	GC_m1_9	2347
JC-02	GC_m1_8	690
JC-03	GC_m1_7	2178
JC-04	GC_m1_6	1655
LJ-01	GC_m1_t3_2	3895
LJ-02	GC_m1_t3_t1_1	886
LJ-03	GC_m1_t3_1	843

(This page left intentionally blank.)

Appendix C. Critical Areas Scoring

Table C-1. Tier I Scoring Assumptions

Flooding

Hot Spots – Flooding

Criteria	Metric Value	Score
At least one location with non-survey flooding hot spot, or with survey response "flooding in home" or "flooded street/driveway."	High	1
Flooding concerns were indicated on survey, but none more severe than ponding in yard; no non-survey hot spots.	Moderate	0.5
No flooding risks indicated in survey or non-survey hot spots.	Low	0

FEMA floodplain

Criteria	Metric Value	Score
Does the subwatershed contain significant developed areas that intersect the floodplain?	High Risk	1
If no to above, does development exist near the floodplain boundary?	Moderate Risk	0.5
All other subwatersheds.	Low Risk	0

Data source: NLCD 2001, aerial photographs, and scanned/georeferenced 1994 FEMA floodplain maps.

Sedimentation

Hot Spots – Instream or inlake sediment: Average rating from stakeholder survey (non-survey hot spots count as highest rating).

Criteria	Metric Value	Score
75% quartile or higher	3.3	1
Median	2.0	0.5
All other subwatersheds	<2	0

Trash

Hot Spots – Trash: Average rating from stakeholder survey (non-survey hot spots count as highest rating).

Criteria	Metric Value	Score
75% quartile or higher	2.4	1
Median	1.0	0.5
All other subwatersheds	<1	0

Water Quality and Aquatic Ecosystems

303(d) listed waterbodies

Criteria	Metric Value	Score
Is a 303(d) listed waterbody present in the subwatershed?	Listed	1
All other subwatersheds	Not Listed	0

Data source: 2008 South Carolina 303(d) List

Use advisories

Criteria	Metric Value	Score
Has a fish use advisory been issued for a waterbody in the subwatershed?	Advisory	1
All other subwatersheds	None	0

Data source: DHEC 2008 Fish Consumption Advisory Areas; mercury advisories were the only type occurring in the watershed.

Wildlife (impacted subwatersheds are scored higher)

Percent forest and wetlands in SW (protected and unprotected)

Criteria	Metric Value (upper limit)	Score
25% quartile or lower	18%	1
Median or lower	25%	0.5
All other subwatersheds	35%	0

Data source: NLCD 2001 Land Use/ Land Cover

Percent forest and wetlands in riparian zone (protected and unprotected)

Criteria	Metric Value (upper limit)	Score
25% quartile or lower	37%	1
Median or lower	44%	0.5
All other subwatersheds	58%	0

Data source: NLCD 2001 Land Use/ Land Cover and riparian zone delineated by Tetra Tech.

Observations of threatened and endangered species

Criteria	Metric Value (upper limit)	Score
No observations	0	1
One observation	1	0.5
More than one observation	2	0

Data source: SC Department of Natural Resources (DNR)

Table C-2. Tier I Metrics

	Flooding		Sedimentation	Trash	Water Quality and Aquatic Ecosystems		Wildlife		
SW_ID	**Hot Spots -Flooding**	**FEMA Floodplain**	**Hot Spots - Instream Sediment**	**Hot Spots -Trash**	**303(d)**	**Use Advisory**	**Percent Forest and Wetlands in SW (protected and unprotected)**	**Percent Forest and Wetlands in Riparian Zone (protected and unprotected)**	**Observations of Threatened and Endangered Species**
EM-01	Low	High Risk	2.5	0.0	Not Listed	None	10%	34%	0
GC-01	Low	Low Risk	3.0	2.0	Not Listed	None	49%	76%	2
GC-02	Low	Low Risk	5.0	0.0	Not Listed	None	59%	83%	3
GC-03	Moderate	Moderate Risk	3.0	3.0	Not Listed	None	20%	34%	0
GC-04	Low	High Risk	1.0	2.0	Listed	Mercury	17%	37%	0
GC-05	Moderate	High Risk	3.4	2.4	Not Listed	None	18%	37%	0
GC-06	High	High Risk	2.0	2.2	Listed	None	26%	58%	2
GC-07	High	High Risk	3.3	2.5	Listed	None	17%	38%	1
GC-08	Low	High Risk	0.0	0.0	Not Listed	None	32%	50%	0
GC-09	Low	Moderate Risk	0.0	0.0	Not Listed	None	35%	72%	1
JC-01	Low	Moderate Risk	0.0	0.0	Listed	Mercury	25%	50%	2
JC-02	Low	Low Risk	0.0	0.0	Not Listed	Mercury	85%	96%	2
JC-03	Low	Moderate Risk	1.0	1.0	Listed	Mercury	26%	44%	0
JC-04	High	Moderate Risk	4.0	3.5	Not Listed	Mercury	19%	35%	0
LJ-01	Low	High Risk	0.0	0.0	Not Listed	None	25%	39%	2
LJ-02	Low	Moderate Risk	0.0	0.0	Not Listed	None	40%	58%	0
LJ-03	Low	High Risk	4.0	5.0	Not Listed	None	7%	9%	1
Statistics									
Minimum	NA	NA	0.0	0.0	NA	NA	7%	9%	0.0
25%	NA	NA	0.0	0.0	NA	NA	18%	37%	0.0
Median	NA	NA	2.0	1.0	NA	NA	25%	44%	1.0
75%	NA	NA	3.3	2.4	NA	NA	35%	58%	2.0
Maximum	NA	NA	5.0	5.0	NA	NA	85%	96%	3.0

Table C-3. Tier I Scores

SW_ID	Flooding: Hot Spots - Flooding	Flooding: FEMA floodplain	Sedimentation: Hot Spots - Instream sediment	Trash: Hot Spots - Trash	Water Quality and Aquatic Ecosystems: 303(d)	Water Quality and Aquatic Ecosystems: Use advisory	Wildlife: Percent forest and wetlands in SW (protected and unprotected)	Wildlife: Percent forest and wetlands in riparian zone (protected and unprotected)	Wildlife: Observations of threatened and endangered species
Weight	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
EM-01	0.0	1.0	0.5	0.0	0.0	0.0	1.0	1.0	1.0
GC-01	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0
GC-02	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
GC-03	0.5	0.5	0.5	1.0	0.0	0.0	0.5	1.0	1.0
GC-04	0.0	1.0	0.0	0.5	1.0	1.0	1.0	1.0	1.0
GC-05	0.5	1.0	1.0	1.0	0.0	0.0	1.0	0.5	1.0
GC-06	1.0	1.0	0.5	0.5	1.0	0.0	0.0	0.0	0.0
GC-07	1.0	1.0	1.0	1.0	1.0	0.0	1.0	0.5	0.5
GC-08	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
GC-09	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5
JC-01	0.0	0.5	0.0	0.0	1.0	1.0	0.5	0.0	0.0
JC-02	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
JC-03	0.0	0.5	0.0	0.5	1.0	1.0	0.0	0.5	1.0
JC-04	1.0	0.5	1.0	1.0	0.0	1.0	0.5	1.0	1.0
LJ-01	0.0	1.0	0.0	0.0	0.0	0.0	0.5	0.5	0.0
LJ-02	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	1.0
LJ-03	0.0	1.0	1.0	1.0	0.0	0.0	1.0	1.0	0.5

Table C-4. Tier II Scoring Assumptions

BMP Retrofits

Upstream of Tier I Critical Area

Criteria	Metric Value	Score
Is the subwatershed upstream of, or within a Flooding, Water Quality and/or Aquatic Ecosystems Tier 1 Critical Area?	Yes	1
All other subwatersheds	No	0

Impervious area

Criteria	Metric Value (lower limit)	Score
Is the subwatershed's average imperviousness greater than or equal to the median percent?	22%	1
Is the subwatershed's average imperviousness greater than or equal to the 25% quartile?	19%	0.5
All other subwatersheds	2%	0

Data source: NLCD 2001 Impervious Cover

Impervious area in riparian zone

Criteria	Metric Value (lower limit)	Score
Is the subwatershed's average percent imperviousness within the riparian zone greater than median percent?	10%	1
Is the subwatershed's average percent imperviousness within the riparian zone greater than the 25% quartile?	4%	0.5
All other subwatersheds	0%	0

Data source: NLCD 2001 Impervious Cover and riparian zone delineated by Tetra Tech.

Developed area in riparian zone

Criteria	Metric Value (lower limit)	Score
Is the subwatershed's average percent developed area within the riparian zone greater than the median percent?	39%	1
Is the subwatershed's average percent developed area within the riparian zone greater than the 25% quartile?	14%	0.5
All other subwatersheds	1%	0

Data source: NLCD 2001Land Use/ Land Cover and riparian zone delineated by Tetra Tech.

Hot Spots – Post-construction

Criteria	Metric Value	Score
Does the subwatershed contain one or more post-construction hot spots designated by stakeholders?	Yes	1
All other subwatersheds	No	0

High score in restoration (within SW or upstream)

Criteria	Metric Value	Score
Is the subwatershed within or upstream of a Tier II Stream and Riparian Buffer Restoration Critical Area?	Yes	1
All other subwatersheds	No	0

Trash

Upstream of Tier I Critical Area

Criteria	Metric Value	Score
Is the subwatershed upstream of, or within a Trash Tier 1 Critical Area?	Yes	1
All other subwatersheds	No	0

Stream and Riparian Buffer Restoration

Upstream of Tier I Critical Area

Criteria	Metric Value	Score
Is the subwatershed upstream of, or within a Sedimentation and Water Quality and Aquatic Ecosystems Tier 1 Critical Area?	Yes	1
All other subwatersheds	No	0

Percent forest and wetlands in riparian zone (protected and unprotected)

Criteria	Metric Value (upper limit)	Score
25% quartile or lower	37%	1
Median or lower	44%	0.5
All other subwatersheds	58%	0

Data source: NLCD 2001 and riparian zone delineated by Tetra Tech.

Hot Spots – Bank erosion

Criteria	Metric Value	Score
Does the subwatershed contain one or more bank erosion hot spots designated by stakeholders?	Yes	1
All other subwatersheds	No	0

Subsurface K-factor within 10-ft of stream

Criteria	Metric Value (lower limit)	Score
75% quartile or higher	29%	1
Median or higher	27%	0.5
All other subwatersheds	22%	0

Data source: USDA Natural Resources Conservation Service (NRCS) Soil Survey GIS Data

Impervious surface within 10-ft of stream

Criteria	Metric Value (lower limit)	Score
75% quartile or higher	16%	1
Median or higher	13%	0.5
All other subwatersheds	3%	0

Data source: NLCD 2001 Impervious Cover and riparian zone delineated by Tetra Tech.

Stormwater outfalls per stream mile

Criteria	Metric Value (lower limit)	Score
75% quartile or higher	342%	1
Median or higher	204%	0.5
All other subwatersheds	37%	0

Data source: Outfall locations received from City of Columbia and Richland County.

Preservation

Adjacent to Tier I Critical Area

Criteria	Metric Value	Score
Is the subwatershed within or adjacent to any Wildlife Tier 1 Critical Areas?	Yes	1
All other subwatersheds	No	0

Percent forest and wetlands in SW (unprotected)

Criteria	Metric Value	Score
75% quartile or higher	22%	1
Median or higher	16%	0.5
All other subwatersheds	8%	0

Data source: NLCD 2001 Land Use/ Land Cover and SC Gap Analysis Program Stewardship Data

Percent forest and wetlands in riparian zone (unprotected)

Criteria	Metric Value	Score
75% quartile or higher	39%	1
Median or higher	34%	0.5
All other subwatersheds	24%	0

Data source: NLCD 2001 Land Use/ Land Cover

New Development Regulations

Upstream of highest scoring Tier I Critical Area

Criteria	Metric Value	Score
Is the subwatershed upstream of one of the highest scoring Tier 1 Critical Areas?	Yes	1
All other subwatersheds	No	0

Hot Spots – Construction

Criteria	Metric Value	Score
Does the subwatershed contain one or more construction hot spots designated by stakeholders?	Yes	1
All other subwatersheds	No	0

Percent forest and wetlands in SW (unprotected)

Criteria	Metric Value	Score
75% quartile or higher	22%	1
Median or higher	16%	0.5
All other subwatersheds	8%	0

Data source: NLCD 2001 Land Use/ Land Cover and SC Gap Analysis Program Stewardship Data

Percent forest and wetlands in riparian zone (unprotected)

Criteria	Metric Value	Score
75% quartile or higher	39%	1
Median or higher	34%	0.5
All other subwatersheds	24%	0

Data source: NLCD 2001 Land Use/ Land Cover

Surface K-factor in SW

Criteria	Metric Value	Score
75% quartile or higher	15%	1
Median or higher	14%	0.5
All other subwatersheds	13%	0

Data source: USDA Natural Resources Conservation Service (NRCS) Soil Survey GIS Data

Average % Slope

Criteria	Metric Value	Score
75% quartile or higher	4.9%	1
Median or higher	4.7%	0.5
All other subwatersheds	4.2%	0

Data source: Calculated from USGS National Elevation Dataset

Population Trend to 2018

Criteria	Metric Value	Score
Is the subwatershed likely to experience a relatively high rate of population growth between now and 2018?	High	1
– A moderate rate?	Moderate	0.5
All other subwatersheds	Low	0

Data source: Comparison of population density from 2000 U.S. Census; highest rates were estimated for developable subwatersheds with the lowest densities in 2000.

Other Policies and Outreach

Upstream of highest scoring Tier I Critical Area

Criteria	Metric Value	Score
Is the subwatershed upstream of, or within one of the highest scoring Tier 1 Critical Areas?	Yes	1
All other subwatersheds	No	0

Upstream of multiple watershed concerns

Criteria	Metric Value	Score
Is the subwatershed upstream of, or within a Critical Area for **all 5** watershed concerns?	5	1
Is the subwatershed upstream of, or within a Critical Area for **more than 2** watershed concerns?	More than 2	0.5
All other subwatersheds	No	0

Table C-5. Tier II Metrics – BMP Retrofits and Trash

	BMP Retrofits						Trash
SW_ID	Upstream of Critical Area	Impervious (%)	Impervious (%) in riparian zone	Developed (%)	Hot Spots - Post-construction	High score in restoration (within SW or upstream)	Upstream of Critical Area
EM-01	Yes	28%	16%	63%	No	Yes	Yes
GC-01	Yes	9%	3%	14%	No	Yes	Yes
GC-02	Yes	5%	4%	12%	Yes	Yes	Yes
GC-03	Yes	21%	10%	45%	No	Yes	Yes
GC-04	Yes	23%	9%	43%	No	Yes	Yes
GC-05	Yes	26%	17%	59%	No	No	Yes
GC-06	Yes	22%	10%	34%	No	No	Yes
GC-07	Yes	28%	21%	55%	No	No	Yes
GC-08	No	32%	0%	2%	No	No	No
GC-09	No	8%	2%	7%	No	No	No
JC-01	Yes	19%	6%	39%	No	No	Yes
JC-02	Yes	2%	0%	1%	No	No	Yes
JC-03	Yes	24%	11%	42%	Yes	No	Yes
JC-04	Yes	25%	10%	34%	Yes	Yes	Yes
LJ-01	Yes	21%	13%	53%	No	Yes	Yes
LJ-02	Yes	19%	7%	30%	No	Yes	Yes
LJ-03	Yes	46%	44%	89%	Yes	Yes	Yes
Statistics							
Minimum	NA	2%	0%	1%	NA	NA	NA
25%	NA	19%	4%	14%	NA	NA	NA
Median	NA	22%	10%	39%	NA	NA	NA
75%	NA	26%	13%	53%	NA	NA	NA
Maximum	NA	46%	44%	89%	NA	NA	NA

Table C-6. Tier II Metrics – Restoration and Preservation

SW_ID	Stream and Riparian Buffer Restoration						Preservation		
	Upstream of Critical Area	Percent Forest and Wetlands in Riparian Zone (protected and unprotected)	Hot Spots - Bank Erosion	Subsurface K-factor within 10-ft of Stream	Impervious Surface within 10-ft of Stream	Stormwater Outfalls per Stream Mile	Adjacent to Critical Area	Percent Forest and Wetlands in SW (unprotected)	Percent Forest and Wetlands In Riparian Zone (unprotected)
EM-01	Yes	34%	No	0.20	16%	7.0	Yes	10%	34%
GC-01	Yes	76%	No	0.29	3%	0.6	No	8%	18%
GC-02	Yes	83%	No	0.28	5%	0.0	Yes	1%	2%
GC-03	Yes	34%	No	0.19	16%	0.4	Yes	20%	34%
GC-04	Yes	37%	Yes	0.21	13%	3.0	Yes	16%	35%
GC-05	Yes	37%	No	0.19	20%	8.9	Yes	16%	32%
GC-06	Yes	58%	No	0.28	10%	4.9	Yes	14%	29%
GC-07	Yes	38%	No	0.28	29%	1.1	No	17%	38%
GC-08	No	50%	No	0.35	0%	0.0	No	32%	50%
GC-09	No	72%	No	0.34	2%	0.6	No	35%	72%
JC-01	Yes	50%	No	0.23	3%	3.6	No	6%	24%
JC-02	Yes	96%	No	0.31	0%	0.0	No	6%	2%
JC-03	Yes	44%	No	0.26	14%	2.4	No	22%	41%
JC-04	Yes	35%	No	0.22	15%	3.4	Yes	19%	35%
LJ-01	Yes	39%	No	0.25	13%	2.9	No	23%	39%
LJ-02	Yes	58%	No	0.32	6%	0.0	No	23%	40%
LJ-03	Yes	9%	No	0.27	40%	2.0	No	7%	9%
Statistics									
Minimum	NA	9%	NA	0.19	0%	0.0	NA	1%	2%
25%	NA	37%	NA	0.22	3%	0.4	NA	8%	24%
Median	NA	44%	NA	0.27	13%	2.0	NA	16%	34%
75%	NA	58%	NA	0.29	16%	3.4	NA	22%	39%
Maximum	NA	96%	NA	0.35	40%	8.9	NA	35%	72%

Table C-7. Tier II Metrics – New Development Regulations

SW_ID	New Development Regulations						
	Upstream of Highest Scoring Critical Area	Hot Spots - Construction	Percent Forest and Wetlands in SW (unprotected)	Percent Forest and Wetlands in Riparian Zone (unprotected)	Surface K-factor in SW	Average % Slope	Population Trend to 2018
EM-01	Yes	Yes	10%	34%	0.14	4.8%	Low
GC-01	Yes	No	8%	18%	0.13	4.4%	Moderate
GC-02	Yes	Yes	1%	2%	0.14	5.0%	Low
GC-03	Yes	No	20%	34%	0.13	4.8%	Low
GC-04	Yes	Yes	16%	35%	0.14	3.8%	Moderate
GC-05	Yes	Yes	16%	32%	0.15	4.2%	Low
GC-06	Yes	Yes	14%	29%	0.15	4.2%	Moderate
GC-07	Yes	No	17%	38%	0.17	1.9%	Moderate
GC-08	No	No	32%	50%	0.20	1.8%	Low
GC-09	No	No	35%	72%	0.26	1.1%	Low
JC-01	Yes	No	6%	24%	0.12	5.4%	High
JC-02	Yes	No	6%	2%	0.14	4.7%	High
JC-03	Yes	No	22%	41%	0.14	4.8%	Low
JC-04	Yes	Yes	19%	35%	0.13	4.9%	Moderate
LJ-01	Yes	No	23%	39%	0.14	4.7%	High
LJ-02	Yes	No	23%	40%	0.14	5.8%	High
LJ-03	Yes	No	7%	9%	0.13	5.3%	Low
Statistics							
Minimum	NA	NA	1%	2%	0.12	1.1%	NA
25%	NA	NA	8%	24%	0.13	4.2%	NA
Median	NA	NA	16%	34%	0.14	4.7%	NA
75%	NA	NA	22%	39%	0.15	4.9%	NA
Maximum	NA	NA	35%	72%	0.26	5.8%	NA

Table C-8. Tier II Metrics – Other Policies and Outreach

SW_ID	Other Policies and Outreach	
	Upstream of Highest Scoring Critical Area	Upstream of Multiple Watershed Concerns
EM-01	Yes	More than 2
GC-01	Yes	More than 2
GC-02	Yes	More than 2
GC-03	Yes	More than 2
GC-04	Yes	More than 2
GC-05	Yes	More than 2
GC-06	Yes	More than 2
GC-07	Yes	More than 2
GC-08	No	No
GC-09	No	No
JC-01	Yes	More than 2
JC-02	Yes	More than 2
JC-03	Yes	More than 2
JC-04	Yes	More than 2
LJ-01	Yes	More than 2
LJ-02	Yes	More than 2
LJ-03	Yes	More than 2

Table C-9. Tier II Scores – BMP Retrofits and Trash

SW_ID	BMP Retrofits						Trash
	Upstream of Critical Area	Impervious (%)	Impervious (%) in Riparian Zone	Developed (%)	Hot Spots - Post-construction	High Score in Restoration (within SW or upstream)	Upstream of Critical Area
Weight	1	1	1	1	1	1	1
EM-01	1.0	1.0	1.0	1.0	0.0	1.0	1.0
GC-01	1.0	0.0	0.0	0.5	0.0	1.0	1.0
GC-02	1.0	0.0	0.5	0.0	1.0	1.0	1.0
GC-03	1.0	0.5	1.0	1.0	0.0	1.0	1.0
GC-04	1.0	1.0	0.5	1.0	0.0	1.0	1.0
GC-05	1.0	1.0	1.0	1.0	0.0	0.0	1.0
GC-06	1.0	1.0	1.0	0.5	0.0	0.0	1.0
GC-07	1.0	1.0	1.0	1.0	0.0	0.0	1.0
GC-08	0.0	1.0	0.0	0.0	0.0	0.0	0.0
GC-09	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JC-01	1.0	0.5	0.5	1.0	0.0	0.0	1.0
JC-02	1.0	0.0	0.0	0.0	0.0	0.0	1.0
JC-03	1.0	1.0	1.0	1.0	1.0	0.0	1.0
JC-04	1.0	1.0	1.0	0.5	1.0	1.0	1.0
LJ-01	1.0	0.5	1.0	1.0	0.0	1.0	1.0
LJ-02	1.0	0.5	0.5	0.5	0.0	1.0	1.0
LJ-03	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table C-10. Tier II Scores – Restoration and Preservation

SW_ID	Stream and Riparian Buffer Restoration						Preservation		
	Upstream of Critical Area	Percent Forest and Wetlands in Riparian Zone (protected and unprotected)	Hot Spots - Bank Erosion	Subsurface K-factor within 10-ft of Stream	Impervious Surface within 10-ft of Stream	Stormwater Outfalls per Stream Mile	Upstream of Critical Area	Percent Forest and Wetlands in SW (unprotected)	Percent Forest and Wetlands in Rriparian Zone (unprotected)
Weight	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
EM-01	1.0	1.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0
GC-01	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
GC-02	1.0	0.0	0.0	0.5	0.0	0.0	1.0	0.0	0.0
GC-03	1.0	1.0	0.0	0.0	1.0	0.0	1.0	0.5	0.5
GC-04	1.0	1.0	1.0	0.0	0.5	0.5	1.0	0.5	0.5
GC-05	1.0	0.5	0.0	0.0	1.0	1.0	1.0	0.0	0.0
GC-06	1.0	0.0	0.0	0.5	0.0	1.0	1.0	0.0	0.0
GC-07	1.0	0.5	0.0	0.5	1.0	0.0	0.0	0.5	0.5
GC-08	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0
GC-09	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0
JC-01	1.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0
JC-02	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0
JC-03	1.0	0.5	0.0	0.0	0.5	0.5	0.0	1.0	1.0
JC-04	1.0	1.0	0.0	0.0	0.5	1.0	1.0	0.5	0.5
LJ-01	1.0	0.5	0.0	0.0	0.5	0.5	0.0	1.0	1.0
LJ-02	1.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0
LJ-03	1.0	1.0	0.0	0.5	1.0	0.5	0.0	0.0	0.0

Table C-11. Tier II Scores – New Development Regulations

	New Development Regulations						
SW_ID	Upstream of Critical Area	Hot Spots - Construction	Percent Forest and Wetlands in SW (unprotected)	Percent Forest and Wetlands in Riparian Zone (unprotected)	Surface K-Factor in SW	Average % Slope	Population Trend to 2018
Weight	**1**	**1**	**1**	**1**	**1**	**1**	**1**
EM-01	1.0	1.0	0.0	0.0	0.5	0.5	0.0
GC-01	1.0	0.0	0.0	0.0	0.0	0.0	0.5
GC-02	1.0	1.0	0.0	0.0	0.5	1.0	0.0
GC-03	1.0	0.0	0.5	0.5	0.0	0.5	0.0
GC-04	1.0	1.0	0.5	0.5	0.5	0.0	0.5
GC-05	1.0	1.0	0.0	0.0	1.0	0.0	0.0
GC-06	1.0	1.0	0.0	0.0	1.0	0.0	0.5
GC-07	1.0	0.0	0.5	0.5	1.0	0.0	0.5
GC-08	0.0	0.0	1.0	1.0	1.0	0.0	0.0
GC-09	0.0	0.0	1.0	1.0	1.0	0.0	0.0
JC-01	1.0	0.0	0.0	0.0	0.0	1.0	1.0
JC-02	1.0	0.0	0.0	0.0	0.5	0.5	1.0
JC-03	1.0	0.0	1.0	1.0	0.0	0.5	0.0
JC-04	1.0	1.0	0.5	0.5	0.0	1.0	0.5
LJ-01	1.0	0.0	1.0	1.0	0.0	0.0	1.0
LJ-02	1.0	0.0	1.0	1.0	0.0	1.0	1.0
LJ-03	1.0	0.0	0.0	0.0	0.0	1.0	0.0

Table C-12. Tier II Scores – Other Policies and Outreach

SW_ID	Other Policies and Outreach	
	Upstream of Critical Area	Upstream of Multiple Watershed Concerns
Weight	**1**	**1**
EM-01	1.0	0.5
GC-01	1.0	0.5
GC-02	1.0	0.5
GC-03	1.0	0.5
GC-04	1.0	0.5
GC-05	1.0	0.5
GC-06	1.0	0.5
GC-07	1.0	0.5
GC-08	0.0	0.0
GC-09	0.0	0.0
JC-01	1.0	0.5
JC-02	1.0	0.5
JC-03	1.0	0.5
JC-04	1.0	0.5
LJ-01	1.0	0.5
LJ-02	1.0	0.5
LJ-03	1.0	0.5

(This page left intentionally blank.)

Appendix D. BMP Retrofit Maintenance Activities

Table D-1. Major Activities Required to Maintain Stormwater BMP Retrofits

BMP Retrofit	Annually/Bi-annually	Regularly/After Major Storm Events
Wet Pond	Check for and remove excess sediment accumulation (annually) Inspect inlet/outlet structures and associated valves for permanent damage Remove woody vegetation along dam faces Remove invasive plant species and reseed/replant desired vegetation Mow perimeter of pond Stabilize any bank erosion Control for pests such as beavers and muskrats	Check for and remove floating trash and debris Keep outlet draw-down orifices free-flowing by removing any obstructions
Stormwater Wetland	Check for and remove excess sediment accumulation (annually) Inspect inlet/outlet structures and associated valves for permanent damage Remove woody vegetation along dam faces Remove invasive plant species and reseed/replant desired vegetation Stabilize any bank erosion Control for pests such as beavers and muskrats	Check for and remove floating trash and debris Keep outlet draw-down orifices free-flowing by removing any obstructions
Bioretention/Rain Gardens	Add fresh mulch layer (replace all mulch every 2-3 years) Inspect underdrain for clogging Soil test for toxins and heavy metals Adjust pH with lime as needed Remove and replace any dead or diseased plants	Water plants during drought conditions Remove trash and debris from outlet structure
Tree Boxes	Replace top media layer (mulch and stone) Remove debris/trash	Water plants in drought conditions during establishment
Green Streets	Clean underdrains for all infiltrative devices	Street sweepings

BMP Retrofit	Annually/Bi-annually	Regularly/After Major Storm Events
	Inspect inlets, grates, and sedimentation devices Replace dead or diseased vegetation	Debris removal Landscape maintenance
Permeable Pavement	Repeat surface infiltration test Check underdrain for clogging (if applicable) Vacuum street sweep	None
Rain Barrels	Remove sediment from bottom of rain barrel	Check gutter connections Clean gutters of leaves as needed Check mosquito screens
Cisterns	Remove sediment from bottom of cistern Maintain pumps and filters per manufacturer's recommendations	Check gutter connections Clean gutters of leaves as needed Check mosquito screens
Green Roofs	Clean drains and downspouts Inspect roof membranes and re-waterproof if needed Inspect drainage layer flow paths	Watering and fertilizing as needed during plant establishment Inspect for leaks along abutting walls, roof vent pipes, AC units, etc. Remove any weed species during establishment
Filter Strip & Level Spreader	Remove woody growth within spreader lip and impeding downslope flow Remove debris and sediment accumulation in spreader, forebay, and channel	Examine spreader and riparian buffer for erosion and gulley formation Remove sediment/debris buildup, if necessary, at 2-year+ storm events Mow vegetation downslope of level spreader

References:

Hunt, W.F. and B. Lord. 2006. Maintenance of Stormwater Wetlands and Wet Ponds. Urban Waterways. NCCES, Raleigh, NC.

Tetra Tech. 2005. Stormwater Best Management Practice Information Packet for Landowners. Prepared for NC Ecosystem Enhancement Program.

Hunt, W.F. and M.P. Jones. 2008. Rainwater Harvesting: Guidance for Homeowners. Urban Waterways. NCCES, Raleigh, NC.

Hathaway, J.M. and W.F. Hunt. 2006. Level Spreaders: Overview, Design, and Maintenance. Urban Waterways. NCCES, Raleigh, NC.

(This page left intentionally blank.)

Appendix E. Public Comments

Table E-1. Public Comments Received at the Public Meeting or during the public comment period

Name	Affiliation	Live in Watershed	Watershed Goals and Objectives	Critical Areas	Management Scenarios	Other
Mike Paget		Yes		Trenholm Plaza parking lot has paved "chutes" that intentionally direct trash and runoff into Gills Creek		
James E Benson	Trenholm Acres Community Association	Yes	There is a water stream that runs from 277 across Parkview, Highview, Pinedale, and Claudia Drive into a water stream at Columbia Place, from there into Decker Blvd.	We have a hard time maintaining it. The county cut the grass and weeds a few months ago. We need some advice and help with project.	Columbia Place - Park Lane - Decker. Trash, develop into park.	
Judy Timmons	GCQA and Forest Lake Pres. Ch.	Yes		Forest Lake Presbyterian Church, North Trenholm Road, Columbia, C. Runoff from parking lot into storm drain which drains into Spring Lake.	Would like help about drainage from parking lot.	

Name	Affiliation	Live in Watershed	Watershed Goals and Objectives	Critical Areas	Management Scenarios	Other
Steve Stahcyk	Gregg Park	Yes	Clean up nutrients, sediments; maintain recharge areas such as swamps	Educating homeowners about their responsibilities to maintain their water courses - also boards of private communities	I would like to see a liaison set up with the Gregg Park Board of Directors to teach them proper management of their waterways. Currently, they have a Lakes & Trials subcommittee, but it is inactive.	
John Hard		Yes				Good meeting very informative. Richland Mall has a lot of paved surface. Might look at improving water quality and decrease quantity.

(This page left intentionally blank.)