The Georgia Environmental Protection Division (GA EPD) water quality rules (391-3-6.03(i)) state that fecal coliform cannot exceed a geometric mean of 200 per 100 ml during months of May through October and 1,000 per 100 ml during months of November through April. The standard can be increased during the summer months if data show that non-human sources exceed 200 per 100 ml for the geometric mean. A geometric mean is based on four samples collected over a 30-day period at intervals not less than 24 hours.

1.2.1 TMDL Plans and Historic Water Quality Data

The Georgia Environmental Protection Division issued a TMDL for 79 stream segments in the Chattahoochee River Basin in November 2008 (GA EPD 2008). This plan included percent reductions for Crooked, Marsh, and Ball Mill Creeks. Estimated current loads, the allowable load (or TMDL load), and percent reduction by stream segment are listed in Table 1-1.

Table 1-1. TMDL Fecal Coliform Load Reductions for Ball Mill, Crooked, and Marsh Creeks in Sandy Springs*

Stream Segment	Current Load (counts/30 days)	TMDL (counts/30 days)	Percent Reduction
Ball Mill Creek	2.49×10^{12}	1.23×10^{12}	51%
Crooked Creek	3.62×10^{12}	8.36×10^{11}	77%
Marsh Creek	9.64×10^{11}	3.85×10^{10}	60%

** GA EPD, 2008*

In addition, Long Island and Nancy Creeks are listed for fecal coliform in the same TMDL and have percent reductions of 52 percent and 84 percent, respectively. These creeks are covered under separate WIPs – Nancy Creek Watershed Improvement Plan and Long Island Creek Watershed Improvement Plan. The Nancy and Long Island WIP describe projects that will improve water quality and habitat for specific locations. However, general measures and activities to control fecal coliform bacteria outlined in this report can apply to all watersheds in Sandy Springs.

Fulton County has been collecting fecal coliform data on a quarterly basis over the past several years in segments listed on the 303(d) list for fecal coliform within the County limits. The data shown in Table 1-2 summarize the data from 2007 through 2009 at three of these stations that are within the study area. Several data exceed the water quality standards fecal coliform.

Table 1-2. Summary of Fecal Coliform Data (MPN/100ml) Collected by Fulton County from 2007 to 2009*

Fecal Coliform Count	Long Island Creek @ Northside Drive	Marsh Creek @ Brandon Mill Road	Ball Mill Creek near the Chattahoochee River
Minimum	255	129	96
Maximum	4,332	1,174	807
Average	1,312	615	355

** Data collected quarterly each year. Four samples taken each month and a geometric mean calculated from the four samples. These summary values represent the minimum, maximum and average geometric mean values for each quarterly set of samples.*

These data were plotted against discharge and precipitation records from the closest USGS gage #0235350 on Crooked Creek near Sandy Springs. There was a slight positive relationship between the amount of precipitation and greater discharge to fecal coliform bacteria; however, the correlation was very weak and the data were very scattered along the curve. This analysis indicates that the source of fecal coliform contamination in these creeks is diffuse throughout the watershed and from multiple types of sources. This corresponds with the TMDL plans for these creeks, which conclude that a combination of sources from urban runoff, animal waste, sanitary sewer overflows (SSOs), illicit connections, and possible failing septic tanks are likely sources of contamination.

1.3 Methods for Fecal Coliform Source Reduction

Fecal coliform reduction can be achieved through reduction in the source or treatment. There are various management strategies and treatment facilities. Management strategies can include:

- Ordinance development targeted at improving or protecting water quality
- Public education and outreach programs
- Monitoring programs to detect sources of contamination (dry weather screening, sewer inspections, etc.) and/or monitor for improvements.

Treatment facilities are structural Best Management Practices (BMPs) that target treating and reducing fecal coliform in stormwater runoff and can include:

- Wet detention facilities (ponds)
- Bioretention areas or other BMPs that promote infiltration such as sand filters
- Improve and increase the width and quality of riparian buffers
- Proprietary BMPs installed in stormwater conveyance that captures and treats fecal coliform.

Overall, regardless of the strategy, a program geared towards reducing fecal coliform contamination should be comprehensive and focus on the following principles:

- Decrease the supply/source – reduction will occur if sources of fecal coliform are isolated and eliminated
- Reduce the transportation and conveyance of fecal coliform bacteria
- Increase the time or distance that fecal coliform bacteria must travel to promote die-off before entering streams.

This report outlines specific measures taken by the City of Sandy Springs to identify and eliminate sources of bacteria from waterways, current projects that will reduce fecal coliform, and suggestions for future activities.

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1. INTRODUCTION

1.1 Goal of the Study

The goal of this study is to develop a watershed improvement plan that targets the reduction of fecal coliform bacteria in the Crooked, Ball Mill and Marsh Creek watersheds in addition to the tributaries draining directly into the Chattahoochee River. The plan developed to meet this goal is outlined in this report, the Fecal Coliform Watershed Improvement Plan (WIP). The Fecal Coliform WIP outlines the methods, results and recommendations aimed at improving and where possible restoring watershed function. This goal is achieved by implementing management activities and projects to meet specific water quality and/or habitat improvement goals.

The City of Sandy Springs initiated three separate studies in order to comply with various state and federal permit requirements and to understand the full scope and cost of developing a stormwater program. The three studies include future floodplain mapping, stormwater infrastructure inventory, and watershed improvement planning. A Watershed Improvement Plan has been developed for Nancy Creek and Long Island Creek (Brown and Caldwell 2010).

This report outlines the background, methodology, and results of the Fecal Coliform WIP. The Fecal Coliform WIP will satisfy municipal separate stormwater sewer system (MS4) Phase II, Metro District, and Total Maximum Daily Load (TMDL) Plan requirements as well as identify projects that will improve watershed conditions. The report is organized into the following chapters:

- Chapter 1 – Provides an introduction to the primary sources of fecal coliform in urban watersheds and an overview of the TMDL plans previously developed for the streams listed as not meeting water quality standards in Sandy Springs
- Chapter 2 – Provides background about the watershed and explains the development of watershed characteristics that are used to develop the baseline conditions model
- Chapter 3 – Summarizes the methodology and results from the stream inventory
- Chapter 4 – Covers historic stormwater best management practice (BMP) and stream restoration project evaluation and recommendations
- Chapter 5 – Discusses management activities and an implementation plan to improve water quality conditions and reduce fecal coliform in local streams.

1.2 Sources of Fecal Coliform Contamination

Generally, sources of fecal coliform contamination come from two categories – point and non-point. Point sources can be defined as discernable, discrete pollutants, such as leaking sanitary sewer pipes. Non-point sources can be defined as diffuse accumulation of fecal coliform over the land surfaces from various inputs and then wash off from the landscape during rain events. Based on direct observation from the stream inventory and the GAEPD Tier 2 TMDL Implementation Plan; urban runoff and animal sources (wildlife, pets, and livestock) in combination with sewer leaks/breaks and illicit discharges are the likely sources of fecal coliform contamination in Sandy Springs.

2. WATERSHED CHARACTERISTICS

2.1 Digital Elevation Model (DEM) and Watershed Delineation

The first step in watershed characterization is to determine the delineation of the area of study. This is accurately completed using DEM information when available. However, the actual drainage area will be impacted by the stormwater pipe network. The watersheds delineated for this study are based on the 16-foot DEM provided by the City of Sandy Springs. Areas outside of the City limits were supplemented with the best available topography data from the National Elevation Dataset (NED), the 1/3 arc second topography, which is a 30-foot DEM. Because so much of the City is urbanized, there is a large proportion of stormwater for smaller storm events that is routed through pipe networks as opposed to overland or open channel flow. In an effort to capture the true movement of stormwater in the study area, burnlines were created using both the USGS streams coverage and the stormwater pipe network provided by the City of Sandy Springs. The DEM was reconditioned using these burnlines. Watersheds boundaries delineated for this study will vary slightly from watersheds delineated for other studies done for Sandy Springs because of this correction for the piped network.

The study area watersheds were automatically delineated based on the reconditioned DEM using the ArcHydro program, which is an extension for ArcGIS. For this project, Crooked Creek, Ball Mill, and Marsh Creek watersheds were delineated, as shown on Figure 2-1.

2.2 Impervious Cover

Impervious cover is one of the most important aspects in a watershed study. Impervious area relates to the amount of roads, rooftops, sidewalks and other areas that do not allow rainwater to soak into the ground. Watersheds with high impervious area have high runoff and velocity from stormwater that impair streams. High runoff and velocity allows pollutants, including fecal coliform bacteria, to be transported to streams quickly.

The impervious cover provided on Figure 2-2 was created from several data sources. Street shapes were extracted from the existing zoning coverage provided by the City of Sandy Springs. For areas outside the Sandy Springs City limit that were part of the Crooked Creek study area, impervious area information for streets was obtained from Gwinnett County. Any street area shapes outside of the City Limits and the Crooked Creek study area were digitized by creating a 25-foot buffer around the centerlines of the Atlanta Regional Commission (ARC) 2005 streets dataset obtained from Georgia Department of Transportation (GA DOT) records.

The City provided a building footprint coverage, and all of these shapes were included in the impervious cover file. Impervious cover in commercial areas and residential apartment and townhome complexes was updated based on a combination of the most recent aerial photography provided by the City and the building footprint coverage. In addition, the adjacent parking lots and driveway shapes for commercial buildings, apartment buildings, and townhomes complexes were digitized based on aerial photography.

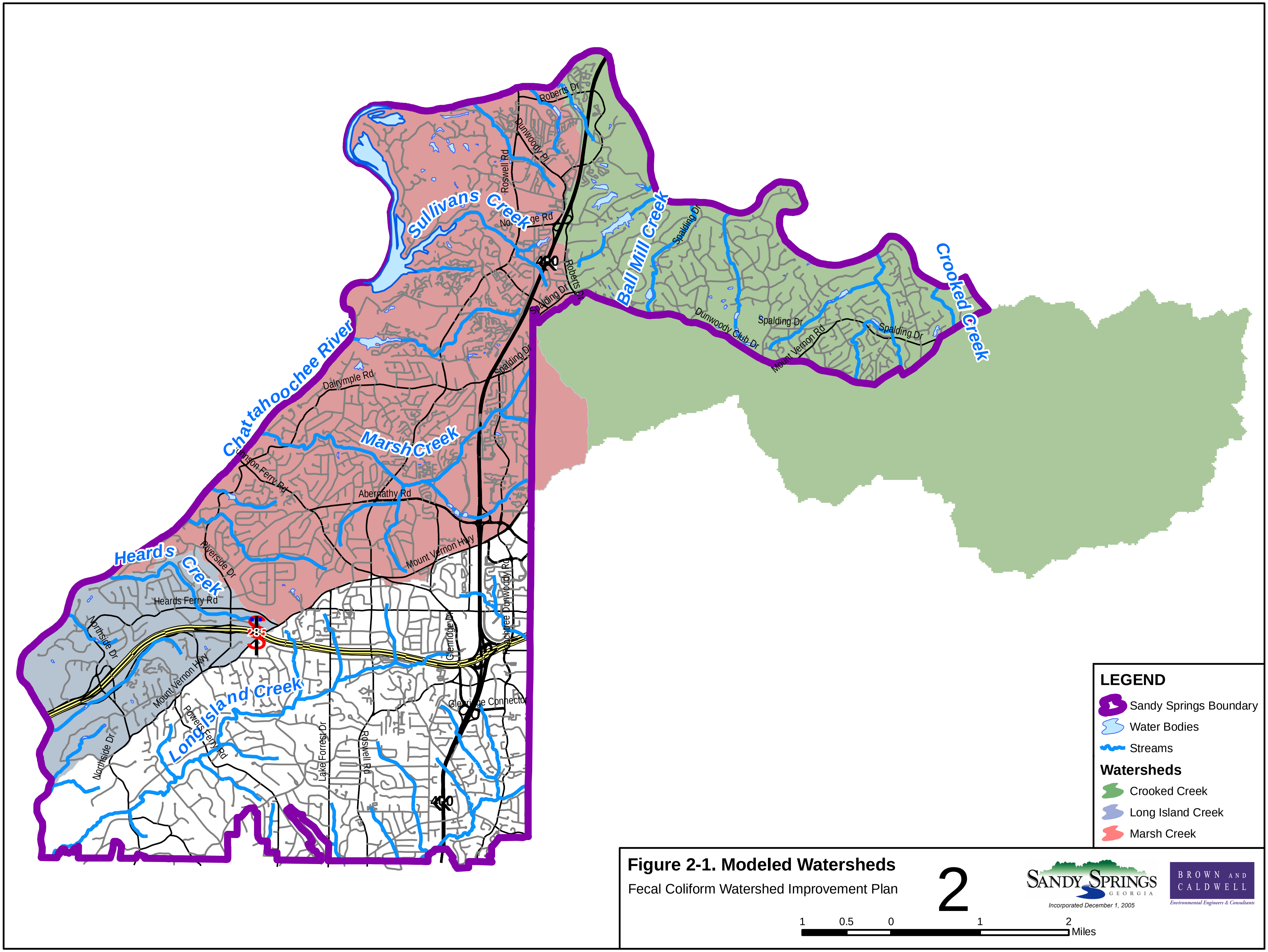

Figure 2-1. Modeled Watersheds

Fecal Coliform Watershed Improvement Plan

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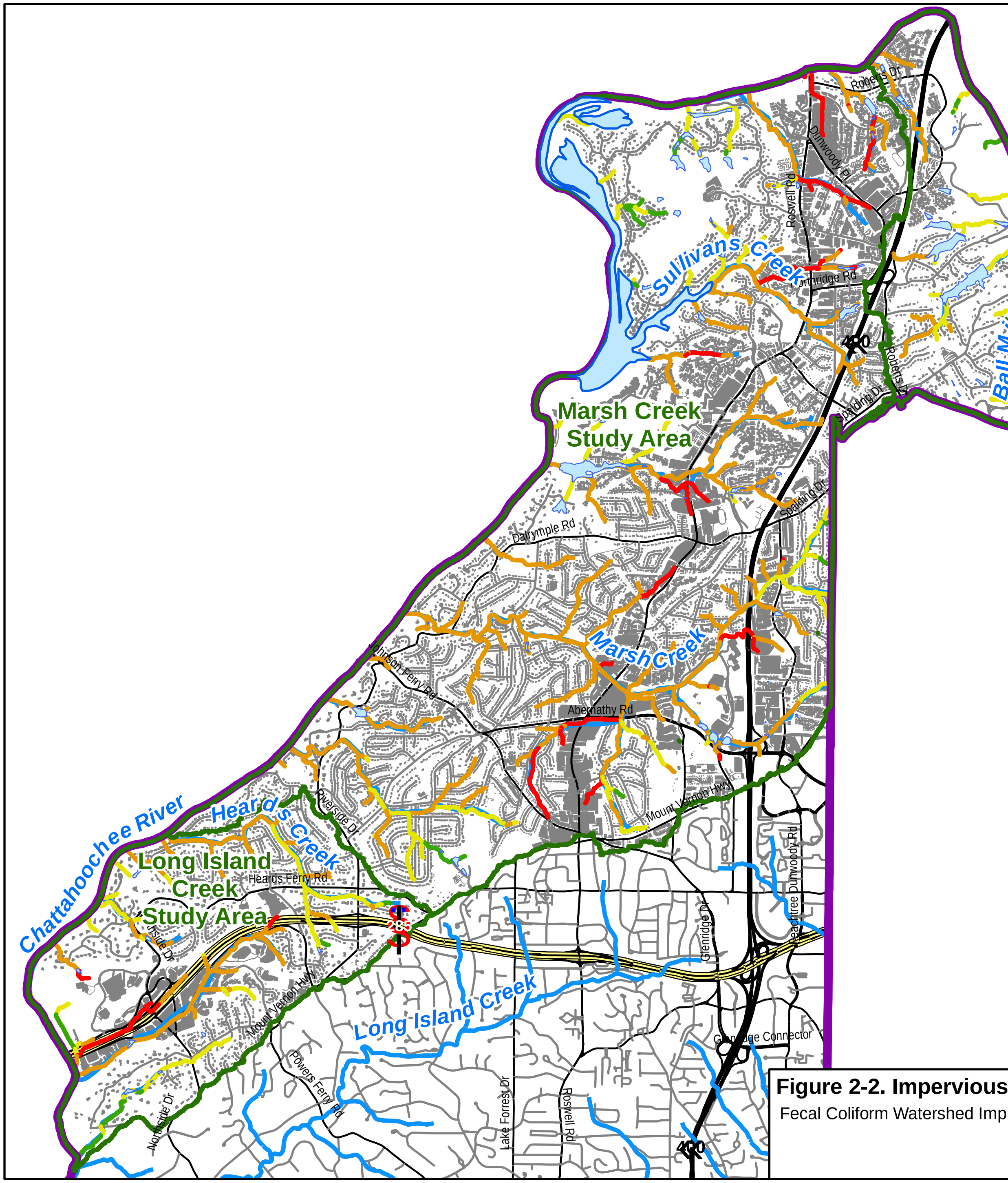

LEGEND

- Study Areas
- Sandy Springs Boundary
- Water Bodies
- Streams
- Impervious Cover

Cumulative Impervious Cover (percent)

- 0 - 10
- 10 - 25
- 25 - 50
- 50 - 100

Figure 2-2. Impervious Cover

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0 0.25 0.5 1 1.5 2 Miles

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- Impervious cover for single-family residential areas was created by buffering the house footprints based on average percents of impervious area per lot based on land use category as follows:
- Land Use Code R12 (2-acre lot size) – Buffered the home footprints by 25 feet. These are typically very large homes with pools, large terraces and very long driveways with ample yard and wooded areas.
- Land Use Code R20 (1-acre lot size) – Buffered the home footprints by 15 feet. These are typically large homes with pools and/or terraces and long driveways with ample yards.
- Land Use Code R25 (1/2-acre lot size) – Buffered the home footprints by 15 feet. These are typically moderate sized homes with medium sized yards, medium length driveways and most have pools or terraces.
- Land Use Code R30 (1/3-acre lot size) – Buffered the home footprints by 6 feet. These are typically medium sized homes with moderate yards, driveways and very few pools or other large paved areas.
- Land Use Code R38 (1/4-acre lot sizes) – Buffered the home footprints by 4 feet. These are typically medium to large homes placed close together and occupying most of the lot with only a short driveway.
- Land Use Code R65 (1/8-acre lot sizes) – Buffered the home footprints by 4 feet. These are typically medium to large homes placed very close together occupying nearly all the lot with only a short driveway

A building footprint coverage was also obtained from Gwinnett County for the Crooked Creek study area. Additionally, coverages of land cover, structures, recreational areas, transportation and utilities were also obtained from Gwinnett County. These coverages all contained a field indicating any impervious areas, and all areas marked as impervious were included in the impervious cover file. It should be noted that building footprint data was not available for areas in DeKalb County that drain into the study area. In this area large commercial or retail areas where manually digitized but no data was developed for individual homes and driveways.

The impervious cover polygons were used in WIP Tools model to generate the cumulative impervious cover for the study area. On Figure 2-2, the watershed streams are color coded based on the model results for cumulative impervious cover.

2.3 Existing Land Use

Existing land use is directly related to water quality in streams and is therefore a necessary input for the baseline conditions WIP Tools model. Table 2-1 provides the codes used to develop this land use coverage. The land use coverage, shown on Figure 2-3, was developed by reviewing the most recent aerial photography in combination with the current zonings codes for each parcel. The zoning codes shown on Table 2-2 were assigned the most applicable land use category based on the most similar use. Aerial photography was used to confirm this land use category assignment. However, in some cases, the aerial photography showed areas of recent development not captured in the zoning coverage. In these cases, the aerial photography was assumed to be the most recent representation of the current conditions in the City of Sandy Springs, so the land use was updated to reflect the current land uses in the aerial photography.

For areas outside the Sandy Springs City limit that were part of the Crooked Creek study area, land use information was obtained from Gwinnett County. The Gwinnett County land use codes were translated into the study-specific land use categories used for the City as seen in Table 2-1. Table 2-3 shows the Gwinnett County land use categories and their respective Sandy Springs land use categories. For areas outside the Sandy Springs City limit that were part of the Crooked Creek study area, roads coverage information was obtained from Gwinnett County. Areas outside of the City limits and not covered by the Gwinnett County data were supplemented with the ARC existing conditions land use coverage. These areas were verified using the aerial topography and assigned the study-specific land use codes given in Table 2-1.

Table 2-1. Land Use Categories

Land Use Code	Land Use Description
C	Commercial
I	Industrial
PF	Open Space Fair
PG	Open Space Good
PRF	Pasture - Range Fair
R12	Residential - 2 acre lot size
R20	Residential - 1 acre lot size
R25	Residential - 1/2 acre lot size
R30	Residential - 1/3 acre lot size
R38	Residential - 1/4 acre lot size
R65	Residential - 1/8 acre lot size
SOD	Streets - Open Ditch/includes ROW
POND	Water
WGCF	Woods - Grass Combination Fair
W	Woods

Table 2-2. Zoning Code Assignment of Land Use

Zoning Code and Label	Corresponding Land Use Code and Description	Notes
R-1 - Single Family	R12 - Residential – 2 acre lot size	
R-2 - Single Family	R20 - Residential – 1 acre lot size	
R-2A - Single Family	R20 - Residential – 1 acre lot size	
R-3 - Single Family	R25 - Residential – 1/2 acre lot size	
R-3A - Single Family	R25 - Residential – 1/2 acre lot size	
R-4 - Single Family	R30 - Residential – 1/3 acre lot size	
R-4A - Single Family	R30 - Residential – 1/3 acre lot size	
R-5 - Single Family	R38 or R64 - Residential - 1/8 or 1/4 acre lot size	Lot size taken from aerials to determine correct Land Use Code designation
R-5A - Single Family	R38 or R65 - Residential - 1/8 or 1/4 acre lot size	Lot size taken from aerials to determine correct Land Use Code designation
R-6 - Two family	R# - Residential	Lot size taken from aerials to determine correct Land Use Code designation
A - Medium Density Apartment	C - Commercial	
A-1 - Apartment Limited Dwelling	C - Commercial	
A-L - Apartment Dwelling	C - Commercial	
A-O - Apartment Office	C - Commercial	
TR - Townhouse Residential	R65 - Residential - 1/8 acre lot size	

Table 2-2. Zoning Code Assignment of Land Use		
Zoning Code and Label	**Corresponding Land Use Code and Description**	**Notes**
O-I - Office and Institutional	C - Commercial	
C-1 - Community Business	C - Commercial	
C-2 - Commercial	C - Commercial	
MIX - Mixed Use	C - Commercial	
CUP - Community Unit Plan	R# - Residential	Lot size taken from aerials to determine correct Land Use Code designation
NUP - Neighborhood Unit Plan	R# - Residential	Lot size taken from aerials to determine correct Land Use Code designation
M-1 - Light Industrial	I - Industrial	
M-2 - Heavy Industrial	I - Industrial	
AG-1 - Agricultural	PRF - Pasture-Range Fair	

Table 2-3. Gwinnett County Land Use Code Assignments to Sandy Springs Land Use Codes		
Gwinnett County Land Use Code and Label	**Corresponding Sandy Springs Land Use Code and Description**	**Notes**
AGRI - Agriculture	PRF - Pasture - Range Fair	
CR – Commercial/Retail	C - Commercial	
ESTATE – Estate Residential	R12 - Residential - 2 Acre	
HDR – High Density Residential	R65 or R38 - Residential - 1/8 or 1/4 Acre	Lot size taken from aerials to determine correct Land Use Code designation
HI – Heavy Industrial	I - Industrial	
IP – Institutional/Public	C - Commercial	
LDR – Low Density Residential	R20 - Residential - 1 Acre	
LI – Light Industrial	I - Industrial	
OP – Office Professional	C - Commercial	
MDR – Medium Density Residential	R25 or R30 - Residential - 1/2 or 1/3 Acre	Lot size taken from aerials to determine correct Land Use Code designation
PARK - Parks	W or PG – Woods or Open Space Good	Area checked against aerials to determine correct Land Use Code designation
PRC – Park, Recreation, and Conservation	W or WGCF – Woods or Woods-Grass Combination Fair	Area checked against aerials to determine correct Land Use Code designation
TCU – Transportation/ Communication/Utilities	SOD – Streets – Open Ditch/Includes ROW	
UNDEV - Undeveloped	W or WGCF – Woods or Woods-Grass Combination Fair	Area checked against aerials to determine correct Land Use Code designation
WATER - Water	POND - Water	

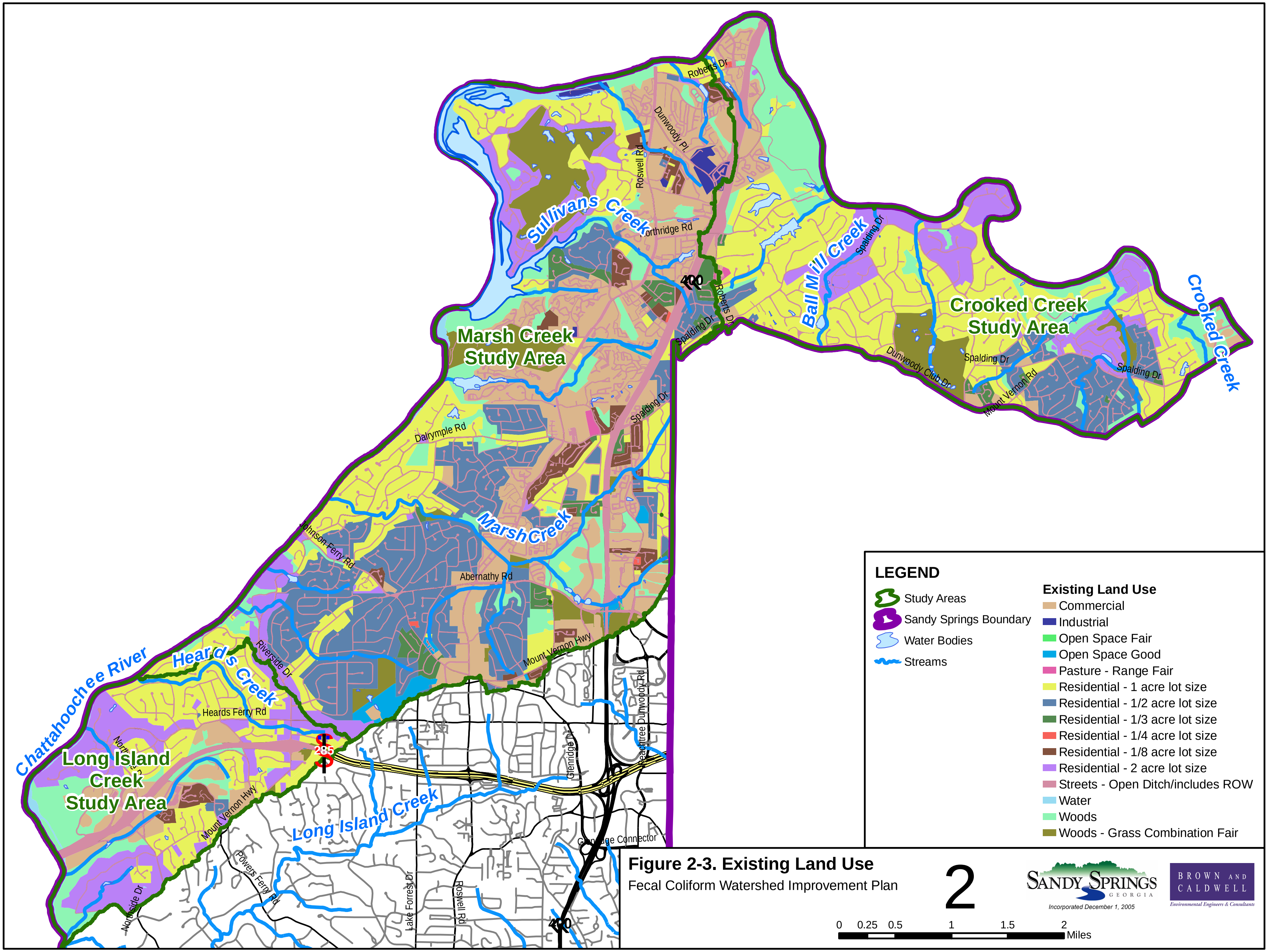

Figure 2-3. Existing Land Use

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The land use category SOD (Streets – open ditch/includes ROW) was created using a combination of the Sandy Springs streets coverage file, the Gwinnett County roads coverage file, and the ARC zoning coverage. Any street area shapes outside of the City Limits or not represented accurately in the Gwinnett County roads coverage or Sandy Springs zoning coverage were digitized by creating a 25-foot buffer around the centerlines of the ARC streets coverage.

The land use category POND (Water) was created using a combination of a water bodies file obtained from the United States Geological Survey (USGS) and the aerial photography. All features in the USGS file were verified with the aerial photography, and any additional water bodies seen in the aerials were also included as POND shapes in the land use file.

Finally, the open space and wooded land use categories, PF (open space fair), PG (open space good), PRF (pasture – range fair), WGCF (woods – grass combination fair), and W (woods) were digitized directly from the aerial photography provided by the City. Regions designated as PF (open space fair) were areas of open space, such as grass or dirt that were interspersed with shrubbery, trails or paths, and/or small out parcel buildings, as found at recreation fields or parks. Areas designated as PG (open space good) were regions where open space, such as grass or dirt, occupied more than 85 percent of the area. Comparably, areas designated as W (woods) were regions where trees occupied more than 85 percent of the area. Areas designated as WGCF (woods – grass combination fair) were areas that were an approximate 50/50 mix of open space and woods. Finally, areas designated as PRF (pasture-range fair) were areas with open space that appeared to be fertilized and possibly treated as agricultural areas.

2.4 Soils

Determination of soil type is important when considering erosion rates, rainfall infiltration, building suitability, and many other factors. The soils data for this study was obtained directly from the National Resources Conservation Service (NRCS) by Manhard Consulting, Ltd, the floodplain mapping contractor for the City of Sandy Springs. For this study, the soils file was updated to reflect all areas of open water identified during the digitizing of the land use. All areas of open water were assigned MUSYM 'W' and classified as type D, in accordance with NRCS standards. In addition, areas that were classified as urban lands in the NRCS soil survey were classified as type D because of the impervious nature or typically compacted soils common with these land uses. Figure 2-4 shows the soil polygon file color coded by hydrologic soil group.

2.5 Lakes

The Fecal WIP Study Areas have many small to medium size lakes. Lakes can provide water quality benefits and must be included in the development of the WIP Tools model. The surface area at the normal elevation or pool of lakes and ponds is determined by creating a polygon area. The USGS Hydro Area polygon was the starting basis for the lakes. For areas that appeared to have been developed since the USGS file was created or other lakes that were not included in the USGS file, the contours from the City and the aerial photos were used to create the a lake footprint at normal pool. Any polygons that appeared to be delineated in the USGS file due to damp soil and are not actually lakes (based on aerial photograph) were deleted from the lake polygon file and not included in the WIP Tools model.

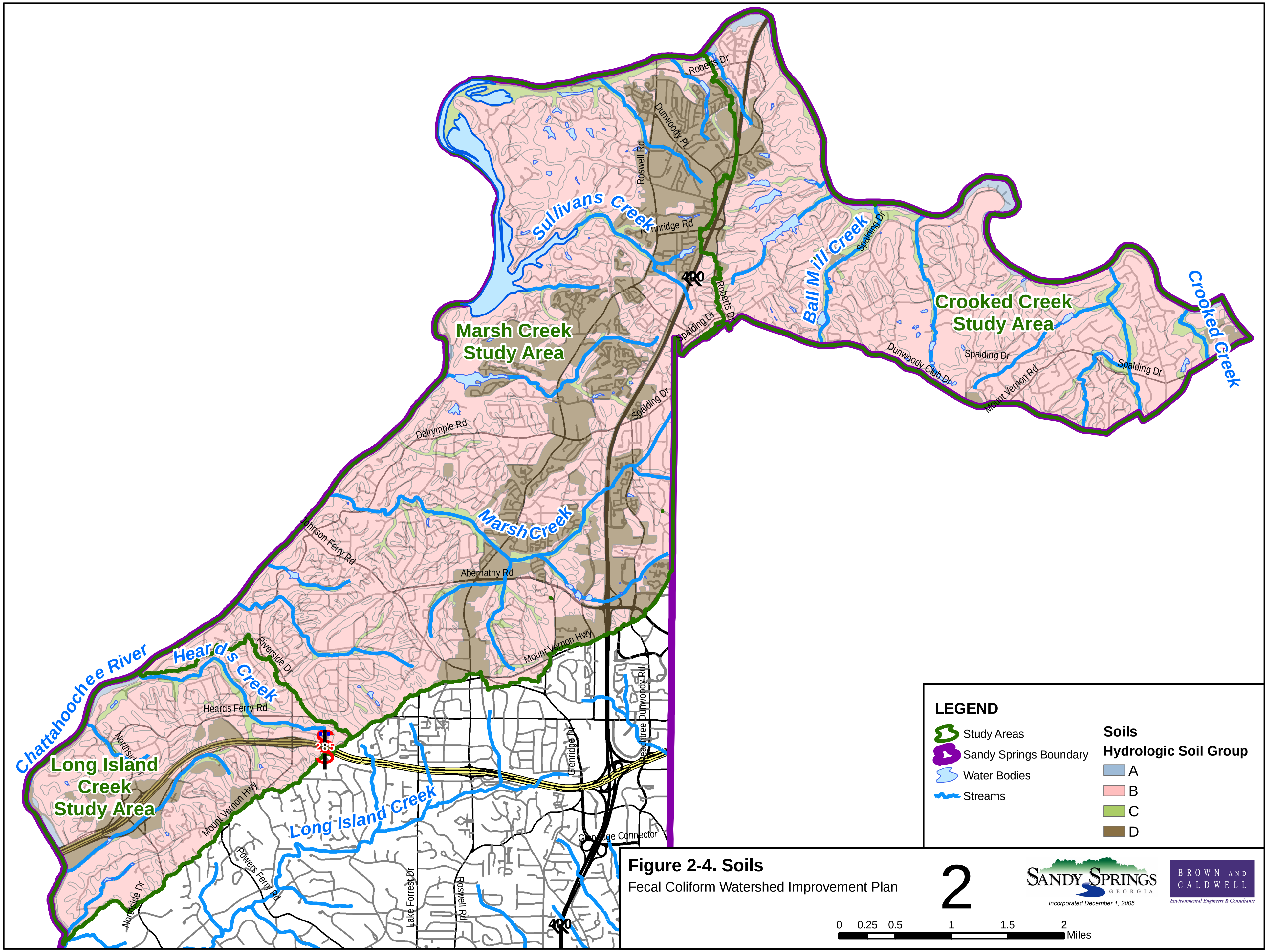

Figure 2-4. Soils

Fecal Coliform Watershed Improvement Plan

2.6 Urban/Rural Discharge Ratio

The urban/rural discharge ratio is used to classify stream segments by the amount of flow increase resulting from urbanization (Figure 2-5). The ratio is calculated as:

Existing urban 1-year discharge/Undeveloped (rural) 1-year discharge

The 1-year frequency is used because it is often characterized as the channel-forming streamflow. A modification of the formulas found in the *USGS Flood-Frequency Relations for Urban Streams in Georgia – 1994 Update* was used to calculate the urban/rural discharge ratio for all streams in the study area (USGS 1994). For Region 1 which includes the Chattahoochee River and tributaries, the USGS Regression equations for the 2-year event are:

$Q_2 = 167A^{0.73}\,TIA^{0.31}$ (urban)

$Q_2 = 207A^{0.654}$ (rural)

Where Q_2 is the 2-year peak discharge in cubic feet per second,

A is the drainage area in square miles, and

TIA is the total impervious area in percent.

Where Q_2 is the 2-year peak discharge in cubic feet per second, A is the drainage area in square miles, and TIA is the total impervious area in percent. The 1-yr urban/rural discharge ratio is used in the erosivity calculation in the WIP Tools model. Retrofitting or modifying BMPs will reduce the 1-year urban discharge, thus reducing the downstream erosivity. To estimate the 1-year rural and urban flood peak discharge, the above equations were reduced by a factor of 0.875. The factor of 0.875 is arrived at by dividing the total precipitation depth for a 2-year 24-hour storm event by the depth of the 1-year 24-hour storm event. As a result, the equation used to calculate the Urban-Rural Discharge ratio(Q_{ur}) is:

$Q_{ur} = Q_u / Q_r$

$= 146A^{0.73}\,TIA^{0.31}/181A^{0.654}$

Where Q_u is the urban 1-year discharge in cubic feet per second, and

Q_r is the rural 1-year discharge in cubic feet per second.

For Fecal WIP Study area, the urban/rural discharge ratio ranged from 0.67 for streams in wooded areas to 2.99 in some stream segments in heavily urbanized areas. The input parameters for the urban discharge were drainage area and percent impervious cover, whereas only drainage area was used to develop the rural discharge. As a result, areas with the highest amounts of impervious surface had the highest urban/rural discharge ratios. Generally, streams with higher urban/rural discharge ratios are expected to be more impacted due to urbanization causing changes in streamflow hydrology. However, this is not always the situation. For example, in some locations, bedrock outcrops may prevent stream down-cutting and enlargement even though streamflow has been substantially increased due to urbanization. Conversely, where stream conditions are degraded but a minimal hydrologic alteration is indicated by urban/rural ratios near 1.0, stream changes are likely the result of direct human actions such as bank vegetation removal or channel straightening. With these exceptions noted, the urban/rural discharge ratio provides a means to identify locations where hydrologic controls would be most useful at reducing streamflows to more natural channel-forming flows.

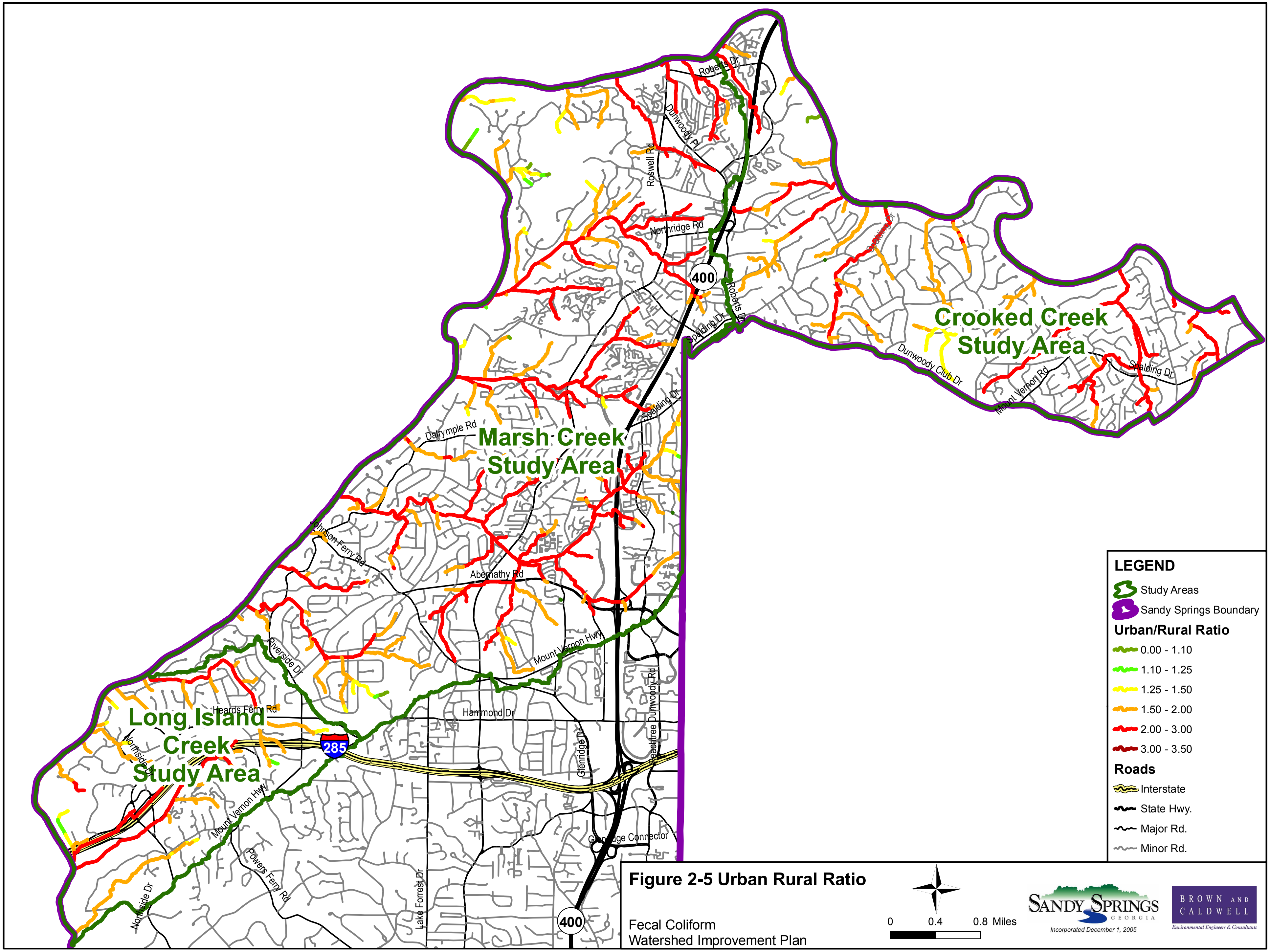

Figure 2-5 Urban Rural Ratio

Fecal Coliform
Watershed Improvement Plan

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2.7 Impaired Streams

The primary reason for developing the Watershed Improvement Plan for the Crooked Creek, Ball Mill Creek and Marsh Creek study areas is to address water quality concerns. There are two impaired stream segments in the Crooked Creek study area. First, 2.9 miles of Ball Mill Creek from the headwaters to the confluence with the Chattahoochee River, of which approximately 1.5 miles are located in Sandy Springs, are listed as not meeting the designated use of fishing based on the GA EPD 2008 305(b)/303(d) list of waters. Ball Mill Creek is listed as impaired for fecal coliform with the potential cause due to urban runoff or urban effects. Second, 2.2 miles of Crooked Creek from the headwaters to the confluence with the Chattahoochee River, of which approximately 0.6 mile is located in Sandy Springs, are listed as not meeting the designated use of fishing based on the GA EPD 2008 305(b)/303(d) list of waters. Crooked Creek is listed as impaired for fecal coliform with the potential cause due to urban runoff or urban effects. There is one impaired stream segment in the Marsh Creek study area, 4.5 miles of Marsh Creek from the headwaters to the confluence with the Chattahoochee River, of which approximately 3.9 miles are located in Sandy Springs, are listed as not meeting the designated use of fishing based on the GA EPD 2008 305(b)/303(d) list of waters. Marsh Creek is listed as impaired for fecal coliform with the potential cause due to urban runoff or urban effects. Each of these impaired stream segments can be seen on Figure 2-6.

2.8 WIP Tools – Baseline Conditions Model

The baseline conditions model developed using WIP Tools represents the current or existing conditions within the Fecal Coliform WIP Study Area. Land use, soils, existing lakes, and other watershed inputs described above were used to develop the model. The model includes the effects of existing best management practices (BMPs) identified as a part of the Historic CIP (refer to chapter 4 for information on these project) that may provide water quality benefits such as stormwater detention ponds. Additional BMPs may be present in the study area that provide water quality benefits but analysis of these facilities was beyond the scope of this project. The following section gives an overview of the development of the model and the model results.

WIP Tools is a raster based project evaluation and water quality model deployed as an extension in ArcGIS. It was created by Brown and Caldwell to aid in the development of a Capital Improvement Plan (CIP) for Watershed Improvement Planning. WIP Tools allows for the analysis of multiple 'what-if' scenarios in which a user can 'turn-on' projects, generated results and then try another set of projects. The raster based format allows projects to be placed and evaluated, and results to be extracted anywhere in the study area. The WIP Tools model works in a systematic manner starting at the top menu item and moving downward (see image below). Each of the following sections gives an overview of the key inputs and results by WIP Tools menu item. More details on the equations and methodology in the WIP Tools model may be found in the WIP Tools User's Guide located in Appendix F.

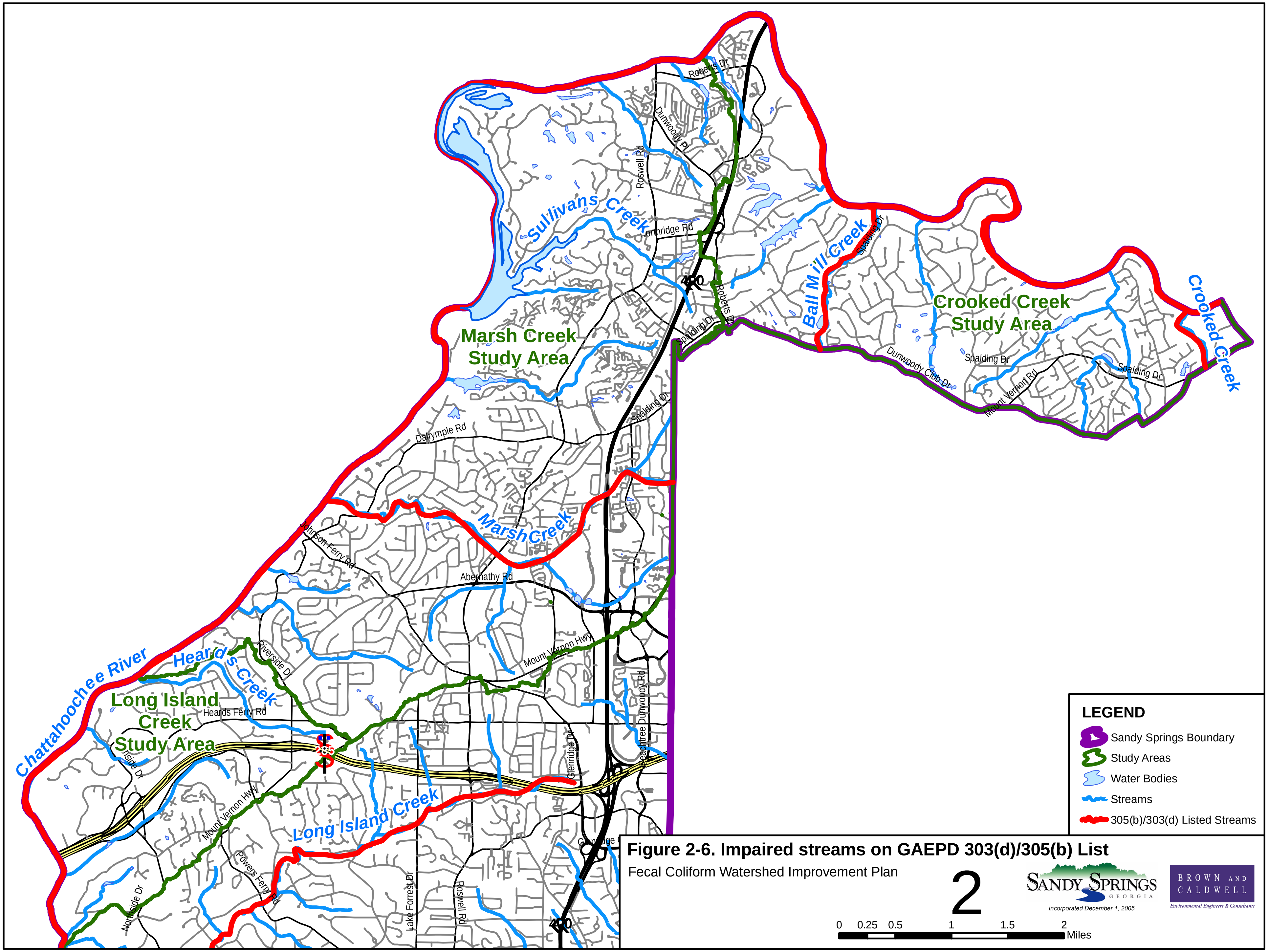
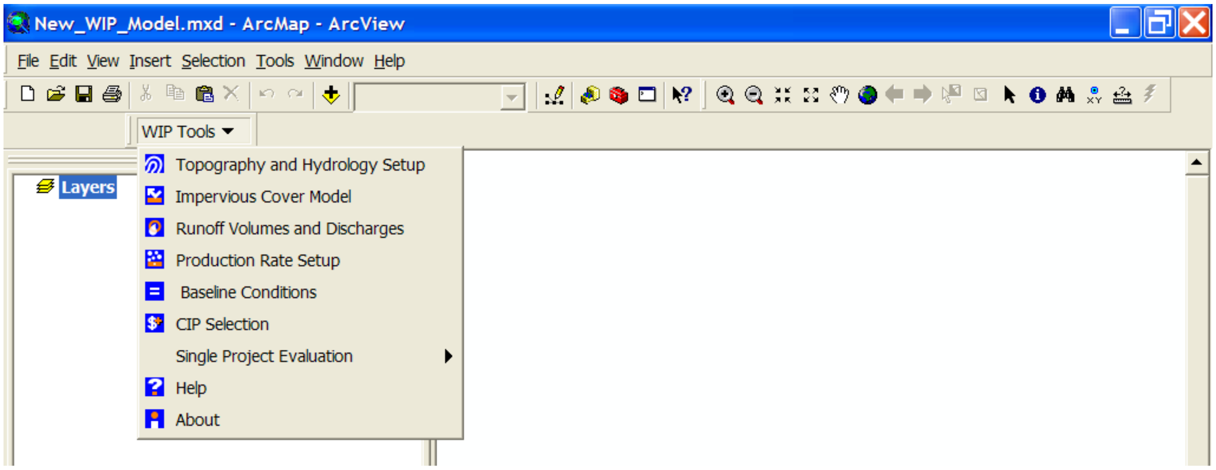


Figure 2-6. Impaired streams on GAEPD 303(d)/305(b) List

Fecal Coliform Watershed Improvement Plan



WIP Tools Menu Items

2.8.1 Topography and Hydrology Setup

The first menu item was the Topography and Hydrology Setup. The primary inputs for this tool are the watershed DEM and the threshold for stream formation. The development of the DEM was detailed earlier in this chapter. A 25-acre threshold was selected for stream formation. The outputs for this step include a cumulative drainage area raster, a stream raster and a stream vector.

2.8.2 Impervious Cover Model

The next step was the development of the impervious cover model. The inputs include the impervious cover polygon file (Section 2.2) and the lakes polygon file (Section 2.5). Output included an impervious cover raster, a cumulative impervious cover raster and a cumulative impervious cover vector (applied only to the stream segments). The cumulative impervious cover vector is included on Figure 2-2.

2.8.3 Runoff Volumes and Discharges

The runoff volumes and discharges tool requires three inputs: hydrologic region, land use and soil data. The hydrologic region specifies the USGS equations to use for calculating discharges. The land use data (Section 2.3) along with the hydrologic soil group (Section 2.4) was used to determine the SCS curve number for each raster cell. The curve numbers used for the WIP Tools model were the same as those used for the floodplain study in order to provide consistency. Table 2-4 lists the curve number by land use and soil group.

Table 2-4. Curve Number by Land Use and Hydrologic Soil Group

	Soil Group			
Land Use	**A**	**B**	**C**	**D**
Commercial	89	92	94	95
Industrial	81	88	91	93
Open Space Fair	49	69	79	84
Open Space Good	39	61	74	80
Pasture - Range Fair	49	69	79	84

Table 2-4. Curve Number by Land Use and Hydrologic Soil Group				
	Soil Group			
Land Use	A	B	C	D
Residential - 2 acre lot size	46	65	77	82
Residential - 1 acre lot size	51	68	79	84
Residential - 1/2 acre lot size	54	70	80	85
Residential - 1/3 acre lot size	57	72	81	86
Residential - 1/4 acre lot size	61	75	83	87
Residential - 1/8 acre lot size	77	85	90	92
Streets - Open Ditch/includes ROW	83	89	92	93
Water	100	100	100	100
Woods - Grass Combination Fair	35	56	70	77
Woods	36	60	73	79

The output for this tool includes the water quality volume, channel protection volume, 25-year flood storage volume, 1-year undeveloped (rural) discharge, 2-year urban discharge, 10-year urban discharge and 25-year urban discharge.

2.8.4 Production Rate Setup

This tool develops the production generated by each grid cell for each water quality constituent selected for modeling. The user may model one or many constituents. However, the constituents selected in this tool are the only ones available for analysis in subsequent tools. The production included both upland production and stream production. The inputs include the stream bank erosion (Section 3.3.3), land use (Section 2.3), default in-stream production rate, other default stream parameters, and a die-off raster. For this study area total nitrogen, total phosphorus, total suspended sediment (TSS), fecal coliform and biochemical oxygen demand (BOD) were modeled.

The default in-stream production was assumed to be zero for all parameters except TSS. The value for TSS was set to 8 lb/ft^2. This value was based on stream erosion monitoring performed in the Chattahoochee Tributaries of Gwinnett County, Georgia. The default stream parameters include the hydraulic geometry coefficient, hydraulic geometry exponent, default roughness values and default percent exposed bank. For areas where no bank height information was available, a hydraulic geometry relationship was developed. Using the data points collected for the Fecal WIP study area the hydraulic geometry coefficient was 2.522 and the hydraulic geometry exponent was 0.1056. A default roughness value of 0.05 was selected. The default percent exposed bank was determined by calculating the average percent bank exposed of all Fecal Coliform WIP study area stream walk data. The default percent of bank exposed for the Fecal Coliform WIP was 28.3 percent.

The die-off raster was only required for parameters that implement the first order decay functionality. The best estimates of effective in-stream "die-off" rates for fecal coliform and similar microbes in fresh water point toward first-order decay rates of between 0.7 and 1.5 per day (Mancini 1978, EPA 1985 and CWP 2000). The overland component was more difficult to determine. The EPA (EPA 1985) stressed that an on-surface k rate be higher than what is used for in-stream. At first glance that seems to make sense in that there is more opportunity for exposure to ultraviolet light, infiltration into the ground, or entrapment. However, more recent studies have produced significantly lower estimates (Meals and Braun 2006). For the Fecal Coliform WIP study area a K raster was developed for fecal coliform with a value of 1.1/day for streams and 0.7/day for upland areas.

In addition, the user may edit some of the default tables that are installed as a part of the WIP Tools extension. This includes the export coefficients by land use. This editing is done outside of the WIP Tools model. Table 2-5 list the values used for the Fecal Coliform WIP study area.

Table 2-5. Export Coefficient by Land Use

Land Use	Total Nitrogen lb/ac/yr	Total Phosphorus lb/ac/yr	TSS lb/ac/yr	Fecal Coliform cfu 10^9/yr	BOD lb/ac/yr
Commercial	11	1.5	525	9.1	42
Industrial	9.9	1.3	690	2.7	54
Open Space Fair	2.7	0.3	35	7.9	3
Open Space Good	1.8	0.2	23	7.9	2
Pasture - Range Fair	7.5	1.1	200	8.7	15
Residential - 2 acre lot size	2.8	0.3	35	6.9	8
Residential - 1 acre lot size	3.5	0.4	50	6.9	9
Residential - 1/2 acre lot size	4.6	0.6	80	7.6	15
Residential - 1/3 acre lot size	5.8	0.8	110	8.5	20
Residential - 1/4 acre lot size	6.7	0.9	125	9.1	25
Residential - 1/8 acre lot size	10	1.5	525	9.1	42
Streets - Open Ditch/includes ROW	8.2	1.5	590	6.9	67
Water	5.5	0.5	18	10	10
Woods - Grass Combination Fair	2.4	0.3	25	12	13
Woods	2.5	0.3	30	15	15

2.8.5 Baseline Conditions

This tool generated the baseline conditions scenario for the study area. This was the current study area conditions prior to the implementation of proposed projects. The water quality benefits provided by existing BMPs may be included in the baseline conditions scenario. The parameter load and yield were developed by accumulating the production developed in the previous step. If an existing BMP was encountered, then the accumulated load was reduced by the BMP efficiency and then the accumulation continued moving downstream to the next raster cell. In addition, if first order decay was implemented the accumulation is multiplied by the decay at that raster cell and then the accumulation continued downstream. Figures 2-7 through 2-11 show the results of the baseline conditions model for each parameter modeled for the Fecal Coliform WIP study area.

2.8.6 Single Project Evaluation – Load Reduction

Once all the proposed efficiencies and discharges were assigned to each BMP, the WIP Tools model was used to evaluate the benefit provided by each project (if implemented). The Single Project Evaluation – Load Reduction Tool was used to determine TSS reduction and Fecal Coliform reduction provided by each project in isolation. This calculation 'turns on' just the project of interest and any existing BMPs that provide benefit and calculates the load reduction provided by that BMP. The load reduction was added to the attribute table of the project points file and the computation continues on for the next project. Information from project evaluation was used to create the final recommended CIP described in Chapter 4.

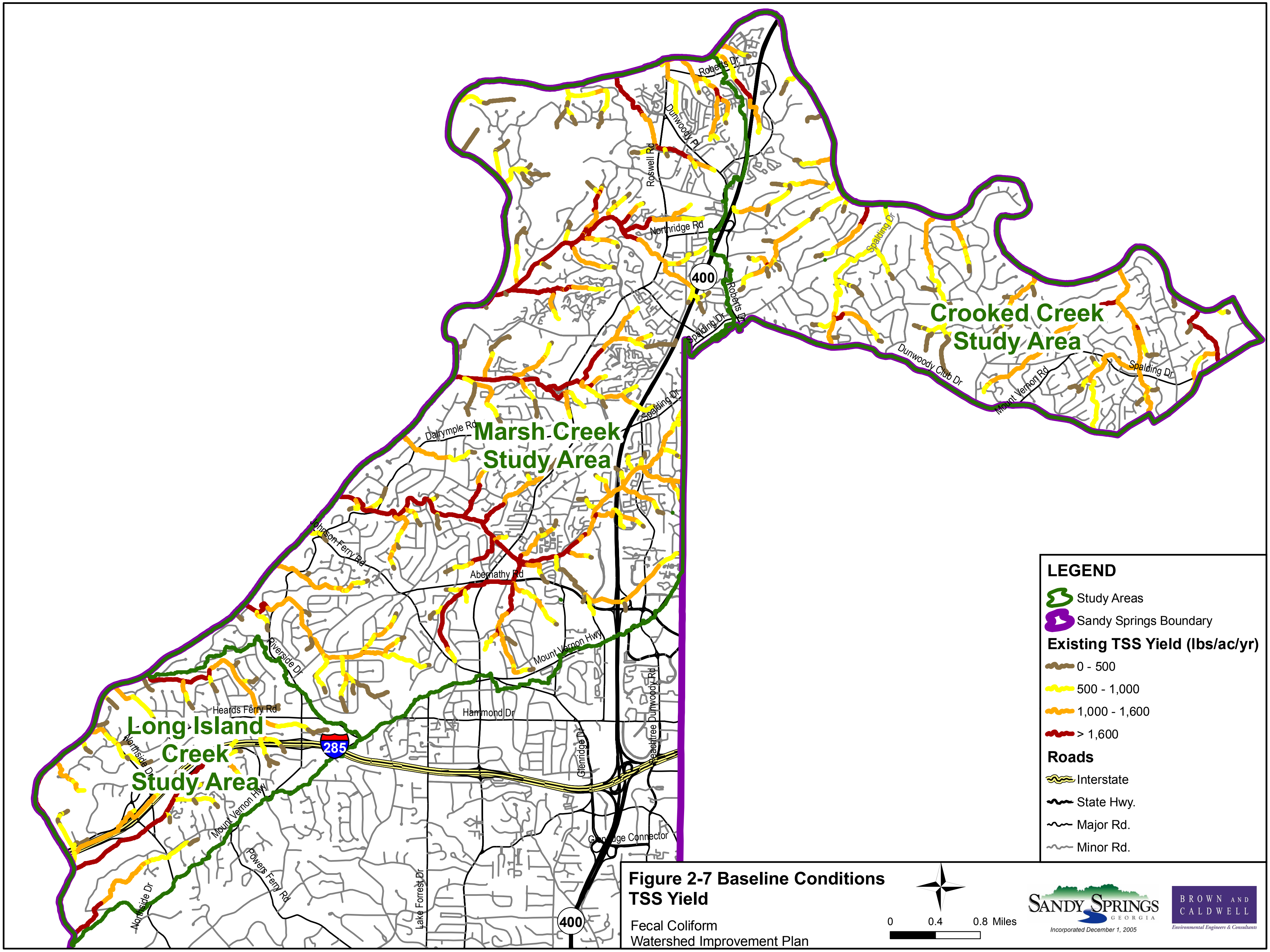


Figure 2-7 Baseline Conditions TSS Yield

Fecal Coliform
Watershed Improvement Plan

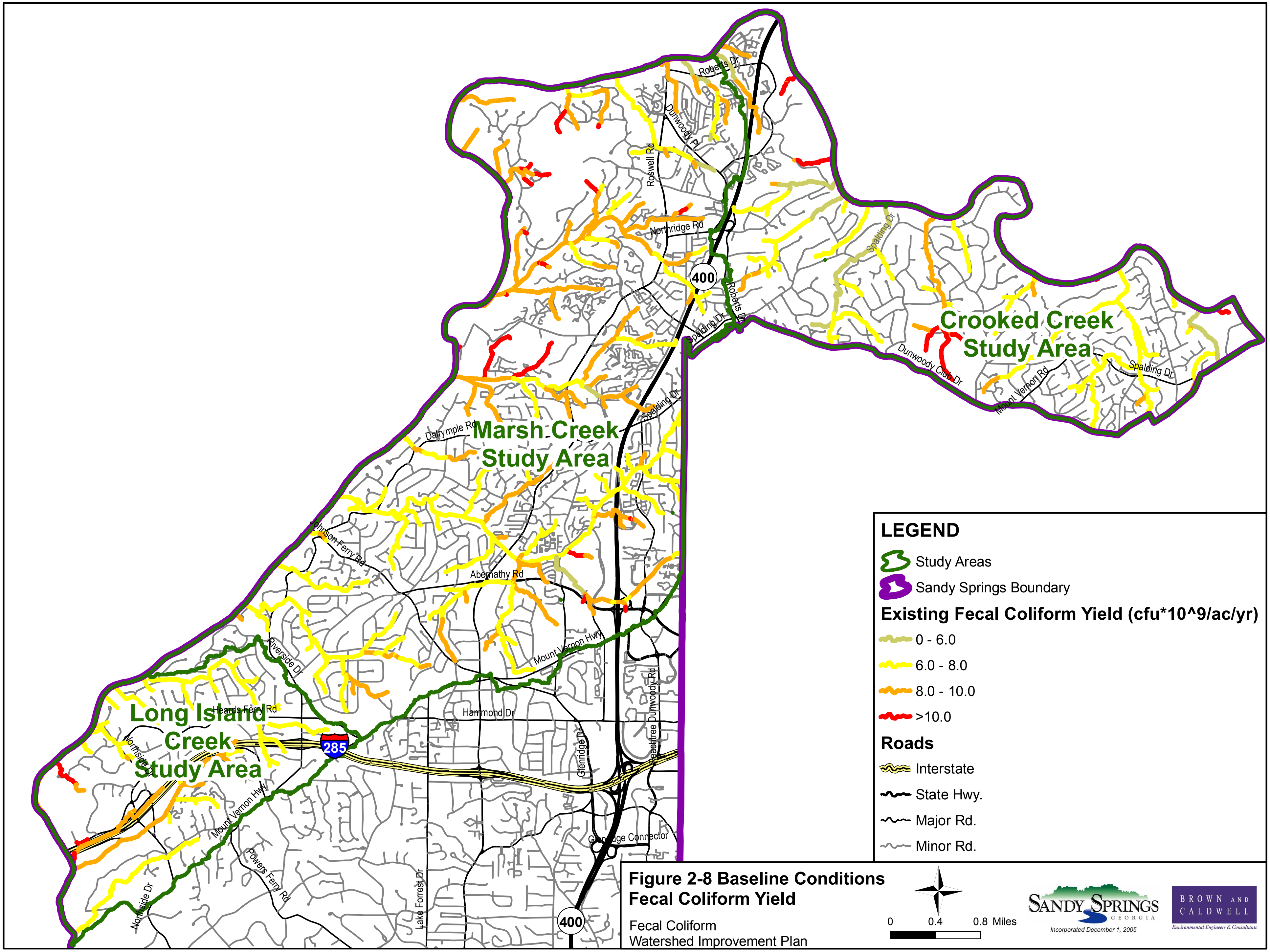


Figure 2-8 Baseline Conditions
Fecal Coliform Yield

Fecal Coliform
Watershed Improvement Plan

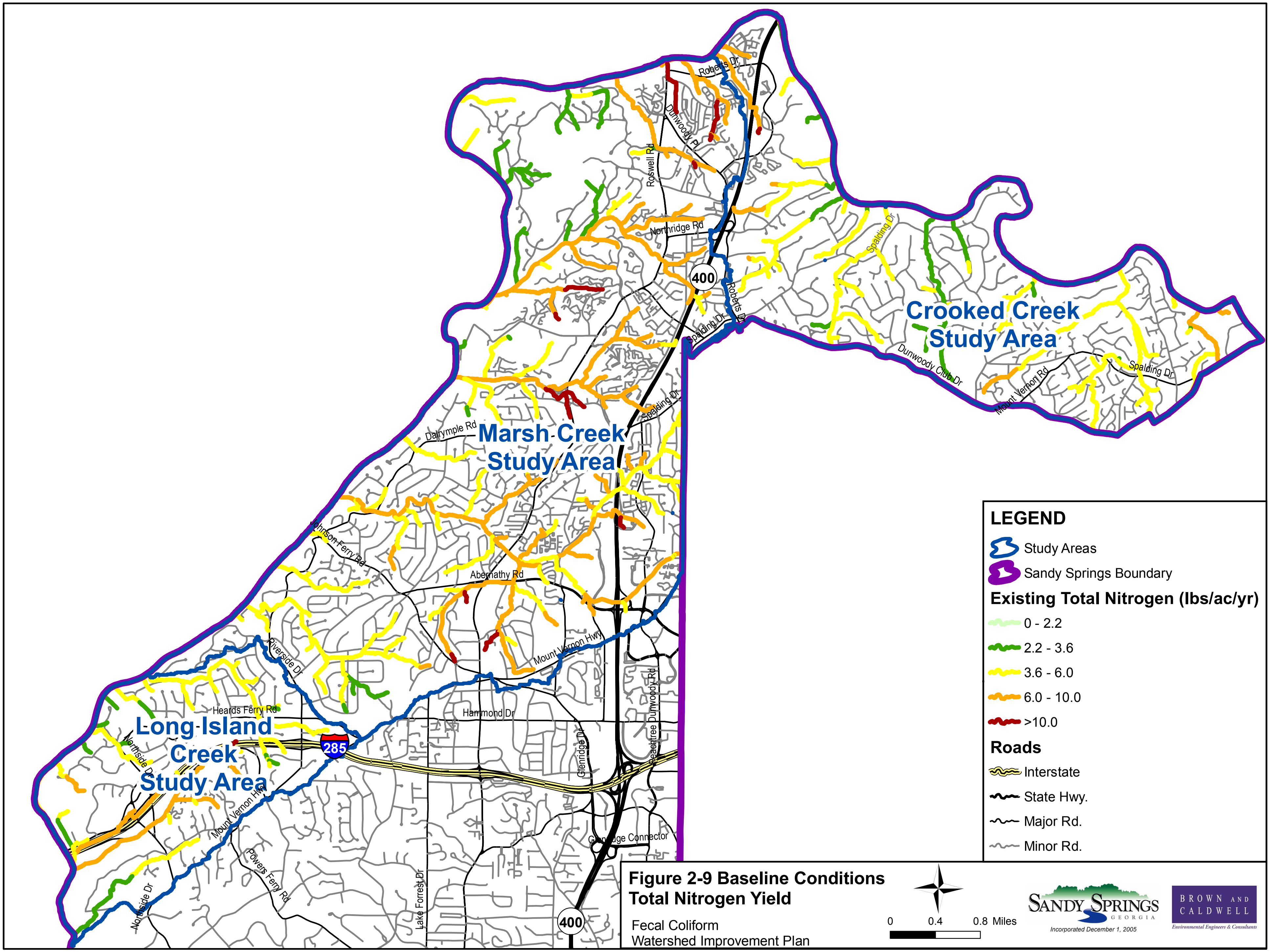


Figure 2-9 Baseline Conditions Total Nitrogen Yield

Fecal Coliform
Watershed Improvement Plan

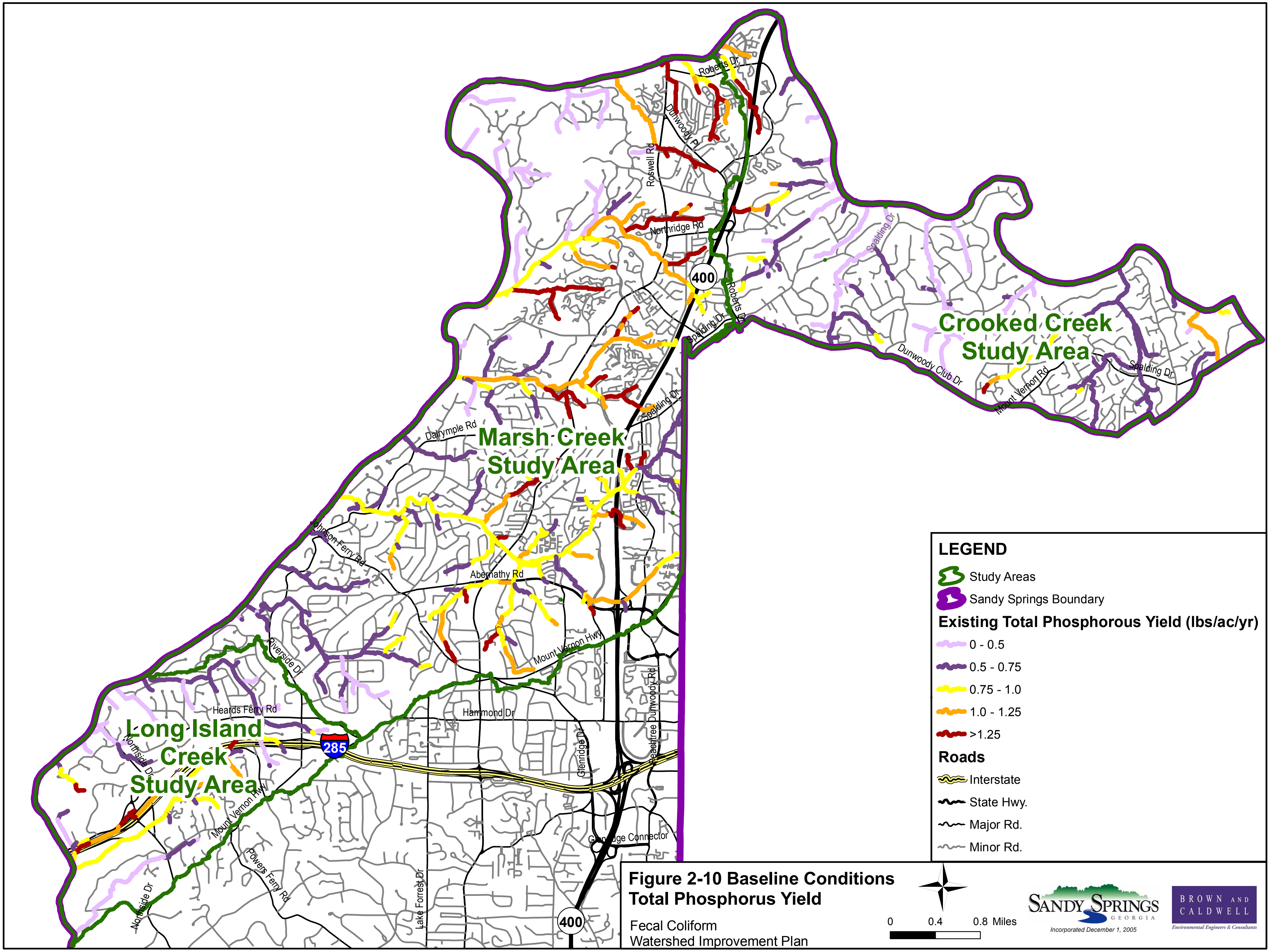


Figure 2-10 Baseline Conditions Total Phosphorus Yield

Fecal Coliform
Watershed Improvement Plan

SANDY SPRINGS GEORGIA
Incorporated December 1, 2005

BROWN AND CALDWELL
Environmental Engineers & Consultants

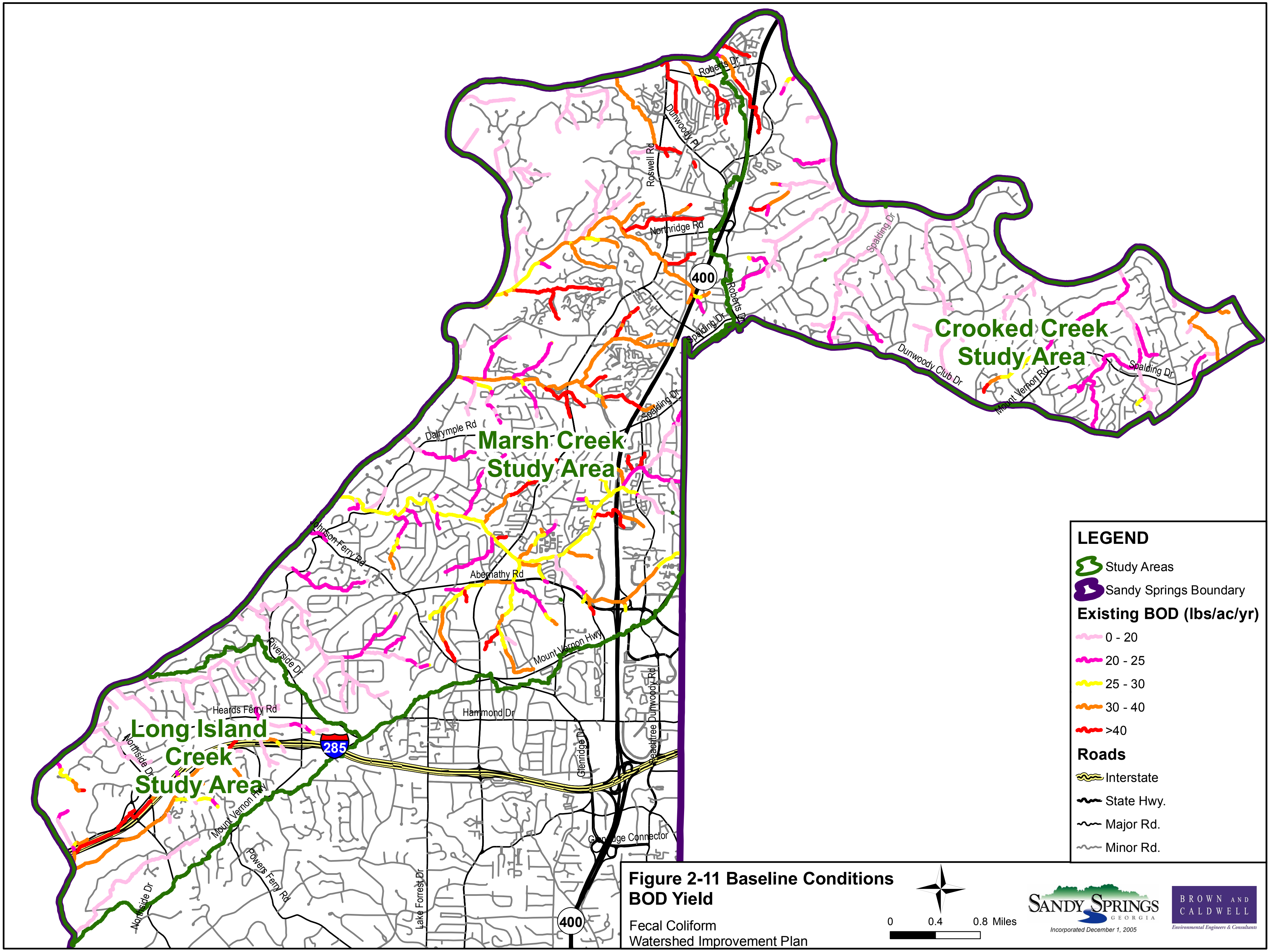


Figure 2-11 Baseline Conditions BOD Yield

Fecal Coliform

Watershed Improvement Plan

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3. STREAM INVENTORY METHODS AND CONDITIONS

3.1 Introduction

Brown and Caldwell assessed 30.5 stream miles in study area basins within the City of Sandy Springs from October 8, 2009 to October 26, 2009. The basins were delineated as part of the overall watershed improvement and floodplain mapping studies for the City of Sandy Springs. Basins and drainage areas were grouped into study areas for simplicity and coordination between studies. Tributaries that directly drain into the Chattahoochee River were grouped with the closest basin for stream inventory purposes. The basins and stream segments included (Figure 3-1):

- Crooked Creek – 7.5 miles including Ball Mill Creek, Crooked Creek, and other tributaries to the Chattahoochee River within the Crooked Creek study area
- Marsh Creek – 18.6 miles including Marsh Creek, Sullivans Creek and tributaries to the Chattahoochee River within the Marsh Creek study area
- Long Island Creek – 4.4 miles of tributaries to the Chattahoochee River within the Long Island Creek study area (which is separate from the Long Island basin). (Note: The Long Island Creek WIP also included stream inventory).

Stream reaches were inventoried along the main stem of each creek and selected tributaries. The primary focus of the inventory was to identify potential sources of fecal coliform in surface water in addition to potential bank erosion issues, buffer encroachments, channel alterations, and other miscellaneous observations. The data collected during the inventory was used in the WIP Tools model and in the development of the Fecal Coliform WIP.

Data were collected for man-made and hydrologic channel alterations, streambank erosion, riparian buffer encroachment, water quality issues, City maintenance problems, and other miscellaneous observations such as debris dams or excessive invasive plant presence (Table 3-1). Special attention was paid to potential fecal coliform sources such as evidence of sewage leaks or spills, stormwater outfalls draining urbanized areas, and presence of wild and domestic animal in or near the streams.

Table 3-1. Stream Inventory Data Collection

Category	Description
Water Quality	Points or reaches where water quality issues are noted, primarily for fecal coliform contamination
Channel Alteration	Reaches where channel morphology has been altered due to direct or indirect anthropogenic causes such as altered hydrology or channelization
Bank Erosion	The extent, height and length of bank erosion in each watershed
Buffer Encroachment	Reaches where land-use practices have encroached upon the 50-ft riparian buffer
Miscellaneous	Other problems or unique features such as woody debris dams, water withdrawals, wetland areas, or reference reaches
Representative Sites	Locations that represent conditions observed within a given reach

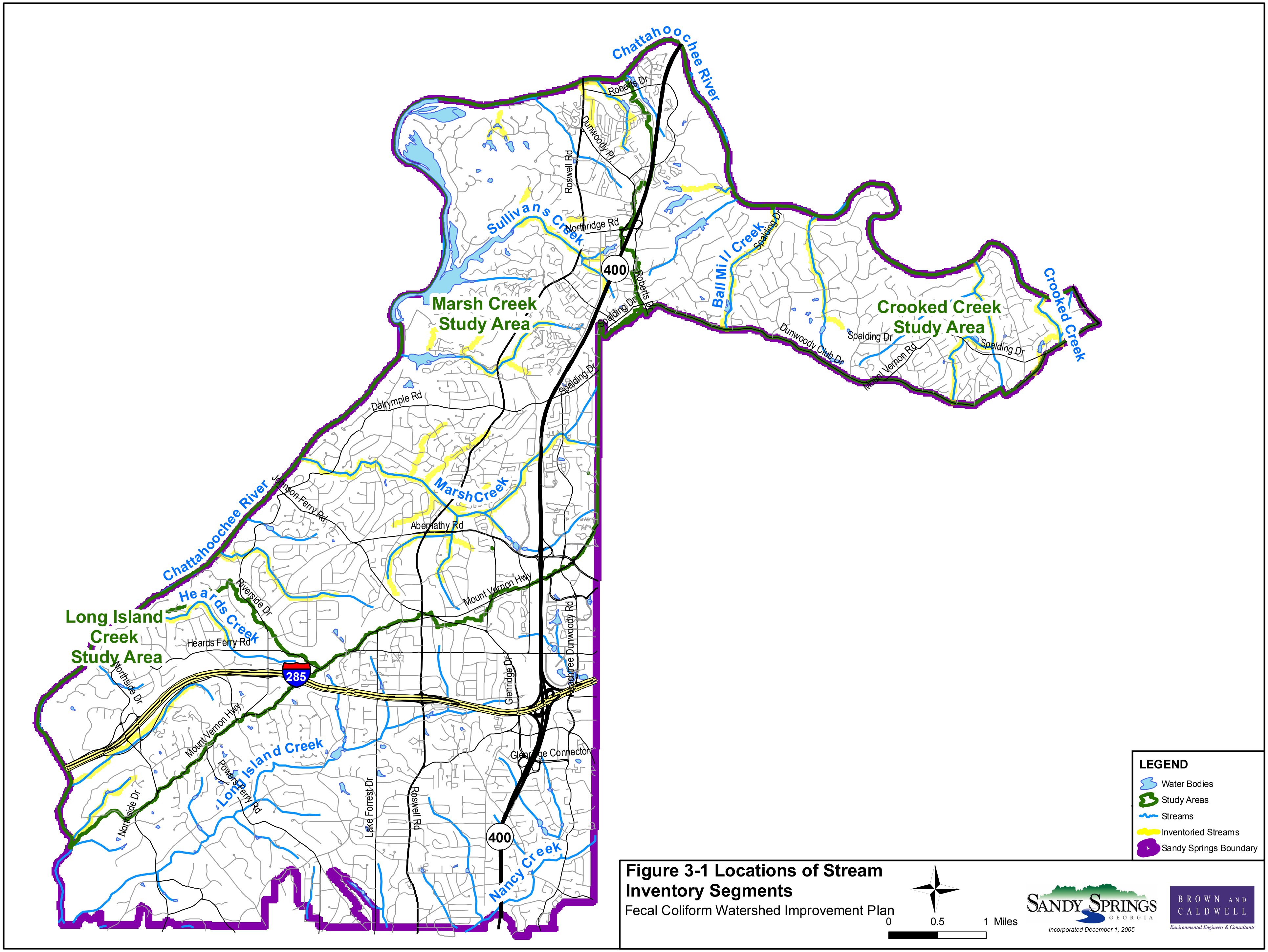


Figure 3-1 Locations of Stream Inventory Segments
Fecal Coliform Watershed Improvement Plan

Habitat assessment and physical stream cross-section measurements were taken at representative reaches throughout the study area. The cross-section measurements were used to determine the Rosgen Stream Classification, which is a measure of the relative stream stability based on channel dimension. Overall, 422 stream inventory data points (inventory points) and 29 representative reach data points were collected by walking stream reaches in the upstream direction.

3.1.1 Summary of Methods

Inventoried streams were selected in coordination with the City out of a total of approximately 73 stream miles with a minimum drainage area of 25 acres. This drainage area threshold was selected because it approximates the threshold for stream initiation in urban settings according to previous observations. Inventoried streams cover all GA EPD lists of streams not meeting water quality standards (303(d) listed reaches) and are evenly distributed throughout the study area.

Stream mileage was derived from vector features generated from a 16′x16′ digital elevation model (DEM) provided by the City in the ArcGIS Spatial Analyst tool, ArcHydro, using a stream formation threshold of 25 acres. This file was used as the guide for the stream inventory.

To prepare for the inventory, unique codes were assigned to each stream segment based on the sub-watershed and stream order. These codes were used to assign reaches for daily inventory tasks, summarize conditions on each reach, and summarize the conditions of each sub-watershed.

Each inventory point collected was populated with the appropriate codes based on observations made on the portion of the channel at the inventory point location and downstream over the specified length listed for each parameter populated. Observations were made under the categories outlined in Table 3-1. Where length measurements apply, lengths are estimated to the nearest 50 feet, with the exception of severe bank erosion (75 percent to 100 percent eroded area), which was recorded to the nearest 25 feet.

Field data were collected using Magellan Mobile Mapper CX ™ handheld PCs with integrated GPS using ESRI's ArcPad 7.1.1 software. Summary forms of each reach were also generated to summarize field notes and observations of general conditions within each stream reach. Data were merged into a central geo-database for the entire inventory under two independent feature classes: Stream Inventory Points and Representative Reach points. Some data were used in the WIP tools model (i.e., streambank erosion) and all data were used to evaluate the overall conditions and health of the stream reaches inventoried in the study areas.

The following sections summarize results from the stream inventory.

3.2 Point and Non-point Source Pollution

Both point and non-point pollution sources were inventoried (Table 3-2). Observed point source pollution included sewer line leaks or breaks, chemical discharges, excessive trash dumping or drainage from dumpsters, and other unknown, potentially illicit discharges. Observed non-point source pollution included stormwater outfalls draining runoff from urbanized areas, livestock, kennels and domestic animals, and wildlife.

The following types of water quality concerns were inventoried in the field:

- **Sewer line or SSO (SL).** Leaking, ruptured or overflowing sanitary sewer line
- **Septic tank (ST).** Septic tank failure, disconnect or other contamination path
- **Chemical discharge (PC).** Chemical discharge directly into the stream from a known source

- **Unknown or Illicit Discharge (ID).** Potentially illicit discharge of unknown origin
- **Livestock (LS).** Livestock access to the stream or runoff from feedlot or pasture
- **Domestic animals (KD).** Kennels or domestic animals kept near the stream or evidence of kennel wash down and runoff into the stream
- **Other animals (OA).** Waterfowl and wildlife communities present or indications of being present (footprints, feces, etc.)
- **Trash/Dumpsters (TD).** Dumpsters adjacent to the creek or dumped trash that would attract rodents and other animals
- **Urban runoff (UR).** Direct discharge into the stream from runoff from built-out conditions (stormwater outfalls, runoff from parking lots, etc.).

Table 3-2. Inventoried Observations of Water Quality Point and Non-point Pollution Sources

Category		Number of Observations
Point source	Unknown Potentially Illicit Discharge	10
	Broken Sewer Line or Overflow	8
	Trash or Dumpsters	6
Non-point source	Urban Run-Off	136
	Wildlife	68
	Kennels or Domestic Animals	3
	Livestock	4

3.2.1 Point Source Pollution

Point sources of pollution were observed in all three study areas. All of these point sources were reported to the City as point source data sheets showing a location, description, photographs, and maps of each observation. Appendix G contains copies of the reported potential point sources of pollution. Seven observations that were considered severe were reported immediately, and the City investigated each of these incidences as they were reported. Five were lateral or main sewer line breaks or leaks and the other two were potential illicit discharges. All potential point sources will be investigated by the City (Figure 3-2). Unknown, potentially illicit discharges were observed the most often. These observations included strong chemical odors discharging from culverts or pipes draining into the stream, potential pool drains, and several pipes draining non-odorous water into streams during dry periods. Several observations were made of broken sewer lines or sewer overflow at manholes near streams. Observations of trash dumped into streams or of dumpsters that potentially drain runoff into streams were also made.

Raw sewage from broken sewer lines poses one of the largest point sources of fecal bacteria contamination. Most commonly broken sewer lines were observed at stream crossing where stream banks have eroded and exposed buried sewer pipe, which had subsequently broken. In one case, a length of bank had eroded and undermined a sewer line running parallel to the stream. Trash dumped into streams or dumpsters with drains leading to streams in and around multifamily developments may also pose a source of fecal bacterial.

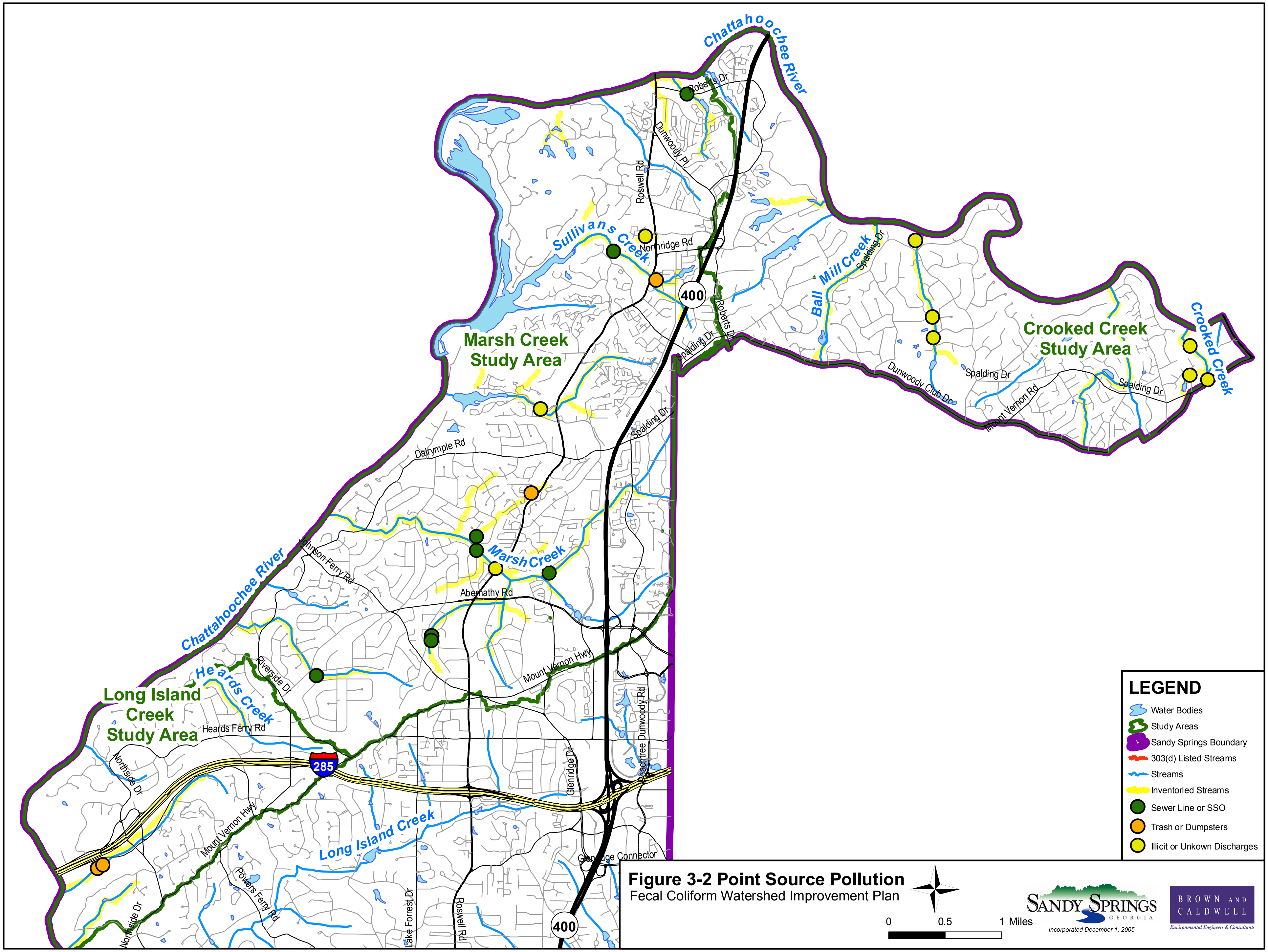


Figure 3-2 Point Source Pollution
Fecal Coliform Watershed Improvement Plan

Bank failure exposed and cracked clay sewer line

Drainage from a dumpster flowing into stream

3.2.1.1 Sewer Line Crossings

The City requested that field staff note the location of all sewer crossings in the database. In total, 117 sewer crossings were observed during the assessment of the 30 stream miles (Figure 3-3). Many of these crossings were private lateral lines. As noted in the previous section, the majority of the sanitary sewer leaks reported were a result of damage caused to sewer lines and private lateral lines from streambank erosion and debris jams forming upstream and around the sewer line. In some instances Brown and Caldwell reported to the City the locations of sewer lines that had not yet broken and caused a spill, but would likely do so in the near future based on the condition of the pipe and stress on the pipe from stream conditions. In addition, several of the sewer line crossings that were not reported may pose problems in the future based on pipe condition, as shown in the pictures below. Many of these types of crossings are private, lateral sewer crossings, which are considered a landowner responsibility. However, the City has issued notice of violations through Code Enforcement if leaking lateral lines are found and will continue to look for these water quality issues.

Undermined sewer crossing support

Exposed PVC sewer pipe with debris loading

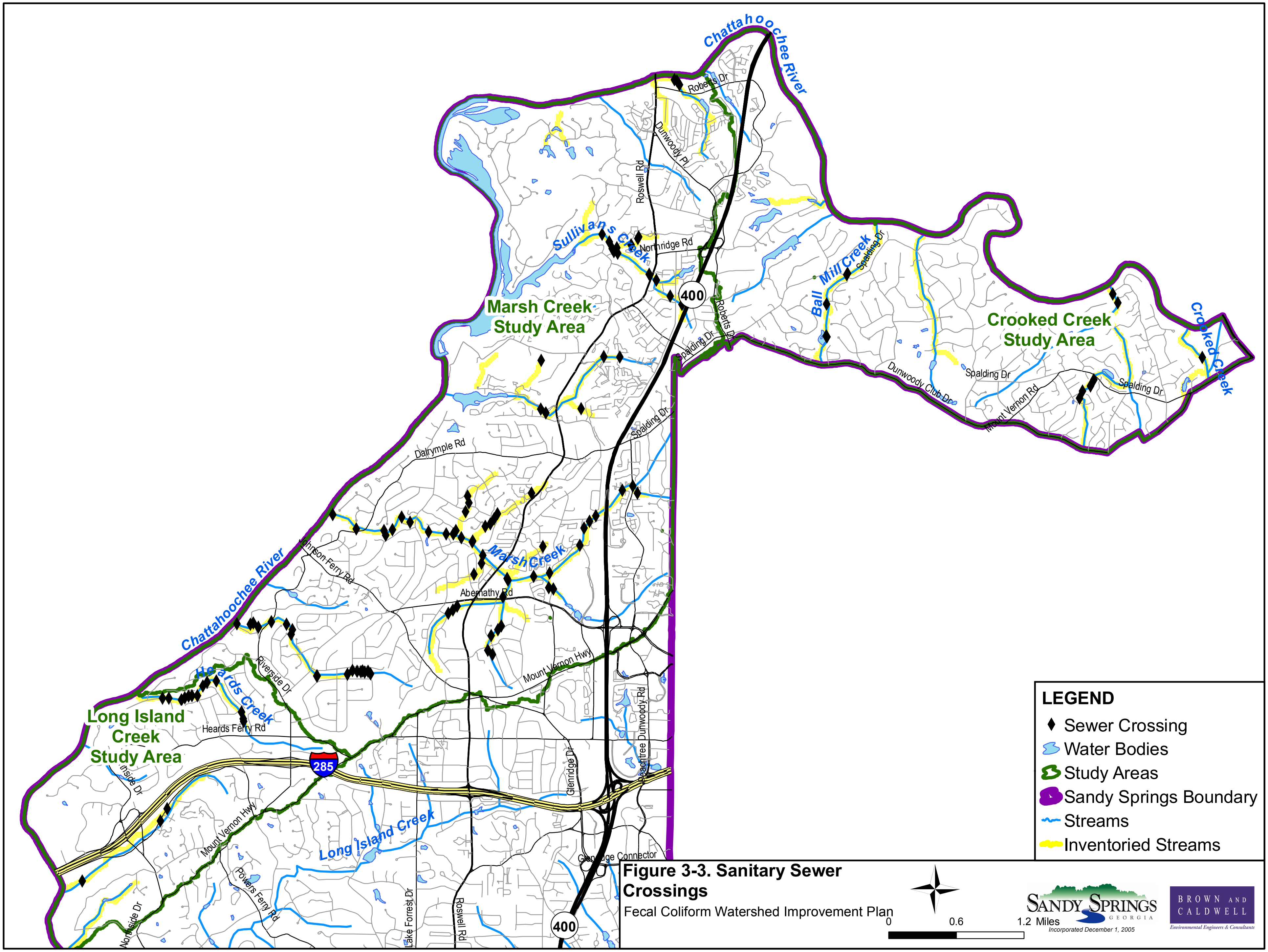


Figure 3-3. Sanitary Sewer Crossings

Fecal Coliform Watershed Improvement Plan

3.2.2 Non-point Source Pollution

3.2.2.1 Urban Runoff

Urban runoff enters streams either from directly connected impervious surfaces through a stormwater sewer system or by overland flows through encroached stream buffers. Urban runoff was the most commonly observed potential source of fecal coliform contamination in the study area. Urban runoff is cited as the most likely cause of fecal coliform contamination in the Atlanta Regional Commission (ARC) TMDL Implementation Plans (2004) for the three 303(d) listed streams in this study – Crooked, Ball Mill, and Marsh Creeks.

Stormwater outfalls draining urbanized areas directly into the stream was the most commonly observed non-point source water quality problem. Of the 422 data points collected on the stream walks, over one third (136 points) reference urban runoff as a water quality concern or reference stormwater outfalls directly into the stream (Figure 3-4). Observations of urban runoff impacts were made throughout the City, but these observations were concentrated in more urbanized areas such as the Marsh Creek watershed, Sullivan's Creek, and several tributaries to the Chattahoochee along Sandy Springs' western border.

This study did not include water quality sampling of the stormwater outfalls, and therefore the presence of fecal bacteria in the urban runoff was not determined. However, previous studies point to runoff from urbanized land as the most significant source of bacterial contamination of surface runoff in developed areas. Runoff from residential development was found to contribute the most fecal bacteria in a survey of nationwide water quality data (Pitt and Maestre 2005) followed by open space (parks), and commercial development. The sources of bacteria are likely a combination of waste from domestic and wild animals and humans (Young and Thackston 1999, and Hyer and Mayer 2004). Sources of bacteria in surface runoff can vary from place to place depending on density of pets and wildlife.

The trend of residential development increasing fecal bacteria concentrations in surface runoff is likely a result of direct discharge of surface runoff from residential areas into streams either via stormwater conveyance or via overland flow through encroached stream buffers.

Several outfalls draining commercial and high density residential land near Northridge Crossing Drive

Stormwater outfall on Marsh Creek near 550 Abernathy Road

3.2.2.2 Domestic and Wild Animals

The presence of wild animals was observed throughout the watersheds of Sandy Springs as evidenced by feces, footprints, or direct observation (Figure 3-5). Raccoon and deer scat and tracks along with squirrel and other small mammal tracks were observed along the streams and in the stream bed. Deer presence was characteristically noted in more wooded areas bordering the Chattahoochee River.

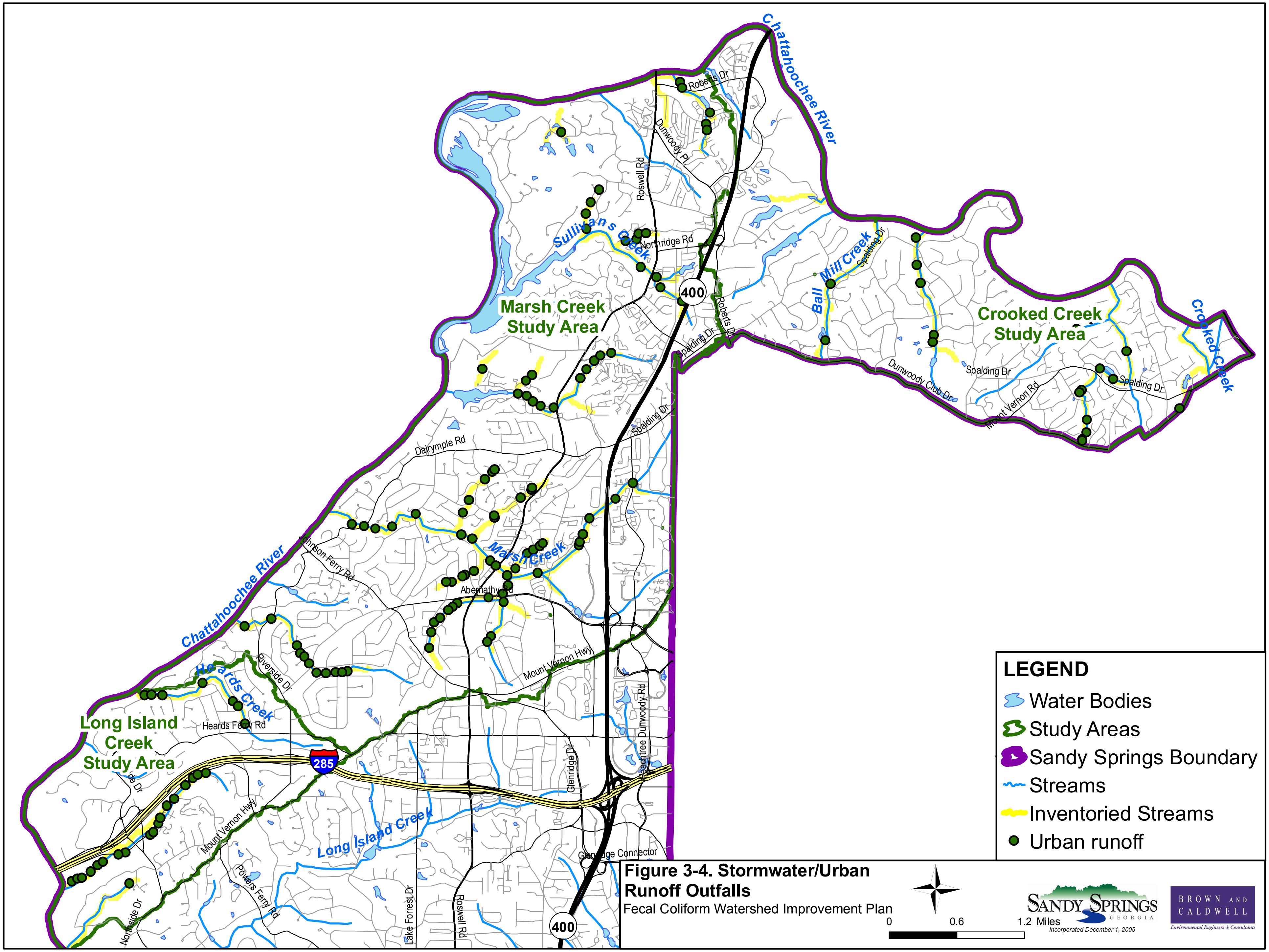


Figure 3-4. Stormwater/Urban Runoff Outfalls

Fecal Coliform Watershed Improvement Plan

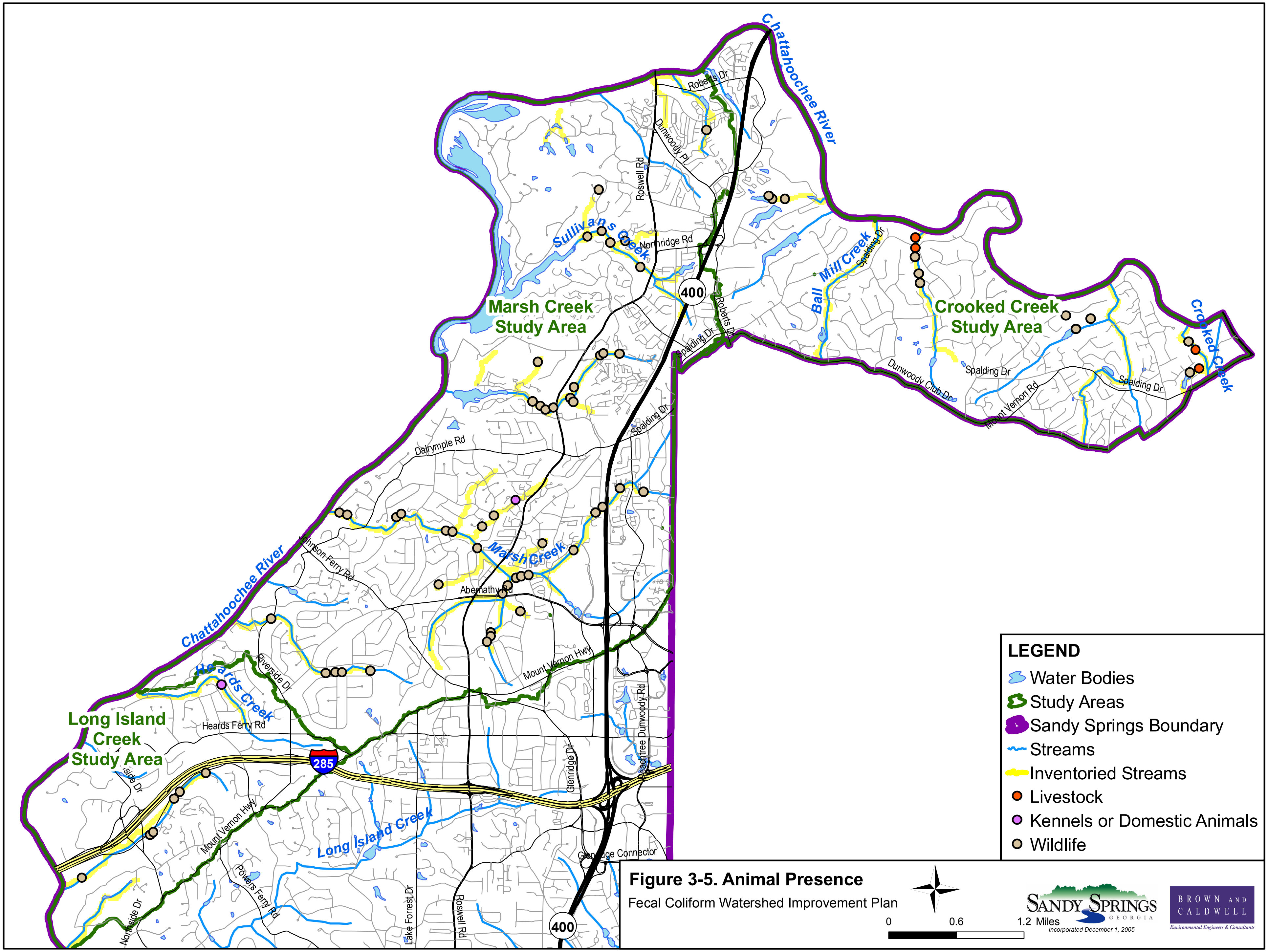


Figure 3-5. Animal Presence

Fecal Coliform Watershed Improvement Plan

Livestock were noted along Crooked Creek (horses) and along a tributary to the Chattahoochee River immediately east of Ball Mill Creek (donkeys). In both cases, vegetation along the stream had been encroached by the pastures leaving little buffer to filter or absorb runoff from the pastures. In the case of the horse pasture at Crooked Creek, the slope of the field would likely convey all runoff directly into a nearby tributary and a drainage ditch, both draining into Crooked Creek.

Pet walking areas, or observations of pets kept near the stream were noted in three locations. Data were only collected if evidence of pet access into streams or kennels were directly adjacent or within the stream. Multiple residential areas had fenced yards with dogs that had yard drainage into the stream that could not be directly verified so were not recorded. It has been well documented that runoff from developed areas where pets are kept likely contains a significant amount fecal bacteria (Young and Thackston 1999, and Hyer and Moyer 2004). There was one vet clinic observed adjacent to the creek on Abernathy Road but was not coded because of the site cleanliness and pet waste bag dispensers throughout the parking lot. No other animal boarding facilities, vet clinics, or other pet facilities were noted directly adjacent to or draining to a stream.

Bacterial tracing studies of stormwater have identified types of animal contributing fecal bacteria to streams including waterfowl, dog, cat, raccoon, deer, and rodents (Hyer and Moyer 2004, Whitlock et al. 2002, Geldreich et al. 1968). The relative contribution of fecal bacteria from each type of animal varies greatly from location to location and can only be identified by site specific sampling.

Horse pasture on western side of Crooked Creek with minimal buffer and ditches draining directly into stream

Raccoon and rodent prints in stream bed observed throughout the study area

3.3 Channel and Riparian Buffer Conditions

Channel and riparian buffer conditions were documented during the stream inventory. Channel alterations were divided into two categories – man-made and hydrologic. Man-made alterations are defined as direct modifications to the channel that have altered the channel dimension, pattern, or profile and include channelization, piping, use of riprap (toe or entire bank), concrete lining, stormwater outfalls, or floodplain build-up along the channel. Hydrologic alternations are defined as changes to the channel morphology due to changes in watershed hydrology and sediment input such as urbanization. Examples of hydrologic alteration include channel incision (current or historic), widening, aggradation, impacts from drainage ditches to the channel, stable knick-points, and unstable headcuts. The amount of streambank erosion was documented for each bank separately. The magnitude of erosion (visually assessed in terms of quartile of percent bank eroding area), length of erosion, and height of bank were recorded for each erosion observation. These data were used to model total suspended sediment yield as discussed in Chapter 2. Finally, riparian buffer encroachments were documented in terms of type of buffer encroachment (e.g., lawns, utilities and impervious surfaces), the length of the encroachment, and the width it extends into the buffer.

The dominant land use observed in the study area in Sandy Springs was single family residential with concentrations of multifamily residential, commercial and retail corridors along the Roswell Road and the I-285 corridors. These established suburban land uses were likely the drivers for channel alterations observed throughout the watershed.

The length of the man-made and hydrologic alterations, stream bank erosion, and buffer encroachments were recorded as discrete lengths in 50-foot increments from 50 feet to 500 feet, with the exception of severe bank erosion (75 percent to 100 percent eroded area), which was recorded to the nearest 25 feet. The severity of impacts from drainage ditches and outfalls, as well as the elevation of headcuts and knickpoints were also noted.

3.3.1 Man-made Channel Alterations

The following types of man-made and hydrologic alternations were inventoried in the field:

- **Channelized reach (CR)**. Straightened/dredged sections of the channel and/or areas where the channel has been relocated
- **Piped reach (PR)**. Sections of the stream that have been piped over long distances, generally excluding road crossings
- **Rip-rap channel (RCT or RCA)**. Areas where the channel or bank is lined with rip-rap along the bank toe (RCT) or along the entire bank (RCA), excluding sewer line crossings
- **Floodplain built-up (FB)**. Areas where the floodplain has been developed with structures leaving the channel confined to a narrow valley
- **Outfall (OF).** Stormwater outfall pipe discharging directly into the stream.

Man-made channel alterations were observed at 68 percent of the stream inventory points. The majority of observed man-made impacts consisted of rip-rap lined banks and toe of bank (13.1 percent of inventoried length) and piped reaches (8.9 percent of inventoried length) (Table 3-3 and Figure 3-6). Stream channelization was observed on 4.6 percent of inventoried stream length. Some development within the floodplain was observed (1.0 percent of inventoried length). The streams of the Marsh Creek watershed where most impacted by man-made alterations in all categories.

Many of the riprap lined and channelized reaches were associated with stormwater and road culverts. Riprap lined banks were also observed in residential and commercial areas where yards and paved areas extended to the streambank. Piped reaches generally occurred at road crossings; however, extensive lengths of stream had been piped in several locations for residential developments. Stormwater outfalls draining residential and commercial developments were observed throughout the study area. Impacts to the channel from outfalls (i.e., localized scour of banks and bed) were generally minimal to moderate with some instances of severe bed and bank scour.

Table 3-3. Observations of Man-made Alterations

Category	Number of Observations	Total Length (feet)*	Total Length (miles)*	Percent of Inventoried Length
Channelized reach	23	7,350	1.4	4.6%
Piped reach	54	14,200	2.7	8.9%
Riprap toe	16	4,100	0.8	2.6%
Riprap all bank	84	17,100	3.2	10.5%
Floodplain build-up	8	1,800	0.3	1.0%
Stormwater outfalls	103	-	-	-

** Estimates of lengths entered in the field – sum of each observation.*

Man-made alterations can change the hydraulics of a stream reach causing localized problems such as scour and bank erosion, and can have cumulative effects downstream from the changed reach conditions. For example, channelization of a reach generally causes a localized increase in channel slope potentially causing upstream incision and downstream aggradation (Simon and Rinaldi 2006).

Channelized reaches were observed in densely developed areas such as this stream crossing with Roswell Road

Riprap lined banks were the most commonly observed man-made alteration

3.3.2 Hydrologic Alterations

The following types of hydrologic alterations were inventoried in the field:

- **Channel incised (CI)**. The channel has cut-down into the stream bed or the stream is actively degrading
- **Channel widened (CW)**. The channel has widened due to bank failure or is in the process of widening, which is characterized by large point bars, fallen trees, and/or bank erosion
- **Channel incised and widened (IW)**. The channel has incised and widened
- **Channel aggraded (CA)**. The channel has accumulated deposits of sediment in the form of islands and/or point bars, generally characterized by deep sand deposits
- **Headcut (HC).** An abrupt (vertical) change in streambed elevation that is actively migrating upstream
- **Knickpoint (KP)**. An abrupt (vertical) stationary change in streambed elevation (usually >2 ft) due to natural or anthropogenic causes such as bedrock outcrops or embedded logs
- **Drainage Ditch (DD).** Lateral drainage channel directly discharging into the stream that is actively causing erosion.

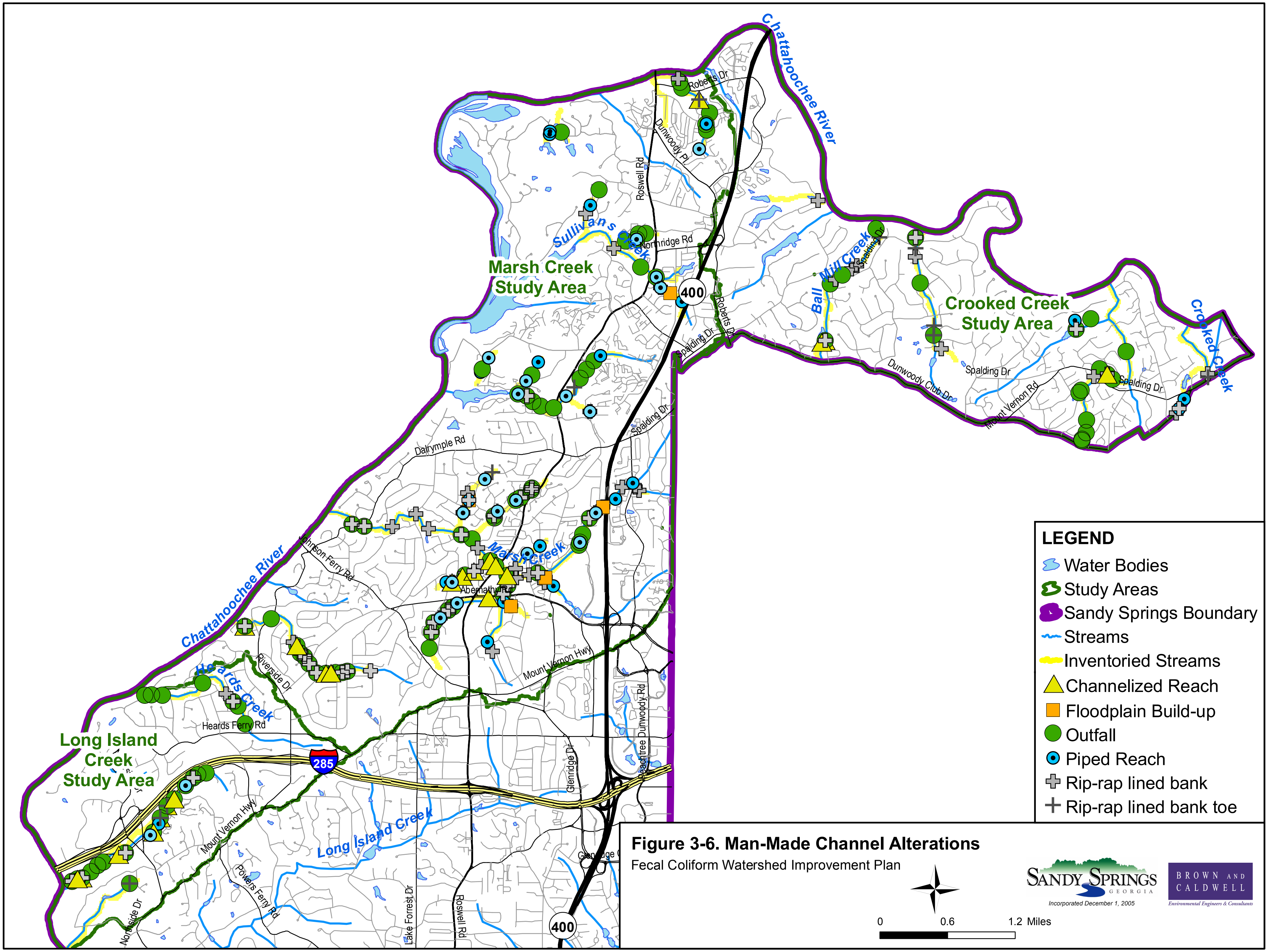


Figure 3-6. Man-Made Channel Alterations

Fecal Coliform Watershed Improvement Plan

Of the 30 stream miles inventoried, nearly one third showed some form of hydrologic alteration. The majority of hydrologic alterations observed in the study area were aggraded channels with build up of fine sediment in the channel bed (22.0 percent of inventoried length), and channel incision, or downcutting of the channel bed (5.6 percent of inventoried length) (Table 3-4 and Figure 3-7). Most of the channel incision was historic incision, meaning that the incision occurred in the past and the stream is adjusting or has adjusted to the new stream bed elevation.

Aggradation was observed throughout the study area, especially in low-grade areas near the Chattahoochee River and upstream of road crossings. Channel incision was noted extensively in the unnamed tributary to the Chattahoochee River located between Sullivans Creek and Marsh Creek, and an unnamed tributary located just east of Ball Mill Creek. Headcuts and knickpoints were observed throughout the study area. Knickpoints are stable vertical drops in the channel, mostly from bedrock outcroppings causing small waterfalls and cascades in the channel. Headcuts are unstable breaks in grade that migrate upstream leaving an incised channel behind. Headcuts were generally observed in the Marsh Creek watershed and north to Sullivans Creek. Most observed headcuts were located at the confluence of drainage ways with a stream channel or at confluences with tributaries. Drainage ditches directly connected to the stream were observed throughout the study area and exhibited minimal to locally moderate channel impacts in terms of channel and bed scour.

Urbanization within a watershed and the conversion of vegetated landscape to impervious cover leads to increased surface runoff during precipitation events as discussed in Chapter 2. The increased stormwater runoff causes streams to change shape due to increased stream power relative to sediment supply generated by the altered hydrology (Booth 1990). Simon and Hupp (1986) describe six stages of stream morphology changes starting with a pre-disturbance channel geometry, to initial disturbance (generation of headcuts), then incision, which leads to a deep channel and potentially unstable banks. The channel then widens and deepens until it is adjusted to the hydrology. During this process, aggradation is common due to the changed channel morphology not being able to transport the sediment load in the system. Eventually, the channel recreates a more stable pattern within the widened and deepened channel.

The hydrologic alteration observed in the study area fits this process. Given the hydrologic disturbance of watershed urbanization, channel incision and, in some places, subsequent channel widening is occurring throughout the study area. Approximately 22 percent of the streams inventoried were aggraded and had an abundance of sediment deposition observed in the channel.

Table 3-4. Observations of Hydrologic Alterations

Category	Number of Observations	Total Length (feet)*	Total Length (miles)*	Percent of Inventoried Length
Aggradation	109	35,550	6.7	22.0%
Incision	31	8,750	1.7	5.6%
Widening	17	4,350	0.8	2.6%
Incision & Widening	6	1,250	0.2	0.7%
Knickpoint	22	-	-	-
Headcut	17	-	-	-
Drainage ditch	19	-	-	-

** Estimates of lengths entered in the field – sum of each observation.*

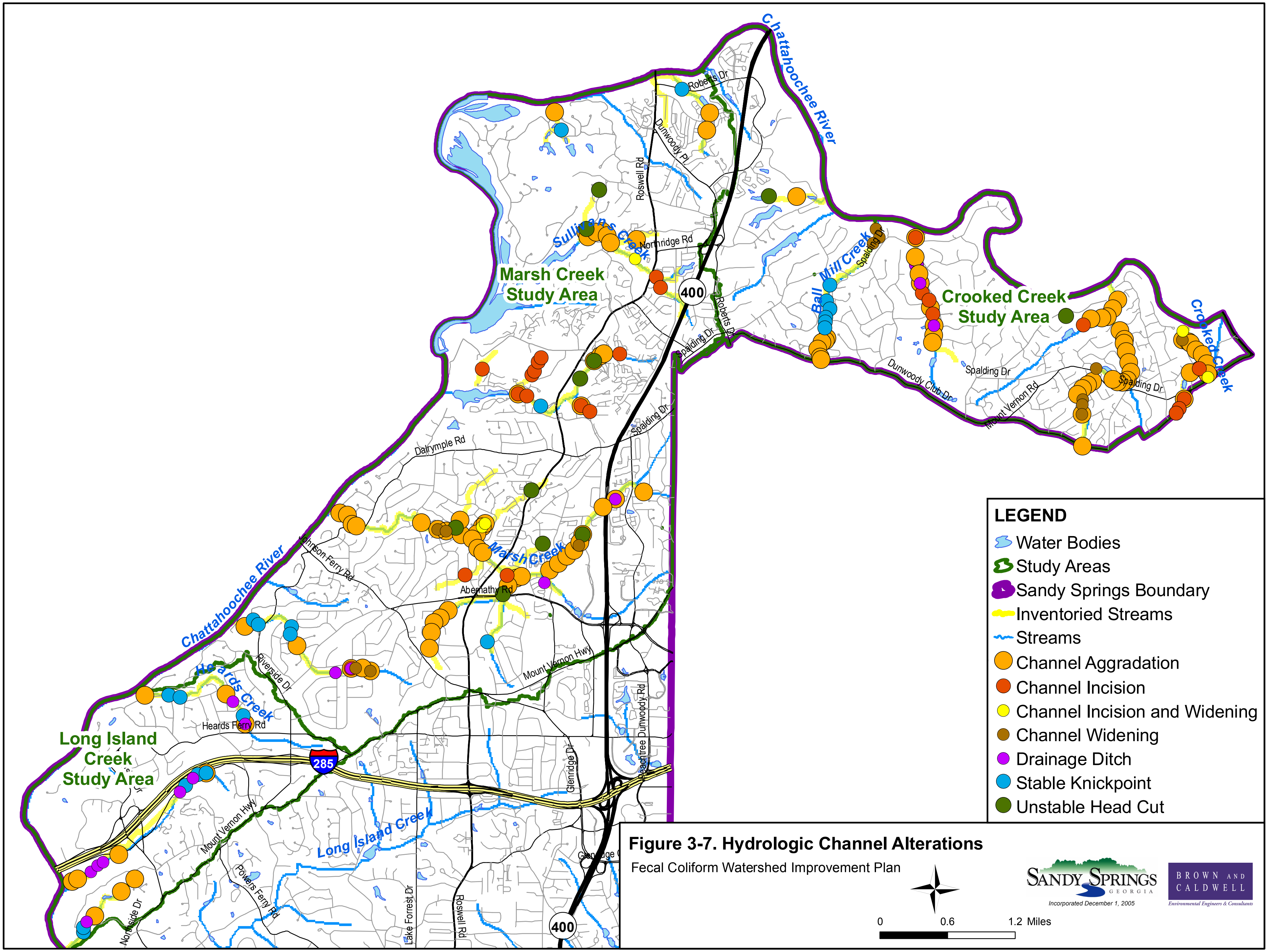


Figure 3-7. Hydrologic Channel Alterations

Fecal Coliform Watershed Improvement Plan

Sediment deposits in the form of sand and gravel bars and islands indicative of channel aggradation

A tributary incised to match bed elevation of main stream

3.3.3 Streambank Erosion

Bank erosion in streams is a natural process in alluvial streams. However, it can be increased in urbanized watersheds. Active erosion is recognized by loss or reduction of vegetative protection, bank undercutting, vertical slopes and bank slumping. For the purposes of this inventory, the relative amount of erosion occurring over lengths from 50 to 500 feet was assessed and recorded separately for each bank. Bank height averaged over the length of observed erosion was recorded to the nearest 0.5 feet. The percentage of actively eroding area was recorded as the midpoint of a range of 25 to 50 percent, 50 to 75 percent, or greater than 75 percent eroding area with an assumed baseline condition of 0 to 25 percent eroding area. These percentages refer to the amount of streambank that is actively eroded during storm flows. These values are based on qualitative visual assessments, and field crews were trained to record the same ranges for similar types of bank erosion to maintain data consistency. These data were used as input in the WIP tools model for Total Suspended Sediment (TSS) yield estimates for each stream in the study area (See Chapter 2).

Approximately 42 percent of the stream miles assessed had banks with greater than 25 percent eroded area (Table 3-5, Figures 3-8 and 3-9), indicating that much of the stream banks were experiencing active erosion above baseline conditions. Sources of increased erosion were observed to be primarily from urbanization in addition to localized impacts to stream condition (i.e., channelized reaches). In addition, evidence of recent scour and bank failure was observed, likely due to the recent flood of September 2009. Further, banks with increased erosion were observed in scour areas associated with undermined trees fallen in the stream and at the outside of particularly tight meander bends.

Table 3-5. Streambank Erosion by Reach Length and Magnitude

Percentage of Bank Eroded (%)	Length of Streambank (feet)*	Length of Streambank (miles)*	Percentage of Total Streambank Miles**
<25***	187,400	35.5	58.2%
25-50	62,200	11.8	19.3%
50-75	50,800	9.6	15.8%
>75	21,600	4.1	6.7%

** Estimates of lengths entered in the field – sum of each observation. Includes a summation of both left and right streambank observations.*

*** Total mileage is twice the stream miles walked (30.5 times 2 equals 61 miles)*

*** Lengths for the 0-25% eroded area category generated by subtracting the sum of 25-100% lengths from total stream miles walked for both banks.*

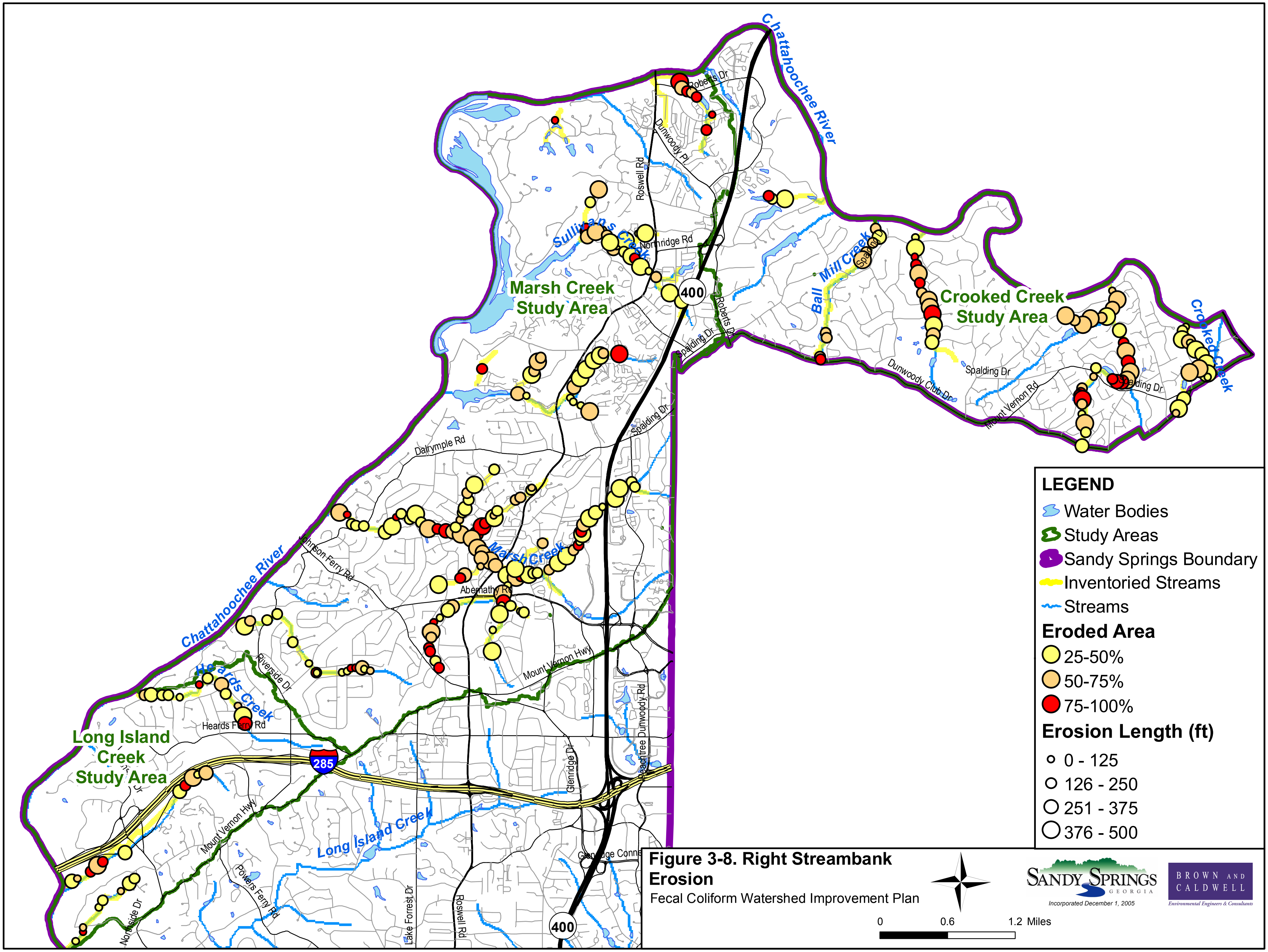


Figure 3-8. Right Streambank Erosion
Fecal Coliform Watershed Improvement Plan

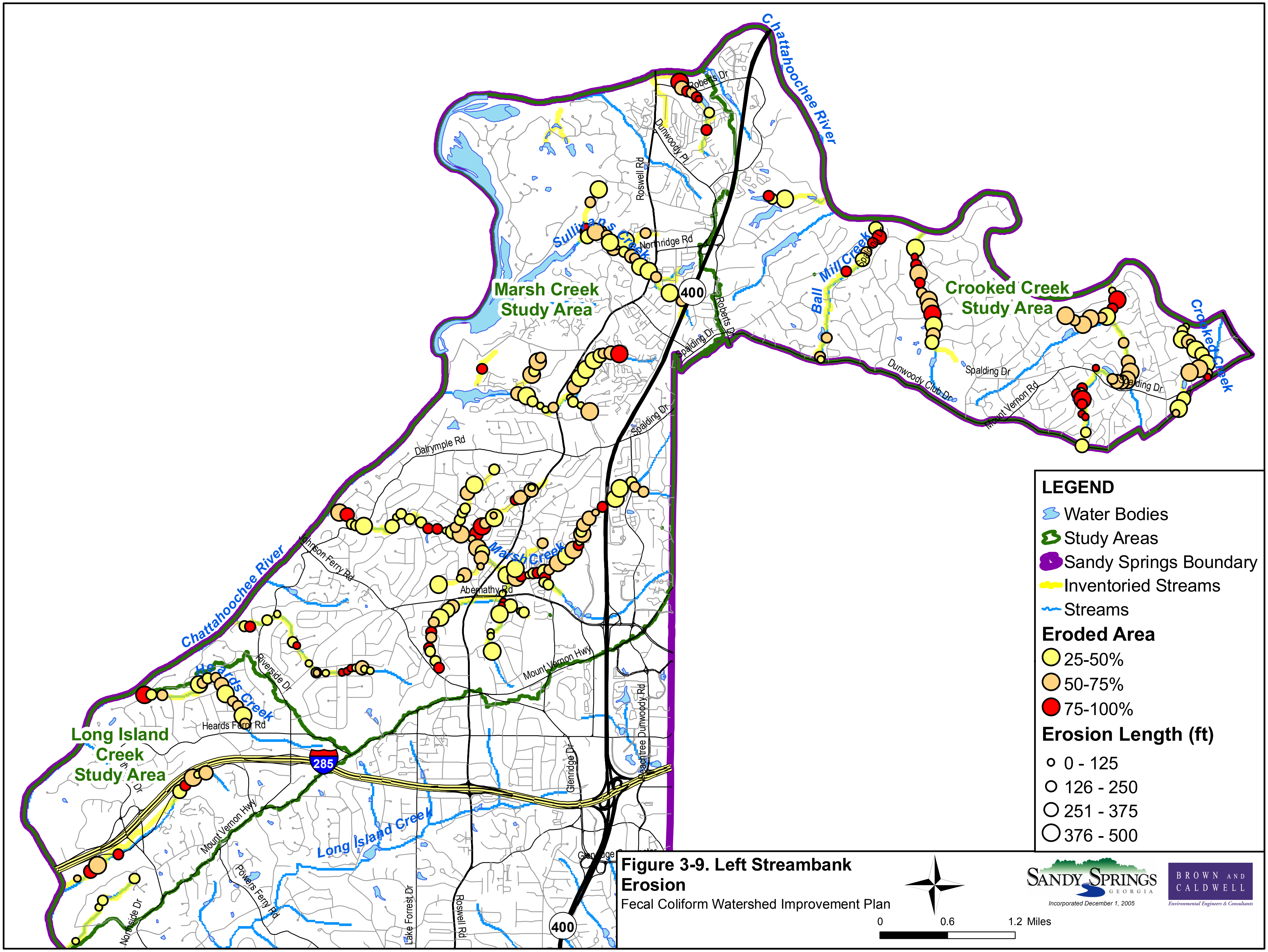


Figure 3-9. Left Streambank Erosion

Fecal Coliform Watershed Improvement Plan

Example of bank erosion in the 75-100% range

Example of bank erosion in the 25-50% range

3.3.4 Riparian Buffer Encroachment

The following types of hydrologic alterations have been inventoried in the field:

- **CP** – Active pastures or croplands within the stream buffer
- **AU** – Cleared/maintained utilities parallel to the stream and within the stream buffer
- **EU** – Cleared/maintained utilities perpendicular to the stream and within the stream buffer
- **CG** – Recently cleared and grubbed for development
- **IM** – Impervious cover such as roads, sidewalks, buildings, or other structures
- **LA** – Landscaping such as small planted shrubs and landscaping plants and/or mulched beds
- **LN** – Grassed lawns
- **OF** – Pastures or old residential areas that are re-vegetating but not considered a forested riparian buffer.

Riparian buffers provide multiple benefits to streams including interception of sediment and nutrients in overland runoff and the maintenance of in-stream habitat via water temperature moderation and introduction of woody debris (Wegner 1999), and bank stabilization (Simon and Collision 2001). The City currently requires a 50-foot undisturbed riparian buffer and 25-foot impervious set-back along all streams for new developments.

Brown and Caldwell field staff documented encroachments into the 50' buffer along inventoried streams. Just over one third of inventoried stream miles (34.5 percent) had riparian buffers that were less than 25 feet wide (average of left and right buffer encroachments, Table 3-6, Figures 3-10 and 3-11). The majority of buffer encroachments came from residential lawns and landscaping (20.8 percent), followed by impacts from impervious surfaces or structures (7.9 percent). Percentages reflect the average length of buffer encroachment on both banks.

Buffer encroachment was common in residential areas with grassed lawns directly adjacent to streambank

Impervious surface and structure encroachment was second-most common buffer encroachment observed

Table 3-6. Inventoried Observations of Inadequate Riparian Buffers

Buffer Land Use	Right Bank Total Length (feet)*	Left Bank Total Length (feet)*	Total Length (feet)*	Total Length (miles)*	Percent of Total Length**
Grassed lawn	23,700	20,400	44,100	8.4	13.8%
Landscaped area	12,525	9,900	22,425	4.3	7.0%
Impervious or structure	14,100	1,1000	25,100	4.8	7.9%
Cleared and maintained parallel or perpendicular utility	3,300	5,600	8,900	1.7	2.8%
Old field	500	1,700	2,200	0.4	0.7%
Crops and pasture	2,400	2,250	4,650	0.9	1.5%
Cleared and grubbed	1,425	1,075	2,500	0.5	0.8%

NOTE: The width of encroachment was combined for the table and summarized by land use.

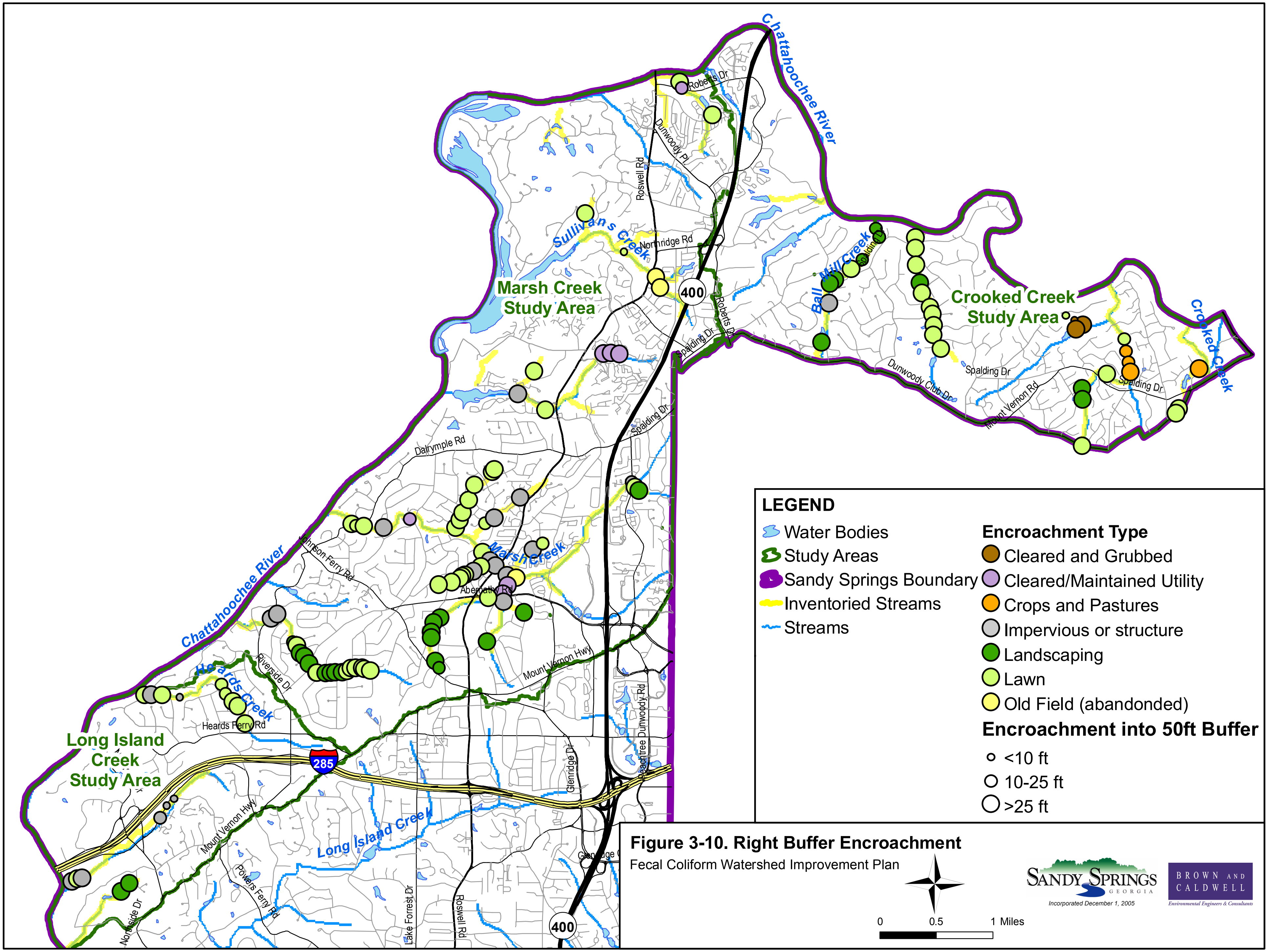
** Estimates of lengths entered in the field – sum of each observation. Right and Left banks designated facing downstream.*

*** Total mileage is twice the stream miles walked (30.5 times 2 equals 61 miles).*

3.3.5 Miscellaneous Observations

Other data were collected on miscellaneous observations made during the stream inventory, which included the following:

- **Reference reach (RR)** – Stream reach that exhibits a stable stream and habitat diversity that could be considered a reference for a high quality stream in a suburban setting
- **Invasive species (IS)** – Dense areas of kudzu, privet or bamboo along the stream in the riparian buffer
- **Debris dams (DD)** – Debris build up around road culverts or in the stream channel that is substantial enough to cause scour around the debris and potentially cause local flooding due to the dam effect of debris
- **Beaver dam (BD)** – Beaver dams that have caused an impounding effect on the stream
- **Water withdrawal (WW)** – Pipe in the stream that withdraws water from the stream for irrigation or other purposes
- **In-channel wetland (IW)** – Braided stream system that mimics a wetland community more than a defined stream channel
- **Off-channel wetland (OW)** – Wetland system in the floodplain adjacent to the stream channel
- **Unusual/Comment (UC**) – Any unique or unusual observation worth noting and does not fit into any other category.



LEGEND

- Water Bodies
- Study Areas
- Sandy Springs Boundary
- Inventoried Streams
- Streams

Encroachment Type

- Cleared and Grubbed
- Cleared/Maintained Utility
- Crops and Pastures
- Impervious or structure
- Landscaping
- Lawn
- Old Field (abandonded)

Encroachment into 50ft Buffer

- <10 ft
- 10-25 ft
- >25 ft

Figure 3-10. Right Buffer Encroachment

Fecal Coliform Watershed Improvement Plan

0 0.5 1 Miles

SANDY SPRINGS GEORGIA Incorporated December 1, 2005

BROWN AND CALDWELL Environmental Engineers & Consultants

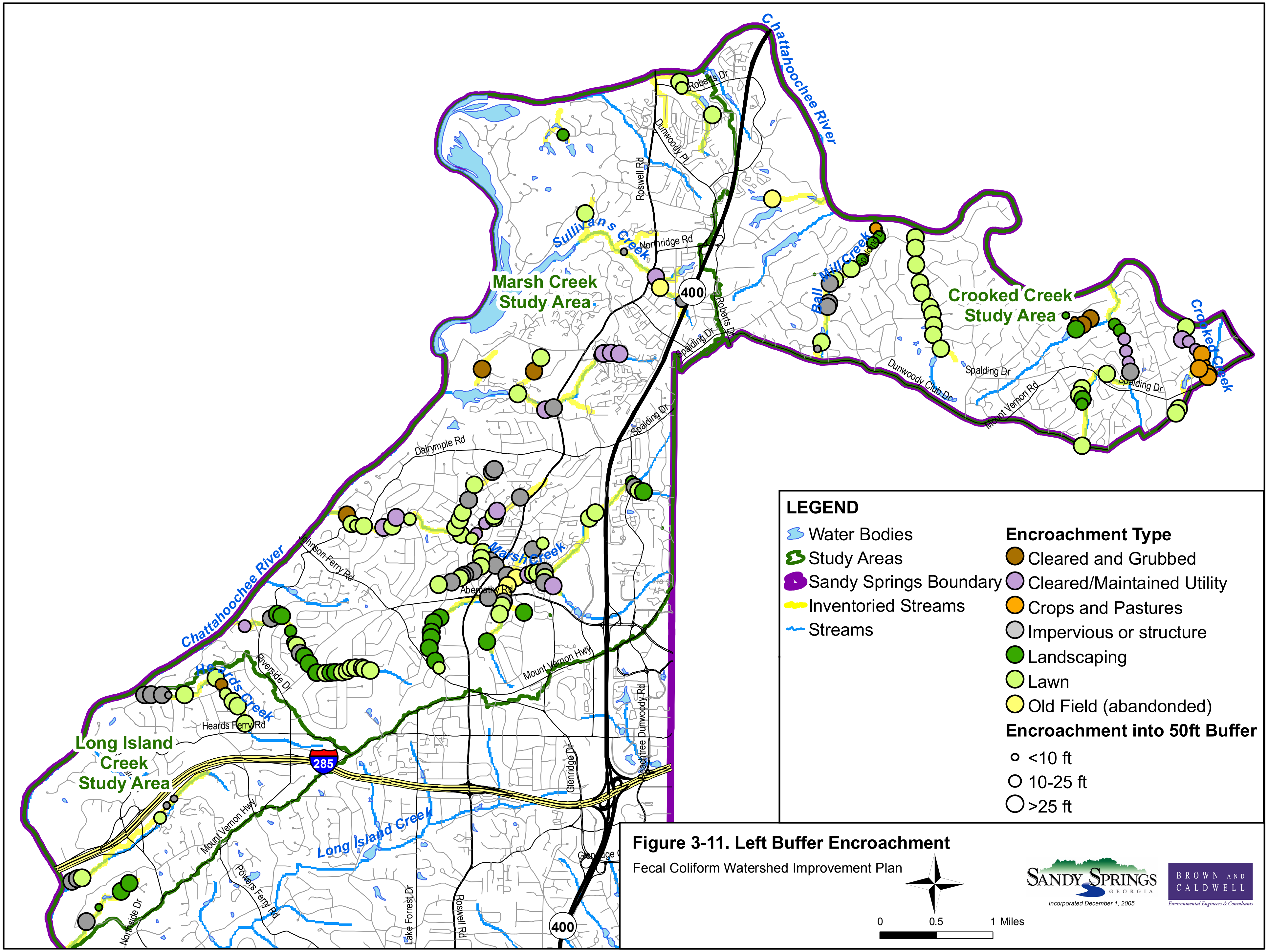


Figure 3-11. Left Buffer Encroachment

Fecal Coliform Watershed Improvement Plan

Debris jams were observed sporadically throughout the study area, though were most concentrated on Marsh Creel and its tributaries. Most of the debris jams were caused by fallen trees that had been undermined along the bank although sewer pipe crossings and some road culverts caused debris buildup. Invasive species were seen throughout the watershed along the riparian corridor. The majority of the invasive species noted were privet, kudzu, English ivy and bamboo. Small, residential water withdrawals were also common, but the most common unusual comment observed during the stream inventory concerned maintenance issues. (Table 3-7 and Figure 3-12).

Table 3-7. Inventoried Observations of Miscellaneous Features

Category	Number of Observations
Invasive plant species	51
Debris Dam	23
Beaver Dam	0
Wetland	5
Unusual / Comment	81
Water withdrawal	16
Reference Reach	12

3.4 Habitat Assessment and Channel Measurements

During the stream inventory, field staff collected stream habitat and channel geometry measurements at representative sites throughout the study area at roughly one site per square mile of drainage area. Habitat assessments were performed using the Habitat Assessment Procedure in the *Georgia Department of Natural Resources SOP for Macroninvertebrate Biological Assessment of Wadeable Streams in Georgia* (GA DNR 2007). This methodology was created for assessing reaches at the 100 meter scale; however, for the purposes of this study, it was applied to assess average conditions along the entire length of the channel downstream of the assessment point.

Field crews also collected channel cross section geometry measurements used to classify a stream reach using Rosgen Stream Classification methodology (Rosgen, 1994). This methodology is also generally applied over a reach scale; however, for the purposes of this study measurements were conducted solely at one cross section. The Rosgen channel classifications generated at each point reflect a snapshot of channel conditions using the assumptions of the relationship between channel form and process contained in the Rosgen methodology.

Habitat scores ranged from a minimum of 42 to a maximum of 164 with an average score of 106. Scores were evenly distributed throughout each quartile of the minimum to maximum range (Table 3-8, Figure 3-13). The higher scores were generally located in stable, bedrock dominated reaches with intact buffers and less dense development (e.g., low to medium density residential and Chattahoochee NRA). Sand deposition in the stream bed, impacted stream buffers and relatively unstable banks observed throughout the study area accounted for the lower scores. The lowest scores were concentrated in the Marsh Creek watershed, for reasons stated above and the overall higher level of urban impacts compared to the rest of the streams inventoried. The dominant bed material observed in the study area was sand, but cobbles and bedrock outcroppings were also observed frequently.

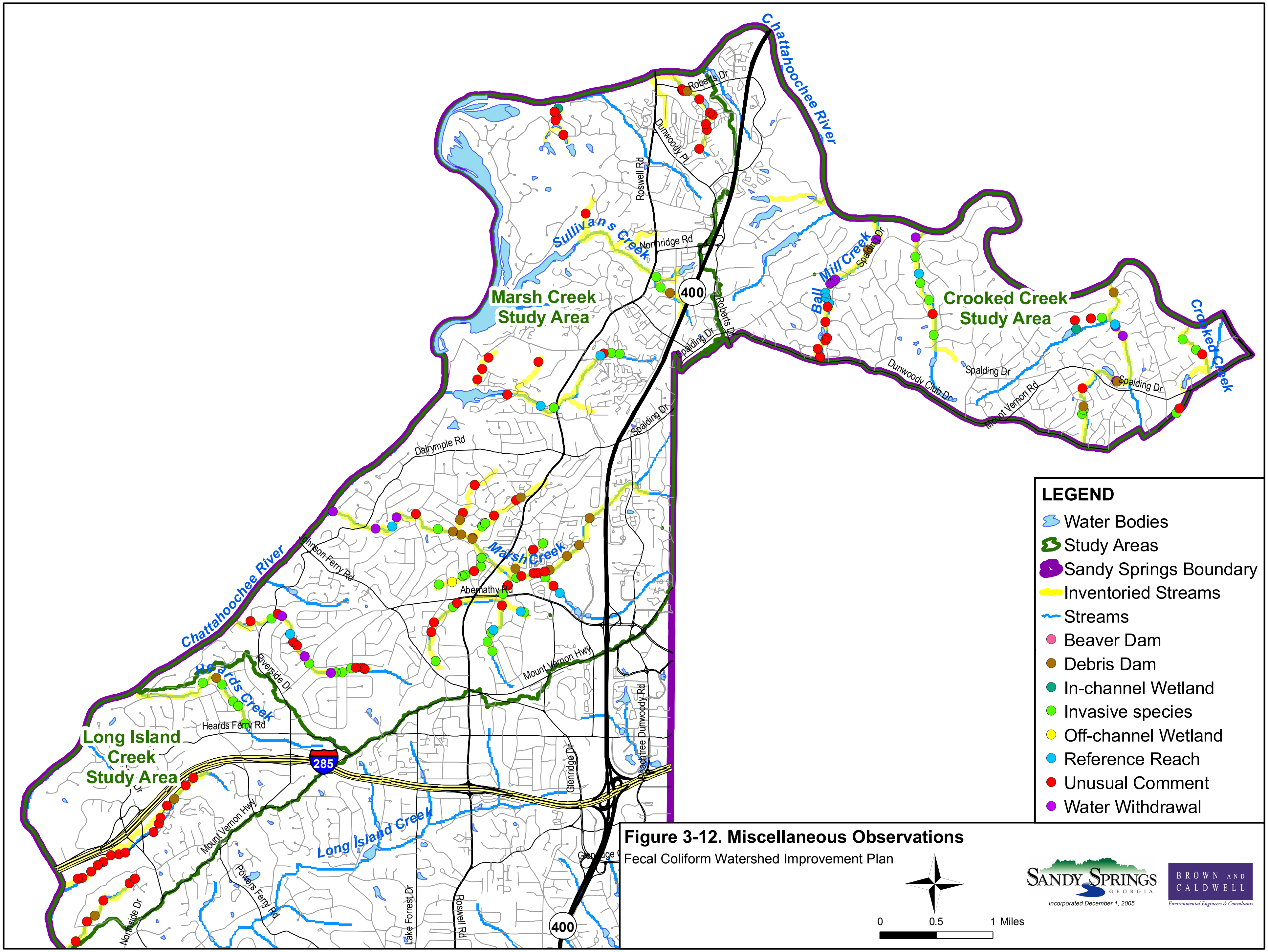


Figure 3-12. Miscellaneous Observations
Fecal Coliform Watershed Improvement Plan

Table 3-8. Habitat Assessment Scores		
Habitat Assessment Score Range	**Percent of Reference Reach***	**Number of Scores**
Less than 98	<60%	14
99-121	60-74%	4
122-146	75-89%	5
Greater than 146	>89%	6

**The highest score of 164 was used as a reference reach for comparisons.*

Using the Rosgen Stream Classification method, the majority of measured channels fell under the E channel type, which refers to slightly entrenched channels with low width to depth ratios indicative of some, though not extensive, channel degradation (Table 3-9 and Figure 3-14). The G channel type was the second most common identified and describes a deeply entrenched channel that is either actively incising or has incised into cohesive sediment and has not gone through a widening stage. Channel types of C and F occurred with the least frequency. F channels are entrenched but have a lower width to depth ratio and may describe channels that have incised and then widened. C channels are considered stable channels that have not been heavily impacted by altered hydrology or sediment input.

Table 3-9. Rosgen Channel Types		
Channel Type	**Number of Stream Reaches**	**Channel Type Description***
C3 C5	2 1	Slightly entrenched channels with a higher width to depth ratio (>12). Considered a stable reach in Sandy Springs.
E1 E3 E4 E5	3 2 1 9	Slightly entrenched channels with low width to depth ratios (<12). Considered a stable reach in Sandy Springs.
F3 F5	2 1	Deeply entrenched channels with a higher width to depth ratios (>12). F channels are characterized as incised and widened channels that show signs of historic and/or current disturbance. Considered a degraded reach in Sandy Springs.
G1 G5	2 6	Deeply entrenched channels with lower width to depth ratios (<12). These channels generally have incised into relatively cohesive sediment and have not widened, or are actively incising. Considered a degraded reach in Sandy Springs.

**Number connotation on channel type refers to type of substrate – 1 = bedrock, 2 = boulder, 3 = cobble, 4 = gravel, 5 = sand, 6 = silt/clay*

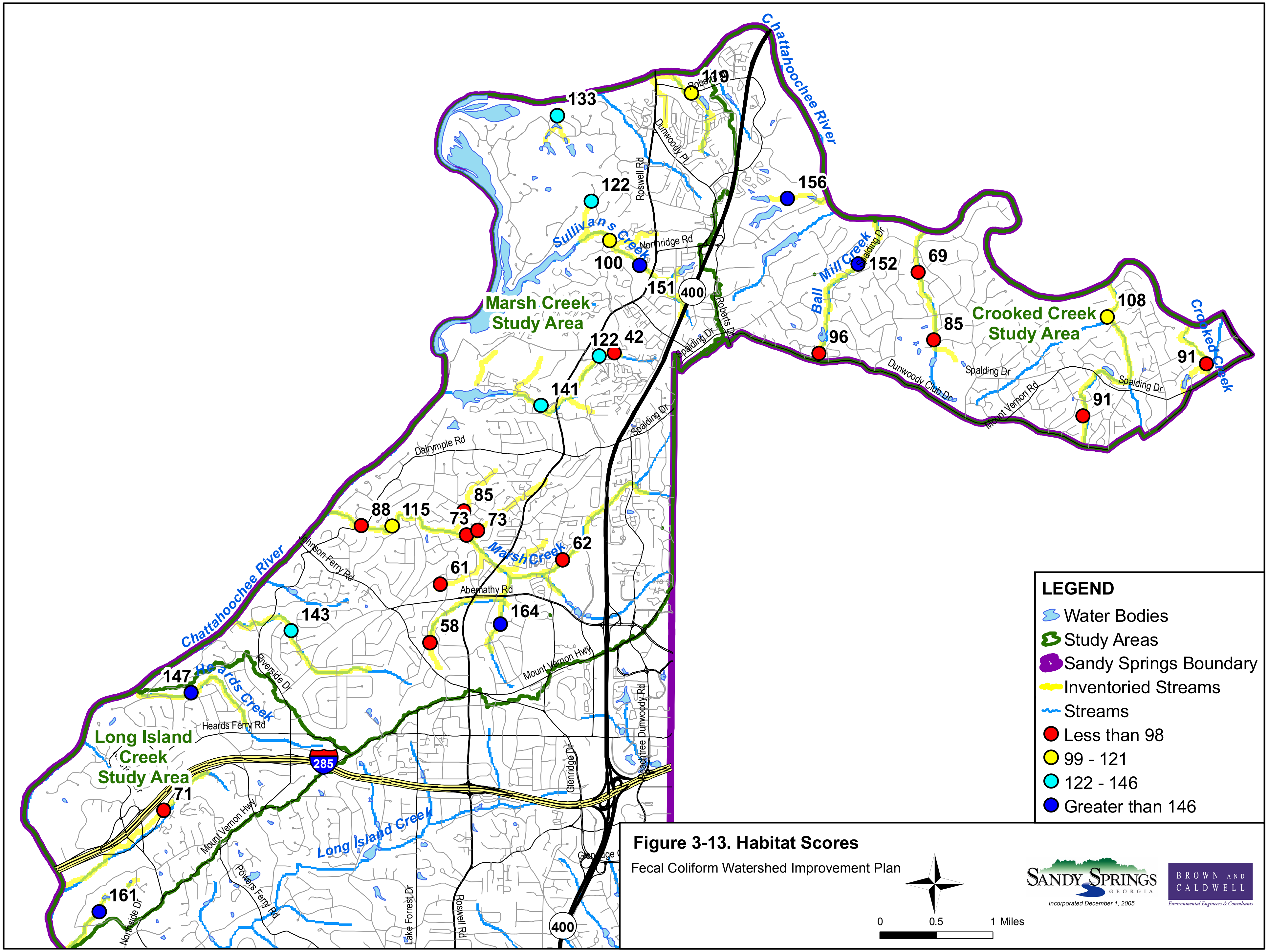


Figure 3-13. Habitat Scores

Fecal Coliform Watershed Improvement Plan

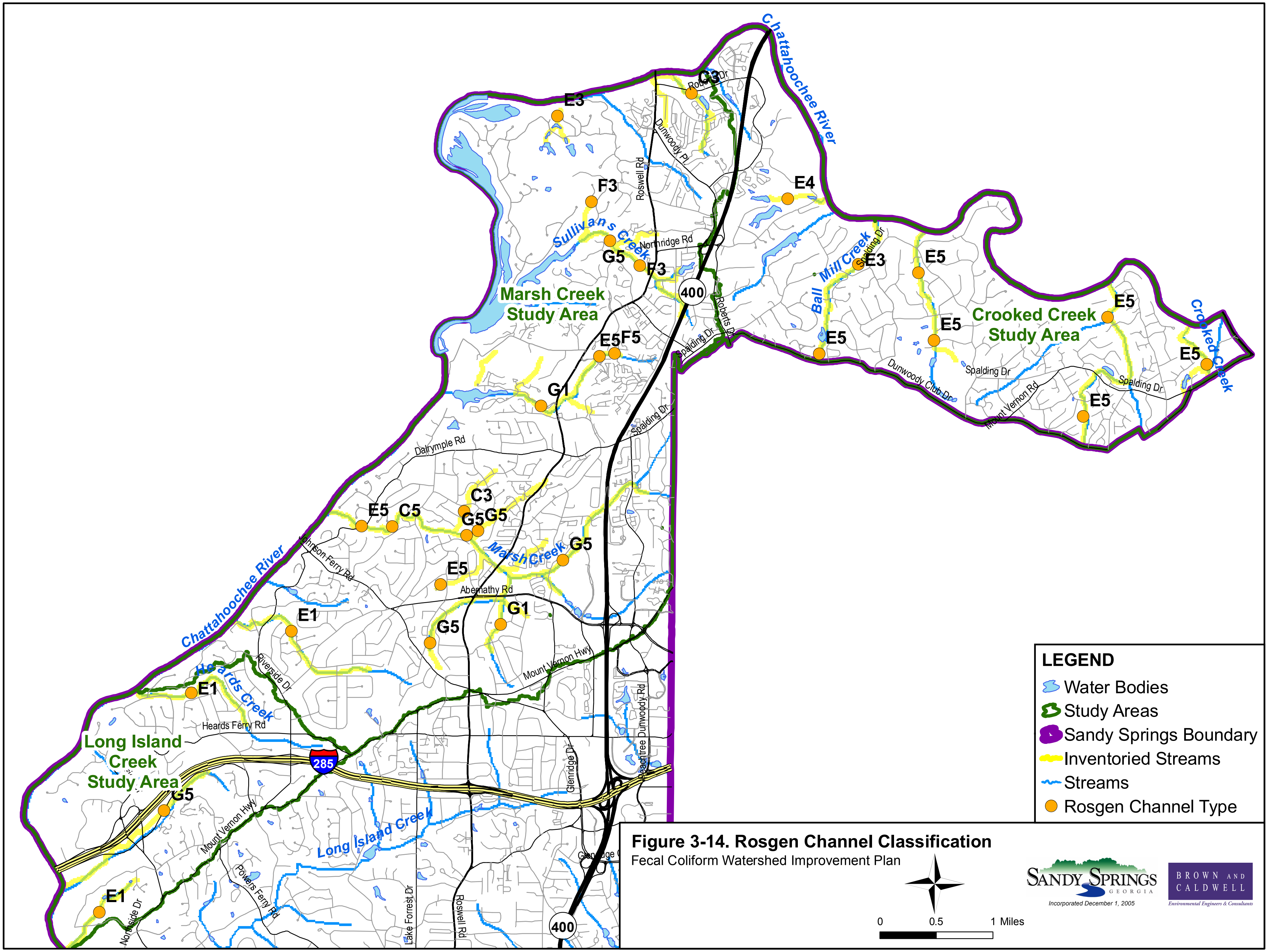


Figure 3-14. Rosgen Channel Classification
Fecal Coliform Watershed Improvement Plan

4. HISTORIC PROJECT EVALUATION AND IMPLEMENTATION RECOMENDATIONS

4.1 Evaluation Introduction

The goal of the Sandy Springs WIP is to reduce and eliminate sources of fecal coliform bacteria from watersheds within the City limits, and especially from streams listed by the GA EPD as not meeting water quality standards. This goal is achieved by implementing a variety of structural, non-structural, and public education projects and activities. This chapter discusses structural best management practices (BMPs), specifically the stormwater BMPs identified in earlier studies. These BMPs are referred to as “historic BMPs”. Evaluation of these projects requires a rigorous method in order to ensure the most cost effective projects are recommended for a capital improvement project (CIP) list.

A combination of tools was used in evaluating watershed projects. First, the watershed planning, water quality model, WIP Tools, was used to determine watershed-wide water quality conditions, and to assist in evaluating individual projects. Second, a spreadsheet with numerous functions called the CIP Prioritization Tool was utilized. The CIP Prioritization Tool is used to calculate removal efficiencies for new and retrofit projects, assign project scores based on the Sandy Springs Prioritization Matrix, generate project summary sheets and calculate total estimated project costs. Project costs include engineering, construction, easement value, and a contingency factor. The following section details the project evaluation process.

For this plan, stormwater detention facilities are referred to as best management practices (BMPs). The BMPs and Stream Restoration Projects evaluated for the Fecal Watershed Improvement Plan come from the historical CIP. During the first phase of this project the available historical data including reports, GIS, photos and models were reviewed and cataloged. Appendix A contains a technical memorandum that outlines the available historical data reviewed and used for this project.

4.2 Historic Project Review

In the 2001-03 time frame, Fulton County prepared Water Resource Management Plans (WRMP) that covered all of the then unincorporated areas of the County. The WRMPs included a stormwater infrastructure and stream inventory, watershed modeling and the creation of a CIP. Data included in the WRMP reports include: storm sewer system infrastructure; stream survey cross-sections; SWMM modeling files; stream photos and associated photologs, and prioritized CIP projects with estimated implementation costs. Each of the WRMPs was performed by a different firm, and therefore the criteria for project evaluation were not consistent. Applicable WRMPs for the Fecal WIP study area include Big Creek WRMP, Johns Creek WRMP and Sandy Springs WRMP (Figure 4-1). Some GIS data was obtained from the Sandy Springs WRMP and the Big Creek WRMP.

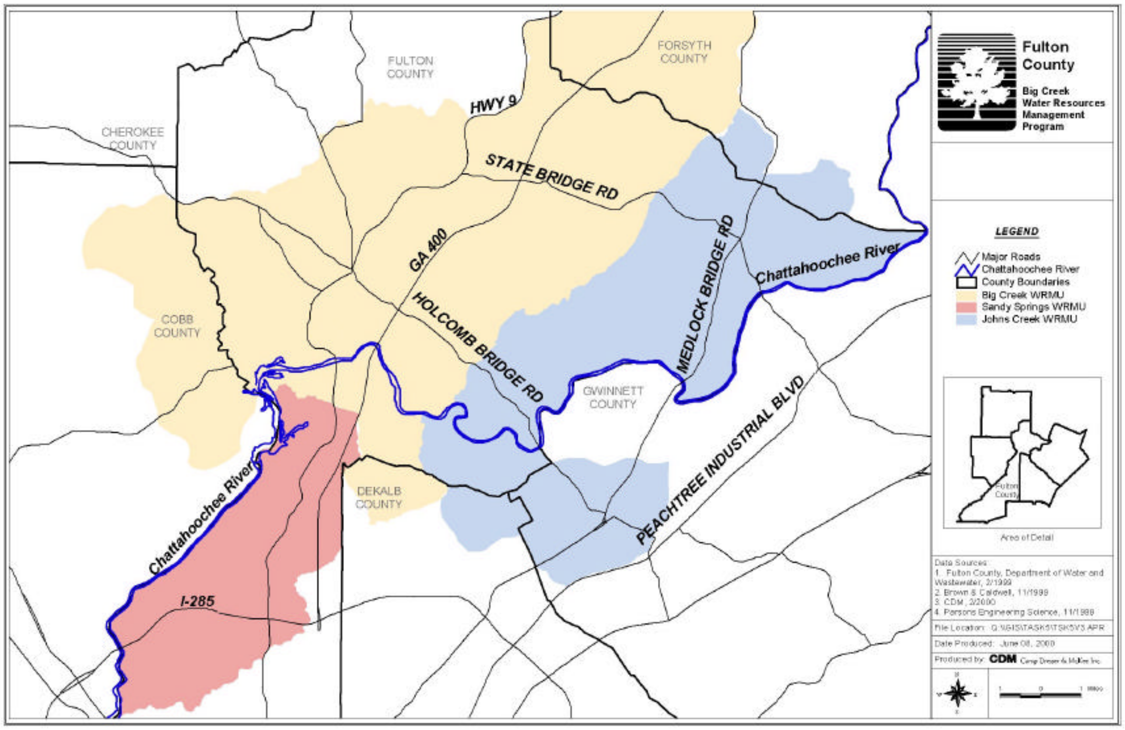


Figure 4-1. WRMP Study Areas
(Figure from the Big Creek WRMP)

Another source of BMP information is the 2006 CIP Priority Projects List report prepared by Brown and Caldwell for Fulton County (Brown and Caldwell 2006). This report was prepared to compile recommended CIP projects from all the WRMPs grouped by watershed management district. The area which is now the City of Sandy Springs was included in the Sandy Springs Stormwater Management District report. CIP projects were aggregated from the various WRMPs. These projects included flood control, BMP, and stream restoration projects. Data from the 2006 report includes a Priority Projects table of the 151 identified CIP projects, a map with the location of all potential projects, and a 2-page project summary for each identified project which included a site map, photographs, and cost estimate. Using the Sandy Springs Stormwater Management District report and available GIS data, 92 historical CIP projects were identified for the Fecal Coliform WIP Study Area as given in Table 4-1.

Table 4-1. Historical CIP Projects

Type	Number of Projects
Flood Control	22
Lake Modification	18
Pond Retrofit	3
Regional Detention Pond	2
Detention Pond/Wetland	24
Grass Swale	2
Parking Lot Bioinfiltration	1
Check Dam	7
Stream Protection/Restoration	13
TOTAL	**92**

Each of the historical CIP projects was reviewed for use in the current study. Based upon the review, 39 projects were removed from the watershed CIP listing or will be evaluated by another study (flood control or infrastructure). Of these projects, 22 were flood control projects, for the remaining 17 removed projects the reason for removing each of the projects is listed in Table 4-2.

Table 4-2. Historical CIP Projects Removed from CIP Consideration

Old Project ID	Reason	Project Type
BC-CDM-03	Very small project and half of it is located outside the City limits	Stream Stabilization
BC-CDM-74	BMP footprint covers a house	Lake Modification
JC-PAR-51	Huge new regional facility, footprint covers portions of houses; too difficult to permit	Regional Detention Pond
JC-PAR-60	Large New facility that is online; too difficult to permit	Regional Detention Pond
SS-BMP-24220324	Very small measure, can't really be evaluated like other projects	Parking Lot Bioinfiltration
SS-BMP-24330220	Large New facility that is online; too difficult to permit	Detention Pond/Wetland
SS-BMP-24340321	Very close to new houses	Check Dam
SS-BMP-24340412	Large New facility that is online; too difficult to permit	Detention Pond/Wetland
SS-BMP-24340414	Large New facility that is online; too difficult to permit	Detention Pond/Wetland
SS-BMP-24340418	Just upstream and downstream of existing BMPs, makes more sense to retrofit existing than to build new one in between	Detention Pond/Wetland
SS-BMP-24340423	Large New facility that is online; too difficult to permit	Detention Pond/Wetland
SS-BMP-24440115	Footprint covers portion of site/buildings under construction	Detention Pond/Wetland
SS-STM-CC	Points of bank erosion, not actual stream restoration project	Stream Protection/Restoration
SS-STM-HC	Points of bank erosion, not actual stream restoration project	Stream Protection/Restoration
SS-STM-MC	Points of bank erosion, not actual stream restoration project	Stream Protection/Restoration
SS-STM-PB	Points of bank erosion, not actual stream restoration project	Stream Protection/Restoration
SS-STM-SC	Points of bank erosion, not actual stream restoration project	Stream Protection/Restoration

In addition eleven projects were modified as listed in Table 4-3.

Table 4-3. Modified Historical CIP Projects

Old Project ID	Explanation of Modification
BC-CDM-52	Split into two projects
BC-CDM-86	Split into two projects
SS-BMP-24230408	Changed from check dam to new BMP
SS-BMP-24330110	Changed from grass swale to new BMP
SS-BMP-24330209	Changed from check dam to existing BMP
SS-BMP-24330210	Changed from check dam to new BMP
SS-BMP-24330211	Changed from check dam to new BMP
SS-BMP-24330418	Changed from grass swale to new BMP
SS-BMP-24330437	Split into two projects
SS-BMP-24340310	Changed from check dam to new BMP
SS-BMP-24340311	Changed from check dam to new BMP

4.3 Project Development

As a result of the historical CIP project review (Section 4.2) plus one additional existing BMP project not previously considered, a total of 57 projects were carried forward. However, two of these projects are functioning wet ponds that do not need additional retrofit, so these BMPs were removed from the list bringing the total number of projects fully evaluated to 55. The types of projects are listed in Table 4-4 and the location of each project is shown on Figure 4-2.

Table 4-4. Evaluated Projects by Project Type

	Number of Projects
Existing BMP (Historic CIP)	26
New BMPs (Historic CIP)	21
Existing BMP	1
Stream Restoration	7
Total	55

4.3.1 BMP Project Development

Each project has an asset number and project number associated with it. The asset number is a City of Sandy Springs designation based on a numerical value assigned to each asset within the City and named for example "AGM five digit number". If an asset number did not exist for a particular project, then the nearest asset was assigned to that project. If no asset was in close proximity, the code "BAC five digit code" was assigned to that project. The project number is a combination of the parcel number, what type of project it is, and a numerical designation to represent the project within each parcel. A couple of the projects are located in the right-of-way and do not have a parcel number. As a result, the project number was developed using the location of the project, for example "GA400 Spalding-BMP-1".

During the project review, each BMP was assigned an existing project type. The project type includes Dry Basin or Wet Pond. The project type was assigned based on aerial photography or previous photography from prior studies. Each existing BMP type is explained below.

- Dry Pond (DP) – denotes a dry facility (no permanent pool) designed to collect and store storm water runoff and release the runoff at a reduced rate. The primary purpose of this facility type typically is flood control; however newer facilities may be designed to provide water quality and channel protection benefits. This designation also includes facilities such as a dry extended detention basin and micropool extended detention.
- Wet Pond (WP) – is a facility with a permanent pool of water. If designed using current standards, the facility will have a permanent pool to store the water quality volume. In addition, the channel protection volume will be released over a 24-hour period, and the facility may provide additional storage for larger storm events. However, some facilities may have been developed for farm or recreational use without stormwater design considerations. This designation also includes facilities such as wet extended detention and constructed wetlands.

Table 4-5 shows project type breakdown for the existing BMPs (historic CIP plus additional from City).

Table 4-5. Existing BMP Project Type

	Dry Pond (DP)	Wet Pond (WP)	Total
Evaluated BMPs	6	21	27

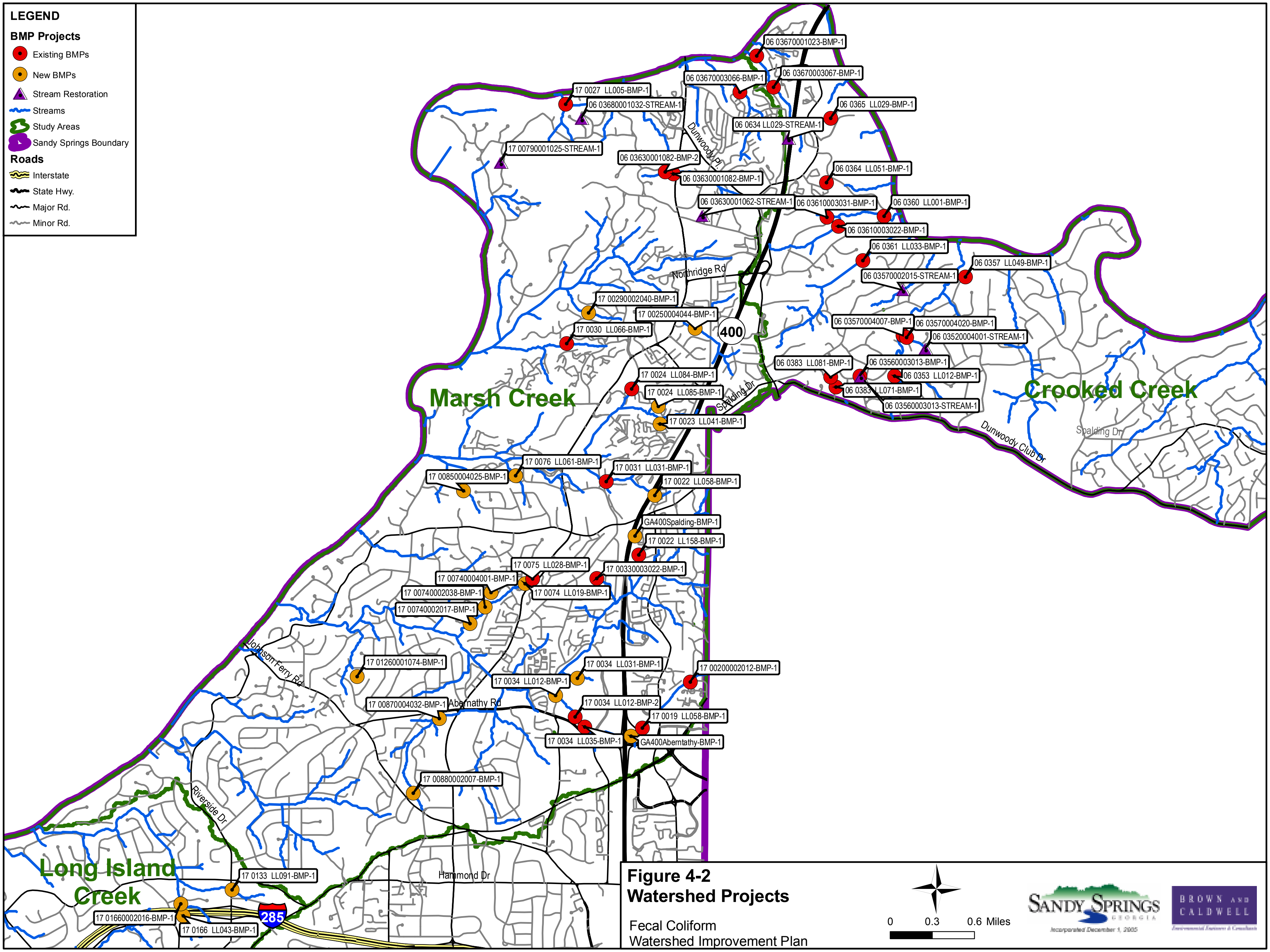


Figure 4-2
Watershed Projects

Fecal Coliform
Watershed Improvement Plan

In order to evaluate a potential BMP project for inclusion in the updated CIP, specific recommendations for retrofit must be assigned to each project. No details on the proposed recommendations were available for the historic CIP projects. As a result, recommendations were developed using available GIS and project data.

Using the baseline conditions model (described in Section 2.8) the cumulative drainage area, required water quality volume, required channel protection volume were determined for each BMP. The highest ponding elevation polygon file is used to estimate the BMP storage volume. The following regression equation is used to estimate the wet volume:

$$y = 0.1731x^{1.3437}$$

Where,

x = lake surface area at normal pool (square feet)

y = wet volume (cubic feet)

The lakes file (described is Section 2.5) is used as input into the above equation, which was developed by Brown and Caldwell using data from hundreds of BMPs.

By comparing the existing estimated volumes (both dry storage and wet volume, if applicable) of the BMP to the required volumes and examining site constraints; proposed facility type and retrofit options were assigned. Table 4-6 lists each type of proposed facility and the number of BMPs for that type. The table includes both new and existing BMPs. Figure 4-2 shows the locations of the historic BMPs listed in Table 4-6. Also, at this point in the review it was determined that some BMPs have design restrictions make the BMP not suitable for retrofit. Three BMPs were placed in the Not Recommended category and no further analysis was performed for these BMPs.

Table 4-6. Proposed BMP Project Type

BMP Type	Dry Extended Detention (DED)	Micropool Extended Detention (MED)	Wet Pond Extended Detention (WPED)	Wet Pond (WP)	Shallow Wetland (SW)	Shallow Wetland Extended Detention (SWED)	Total
Existing BMPs	0	4	3	20	0	0	27
New BMPs	4	1	7	6	2	1	21
Total	4	5	9	26	2	1	48

The retrofit options fall into three categories: outlet control structure retrofits, volume retrofits and additional (add-on) modifications. Each BMP much have at least one structure or volume modification and add-ons are optional (Table 4-7). Every volume modification must also have a corresponding volume increase which notes the amount of volume expansion to be provided by the volume modification. For example, if a 50 percent increase in volume is to be provided then the volume increase is noted by 1.5. All of the retrofit options are recorded in the GIS database.

Table 4-7. Retrofit Options	
Code	**Description**
Outlet Control Structure Modification	
S1	Reduce the lower orifice area
S2	Lower pond level and modify structure
S3	Build/modify structure for wet detention
S4	Build/ modify structure for dry detention
S5	Build/modify structure and change dry to wet
Volume Modifications	
V1	Dredge wet pond within existing footprint
V2	Excavate dry pond within existing footprint
V3	Enlarge pond by building up berms
V4	Enlarge pond by expanding footprint
V5	Increase dam height
V6	Rebuild dam downstream
Additional Modifications	
A1	Build or replace outlet filtering device
A2	Build a sediment forebay
A3	Add baffle to prevent existing short circuiting
A4	Add erosion control measure at outlet
A5	Add erosion control measure at inlet
A6	Bank stabilization
A7	Remove trees from dam embankment

Next, pollutant removal efficiencies and proposed 1-year discharges are assigned to each BMP using a CIP Prioritization Tool. Pollutant removal efficiencies were used to determine the water quality removal benefits, and the one-year discharge reduction calculations were used to determine the channel protection benefits. The CIP Prioritization Tool is a macro-based Excel spreadsheet that performs several functions, including calculating project costs, benefit/cost scores, , proposed BMP pollutant removal efficiencies, proposed channel protection discharges as well as generating two page project summary sheets. Both existing and proposed efficiencies are assigned for each parameter to be modeled. Table 4-8 lists the efficiency for each parameter for each type of BMP facility.

Table 4-8. BMP Removal Efficiencies					
Project Type	**Total Nitrogen**	**Total Phosphorus**	**TSS**	**Fecal Coliform**	**BOD**
Dry Extended Detention	0%	0%	0%	0%	0%
Micropool Extended Detention	15%	30%	80%	70%	30%
Shallow Wetland	30%	40%	80%	70%	40%
Wet Pond	30%	50%	80%	70%	50%
Wet Pond Extended Detention	25%	40%	80%	70%	40%
Dry Detention	0%	0%	0%	0%	0%

For the existing efficiency, the current wet volume of a BMP was compared to the required water quality volume. If this volume is met then the BMP is assigned 75 percent of efficiency listed in Table 4-8. The maximum efficiency is reduced because it is assumed that the BMP is not functioning optimally due to lack of sediment forebay or other design issues that limit the effectiveness of the facility. If the BMP only gets a portion of the water quality volume, then the efficiency is assigned by linearly interpolating between 0 and 75 percent of the efficiency based on the portion of the volume provided. The proposed efficiency is assigned in a similar manner. However, the full efficiency listed in Table 4-8 may be achieved since the BMP will be designed to function effectively. The proposed wet volume (based on volume modifications if applicable) is compared to the required water quality volume. Once again linear interpolation is used to assign an efficiency if the full water quality volume is not obtained.

In addition, BMPs that provide some or all of the channel protection benefit were assigned existing and proposed 1-year discharges. The existing 1-year discharge is extracted from the WIP Tools model for each BMP. The proposed 1-year discharge is assigned using the CIP Tool. If a BMP gets all of the channel protection volume (based on volume modifications if applicable) then the 1-year discharge equals the required channel protection volume divided by 24 hours detention time to get an estimate of the average discharge rate. If a BMP gets a portion of the channel protection, then similar to water quality efficiencies, a linear interpolation between the existing 1-year discharge and the channel protection discharge (channel protection volume/24 hours) was performed based on the portion of the channel protection volume obtained.

These projects moved on to the next step of evaluation, which includes evaluating project benefits using WIP Tools, and estimating project cost and scoring based on the Prioritization Matrix. Details of the WIP Tools evaluation process and the Prioritization Matrix are described in the next section.

4.3.2 Stream Project Development

Using available GIS data and project descriptions from the WRMP reports, each of the historic stream projects were assigned a project type. Stream restoration projects were categorized as Priority 1, 2, 3, and 4 Restoration and are listed on Table 4-9 and their locations shown on Figure 4-2.

For natural channel stream restoration based on Rosgen classification; there are general four levels of restoration. Priority 1 restoration involves re-establishing the stream channel on the previous floodplain using the relic channel (if known) or constructing a new bankfull discharge channel using design criteria for the dimension, pattern, and profile to create a new stable channel to match the watershed conditions (Figure 4-3). Priority 2 restoration involves constructing a new bankfull discharge channel in the bed of the existing channel by cutting a new floodplain bench at the current elevation of the stream channel in order to gain as much floodplain connectivity as space will allow. The pattern and profile are adjusted within the existing channel. This type of restoration is common in incised and widened channels (Figure 4-4). Priority 3 restoration is similar to Priority 2 but the level of grading to create a floodplain bench is minimized due to a variety of constraints. Priority 4 restoration involves streambank stabilization measures using a combination of grading, bioengineering, and/or hard structure reinforcement (Figure 4-5). These restoration measures are usually done when budget, space, or other constraints prevent a different restoration approach.

Table 4-9. Historic CIP Stream Restoration Projects

Type of Stream Restoration	Number of Observations	Length of Stream (feet)*	Length of Stream (miles)*
Priority 2	3	3,418	0.65
Priority 4	4	4,417	0.84

** Estimates of lengths based Historic CIP GIS data.*

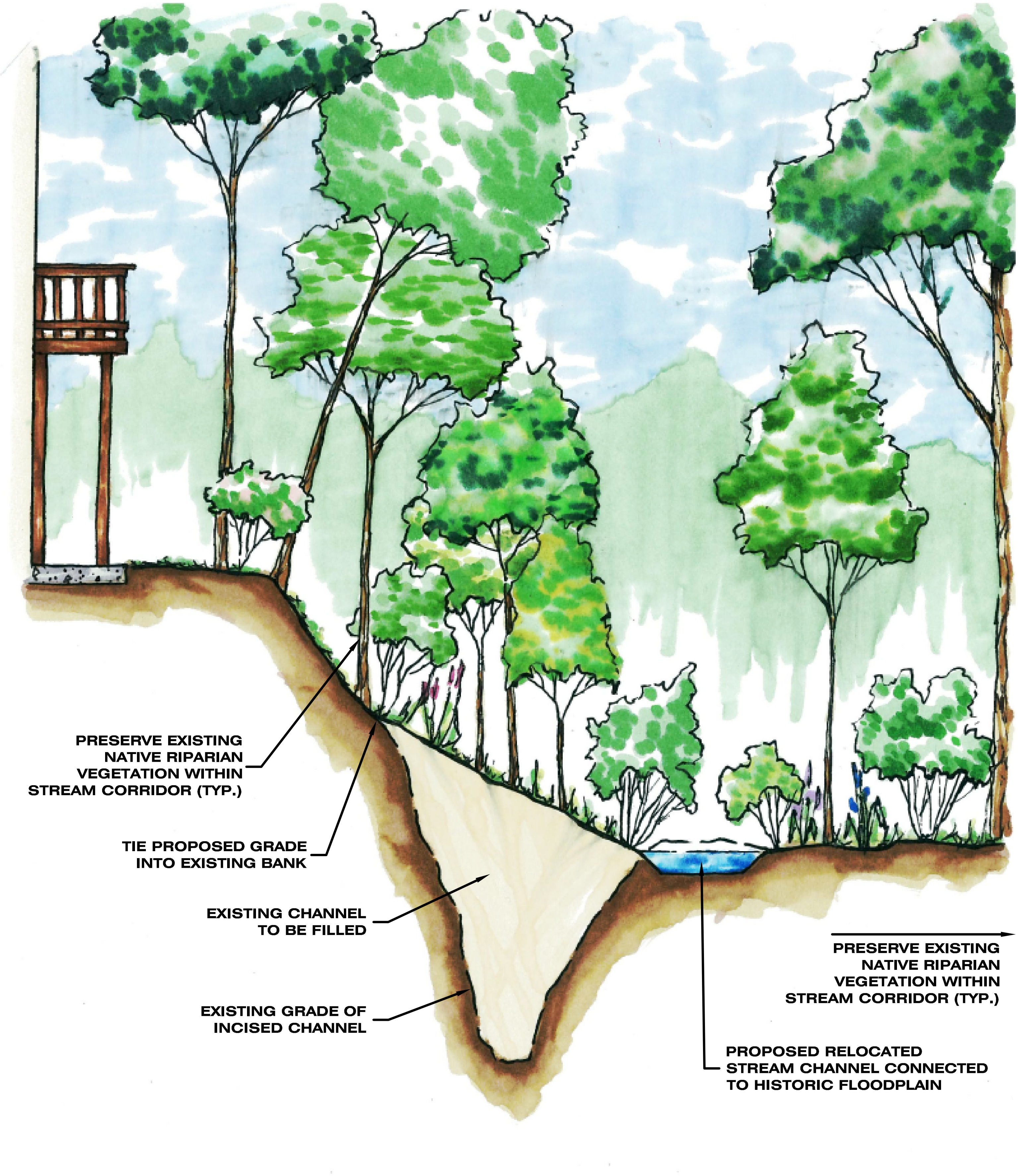


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FIGURE 4-3
STREAM RESTORATION (PRIORITY 1)

TYPICAL CROSS-SECTION

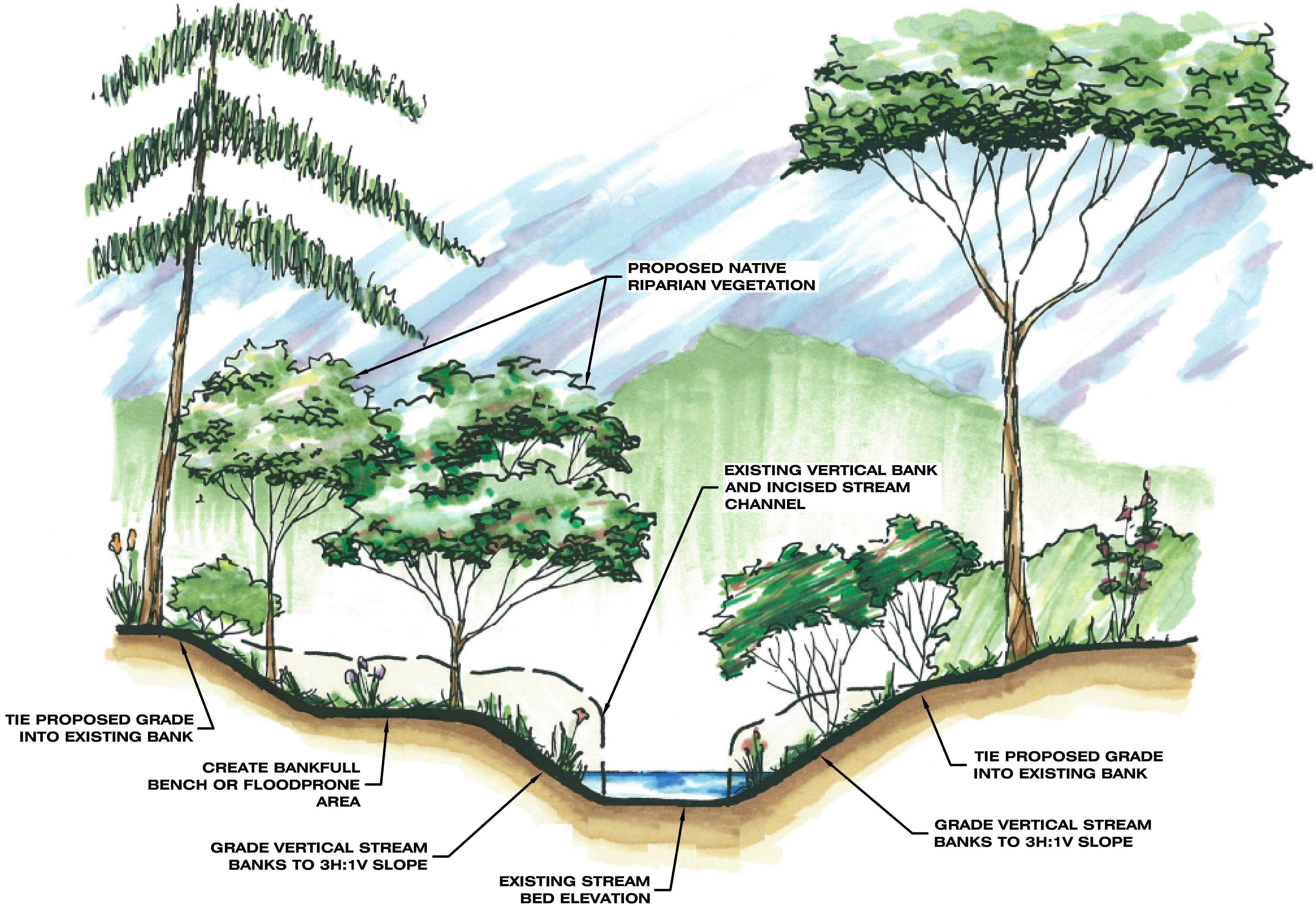

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FIGURE 4-4
STREAM ENHANCEMENT (PRIORITY 2 &3)

TYPICAL CROSS-SECTION

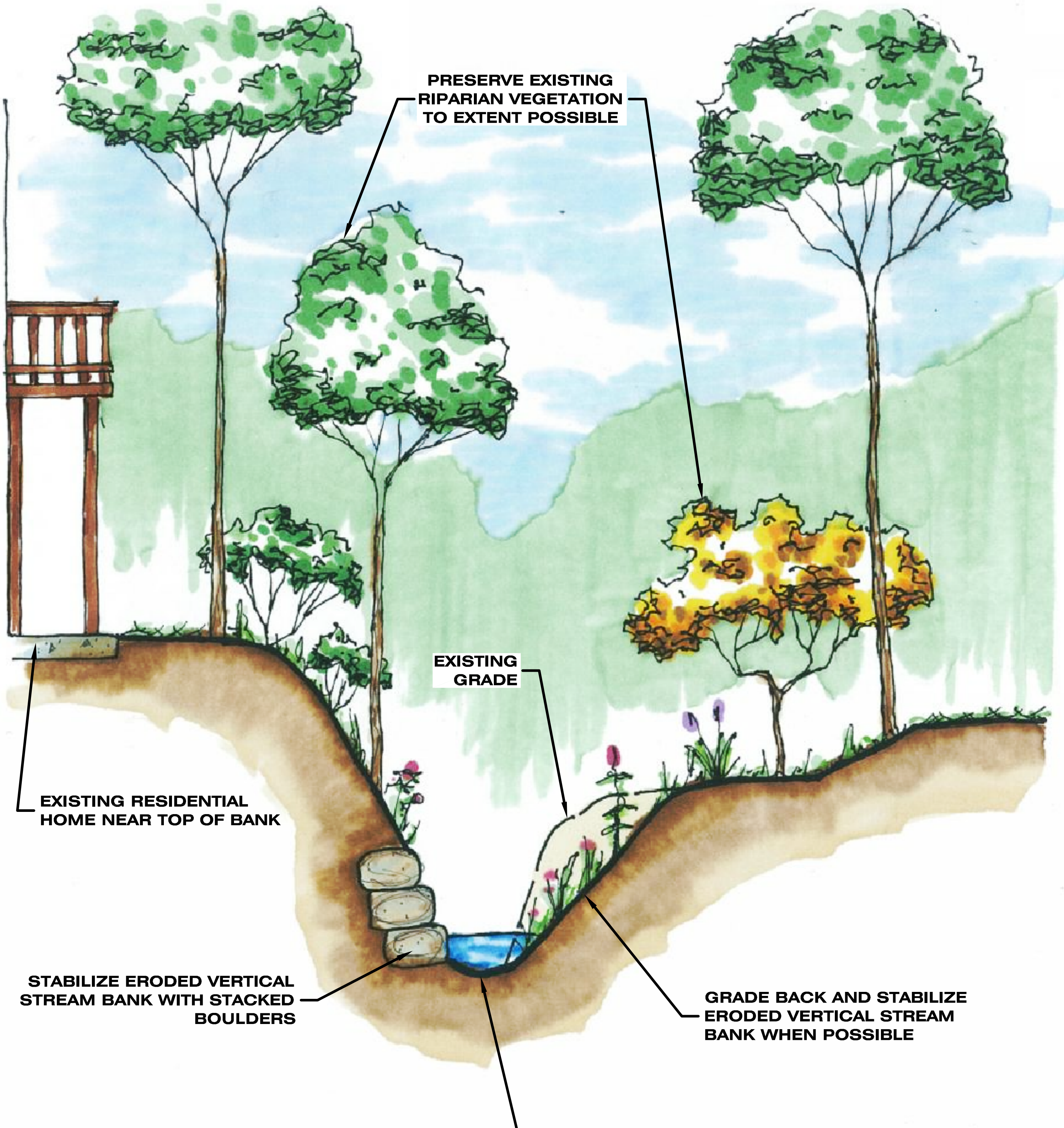

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FIGURE 4-5
STREAM STABILIZATION (PRIORITY 4)

TYPICAL CROSS-SECTION

4.4 Project Evaluation

One of the key aspects of Watershed Improvement Planning is developing a CIP to meet specific water quality goals. This study used a robust approach to evaluate and prioritize potential projects including a Prioritization Matrix developed by the City of Sandy Springs. The prioritization criteria contained in the matrix cover a range of considerations that are important in the evaluation of potential watershed improvement projects. The City of Sandy Springs developed the Prioritization Matrix to evaluate watershed, infrastructure, and floodplain projects. The Prioritization Matrix was incorporated into the CIP Prioritization Tool.

The Prioritization Matrix was developed using an asset management approach that includes the likelihood of failure of the project/condition and the consequence of that failure. Each project/condition was ranked for both the existing condition (likelihood of failure) and the proposed, improved condition (reduced likelihood of failure). The criteria used to rank watershed projects include the current condition of the BMP outlet structure or stream bank, the water quality and environmental benefits, permitting issues, as well as public acceptance of the project, among other factors. Table 4-10 outlines all of the prioritization criteria, possible scores and the weighting for each criterion. In addition, the technical memorandum in Appendix B details each of the prioritization criterion and the methods used to assign scores for the criterion.

The difference between the existing condition score and the proposed condition score is considered the change in risk score. The greater the change in the risk score is, the greater the improvement to the watershed conditions. This final score is then divided by a scaled project cost. A scaled project cost was used in order to compare different types of projects, i.e., floodplain, infrastructure, or watershed improvement. The following equation is used to calculate the overall project score.

Benefit Cost Score= (Existing Likelihood Score x Existing Consequence Score) – (Proposed Likelihood Score x Proposed Consequence Score) / Scaled Project Cost

Many pieces of data are needed to generate the results for the Prioritization Matrix. Most of this data was generated in GIS, either through data analysis or the WIP Tools model. The structure of the GIS files was detailed in the GIS data structure technical memorandum located in Appendix C. This technical memorandum included information on how each piece of data is used whether it is for the Prioritization Matrix, WIP Tools model, project summary sheet or some combination of the three. The four GIS files detailed in the technical memorandum were combined and exported as a database file. The database file was imported into the CIP Prioritization Tool spreadsheet. The CIP Prioritization Tool then generated a summary of the Prioritization Matrix results (Tables 4-11 and 4-12), sorted by the benefit/cost score.

In addition, the CIP Prioritization Tool is used to generate project summary sheets which can be found in Appendix D. These sheets include the project cost benefit score, key project information, a site map and site photographs. Limited photographs are available for the BMP projects because site visits were not performed as a part of this project.

Another key component of the CIP Prioritization Tool is the project cost development. The spreadsheet has tabs for retrofit BMPs, new BMPs and stream projects giving the user the ability to easily change or update unit costs or other components of the project cost development. Details of the methods used to generate the estimated project costs are included in a technical memorandum in Appendix E.

Table 4-10. Prioritization Matrix – Likelihood and Consequence of Failure

Category / Criteria	BMPs			Stream Projects		
	Score Possibilities	**Weighting Factor**	**Score x Weighting Factor**	**Score Possibilities**	**Weighting Factor**	**Score x Weighting Factor**
Physical Condition (60%)						
TSS Yield	1-10	0.2	0.2-2.0	1-10	0.25	0.25-2.5
Bank Erosion	N/A	N/A	N/A	1,2,3,4,6,8,10	0.30	0.3-3.0
Fecal Coliform Yield	1-10	0.2	0.2-2.0	1-10	0.05	0.05-0.5
Condition of Structure	1,2,4,5,6,8,10	0.2	0.2-2.0	N/A	N/A	N/A
Performance (40%)						
Storage Volume	1-10	0.35	0.35-3.5	N/A	N/A	N/A
Habitat Score	N/A	N/A	N/A	1,2,3,4,6,8,10	0.35	0.35-3.5
Work Order Requests	1,5,10	0.05	0.05-0.5	1,5,10	0.05	0.05-0.5
Likelihood of Failure Score		**1.0**	**1.0-10.0**		**1.0**	**1.0-10.0**
Environmental (30%)						
Compliance with regulations	10	0.1	1.0	5	0.1	0.5
Fecal Coliform TMDL	1,10	0.1	0.1,1.0	1,10	0.1	0.1,1.0
Biota TMDL	1,10	0.1	0.1,1.0	1,10	0.1	0.1,1.0
Social (40%)						
Public Impact	N/A	N/A	N/A	1,5,10	0.2	0.2-2.0
City Property	1,5,10	0.2	0.2-2.0	1,5,10	0.2	0.2-2.0
Urban/Rural Discharge Ratio	1,5,10	0.2	0.2-2.0	N/A	N/A	N/A
Economic (30%)						
Property Damage – based on field assessment	N/A	N/A	N/A	1,5,10	0.3	0.3-3.0
Property Damage – BMP height	1,2,4,5,6,8,10	0.15	0.15-1.5	N/A	N/A	N/A
Property Damage – BMP Volume	1-10	0.15	0.15-1.5	N/A	N/A	N/A
Consequence of Failure		**1.0**	**1.0-10.0**		**1.0**	**1.0-10.0**

4.5 Implementation Recommendations

The goal of the Fecal Coliform WIP is to reduce and/or eliminate sources of bacteria from streams within the city limits of Sandy Springs. A variety of structural, non-structural and public education activities are required to meet this goal. This section provides an overview of the structural BMP project costs, benefit/cost scores and asset ownership. Asset ownership is important because the City's current level of service only includes projects located within the right of way or on city owned assets or property. Chapter 5 outlines a comprehensive list of activities and recommendations to achieve fecal coliform reduction.

A CIP of historic BMPs and stream projects was developed using methods described above. A total of 48 BMP and 7 stream projects were evaluated. This CIP is designed to be flexible, providing the City options to implement projects based on parcel ownership, benefit/cost ranking, cost or other factors. This section outlines those options and presents projects sorted by parcel ownership and benefit/cost score.

Projects can be sorted in various ways in order to prioritize projects for implementation. The CIP is presented below in the following categories: city owned assets (2 projects), "single family residential attached" parcels (4 projects), projects scoring above a benefit/cost score of 5 (2 projects), and all 48 BMP projects and all 7 stream projects. At this time, the City of Sandy Springs is refining the level of service for the stormwater management program. The City will likely concentrate short-term on CIP projects on city owned property and within the ROW. If the City modifies its level of service in the future, a prioritized list of CIP projects is available to review and implement as needed. High ranking BMP projects typically include small stormwater BMPs that can be modified to meet water quality and/or channel protection volumes relatively inexpensively. All of these projects evaluated, however, are on private "non-single family non-attached" property.

Costs for implementation depend on which projects are selected. The total estimated cost to implement all 48 BMP projects evaluated is $42,411,000. The cost to implement the two projects on city owned property or within the ROW is approximately $1,173,000. The two projects with a benefit/cost score above 5 have an estimated cost of $438,000 to implement. The cost to implement the 4 projects that are located on single family residential attached is estimated to be $2,324,000. The City can use these results to determine the appropriate projects to implement. A review of these projects are provided in Sections 4.5.1 and 4.5.2 and Appendix D contains the more details about each project in the form of individual project sheets.

4.5.1 BMP Projects

Forty-eight historic BMP projects were evaluated within the Fecal Coliform WIP study area. In order to improve water quality and aquatic habitat for fish, macroinvertebrates and other stream life, implementing watershed improvements such as stormwater BMPs have numerous benefits. Building new stormwater BMPs or retro-fitting exiting ones mitigate the negative impact of increased hydrologic runoff from impervious surfaces. Controlling the hydrology also decreases the sediment load and associated pollutants that enter City streams, ponds, and lakes. Stormwater BMPs can also be improved aesthetically to create an amenity for a neighborhood.

Projects can be sorted in various ways in order to prioritize projects for implementation. Currently, there are two stormwater BMP projects that are located near on or city owned assets (Table 4-13) that were evaluated. The City may also want to consider smaller, demonstration-type BMPs to implement on City facilities such as rain gardens or other low impact development projects.

The two projects within the city's level of service are provided in Table 4-13.

Table 4-11 Prioritization Matrix Results
for BMP Projects

		Existing Consequence								Existing Likelihood							Proposed Consequence								Proposed Likelihood							Benefit				
Category		Environmental (30%)			Social (40%)		Financial (30%)			Physical Condition (60%)			Performance (40%)				Environmental (30%)			Social (40%)		Financial (30%)			Physical Condition (60%)			Performance (40%)								
Weight		0.10	0.10	0.10	0.20	0.20	0.15	0.15	1.00	0.20	0.20	0.20	0.35	0.05	1.00		0.10	0.10	0.10	0.20	0.20	0.15	0.15	1.00	0.20	0.20	0.20	0.35	0.05	1.00					
Project ID	Asset Number	Reg comp.	Fecal TMDL	Biota TMDL	City Property	U/R Ratio	Height of Dam	Volume	Consequence Score	TSS Yield	Fecal Yield	Structural Condition	Storage Volume	Work Orders	Likelihood Score	Existing Risk	Reg comp.	Fecal TMDL	Biota TMDL	City Property	U/R Ratio	Height of Dam	Volume	Consequence Score	TSS Yield	Fecal Yield	Structural Condition	Storage Volume	Work Orders	Likelihood Score	Proposed Risk	Change in Risk	Cost	Cost Scale	Benefit /Cost
17 0034 LL012-BMP-1	AGM_13752	1.00	1.00	0.10	0.20	2.00	0.15	0.15	4.45	1.00	0.60	1.00	3.50	0.05	6.15	27.37	1.00	1.00	0.10	0.20	0.20	0.15	0.60	2.65	0.80	0.40	0.20	3.50	0.05	4.95	13.12	14.25	$1,019,000	7	2.04
17 0034 LL031-BMP-1	AGM_13756	1.00	1.00	0.10	0.20	2.00	0.15	0.15	4.45	1.80	2.00	1.00	3.50	0.05	8.35	37.16	1.00	1.00	0.10	0.20	0.20	0.15	0.60	2.65	0.20	0.60	0.20	1.31	0.05	2.36	6.24	30.91	$1,032,000	7	4.42
17 00880002007-BMP-1	AGM_17821	1.00	1.00	0.10	0.20	2.00	0.15	0.15	4.45	2.00	1.60	1.00	3.50	0.05	8.15	36.27	1.00	1.00	0.10	0.20	0.20	0.15	0.75	2.65	0.20	0.40	0.20	0.75	0.05	1.60	4.25	32.02	$1,405,000	7	4.57
GA400Aberntathy-BMP-1	AGM_05925	1.00	1.00	0.10	0.20	2.00	0.15	0.15	4.45	1.60	1.60	1.00	3.50	0.05	7.75	34.49	1.00	1.00	0.10	0.20	0.20	0.15	1.20	2.65	0.20	1.60	0.20	0.35	0.05	2.40	6.36	28.13	$8,620,000	10	2.81
17 01260001074-BMP-1	AGM_15241	1.00	1.00	0.10	0.20	1.00	0.15	0.15	3.45	0.40	1.40	1.00	3.50	0.05	6.35	21.91	1.00	1.00	0.10	0.20	0.20	0.15	0.45	2.65	0.20	0.40	0.20	1.76	0.05	2.61	6.93	14.98	$375,000	4	3.74
GA400Spalding-BMP-1	AGM_26587	1.00	1.00	0.10	0.20	1.00	0.15	0.15	3.45	1.20	1.20	1.00	3.50	0.05	6.95	23.98	1.00	1.00	0.10	0.20	0.20	0.15	0.30	2.65	0.20	0.40	0.20	2.43	0.05	3.28	8.70	15.27	$267,000	4	3.82
17 0074 LL019-BMP-1	AGM_15612	1.00	1.00	0.10	0.20	2.00	0.15	0.15	4.45	1.80	1.60	1.00	3.50	0.05	7.95	35.38	1.00	1.00	0.10	0.20	1.00	0.15	0.90	3.45	0.20	0.40	0.20	2.30	0.05	3.15	10.87	24.51	$1,630,000	8	3.06
17 00740004001-BMP-1	AGM_15555	1.00	1.00	0.10	0.20	1.00	0.15	0.15	3.45	0.40	1.40	1.00	3.50	0.05	6.35	21.91	1.00	1.00	0.10	0.20	0.20	0.15	0.60	2.65	0.20	0.40	0.20	3.50	0.05	4.35	11.53	10.38	$1,106,000	7	1.48
17 00740002038-BMP-1	AGM_15559	1.00	1.00	0.10	1.00	2.00	0.15	0.15	5.25	1.80	1.60	1.00	3.50	0.05	7.95	41.74	1.00	1.00	0.10	1.00	2.00	0.15	0.30	5.25	1.80	1.60	0.20	3.50	0.05	7.15	37.54	4.20	$306,000	4	1.05
17 00740002017-BMP-1	AGM_15580	1.00	1.00	0.10	0.20	2.00	0.15	0.15	4.45	2.00	1.60	1.00	3.50	0.05	8.15	36.27	1.00	1.00	0.10	0.20	2.00	0.15	0.90	4.45	0.40	0.40	0.20	3.38	0.05	4.43	19.71	16.56	$1,630,000	8	2.07
17 0133 LL091-BMP-1	AGM_09788	1.00	0.10	0.10	0.20	1.00	0.15	0.15	2.55	1.40	1.40	1.00	3.50	0.05	7.35	18.74	1.00	0.10	0.10	0.20	0.20	0.15	0.75	1.75	0.20	1.40	0.20	0.45	0.05	2.30	4.02	14.72	$1,310,000	7	2.10
17 01660002016-BMP-1	AGM_11305	1.00	0.10	0.10	0.20	1.00	0.15	0.15	2.55	1.40	1.20	1.00	3.50	0.05	7.15	18.23	1.00	0.10	0.10	0.20	0.20	0.15	0.45	1.75	0.20	1.20	0.20	3.41	0.05	5.06	8.86	9.37	$618,000	5	1.87
17 0166 LL043-BMP-1	AGM_11359	1.00	0.10	0.10	0.20	1.00	0.15	0.15	2.55	1.40	1.20	1.00	3.50	0.05	7.15	18.23	1.00	0.10	0.10	0.20	0.20	0.15	0.90	1.75	0.20	0.40	0.20	0.35	0.05	1.20	2.10	16.13	$2,804,000	10	1.61
17 00850004025-BMP-1	AGM_15888	1.00	0.10	0.10	0.20	1.00	0.15	0.15	2.55	1.60	1.80	1.00	3.50	0.05	7.95	20.27	1.00	0.10	0.10	0.20	0.20	0.15	0.60	1.75	0.20	0.40	0.20	1.30	0.05	2.15	3.77	16.50	$889,000	6	2.75
17 0076 LL061-BMP-1	AGM_23984	1.00	0.10	0.10	0.20	2.00	0.15	0.15	3.55	1.60	1.40	1.00	3.50	0.05	7.55	26.80	1.00	0.10	0.10	0.20	0.20	0.15	0.60	1.75	0.20	0.40	0.20	1.85	0.05	2.70	4.72	22.08	$982,000	6	3.68
17 0022 LL058-BMP-1	AGM_26613	1.00	0.10	0.10	0.20	2.00	0.15	0.15	3.55	1.40	1.60	1.00	3.50	0.05	7.55	26.80	1.00	0.10	0.10	0.20	1.00	0.15	0.45	2.55	0.20	0.40	0.20	3.57	0.05	4.42	11.27	15.53	$376,000	4	3.88
17 0024 LL085-BMP-1	AGM_19565	1.00	0.10	0.10	0.20	1.00	0.15	0.15	2.55	1.60	1.60	1.00	3.50	0.05	7.75	19.76	1.00	0.10	0.10	0.20	0.20	0.15	0.60	1.75	0.20	0.40	0.20	2.35	0.05	3.20	5.60	14.16	$825,000	6	2.36
17 0023 LL041-BMP-1	AGM_16991	1.00	0.10	0.10	0.20	1.00	0.15	0.15	2.55	1.00	1.40	1.00	3.50	0.05	6.95	17.72	1.00	0.10	0.10	0.20	0.20	0.15	0.75	1.75	0.20	0.40	0.20	0.35	0.05	1.20	2.10	15.62	$1,345,000	7	2.23
17 00250004044-BMP-1	AGM_22715	1.00	0.10	0.10	0.20	2.00	0.15	0.15	3.55	1.80	1.40	1.00	3.50	0.25	7.95	28.22	1.00	0.10	0.10	0.20	0.20	0.15	0.60	1.75	1.20	0.60	0.20	3.50	0.05	5.55	9.71	18.51	$862,000	6	3.09
17 00290002040-BMP-1	AGM_23229	1.00	0.10	0.10	0.20	2.00	0.15	0.15	3.55	1.80	1.40	1.00	3.50	0.05	7.75	27.51	1.00	0.10	0.10	0.20	1.00	0.15	0.60	2.55	0.20	0.40	0.20	3.19	0.05	4.04	10.30	17.21	$733,000	5	3.44
17 00870004032-BMP-1	AGM_18783	1.00	1.00	0.10	0.20	2.00	0.15	0.15	4.45	2.00	1.40	1.00	3.50	0.05	7.95	35.38	1.00	1.00	0.10	0.20	2.00	0.15	0.90	4.45	0.80	0.40	0.20	3.29	0.05	4.74	21.09	14.28	$1,964,000	8	1.79
17 00200002012-BMP-1	AGM_14543	1.00	1.00	0.10	0.20	1.00	0.15	0.45	3.45	1.40	1.60	0.80	3.50	0.05	7.35	25.36	1.00	1.00	0.10	0.20	0.20	0.15	0.45	2.65	0.60	0.60	0.20	3.50	0.05	4.95	13.12	12.24	$311,000	4	3.06
06 03570004020-BMP-1	AGM_18957	1.00	1.00	0.10	0.20	1.00	0.15	0.60	3.45	1.20	1.20	0.80	3.50	0.05	6.75	23.29	1.00	1.00	0.10	0.20	0.20	0.15	0.60	2.65	0.20	0.40	0.20	3.50	0.05	4.35	11.53	11.76	$274,000	4	2.94
06 0383 LL081-BMP-1	AGM_16294	1.00	1.00	0.10	0.20	0.20	0.15	0.45	2.65	0.20	0.60	0.80	0.35	0.05	2.00	5.30	1.00	1.00	0.10	0.20	0.20	0.15	0.45	2.65	0.20	0.40	0.20	0.35	0.05	1.20	3.18	2.12	$333,000	4	0.53
06 0383 LL071-BMP-1	AGM_16277	1.00	1.00	0.10	0.20	0.20	0.15	0.60	2.65	0.20	0.40	0.80	0.35	0.05	1.80	4.77	1.00	1.00	0.10	0.20	0.20	0.15	0.60	2.65	0.20	0.20	0.20	0.35	0.05	1.00	2.65	2.12	$411,000	4	0.53
17 0019 LL058-BMP-1	AGM_05898	1.00	1.00	0.10	0.20	2.00	0.15	0.60	4.45	1.60	1.40	1.00	3.50	0.05	7.55	33.60	1.00	1.00	0.10	0.20	0.20	0.15	0.60	2.65	0.80	0.60	0.20	3.50	0.05	5.15	13.65	19.95	$378,000	4	4.99
17 0075 LL028-BMP-1	AGM_15523	1.00	1.00	0.10	0.20	1.00	0.45	0.30	3.75	1.20	1.60	0.80	3.50	0.05	7.15	26.81	1.00	1.00	0.10	0.20	0.20	0.45	0.30	2.95	0.40	0.60	0.20	3.50	0.05	4.75	14.01	12.80	$144,000	3	4.27
17 00330003022-BMP-1	AGM_19878	1.00	1.00	0.10	0.20	1.00	0.15	0.60	3.45	1.40	1.40	0.40	0.35	0.05	3.60	12.42	1.00	1.00	0.10	0.20	0.20	0.15	0.60	2.65	0.20	0.40	0.20	0.35	0.05	1.20	3.18	9.24	$276,000	4	2.31
17 0022 LL158-BMP-1	AGM_26479	1.00	1.00	0.10	0.20	2.00	0.15	0.45	4.45	1.40	1.40	0.80	3.17	0.05	6.82	30.35	1.00	1.00	0.10	0.20	1.00	0.15	0.45	3.45	0.20	0.40	0.20	3.17	0.05	4.02	13.87	16.48	$159,000	3	5.49
17 0031 LL031-BMP-1	AGM_25470	1.00	0.10	0.10	0.20	2.00	0.45	0.90	3.85	1.20	0.60	0.80	2.11	0.05	4.76	18.33	1.00	0.10	0.10	0.20	0.20	0.45	0.90	2.05	0.20	0.40	0.20	2.11	0.05	2.96	6.07	12.26	$564,000	5	2.45
17 0024 LL084-BMP-1	AGM_19601	1.00	0.10	0.10	0.20	2.00	0.45	0.60	3.85	1.80	1.80	1.60	3.24	0.25	8.69	33.46	1.00	0.10	0.10	0.20	1.00	0.45	0.60	2.85	0.20	0.60	0.20	3.24	0.05	4.29	12.23	21.23	$279,000	4	5.31
17 0030 LL066-BMP-1	AGM_23629	1.00	0.10	0.10	0.20	2.00	1.05	1.05	4.45	2.00	1.60	0.80	0.35	0.05	4.80	21.36	1.00	0.10	0.10	0.20	0.20	1.05	1.05	2.65	0.20	0.40	0.20	0.35	0.05	1.20	3.18	18.18	$540,000	5	3.64
06 03570004007-BMP-1	AGM_18991	1.00	1.00	0.10	0.20	1.00	0.15	0.45	3.45	1.00	0.80	0.80	3.50	0.05	6.15	21.22	1.00	1.00	0.10	0.20	0.20	0.15	0.45	2.65	0.60	0.80	0.20	3.50	0.05	5.15	13.65	7.57	$226,000	3	2.52
17 0027 LL005-BMP-1	AGM_16998	1.00	0.10	0.10	0.20	1.00	0.15	1.35	2.55	0.80	0.60	1.00	0.35	0.05	2.80	7.14	1.00	0.10	0.10	0.20	0.20	0.15	1.35	1.75	0.20	0.40	0.20	0.35	0.05	1.20	2.10	5.04	$492,000	4	1.26
06 03670003066-BMP-1	AGM_25822	1.00	0.10	0.10	0.20	2.00	0.15	1.20	3.55	1.40	0.60	1.00	1.17	0.50	4.67	16.57	1.00	0.10	0.10	0.20	0.20	0.15	1.20	1.75	0.20	0.40	0.20	1.17	0.05	2.02	3.53	13.04	$651,000	5	2.61
06 03630001082-BMP-2	AGM_26076	1.00	0.10	0.10	0.20	1.00	0.15	1.05	2.55	0.60	0.60	0.80	0.35	0.05	2.40	6.12	1.00	0.10	0.10	0.20	0.20	0.15	1.05	1.75	0.20	0.40	0.20	0.35	0.05	1.20	2.10	4.02	$464,000	4	1.01
06 03610003022-BMP-1	AGM_21724	1.00	0.10	0.10	0.20	2.00	1.50	1.50	4.90	0.80	0.60	0.80	0.35	0.05	2.60	12.74	1.00	0.10	0.10	0.20	0.20	1.50	1.50	3.10	0.20	0.40	0.20	0.35	0.05	1.20	3.72	9.02	$775,000	6	1.50
06 03560003013-BMP-1	AGM_18904	1.00	1.00	0.10	0.20	1.00	0.15	0.90	3.45	0.20	0.60	0.80	0.35	0.05	2.00	6.90	1.00	1.00	0.10	0.20	0.20	0.15	0.90	2.65	0.20	0.40	0.20	0.35	0.05	1.20	3.18	3.72	$410,000	4	0.93
06 0353 LL012-BMP-1	AGM_18255	1.00	1.00	0.10	0.20	2.00	1.05	1.50	5.35	1.20	0.40	0.80	1.88	0.05	4.33	23.19	1.00	1.00	0.10	0.20	0.20	1.05	1.50	3.55	0.20	0.20	0.20	1.88	0.05	2.53	9.00	14.19	$332,000	4	3.55
06 0357 LL049-BMP-1	AGM_18471	1.00	1.00	0.10	0.20	0.20	0.45	0.30	2.95	0.20	0.60	1.20	1.42	0.05	3.47	10.24	1.00	1.00	0.10	0.20	0.20	0.45	0.30	2.95	0.20	0.40	0.20	1.42	0.05	2.27	6.70	3.54	$330,000	4	0.89
06 0361 LL033-BMP-1	AGM_21757	1.00	0.10	0.10	0.20	2.00	1.50	1.50	4.90	0.80	0.60	1.00	0.35	0.25	3.00	14.70	1.00	0.10	0.10	0.20	0.20	1.50	1.50	3.10	0.20	0.40	0.20	0.35	0.05	1.20	3.72	10.98	$1,127,000	7	1.57
06 03610003031-BMP-1	AGM_21718	1.00	0.10	0.10	0.20	2.00	1.50	1.35	4.90	0.40	0.60	1.00	0.35	0.05	2.40	11.76	1.00	0.10	0.10	0.20	0.20	1.50	1.35	3.10	0.20	0.40	0.20	0.35	0.05	1.20	3.72	8.04	$513,000	5	1.61
06 0360 LL001-BMP-1	AGM_18330	1.00	0.10	0.10	0.20	2.00	1.05	1.05	4.45	1.00	0.40	0.80	0.90	0.05	3.15	14.02	1.00	0.10	0.10	0.20	0.20	1.05	1.05	2.65	0.20	0.20	0.20	0.90	0.05	1.55	4.11	9.91	$555,000	5	1.98
06 0364 LL051-BMP-1	AGM_24299	1.00	0.10	0.10	0.20	2.00	0.15	0.90	3.55	0.40	0.80	1.00	0.35	0.05	2.60	9.23	1.00	0.10	0.10	0.20	0.20	0.15	0.90	1.75	0.20	0.40	0.20	0.35	0.05	1.20	2.10	7.13	$467,000	4	1.78
06 0365 LL029-BMP-1	AGM_17715	1.00	0.10	0.10	0.20	0.20	0.45	0.60	2.05	0.20	1.00	1.20	0.35	0.05	2.80	5.74	1.00	0.10	0.10	0.20	0.20	0.45	0.60	2.05	0.20	0.60	0.20	0.35	0.05	1.40	2.87	2.87	$404,000	4	0.72
06 03630001082-BMP-1	AGM_26082	1.00	0.10	0.10	0.20	2.00	0.15	0.60	3.55	0.40	0.60	1.60	0.35	0.05	3.00	10.65	1.00	0.10	0.10	0.20	0.20	0.15	0.60	1.75	0.20	0.40	0.20	0.35	0.05	1.20	2.10	8.55	$414,000	4	2.14
06 03670003067-BMP-1	AGM_25770	1.00	0.10	0.10	0.20	2.00	0.15	0.90	3.55	1.40	0.60	0.40	1.62	0.05	4.07	14.45	1.00	0.10	0.10	0.20	0.20	0.15	0.90	1.75	0.20	0.40	0.20	1.62	0.05	2.47	4.32	10.13	$528,000	5	2.03
06 03670001023-BMP-1	AGM_25933	1.00	0.10	0.10	0.20	2.00	0.15	0.90	3.55	1.20	0.60	1.00	3.50	0.05	6.35	22.54	1.00	0.10	0.10	0.20	0.20	0.15	0.90	1.75	0.20	0.20	0.20	0.97	0.05	1.62	2.83	19.71	$956,000	6	3.29

Sandy Springs WIP
Table 4-12 Prioritization Matrix Results for Stream Projects

		Existing Consequence							Existing Likelihood							Proposed Consequence							Proposed Likelihood							Benefit			
	Category	Environmental (30%)			Social (40%)		Financial (30%)		Physical Condition (60%)			Performance (40%)				Environmental (30%)			Social (40%)		Financial (30%)		Physical Condition (60%)			Performance (40%)							
	Weight	0.10	0.10	0.10	0.20	0.20	0.30	1.00	0.25	0.30	0.05	0.35	0.05	1.00		0.10	0.10	0.10	0.20	0.20	0.30	1.00	0.25	0.30	0.05	0.35	0.05	1.00					
Project ID	**Asset Number**	Reg comp.	Fecal TMDL	Biota TMDL	Public Impact	City Property	Property Damage	Consequence Score	TSS Yield	Bank Erosion	Fecal Yield	Habitat Score	Work Orders	Likelihood Score	**Existing Risk**	Reg comp.	Fecal TMDL	Biota TMDL	Public Impact	City Property	Property Damage	Consequence Score	TSS Yield	Bank Erosion	Fecal Yield	Habitat Score	Work Orders	Likelihood Score	**Proposed Risk**	**Change in Risk**	**Cost**	**Cost Scale**	**Benefit /Cost**
06 03520004001-STREAM-1	BAC_00043	0.50	1.00	0.10	2.00	1.00	0.30	4.90	1.00	0.90	0.30	0.35	0.05	2.60	**12.74**	0.50	1.00	0.10	2.00	1.00	0.30	4.90	0.50	0.30	0.30	0.70	0.05	1.85	**9.07**	**3.68**	**$453,000**	**4**	**0.92**
06 03570002015-STREAM-1	BAC_00042	0.50	0.10	0.10	2.00	0.20	0.30	3.20	2.00	0.90	0.30	0.35	0.05	3.60	**11.52**	0.50	0.10	0.10	2.00	0.20	0.30	3.20	1.75	0.30	0.30	0.70	0.05	3.10	**9.92**	**1.60**	**$1,099,000**	**7**	**0.23**
06 03560003013-STREAM-1	BAC_00041	0.50	1.00	0.10	2.00	1.00	0.30	4.90	0.25	0.90	0.15	1.40	0.05	2.75	**13.48**	0.50	1.00	0.10	2.00	1.00	0.30	4.90	0.25	0.30	0.15	1.05	0.05	1.80	**8.82**	**4.66**	**$1,286,000**	**7**	**0.67**
06 03630001062-STREAM-1	BAC_00039	0.50	0.10	0.10	2.00	1.00	0.30	4.00	1.25	0.90	0.40	0.35	0.05	2.95	**11.80**	0.50	0.10	0.10	2.00	1.00	0.30	4.00	0.25	0.30	0.40	0.70	0.05	1.70	**6.80**	**5.00**	**$1,117,000**	**7**	**0.71**
06 03680001032-STREAM-1	BAC_00040	0.50	0.10	0.10	2.00	0.20	0.30	3.20	0.25	0.90	0.30	1.05	0.05	2.55	**8.16**	0.50	0.10	0.10	2.00	0.20	0.30	3.20	0.25	0.30	0.30	0.70	0.05	1.60	**5.12**	**3.04**	**$1,123,000**	**7**	**0.43**
06 0634 LL029-STREAM-1	BAC_00038	0.50	0.10	0.10	2.00	1.00	0.30	4.00	1.50	0.90	0.30	1.05	0.05	3.80	**15.20**	0.50	0.10	0.10	2.00	1.00	0.30	4.00	0.25	0.30	0.30	0.70	0.05	1.60	**6.40**	**8.80**	**$1,712,000**	**8**	**1.10**
17 00790001025-STREAM-1	BAC_00037	0.50	0.10	0.10	2.00	0.20	0.30	3.20	0.25	0.90	0.50	1.05	0.05	2.75	**8.80**	0.50	0.10	0.10	2.00	0.20	0.30	3.20	0.25	0.30	0.50	0.70	0.05	1.80	**5.76**	**3.04**	**$719,000**	**5**	**0.61**

Table 4-13. Projects Located on City-Owned Parcels or within ROW*				
Project ID	**Type**	**Study Area**	**Benefit/Cost**	**Cost**
17 00200002012-BMP-1	Existing	Marsh Creek	**4.14**	**$311,000**
17 00250004044-BMP-1**	New	Marsh Creek	**3.81**	**$862,000**
Sub-total				**$1,173,000**

** Or, as legally determined by the City*

*** Possible future City-owned*

Project 17 00200002012-BMP-1 is located off Lisa Lane and includes retrofitting an existing dry pond into a micropool extended detention pond. The existing BMP is located in a residential area. In a micropool extended detention pond, only a small volume of water is maintained at the outlet from the pond. The outlet structure is sized to detain the water quality volume for 24 hours. Temporary storage may also be provided for channel protection and for larger storm events. The proposed retrofit will achieve a portion of channel protection benefits by converting it to a micropool extended detention and re-designing the outlet control structure.

Project 17 00250004044-BMP-1 would be a new wet pond. This project is also located in a residential and commercial area near Granite Ridge Place. This project was included in the historic project CIP as project number SS-BMP-24440109. A new pond would be built that includes both water quality and channel protection benefits. In a wet pond, the permanent pool of water is equal to the water quality volume. Temporary storage may also be provided above the permanent pool elevation for channel protection and for larger storm events. The City may purchase property if grant funding is obtained, and at that time the project would be considered under the City's current LOS.

In the future, the City of Sandy Springs may expand stormwater services to "single family residential attached" assets. "Attached" is defined as having a piped network connection from the road right of way flowing onto private parcels. Thus, there is a connection from traditional stormwater road drainage right-of-way to a limited number of private parcels. There are four projects within the Fecal Coliform WIP study area that are part of this designation (Table 4-14).

Table 4-14. BMP Projects with Single Family Residential Attached Designation				
Project ID	Type	Study Area	Benefit/Cost	Cost
06 03570004020-BMP-1	Existing	Crooked Creek	2.94	$274,000
17 0133 LL091-BMP-1	New	Long Island Creek	2.10	$1,310,000
06 03560003013-BMP-1	Existing	Crooked Creek	0.93	$410,000
06 0357 LL049-BMP-1	Existing	Crooked Creek	0.89	$330,000
Sub-total				**$2,324,000**

Proposed site of existing stormwater BMP that could be modified to increase water quality benefits off Innsbruck Drive

Project 06 03560003013-BMP-1 (see map at left) is a project within this designation. The project would retrofit an existing wet pond and would fit well into the existing parcel. The BMP is currently located in a residential area near Innsbruck Dr. In a wet pond, the permanent pool of water is equal to the water quality volume. Temporary storage may also be provided above the permanent pool elevation for channel protection and for larger storm events. This proposed retrofit will achieve both full water quality and channel protection benefits by building or significantly redesigning the control structure of the wet pond. Additional modifications include building a sediment forebay.

Another method used to review stormwater BMP projects is solely by the benefit/cost score. These projects would have the most benefit per dollar for environmental, social, and financial criteria as defined by the Sandy Springs Prioritization Matrix. There are two projects with a benefit/cost score greater than 5. Both of these projects have an asset ownership classification of "non-single family non-attached" and thus are not currently part of the City's level of service.

Modification of this outlet structure would increase water quality benefits as part of project 17 0024 LL084-BMP-1

Project 17 0024 LL084-BMP-1 is one of the two projects with a benefit/cost score over 5. The project includes retrofitting an existing dry pond into a wet pond extended detention. The existing BMP is located in a commercial area near Roswell Road. In a wet extended detention pond, the water quality volume is split evenly between the permanent pool and extended detention storage provided above the permanent pool. During storm events, water is detained above the permanent pool and released over 24 hours. Temporary storage may also be provided above the water quality elevation for channel protection and for larger storm events.

This proposed retrofit will achieve full water quality and a portion of the channel protection benefits by converting it to a wet pond extended detention and redesigning the outlet control structure.

Table 4-15 presents the stormwater BMP projects that have a benefit/cost ratio score over 5.

Table 4-15. BMP Projects with Benefit/Cost Score Over 5

Project ID	Type	Study Area	Benefit/Cost	Cost
17 0022 LL158-BMP-1	Existing	Marsh Creek	**5.49**	**$159,000**
17 0024 LL084-BMP-1	Existing	Marsh Creek	**5.31**	**$279,000**
Sub-total				**$438,000**

Project 06 0353 LL012-BMP-1 is an example of a project within the “single family residential non-attached” category (not currently within the City’s level of service). The project includes retrofitting an existing wet pond. The existing BMP is located in a residential area near Grapevine Run. This proposed retrofit will achieve full water quality and a portion of the channel protection benefits by building or significantly redesigning the outlet control structure of the wet pond. The permanent pool may need to be lowered to achieve these benefits.

Water quality and channel protection benefits could be achieved by re-designing the outlet control structure at this existing pond as part of Project 06 0353 LL012-BMP-1

The following Table 4-16 presents the list of all 48 BMP projects with type, study area, benefit/cost score, and cost. As the City receives stormwater related service requests, this list of stormwater BMP projects can be compared to the service request to determine if there is a watershed benefit to the project.

Table 4-16. Historic BMP Projects within Fecal Coliform WIP Study Area

Project ID	Type	Study Area	Benefit/Cost	Cost
17 0022 LL158-BMP-1	Existing	Marsh Creek	**5.49**	**$159,000**
17 0024 LL084-BMP-1	Existing	Marsh Creek	**5.31**	**$279,000**
17 0019 LL058-BMP-1	Existing	Marsh Creek	**4.99**	**$378,000**
17 00880002007-BMP-1	New	Marsh Creek	**4.57**	**$1,405,000**
17 0034 LL031-BMP-1	New	Marsh Creek	**4.42**	**$1,032,000**
17 0075 LL028-BMP-1	Existing	Marsh Creek	**4.27**	**$144,000**
17 00200002012-BMP-1	Existing	Marsh Creek	**4.14**	**$311,000**
17 0022 LL058-BMP-1	New	Marsh Creek	**3.88**	**$376,000**

Table 4-16. Historic BMP Projects within Fecal Coliform WIP Study Area				
Project ID	**Type**	**Study Area**	**Benefit/Cost**	**Cost**
GA400Spalding-BMP-1	New	Marsh Creek	**3.82**	**$267,000**
17 00250004044-BMP-1	New	Marsh Creek	**3.81**	**$862,000**
17 01260001074-BMP-1	New	Marsh Creek	**3.74**	**$375,000**
17 0076 LL061-BMP-1	New	Marsh Creek	**3.68**	**$982,000**
17 0030 LL066-BMP-1	Existing	Marsh Creek	**3.64**	**$540,000**
06 0353 LL012-BMP-1	Existing	Crooked Creek	**3.55**	**$332,000**
17 00290002040-BMP-1	New	Marsh Creek	**3.44**	**$733,000**
06 03670001023-BMP-1	Existing	Crooked Creek	**3.29**	**$956,000**
17 0074 LL019-BMP-1	New	Marsh Creek	**3.06**	**$1,630,000**
06 03570004020-BMP-1	Existing	Crooked Creek	**2.94**	**$274,000**
GA400Aberntathy-BMP-1	New	Marsh Creek	**2.81**	**$8,620,000**
17 00850004025-BMP-1	New	Marsh Creek	**2.75**	**$889,000**
06 03670003066-BMP-1	Existing	Marsh Creek	**2.61**	**$651,000**
06 03570004007-BMP-1	Existing	Crooked Creek	**2.52**	**$226,000**
17 0031 LL031-BMP-1	Existing	Marsh Creek	**2.45**	**$564,000**
17 0024 LL085-BMP-1	New	Marsh Creek	**2.36**	**$825,000**
17 00330003022-BMP-1	Existing	Marsh Creek	**2.31**	**$276,000**
17 0023 LL041-BMP-1	New	Marsh Creek	**2.23**	**$1,345,000**
06 03630001082-BMP-1	Existing	Marsh Creek	**2.14**	**$414,000**
17 0133 LL091-BMP-1	New	Long Island Creek	**2.10**	**$1,310,000**
17 00740002017-BMP-1	New	Marsh Creek	**2.07**	**$1,630,000**
17 0034 LL012-BMP-1	New	Marsh Creek	**2.04**	**$1,019,000**
06 03670003067-BMP-1	Existing	Crooked Creek	**2.03**	**$528,000**
06 0360 LL001-BMP-1	Existing	Crooked Creek	**1.98**	**$555,000**
17 01660002016-BMP-1	New	Long Island Creek	**1.87**	**$618,000**
17 00870004032-BMP-1	New	Marsh Creek	**1.79**	**$1,964,000**
06 0364 LL051-BMP-1	Existing	Crooked Creek	**1.78**	**$467,000**
17 0166 LL043-BMP-1	New	Long Island Creek	**1.61**	**$2,804,000**
06 03610003031-BMP-1	Existing	Crooked Creek	**1.61**	**$513,000**
06 0361 LL033-BMP-1	Existing	Crooked Creek	**1.57**	**$1,127,000**
06 03610003022-BMP-1	Existing	Crooked Creek	**1.50**	**$775,000**

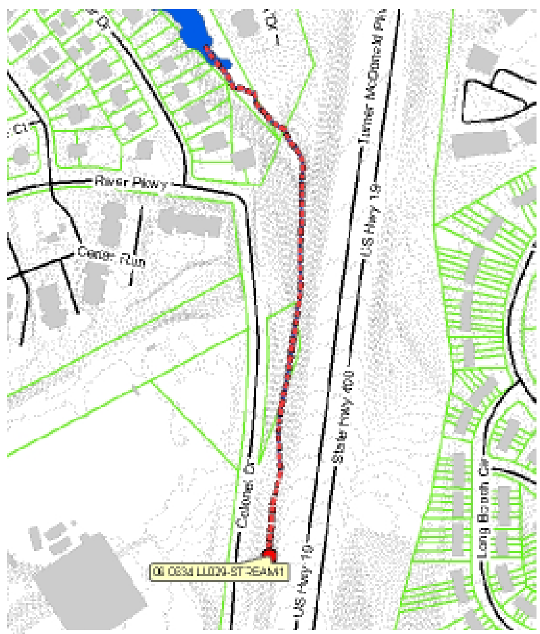
Table 4-16. Historic BMP Projects within Fecal Coliform WIP Study Area				
Project ID	**Type**	**Study Area**	**Benefit/Cost**	**Cost**
17 00740004001-BMP-1	New	Marsh Creek	**1.48**	**$1,106,000**
17 0027 LL005-BMP-1	Existing	Marsh Creek	**1.26**	**$492,000**
17 00740002038-BMP-1	New	Marsh Creek	**1.05**	**$306,000**
06 03630001082-BMP-2	Existing	Marsh Creek	**1.01**	**$464,000**
06 03560003013-BMP-1	Existing	Crooked Creek	**0.93**	**$410,000**
06 0357 LL049-BMP-1	Existing	Crooked Creek	**0.89**	**$330,000**
06 0365 LL029-BMP-1	Existing	Crooked Creek	**0.72**	**$404,000**
06 0383 LL081-BMP-1	Existing	Crooked Creek	**0.53**	**$333,000**
06 0383 LL071-BMP-1	Existing	Crooked Creek	**0.53**	**$411,000**
Sub-total				**$42,411,000**

4.5.2 Stream Restoration Projects

The City of Sandy Springs does not currently include stream restoration projects as part of its stormwater management program. However, for future reference, 7 Historic CIP stream projects were evaluated within the Fecal Coliform WIP study area. Stream restoration projects provide numerous benefits including water quality, aquatic habitat, public safety, and infrastructure improvements within the watershed. In addition, aesthetics will be improved from many of these projects.

An example of a stream restoration project is project 06 0634 LL029-STREAM-1. A level 2 stream restoration is proposed for a 1,600 foot reach located on east side of Dunwoody Middle School between the school and GA-400. There is erosion and debris evident with numerous trees in channel and broken/collapsed culverts. A Level 2 approach includes restoring the stream and floodplain within the existing channel at the present elevation or a new channel adjacent to the old but at the same elevation. The new channel will be based on the dimension, pattern, and profile characteristic of a stable reference reach.

All stream projects and associated costs and benefit/cost scores are presented in Table 4-17.



Location of a potential stream restoration project near Dunwoody Middle School and GA 400

Table 4-17. Stream projects within the Fecal Coliform WIP Study Area.				
Project ID	**Type**	**Study Area**	**Benefit/Cost**	**Cost**
06 0634 LL029-STREAM-1	Stream	Crooked Creek	1.10	$1,712,000
06 03520004001-STREAM-1	Stream	Crooked Creek	0.92	$453,000
06 03630001062-STREAM-1	Stream	Marsh Creek	0.71	$1,117,000
06 03560003013-STREAM-1	Stream	Crooked Creek	0.67	$1,286,000
17 00790001025-STREAM-1	Stream	Marsh Creek	0.61	$719,000
06 03680001032-STREAM-1	Stream	Marsh Creek	0.43	$1,123,000
06 03570002015-STREAM-1	Stream	Crooked Creek	0.23	$1,099,000
Sub-total				$7,509,000

The projects presented in this section of the Fecal Coliform Watershed Improvement Plan outlines dozens of structural BMP projects that can help achieve water quality goals. Selection of projects can be modified if the City revises its level of service. Based on the City's current level of service, the two projects listed under City owned property would be recommended for implementation. The schedule for implementation of these two recommended projects and recommendations for other management activities and projects are presented in Chapter 5.