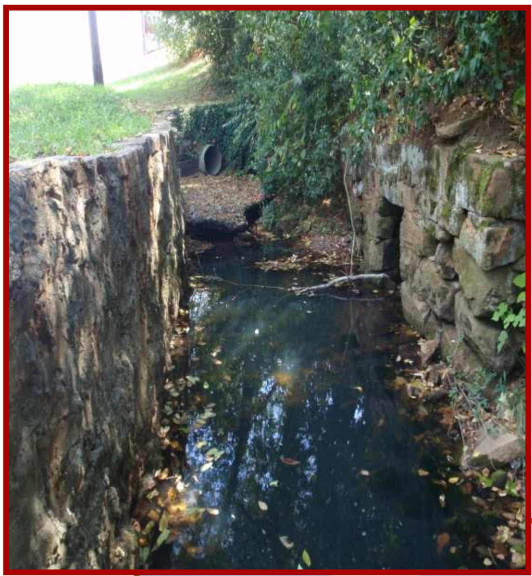
Cabin Creek
Watershed Protection Plan



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March 2012

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Appendix A – 2010 Biological Monitoring Report for Cabin Creek

Appendix B – Water Quality Chart and Graphs

Appendix C – City of Griffin MS4 Permit Notice of Intent (NOI)

Appendix D – 2010 Watershed Hydrology and Water Quality Modeling Report

Appendix E – City of Griffin QAPP

Appendix F – Project Data Sheets for Proposed BMP Sites and Stream Restoration Sites

1 Introduction

The City of Griffin, in Spalding County Georgia, has developed along the divide between the Upper Ocmulgee River system to the east and the Upper Flint River system to the west. A total of six watersheds within the City of Griffin are contained within these two river systems (see Figure 1-1). The Cabin Creek Watershed eventually drains to the Ocmulgee River. The Heads Creek, Shoal Creek, Wasp Creek, Honey Bee Creek, and the Potato Creek Watersheds eventually drain to the Flint River. The City of Griffin lies at the headwaters of all these watersheds.

The City of Griffin is seeking reissuance of its National Pollutant Discharge Elimination System (NPDES) permit for its municipal wastewater treatment plant (WWTP) discharges into Cabin Creek. As a part of issuance of NPDES point source permits, the State of Georgia Environmental Protection Division (EPD) has adopted a watershed approach for evaluating point and nonpoint sources of pollution. EPD requires permit applicants to develop a Watershed Management Plan that addresses ongoing land uses and discharges as well as impacts of future growth and increased discharges that can affect water quality. The May 6, 2004 Guidance for developing a Watershed Management Plan includes the following three components: a Watershed Monitoring Plan, a Watershed Assessment, and a Watershed Protection Plan. The City of Griffin, in preparation for renewal of its WWTP NPDES permit, developed watershed plan documents that meet the Georgia EPD requirements. A Watershed Monitoring Plan was prepared for Cabin Creek by Tetra Tech in August 2009 and has been approved by the EPD. A Watershed Assessment was prepared for Cabin Creek by Tetra Tech in November 2009 and has been approved by the EPD. This Protection Plan is provided as the final component of the Cabin Creek Watershed Management Plan.

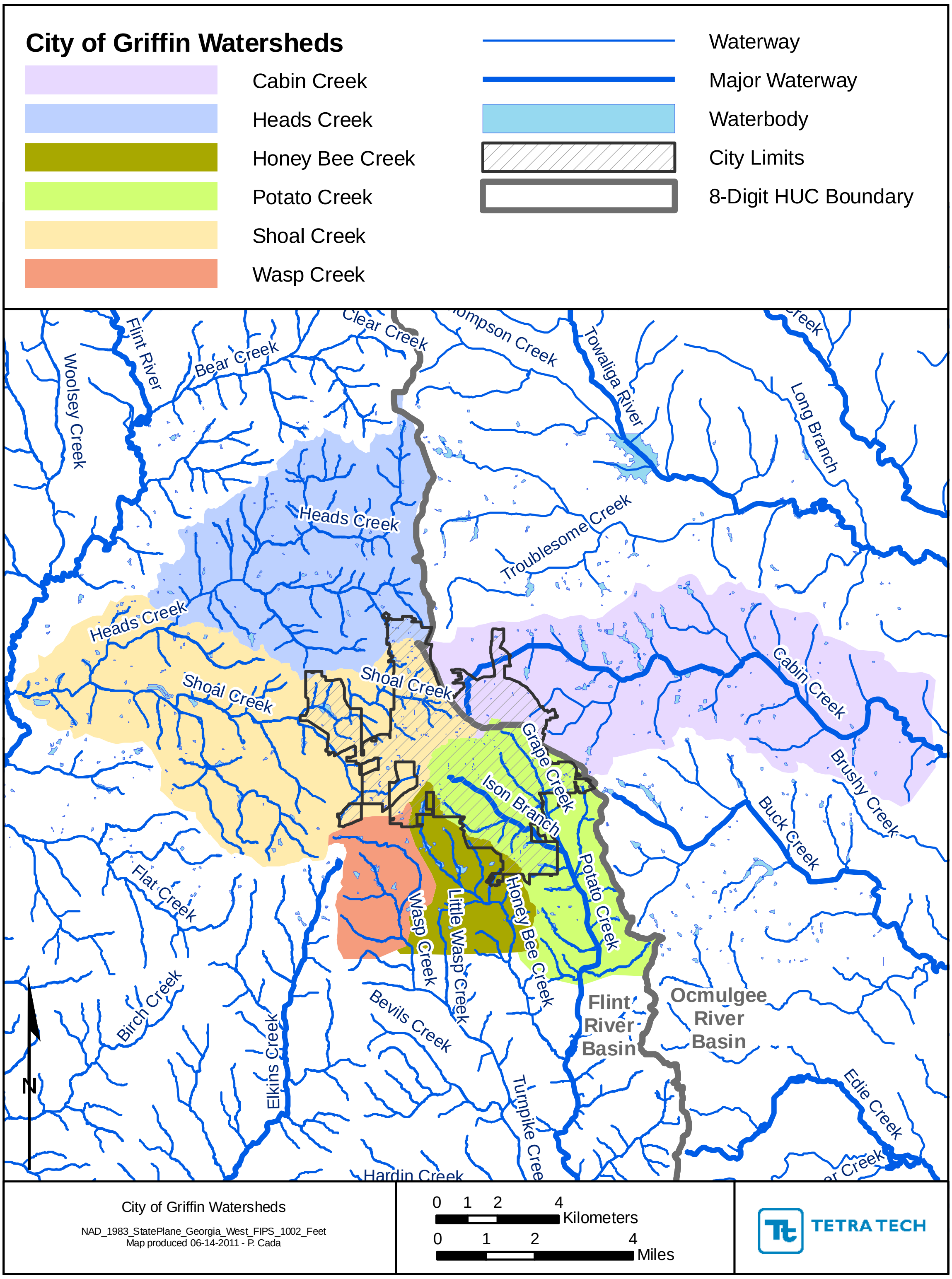

Figure 1-1 City of Griffin Watersheds

The Cabin Creek Protection Plan includes the following components:

1) Goals, objectives, indicators and benchmarks
2) Existing conditions
3) Current watershed protection measures
4) Watershed projects and research
5) Long-term monitoring plan
6) Watershed management needs
7) Watershed management opportunities
8) Management recommendations

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2 Goals, Objectives, Indicators, and Benchmarks

2.1 Goals, Objectives, and Indicators

Watershed protection plans should be built on explicitly defined goals and objectives. In the context of watershed planning, a goal is a general statement about the desired condition or outcome of the watershed protection or restoration strategies, while objectives are specific statements that define what must be true for the goals to be achieved. Essentially, chosen objectives provide the foundation for watershed restoration and protection decisions. Because objectives are often difficult to measure directly, indicators can be used as measurable surrogates.

The recommended Cabin Creek Watershed goals, objectives, and indicators can be used in screening management options and crafting and selecting management strategies during future planning and implementation activities. It is also proposed that they be used to track progress and success in implementation of the plan. The City has adopted similar goals and objectives for the Potato Creek Protection Plan, and is adopting similar goals and objectives for the Shoal Creek Protection Plan in order to provide a standardized means of assessing watersheds and prioritizing projects city-wide.

In developing the draft goals and objectives, Tetra Tech drew upon the following key documents:

- City of Griffin Stormwater Utility Mission Statement
- Cabin Creek Watershed Assessment (Tetra Tech, 2009)
- Stream Channel Erosion Activity Assessment of the Cabin Creek Watershed (Tetra Tech, 2008)
- City of Griffin NPDES Stormwater Permit Notice of Intent (2007)

The Stormwater Utility Mission Statement provides clear guidance in developing goals and objectives,

> *To provide a comprehensive program for watershed management which includes: seeking out alternative funding mechanisms to enhance Griffin's stormwater management system; establish programs to address infrastructure problems; cost-effective design and construction of the necessary improvements; providing leadership through the implementation of Best Management Practices [BMPs] that will enhance water quality throughout the region; and improving the overall quality of life for our citizens.*

Through a comprehensive watershed management program, the Cabin Creek Watershed Management Plan addresses stormwater impacts from planned new development as well as impacts from uncontrolled runoff from existing development. It also addresses the City's desire to lead through example in implementing programs for construction, maintenance, and citizen engagement that reflect outstanding watershed stewardship. Watershed Goals and Objectives were developed based on the Stormwater Utility's existing program and existing conditions in the Cabin Creek Watershed. The following four overarching goals proposed for the protection plan:

1) Enhance water quality in the City and the region;
2) Meet or exceed state and federal water quality requirements, including removal of the City of Griffin streams from the state's list of impaired waters;
3) Implement innovative, cost-effective solutions; and
4) Improve the overall quality of life for citizens in the City of Griffin.

Tetra Tech recommends eight objectives in support of these goals (see Table 2-1). All eight objectives support multiple goals, while Table 2-1 shows these linkages.

Table 2-2 lists indicators in three categories—watershed impact, source, and programmatic. Watershed impact indicators are environmental measures such as benthic macroinvertebrate community, channel stability, and water quality. Source indicators are measures of potential stressors such as impervious area and deficient riparian area vegetation. Programmatic indicators refer to potential or actual management measures. As shown in Table 2-2, most of the indicators serve as measurable, meaningful surrogates for multiple protection objectives.

Finally, Table 2-3 describes each indicator as well as the proposed assessment tool for measurement. The assessment tools are comprehensive and include monitoring, stream surveys, watershed modeling, GIS (geographic information system) analysis, stormwater utility records, CIP (capital improvement projects) program records, and program tracking.

Benchmarks have been developed for select indicators to assess status, help select among management options, and track progress in meeting objectives.

The goals, objectives, indicators, and benchmarks presented in this Plan essentially connect and enhance the tools already being used by the City in its comprehensive watershed management program. They also provide standardized means to assess watersheds and prioritize projects city-wide.

Table 2-1 Objectives Linked to Goals

Watershed Improvement Program Objectives		Goals			
		G1 Enhance Water Quality	G2 Meet Requirements	G3 Be Cost-Effective & Innovative	G4 Improve Quality of Life
A.	Minimize impacts of stormwater runoff and erosion on stream *hydrology* to promote stable stream morphology, protect habitat, and support biota (city-wide)	■	■		■
B.	Minimize impacts to stream *water quality* from pollutants in stormwater runoff, particularly those related to the following: • Elevated concentrations of fecal coliform bacteria (watershed-wide) • Elevated nutrients (watershed-wide) • Degraded habitat and biotic communities • Flashy hydrology • Poor channel stability • High sediment loads	■			■
C.	Meet state and federal requirements such as Phase II stormwater, NPDES permit requirements for the Cabin Creek WWTP, and 303(d) listing of Cabin Creek for impaired biota, toxicity, and fecal coliform	■	■		■
D.	Ensure BMPs are properly maintained and functioning	■	■		■
E.	Minimize impacts of large woody debris to promote stable stream morphology, protect habitat, and support biota	■			■
F.	Use low impact development (LID), green infrastructure, and innovative regional BMPs, to the extent practicable, to enhance water quality and quality of life in the community	■		■	■
G.	Actively engage the community in adopting measures to protect and restore streams	■	■	■	■
H.	Implement cost-effective City programs that provide leadership in watershed stewardship	■		■	■

Table 2-2 Watershed Impact, Source, and Programmatic Indicators Linked to Objectives

Watershed Impact Indicators	Objectives							
	A	B	C	D	E	F	G	H
Benthic communities	■	■	■	■	■	■	■	■
Aquatic habitat	■	■	■	■	■	■	■	■
Fish communities	■	■	■	■	■	■	■	■
Channel morphology	■		■	■	■	■	■	■
Channel stability	■		■	■	■	■	■	■
Instream sediment	■		■	■	■	■	■	■
Hydrology (frequency, magnitude, and duration of flows)	■	■	■	■	■	■	■	■
Drainage complaints	■				■		■	■
Percent riparian area deficient of vegetation	■	■				■	■	■
Percent connected natural area	■	■				■	■	■
Water quality (modeling of future conditions): relative nutrient, upland sediment, and metals loading.		■	■					■
Water quality (observed/measured): instream total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS), fecal coliform (FC), metals, dissolved oxygen (DO), turbidity		■	■					■

Table 2-2 cont'd Watershed Impact, Source, and Programmatic Indicators Linked to Objectives

Source Indicators	Objectives							
	A	B	C	D	E	F	G	H
Impervious area	■	■	■	■		■	■	■
Stormwater outfalls	■	■						■
Property loss due to erosion	■	■	■	■	■	■	■	■
Percent of development with uncontrolled stormwater	■	■	■	■		■	■	■
Percent highways with uncontrolled stormwater	■	■	■			■		■
Sanitary sewer crossings and sewer spills		■						■
Deficient riparian area vegetation	■	■				■	■	■
TP, TN, TSS, metals loading (modeled)		■						

Table 2-2 cont'd Watershed Impact, Source, and Programmatic Indicators Linked to Objectives

Programmatic Indicators	Objectives							
	A	B	C	D	E	F	G	H
# Cisterns installed	■	■				■	■	■
# Disconnected downspouts		■				■	■	■
# Retrofits of existing flood control structures for water quality/hydrology	■	■		■		■	■	■
Length stream restoration	■	■					■	■
Acres buffer restoration using native vegetation	■	■				■	■	■
Percent development using LID and green infrastructure (since 2009)	■	■		■		■	■	■
# BMPs providing neighborhood or community amenity (e.g. open space, garden, water features)	■	■				■	■	■
# Regional BMPs constructed	■	■		■		■	■	■
Percent development with stormwater BMPs functioning as designed	■	■	■	■		■	■	■
Percent City projects with LID or green infrastructure	■	■				■		■
Percent City projects with stormwater BMPs functioning as designed	■	■		■				■
Mitigation cost-effectiveness ($/load reduced)								■
Leveraged funding sources								■

Table 2-3 Description of Watershed Impact, Source, and Programmatic Indicators

Watershed Impact Indicators	Description	Assessment Tool
Benthic communities	Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment	Monitoring
Aquatic habitat	Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment	Stream survey
Fish communities	Standard Operation Procedure for Conducting Biomonitoring on Fish Communities in Wadeable Streams in Georgia (GA DNR, 2005)	Monitoring
Channel morphology	Visual based physical habitat assessment per Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment; other options include the Incised Channel Evolution Model (ICEM) that defines the stages of channel evolution following land development, urbanization, and restoration	Stream survey
Channel stability	Visual based physical habitat assessment per Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment; other options include a comparison of specific stream power and velocity to critical threshold values relevant to channel stability	Stream survey Watershed model
Instream sediment	Visual based physical habitat assessment per Georgia DNR Standard Operating Procedures for Macroinvertebrate Biological Assessment.; other options include qualitative or quantitative estimate of sediment load generated by channel erosion (specify load if quantitative)	Qualitative assessment, literature review, or permanent cross section data
Hydrology (frequency, magnitude, and duration of flows)	A measure or index that uses storm event simulations to provide information on hydrologic alteration and potential impacts to stream morphology, habitat, and biota	Monitoring and storm event simulation
Drainage complaints	Records number of drainage complaints per square mile of developed area	Public works records
Percent riparian area deficient of vegetation	Percent of land within the riparian buffer lacking sufficient natural, vegetative cover. (If using the Multi-Resolution Land Characteristics Consortium [MRLC] Landscape Fire and Resource Management [LANDFIRE] 2001 data, <30 percent coverage within any vegetative layer could be used as an indicator of deficiency.)	Stream survey GIS analysis
Percent connected natural area	Percent of land within a subwatershed that supports natural areas with significant connectivity	GIS analysis
Water quality future conditions	Relative nutrient, metals, and upland sediment, loading	Watershed model
Water quality observed/measured	Instream TP, TN, TSS, FC, metals, DO, turbidity	Monitoring

Table 2-3 cont'd Description of Watershed Impact, Source, and Programmatic Indicators

Source Indicators	Description	Assessment Tool
Percent impervious area	Percent of land in subwatershed with impervious surface	GIS analysis of land use/land cover data
Stormwater outfalls	Number and location of stormwater outfalls per mile of stream	Stream surveys and GIS analysis
Property loss due to erosion	Widening of stream channels resulting in property loss	Stream surveys; aerial photographs
Percent of development with uncontrolled stormwater	Areas of development prior to stormwater control requirements	Stormwater utility records
Percent highways with uncontrolled stormwater	Highways built prior to stormwater control requirements	Stormwater utility records
Sanitary sewer crossings and sewer spills	Number of locations where sanitary sewers cross streams per mile of stream; number of sanitary sewer spills or overflows per square mile of subwatershed	Stream surveys; record of spill notices
Percent riparian area deficient of vegetation	Percent of land within the riparian buffer lacking sufficient natural, vegetative cover	Stream surveys and GIS model
TP, TN, TSS, metals loading (modeled)	Estimated and predicted loading of nutrient, upland sediment, metals, and fecal coliform bacteria	Watershed model

Table 2-3 cont'd Description of Watershed Impact, Source, and Programmatic Indicators

Programmatic Indicators	Description	Assessment Tool
# Cisterns installed	Self explanatory	Program tracking
# Disconnected downspouts	Self explanatory	Program tracking
# Retrofits of existing flood control structures for water quality/hydrology	Self explanatory	CIP program records
Length stream restoration	Self explanatory	Program tracking
Acres buffer restoration	Self explanatory	Program tracking
Percent development using LID and green infrastructure (since 2009)	Self explanatory	Land development records
# Regional BMPs constructed	Self explanatory	CIP program records
Percent development with stormwater BMPs functioning as designed	Self explanatory	Inspections records
Percent City projects with LID or green infrastructure	Self explanatory	Program tracking
# BMPs providing neighborhood or community amenity (e.g. open space, garden, water features)	Rain gardens, constructed wetlands, greenways, ponds, tree planters, or BMPs that provide amenities in neighborhoods, parks, streetscapes, city courtyards/plazas, etc.	Program tracking
Percent City projects with stormwater BMPs functioning as designed	Self explanatory	Inspection records
Mitigation cost-effectiveness	Cost per ton of TSS reduced, cost per pound of nutrients and metals reduced, cost per detention volume, etc.	Program tracking; cost analysis
Leveraged funding sources	Grants received, cost-share dollars from other agencies, and in-kind contributions	Program tracking

2.2 BENCHMARKS

Tetra Tech has developed benchmarks as a means of tracking progress toward the recommended goals and objectives for City of Griffin watersheds. Benchmarks are indicator values that represent conditions at which a particular environmental objective has been achieved. The water quality benchmarks presented here are recommended for use in interpreting dry weather or long-term average concentration data. Benchmarks are also recommended for benthic communities, aquatic habitat, and impervious area. Tetra Tech recommends that the benchmarks be used to flag potential impacts during observed and simulated data review and evaluation. Note that these values are not recommended as standards for regulation or as absolute targets to denote unimpacted conditions.

Water Quality Benchmarks

The water quality benchmarks were developed primarily for use in evaluating baseflow, or dry weather, water quality monitoring data in streams. They are not directly applicable to measurements obtained from individual storms, which can often be much higher, but are applicable to interpreting long-term averages of concentration data obtained from a mix of dry weather and wet weather monitoring. The benchmarks would be appropriate to apply to the City of Griffin dry weather sample data that can be influenced by some wet weather events. The benchmarks should not be applied to data measured exclusively during wet weather events.

To develop the benchmarks, Tetra Tech reviewed the State of Georgia water quality regulations for any relevant standards (State of Georgia, 2010). For constituents that did not have numeric state standards, Tetra Tech reviewed literature values for reference conditions within the Georgia piedmont. The literature review focused on instream, baseflow measurements.

A benchmark range is recommended for each parameter for which targets are not directly established by a published state water quality criterion. If a parameter is observed above this range, this indicates that there is a potential for significant impacts, and that the stream reach should be investigated further. If the parameter is within the range, some moderate impacts due to water quality are likely but to a lesser extent. Reaches within the benchmark range would be considered a lower priority for investigation. Below the range, the parameter is not considered a concern for that stream reach and further investigation is likely unnecessary.

The City of Griffin dry weather monitoring data were used to develop the benchmarks. Tetra Tech used the data collected from January 1, 2005 through June 22, 2010 for the currently sampled Cabin Creek watershed stations: WQ-16, WQ-17, WQ-23, WQ-37, and WQ-43.

For the upper bound TN and TP benchmark ranges, a regression equation from Dodds et al. (2002, 2006) was used to estimate the concentration at which benthic algal density would likely reach nuisance levels in the absence of other limiting factors, such as grazing or insufficient light. The coefficient of variation from the dry weather monitoring data was applied to the regression equation, and a Redfield ratio for TN:TP (molecular ratio of nutrients in phytoplankton) of 7.2 (by mass) was assumed, to develop unique TN and TP benchmarks. From these relationships, Tetra Tech calculated the upper 95 percent confidence intervals for TN and TP at which excessive algal growth would be expected. These values (1.3 mg/L TN and 0.23 mg/L TP) were used as the upper bounds of the benchmark ranges. When calculating the coefficient of variation, samples below the detection limit were included as half of the detection limit.

For the lower bounds of the TN and TP benchmark range, the U.S. Environmental Protection Agency (EPA) nutrient criteria guidance for streams was used, and Tetra Tech consulted the specific guidance for Nutrient Subecoregion 45, which coincides with the City of Griffin. According to this guidance, if reference data are available, the 75th percentile of reference data is recommended as a criterion. If reference data are not available, then the 25th percentile of the distribution of all observed concentrations is recommended as a reasonable approximation of reference conditions. The EPA guidance states that these recommended criteria should be used as guidance, but that states and other agencies should conduct further research to determine the most appropriate criteria for their location (USEPA, 2000). Consistent with the EPA guidance, the 75th percentile of concentrations from least-disturbed EPA Wadeable Stream Assessment reference-sites were used for the lower bounds of the TN and TP benchmark range (Herlihy and Sifneos, 2008).

For most of the remaining constituents, the upper and lower bounds were based on two types of reference values: (1) the highest reference values within the literature, and (2) the 25th percentile of dry weather water quality data (consistent with EPA guidance discussed above). The highest literature reference values were selected because all information sources reflected relatively unimpacted conditions within the Georgia piedmont physiographic region, and the highest values among these sources should represent a potential threshold between natural (background) conditions and impacted conditions. When calculating the 25th percentile of the dry weather data, samples below the detection limit were included as half the detection limit. Collectively, these values provided a reasonable range below which a parameter is not considered a concern and represents achievement of objectives. For most constituents, the literature values represented the upper bound, and the 25th percentile of dry weather data represented the lower bound of the range. For NO_3-NO_2, the benchmarks were reversed because the literature value method produced a lower benchmark than the 25th percentile method. Because the Total Kjeldahl Nitrogen (TKN) literature reference value (2 mg/L) exceeded the TN upper bound (1.3 mg/L), 1.3 mg/L was used as the TKN upper bound.

The benchmark for turbidity is especially uncertain, and this uncertainty should be accounted for when evaluating watershed conditions. Instead of using the maximum reference value, Tetra Tech is recommending 30 nephelometric turbidity units (NTU) as the upper bound benchmark, which represents the average reference conditions found in the literature search.

As noted above, the current set of benchmarks are established primarily for dry weather conditions and are not necessarily applicable during storm events, when runoff or channel erosion processes can cause elevated concentrations. For those constituents for which Georgia has adopted numeric water quality criteria, the differences between wet and dry weather concentrations are addressed through the use of two-number criteria. These criteria consist of an average or chronic value and an acute or instantaneous value. The acute (instantaneous) criterion is applicable to all individual observations, except as otherwise exempted, and is thus applicable to both wet and dry weather benchmarks. The more stringent average or chronic values provide benchmarks that are relevant to dry weather or average conditions, while the acute or instantaneous values provide benchmarks for all individual observations, including wet weather data.

For constituents for which numeric criteria have not been established in regulations, benchmarks for wet weather samples are more difficult to derive. As wet weather data are collected, the City of Griffin could consider wet weather benchmarks in addition to the dry weather benchmarks recommended in this report. Note that reference information on wet weather benchmarks was not readily available during this phase of the project. When reference data are available, wet weather benchmarks can vary considerably by local conditions. Benchmarks for TSS and turbidity, for example, are most relevant under dry weather conditions since these constituents can vary widely by channel condition under wet weather. Given these limitations, the best approach for assessing wet weather data for constituents without acute numeric criteria would be to evaluate the watershed data based on conditions within the watershed and not concentrations that are likely indicators of impacts. If load limits are developed in the future, these limits could be used to develop wet weather benchmarks to ensure that load limits are met.

The recommended benchmarks are summarized in Table 2-4 and Table 2-5. Table 2-4 lists the benchmarks based on water quality standards, while Table 2-5 lists the benchmarks that were based on literature values and EPA criteria guidance. As noted above, the benchmarks were derived for use in evaluating average and baseflow (dry weather) water quality monitoring data in streams.

The benchmark ranges in Table 2-5 should be used to flag conditions in the watershed for further consideration and analysis. It is important to note that biological monitoring may indicate that impacts are occurring even when water quality data are within the ranges specified by the benchmarks. As additional water quality data are collected and compared to the benchmarks, further refinement may be warranted.

Table 2-4 Benchmarks Derived from Georgia Numeric Water Quality Criteria

Parameter	Benchmark[1]	Reference	Typical Nonpoint Sources
pH	Between 6.0 and 8.5	State of Georgia (2010) Standards	Decaying organic matter, groundwater
Dissolved copper (µg/L)[2]	7 µg/L at 50 mg/L CaCO3 (acute criterion, hardness dependent) 5 µg/L at 50 mg/L CaCO3 (chronic criterion, hardness dependent)	State of Georgia (2010) Standards	Road runoff (e.g., brakepads, automotive flaking); parking areas in urban and industrial sites (from vehicular traffic); roofing and storage building materials (e.g., copper gutters)
Dissolved zinc (mg/L)	65 µg/L at 50 mg/L hardness (acute and chronic criterion hardness dependent)	State of Georgia (2010) Standards	Road runoff (e.g., brakepads, automotive flaking); parking areas in urban and industrial sites (from vehicular traffic); corrugated metal roofing and siding; native soils
Dissolved Cadmium (µg/L)[2]	1.0 µg/L at 50 mg/L CaCO3 (acute criterion, hardness dependent) 0.15 µg/L at 50 mg/L CaCO3 (chronic criterion, hardness dependent)	State of Georgia (2010) Standards	Car exhaust
Dissolved Lead (µg/L) [2]	30 µg/L at 50 mg/L CaCO3 (acute criterion, hardness dependent) 1.2 µg/L at 50 mg/L CaCO3 (chronic criterion, hardness dependent)	State of Georgia (2010) Standards	Urban runoff, soil near roads containing legacy contamination from leaded gasoline, and soil near factories that use lead

Table 2-4 cont'd Benchmarks Derived from Georgia Numeric Water Quality Criteria

Parameter	Benchmark[1]	Reference	Typical Nonpoint Sources
FC (# colonies/100 mL)	May – October: 200 # /100mL 30-day geomean November – April: 4000 # /100mL instantaneous; 1000 # /100mL 30-day geomean	State of Georgia (2010) Standards	Wildlife, birds, pets, cattle, malfunctioning septic systems, sewer system leaks and spills, illicit connections
DO (mg/L)	>4 mg/L instantaneous; >5 mg/L daily average	State of Georgia (2010) Standards	Affected by biochemical oxygen demand (BOD) load, groundwater and activity of algae, presence of heterotrophic bacteria and fungi

[1] Note: acute or instantaneous criteria are applicable benchmarks for both wet and dry weather conditions; chronic, average, or geomean criteria are applicable benchmarks for dry weather sampling.

[2]The copper, cadmium, and lead standards will need to be recalculated based on observed hardness and converted to total copper, total cadmium, and total lead to compare to monitoring data.

Table 2-5 Additional Water Quality Benchmarks for Dry Weather Monitoring Data

Parameter	Benchmark Range[1]	References for Lower Bound Benchmarks	References for Upper Bound Benchmarks	Typical Nonpoint Sources
TSS (mg/L)	1 to 13 mg/L	25th percentile of 2005–2010 dry weather observed data	Paul et al (2006) Roy et al (2003) Schoonover et al. (2005) Tetra Tech (2006)	Channel erosion, upland erosion, roads, agricultural tillage, construction/land disturbance
Turbidity (NTU)	14 to 30 NTU	25th percentile of 2005–2010 dry weather observed data	GA EPD (2007a) GA EPD (2007b) Tetra Tech (2006) Roy et al (2003) Pitt (2000) USEPA (2000)	Primarily driven by TSS; color and dissolved organic matter from humus
BOD (mg/L)[2]	1 to 3 mg/L	25th percentile of 2005–2010 dry weather observed data	Fox and Absher (2002)	Manure, plant material, algal blooms, septic systems
TP (mg/L)	0.06 to 0.23 mg/L	Herlihy and Sifneos (2008)	Dodds et al (2006), Dodds et al (2002)	Agricultural and landscaping runoff (fertilizers and organic matter), regeneration from stream sediment
TN (mg/L)	0.7 to 1.3 mg/L	Herlihy and Sifneos (2008)	Dodds et al (2006), Dodds et al (2002)	Agricultural and landscaping runoff (fertilizers and organic matter), atmospheric deposition, septic systems
NO_3-NO_2 as N (mg/L)	0.4 to 1.0 mg/L	GA EPD (2007a) Gore et al (2005) Roy et al (2003) USEPA (2000)	25th percentile of 2005–2010 dry weather observed data	Same as TN
NH_3 as N (mg/L)[2]	0.03 to 1 mg/L	25th percentile of 2005–2010 dry weather observed data	GA EPD (2007a) Gore et al (2005) Meyer et al. (2005) Roy et al, (2003) Schoonover et al. (2005)	Septic systems, agricultural groundwater, fertilizers, instream production from decaying organic matter, regeneration from stream sediment
TKN (mg/L)	0.6 to 1.3 mg/L	25th percentile of 2005 –2010 dry weather observed data	TN upper bound	Same as TN
PO_4 as P(mg/L)[2]	0.01 to 0.1 mg/L	25th percentile of 2005–2010 dry weather observed data	Pitt (2000) Tetra Tech (2006)	Same as TP

[1]Sampling and analysis methods could not be verified for all references.
[2]Lower bound represents detection limit.

Other Benchmarks

Where information was available, Tetra Tech developed the following recommended benchmarks for indicators other than the water quality constituents. These benchmarks represent conditions at which the relevant goals and objectives may be met.

- Benthic Communities—Good or excellent rating.
- Aquatic Habitat—A score of 113 or higher (using the 2007 scoring methods), which indicates optimal or suboptimal habitat conditions.
- Impervious Area—Percent imperviousness of 25 or less is considered a desirable condition. Above this value, severe degradation is expected to occur and indicators of stream quality consistently shift to a poor condition (CWP, 2003). Most stream quality indicators begin to decline at 10 percent impervious, which could be used as a more conservative benchmark.

3 Existing Conditions

The Watershed Assessment, prepared by Tetra Tech in 2009, identified the primary pollutants and pollutant sources in the Cabin Creek Watershed. Much of the supporting information used in the Watershed Assessment originated from water quality and biological monitoring conducted in the watershed from 2002 to 2009, as well as from the Stream Channel Erosion Activity Assessment of the Cabin Creek Watershed that was completed in 2008. Also, since the Watershed Assessment was prepared, a biological monitoring report for Cabin Creek was conducted in 2010 by CCR Environmental (see Appendix A) that provided additional data.

The Cabin Creek Watershed, particularly the headwaters within the Cabin Creek Wastewater Service Area, is highly urbanized and almost completely developed. Cabin Creek and its tributaries are experiencing ecological degradation that is typical of urban watersheds. The streams have been affected directly through channelization, and indirectly through changes in surrounding land use and the resulting changes in volume, velocity, and quality of stormwater runoff. These alterations have also lead to increased stream bank erosion.

The 2008 Stream Channel Erosion Activity Assessment attributes impacts in the Cabin Creek Watershed to many sources, citing beaver impacts, channelization impacts, large woody debris impacts, urban impacts, and upland impacts. There are several areas of high and moderate erosion along the main reach of Cabin Creek and its tributaries; there are also obvious impacts from sedimentation and silt deposition. The assessment determined that the most severe stream bank erosion is occurring regularly along the main stem of Cabin Creek over the 8 miles of stream below the WWTP, to the furthest downstream assessment point at State Highway 16. The unstable and eroding portions of these 8 miles are very likely the dominant sediment source to Cabin Creek, which is just downstream of the service area. The significant erosion processes in the main stem of Cabin Creek include mass wasting of excessively steepened banks, and bank scour—particularly around large, woody debris jams.

Headwater tributaries within Griffin City limits have a smaller length of stream reaches assessed at moderate or high channel erosion activity levels compared to the main stem of Cabin Creek. These reaches are probably a secondary contributor to the total sediment load of Cabin Creek. However, many of the moderate and high erosion activity reaches within the City limits were impacting infrastructure at the time of the assessment, or had the potential to impact to infrastructure in the future. The assessment noted that typical causes of erosion include mass wasting due to excessively high and over-steepened banks, scour around large trash jams, increased bank retreat rates, and gully formation where woody vegetation has been cleared from the bank faces and bank tops.

The percent of impervious area in the service area watershed is approximately 23 percent. This high percentage of impervious surface cover can be expected to result in hydrologic and habitat conditions that will limit aquatic communities, as noticeable stream degradation can occur when impervious cover exceeds 10 percent. A benchmark of 25 percent impervious surface cover was developed for the Cabin Creek Watershed, as severe degradation is expected to occur above this level. Subwatersheds CC6 and CC10 each have an impervious cover greater than this benchmark, with impervious surface coverages of 32 percent and 26 percent, respectively.

3.1 303(D) LISTED WATERBODIES

The Georgia EPD lists Cabin Creek on its 2008 and 2010 Clean Water Act 303(d) lists of impaired streams that do not meet their designated uses. Cabin Creek is on the not supporting list for its designated use of fishing. Three criteria were violated— biota (due to sediment), toxicity, and fecal coliform. Total Maximum Daily Loads (TMDLs) for these three parameters were established in 2002. New TMDLs were established for biota and fecal coliform in 2007. The 303(d) listing attributes the impairments to an industrial facility point source and to urban run-off/urban effects. The entire length of Cabin Creek is listed, from the headwaters to the confluence with the Towaliga River. Of the 16 miles of stream listed by Georgia EPD as impaired, approximately 3 miles are physically located within the wastewater service area boundary and approximately 1.2 miles are physically within the Griffin City limits.

Although a TMDL for DO was established for Cabin Creek in 2002, it has since been delisted for DO impairment.

The most recent TMDLs are summarized in Table 3-1.

Table 3-1 TMDLs for Cabin Creek

Parameter	Waste Load Allocation (WLA)	Load Allocation (LA) Non-Point	Margin of Safety (MOS)	TMDL	Percent Reduction
Chronic Toxicity 2002 TMDL Report	• Griffin Cabin Creek WWTP - 1.0 Toxicity Units • Springs Industries, Inc. - 1.0 Toxicity Units • I-75 South Mobile Homes, Jackson - 1.0 Toxicity Unit	0.0 Toxicity Units	Implicit	1.0 Toxicity Units	N/A
Fecal Coliform 2007 TMDL Report	4.84×10^{11} counts/30 days • Griffin Cabin Creek WWTP – Avg. monthly flow (MGD): 1.5 Avg. monthly FC (No./100mL): 200 • Springs Industries, Inc.- Avg. monthly flow (MGD): 1 Avg. monthly FC (No./100mL): 400	1.15×10^{12} counts/30 days	2.15×10^{11} counts/30 days	2.15×10^{12} counts/30 days	64
Biota (Sediment) 2007 TMDL Report	257.2 tons/yr • Griffin Cabin Creek WWTP – TSS monthly avg. (mg/L): 30 TSS weekly avg. (mg/L): 45 • Springs Industries, Inc.- TSS monthly avg. (kg/day): 470 TSS weekly avg. (kg/day): 941	223.1 tons/yr	Implicit	480.3 tons/yr	51.1
Dissolved Oxygen 2002 TMDL Report	826 lbs/day	44 lbs/day	Implicit	767 lbs/day	18 (WLA) 0 (LA)

The TMDL is the total amount of pollutant that can be assimilated by the receiving water body while achieving water quality standards. A TMDL is comprised of the sum of individual waste load allocations (WLAs) for point sources, and load allocations (LAs) for both non-point sources and natural background levels for a given watershed. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relation between pollutant loads and the quality of the receiving water body.

Conceptually, this definition is denoted by the equation:

$$TMDL = \Sigma\ WLAs + \Sigma\ LAs + MOS$$

3.1.1 Chronic Toxicity

The Georgia EPD originally listed Cabin Creek for toxicity in 1992. Cabin Creek was listed for toxicity on the basis of the results of Whole Effluent Toxicity (WET) tests conducted on effluent from the City of Griffin's Cabin Creek Wastewater Treatment Plant (WWTP) and effluent from industrial wastewater discharged from Spring Industries, Inc. The I-75 South Mobile Homes near Jackson discharged up to 0.03 MGD to Cabin Creek, but there was no information at the time to indicate that its effluent had been tested for toxicity. The Georgia EPD conservatively assumed, as documented in its 2002 303(d) list, that urban runoff also contributed to the toxicity impairment. In addition, the Georgia EPD conservatively assumed that the toxicity impairment extended to the mouth of Cabin Creek (i.e., at its confluence with Towaliga). Allocations were established to ensure that the point sources did not discharge any level of toxicity and that waters originating from non-point sources did not exhibit any level of toxicity.

The No Observed Effect Concentration (NOEC) represents the highest tested concentration of an effluent at which no adverse effects are observed on the aquatic test organisms during a WET test. EPA's Technical Support Document For Water Quality-based Toxics Control (TSD) defines the Toxicity Unit (TUc) associated with an effluent discharge as being equal to 100 divided by the NOEC. For example, an effluent discharge with a NOEC of 50% reflects a TUc of 2.0. Considering that there may be toxicity associated with non-point sources in Cabin Creek, dilution of receiving waters is not considered in the allowable NOEC for the point sources. In addition, it is important to note that EPA's TSD suggests that the TUc associated with a stream that exhibits no toxicity before it receives any wastewater is equal to zero (i.e., TUc = 0). An allocation to an individual point source discharger does not automatically result in a permit limit or a monitoring requirement. Through its NPDES permitting process, Georgia EPD determines whether the individual dischargers have a reasonable potential of discharging chronically toxic effluent. The results of this reasonable potential analysis determines the specific type of requirement(s) for each of the facility's NPDES permits. As part of its analysis, the State's NPDES permitting group uses its most current EPA approved NPDES Reasonable Potential Procedures and Whole Effluent Toxicity Strategy to determine whether chronic WET monitoring requirements or limitations are necessary.

TMDL IMPLEMENTATION PLAN FOR CABIN CREEK –TOXICITY (2003)

Based on Georgia's NPDES permit Reasonable Potential Procedure, a whole effluent toxicity (WET) limit was not placed in the permit. Cabin Creek WWTP passed WET tests at NOEC = 100% in December 2001, April 2002, June 2002 and September 2002. WET at this level would be protective of the instream toxicity during 7Q10 low flow conditions.

The State's NPDES permitting group must use its most current EPA-approved NPDES Reasonable Potential Procedures and Whole Effluent Toxicity Strategy to determine whether chronic WET monitoring requirements or limitations are necessary.

3.1.2 Fecal Coliform

For fecal coliform bacteria, the TMDLs are expressed as counts per 30 days as a geometric mean. The process of developing fecal coliform TMDLs for the Ocmulgee River Basin listed segments included the determination of the following:

• The current critical fecal coliform load to the stream under existing conditions;

• The TMDL for similar conditions under which the current load was determined; and

• The percent reduction in the current critical fecal coliform load necessary to achieve the TMDL.

The calculation of the fecal coliform load at any point in a stream requires the fecal coliform concentration and stream flow. The Loading Curve Approach was used to determine the current fecal coliform load and the TMDL. For the listed segments, fecal coliform sampling data were sufficient to calculate at least one 30-day geometric mean to compare with the regulatory criteria. Cabin Creek was sampled 12 times in 2004. The geometric means calculated from this data ranged from 183 to 577 counts per 100 mL. In cases where no stream flow measurements were available, flow on the day the fecal coliform samples were collected was estimated using data from a nearby gaged stream (USGS Station 02213500). The nearby stream had relatively similar watershed characteristics, including land use, slope, and drainage area. The stream flows were estimated by multiplying the gaged flow by the ratio of the listed stream drainage area to the gaged stream drainage area.

INITIAL TMDL IMPLEMENTATION PLAN FECAL COLIFORM (2007)

The 2007 Initial TMDL Implementation Plan includes a list of BMPs and provides for an initial implementation demonstration project to address one of the major sources of pollutants identified in this TMDL while State and/or local agencies work with local stakeholders to develop a revised TMDL implementation plan. It also includes a process whereby GA EPD and/or Regional Development Centers (RDCs) or other GA EPD contractors will develop expanded plans.

3.1.3 Biota (sediment)

In 1998 and 1999, the Department of Natural Resources (DNR) Wildlife Resources Division (WRD) conducted studies of fish populations at a number of monitoring sites in the Ocmulgee River Basin. WRD used the Index of Biotic Integrity (IBI) and modified Index of Well-Being (IWB) to identify affected fish populations. The IBI and IWB values were used to classify the populations as Excellent, Good, Fair, Poor, or Very Poor. Stream segments with fish populations rated as Poor or Very Poor were listed as Biota Impacted. The Biota Impacted designation indicates that studies have shown a significant modification of the biological community. The TMDLs for these stream segments were completed in January 2002.

In each year between 1999 and 2003, the WRD conducted additional studies of fish populations in the Ocmulgee River Basin. Based on these studies, the 303(d) list has been revised accordingly. The general cause of low IBI scores is the lack of fish habitat due to stream sedimentation. To determine the relationship between the in-stream water quality and the source loadings, each watershed was modeled. The analysis performed to develop sediment TMDLs for the 303(d) listed watersheds utilized the Universal Soil Loss Equation (USLE). The USLE predicts the total annual soil loss caused by erosion. The USLE method considered the characteristics of the watershed including land use, soil type, ground slope, and road surface. NPDES permitted discharges were also considered. Modeling assumptions were considered conservative and provide the necessary implicit margin of safety for the TMDL.

A TMDL was initially completed for Cabin Creek in 2002 and revised in 2007.

INITIAL TMDL IMPLEMENTATION PLAN SEDIMENT (BIOTA IMPACTED) 2007

The 2007 Initial TMDL Implementation Plan includes a list of best management practices and provides for an initial implementation demonstration project to address one of the major sources of pollutants identified in this TMDL while State and/or local agencies work with local stakeholders to develop a revised TMDL implementation plan. It also includes a process whereby GA EPD and/or Regional Development Centers (RDCs) or other GA EPD contractors will develop expanded plans.

3.1.4 Dissolved Oxygen

U.S. Geological Survey (USGS) water quality data collected in 1999 identified Dissolved Oxygen (DO) impairments for Cabin Creek. A TMDL was established for Cabin Creek in 2002 based on this data. Cabin Creek was subsequently delisted for DO impairment based on more current data.

3.2 POLLUTANTS

The Cabin Creek Watershed Assessment evaluated data from the time that monitoring was initiated in 2002 through July of 2009. To better understand current conditions in the watershed, this Protection Plan takes a closer look at water quality data collected since 2005. Data from March 15, 2005 through June 22, 2010 is shown in the Water Quality Data table in Appendix B. Data for select parameters are summarized for sites CC1, CC9, and CC10 in the Data Summary table and in the box and whisker plots in Appendix B. This summary indicates the range of values and degree of dispersion in measurements for DO, TSS, FC, TP, and TN. A pollutant loading analysis was also done as part of this Protection Plan to identify which areas in the Cabin Creek Watershed are contributing the greatest annual sediment and nutrient loads. The analysis was done by hand-calculation using the City of Griffin's quarterly monitoring data from 2005 through 2009. Constituents examined include TSS, TP, ammonia, nitrate, nitrite, and TN. Subwatersheds are defined by the drainage area of each monitoring station and are referred to by the monitoring station site IDs. For example, the land that drains to station CC1 is named subwatershed CC1. Monitoring station CC1 is downstream of station CC10; therefore, subwatershed CC1 includes subwatershed CC10. For each constituent, there is a chart that depicts pollutant loading in lbs/yr, a chart that depicts pollutant loading in lbs/ac/yr, and a chart that depicts the 5-year mean and median pollutant loads by total subwatershed area and per acre. These charts are included in Appendix B. This analysis of recent data, in combination with the information presented in the Watershed Assessment, provides a comprehensive description of pollutants in the Cabin Creek Watershed.

Since 2005, water temperature measurements have all been below the state maximum standard of 90° F (32°C). DO concentrations have also been within state standards, with no individual measurements below 4.0 mg/L. State water quality standards have been violated based on biota, pH, and fecal coliform. The following discussion indicates occurrences, since 2005, when the standards were not met:

> **Biota—**Impaired biota is indicated by a "Very Poor" IBI (Index of Biological Integrity) score for fish at the single fish monitoring station, CC1, in 2005 and 2008, and by a "Poor" IBI score at monitoring station CC0 in 2010. Monitoring station CC0 replaced monitoring station CC1 in August 2009.
>
> **pH**—State standards for pH were violated based on individual measurements greater than 8.5 at station CC10:
>
> > CC10: 11-13-06 (8.63), 6-13-07 (8.62), 8-7-07 (8.55), and 11-15-07 (8.65).
>
> **Fecal Coliform—**State standards for fecal coliform were violated based on an individual measurement greater than 4,000 colonies/100 mL during winter months:
>
> > CC1: 12-10-08 (6,000/100 mL).
>
> Prior to 2010, fecal coliform was not sampled in such a way that the geometric mean could be calculated according to Georgia EPD methodology. Beginning in fiscal year 2010-2011, the City will be sampling fecal coliform between May and October in order to determine the geometric mean of fecal indicator bacteria in the watershed.

These above findings support the current status of Cabin Creek on the EPA's 303(d) list of impaired streams that do not meet their designated uses. Of the three criteria listed for impairment—biota, fecal coliform, and toxicity—water quality testing by the City of Griffin confirms that State water quality standards are being violated in the areas of biota and fecal coliform. Once hardness data is collected in this watershed, the dissolved fractions of copper and zinc can be calculated to determine whether or not state toxicity standards are being violated. Copper and zinc were noted as a potential concern in the Watershed Assessment, as they were detected throughout the watershed.

Sediment is a concern due to the listing of Cabin Creek for biota impairment due to sediment. The Erosion Activity Assessment indicates that the greatest stream bank erosion and sedimentation of the channel bed are downstream of the WWTP and outside of city limits; however, there are erosion hot spots and sediment impacts within the City. TSS concentrations spike on occasion, which are generally associated with heavy rain events. The TSS box and whisker plot indicates how much greater the maximum values are than the 75th percentiles, particularly at stations CC1 and CC10. These two subwatersheds also have relatively high TSS loads compared to subwatershed CC9. Median TSS loads for the 2005 to 2009 time period range from 6.22 lb/ac/yr (CC9) to 26.24 lb/ac/yr (CC1). Average turbidity values are within the benchmark range at all three stations.

Fecal coliform is a particular concern since Cabin Creek is listed for fecal coliform impairment. As with TSS, fecal coliform counts spike on occasion. High fecal coliform levels are also associated with rain events, which wash the bacteria into the stream. Median fecal coliform counts since 2005 are shown in the Data Summary table in Appendix B and range from 400 colonies/100 mL (CC1) to 695 colonies/100 mL (CC9). Some individual measurements are extremely high, as shown by the maximum values indicated on the Data Summary table and on the Fecal Coliform box and whisker plot in Appendix B. Elevated fecal coliform levels are a concern throughout the Cabin Creek Watershed.

The Watershed Assessment noted a concern with consistently high specific conductivity and salinity for sample sites downstream of Springs Industries. Average conductivity and salinity values at these stations were remarkably higher than at other stations throughout the watershed. Although salinity has not been measured since Springs Industries closed in February of 2009, conductivity levels have dropped significantly. While the industry was in operation, conductivity at downstream monitoring stations was typically in the range of 2000-4000 μS/cm; since the industry closed, all measurements have been under 500 μS/cm. This signifies a major improvement in the condition of the Cabin Creek Watershed.

The Watershed Assessment also noted a concern with consistently elevated nutrient levels for sample sites downstream of Springs Industries. The closing of Springs Industries might have alleviated nutrient stressors to some degree, but nutrients are still a concern in the watershed. The 2005 to 2010 Data Summary shows that median TP concentrations range from 0.07 mg/L (CC9) to 0.21 mg/L (CC10). Average TP concentrations exceed the lower bound benchmark for Cabin Creek (0.06 mg/L) at all stations and exceed the upper bound benchmark (0.23 mg/L) at the CC1 and CC10 monitoring stations. Individual TP values continue to exceed the upper bound benchmark at the CC10 and CC0 stations, even after Springs Industries closed.

Median TN values range from 2.2 mg/L (CC9) to 7.6 mg/L (CC1). Average TN concentrations exceed the upper bound benchmark (1.3 mg/L) at all stations. Individual TN values continue to exceed the upper bound benchmark at all stations, even after Springs Industries closed. Average TKN concentrations exceed the upper bound benchmark (1.3 mg/L) at the CC1 and CC10 monitoring stations. Average ammonia concentrations exceed the upper bound benchmark (1.0 mg/L) at monitoring station CC1. The pollutant loading analysis shows very high ammonia loads at the CC1 monitoring station from 2005 through 2010, with a 5-year median value of 3.5 lb/ac/yr. In comparison, the 5-year median ammonia load is 0.12 lb/ac/yr at station CC9 and 0.53 lb/ac/yr at station CC10.

3.3 SOURCES

The now closed Springs Industries stands out as being a likely source for many of the pollutants detected in the watershed. It is upstream of sites CC1, CC4, CC7, and CC10, where many of the water quality impairments were most pronounced, as detailed in the Watershed Assessment. High conductivity and salinity downstream of the industry were likely limiting the biota. There is also a strong possitve correlation between total copper and conductivity in the Cabin Creek Watershed.Therefore, it is belived that Springs Industries was the source of much of the copper. Now that this point source of pollution is closed, conditions should be favorable for more pollution-sensitive aquatic organisms.

The Griffin WWTP might be contributing nitrogen in the form of nitrate and ammonia, as the highest concentrations of these nutrients were typically seen at site CC1, just downstream of the Plant.

Nonpoint source pollution is likely responsible for the high levels of fecal coliform, elevated nutrient levels, high sediment loads, and the presence of zinc and copper. Fecal coliform appears to be a ubiquitous problem throughout the watershed. Given the high percent of residential land that drains into Cabin Creek, pet waste is certainly contributing to this problem, and could potentially be the primary source of fecal coliform bacteria in the Cabin Creek Watershed. Leaky sewer lines are another potential source of fecal coliform bacteria.

Sediment is likely originating from the areas of high stream bank erosion activity, as well as from various upland land uses. Zinc, which is often detected in urban streams, is likely originating from roadways through the use of automobiles. Some amount of copper may also be coming from automobiles.

4 Current Watershed Protection Measures

4.1 CODES AND REGULATIONS

4.1.1 City of Griffin Ordinances

4.1.1.1 Stormwater Management Ordinance

The City of Griffin developed its first stormwater ordinance in January 1997 that established a dedicated funding source for the City to use to meet its future stormwater management program operational and capital investment needs. In other words, the utility would be used to effectively manage, protect, control, regulate, use, and enhance stormwater systems and facilities in Griffin in concert with the management of other water resources. The ordinance states that all property owners and developers of real property within the City shall provide, manage, maintain, and operate on-site stormwater systems sufficient to collect, convey, detain, and discharge stormwater in a safe manner consistent with all City of Griffin development regulations, and the laws of the State of Georgia and the United States. Any failure to meet this obligation shall constitute a nuisance and be subject to an abatement action filed by the City in the Municipal Court.

After the first stormwater ordinance was adopted, the City conducted a cost of services analysis and rate study to identify an equitable approach to funding stormwater management services and facilities. The resulting schedule of service charges was established in the second stormwater ordinance, which was issued in August 1997. That ordinance called for utility fees based on burden of stormwater quality control service requirements and costs posed by various properties throughout the City. Also identified in that ordinance was a provision for stormwater utility service charge credits (see next section), specification on how the stormwater service charge bills would be delivered and collected, and establishment of an effective date when the utility would go into effect.

A third stormwater management ordinance was issued in 1999. That ordinance was revised to meet new state regulations that required restating the legal structure and organization of the stormwater utility as a dedicated enterprise fund of the City. The 1999 ordinance authorized the formation of an organizational and accounting entity dedicated specifically to the management, maintenance, protection, control, regulation, use, and enhancement of stormwater systems in Griffin. The utility would operate under the direction of a Stormwater Utilities Director appointed by the City Manager. The ordinance also redefined the stormwater management problems, needs, goals, program priorities, and funding opportunities of the City. The 1999 ordinance is structured so that credit is given to property owners that are reducing the impact of stormwater generated by their property. By reducing the peak discharge of stormwater from their property, the owners are helping the City protect properties downstream. All properties, other than single family residential properties, which have constructed stormwater retention or detention facilities and maintain them in accordance with City defined standards (see below), may be eligible for a percentage reduction, or credit, in that property's stormwater service fee. The credit shall only be applied to that portion of the property served by the detention basin. To receive any credit towards their stormwater service fee, the property owner must insure the following:

1) That the facility meets design, construction, and maintenance standards in effect at the time of construction (see City of Griffin Detention/Retention Facility Inspection Checklist);
2) A complete Credit Application Form sealed by a professional engineer licensed to practice in Georgia has been submitted; and
3) A signed Right-of-Entry has been provided to the City by the owner. Additional information on this program, including a Credit Application Form, can be found at www.cityofgriffin.com. If all

requirements and conditions are met, the credit will be available upon successful completion of an application process and successful completion of a City inspection. The credit shall remain in force as long as the facility is maintained in satisfactory condition.

The current stormwater management ordinance also includes post-development regulations, which were added to the ordinance in 2007. The ordinance requires developers to prepare a stormwater management plan and specifies stormwater management plan requirements. It also addresses post-development stormwater runoff quality and quantity impacts by requiring the use of BMPs (structural and non-structural) to achieve technical performance criteria. The ordinance itself establishes the major requirements, while the Stormwater Design Manual outlines the more detailed requirements, including design specifications. Note that while the City does not require that a developer use non-structural practices, a developer can reduce the required water quality treatment volume by using the following BMPs:

- Natural area conservation
- Stream buffers
- Vegetated channels
- Overland flow filtration/infiltration zones
- Environmentally sensitive large lot subdivisions

The above practices are defined in the City's Stormwater Design Manual. The City of Griffin encourages the use of LID practices and provides guidelines for the application of LID, including site analysis methods, hydrology considerations, and maintenance needs.

4.1.1.2 Development Ordinance

The City of Griffin adopted a development ordinance in January 2002 to regulate new development so that it meets the orderly, efficient, and economic goals and requirements set forth in the City's Comprehensive Plan. The ordinance requires the review and approval of individual site plans by the City of Griffin Department of Development Services to ensure that the minimum requirements of the Zoning Ordinance, state laws, and other regulations are met, and that public improvements are constructed to the appropriate standards. In addition, adequate provision must be made for open space and recreation, landscaping, roads, drainage, water supply, and sewer capacity, as well as to ensure public health protection from fires or floods.

4.1.1.3 Tree Preservation Ordinance

The City of Griffin has a diversity and abundance of trees and shrubs on public and private lands and hold that these natural resources provide an economic and aesthetic value to the city. Trees increase property values, can positively affect an area economically, and beautify the landscape. Furthermore, certain city streets have historically constituted significant and attractive tree-lined corridors, which have contributed to a realization of increased property values and general improvement of corresponding neighborhoods.

Griffin has instituted a tree preservation ordinance, revised in March 2002, designed to protect the existing urban forest by regulating and controlling the planting, conservation, and replacement of trees and shrubbery on public lands within the City. The ordinance requires that any person planning to remove, destroy, cut, spray, prune, or plant any tree or shrub on public lands, must obtain written permission from the Director of Public Works, or their designee, before commencing work. Failure to do so may result in significant penalties and/or restitution as ordered by the municipal court. In addition, the ordinance created the position of City Arborist who is responsible for the proper planting, removal, care, and maintenance of trees and shrubs growing on City-owned property or City-controlled right-of-way in accordance with the City of Griffin Tree Ordinance and Administrative Guidelines. The City Arborist also serves as staff to the Tree Board, which is comprised of senior representatives from various local departments. The Tree Board is tasked with a number of activities, including approving the removal and/or pruning of trees planted on public lands and the removal and/or pruning of trees on private property, to the extent such activities are regulated by the City ordinances and regulations.

4.1.1.4 Soil Erosion and Sediment Control Ordinance

The soil erosion and sediment control ordinance, updated in January 2010, regulates land-disturbing activities such as clearing, grading, excavating, or filling of land. The City of Griffin soil erosion and sediment control ordinance includes the following provisions:

- Approved plans for those land-disturbing activities that are not exempted shall be prepared before the land-disturbing activity takes place.
- The minimum requirements established by the ordinance and the state general permit shall be incorporated into the erosion, sedimentation, and pollution control plan.
- BMPs shall be required for all land-disturbing activities, including those for which a permit and/or approved plan is not required.
- A discharge of stormwater runoff from disturbed areas where BMPs have not been properly designed, installed, and maintained shall constitute a violation for each day on which such discharge results in the turbidity of receiving waters being increased by more than 25 NTU for waters supporting warm water fisheries or by more than 10 NTU for waters classified as trout streams.
- Every person shall be required, at a minimum, to follow protections at least as stringent as the state general permit and BMPs, including sound conservation and engineering practices to prevent and minimize erosion and resultant sedimentation, which are consistent with, and no less stringent than, those practices contained in the *Manual for Erosion and Sediment Control in Georgia*, as well as the additional minimum requirements specified in section 42-63 of the ordinance.
- Establishes a 25-foot buffer along the banks of all state waters. Land disturbing activity is prohibited within this buffer unless otherwise exempted under the ordinance.
- The following activities are exempt from the City of Griffin soil erosion and sediment control ordinance: surface mining, granite quarrying, minor-land disturbing activities, single-family residences, agricultural operations, forestry land management practices including harvesting, Natural Resource Conservation Service projects, projects less than one acre, public works projects, electrical system projects, and any public water system reservoirs.
- The local issuing authority shall require the posting of a performance bond, cash, irrevocable letter of credit, or any combination thereof up to, but not exceeding, $3,000 per acre or fraction thereof of the proposed land-disturbing activity.
- Penalties for violations include stop work orders, fines, and bond forfeitures.

NPDES General Permits No. GAR10001, No. GAR10002, and No. GAR10003 authorize storm water discharges to the waters of the State of Georgia from construction activities and regulate construction activities that disturb one or more acres.

4.1.1.5 Illicit Discharges and Connections Ordinance

The illicit discharges and connections ordinance regulates nonstormwater discharges to the municipal separate storm sewer system (MS4). The ordinance was updated in 2007 to give the City the authority and enforcement power to eliminate illicit discharges. As part of its illicit discharge detection and elimination program under the MS4 permit, the City is inspecting 20 percent of its storm sewer system outfalls per year for illicit discharges. The program also includes outreach to businesses, citizen reporting methods, volunteer curb marker placement, the inspection of road culvert pipes, and the inspection of wastewater treatment and industrial sites for compliance with stormwater pollution prevention plans (SWPPPs).

4.1.1.6 Floods

The City's floods ordinance was updated in December 2009. The purpose of this ordinance is to protect, maintain, and enhance the public health, safety, environment, and general welfare, as well as to minimize public and private losses due to flood conditions in flood hazard areas. The ordinance protects the beneficial uses of floodplain areas for water quality protection, streambank and stream corridor protection, wetlands preservation, and ecological and environmental protection through provisions designed to:

- Require that uses vulnerable to floods, including facilities that serve such uses, be protected against flood damage at the time of initial construction;
- Restrict or prohibit uses which are dangerous to life, health, and safety due to flooding or erosion hazards, or which increase flood heights, velocities, or erosion;
- Control filling, grading, dredging and other development activities that might increase flood damage or erosion;
- Prevent or regulate the construction of flood barriers that will unnaturally divert floodwaters or that might increase flood hazards to other lands;
- Limit the alteration of natural floodplains, stream channels, and natural protective barriers that are involved in the accommodation of floodwaters; and
- Protect the stormwater management, water quality, streambank protection, stream corridor protection, wetland preservation, and ecological functions of natural floodplain areas.

The City has been conducting surveys and modeling to develop floodplain delineations and base flood elevations (BFEs). New Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRMs) based on the City's floodplain mapping efforts were released in May 2010.

4.1.1.7 Litter Ordinance

The City's litter ordinance, last updated in 2002, provides for the public health, safety, and general welfare through the regulation and control of litter. The City's MS4 permit also contains a provision to control discarded building materials, concrete truck washout, chemicals, and other illegal dumping on both private and public property during construction site inspections. The City of Griffin also conducts annual volunteer stream cleanups citywide. The most recent clean-up in 2011 removed 7,480 pounds of litter and debris from city streams.

4.1.2 Spalding County Ordinances

4.1.2.1 Illicit Discharge and Connection Stormwater Ordinance

The Spalding County illicit discharge and connection stormwater ordinance provides for the health, safety, and general welfare of the citizens of Spalding County through the regulation of non-stormwater discharges to the storm drainage system. The objectives of this ordinance are to:

- Regulate the contribution of pollutants to the county separate storm sewer system (MS4) by stormwater discharges by any user,
- Prohibit illicit connections and discharges to the county MS4s, and
- Establish legal authority to carry out all inspection, surveillance, and monitoring procedures necessary to ensure compliance with the ordinance.

4.1.2.2 Soil Erosion and Sedimentation Control Ordinance

The Spalding County soil erosion and sedimentation control ordinance regulates land disturbing activities and includes the following provisions:

- The following activities are exempt from the Spalding County soil erosion and sediment control ordinance: surface mining, granite quarrying, minor-land disturbing activities, single-family residences, agricultural operations, forestry land management practices including harvesting, Natural Resource Conservation Service projects, projects less than one acre, public works projects, electrical system projects, and any public water system reservoirs.
- Requires that plans for those land-disturbing activities, which are not exempted by this ordinance, shall contain provisions for application of soil erosion and sedimentation control measures and practices. The provisions shall be incorporated into the erosion and sedimentation control plans.
- BMPs shall be required for all land-disturbing activities.
- A discharge of stormwater runoff from disturbed areas where BMPs have not been properly designed, installed, and maintained shall constitute a separate violation for each day on which such discharge results in the turbidity of receiving waters being increased by more than 25 NTUs for waters supporting warm water fisheries or by more than 10 NTUs for waters classified as trout streams.
- Every person shall be required, at a minimum, to follow protections at least as stringent as the state general permit and best management practices, including sound conservation and engineering practices to prevent and minimize erosion and resultant sedimentation, which are consistent with, and no less stringent than, those practices contained in the *Manual for Erosion and Sediment Control in Georgia*, as well as the additional minimum requirements specified in section 104 of the ordinance.
- Establishes a 25-foot buffer along the banks of all state waters. Land disturbing activity is prohibited within this buffer unless otherwise exempt under the ordinance.
- Establishes a 50-foot buffer along the banks of all state waters classified as trout streams. Land disturbing activity is prohibited within this buffer unless otherwise exempt under the ordinance.
- The local issuing authority may require the posting of a performance bond, cash, irrevocable letter of credit, or any combination thereof up to, but not exceeding, $3,000 per acre or fraction thereof of the proposed land-disturbing activity.
- Penalties for violations include stop work order, fines, and bond forfeitures.

4.2 BEST MANAGEMENT PRACTICES

The City of Griffin is proactive in its implementation and maintenance of stormwater BMPs. The City's Stormwater Division prides itself on going above and beyond what is expected, continually developing innovative programs and pushing forward with numerous measures aimed at protecting the City's waters from pollutants, and educating its citizens about stormwater issues. The Stormwater Division posts Annual Reports on its website:
http://www.cityofgriffin.com/Departments/PublicWorks/Stormwater/Education.aspx

Griffin's BMP commitments are described in detail in the City's MS4 permit Notice of Intent (NOI), included as Appendix C, and summarized in Table 4-2, below. This includes an ambitious list of structural and non-structural measures that the City is using to maintain and improve stormwater infrastructure, and water quality in the City's streams.

As an education and outreach measure, the City hosts an annual Erosion & Sedimentation and Stormwater Quality Workshop in October. This has grown into a very large event that includes multiple presentations, vendors, and BMP demonstrations. The event is attended by representatives from federal, state, and local government, as well as private firms. With over 200 participants in 2010, the Workshop has become a significant forum for the discussion of stormwater issues and the demonstration of structural BMP measures that are available for use in the region.

The City of Griffin maintains records of pollutant reductions achieved through non-structural BMPs. Below are recent data on street sweeping and stream clean-up efforts:

- **Street sweeper data (June 2008 to October 2009):**

  The City removed an average of 66 tons of debris from 227 miles of streets per month for a yearly total of 792 tons removed from 2,725 miles of streets.

- **Steam clean-up data (2006 to 2011):**

  The data in Table 4-1 includes all efforts in the City of Griffin. In the Cabin Creek Watershed, stream cleanings occurred in 2008, 2009, 2010, and 2011.

Table 4-1 Stream Clean-up Data

Year	Pounds Removed		
	Garbage	Recyclable Metals	Tires
2006	800	Not measured	440
2007	2,800	820	400
2008	2,180	200	1,000
2009	3,000	460	1,000
2010	4,100	380	400
2011	7,480	220	1,100

In addition to the BMP commitments described in the MS4 NOI, the City has implemented additional BMPs related to sewage management, flood control and stormwater management, and public education and outreach. Table 4-2 summarizes the current watershed protection measures for the Cabin Creek Watershed. Measures are organized by codes and regulations, MS4 permit NOI commitments, and additional BMPs.

Table 4-2 Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
CODES AND REGULATIONS	
City of Griffin ordinances	
Stormwater utility ordinance	Establishes a stormwater utility; requires developers to prepare a stormwater management plan and specifies stormwater management plan requirements; addresses post-development stormwater runoff quality and quantity impacts by requiring the use of BMPs
Development ordinance	Regulates new development
Tree preservation ordinance	Protects the existing urban forest by regulating and controlling the planting, conservation, and replacement of trees and shrubbery on public lands within the City
Soil erosion and sedimentation control ordinance	Regulates land-disturbing activities such as clearing, grading, excavating, or filling of land
Illicit discharges and connections ordinance	Regulates nonstormwater discharges to the municipal separate storm sewer system.
Floods ordinance	Protects, maintains, and enhances public health, safety, environment, and general welfare; minimizes public and private losses due to flood conditions in flood hazard areas; protects the beneficial uses of floodplain areas for water quality protection, streambank and stream corridor protection, wetlands preservation and ecological and environmental protection
Litter ordinance	Provides for public health, safety, and general welfare through the regulation and control of litter
Spalding County ordinances	
Illicit discharge and connection ordinance	Regulates non-stormwater discharges to the county separate storm sewer system
Soil erosion and sedimentation control ordinance	Regulates land disturbing activities

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
MS4 NOTICE OF INTENT (NOI) COMMITMENTS	
Public education and outreach on stormwater impacts	
1. Presentation of stormwater projects at commission meetings	Presented once a year
2A. Water sourcebook program	An ongoing WaterWise program
2B. Water education poster	Distributed annually to elementary schools
2C. Classroom education	Stormwater Division staff educates school and civic association children on stormwater, water quality, soil, erosion and sedimentation, and on fats, oils, and grease (FOG) issues
2D. Career day activities	Stormwater Division staff participate in at least one Career Day annually
3. Web site	Maintained regularly (www.cityofgriffin.com)
4. Flyers	Distributed in utility bills annually
5. Annual reports	Published on website and in local newspaper each year
6. Brochures and bookmarks	Distributed at public buildings, events, and festivals
7. Large display stand	Periodically updated with new material and moved to a new public location
8. Ecomasters CD	500 copies distributed annually to 3rd and 4th graders
9. BMP training site and annual training	The City hosts an annual Erosion & Sedimentation Control and Stormwater Quality Workshop each October that includes multiple speakers, vendors, and demonstrations
10. Annual stormwater workshop	A workshop is held each year on different stormwater issues. The workshop is open to the general public, commercial and industrial customers of the City.
Public participation and involvement	

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
1. Curb marker program	500 markers are installed each year
2. Development of Watershed Advisory Council	Council meetings are held quarterly
3. Consumer satisfaction surveys	Mailed every other year
4. Stream/Lake clean-up event	City of Griffin Stormwater Division hosts an annual stream clean-up event.
<u>Illicit discharge detection and elimination</u>	
1. Brochure mailings to restaurants and businesses	At least 100 brochures mailed each year
2. Citizen complaints/reporting of problems	Available through website and Environmental Hotline
3. Storm sewer outfall inspection	20% of City outfalls are inspected each year and the City attempts to identify and eliminate any free flowing illicit discharges.
4. Curb Marker Program	500 markers are installed each year
5. Inspection of road culvert pipes	Level 1&2 culverts inspected annually, level 3 semi-annually, and level 4 quarterly
6. SWPPP site inspections	Quarterly visual Inspections and annual site inspections at the five sites owned by the City
<u>Construction site stormwater runoff control</u>	
1. Enforcement of litter ordinance	During site inspections
2. Review of erosion control plans	Ongoing for development that disturbs >1 acre of land
3. BMP inspection at construction sites	Ongoing
4. Citizen complaints/reporting of problems	Available through website and Environmental Hotline
5. Pre-construction meetings	Prior to issuance of land disturbing permits for commercial projects
6. BMP training site and annual training	The City hosts an annual Erosion & Sedimentation Control and Stormwater Quality Workshop each October that includes multiple speakers, vendors, and demonstrations

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
Post construction stormwater management in new development and redevelopment	
1. Inspection of ponds and stormwater facilities	Inspected annually, and deficiencies are corrected
2. Structural BMP evaluation	A structural BMP is evaluated annually
3. Loading Simulation Program C++ (LSPC) model distribution	Annual distribution to Planning Department
Pollution prevention/good housekeeping for municipal operations	
1. Street sweeping	The City sweeps a minimum of 700 miles of street every year
2. Vacuum and jet out storm drains	The City cleans a minimum of 2,500 storm drains and jets 10,000 feet of storm drain each year
3. Training program for city workers	Annual training for all Pubic Works departments
4. Review of flood control capital improvement projects	Every new project is evaluated for BMP opportunities
4A. Retrofit of existing structures	Review of one existing project each year
5. Use of City pollution prevention plans	Quarterly visual Inspections and annual site inspections at the five sites owned by the City
6. Maintain a system of benchmarks	All 85 benchmarks are inspected and maintained annually; an inventory is maintained on the website
7. Paperless tracking of storm system operation and maintenance (O&M)	Storm system O&M activities are tracked using CityWorks
8. Tree inventory	Tree planting and removal is tracked through CityWorks
9. Basin assessment	One basin will be assessed each year for potential stormwater quality ponds

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
ADDITIONAL BMPS	
Sewage management	
Sewage collection and treatment system	The City of Griffin maintains an extensive sewage collection and treatment system. The City has a preventative maintenance program for the collection system that includes the use of sewer jets and vacuum trucks and clearing of rights-of-way. Crews TV the lines on a regular basis to check for cracks or breaks. Responses to manhole overflows, broken sewer lines, and clogged lines include cleaning of the line and using hay and lime for absorption and odor control after a spill.
Flood control and stormwater management	
GIS mapping/inventory collection	The City of Griffin has compiled a Geographic Information System (GIS) database inventory of all stormwater drainage structures/features (both natural and manmade attributes) within the City limits; this database continues to be updated/maintained
Stormwater Design Manual	The City Stormwater Design Manual addresses the need to control and minimize the impacts of urban development and stormwater runoff on the environment. It is available on the Stormwater Division website: http://www.cityofgriffin.com/Departments/PublicWorks/Stormwater.aspx
Floodplain mapping	The City of Griffin mapped the urbanized 100-Year floodplain within all its major streams. This floodplain has been incorporated as Zone A in FEMA FIRMs.
Impervious surface limitations	Impervious surface limitations have been incorporated into zoning regulations of the City's Municipal Code
Public education and outreach programs	
Road signage program	In 2000, the City posted signs at named tributary crossings identifying the name of the creek to promote public awareness and understanding of the need to protect the City's water resources
"Only Rain in the Drain" – illicit discharge video	Distributed at events and available on the Public Works and utilities website
Recycling program	The Solid Waste Division has a recycling program that includes curbside recycling pick up, and provides recycling containers to schools to encourage environmental stewardship

Table 4-2 cont'd Summary of Current Watershed Protection Measures

Best Management Practice (BMP)	Comments
Classroom education	Spalding County has established a learning trail and outdoor classroom. A Watershed Assistant has been provided for the Griffin/Spalding school system (funded jointly by the City, County, and University of Georgia Extension Office). The Watershed Assistant presents watershed, water quality, water conservation, and stormwater issues to the 4H Cloverleaf students, which includes all 5th grade students in the Griffin-Spalding County School System, private schools within the County, and home school groups. EnviroScape nonpoint source models are used by the City of Griffin to teach students how water can become polluted, as well as the affect their actions can have on water quality.

5 Watershed Projects and Research

5.1 PARAGON SUB-BASIN STUDY

Paragon Consulting Group, Inc. has conducted a sub-basin study on the Cabin Creek Watershed to identify potential measures for improving water quality in the watershed. Within the limits of the City of Griffin, 40 basins in the Cabin Creek watershed were characterized based on information derived from field visits. The dominant land use was noted, current drainage features were described, and recommendations were made on what type of treatment measures, if any, could be implemented in each basin. The treatment options considered for this project include new stormwater detention ponds, retrofits to existing detention ponds, and proprietary BMP devices capable of treating 8 to 10 acres (such as the Stormceptor STC 11000). Existing outfall structures were identified in the study area and the drainage basins were divided into 196 sub-basins, sized approximately 8 to 10 acres such that each sub-basin could potentially be treated by 1 BMP device. Each sub-basin was assessed to identify if treatment was already included as part of the existing stormwater management system. In addition, each sub-basin was field assessed to identify if it was a candidate for structural BMP retrofit (available space for BMP). Sub-basins for which treatment was already in place and for which no space for BMP retrofit was available were removed from further consideration. The project identified 57 locations that may be suitable for proprietary BMPs, 23 locations where new ponds could be built, and 4 locations where existing ponds could be modified/retrofit.

5.2 2004 AND 2008 GEOMORPHOLOGY STUDIES

The City performed geomorphology studies in the Cabin Creek Watershed in 2004 and 2008. These assessments, conducted by Tetra Tech, included written characterizations of the streams, maps illustrating assessment results in terms of channel erosion activity, and photographs of assessment sites. The 2004 study, *Source Assessment and Data Analysis for the Cabin Creek Watershed* (Tetra Tech, 2005), focused on stream reaches where DO monitoring was being conducted. In the conclusions of that study, it was noted that the greatest impacts from upland sediment erosion will occur during the brief periods during development when bare soils are exposed to rainsplash and overland flow erosion and transport mechanisms.

In the 2008 study, a total of 390 sites were assessed, from the headwaters of Cabin Creek to State Highway 16. The assessment was performed by a fluvial geomorphologist walking either on the stream bed or along the stream bank while conducting Rapid Geomorphic Assessments (RGAs). Impacts from urban, upland, and natural activities were described for each site, as well as suspected sediment source hots pots and other potential influences on the stream channels. The 2008 Cabin Creek Geomorphic Assessment, titled *Stream Channel Erosion Activity Assessment of the Cabin Creek Watershed,* is included as Appendix C of the Cabin Creek Watershed Assessment.

The 2008 Geomorphic Assessment attributes impacts in the Cabin Creek watershed to many sources, citing beaver , channelization, large woody debris, urban, and upland impacts. The assessment describes the overall state of streams in the watershed and identifies regions of low, moderate, and severe erosion. The assessment determined that the most severe stream bank erosion is occurring regularly along the main stem of Cabin Creek over the 8 miles of stream below the WWTP to the furthest downstream assessment point at State Highway 16. The unstable and eroding portions of these 8 miles are very likely the dominant sediment source to Cabin Creek. The significant erosion processes in the main stem of Cabin Creek include mass wasting of excessively steepened banks and bank scour—particularly around large, woody debris jams.

Within the Griffin City limits, the total length of stream reaches assessed to be at moderate and high channel erosion activity levels were much less than along the main stem of Cabin Creek. These reaches are probably a secondary contributor to the total sediment load of Cabin Creek. However, many of the moderate and high erosion activity reaches within the city limits were impacting infrastructure at the time of the assessment, or had the potential to impact infrastructure in the future. The assessment noted that typical causes of erosion include mass wasting due to excessively high and over-steepened banks, scour around large trash jams, increased bank retreat rates, and gully formation where woody vegetation has been cleared from the bank faces and bank tops.

5.3 HYDROLOGY AND WATER QUALITY MODELING

In March 2008, Tetra Tech updated the *Watershed Hydrology and Water Quality Report for the City of Griffin Watersheds*. The Watershed Hydrology Modeling Report presents the results for the model calibration and validation of the Cabin Creek (HUC8 No. 03070103, Upper Ocmulgee), Shoal Creek, Potato Creek, Heads Creek, and Honeybee Creek (HUC8 No. 03130005, Upper Flint) Watersheds. The Water Quality Report presents the results of the preliminary water quality calibration and validation of the same watersheds. The Loading Simulation Program C++ (LSPC) watershed model was used to represent the hydrological conditions. The model is capable of representing loading, both flow and water quality, from nonpoint and point sources. It was used to represent the variability of nonpoint source contributions through dynamic representation of hydrology and land practices. The model included all point and nonpoint source contributions.

In 2010, Tetra Tech amended the LSPC watershed model to include data through the December 2009. This model is for the entire City of Griffin. The 2010 Watershed Hydrology and Water Quality Modeling Report is included in Appendix D.

Improvements in 2010 include the addition of monitored water quality data and U.S. Geologic Survey (USGS) flow records through December 2009. With this additional data, the model simulation time was extended, thereby improving the diversity of precipitation and response conditions for the modeled watersheds. In addition, the 2008 model represented water quality loading through accumulation and wash-off rates only. In this release, the water quality loading simulations were improved through the inclusion of biochemical processes.

Overall, the 2010 model hydrology calibration looks reasonable. However, in 2005 there was a large storm event in July followed by several smaller storms that caused a slightly elevated recession in the simulated results. The large storms in July and August followed by a period of dry weather in September and the first part of October 2005 appear to be causing a slight over prediction of the simulated flow. In 2006, there is good agreement between the simulated and observed flow. The only exception is for a few storm flows observed in the measured data in September that are not seen in the precipitation data, and are underestimated in the simulated flows. In 2007 there was a significant deficit in rainfall. As such, the simulations are reasonably good, but are slightly low for that year. In general, simulated flows during 2007 and a portion of 2008 follow the observed pattern and are within an acceptable margin of error given that much of the year flows were less than 5 cubic feet per second (cfs) and commonly drop to as low as 1 cfs. The 2009 simulations have good agreement.

At each of the calibration stations, the total volume error for the 6-year simulation was less than 10 percent. Similarly, the seasonal volumes for each of the gages were all less than 30 percent. The metric for both gages that was most difficult to calibrate was the error in 50 percent lowest flows. This problem is not uncommon when low flow conditions drop below 10 cfs. For the calibration stations, the flow is frequently less than 10 cfs and further exasperated by the drought conditions of 2006, 2007, and parts of 2008. During these extended dry periods, the observed flow could often drop to a range as low as 3 to 1 cfs, thereby causing large percentage variations detected in the low flow calibration metrics.

Like the hydrology calibration, the water quality calibration appears to be reasonable at the four water quality stations used for calibration (WQ-1 and WQ-28) and validation (WQ-15 and WQ-3). Water temperature simulation at each of the calibration and validation locations is very good. However, for isolated winter dates in 2007 and 2008, the temperature drops to 0°C. The reason for the the simulated temperature drop in these isolated instances is because the simulated water depth is < 2 inches. When the simulated water depth drops below 2 inches, the model applies the ambient air temperature as the water temperature. Overall, the water temperature simulation shows the seasonal trends well at all of the water quality stations.

DO is simulated well at three of the four water quality stations. The one exception is station WQ-15, which is at a location downstream of the point sources (Springs Industries and the Cabin Creek WWTP) in the Cabin Creek Watershed. At WQ-15, the DO simulation is high from 2003 to 2008. Investigations into the high simulation suggest that one or both of the point source inputs are influencing the less than ideal DO response. Much like the temperature calibration, the DO simulation shows the seasonal trends well at all of the water quality stations.

BOD is simulated fairly well at each of the stations, but with notable caveats. At station WQ-15, the simulation misses several of the peak observed concentrations. This station is downstream of the point sources and the peak concentrations might be an artifact of the point source discharges. At water quality stations WQ-1 and WQ-3, the simulation appears to be slightly elevated. At these stations, the simulation is hovering around the detection limit data sets. At WQ-28, the simulated BOD concentrations are slightly less than the simulated concentrations at WQ-1 and WQ-3. At WQ-28, the simulated results are within a very agreeable range.

TN, ammonia, nitrate, and nitrite were generally simulated well at each of the stations. However, one anomaly was observed in the measured data set that was not seen in the simulations. During 2005, there appears to be an increase in TN of about 2 mg/L at water quality stations WQ-1 and WQ-3, as well as an increase in the range of 1 to 2 mg/L at station WQ-28. WQ-15 does not reveal this trend as noticeably because both the simulated and measured results are heavily influenced by the upstream point sources.

TP was well simulated at each of the stations; however, at station WQ-3, the simulation appears to be slightly low. There is a golf course just upstream of WQ-3 that is the likely cause of the higher measured TP concentrations at this station. Unfortunately, the land use descriptions used in the model do not include golf courses, thereby making it difficult to improve the TP agreement at this station. Orthophosphate was difficult to analyze at each of the stations. In several locations, the measured orthophosphate concentrations are greater than the measured TP concentrations. Overall, the orthophosphate simulations follow a reasonable agreeable pattern and the concentrations are within an acceptable range.

6 Long-Term Monitoring Plan

Since 2002, the City of Griffin has implemented a monitoring program in coordination with the Georgia EPD for the Cabin Creek Watershed. The Cabin Creek monitoring stations are listed in Table 6-1 and depicted in Figure 6-1. Current monitoring stations include CC0, CC2, CC3, CC9, CC10, and one water quality reference site (REF-1) in Meriwether County (Figure 6-2).

Table 6-1 Cabin Creek Monitoring Stations

Site ID (Griffin ID)	Description	Sampling Start Date	Sampling End Date	Description
CC0 (WQ-43)	Cabin Creek upstream of Cabin Creek WWTP	August 11, 2009	Present	Measures water quality of headwaters just upstream of WWTP discharge
CC1 (WQ-15)	Cabin Creek downstream of Cabin Creek WWTP	January 22, 2002	July 6, 2009	Measures water quality leaving Griffin jurisdiction from central reach into Spalding County
CC2 (WQ-16)	Southern Tributary @ confluence with Cabin Creek	January 22, 2002	September 21, 2004	Measures water quality leaving Griffin jurisdiction from Southern Tributary into Spalding County
		August 26, 2010	Present	
CC3 (WQ-17)	Northern Tributary @ confluence with Cabin Creek	January 22, 2002	September 21, 2004	Measures water quality leaving Griffin jurisdiction from Northern Tributary into Spalding County
		August 26, 2010	Present	
CC4 (WQ-18)	Cabin Creek @ North Hill Street	January 22, 2002	September 21, 2004	Measures water quality entering Griffin jurisdiction from Spalding County Central Portion of watershed
CC5 (WQ-19)	Northern Tributary @ North Hill Street	January 22, 2002	September 21, 2004	Measures water quality entering Griffin jurisdiction from Spalding County headwaters
CC6 (WQ-20)	Cabin Creek @ North Ninth Street	January 22, 2002	September 21, 2004	Measures water quality leaving Griffin jurisdiction and entering Spalding County central portion of watershed
CC7 (WQ-21)	Springs Industry Tributary @ North Ninth Street	January 22, 2002	September 21, 2004	Measures water quality from Springs Industry Tributary
CC8 (WQ-22)	Headwaters Tributary @ North Ninth Street	January 22, 2002	September 21, 2004	Measures water quality from Downtown Headwaters Area
CC9 (WQ-23)	Minor Eastern Headwaters Tributary near S.R. 155	January 22, 2002	Present	Measures water quality leaving Griffin jurisdiction

Table 6-1 cont'd Cabin Creek Monitoring Stations

Site ID (Griffin ID)	Description	Sampling Start Date	Sampling End Date	Description
CC10 (WQ-37)	Cabin Creek at the end of Bourbon Street	March 17, 2005	Present	Measures water quality in upper portion of service area
REF-1 (WQ-40)	Brittens Creek, Meriwether County	March 17, 2005	Present	Water quality reference site

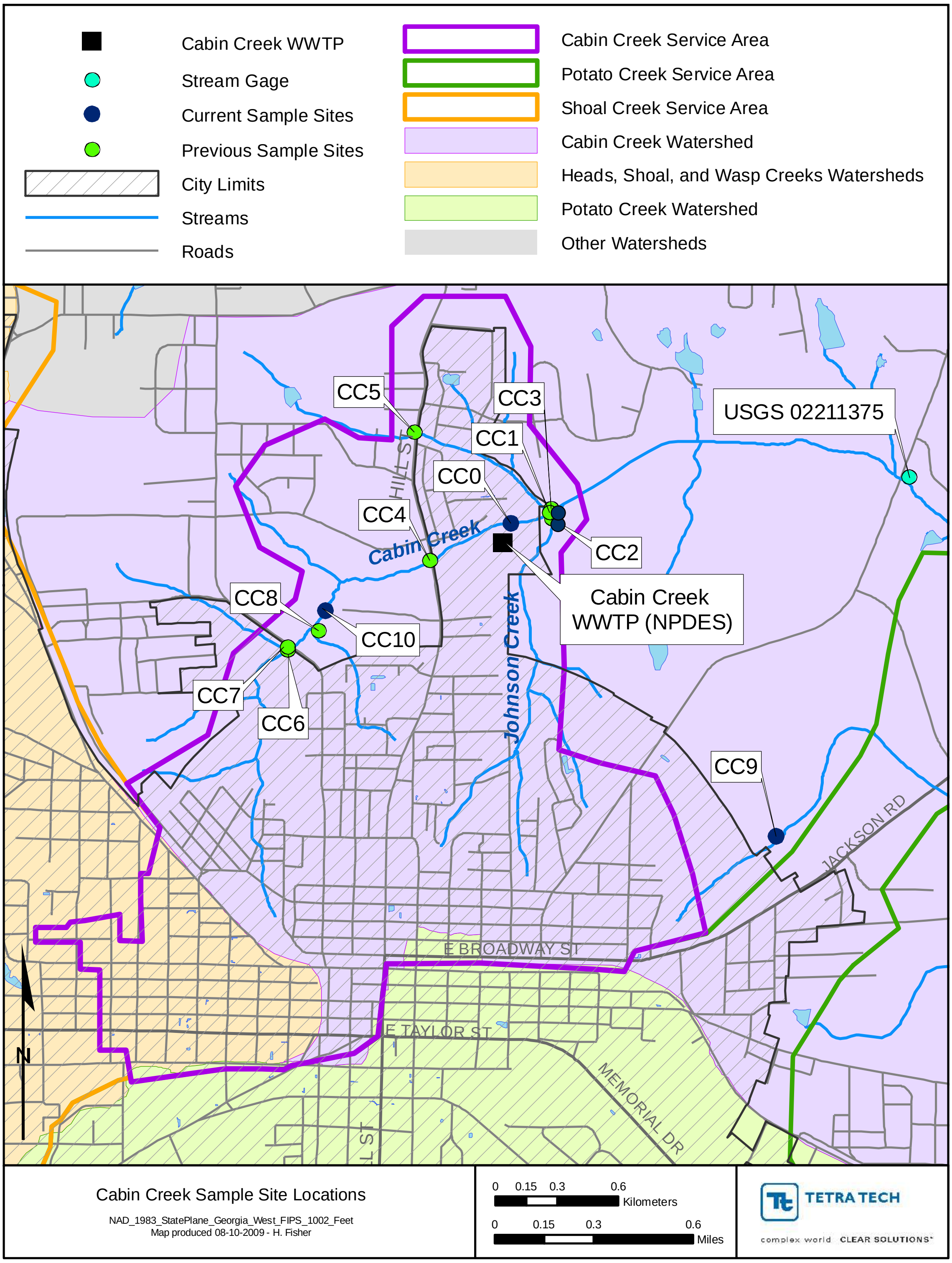

Figure 6-1 Cabin Creek Monitoring Stations

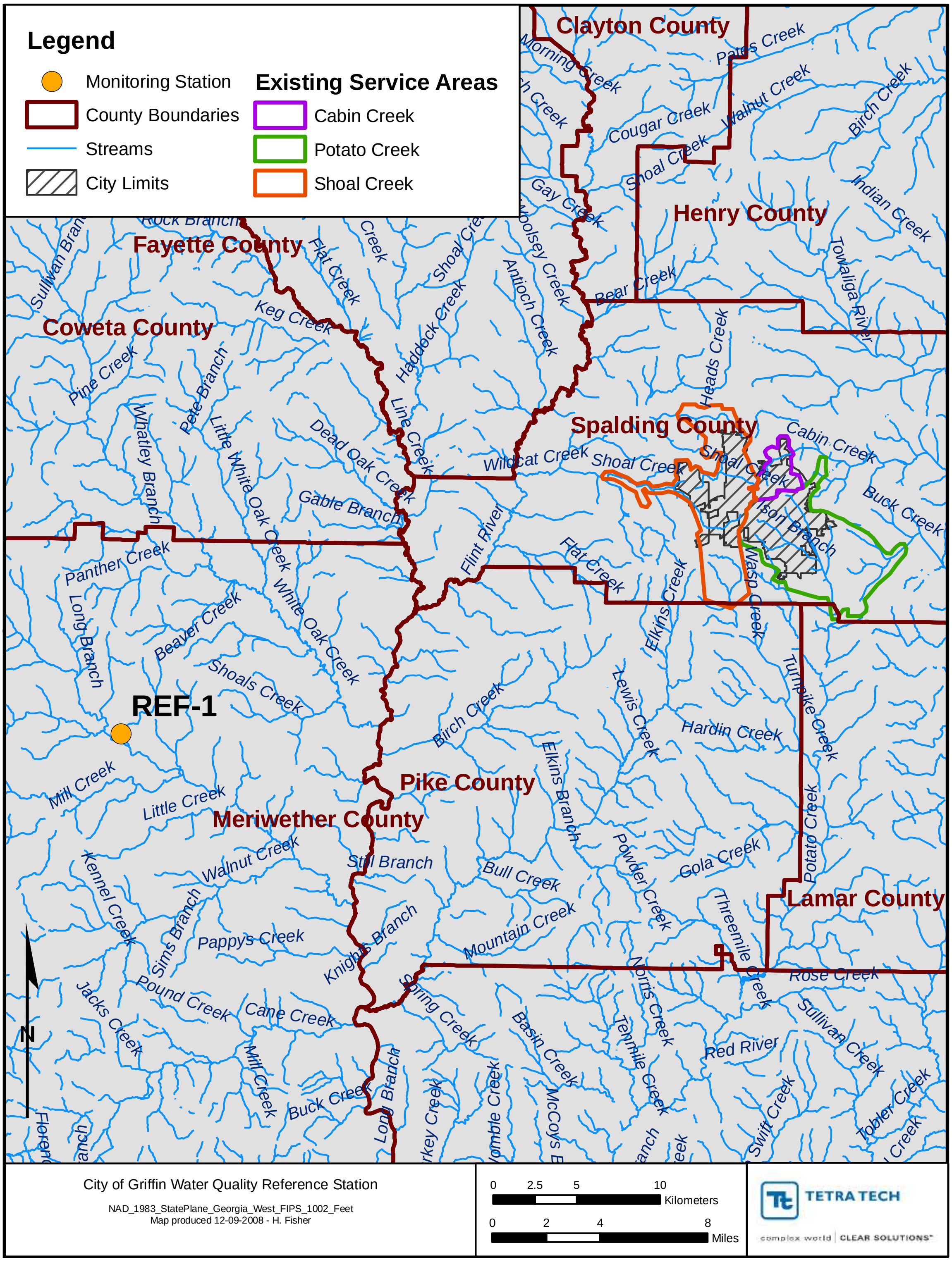

Figure 6-2 City of Griffin Water Quality Reference Monitoring Station

In the winter of 2002, a monitoring program was initiated that included 16 weeks of both in-situ and laboratory grab samples that were used to establish current levels of water quality. When the monitoring program was initiated, there were nine monitoring stations in the watershed that were used to obtain in-situ and grab samples (CC1 through CC9). The stations were later revised to better reflect the needs of the monitoring program and the conditions of the watershed. Monitoring at stations CC2 through CC8 ended on September 21, 2004, while monitoring at a new station, CC10, began in March 2005, resulting in three monitoring stations: CC1, CC9, and CC10. The Georgia EPD recently recommended some changes to monitoring stations that are reflected in the long-term monitoring plan. On August 11, 2009, a new station, CC0, was added upstream of the Cabin Creek WWTP, replacing station CC1 (just downstream of the Cabin Creek WWTP). Monitoring also resumed at two previous stations, CC2 and CC3, in August 2010.

Since 2005, stations have been monitored quarterly for water quality. A USGS stream gage (station 02211375) is located on Cabin Creek at North Second Street, which records gage height and discharge. Precipitation is measured at the Georgia Automated Environmental Monitoring Network (GAEMN) Georgia Experiment Station in Griffin.

The City of Griffin has also collected water quality reference data since March 2005 from station REF-1 at the location shown in Figure 6-2. This site is within the lower Piedmont eco-region.

The current monitoring stations—CC0, CC2, CC3, CC9, and CC10—are the sites that will continue to be monitored for the long-term monitoring plan. These monitoring stations include areas within the headwaters of Cabin Creek to the downstream (eastern) boundary of the City of Griffin, as shown in Figure 6-1. CC10 monitors the water quality of surface water draining from the upper Cabin Creek watershed; CC0 monitors Cabin Creek upstream of the Cabin Creek WWTP; CC9 monitors an unnamed tributary as it leaves the City's jurisdiction; CC2 monitors water quality leaving Griffin jurisdiction from a southern tributary into Spalding County; and CC3 monitors water quality leaving Griffin jurisdiction from a northern tributary into Spalding County. The portions of the Shoal and Potato Creek watersheds within the Cabin Creek service area are monitored using the Shoal and Potato Creek service area monitoring sites, as illustrated in their respective monitoring plans.

The drainage areas of the sample locations are representative of the major land uses and the 303(d)-listed (impaired) waterbodies in the service area. Because no future service area is proposed, the monitoring station selection considered the existing service area only.

Water Quality Monitoring

The long-term monitoring plan for the Cabin Creek Watershed includes continued quarterly water quality monitoring, with two wet and two dry weather samples collected each year. Some parameters will be measured *in-situ* while others will be measured in a laboratory from samples collected at the sites (laboratory grab). The sampling schedule, as well as targets for wet and dry sample collection, is described in the City of Griffin QAPP (Appendix E). All water quality measurements will be taken using standard operating procedures approved or similar to those listed in 40 Code of Federal Regulations (CFR) part 136, excluding the fecal coliform method that uses a standard operating procedure published in *Standard Methods* but not listed in the CFR.

The City of Griffin's monitoring protocols for Cabin Creek are detailed in the Cabin Creek Monitoring Plan, prepared by Tetra Tech in 2009. The monitoring protocol will continue as outlined in the monitoring plan, with the addition of a few new parameters. In fiscal year 2010-2011, one composite sample will be performed at CC0 that will cover the complete hydrograph during a wet weather event. This is a revision from the Watershed Monitoring Plan, based on a recommendation from EPD. Beginning in fiscal year 2010-2011, the City will also begin sampling fecal coliform between May and October in order to determine the geometric mean of fecal coliform bacteria in the watershed. *Eschericha coli* (an important fecal coliform) will be sampled once per year beginning in fiscal year 2010-2011. The

City will also begin sampling water hardness, as calcium carbonate ($CaCO_3$), in fiscal year 2010-2011. This sampling will allow the City to calculate dissolved metals concentrations based on the total metal concentrations sampled for cadmium, copper, lead, and zinc. When possible, the City should measure or estimate stream flow during each sampling event at each monitoring site. If the stream is dry or there is no flow at a monitoring site, this will be noted in the field notes and the Annual Report. The City has conducted priority pollutant scans and sediment sampling in the past and may continue to do these analyses periodically at their discretion. Table 6-2 displays the parameters measured by the City, as well as the referenced standard operating procedure and accompanying detection limit.

Table 6-2 Water Quality Parameters Measured by the City of Griffin

Parameter	Sample Type	Method(s)	Detection Limit
Temperature			
Air	In-situ	Troll 9500	N/A
Water	In-situ	Troll 9500	N/A
Oxygen demand			
DO	In-situ	Troll 9500	N/A
Carbonaceous biochemical oxygen demand (5-day) (CBOD5)	Laboratory grab	SM 5210B	2.0 mg/L
Chemical oxygen demand (COD)	Laboratory grab	Hach Method 8000	2.0 mg/L
Sediment Load			
TSS	Laboratory grab	SM 2540D	1.0 mg/L
Turbidity	In-situ	Horiba U-10 Checker	N/A
Nutrients			
TP	Laboratory grab	Hach Method 8190	0.01 mg/L
Orthophosphate	Laboratory grab	SM 4500-P E	0.02 mg/L
Nitrates (NO_3)	Laboratory grab	Hach Method 8039	0.3 mg/L
Nitrites (NO_2)	Laboratory grab	Hach Method 8507	0.002 mg/L
Ammonia nitrogen	Laboratory grab	SM 4500-NH3 F	0.01 mg/L
TKN	Laboratory grab	SM 4500-Norg B/NH3 D	0.4 mg/L
Flow	In-situ	Visual estimate	N/A
Metals			
Specific conductivity (SpC)	In-situ	Troll 9500	N/A

Table 6-2 cont'd Water Quality Parameters Measured by the City of Griffin

Parameter	Sample Type	Method(s)	Detection Limit
pH	In-situ	Troll 9500	N/A
Total cadmium (Cd)	Laboratory grab	EPA 200.7	0.0005 mg/L
Total copper (Cu)	Laboratory grab	EPA 200.7	0.004 mg/L
Total lead (Pb)	Laboratory grab	EPA 200.7	0.005 mg/L
Total zinc (Zn)	Laboratory grab	EPA 200.7	0.004 mg/L
Dissolved Cd [1]	Calculated	Calculated	Calculated
Dissolved Cu [1]	Calculated	Calculated	Calculated
Dissolved Pb [1]	Calculated	Calculated	Calculated
Dissolved Zn [1]	Calculated	Calculated	Calculated
Hardness as $CaCO_3$[1]	Laboratory grab	Hach 8226	0.3 mg/L
Priority pollutants			
Priority pollutant scan	Laboratory grab	Multiple methods	Parameter dependent
Sediments			
Metals, pesticides, polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs)	Laboratory grab	Multiple methods	Parameter dependent
Fecal Indicator Bacteria			
Fecal coliform	Laboratory grab	SM 9222 D	1 colony/100 mL
E. coli[1]	Laboratory grab	SM 9223 B	1 colony/100 mL

[1] Sampling required to measure these parameters will begin in fiscal year 2010-2011.

A regular assessment of water quality data will be conducted to compare measured data to established benchmarks and to characterize trends in each of the measured parameters. Annual progress reports to the Georgia EPD will relate pollutant concentrations to the water quality benchmarks established in this Watershed Protection Plan. These reports should include a statistical analysis of recent data, as well as figures such as time-series plots or box and whisker plots of pollutant concentrations and charts of pollutant loadings to observe trends over time for constituents of concern.

Biological Monitoring

The City of Griffin has conducted three Biological Assessments to date (2000, 2004/2005, and 2008/2009).

The City of Griffin will continue to conduct regular biological assessments as part of the long-term monitoring plan. In response to a request from Georgia EPD, monitoring was discontinued at station CC1 (just downstream of the Cabin Creek WWTP), while a new station, CC0, was added upstream of the WWTP in August 2009. Also, monitoring station CC2 (shown on Figure 6-1) was added as a site for biological monitoring in August 2010.

Macroinvertebrate and habitat sampling will be conducted twice every 5 years at sites CC0, CC2, CC9, and CC10. Fish community sampling will occur twice every 5 years at site CC0. Monitoring will be conducted using the most recent edition of the Georgia Department of Natural Resources' *Standard Operating Procedures for Macroinvertebrate Biological Assessment of Wadeable Streams in Georgia* and *Standard Operating Procedures for Conducting Biomonitoring on Fish Communities in Wadeable Streams in Georgia*. In-situ measurements and samples for alkalinity and nutrients (total phosphorous, orthophosphate, total Kjeldahl nitrogen, ammonia, nitrite/nitrate) will be taken immediately before habitat data and biological samples are collected. The nutrient data can also be used for one of the dry-weather water quality monitoring events. Sampling for the macroinvertebrate and fish assessments will be performed at least two weeks apart.

7 Watershed Management Needs

To address the impaired biota and water quality in the Cabin Creek Watershed, it is important that management measures are appropriately selected and implemented at strategic locations. Tetra Tech considered recent data and information and developed a framework to prioritize management needs based on spatial variation in the watershed. Information from the watershed assessment was used in conjunction with further analysis of water quality data since 2005 and the 2008 Stream Channel Erosion Activity Assessment.

Through this review, management needs were identified on a subwatershed basis (defining subwatersheds as the land draining to each monitoring station). As noted in Section 6, monitoring station CC1 (just downstream of the WWTP) was recently replaced by monitoring station CC0 (just upstream of the WWTP). Due to their proximity, management needs expressed for subwatershed CC1 in this section will also apply to subwatershed CC0. The watershed impact indicators (described in Section 2.1) were used to prioritize the subwatersheds for particular management needs relating to each indicator. Indicators considered for this evaluation were selected based on their relevance in the Cabin Creek Watershed and whether information or data were readily available.

Where a subwatershed is identified as a priority for a particular indicator, management within that subwatershed is expected to provide water quality improvement within the subwatershed and at downstream locations. Therefore, some subwatersheds are selected as priorities for management because they can address a downstream management need. The strategies for identifying priority subwatersheds differed by indicator and are explained in more detail below.

Sediment, Channel Stability, and Channel Morphology

As discussed in Section 3, sediment is a concern in the Cabin Creek Watershed, as evidenced by areas of high channel erosion activity, instances of relatively high concentrations of TSS at the CC1 and CC10 monitoring stations, relatively high mean TSS loads in the CC1 and CC10 subwatersheds, and the poor condition of biotic communities at the CC1 and CC10 monitoring stations.

Sources of instream sediment include erosion from upland areas and erosion occurring along the banks of the stream channels. Although most of the sediment loading in the Cabin Creek Watershed is attributed to bank and channel erosion, upland sediment is another potential source. The Cabin Creek Watershed is almost completely developed, and because it does not have significant areas of farm land, upland sediment sources are generally limited to athletic fields, residential lots with bare dirt yards, dirt/gravel commercial lots, and small construction projects where bare soil is exposed. Management measures that address upland sources and those that address stream channel sources should be considered.

The 2008 Stream Channel Stability Assessment characterized the geomorphic state of streams and identified areas of high erosion activity in the Cabin Creek Watershed (Figure 7-1). Stream reaches with high erosion activity are likely contributing a large portion of the sediment loading in Cabin Creek. Management measures aimed at stabilizing actively eroding stream banks can significantly reduce the amount of sediment entering the stream. Subwatersheds CC1, CC2, CC3, and CC10 each have areas with high erosion activity, and are priority areas for managing sediment and channel stability. Erosion hot spots in the reaches upstream of the CC10 and CC1 stations are collectively contributing to high TSS loads at these locations. The only area where channelization was noted in the geomorphic assessment is a stream reach in the upper portion of the CC2 subwatershed (assessment site 159), where the stream flows behind a parking lot. None of the Cabin Creek subwatersheds are priorities for managing channel morphology.

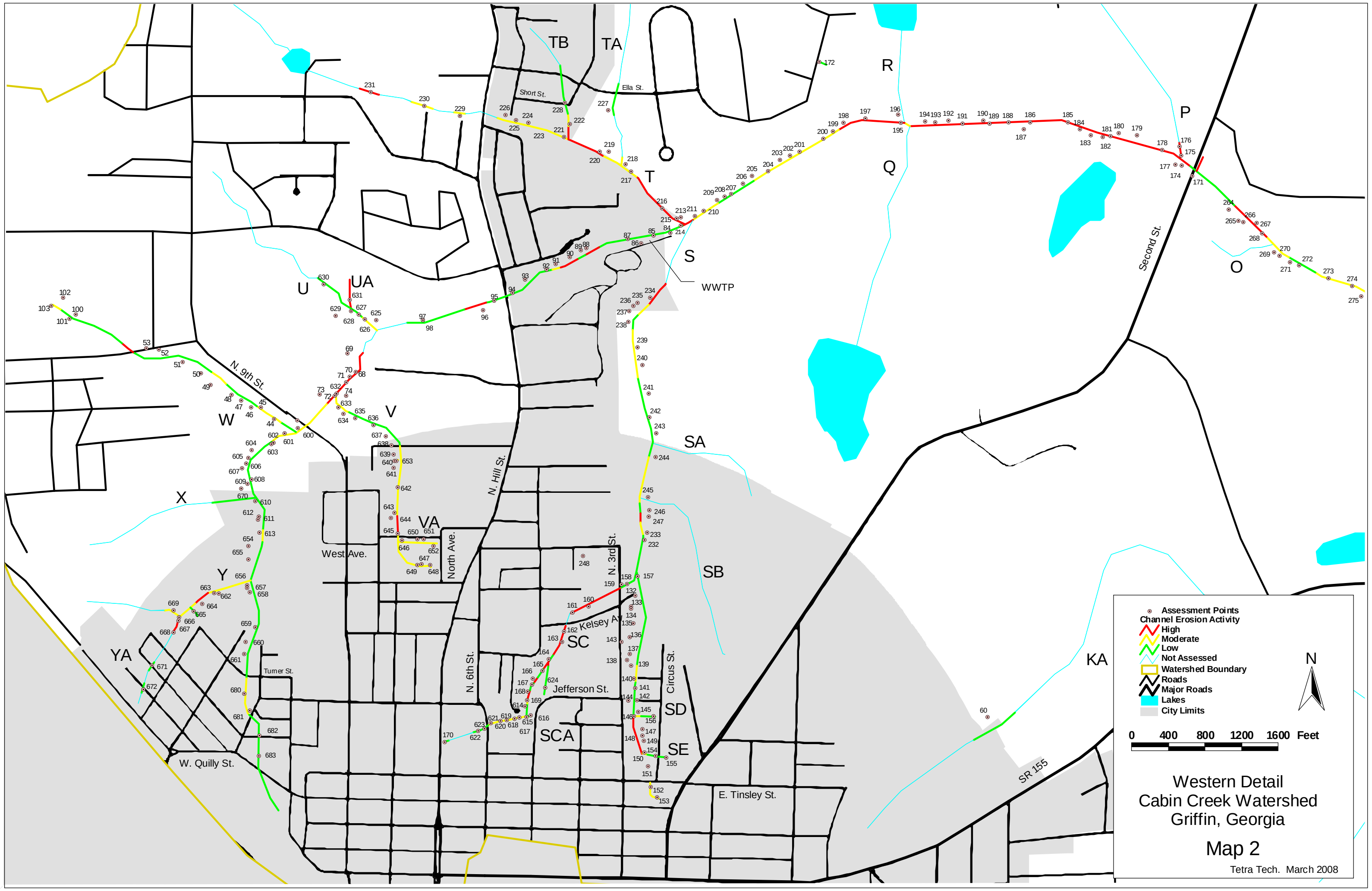

Figure 7-1 Channel Erosion Activity Ratings from 2008 Stream Channel Stability Assessment

Hydrology

Disturbance and development in upland areas can alter the natural hydrology of a watershed and lead to lost watershed functions. These conditions can cause, among other impacts, erosion (both in stream channels and in upland areas), increased flooding, and wetland conversion due to decreases in the water table. At present, hydrology modeling data have not been interpreted to provide estimates of where the greatest impacts of increased peak flow and volume from urban development might be occurring. Subwatersheds in the Cabin Creek Service Area range from 7 percent impervious cover (CC5) to 32 percent impervious cover (CC6). As an initial hypothesis, the subwatersheds with an impervious surface cover greater than 20 percent are placing the greatest hydrologic stress on the stream system. Subwatersheds CC1, CC2, and CC10 should be prioritized for upland flow controls because these areas contain an extensive degree of urban development—greater than 20 percent impervious cover (note that subwatershed CC6 is included in CC10 subwatershed). These subwatersheds also exhibit areas of high channel erosion activity. BMPs implemented in these areas would provide flow control in heavily developed areas and reduce the rate of channel erosion.

Metals

A management need for metals has not been identified for specific subwatersheds. Cooper and zinc have been detected throughout the watershed, but dissolved concentrations of metals have not been calculated. Therefore, metals management in the Cabin Creek Watershed should involve the calculation of the dissolved fraction of metals as part of the long-term monitoring plan before additional BMPs are identified and implemented.

Dissolved Oxygen

DO is not currently a concern in any of the Cabin Creek subwatersheds.

Nutrients

Average TP concentrations from 2005 through 2010 exceed the upper bound benchmark at the CC1 and CC10 monitoring stations. Average TN concentrations exceed the upper bound benchmark at all stations. Average TKN concentrations exceed the upper bound benchmark at the CC1 and CC10 monitoring stations. Average ammonia concentrations exceed the upper bound benchmark at monitoring station CC1. The pollutant loading analysis shows very high ammonia loads at the CC1 monitoring station, which was just downstream of the WWTP outfall. Monthly and weekly average effluent limitations are specified for ammonia in the NPDES permit for the Cabin Creek WWTP, and the WWTP is within permit limits. Although there is no recent nutrient data for the CC2 and CC3 subwatersheds, long-term data presented in the Watershed Assessment show high nitrate concentrations relative to the NO_3-NO_2 benchmarks established for the Cabin Creek Service Area. Nutrient reduction is a priority for the entire watershed. Management opportunities should include both upland (e.g., fertilizer management and BMP retrofits) and instream (e.g., stream restoration) strategies. Because monitoring has been discontinued at station CC1, future monitoring will not include data downstream of the Cabin Creek WWTP. Effluent monitoring charts for the plant are available, however, through the EPA's Enforcement and Compliance History Online (ECHO) site, including data for nitrogen (as ammonia).

Bacteria (Fecal Coliform)

Fecal coliform counts provide an indicator of human health risk to pathogens that might also be present in waterbodies. The Watershed Assessment noted that fecal coliform levels are a problem throughout the Cabin Creek Watershed. The 2005 to 2010 summary indicates that all current monitoring stations have high median concentrations of fecal coliform bacteria. Thus, the entire Cabin Creek Watershed is a priority for managing bacteria. BMP types considered throughout the watershed should include those that are effective at removing fecal coliform bacteria from stormwater. Management needs related to fecal coliform pollution should be reassessed once geometric mean calculations are obtained and evaluated. It would also be advantageous for the City of Griffin to identify the source of fecal coliform bacteria in the Cabin Creek watershed, similar to the Bacterial Identification Study done for the City of Griffin's Potato Creek Watershed.

Physical Habitat and Biology

Aquatic communities provide indicators of overall ecosystem health. The benthic macroinvertebrate community was rated poor at the CC1 monitoring station, very poor at the CC10 station, and fair at the CC9 station in 2008. The fish community was rated very poor at station CC1 in 2009, the lone fish monitoring station in the Cabin Creek Watershed. Monitoring station CC0 replaced monitoring station CC1 in August 2009, and is 1 mile upstream of CC1. The fish and benthic macroinvertebrate communities were rated poor at station CC0 in 2010, indicating that though conditions have improved, they are in need of further improvement. Given these findings, subwatersheds CC1 and CC10 are priority areas for overall improvement of biology. There is insufficient information on the CC2 and CC3 subwatersheds to prioritize these areas based on biology.

Sedimentation, hydrology, and water quality all affect the viability of aquatic life in streams, and the subwatershed priorities for these stressors were addressed individually above. Although these stressors are indicators of habitat degradation, it is also useful to address the degradation of physical aquatic habitat directly. Habitat scores from the 2009 assessment indicated conditions that were marginal at the CC1 and CC10 stations, and suboptimal at the CC9 station. Therefore, habitat improvement is a priority in the CC1 and CC10 subwatersheds.

Where excessive sedimentation is occurring, habitat concerns are best addressed by implementing BMP measures aimed at sediment load reduction. Similarly, where hydrology is negatively impacting aquatic communities, BMP measures that restore appropriate flow regimes should be considered. Once these and other sources of habitat degradation are addressed, then stream reaches can be evaluated for opportunities to improve physical aquatic habitat through restoration. Stream restoration activities should target the habitat parameters (e.g., vegetative protection, epifaunal substrate) that are in poor condition on a site-by-site basis. Habitat degradation should be addressed through the management of stressors, which have been identified at the subwatershed scale, and through restoration activities that directly improve physical habitat at individual sites. Restoration measures will provide an immediate improvement to habitat conditions, and the management of stressors will improve the long-term stability and health of the aquatic habitat and aquatic communities. Further degradation of aquatic communities can be minimized by preserving high quality, forested land in the watershed—particularly along stream corridors. Undeveloped land that is dominated by native vegetation provides food sources and habitat for macroinvertebrates and allows infiltration of stormwater. The preservation of land that is currently providing significant benefits to the watershed is a preventative measure that will ensure that these benefits are not lost.

Summary

Table 7-1 and Figure 7-2 summarize the management needs discussed above, noting which subwatersheds are priorities for each indicator. As management activities are implemented throughout the watershed, these priorities should be reviewed to assess progress in meeting watershed goals and objectives. Periodic adjustments to the priorities may be required based on the progress of watershed improvement projects, changes in watershed conditions, and information obtained from new monitoring stations.

Table 7-1 Management Priorities by Subwatershed

Watershed Impact Indicator	Considered in Evaluation	Priority Subwatersheds*
Benthic communities	Yes	CC1 and CC10
Aquatic habitat	Yes	CC1 and CC10
Fish communities	Yes	CC1 and CC10
Channel morphology	Yes (2008 assessment)	None
Channel stability	Yes (2008 assessment)	CC1, CC2, CC3, and CC10
Instream sediment	Yes (2008 assessment)	CC1, CC2, CC3, and CC10
Hydrology (frequency, magnitude, and duration of flows)	Best professional judgment through impervious data and geomorphic assessment	CC1, CC2, and CC10
Drainage complaints	No	N/A
Percent riparian area deficient of vegetation	No	N/A
Percent connected natural area	No	N/A
Water quality (modeling of future conditions): relative nutrient, upland sediment, and metals loading.	No	N/A
Water quality (observed/measured):		
Nutrients	Yes	All
Instream sediment as TSS	Yes (2005–2009 loading analysis)	CC1 and CC10
Bacteria (fecal coliform)	Yes	All
Metals	Yes	None
DO	Yes	None

* Listed subwatersheds include upstream/nested subwatersheds.

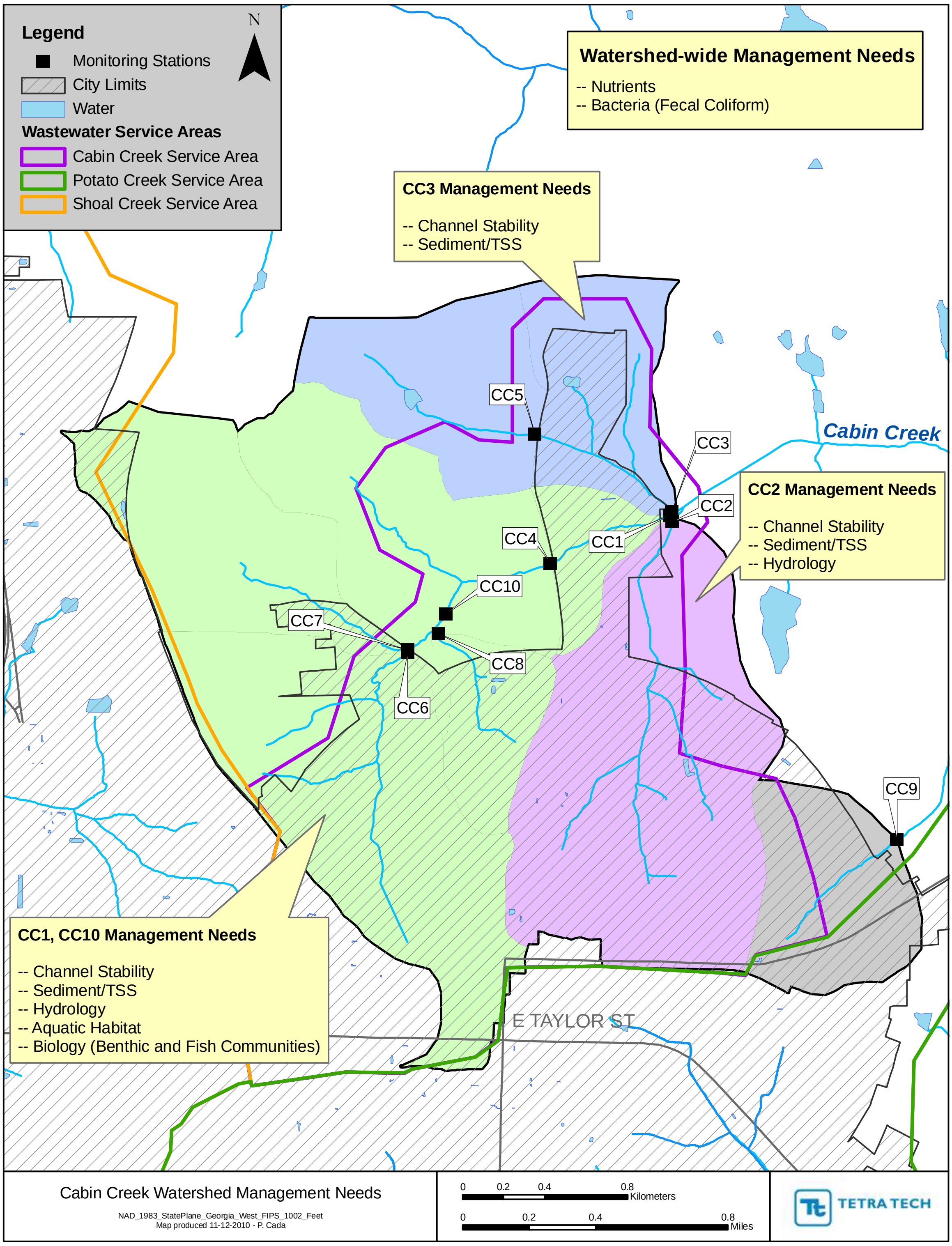

Figure 7-2 Cabin Creek Management Needs

8 Watershed Management Opportunities

Management opportunities have been identified that will best address the management needs of the Cabin Creek Watershed. The management needs identified in Section 7 are expressed in terms of watershed impact indicators. Because each watershed impact indicator addresses multiple objectives, management opportunities identified through these indicators will help achieve multiple objectives.

8.1 Identification of Potential Stream Restoration and BMP Sites

A desktop analysis was conducted to identify potential stream restoration and BMP sites in the Cabin Creek Service Area. Screening criteria, methodologies, and results are presented below.

Selection of Potential Stream Restoration Sites

The selection of stream restoration opportunities in the City of Griffin's Cabin Creek Service Area was based on the 2008 Stream Channel Stability Assessment. In that assessment, all stream reaches in the Cabin Creek Service Area that were identified as erosion hot spots were selected for further evaluation. The 13 selected reaches are identified in Figure 8-1.

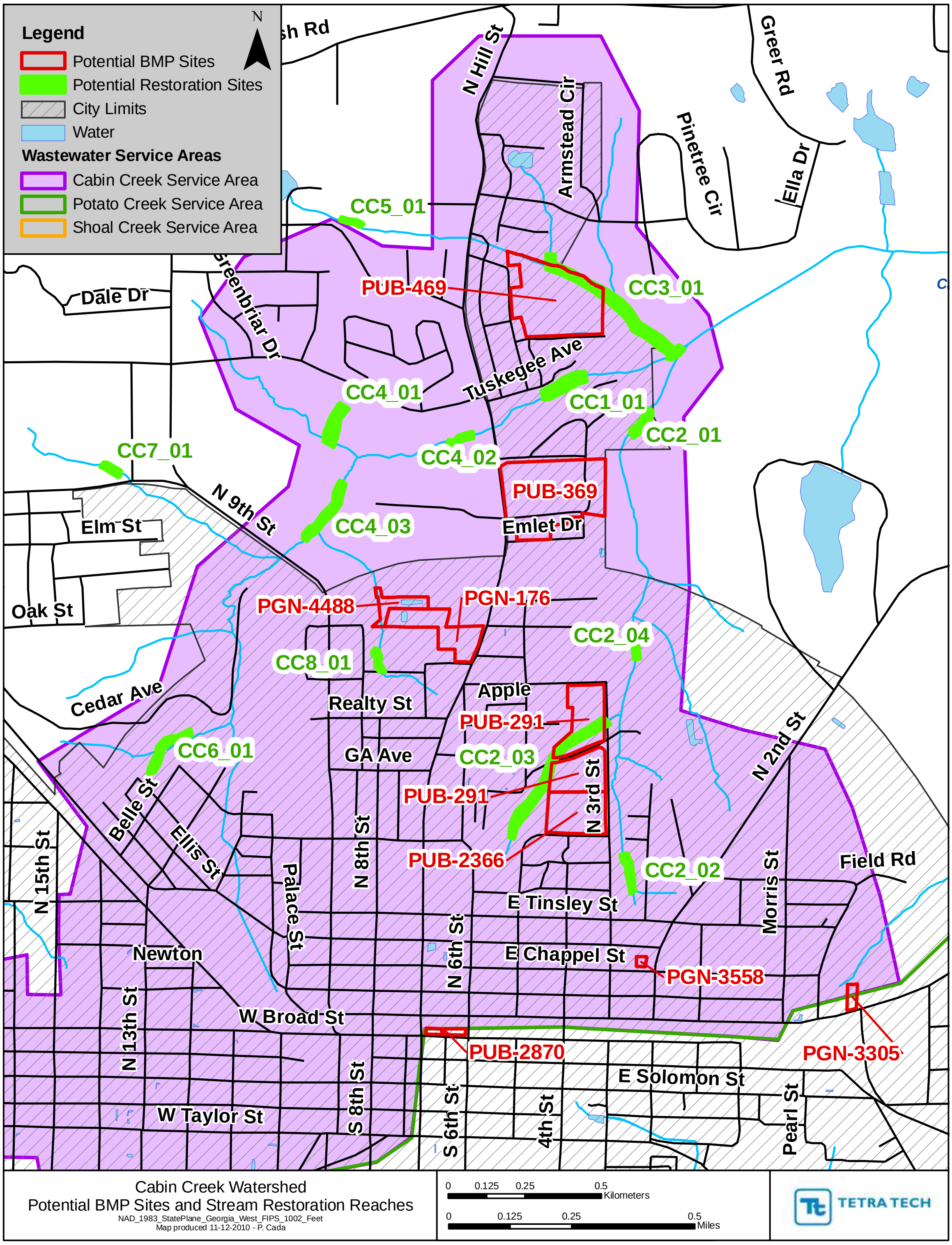

Figure 8-1 Potential BMP Sites and Stream Restoration Reaches

Selection of Potential BMP Sites

In preparation for the field investigation of potential new BMP opportunities in the City of Griffin's Cabin Creek Service Area, Tetra Tech conducted a desktop screening analysis using a variety of available data. GIS data included parcel information, aerial photography, sanitary and storm sewer locations, topographic and hydrographic data, wetland and hydric soil delineations, as well as a pond inventory and proposed BMP retrofits created by Paragon Consulting Group.

1) Initial BMP Site Selection

Selecting new BMP sites within a watershed typically requires reasonable assumptions to focus the search. The City of Griffin's parcel layer includes each individual parcel within the Cabin Creek Service Area. Similar to the Potato Creek BMP screening, Tetra Tech used the following three site selection criteria to identify potential sites for further screening: Paragon's modified and proposed BMP sites, public parcels, and riparian parcels adjacent to priority stream restoration reaches.

- Paragon—Paragon Consulting Group previously performed a field investigation for the City of Griffin that involved assessing existing stormwater ponds for water quality-based retrofits, as well as identifying new sites for water quality ponds and proprietary BMPs. Paragon's pond sites within the Cabin Creek Service Area were selected for further screening and prioritization.
- Public—Tetra Tech identified publicly owned parcels as opportunities because private land is potentially costly and complicated to acquire for BMP easements.
- Stream—Stream corridor BMP sites were identified in riparian areas along potential stream restoration reaches. Privately-owned parcels were included in the list of potential stream corridor sites because of the sites' high potential for immediate downstream improvement and typical unsuitability of riparian parcels for development by private interests.

The three site selection criteria and the number of potential sites associated with each criterion are provided in Table 8-1.

Table 8-1 Site Selection Criteria with Number of Potential Sites

Site Selection Criteria	Number of Sites—Cabin
Proposed Paragon sites (PGN)	New (41), modified (4)
Public parcels (PUB)	City (20), county (0)
Stream corridor BMP sites (STRM)	21
Total	**82***

*The total does not include duplicate counts for four sites that are included in more than one category.

2) Initial Constructability Analysis

Tetra Tech performed an initial constructability analysis for each site/parcel identified by the site selection criteria to remove infeasible sites from further BMP screening. The main criteria used to determine if a site is unfeasible for BMP construction include the following:

1) Insufficient upland (offsite) drainage;

2) Lack of available BMP area (non-forested); and

3) Stream/wetland impacts.

Unlike the Potato Creek BMP screening analysis, Tetra Tech removed all potential BMP sites if they were predominantly forested, unless the site exhibited excellent potential for effective stormwater treatment. Typically, BMP sites must receive considerable drainage from upland areas to be cost effective. The City's storm sewer network and topography data were used to assess a site's potential to collect and treat significant runoff volumes. For large public sites like schools, Tetra Tech used professional judgment to determine if treatment could be limited to onsite runoff due to the large impervious area associated with such locations.

Tetra Tech also assumed that a minimum of 0.5 acres of open land would be needed on each site to feasibly construct a stormwater BMP. This criterion was neglected for highly impervious sites in the downtown area where LID BMPs like permeable pavement and rainwater harvesting might be implemented using a 1:1 drainage to treatment area ratio.

Current federal and state regulatory interpretation of Section 404/401 compliance requirements limits the use of instream stormwater facilities, such as regional ponds or wetlands where impacts to perennial and intermittent streams are necessary. The existence of perennial wetlands (according to National Wetlands Inventory) also limits the use of infiltrative-type BMPs and requires an extensive permitting process to meet U.S. Army Corps of Engineers (USACE) Section 404 compliance. As a result, Tetra Tech removed potential sites from further screening if they required an impact to natural wetlands or instream construction for implementation of a BMP.

3) BMP Screening Criteria

Following the initial BMP site selection and constructability analysis using the aforementioned criteria, a series of screening attributes were developed to score and prioritize the remaining potential sites. The attributes were devised to use "0" and "1" scoring, where "1" represents a positive attribute for BMP constructability and "0" represents a negative attribute.

Tetra Tech used a manual, GIS-based approach to screen the potential sites for all of attributes because automatic processes would not yield accurate results. All of the screening criteria are described below.

1. Redundant Treatment – The locations of potential BMP sites were evaluated relative to the City of Griffin's BMP geodatabase coverage to reduce redundant treatment. Existing BMPs included dry detention ponds. Sites without adjacent BMPs in their drainage area were scored a "1".
2. Adjacent Streams – Zero scoring was assigned to sites where BMP construction would impact a stream or wetland, which requires additional permitting to meet USACE Section 404 compliance. The data source for the stream layer is the National Hydrography Dataset.
3. Utility Conflicts – Sanitary sewers and water supply lines were the only utility layers available for the site screening. Conflicts were determined if the utility line intersected the site in the general vicinity of where a BMP could be located. Note that utility conflicts do not eliminate a BMP from being constructed within their easement, but could increase long-term maintenance cost (if sewer maintenance has to impact a BMP structure) and require additional permitting issues.
4. Publicly-Owned Parcel – Although this attribute was used as site selection criteria, publicly-owned parcels were also assigned a "1" score in the screening process due to their appeal for BMP retrofits.
5. High-Loading Land Use – Potential BMPs were credited with a "1" for this attribute if their drainage area included significant areas of land use with greater pollutant export rates. These types of land use include parking lots, industrial areas, high traffic roadways, golf courses, etc.

6. Downstream Condition – The erosion condition (based on 2008 Tetra Tech assessment) of the downstream channel was considered for each potential BMP site. BMPs were assigned the following scores depending on the channel condition immediately downstream.

Condition	Score
Not assessed	0
Low	0
Moderate	1
High	2

Sites were then scored for all six screening criteria and re-ranked accordingly by total score. Table 8-2 shows an example of the BMP attribute scoring for the second prioritization process.

Table 8-2 Example of BMP Site Scoring for Three BMP Sites

Site ID	Watershed	Adjacent BMPs	Utility Conflicts	Publicly-Owned	High-Loading Land Use	Stream/Wetland impact	Downstream Condition	Total Score
PUB-2870	Cabin	1	1	1	1	1	0	5
PUB-291	Cabin	1	1	1	1	1	0	5
PGN-3305	Cabin	1	1	0	1	1	0	4

4) BMP Screening Process

After eliminating potential sites due to constructability limitations (e.g., no offsite drainage, insufficient area for BMP, heavily forested, stream/wetland impacts), the number of potential BMP sites was reduced from 82 sites to 16 sites. As part of the screening process, the 6 BMP screening criteria were applied to each of these 16 sites, which were subsequently ranked by their total screening score.

At this point the prioritization process deviated slightly from the Potato Creek methodology because the goal for the Cabin Creek Watershed was to include a proportionally large number of sites for field visits. During the screening criteria evaluation, seven sites were removed as potential BMP sites due to low screening scores and further professional judgment regarding difficult project constructability and effectiveness. The remaining nine sites were ranked by screening score.

5) BMP Screening Results

Following the screening and prioritization process, Tetra Tech selected all nine of the remaining screened sites for the field investigation. Table 8-3 shows the final list of sites, while Figure 8-1 shows the locations of the sites throughout the watershed.

Table 8-3 Final BMP Screening Site List

Rank #	BMP ID	Watershed	Parcel Owner	Total Score
1	PUB-2870	Cabin	City of Griffin	5
1	PUB-291	Cabin	Griffin-Spalding County Board of Education	5
2	PGN-3305	Cabin	Robert W. Willis, Sr.	4
2	PUB-2366	Cabin	City of Griffin Board of Education	4
3	PUB-369	Cabin	City of Griffin	3.5
3	PUB-469	Cabin	Griffin-Spalding County Board of Education	3.5
4	PGN-176	Cabin	St. Phillip Villas, LP	3
4	PGN-3558	Cabin	Ida Rhoe Johnson, LLC	3
4	PGN-4488	Cabin	Unknown	3

8.2 FIELD ASSESSMENT

A field crew consisting of three Tetra Tech employees and one City of Griffin staff member field located and assessed each of the 13 stream restoration sites and 9 BMP sites identified during the screening and site selection process for the Cabin Creek Watershed. The field crew identified and visited three additional public sites during the field assessment that did not get included in the screening process based on additional recommendations from City staff, and based on additional opportunities identified in the field. During the field visit, the BMP team evaluated the potential sites to determine if construction is feasible. For each site, the field crew created site sketches along with notes for potential stream restoration and BMP options and site constraints, and collected photographic documentation. For the feasible BMP sites, the field crew also assigned an engineering cost factor that reflects the extent that a site's constraints will influence the overall project cost (further described in Section 8.3)

Results of Stream Restoration Assessment

Five of the 13 sites identified as potential restoration reaches were dropped prior to field evaluation due to property constraints. The eight remaining sites are listed in Table 8-4 and identified in Figure 8-2.

Table 8-4 Final Selected Stream Restoration Sites

Stream Restoration ID	Restoration Length (ft)	Parcel Owner(s)
CC1-01	500	Jesse J. Owens, Spalding Concrete Co., and City of Griffin
CC2-01	330	City of Griffin
CC2-02	410	Andrew L. Cox, Michelle Renee Vaughn, and Zions Center
CC2-03	1700	Kyle D. Johnson, City of Griffin, and Griffin-Spalding County Board of Education
CC2-04	140	Plum Creek Timberlands, LP
CC3-01	1760	Diane B. Etal Blaine, Seventh Day Adventist, A.M. Reeves, Donnie & Dale Parsons, City of Griffin, and Griffin-Spalding County Board of Education
CC6-01	650	James Morgan Estate, Katie C. Humprey, Johnny J. Hughley, Carrie F. Carter, Griffin Area Habitat for Humanity Inc., and Spalding County
CC8-01	260	Donald C. Vaughn, Dorothy Mae Colbert, James L. Hamilton, William Keith Dryden, Dan L. Etal Dunson, and Evelyn North Romain

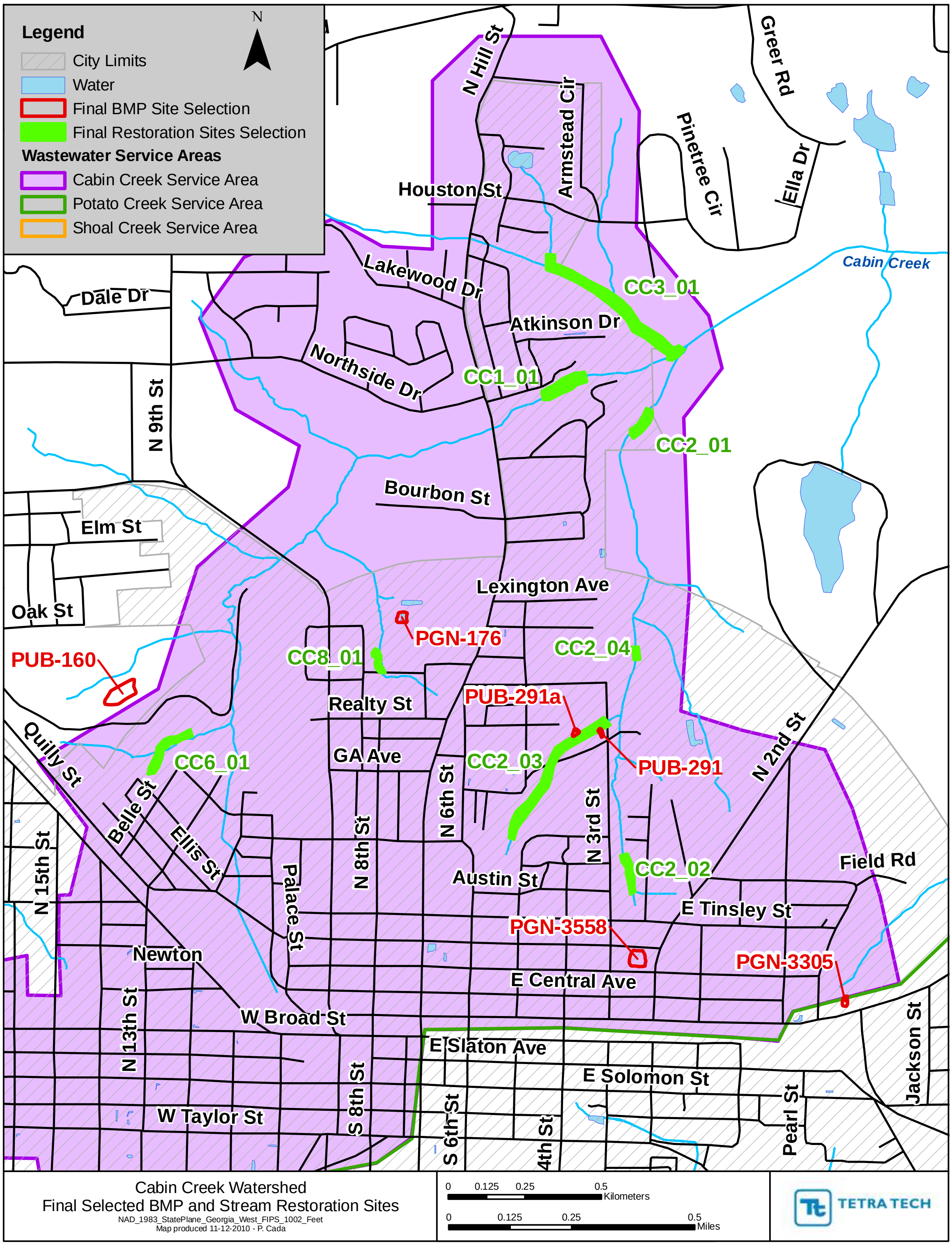

Figure 8-2 Selected BMP Sites and Stream Restoration Reaches

Results of BMP Assessment

Many of the BMP sites were deemed unfeasible as a retrofit opportunity upon the detailed field assessment due to various site constraints, which included utility conflicts, insufficient BMP area, steep slopes, and inadequate elevation grade between stormwater outfalls and BMP area. Out of the final nine sites selected during the screening process, four sites in the Cabin Creek Watershed were recommended as potential retrofit sites and included in rating and prioritization evaluation (discussed below). Tetra Tech also identified two additional sites during the field assessment that are suitable for BMP construction and meet the BMP implementation goals. These sites were identified during the field activities as exhibiting high retrofit potential and field assessments were conducted on the sites. The resulting six recommended BMP sites are listed in Table 8-5 along with the parcel owner, parcel ID, and the proposed BMP type. The BMP types (wetland, wet pond, bioretention, and detention basin) are described in the City's Stormwater Design Manual. Figure 8-2 shows the site locations within the Cabin Creek Watershed. Project data sheets for each of these sites are included in Appendix F.

Table 8-5 Final Selected BMP Sites

BMP ID	Proposed BMP Type	Parcel Owner	Parcel ID
PGN-3305	Dry detention	Kendall Gaston and Robert W Willis Sr.	019 02008
PGN-3558	Dry detention	Ida Rhoe Johnson, LLC and Possum Trot, LLC	006 13016
PUB-291	Bioretention	Griffin-Spalding County Board of Education	003 05002
PGN-176	Dry detention	St. Phillip Villas, LP	002 18010
PUB-291a	Dry detention/level spreader	Griffin-Spalding County Board of Education	003 05002
PUB-160	Wet pond	Spalding County	001 01001B

8.3 Rating System and Results

Evaluation and Rating of Stream Restoration Reaches

The eight final stream restoration sites remaining following field evaluation were characterized and evaluated based on information from the 2004 Stream Channel Stability Assessment, Spalding County parcel data, aerial photographs, and site visits. Six attributes were selected for the rating process that relate to constructability and public benefit. Higher scores were given to sites with public land ownership, good education potential, public amenity potential, good design potential and minimal earthwork needs, no utility conflicts, and a riparian zone that is less than 50 percent forested. An evaluation of the sites, with respect to the rating criteria, is presented in Table 8-6. The rating results are presented in Table 8-7. The highest possible score is 12. The sites are listed in order of their ranking in Table 8-8.

A description of each of the eight sites is presented below, and the location of each is shown in Figure 8-2. Project data sheets for each of these sites are included in Appendix F.

Potential Stream Restoration Sites:

CC2-03: The proposed restoration reach is 1,700 feet in length, and is on a tributary of Cabin Creek. This is a channelized reach of stream that flows northeast behind an apartment complex, through a city-owned parcel, across Kelsey Street, then in between the parking lot for the Kelsey School to the south and a Griffin-Spalding athletic field to the north. The channel is heavily incised with steep, highly unstable banks that are covered in kudzu. Banks are 4 to 5 meters high. The right bank has eroded to the edge of the Kelsey School parking lot. South of Kelsey Street there is a section of the right bank that is vertical and bare. Restoration would involve creating of a more stable channel profile with shallower side slopes, removing kudzu, and revegetating the banks with native species. Stabilizing the bank adjacent to the parking lot is a priority.

CC2-04: The proposed restoration reach is 140 feet in length and is on a tributary of Cabin Creek. This is a forested stream reach on property owned by Plum Creek Timberlands, LP. The channel has a well defined pool-riffle sequence. The banks on the outside of meander bends are eroding. Restoration would involve reshaping the banks to create a more stable channel profile and revegetating graded areas.

CC1-01: The proposed restoration reach is 500 feet long and is on the main stem of Cabin Creek by the Griffin WWTP. The channel has bare, vertical banks that are 3 to 4 meters high. Mass wasting is occurring on the right bank. Large woody debris is contributing to bank erosion. Heavy sand deposits are present on the channel bed. Restoration would involve laying back the banks and creating a more stable channel profile.

CC2-01: The proposed restoration reach is 330 feet in length, and is on a tributary of Cabin Creek. This is a forested stream reach adjacent to the Waste Water Treatment Plant. Banks are 2.5 meters high and are eroding on the outside of bends. The channel is deeply incised in the lower reach as it joins Cabin Creek. Restoration would involve reshaping and stabilizing the banks, and possibly adjusting the profile so that the main channel is several feet further away from the WWTP.

CC2-02: The proposed restoration reach is 410 feet in length and is on a tributary of Cabin Creek. The streambank is blanketed in kudzu and adjacent vegetation is secondary growth forest. Banks are steep and eroding. There is a large woody debris jam in the stream, and the stream bed is covered in broken glass and litter. Restoration would include reshaping and stabilizing the banks, removing kudzu and revegetating with native species, removing the large woody debris, and cleaning up and restoring the channel bed.

CC8-01: The proposed restoration reach is 260 feet in length and is in a residential area on a tributary of Cabin Creek. The stream runs between houses and an apartment building. The reach is blanketed in thick kudzu. Beneath the kudzu, the banks are fairly steep, 2 to 4 meters high, and mostly bare. Restoration would include reshaping and stabilizing the banks, removing the kudzu, and revegetating with native species.

CC3-01: The proposed restoration reach is 1,760 feet in length and is on a tributary of Cabin Creek. The reach is bordered by privet and secondary growth forest, and a sanitary sewer easement runs parallel to the left bank. Banks are 2 to 2.5 meters high. The reach is deeply incised and eroding on the outside of bends. Woody debris jams are creating additional scour on the banks. Restoration would include laying back banks and revegetating graded areas.

CC6-01: The proposed restoration reach is 650 feet in length and is on a tributary of Cabin Creek. The reach is forested and a sanitary sewer easement runs parallel to the right bank. Banks are 1 to 2 meters high. The reach includes areas of eroding and failed banks, a headcut, and exposed sewer line along the channel bed. Restoration would include stabilization of the headcut, protection of the sewer line, and reshaping and stabilizing the eroding banks. It would also be possible to remeander the channel into the woods, and away from the sewer line that runs close to the right bank.

Table 8-6 Stream Restoration Site Evaluation

	Restoration Reach				
Restoration Site Attribute	**CC1-01**	**CC2-01**	**CC3-01**	**CC2-02**	**CC2-03**
Ownership	Two private land owners: Spalding Concrete Company to the south and private owner of undeveloped cul-de-sac to the north, and a small area owned by City of Griffin	Public: City of Griffin	Two public land owners (City of Griffin and Griffin-Spalding County Board of Education) and four private land owners	Three private land owners	City of Griffin, Griffin-Spalding Board of Education, and one private land owner
Education potential	Poor—located in wooded area behind WWTP	Poor—located in wooded area behind WWTP	Poor—located in wooded area behind WWTP	Poor—surrounded by private residences	Good—site is on/adjacent to school and Parks Department land
Public amenity potential	Poor—located in wooded area behind WWTP	Poor—located in wooded area behind WWTP	Poor— located in wooded area behind WWTP	Poor—surrounded by private residences	Good—site is on/adjacent to school and Parks Department land
Earthwork/design potential	Good design potential. Enough room to lay back both banks. Sewer line is 100 ft. from the stream.	Fair design potential; constrained on left bank by proximity of WWTP	Good design potential; minimal earthwork	Fair design potential; moderate access constraints (surrounded by residences); otherwise adequate	Fair design potential; constrained by proximity of parking lot and potential sewer line
Utility conflicts	No conflicts	Yes—WWTP infrastructure along left bank	Yes- Sanitary sewer easement is 10' from left bank	No conflicts	Yes—GIS shows sewer line parallel to stream (not observed in the field)
Forested/clear riparian zone	Forested	Forested (>50%)	Forested (>50%)	Forested (>50%)	Unforested

Table 8-6 cont'd Stream Restoration Site Evaluation

	Restoration Reach		
Restoration Site Attribute	**CC6-01**	**CC2-04**	**CC8-01**
Ownership	Spalding County, Griffin Area Habitat for Humanity, and four private land owners	Private: Plum Creek Timberlands, LP	Six private land owners
Education Potential	Poor—site is between private residences and forested county land	Good—adjacent to a City/County park	Poor—surrounded by private residences
Public amenity potential	Poor—site is between private residences and forested county land	Good—adjacent to a City/County park	Poor—surrounded by private residences
Earthwork/Design Potential	Fair design potential; moderate access constraints; construction limitations due to sewer line	Good design potential; minimal earthwork; access road to site	Fair design potential; moderate access constraints
Utility conflicts	Yes- Sanitary sewer on channel bed and along right bank	Yes- sanitary sewer	Yes—sanitary sewer
Forested/Clear riparian zone	Forested (>50%)	Forested (>50%)	Unforested

Table 8-7 Stream Restoration Rating Results

Restoration Site Attribute	Rating	CC1-01	CC2-01	CC3-01	CC2-02	CC2-03	CC6-01	CC2-04	CC8-01
Ownership									
Primarily private	0	0		0	0			0	0
A considerable reach that is public, but some private	1					1	1		
Public	2		2						
Education Potential									
Poor	0	0	0	0	0		0		0
Good	2					2		2	
Public amenity potential									
No	0	0	0	0	0	0	0		0
Yes	2					2		2	
Earthwork/design potential (presume priority 2 restoration)									
Major alterations required/poor design potential	0								
Moderate alterations required/fair design potential	1		1		1	1	1		1
Minimal alterations required/good design potential	2	2		2				2	
Utility conflicts									
Yes	0		0	0		0	0	0	0
No	2	2			2				
Forested/clear riparian zone									
Heavily forested	0	0	0	0	0		0	0	
>50% clear	2					2			2
Total		**4**	**3**	**2**	**3**	**8**	**2**	**6**	**3**

Table 8-8 Restoration Site Rankings

Reach ID	Rating Score	Ranking
CC2-03	8	1
CC2-04	6	2
CC1-01	4	3
CC2-01	3	4
CC2-02	3	4
CC8-01	3	4
CC3-01	2	5
CC6-01	2	5

Evaluation and Rating of Potential BMP Sites

Prioritization and evaluation of the six recommended BMP retrofit sites consisted of scoring and ranking the sites according to eight BMP attributes. Some of these attributes, like "education potential," are qualitative and thus involve only a "yes" and "no"; attributes like runoff volume and pollutant reduction potential are quantitative and required additional hydrologic and BMP sizing calculations. Watershed size and characteristics were determined for each of the seven recommended sites as well as determinations of target and available footprint and storage volume. Target water quality and stream protection volumes were calculated according the City of Griffin Stormwater Design Manual. Available site footprint was determined using GIS imagery and sketches made of each site during field assessment. Available water quality volume and stream protection volume were based on available site footprint and the field reviewers estimate of available storage depths of the proposed BMP.

Scoring BMP sites for the quantitative attributes also required threshold criteria (ranges of values) developed from all the site attribute values. Thresholds were selected to assign scores to ranges of attribute values, either based on the distribution of the attribute values or by using a ranking of the attribute values. BMP scoring was based on a total maximum score of 100 points with each attribute receiving a possible score between 0 and 10. Because there are only nine prioritization attributes and some attributes have more importance for BMP implementation than others, Tetra Tech applied weighting factors to each attribute to ensure that the maximum possible score equals 110. The weightings were based on the relative importance of the attribute to overall achievement of the goals and objectives. Each BMP prioritization attribute and its associated scoring criteria are described below. The weighting assumptions are discussed in the next section.

1. *Drainage Area Treated* – The amount of treated drainage area helps represent the combined water quality and quantity improvement attained from the BMP. The loading attributes described below differentiate how much load and flow are addressed depending on the type of BMP, whereas this attribute measures how much land in general is treated. The scoring criteria for the drainage area attribute are shown in Table 8-9. The treated drainage area represents the fraction of the total site drainage area that the BMP is capable of treating to equally score the undersized BMPs.

Table 8-9 Treated Drainage Area Scoring Criteria

Drainage Area Threshold	# of Sites	Score
<3 acres	2	0
3 – 10 acres	2	2.5
10 – 30 acres	1	5
30+ acres	1	10

2. *Ownership* – Publicly owned parcels were given priority over privately owned parcels because easements and land acquisition will be easier and less expensive to acquire on public land. Thus, public parcels received a score of "10" while private parcels were scored "0."
3. *Education Potential* – A benefit of retrofit sites located on publicly exposed parcels is to provide opportunity for community education regarding stormwater management and watershed ecology. Examples of sites with good education potential include schools, high-trafficked public properties, churches, and parks. BMP sites that provide educational opportunities were scored a "10" while those that do not received a "0."
4. *Maintenance Needs* – Regular BMP maintenance is required to ensure that a BMP performs as intended. Just as each type of BMP is different, so is the intensity and frequency of the necessary maintenance activities. BMP maintenance needs were considered either "frequent or intensive," "moderate," or "infrequent or minimal," and assigned scores of "0," "5," and "10," respectively. These levels of maintenance needs are based on the frequency of inspection, sediment cleanout, vegetation management, as well as the level of effort required for the various maintenance activities.
5. *Potential for Controlling Storm Flows* – This attribute categorizes the extent that a proposed BMP controls the stream protection runoff volume within its specific drainage area. Performance standards in the City of Griffin's Stormwater Design Manual define the stream channel protection volume as the 1-year frequency storm event depth distributed over a 24-hour rainfall period. The scoring criterion for this attribute is the percentage of drainage area runoff from the 1-year, 24-hour storm event that can be stored within each BMP. This "storm control" volume includes both the water quality storage volume (e.g., 1.2" rainfall event) and any additional detention volume (when available) sized for the 1-year event. Runoff volumes were estimated using the "Simple Method" as defined in the City of Griffin's Stormwater Design Manual (Paragon, 2007). Tetra Tech used NOAA's Precipitation-Frequency Data Server (http://hdsc.nws.noaa.gov/hdsc/pfds) to determine a 1-year, 24-hour rainfall depth of 3.25 inches for the City of Griffin. Table 8-10 shows the scoring regime for the percent reduction in runoff volume provided by each potential BMP retrofit.

Table 8-10 Scoring Criteria for Storm Flow Reduction

Percent of Stream Protection Volume	Score
0–25%	0
25–50%	2.5
50–75%	5
75–90%	7.5
90–100%	10

6. *Potential for Reducing Pollutant Loads* – The existing LSPC model constructed by Tetra Tech for the Cabin Creek Watershed was used to estimate the annual pollutant loads of TSS, TP, and TN delivered to each BMP site from its contributing drainage area. Typical removal efficiencies for the three recommended BMP types were obtained from the Georgia and North Carolina BMP Manuals (see Table 8-11) and applied to the annual runoff loads. Many of the potential BMP measures will be undersized because the sites do not provide enough land area to treat the entire water quality volume. To estimate the relative load reduction for undersized BMPs, Tetra Tech scaled the removal efficiency by the fraction of the water quality volume that is available for treatment. The assumed scaling factors are shown in Table 8-12. Thus, the total annual pollutant load removed by each potential BMP site equals the annual runoff load estimated by the LSPC model multiplied by both the recommended BMP removal efficiency and the undersized scaling factor (if necessary). The calculated pollutant load reductions are reported in Table 8-13.

Table 8-11 BMP Removal Efficiencies

BMP Type	Source	TSS	TP	TN
Dry extended detention	NC BMP Manual (NCDENR, 2007)	50%	10%	10%
Wetland	GA BMP Manual (ARC, 2001)	80%	40%	30%
Bioretention	GA BMP Manual (ARC, 2001)	80%	60%	50%
Wet pond	GA BMP Manual (ARC, 2001)	80%	50%	30%

Table 8-12 Scaling Factors for Undersized BMPs

Percent of Water Quality Volume Treated	Percent of Full Removal Credit
25–9%	50%
50–74%	67%
75–99%	83%
100%	100%

Table 8-13 Pollutant Load Reductions

BMP ID	TSS Removal (lbs/yr)	TN Removal (lbs/yr)	TP Removal (lbs/yr)	Attribute Score
PGN-3305	5141	7.6	0.3	5
PGN-3558	13380	20.8	0.8	7
PUB-291	1611	7.0	0.4	3
PGN-176	1453	2.9	0.1	2
PUB-291a	1470	2.2	0.1	1
PUB-160	3868	36.2	2.2	8

To assign attribute scores, the load reductions for each pollutant were ranked separately and averaged to determine a total average rank value for each BMP. The average rank was then used to develop percentiles for attribute scoring. Sites with a total average pollutant reduction rank in the 0-10th percentile range received a score of "1," a site ranking in the 10th-20th percentile range received a score of "2," and so on.

7. *LID, Green, and Innovative BMPs* – One objective of the watershed protection plan is to implement LID, green infrastructure, or regional innovative BMPs. Of the four types of BMPs recommended for the Cabin Creek Watershed, both bioretention and constructed wetlands fit this category and were scored a "10" while detention basins received a "0" score.

8. *Removal Efficiency Cost* – Cost estimates were developed for each BMP, comprising land acquisition, scaled construction, design and engineering, and operation and maintenance over a 20-year life-cycle. For private properties, land acquisition costs were based on the recent tax value (land portion only) for each parcel reported by the Spalding County Tax Assessor's Office (http://qpublic3.qpublic.net/ga_search.php?county=ga_spalding) and prorated to the amount of area needed to construct the proposed BMP. It was assumed that an easement would be purchased from the landowner, and the acquisition costs was assumed to be 80 percent of the land value to account

for the lesser cost of an easement. The acquisition cost for public properties was assumed to be zero.

The construction costs were estimated from the unit cost equations reported in Schueler et al. (2007) and were adjusted from 2006 to 2010 dollars using an annual inflation rate of 3 percent. The construction cost assumptions are displayed in Table 8-14. Note that for construction cost of undersized bioretention cells, which is estimated based on the contributing drainage area (CDA), the CDA was adjusted to reflect the percentage of water quality volume that the specific BMP is capable of treating.

To more accurately reflect each BMP's construction costs given the site constraints, the general construction cost estimates were adjusted by a designer's cost factor (1-10) that was assigned during the field assessment. Higher numbers reflect more site constraints that would require greater construction costs, such as significant earthwork and utility alterations. A designer's cost factor of "5" represents the average construction cost estimated by the unit cost equations, so the construction cost was adjusted by 5 percent for each incremental deviation in the cost factor from "5." For example, construction cost for projects with cost factors of "3" and "7" would be adjusted by (-) 10 percent and 10 percent, respectively. Design and engineering costs were assumed to be 25 percent of the scaled construction cost.

Table 8-14 Construction Cost Assumptions, 2010 Dollars (Scheueler et. al, 2007)

BMP Type	Site Condition	Cost Assumption
Bioretention	Existing facility absent	$10.50 per CF treatment volume (Scheueler et. al, 2007, Table E.4)
Dry detention	Existing BMP	$11.54*Vs^{0.780}$, Vs= Treatment Volume (Scheueler et. al, 2007, CC equation for new extended detention)
	Existing facility absent	$5 per CF treatment volume (Scheueler et. al, 2007, Table E.4)
Wet pond	Unique site conditions	Site specific estimate for installation of riser barrel outlet and associated inlet features
	Existing facility absent	$8350 per impervious acre treated (Scheueler et. al, 2007, Table E.2 median cost for new wet pond)
Wetland	Existing facility absent	$9600 per impervious acre treated (Scheueler et. al, 2007, Table E.2 high range of new wetland unit cost)

Operation and maintenance (O&M) cost assumptions were based on information collected for a recent Tetra Tech publication on a green BMP O&M study (Tetra Tech, 2009). The study provided unit area annual O&M costs for multiple BMPs, including the four shown in Table 8-15.

Table 8-15 O&M Annual Cost Assumptions, 2010 Dollars (Tetra Tech, 2009)

BMP ID	Cost Equation
Constructed Wetland	0.28*A
Dry Detention Basin	0.56*A
Bioretention	1.47*A
Wet Pond	0.23*A

A = BMP surface area (sq. ft.)

The construction and O&M cost components were summed to calculate a total 20-year cost estimate. Final BMP Cost Estimates are shown in Table 8-16.

Table 8-16 Final BMP Cost Estimates

BMP ID	Raw Const. Cost Estimate	Const. Cost Adjusted to Cost Factor	Inflation Adjusted Const. Cost	Design and Eng.	20-Yr O&M	Property Acquisition	Total 20-Yr Cost
PGN-3305	$48,756	$63,382	$71,338	$17,834	$33,795	$1,970	$124,937
PGN-3558	$260,729	$260,729	$293,452	$73,363	$180,724	$32,402	$579,940
PUB-291	$31,060	$21,742	$24,471	$6,118	$54,297	$0	$84,885
PGN-176	$18,880	$15,104	$17,000	$4,250	$37,143	$5,708	$64,101
PUB-291a	$15,977	$12,782	$14,386	$3,597	$38,268	$0	$56,250
PUB-160	$100,000	$120,000	$135,061	$33,765	$142,352	$0	$311,178

The total 20-year cost for each BMP was divided by the 20-year load reductions provided by the BMP to obtain cost-effectiveness ratios for TSS, TN, and TP. The cost-effectiveness ratios for each BMP are shown in Table 8-17. Scoring of removal efficiency costs was performed similarly to the pollutant load reduction attribute where percentiles for the average ranking for each pollutant were used to score each site.

Table 8-17 Pollutant Removal Cost Estimates

BMP ID	TSS Removal Cost ($/lb/yr)	TN Removal Cost ($/lb)	TP Removal Cost ($/lb/yr)	Attribute Score
PGN-3305	$1.22	$821	$20,183	6
PGN-3558	$2.17	$1,394	$35,626	2
PUB-291	$2.64	$605	$11,804	5
PGN-176	$2.21	$1,124	$34,342	3
PUB-291a	$1.91	$1,293	$31,757	3
PUB-160	$4.02	$429	$6,993	6

9. *Priority Subwatershed* – To better coordinate BMP implementation with the magnitude and extent of subwatershed issues, Tetra Tech developed a prioritization attribute that developed subwatershed management needs based on field-observed data. Management needs were assigned for instream sediment, channel stability, hydrology, nutrients, bacteria, biology, and DO. A BMP retrofit site was credited with a management need if it is located in a subwatershed, or

upstream of a subwatershed, with any of the above water quality/stream impairments. Tetra Tech summed the number of management needs allocated to each potential retrofit site and scored them accordingly based on the priority categories shown in Table 8-18.

Table 8-18 Subwatershed Priority Categories

# of Management Needs	Priority	Score
6	High	10
4–5	Medium	5
0–3	Low	0

Final BMP Scoring and Ranking

Following the evaluation and scoring of each recommended BMP site according to each prioritization attribute, all of the scores for each attribute were adjusted by a weighting factor. The selected BMP attributes cover a range of BMP selection criteria, including the magnitude and cost efficiency of pollutant load reduction, feasibility of land acquisition and construction, overall project costs, as well as several other indirect benefits. The weighting factors help emphasize BMP prioritization with respect to the project goals and balance the importance and skew that some attributes impose on the total prioritization score. For example, most of the quantitative attributes, like storm flow, pollutant load reduction, and cost-effectiveness, were considered the most importance factors for BMP prioritization because they directly target the watershed protection goals 1-3 specified in Section 2. Education potential and LID/green BMP classification (which have large scoring margins between the “yes” and “no” criteria) were weighted to have less influence on the total score. Although these qualities also address the goals and objectives, they are less critical to achieving the overall water quality and quantity goals. Table 8-19 shows the assigned weighting factor for each attribute, all the individual attribute scores for each BMP, and the final prioritization ranking based on the total BMP scores.

The highest ranking opportunity provides multiple benefits, including major water quality and hydrology benefits. The potential BMP site with the highest prioritization for implementation is the proposed wet pond at the old rock quarry along Cedar Ave (PUB-160) that is owned by Spalding County. Although the proposed retrofit site and associated drainage area are located upstream of the Griffin City limits, this publicly owned area provides an excellent opportunity to mitigate peak flows and reduce headwater runoff loads before entering jurisdictional waters. There is a great drop in total score between the top-ranked site (total score = 68) and the second-ranked site (total score = 46). The second highest ranking site (PUB-291) is an aging parking lot serving the Kelsey School. It is public property owned by the Griffin-Spalding County Board of Education, which presents an opportunity for incorporating bioretention. Site PGN 3558, ranked third, is comprised of two vacant lots under private ownership. Positive attributes to this site include good drainage area treated, good storm flow control, good pollutant reduction, and good removal efficiency costs.

Table 8-19 BMP Attribute Scores and Final Ranking

BMP Ranking Attribute	*Weighting*	PUB-160	PGN-3558	PUB-291	PUB-291a	PGN-176	PGN-3305
Drainage area treated	*1*	10	5	0	0	2.5	2.5
Ownership	*1*	10	0	10	10	0	0
Education potential	*0.5*	0	0	5	5	0	0
Maintenance needs	*1*	0	5	0	5	5	5
Storm flow control	*2*	20	10	5	5	20	0
Pollutant reduction	*2*	16	14	6	2	4	10
LID, green, or innovative BMP	*0.5*	0	0	5	0	0	0
Removal efficiency cost	*2*	12	4	10	6	6	12
Priority subwatershed	*1*	0	5	5	5	0	0
Total Score		68	43	46	38	37.5	29.5
Rank		1	3	2	4	5	6

8.4 BMP Modeling and Optimization

BMP optimization modeling was performed for the Cabin Creek Watershed. The Cabin Creek model was developed using BMPDSS Navigator spreadsheet-based decision support system. Inputs to the model include subwatershed delineation, land use distribution by subwatershed, BMP locations and design, BMP capital and O&M costs, and water quality goals at specific locations in the watershed.

The objective of this study was to recommend the most cost effective set of best management practices for achieving a set of water quality targets. Existing condition loads were calculated by taking yearly loads derived from the Hydrology and Water Quality model, calculating the 5-yr (2005-2009) average annual load for each of three Cabin Creek monitoring stations, then averaging those values to get a 5-yr watershed average. Water quality targets were developed for both TSS and nutrients in the Cabin Creek Watershed. For each nutrient parameter, as well as TSS, the target was developed by calculating a 15 percent reduction in average load from existing conditions. Targets were developed in this manner in order to calculate reasonably attainable load reductions based on the recent water quality of this individual watershed.

The BMPDSS model optimizes BMP size and selection to achieve these water quality targets for annual average pollutant loading. Two assessment points were selected for the model at the outlet of subwatersheds CCK 25 and CCK 20. Locations of the assessment points and proposed BMPs, including ponds and proprietary devices, are shown in Figure 8-3. Assessment point CCK 25 is downstream of monitoring station CC0, and includes subwatersheds draining to monitoring stations CC0, CC2, and CC3. Assessment point CCK 20 is downstream of monitoring station CC9. The original loading targets are in units of lbs per acre per year. Evaluation factors were calculated by multiplying the unit area loading targets by the total drainage area of each assessment point. The results of this calculation are presented below in Tables 8-20 and 8-21.

Table 8-20 Water Quality Loading Targets for Cabin Creek at CCK 20

Water Quality Parameter	Existing Unit Area Load (lbs / acre / year)	Existing Watershed Load (lbs / year)	Unit Area Loading Target (lbs / acre / year)	Watershed Evaluation Target Value (lbs / year)
TN	4.13	16,484	18.85	19,143
TP	0.087	272	0.479	486
TSS	414	420,319	460.7	467,856

Table 8-21 Water Quality Loading Targets for Cabin Creek at CCK 25

Water Quality Parameter	Existing Unit Area Load (lbs / acre / year)	Existing Watershed Load (lbs / year)	Unit Area Loading Target (lbs / acre / year)	Watershed Evaluation Target Value (lbs / year)
TN	21.6	50,863	18.85	44,394
TP	0.521	1,229	0.479	1,128
TSS	604	1,423,110	460.7	1,084,998

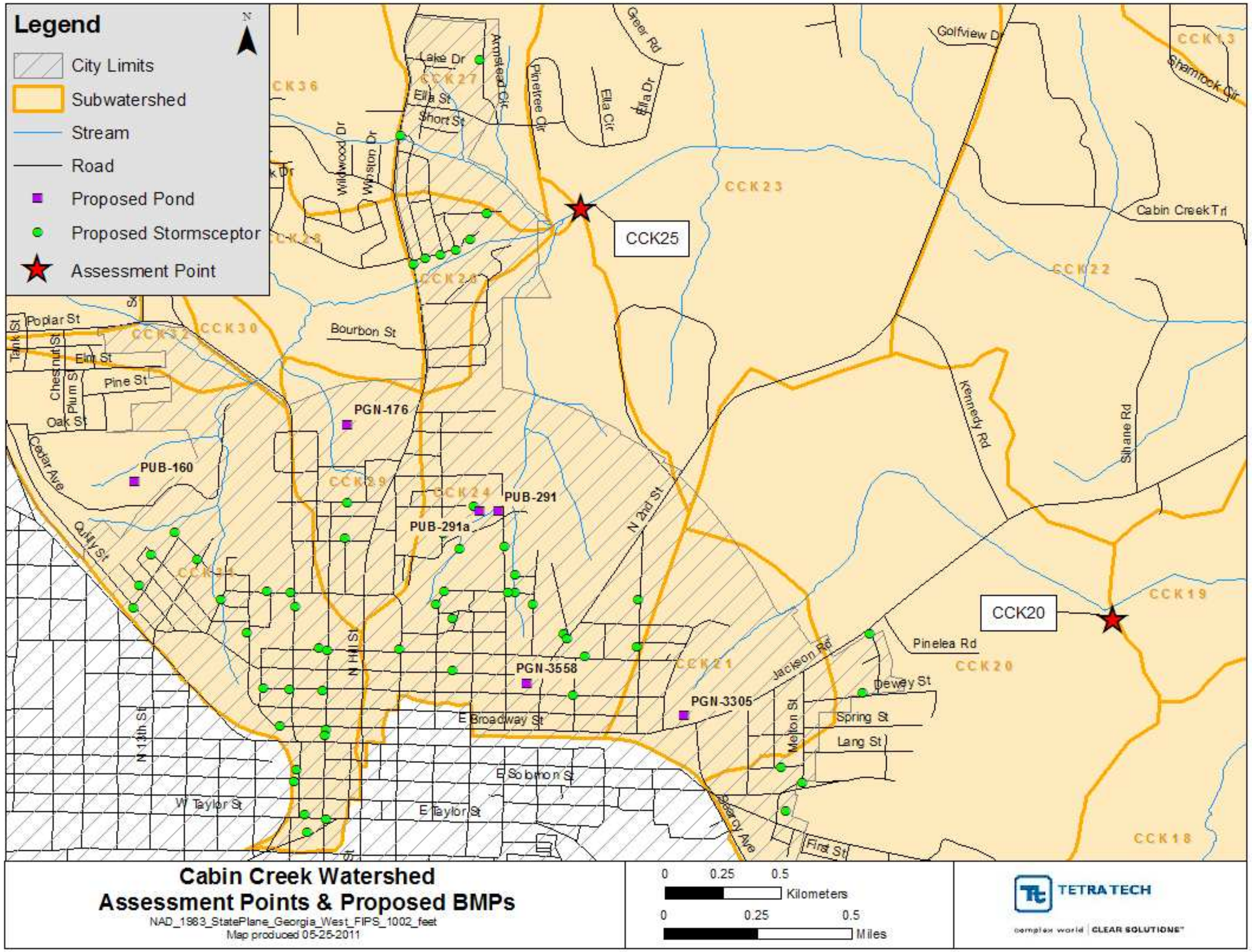

Figure 8-3 Cabin Creek Assessment Points and Proposed BMPs

Results

Six proposed detention-style BMPs were evaluated for the Cabin Creek Watershed consisting of dry detention, bioretention, wet pond, and dry detention plus level spreader. Additionally, a series of proprietary hydrodynamic separators were evaluated. Each detention-style BMP was assigned a maximum surface area. Square geometry was assumed and BMP width was fixed. During the optimization, BMP length was allowed to vary between zero and the maximum length in steps of 10 percent. Optimization was performed using the nutrient and sediment loading criteria as objectives. Calendar year 2005-2009 was selected for the simulation to coincide with the calibration period of the Cabin Creek Hydrology and Water Quality model.

Even at the maximum implementation the loading targets were not attainable for assessment point CCK 25. Table 8-22 below presents a summary of the maximum sizing for proposed detention BMPs in the Cabin Creek Watershed. Optimization results are ranked descending by the removal efficiency cost attribute score as indicated in Table 8-17. The six proposed detention BMPs show optimization at the maximum length. The model was not able to converge on a solution that met all evaluation targets as the loads at subwatershed CCK 25 are particularly high due to the wastewater treatment plant upstream.

Table 8-22 Optimized BMP Sizing and Cost-effectiveness for Pollutant Removal

BMP ID	Width (ft)	Length (ft)	Removal Efficiency Cost Attribute Score	TSS Removal Cost ($/lb/yr)	TN Removal Cost ($/lb/yr)	TP Removal Cost ($/lb/yr)
PGN-3305	70	70	6	$0.88	$119	$2,704
PUB-160	188	188	6	$0.49	$67	$1,511
PUB-291	54	54	5	$6.10	$829	$18,842
PUB-291a	40	40	3	$2.06	$280	$6,375
PGN-176	81	81	3	$0.78	$106	$2,417
PGN-3558	161	161	2	$1.31	$177	$4,036

The Stormsceptor inline hydrodynamic separator model STC 11000s was the proprietary BMP device proposed for implementation in the Cabin Creek Watershed. These units were modeled as generic, impermeable storage compartments using removal efficiencies of 80 percent for TSS and 50 percent for TN and TP. Removal efficiencies were applied to the outflow at each timestep. In practice, actual removal efficiencies will vary depending on the condition of the system and magnitude of individual storm sizes.

The cost of one Stormsceptor unit was calculated as the unit capital cost plus operation and maintenance over 20 years. Assuming capital costs of $50,250 per unit, $600.00 annual maintenance, and a 5 percent discount rate the present worth life cycle cost of one unit is $57,727.33. The capital cost per Stormsceptor unit was obtained on December 6, 2010 through conversation with a local manufacturer's sales representative.

Each subwatershed was assigned a maximum number of Stormsceptor units from GIS coverage of treatable basins developed by Paragon. The number of units in each subwatershed was set as a decision variable with bounds between zero and the maximum number of units increasing in steps of one unit. Table 8-23 presents a summary of the Stormsceptor optimization for the Cabin Creek Watershed. Cost-effectiveness values for pollutant removal in $/lb/year/unit were also calculated and are presented in Table 8-23. The 57 proprietary BMPs selected in Table 8-23 represent 100 percent of the potential Stormsceptor devices identified during the Paragon study. The locations of all potential Stormsceptors are shown in Figure 8-3.

Pollutant removal cost was calculated as the pounds of pollutant removed divided by the cost per Stormsceptor unit. While all devices have the same cost and were modeled with the same removal efficiencies, unit pollutant removal costs will vary due to variations in land use distributions, pollutant loadings, and Stormsceptor drainage areas. Therefore, lower removal costs suggest more cost-effective opportunities for Stormsceptor implementation in a given subwatershed.

Table 8-23 Stormsceptor Optimization Results

BMP	Subwatershed	Number of Units Selected	Maximum # of Units	TSS Removal Cost ($/lb/yr/unit)	TN Removal Cost ($/lb/yr/unit)	TP Removal Cost ($/lb/yr/unit)
Stormscepter20	CCK20	5	5	$2.70	$366	$8,272
Stormscepter24	CCK24	19	19	$0.59	$80	$1,822
Stormscepter26	CCK26	6	6	$1.40	$191	$4,337
Stormscepter27	CCK27	2	2	$18.93	$2,569	$58,166
Stormscepter29	CCK29	2	2	$2.90	$394	$8,956
Stormscepter31	CCK31	23	23	$0.37	$51	$1,155

Simulated Pollutant Loads and Flows

Tables 8-24 and 8-25 present the loading targets evaluated for the Cabin Creek Watershed, along with the simulated pollutant loads at both assessment points with those optimized BMPs from Tables 8-22 and 8-23, and without BMPs, highlighting the water quality benefit for each pollutant under the optimized scenario. Nutrient criteria for total nitrogen and total phosphorous and total suspended solids were used as objectives for the optimization.

Table 8-24 Simulated Pollutant Loads at CCK 20 Assessment Point

Water Quality Parameter	Evaluation Target (lbs / yr)	Value at Watershed Outlet Without BMPs (lbs / yr)	Value at Watershed Outlet With BMPs (lbs / yr)
TN	19,143	16,484	16,017
TP	486	272	242
TSS	467,856	420,319	399,046

Table 8-25 Simulated Pollutant Loads at CCK 25 Assessment Point

Water Quality Parameter	Evaluation Target (lbs / yr)	Value at Watershed Outlet Without BMPs (lbs / yr)	Value at Watershed Outlet With BMPs (lbs /yr)
TN	44,394	50,863	49,243
TP	1,128	1,229	1,210
TSS	1,084,998	1,423,110	1,310,552

For the simulation period, no BMPs were required to achieve the evaluation targets for subwatershed CCK20 as the existing annual loads for this subwatershed were already under the target loads. While removal efficiencies were calculated assuming maximum lengths for all ponds and all proposed Stormsceptors, none of the BMPs upstream of CCK 20 are necessary to meet the target at that assessment point. None of the evaluation targets were achievable at subwatershed CCK25 with the maximum implementation of proposed BMPs. The reasons for this are (1) the BMPs treat a relatively small portion of the total drainage area, and more importantly (2) in-stream loads at this subwatershed are significantly influenced by the wastewater treatment point source upstream.

A peak flow target was also set for the main stem of Cabin Creek, although this target was not included as an evaluation factor for the optimization. The flow target was set at the estimated 2-year peak discharge based on Cabin Creek stream gage discharge data area weighted to the drainage area of Assessment Point CCK 25. The objective is to not exceed this discharge limit more than one time per year. The peak flow target was not achievable under full implementation of all available BMPs. This objective was not used for optimization; however, the peak flow reduction benefit of the near-optimal solution is presented below in Table 8-26. The fully implemented set of BMPs results in a 14 percent reduction in peak flow.

Table 8-26 Summary of peak flow targets for Cabin Creek Watershed

Flow Parameter	Assessment Point	Evaluation Target (cfs)	Value Without BMPs (cfs)	Value With BMPs (cfs)
Peak Flow	CCK 25	350	336	289

Discussion

The results presented in Table 8-22 represent the cost-effectiveness of pollutant removal for each of the proposed detention BMPs under the optimized scenario. These measures of removal efficiency account for the optimized size of the ponds and are more refined than the removal efficiency costs presented in Table 8-17. Continuous simulation model with BMPDSS Navigator provides a robust framework of optimizing from among a suite of proposed BMPs in a watershed context that includes additional processes such as in-stream decay.

It is important to note that the simulation run that was done for this BMP optimization exercise used only two specific assessment points in the Cabin Creek Watershed. Just because a target is met at one assessment point does not mean it is met at every upstream location in the watershed. Likewise, when a target is not met at an assessment point, it does not indicate that the entire upstream basin is in poor condition. For example the wastewater treatment plant that is just upstream of the CCK 25 assessment point could be the single reason that the targets cannot be met at that location. For planning purposes, the results of this optimization modeling should be used in conjunction with the recommendations presented in Section 8.5 to implement a comprehensive management plan.

Optimization modeling is a valuable tool, but it is limited to the constraints of the model, and doesn't account for secondary benefits. For example, the TSS reduction shown for each of the ponds only accounts for the amount of sediment being trapped by the pond. The realized benefit in TSS reduction will be much greater, since a detention pond will reduce the velocity of flows, and therefore reduce bank erosion everywhere downstream of the pond. In addition to the measures included in the optimization modeling, other measures can also support watershed improvements. A comprehensive management plan that includes BMPs, stream restoration, Low Impact Development (LID) measures, and programmatic measures will most fully address the problems in the Cabin Creek Watershed through an integrative approach.

8.5 MANAGEMENT RECOMMENDATIONS

In this section, management actions are recommended that will help the City of Griffin meet its objectives for the Cabin Creek Watershed and achieve the overarching goals of this Protection Plan.

Structural BMPs

Significant protection can be provided to the Cabin Creek Watershed through the construction of structural BMPs that reduce storm flows and filter pollutants. These measures can include dry detention basins, wet ponds, bioretention areas, and level spreaders. In Section 8.3, six BMP sites are identified as opportunities for implementing projects that will achieve multiple objectives. The rankings and BMP optimization results provided in Section 8.3 can help the city prioritize these projects. Estimated costs for structural BMP measures are detailed in Table 8-16.

Stream Restoration

In Section 8.3, eight stream restoration sites were identified that would improve water quality. Restoration projects that the City deems feasible should be incorporated into an Implementation Plan. If BMP projects are planned upstream of a selected restoration reach, the stream restoration project should not be initiated until upstream BMP projects are complete. This will give the restoration projects a better chance of success due to better management of storm flows. Stream restoration costs can vary widely depending on many situational factors. Estimated costs for stream restoration are presented in Table 8-27. Costs are broken out by the level of restoration involved. For the purposes of this Watershed Protection Plan, the high level of stream restoration would involve extensive excavation and construction activities that could include reconnecting a stream to its floodplain, creating a new channel, and restoring meanders and other features to a channel. The medium level of stream restoration would involve less extensive measures such as spot repairs for bank or channel erosion, levee removal, and instream grade control structures. The low level of stream restoration would include vegetation management, buffer restoration/enhancement, and preservation. The restoration sites identified in the Cabin Creek Watershed are candidates for high level restoration, but some projects could be scaled back to medium level restoration if necessary. Each of the Cabin Creek sites will also vary considerably in the width of riparian zone restoration.

In addition to the eight recommended restoration areas identified by Tetra Tech, numerous medium level restoration opportunities exist throughout the watershed. These are small, isolated areas of erosion along streambanks, around storm drain outfalls, or at headcuts (where there is an abrupt change in stream gradient over an erodible surface). The cumulative contribution of TSS loads from these numerous erosional areas can be significant. Stormwater Division personnel should identify such “erosion hot spots” during their routine inspections, and spot repairs should be done using bank stabilization measures.

Low level restoration opportunities exist wherever stream banks are generally stable, but bank vegetation and riparian vegetation are lacking or are poor quality. Low level restoration can be facilitated through educational workshops discussed under non-structural BMPs, below.

Table 8-27 Stream Restoration Unit Cost Estimates

Restoration Level*	Unit	Approximate Unit Fee**
High—Complete channel reconstruction, bank stabilization, buffer restoration, instream structures, etc. They would all be riffle-pool channel design and have an average of 60 feet of riparian restoration on either side of the stream.	Linear foot	$150–$350
Medium—Spot repairs to stabilize streambanks, headcuts, and erosion around culverts.	Linear foot	$75–$200
Low—Minor bank shaping and vegetation enhancement, including a 2-meter strip of complete vegetation plantings on each bank.	Linear foot	$50–$100

* Restoration level categories provided by Tetra Tech.

** Approximate Unit Fees are for preliminary planning purposes only and might change considerably based on the nature of a particular project characteristics and/or goals.

Note: Restoration costs can vary widely based on a number of factors including stream width, amount of earthwork required, size of the project (as the size of the project increases, the cost per unit will typically decline), etc. Restoration projects that include stormwater BMPs, wooded riparian zones, access and property constraints, flashy urban settings, or topographic/substrate issues can be expected to be associated with significant cost adjustments (for both design and construction). Design costs can be generally assumed to be approximately 30 percent for high level restoration, 15 percent for medium level restoration, and 10 percent for low level restoration of the costs provided. External cost considerations may include costs for formal bid document preparation, federal, state or local permitting (USACE, State Stream Buffer Variance, Land Disturbance Permitting, etc.), and extensive hydraulic/hydrologic modeling.

Source: Ecological Consultants, 2010, personal communication

Non-structural BMPs

The structural BMPs and restoration measures recommended above represent an important step towards addressing management needs in the Cabin Creek Watershed. However, stormwater BMP retrofits and stream restoration, in isolation, will not meet the Protection Plan goals and objectives. Some land with high impervious surface coverage or high contributing pollutant loads will remain untreated or continue to have uncontrolled runoff, either due to lack of landowner interest or a feasible structural BMP opportunity. Some pollutant sources, like fertilizers and pet waste, cannot be addressed by a limited number of structural BMPs; therefore, public policies, education, and outreach are necessary to encourage further pollutant load reduction. The City is currently operating a number of programs that address these management needs. As outlined in Section 4, ordinances have been updated or adopted to regulate how land is used and to minimize pollutant discharges. The City's MS4 stormwater program contains a diversity of strategies that target the multiple pollutant sources and stressors within the Cabin Creek Watershed and citywide.

Because much has been accomplished to date, recommendations for future non-structural practices are limited to several key strategies that are likely to provide measurable improvements in water quality. As sediment and nutrient loading are important concerns in the watershed, strategies to preserve and restore riparian areas would fill a management gap not provided by currently programs or recommended structural projects. To accomplish this, a phased-approach could be used that begins with citizen education and transitions to requiring wider riparian buffer protection. The City could conduct citizen education workshops on maintaining and restoring vegetation along streams and using appropriate erosion control practices in landscaping. The efforts could involve riparian management events in which volunteers help to remove invasive species and restore native riparian vegetation. It is important that citizens from all income levels are encouraged to participate. There are opportunities to develop community pride and improve knowledge about watershed protection in every neighborhood in the Cabin Creek Watershed. Some of the poorest neighborhoods could see the greatest benefit from such events. Many poor neighborhoods located near headwater streams in this area have bare dirt yards that are highly prone to erosion. Educating these residents about erosion control, and providing them with resources, such as free mulch or grass seed, could help reduce upland sediment sources. As education events are implemented, the City could work on policies that increase undisturbed buffer requirements. For example, undisturbed buffer requirements could be increased from 25 to 50 feet from streams, with an additional 50 feet beyond this buffer where certain land uses are allowed but structures and other impervious surfaces are prohibited.

Fertilizer is another pollutant source for which non-structural practices can be successful in contributing to watershed improvement. Efforts could be directed toward encouraging or requiring the reduction of fertilizer use on private property. Educational landscaping workshops can be provided for the public on how to select the proper fertilizer and application rate. The workshops could also provide instruction on other landscaping techniques as an incentive for the public to participate. Educational efforts that provide direct and detailed instruction can be more effective than more indirect methods (mailings, public service announcements, etc.) because the attendees already have an interest and time investment in the techniques.

Fertilizer ordinances have been used in some local communities to reduce nutrient loading, and these ordinances can have multiple purposes. Some regulations prevent the application of fertilizer where it is not necessary (driveways, sidewalks, and other impervious surfaces) or where it has more significant impacts (near streams, wetlands, and other waterbodies). Fertilizer ordinances can also regulate application techniques, including how the timing and areal application rates are chosen for each property. These ordinances can be written to provide flexibility for individual landowners.

Installation of tree boxes was initially considered as a distributed BMP opportunity during the BMP field assessment but was removed from further consideration due to the presence of mature trees along many of the city streets. Other program opportunities might become available to implement distributed BMPs in the future.

In summary, the non-structural techniques that appear to be most beneficial for future consideration are policies and programs that:

1) Promote riparian buffer preservation and restoration,
2) Encourage the reduction of fertilizer application, and
3) Plan future landscape and infrastructure improvement efforts to allow for implementation of distributed BMPs.

The extensive non-structural BMPs that the City is currently operating provide important benefits to the watershed. These additional non-structural BMPs are recommended for integration into the City's existing efforts to further address the Cabin Creek Watershed goals and objectives.

Implementation Schedule

The City of Griffin will implement new watershed management actions over the next few years, in addition to continuing their current management practices and stormwater programs. In an effort to meet the goals and objectives presented in this Protection Plan, the City will actively work to maintain and improve conditions in the Cabin Creek Watershed. Table 8-28 proposes a schedule for implementing new management actions over the next five fiscal years. Sources of funding will include the city's Stormwater Utility, Section 319 grants, and Water and Wastewater Division funds.

The City of Griffin will submit the following information to Georgia EPD by June 30th of each year:

a. Annual certification of Watershed Protection Plan implementation
b. Electronic submittal that includes:
    - Long-term trend water quality monitoring data using EPD's Excel template, available on GAEPD's website at: http://www.gaepd.org/Documents/techguide wpb.html#wappg;
    - Long-term habitat and biological monitoring data;
    - Copies of all field data sheets, laboratory taxa lists, macroinvertebrate multimetric spreadsheets and fish IBI and Iwb metric calculations; and
    - GIS coverages of the City's jurisdictional limits, service area and subwatershed delineations, unless already submitted.
c. Progress Report that includes:
    - Discussion of the monitoring data and results;
    - An evaluation of what the data shows in terms of water quality, the health of the biological communities, and any trends that are being shown by the data;
    - Specific actions or BMPs that have been implemented; and,
    - Summary of any changes and/or revisions to the Watershed Protection Plan, if necessary.

Table 8-28 Implementation Schedule

Fiscal Year (July 1 to June 30)	Management Action	Estimated Cost Range
2010-2011	Initiate coordination between City departments to allow for stormwater BMP planning as part of infrastructure improvement projects	
2011-2012	Identify areas in need of spot repairs (medium level restoration) through routine stormwater inspections; schedule priority repairs for the upcoming 1–2 years	
	Select one BMP project based on BMP modeling results and City resources for implementation in fiscal year 2013–2014	
2012-2013	Conduct spot repairs on small, actively eroding areas identified through stomwater inspections	
2013-2014	Continue with spot repairs on small, actively eroding areas identified through stormwater inspections	
	Acquire property for the selected BMP project site	$0–$32,400
	Conduct design and engineering for the BMP measure	$3,600–$73,400
	Construct the BMP measure	$14,400–$293,500
	Select a stream restoration site (high level restoration) based on Protection Plan recommendations and begin detailed site investigation to determine scope of work and costs	
2015-2016	Design and construct the selected stream restoration project	$18,000–$366,900

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