The Unadulterated Facts

ACCG Summary of SB 299

Current DNR rules require 150-ft stream buffers on waters seven miles upstream of drinking water reservoirs and intakes, allowing some variances if other water protection measures are taken. This bill will allow for diminishment of those buffers so long as the water treatment facility remains able to clean the water to drinking standards. The state's 25-ft (all streams) and 50-ft buffers (trout streams) are not impacted by this legislation.

Here is a link to the legislation: http://www.legis.ga.gov/Legislation/20132014/137628.pdf

Georgia Environmental Planning Criteria

The Georgia Department of Natural Resources *environmental planning criteria a*re the part of the Minimum Planning Standards that deals specifically with the protection of water supply watersheds, groundwater recharge areas, wetlands, river corridors, and mountains. These criteria were developed by the Department of Natural Resources (DNR) as mandated in Part V of the Georgia Planning Act and in the Mountains and River Corridors Protection Act.

Here is a link to the Environmental Planning Criteria:
http://www.dca.state.ga.us/development/planningqualitygrowth/programs/downloads/EPC.pdf

391-3-16-.01 Planning Criteria for Water Supply Watersheds

Among other measures, the water supply watershed planning criteria require that the corridors of all perennial streams in a large water supply watershed tributary to a water supply reservoir within a seven (7) mile radius of the reservoir boundary to have:

1. A buffer shall be maintained for a distance of 100 feet on both sides of the stream as measured from the stream banks.

2. No impervious surface shall be constructed within a 150 foot setback area on both sides of the stream as measured from the stream banks.

3. Septic tanks and septic tank drainfields are prohibited in the setback area of the above.

These 150-ft buffers have been controversial since their inception, particularly in North Georgia, with concerns that such a wide swath would use up all buildable land due to steep slopes and numerous streams. The violation of property rights and governmental “takings” are always mentioned in these concerns.

The Unadulterated Facts

DNR Task Force and Rules to Propose Alternatives to the 150-ft Buffer

Following unsuccessful legislation to significantly limit these buffers, in 2007, a task force convened by DNR recommend alternatives to the 150-ft buffer. The task force's recommendations were adopted by the DNR board. **Both the rule change and a summary table are attached for your review**.

It is important to note that no local government has adopted any of these alternatives since their inception. Many believe that they are too complex and are too difficult and expensive to understand and implement. That wasn't the intent of the task force, but it may be the case. The goal was to find alternative measures that would just as adequately protect water quality for several counties seeking relief.

Senate Bill 299 as it Impacts the Planning Criteria

The above DNR rules contain the sentence "the rules establish a basis to be used by local governments to allow development of a water supply watershed without contaminating the water source to a point where it cannot be treated to meet drinking water standards." This is similar to the new sentence in SB 299.

A different new sentence in SB 299 saying local governments are to submit watershed protection plans is current EPD practice and has always been part of the EPD rules. This is nothing new or needed as local governments are already required to submit these plans.

The main new aspect of SB 299 is removing 'shall" and replacing it with "may" in terms of what is in a watershed protection plan. This opens the door to eliminate the 150-ft buffers.

The Bottom line is that passage of SB 299 will give the DNR Board the statutory authority to remove buffers in their entirely from the rule. Proponents maintain that DNR/EPD needs flexibility, and will still require whatever measures are necessary to protect water quality. Opponents argue that this will not guarantee the protection of water quality.

Keep in mind that the statewide 25-ft buffer for all streams, and 50-ft buffers for trout (cold water) streams will remain intact and are not affected by SB 299.

Why do I support this bill?

- Protecting our drinking sources are of concern and importance to our local governments and their citizens
- Buffers in the State of Georgia currently exist; Warm water and Cold water buffers being 25' and 50' respectively
- Studies from both UGA and NC State have shown that in most cases 50' vegetative buffers are more than adequate for protecting our streams
- This bill allows our local governments and their citizens to craft watershed plans that will be specific to the terrain, vegetation, ecosystems, and land use of local and distinct areas in our state
- The existing requirement of 300' has multiple side-effects and problems for many areas, particularly in North Georgia
    - Our best usable land in North Georgia is along our rivers. For decades families have farmed this land. A 300' buffer will impede over 9,300 acres of land in Lumpkin County alone.
    - Entire parcels will be eliminated from use and deemed worthless
    - Lumpkin County currently is occupied by a permanent vegetative buffer known as the U.S.F.S. They conserve and maintain 1/3 of our total land area in the county.
    - 300' is an arbitrary number that seeks to be a once size fits all number when in fact, less buffer is more than adequate along the thousands of small streams in Georgia
    - Why not use an existing buffer that folks are accustomed to and have been socialized to accept instead of imposing an additional and arbitrary number on the whole state?
    - Take, for example, a perennial stream that has base flow for one day out of the year. Such a stream is considered waters of the state and a buffer is currently imposed. This would include springs that may pop up out of the ground when the water table rises one day out of the year. A 300' buffer would render useless properties and would impose barriers far beyond what is necessary to preserve and protect our reservoirs.
    - Show exhibits
    - Our citizens are being asked to give up an exorbitant amount of property without due compensation. This is an affront to all we as Georgians believe when it comes to property rights.
- In 2001, Lumpkin County began construction of its Yahoola Creek Reservoir. A permit was obtained by the City of Dahlonega in 2004 to withdraw drinking water from this source. Since then, the county has refused to adopt the 300' buffers because of the enormous negative impact they would have on the land owners upstream from this reservoir. For 14 years, Yahoola Creek Reservoir has been used exclusively by the City of Dahlonega to provide drinking water to its customers. Treatment of this water has never been extraordinary, but rather we have some of the purest and cleanest waters in the state. So, WITHOUT 300' buffers in place in Lumpkin County, we have operated a limited withdrawal permit and maintained exceptional water quality. Unfortunately, our citizens continue to pay debt service for a reservoir we cannot use because of the current buffer requirements that we simply cannot afford to implement.

Buffers (specifically vegetative) are used and meant to protect from a number of issues concerning water quality.

1. Sedimentation, turbidity
    a. We currently maintain and restrict our sedimentation through a 50' vegetative stream buffer that is more than sufficient to control such pollution.
2. Reduce nitrates, phosphates – These are nutrients for trees
    a. Nitrates travel through the soil not the surface and therefore need good roots systems to absorb them and keep them from the water
    b. These are caused primarily by cattle, septic absorption fields, and fertilizers
    c. Arbitrary buffer widths cannot possibly remove these from the water system.
3. The real problem with buffers not working is not about the width but about enforcement. When developers and land owners cut into buffers and scar property this causes obvious problems. The state professional groups are and have been working diligently to implement better enforcement mechanisms and have been successful. They have begun at the design phase and required professionals like myself to become educated and aware of buffers importance and the ways to protect our streams from pollutants.

As someone who desires to protect our drinking water sources, while protecting the rights of our local land owners, I strongly believe the best practice is to allow the local jurisdictions implement their own watershed management plans that meet local needs, while adhering to state water quality standards. In no way does a 300' one size fits all buffer approach guarantee water quality. I am asking that SB 299 be approved by this body and allow a more sensible approach be brokered.

Lumpkin County Watershed Research Committee
Agenda
June 10, 2014

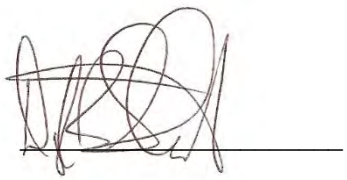
I. Call to Order
II. Approval of Meeting Minutes
III. Presentation of Data/Information
    a. Identifying the problems
    b. Quantifying the Problems
    c. Find study of road impacts
    d. Set and determine baselines
    e. How to implement and promote buy-in from public of plan
IV. General Discussion
V. Set Tasks for Next Meeting
VI. Motion to adjourn

Lumpkin County Watershed Research Committee
Agenda
May 27, 2014

I. Call to Order
II. Approval of Meeting Minutes
III. Presentation of Data/Information
    a. Identifying the problems
    b. Quantifying the Problems
    c. Find study of road impacts
    d. Set and determine baselines
    e. How to implement and promote buy-in from public of plan
IV. General Discussion
V. Set Tasks for Next Meeting
VI. Motion to adjourn

Lumpkin County Watershed Research Committee
Summary Meeting Minutes
April 15, 2014

I. Call to Order
   a. Commissioner Sherrill called the meeting to order at 6:03 P.M. in the downstairs conference room of the admin building
II. Introductions of Members and the Public present
   a. Members Present were:
      i. Kenneth Beasley
      ii. Mark Anderson
      iii. Rhett Stringer
      iv. Larry Reiter
      v. Robert Fuller
      vi. Sam Johnson
      vii. John Jarrard
      viii. Tracy Grizzle
      ix. Doug Sherrill
   b. Members Absent were:
      i. Mark Shearer
      ii. Hoyt Robinson
III. Discussion of Intent of Committee
   a. General discussion of tasking committee and advisory role on behalf of the Board of Commissioners
   b. Discussed handouts and defined basic terms for watershed management
IV. Discussion with Senator Gooch
   a. Senator Gooch discusses history of reservoir and SB299, fielding questions from the committee
V. General Discussion
   a. Discussed intent of committee and goals as we move forward
   b. Discussed items to accomplish prior to next meeting and assigned such items to committee members
VI. Motion to adjourn
   a. Motion to adjourn at 7:35 P.M.



Chairman of Committee

Doug Sherrill, District 1 Commissioner

Lumpkin County Watershed Research Committee
Meeting Minutes
April 29, 2014

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      viii. Mark Shearer
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   c. Members Absent were:
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      ii. Tracy Grizzle
II. Approval of April 15, 2014 Meeting Minutes
   a. Robert Fuller Made motion, Seconded by Mark Anderson; All approved
III. Presentation of Data/Information
   a. Fuller discusses sampling and recommends ideas
   b. Reiter discusses and presents land use classifications within the watershed
   c. Committee discusses options for sampling, water quality issues, watershed distinct from water itself, federalism, costs to county, stakeholders
IV. General Discussion
   a. Land Values
   b. Costs to implement plan
   c. Buffers and their importance
   d. Controlling types of land use
   e. Cheap BMP's
   f. Discussed meeting's accomplishments
V. Set Tasks for Next Meeting
   a. Identifying the problems
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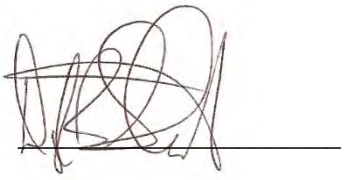

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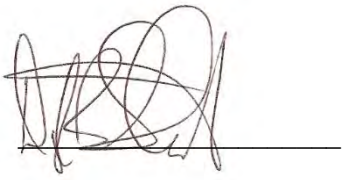

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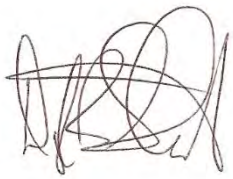
   b. Discussed handouts and defined basic terms for watershed management
IV. Discussion with Senator Gooch
   a. Senator Gooch discusses history of reservoir and SB299, fielding questions from the committee
   b. Senator Gooch said the EPD will need to adopt new rules relating to the passage of SB299 that better address such issues as property rights
   c. Senator Gooch mentioned that he would be willing to help facilitate a meeting with the EPD and the committee
   d. Dr. Fuller asked Senator Gooch if the legislature would be more willing to support funding of the EPD for better enforcement
   e. Dr. Fuller said his approach and other's should be 'Do no harm'
   f. Gooch concluded by discussing potential options within the plan to include: various land uses and density restrictions
V. General Discussion
   a. Discussed intent of committee and goals as we move forward
   b. John Jarrard said problems with contamination of watershed, in his opinion, included sedimentation and nutrient loading i.e. nitrates and phosphates.
   c. Larry Reiter discussed soil erosion and the problems it causes; the importance of stabilization of land disturbance and proposed reducing the time of stabilization from 14 days to 7 days.

d. John Jarrard mentioned helping farmers better implement BMP's; he sees no problems currently with water quality issues but a shallow reservoir and rising temperatures. He said something should be done to prevent future problems.
e. Mark Anderson asked what the existing quality of the water happened to be. Jarrard believes it to be some of the best water in the state. Dr. Fuller said we need data and should have monitoring.
f. Sam Johnson mentioned the importance of stream buffers as they relate to trout health; he said Brook Trout are the only native trout in the waters and that there exists empirical evidence that says reduction in buffers harms fish and habitat. Johnson thinks buffers should be based on use of land.
g. Mark Anderson discussed buffers sizes and questioned evidence for varying sizes
h. Larry Reiter discussed regulation options and the watershed plan. Reiter elaborated on the Georgia Blue Book and its methodologies relating to maintenance of structural BMP's. He says vegetative are always the best to implement.
i. Jarrard says the city has data on the watershed study and can provide such to the committee if needed.
j. Dr. Fuller asks if long term data exists for water quality and again recommends long-term monitoring
k. Kenneth Beasley says he can have the NRCS provide help and expertise to the committee
l. Reiter says stormwater problems are largely due to bank erosion because there has been no historical regulations in place, despite current ordinances that help mitigate sedimentation
m. Discussed items to accomplish prior to next meeting and assigned such items to committee members
n. Reiter says he will prepare GIS data for land use
o. Jarrard says he will work on data
p. Dr. Fuller says he will begin determining if interns can help

VI. Motion to adjourn

a. Motion to adjourn at 7:35 P.M. Dr. Fuller made the motion to adjourn and Beasley seconded the motion. All in favor, none opposed.



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Chairman of Committee

Doug Sherrill, District 1 Commissioner

Lumpkin County Watershed Research Committee
Detail Meeting Minutes
April 29, 2014

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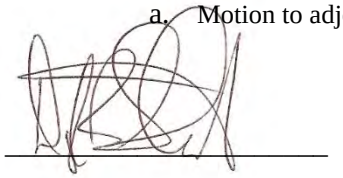
      viii. Mark Shearer
      ix. Doug Sherrill
   c. Members Absent were:
      i. Kenneth Beasley
      ii. Tracy Grizzle
II. Approval of April 15, 2014 Meeting Minutes
   a. Robert Fuller Made motion, Seconded by Mark Anderson; All approved
III. Presentation of Data/Information
   a. Fuller discusses sampling and recommends ideas
      i. Recommends 1 year of data
      ii. He prepared a sampling plan
      iii. He would like to see the county engage a consultant
   b. Reiter discusses and presents land use classifications within the watershed
      i. Reiter says current density is 6.6 acres per house in the watershed
      ii. Shearer inquired whether homeowners can be restricted from cutting trees
   c. Committee discusses options for sampling, water quality issues, watershed distinct from water itself, federalism, costs to county, stakeholders
      i. Jarrard says city takes weekly grab samples; 3 times a year they are more in depth downstream @ Hwy 52
      ii. Jarrard discusses EPD requirements for sampling
      iii. Shearer asks about the historical data existing and a year worth of data needed
      iv. Reiter states it does not matter about sampling when it comes to illegal activities
      v. Consensus was that a baseline of data is needed
      vi. Jarrard states that the discharge permit requires upstream sampling locations
      vii. Shearer inquires about the tolerance levels on water quality and whether the existing treatment facility operations have an adverse effect on water quality or otherwise
      viii. Sherrill discussed the importance of the existing city watershed plan
      ix. Shearer says the plan must include land uses, that it is the watershed we are protecting not just the water
      x. Fuller inquires whether or not a local law can trump at federal law and specifically if agricultural regulations can be passed at the local level
      xi. Sherrill discusses federalism as a general principle
      xii. Jarrard says we must educate the farmers and that education is very important to understanding BMP's
      xiii. Robinson inquires on the specific definition of a critical area
      xiv. Peters says that we should control and manage development; that density may need to be restricted in certain areas and that site plans may need to be required

xv. Fuller discusses water sampling costs and says possibly $10,000 for one year at 3 sites
xvi. Shearer says the county should invest in this important endeavor

IV. General Discussion
- a. Robinson says the landowner should be considered at the top of the list of stakeholders; that the college should be involved because of their large use of the water and maybe they should set up a department to help with this effort
- b. Shearer says permit for water is a revenue source and promotes economic development and that the plan will add stakeholders
- c. Jarrard says the city can save money the better the county plan is
- d. Robinson/Anderson/Peters all say the land is devalued because of restrictions; they mention the importance of property rights in the equation and want to know the value of land with restrictions
- e. Peters wants to know if the plan should foresee all watersheds
- f. Fuller says we should do no harm downstream; wants to quantify the potential for downstream harm but says there must be a balanced approach…maybe government should pay for impact to land
- g. Peters says should property owners be restricted if they can prove they are not harming
- h. Robinson discusses the Duke Energy crisis
- i. Shearer says just because a property owner thinks they are doing no harm doesn't mean it is so
- j. Fuller said he used to let his cows in the stream until he sampled it
- k. Reiter says more people means more pollution
- l. Shearer asks about buffers and the discussion is about defining buffers and their worth
- m. Shearer wants to know if we can control the type of development around a stream; i.e home business, Oil garage, etc.
- n. Robinson discusses the possibility of special zone monitoring
- o. Reiter says we could require special BMP's for development in this area
- p. Anderson inquires about stream flow, defining a stream and which ones should be included
- q. Discussed meeting's accomplishments
  - i. Problems generally identified
  - ii. Land development issues
  - iii. Density
  - iv. Smart land use and special planning

V. Set Tasks for Next Meeting
- a. Identifying the problems
  - i. Fuller discusses Roads, county and state practices
  - ii. Jarrard says city should be closely involved in water quality
- b. Quantifying the Problems
- c. Find study of road impacts
- d. Set and determine baselines
- e. How to implement and promote buy-in from public of plan

VI. Motion to adjourn
- a. Motion to adjourn at 8:00 P.M.



Chairman of Committee

Doug Sherrill, District 1 Commissioner

AGREEMENT IN PRINCIPLE

Management Principles	Option (i)	Option (ii)	Option (iii)	Option (iv)
Critical Area	1st 1 Mile 100'	------	-----	----
Setback	------	------	------	50'
Buffer Width	50'	75'	100'	100'
Public Education Implementation	X	X	X	
Diffuse Flow Requirement	X	X	X	
Declarations of Development on Deed and/or Plat	X	X	X	
Stormwater Ordinance	X	X	X	
Must Maintain LIA[1]	X	X	[3]	
Buffer Vegetation	X	X	[3]	
Monitoring Program	X	X	[3]	
Septic Tank Notification		X	[3]	
Septic Tank Inspection Every 7 Years	X			
10% EIA	X	X		

1 **Local Issuing Authority**

2 **Effective Impervious Area**

3 **Recommended But Not Required**

A) Allow one year of implementation of public education, LIA status, monitoring, stormwater ordinance, replant buffer, resolve multi-jurisdictional issues before buffer reductions allowed – must report and get approval from EPD.

DRAFT

ITEMS TO RESOLVE (ASSIGNMENTS):

A) New rules explicitly apply to all "perennial and intermittent streams": Definition of perennial streams (Doug Baughman)

B) 7 mile/multi-jurisdictional agreements (DCA - Mike Gleaton & Jim Frederick)

C) Hardship Variance (Julie Mayfield)

D) Grandfathering (Greg Blount)

E) Septic tank location (Bill Sapp, Gil Rogers, Shana Udvardy)

FINAL

Forsyth County Watershed Protection Plan

Prepared for

Forsyth County Water and Sewer Department

May 2006

CH2MHILL
115 Perimeter Center Place, NE
Suite 700
Atlanta, GA 30346

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Executive Summary

Forsyth County has experienced increasingly rapid growth over the last decade, which has changed watershed characteristics and increased demands on natural resources. In response to this growth, the County developed the Community Watershed Assessment and Management Plan (WAMP) in 2000 in conjunction with neighboring jurisdictions in the same watersheds (that is, Hall County and the City of Gainesville). The WAMP included an assessment of current watershed conditions and has been the foundation for watershed management and protection strategies for the County. Since the 2000 WAMP was developed, additional guidance was set forth from the Metropolitan North Georgia Water Planning District (District) in 2003 and the Georgia Environmental Protection Division (GAEPD) in 2005. This Watershed Protection Plan (WPP) is structured to comply with regulatory guidance and to provide comprehensive documentation of Forsyth County's existing and planned strategies for water quality maintenance and improvement.

Ultimately, recommendations for watershed protection in this plan will be incorporated into surface water withdrawal and wastewater discharge permits issued by the GAEPD. GAEPD guidance indicates that municipalities are required to integrate the District's watershed-specific protection plans and requirements directly into NPDES permits, while at the same time, linking compliance among water supply, wastewater, and stormwater permits. The GAEPD has indicated that failure to implement an effective watershed protection program will result in violation of the permit and/or denial of authorization for future permit requests.

The purpose of this WPP is to (1) summarize the existing and proposed programs that will be used to reduce nonpoint source runoff and improve water quality and aquatic integrity, and (2) describe current and future point source management strategies. Forsyth County's WPP includes a suite of activities to be implemented over time by multiple departments. The WPP is a living document based on an adaptive management approach that allows time to evaluate options and make optimal decisions on allocation of limited resources to achieve desired results.

Since the 2000 WAMP was completed, Forsyth County has performed a number of watershed-related activities including:

- Adopting more protective ordinances based on District models
- Developing a comprehensive land use plan
- Strengthening development reviews
- Instituting a Stormwater Management Program and adopting the Georgia Stormwater Management Manual (GSMM)
- Budgeting for watershed management and protection activities
- Developing and maintaining a schedule for implementation of watershed management and protection activities
- Identifying structural and non-structural best management practices (BMPs) to promote water quality

- Developing and implementing an environmental monitoring program that includes 303(d)-listed streams
- Participating in the Etowah Habitat Conservation Plan
- Following implementation plans for 303(d)-listed streams
- Submitting to GAEPD and the District annual reports that measure progress toward improving and maintaining watershed health

These activities and recommendations for future implementation are described in this document. The GAEPD has stated that implementation of the WPP will be coupled with regulatory permits for water and wastewater facilities. In cases where a degradation trend is identified, permit holders must modify the plan to address causes of the degradation. Permit holders will need to document that they have made meaningful progress in protecting water quality, as described in the guidance provided by GAEPD in March 2005.

Watershed Protection Plan

Introduction

This document, known as a Watershed Protection Plan (WPP), consolidates Forsyth County's watershed protection and stormwater management efforts. This WPP also updates information from the Watershed Management Plan, which was Chapter 7 of the original Community Watershed Assessment and Management Plan (WAMP), completed in 2000 as part of a multi-jurisdictional effort with the City of Gainesville and Hall County. The WPP is based on data and analysis from the County's Watershed Assessment (also part of the WAMP from 2000) and subsequent monitoring efforts, as well as recent regulatory guidelines. The main components of the WPP involve defining the problems within the watersheds and developing flexible, practicable solutions to the problems, based on the guidance from the Georgia Environmental Protection Division (GAEPD) and the Metropolitan North Georgia Water Planning District (District). The ultimate goal of the WPP is to develop a framework for a long-term program to protect and improve the County's watersheds, as well as restore streams to their designated uses. Through this integrated protection plan, specific actions and schedules are detailed to protect property, accommodate responsible development, and conserve and restore the ecosystems.

Ultimately, recommendations for watershed protection in this WPP will be incorporated into surface water withdrawal and wastewater discharge permits issued by the GAEPD. The GAEPD has indicated that failure to implement an effective watershed protection program will result in violation of the permit and/or denial of no authorization for future permit requests. Therefore, the County is developing programs that can be implemented in a timely manner and will provide measurable improvements in water quality. An adaptive management approach will continue to be taken in managing Forsyth County's water resources to integrate new requirements, while also balancing the County's limited financial resources.

Purpose and Approach

The purpose of this WPP is to (1) summarize the existing and proposed programs that will be used to reduce nonpoint source runoff and improve water quality and aquatic integrity, and (2) describe current and future point source management strategies. In addition, an approach is outlined for implementation of long-term monitoring of the overall watershed protection program and executionand funding of activities. This WPP will serve as the County's blueprint for protecting water quality and aquatic integrity. Revisions to this document will be included in an annual report submitted by the County to GAEPD and in annual reporting to the District.

The overall approach to watershed protection is designed to address the issues identified during the watershed assessment and impacts associated with anticipated changes in land use as the County continues to develop. Recommendations are focused on programs, policies, and protection actions that are most likely to improve water quality and aquatic integrity. When managed appropriately, these improvements do not have to detract from a

community's ability to accommodate continued growth. On the contrary, numerous metropolitan areas in the US have found that such improvements actually boost their "quality of life" image, and thus attract more residents and business interests who see value in maintaining a creative balance between continued growth and environmental stewardship.

Watershed Protection Plan Components

The original WAMP was organized around three major components (community-wide strategies for improving watersheds, new development requirements, and improving impacted areas). However, additional guidance from GAEPD has triggered a change in the organization of the WPP to reflect the most recent State and regional regulations. As a result, the main components of the WPP involve: (1) describing responsible legal authorities and funding sources for watershed protection and management, (2) identifying pollutant sources and monitoring water quality, and (3) developing feasible solutions to watershed problems while using the guidance from the GAEPD. The components described in the original WAMP from 2000 are still relevant to Forsyth County's watershed and stormwater activities, and this document is organized to provide information to update the original WAMP.

Regulatory Drivers

The regulatory guidelines that have driven the organization and content of this document include: (1) GAEPD Watershed Assessment and Protection Plan Guidance (GAEPD, 2005), (2) the District's Watershed Management Plan (District-wide WMP, CH2M HILL, 2003), and (3) other new guidelines from the District, such as model ordinances for stormwater, floodplain management, erosion control, conservation subdivisions, litter control, and stream buffers. The County has already implemented changes to comply with GAEPD and District regulations and guidance. For example, the County has revised its local ordinances to follow these guidelines and to enforce best management practices (BMPs) that protect and improve water quality.

As outlined by GAEPD (2005), watershed assessments are an integral part of the permitting process for new National Pollutant Discharge Elimination System (NPDES) wastewater permits. As part of the watershed assessment, the State requires the applicant to characterize the watershed, assess the water quality impacts from future development, and develop a protection plan to control water quality impacts. Regulatory guidance clearly states that "the owner will develop a control strategy to reduce the nonpoint source impacts of secondary development in the area." When GAEPD issues a new or expanded discharge permit, the applicant is expected to implement the strategies developed in the WPP according to a schedule included in the permit.

Due to its location within the District, Forsyth County is required to implement the recommendations (or equivalent) in the District-wide WMP (CH2M HILL, 2003). While the original WAMP includes recommendations similar to most of the recommendations in the District's plan, some updates regarding compliance activities are included in this WPP to fully meet the intent of the District-wide watershed management recommendations. The District has also developed model ordinances to promote watershed management and protection throughout the metropolitan Atlanta area. Forsyth County has met the intent of

all model ordinances, and continues to update ordinances based on revisions from the District. Ordinances are described in further detail in under "Legal Authority."

Phase I of the United States Environmental Protection Agency (USEPA) Stormwater Program was promulgated in 1990 under the Clean Water Act (CWA). Phase I relies on the NPDES permit coverage to address stormwater runoff from: (1) medium and large municipal separate storm sewer systems (MS4s) that generally serve populations of 100,000 or greater, (2) construction activities disturbing 5 acres of land or greater, and (3) 11 categories of industrial activities. In 1999, USEPA published the Stormwater Phase II Final Rule, which expands the Phase I program by requiring operators of small MS4s and operators of small construction sites (1 to 5 acres) to be covered by NPDES permits and to implement programs and practices to control polluted stormwater runoff. Forsyth County is included under the MS4 program as a Phase I community, and as such, will be required to implement the requirements for stormwater management found in the County's Stormwater Management Program (SWMP), approved by GAEPD in the fall of 2005.

There are significant overlaps between the WPP for the County's NPDES discharge permits, the District-wide WMP, and the MS4 Phase I requirements. This WPP sets forth the overall strategy Forsyth County will use to meet these various requirements.

Reporting Requirements

A report and certification of WPP implementation will be prepared each year and submitted to GAEPD and the District. This report will summarize all the data collected during the year and will interpret results concerning progress and any revisions to the WPP. The annual report will also include both hard copy and electronic versions of the water quality data, and biological data, if appropriate, for use by GAEPD. These data will be submitted in Microsoft Excel. Internal reports summarizing the condition of streams sampled for both the long-term and the short-term water quality monitoring will be prepared quarterly. This frequency will promote continuous review of the data and help to identify trends in water quality that may be of concern.

Legal Authority

The following sections describe those entities with watershed protection responsibilities in the Lake Lanier and the Upper Metro Chattahoochee and Upper Coosa River Basins, based on political jurisdiction and/or NPDES permit responsibilities. Legal authority for watershed protection in Georgia is generally related to political jurisdiction or an NPDES permit. In Georgia, as a home rule state, local governments maintain authority over all land use and zoning decisions within their jurisdiction and, as a result, have a significant influence on nonpoint source pollution and stormwater management. These political jurisdictions are typically the holders of the NPDES stormwater permits. Municipal point sources, such as Forsyth County's Fowler Water Reclamation Facility (WRF), are also regulated through the NPDES permitting system and have an associated service area for which the County is responsible.

Political jurisdictions, watershed boundaries, and service areas do not necessarily coincide, which generally makes stormwater and watershed management activities a challenge to

plan, fund, and implement. To ensure that watershed protection activities are implemented, GAEPD has provided guidance indicating that it will require integration of the District's recommendations on watershed-specific protection plans and requirements directly into an entity's NPDES permits, while at the same time linking compliance among water supply, wastewater, and stormwater permits.

Political Jurisdictions within Forsyth County Watersheds

In order to effectively implement watershed protection strategies, it is important to identify the responsible parties for the entire watershed. The following sections review the jurisdictions and other responsible parties that occur within the same watersheds as Forsyth County, including incorporated areas within the County and areas upstream or downstream of the County, as well as watershed protection groups. Contact information for responsible parties is located in Appendix A.

Surrounding Political Jurisdictions

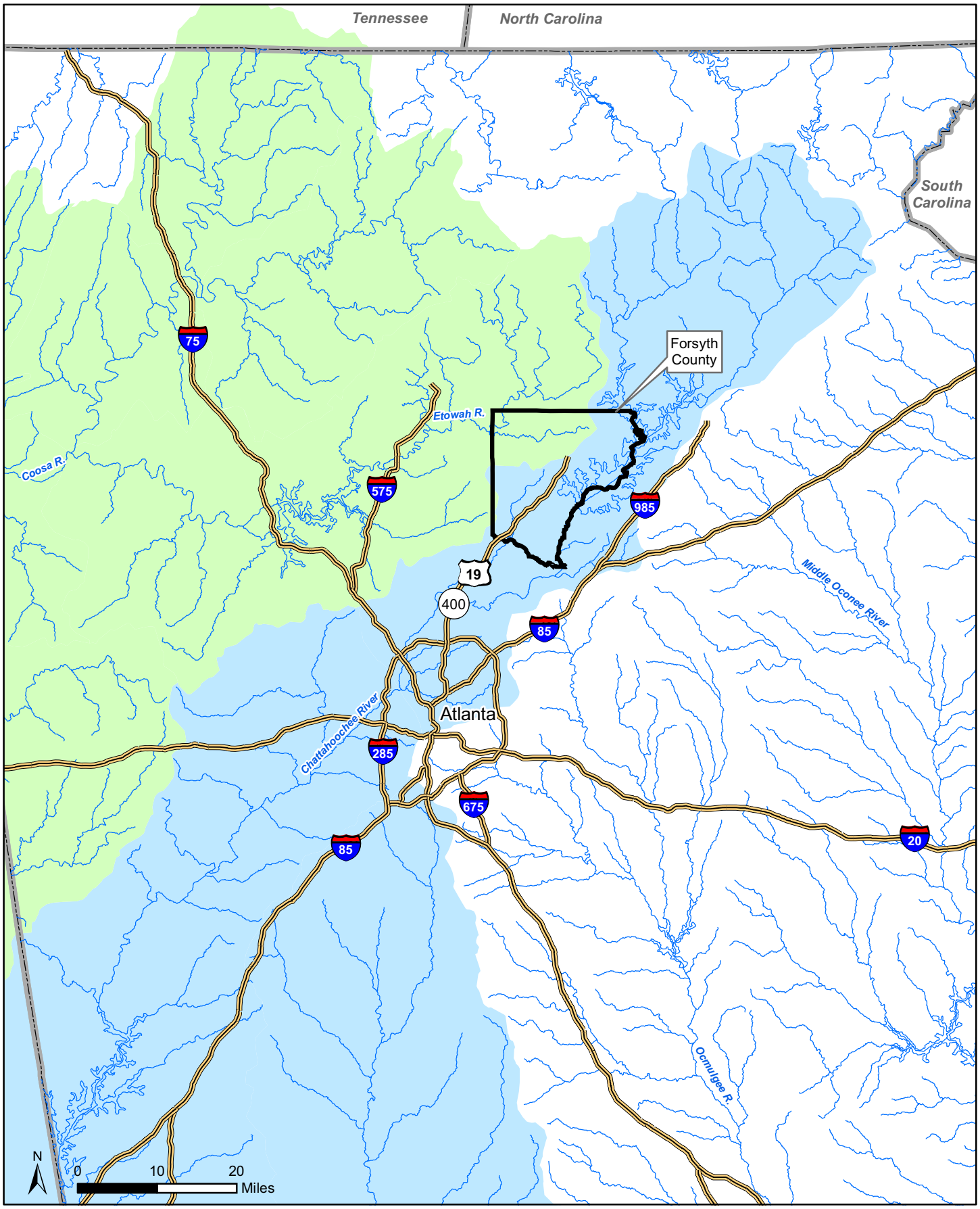
Forsyth County is located in two major river basins (see Figure 1), known as the Alabama – Coosa – Tallapoosa (ACT) and the Apalachicola - Chattahoochee – Flint (ACF), both of which ultimately drain to the Gulf of Mexico. The northwestern corner of the County, representing approximately 30 percent of total area, drains to the Etowah or Little River in the Coosa River Basin, while the rest of the County is in the Chattahoochee River Basin, draining either to Lake Lanier or to the river (see Table 1).

TABLE 1
Distribution of the County across Major Watersheds
Forsyth County Watershed Protection Plan

Major Watershed	Acres	Square Miles	Percent of County
ACT River Basin			
Etowah River	44,358	69.3	28 %
Little River	1,732	2.7	1 %
ACF River Basin			
Lake Lanier	53,361	83.4	34 %
Upper Metro Chattahoochee River	58,594	91.6	37 %
Upper Chattahoochee River	180	0.3	0 %
Forsyth County Total	158,225	247.2	100 %

Note: Table includes the City of Cumming

Table 2 and Figure 1 illustrate Forsyth County's contribution, relative to its neighbors, to the major watersheds in which it is located. The County is responsible for less than 1 percent of the Upper Chattahoochee watershed, upstream of Lake Lanier. However, the County is responsible for 42 percent of the tributary area draining directly to Lake Lanier. Hall County also represents a large portion of the Lake Lanier watershed (44 percent). Thus, Forsyth and Hall Counties play an important role in managing and protecting these waters.



Limited Access Road
River or Stream
ACT River Basins
ACF River Basins
Forsyth County Boundary
State Boundary

CH2MHILL

Figure 1
Basin Map
Watershed Protection Plan
Forsyth County, GA

File Path: \\boomer\l\projects4\Forsyth_Watershed\MXD\Basin_Map.mxd, Date: January 24, 2006, User: BBODINSO

TABLE 2

Political Jurisdictions in the Study Area (percent of acreage per watershed)
Forsyth County Watershed Protection Plan

Jurisdiction	NPDES MS4 Community Status	Upper Metro Chattahoochee	Lanier Tributaries	Metro Chattahoochee	Etowah River	Little River
Forsyth	Phase I	0.03%	42.2%	16.0%	9.4%	1.3%
Cumming	Phase II		1.4%	0.6%		
Cherokee	Phase II			0.3%	32.7%	46.8%
Canton	Phase II				2.0%	0.5%
Holly Springs	Phase II					2.3%
Woodstock	Phase II					4.1%
Cobb	Phase I			12.9%		22.6%
Marietta	Phase I			2.1%		1.1%
Dawson		1.8%	1.1%		25.9%	
Dawsonville					0.5%	
DeKalb	Phase I			13.3%		
Atlanta	Phase I			0.4%		
Chamblee	Phase I			0.6%		
Decatur	Phase I			0.4%		
Doraville	Phase I			0.7%		
Fannin					0.2%	
Fulton	Phase I			14.2%		18.5%
Alpharetta	Phase I			3.8%		0.3%
Atlanta	Phase I			8.1%		
Roswell	Phase I			6.1%		2.7%
Gwinnett	Phase I		1.7%	12.7%		
Buford	Phase I			2.4%		
Duluth	Phase I			1.4%		
Sugar Hill	Phase I			1.7%		
Suwanee	Phase I			1.9%		
Habersham		26.6%				
Hall	Phase II	19.1%	43.7%	0.4%		
Gainesville	Phase II	0.7%	6.8%			
Flowery Branch	Phase II		1.3%			
Oakwood	Phase II		1.8%			

TABLE 2

Political Jurisdictions in the Study Area (percent of acreage per watershed)
Forsyth County Watershed Protection Plan

Jurisdiction	NPDES MS4 Community Status	Upper Metro Chattahoochee	Lanier Tributaries	Metro Chattahoochee	Etowah River	Little River
Lumpkin		22.2%			13.1%	
Pickens					15.6%	
Jasper					0.6%	
Towns		0.3%				
Union		0.5%				
White		28.7%				

Incorporated Areas within the County

Although there are several other small, unincorporated communities in Forsyth County, the City of Cumming is the only incorporated area (see Figure 1 and Table 3). As a result, the City, a Phase II MS4 permit holder, and the County, a Phase I MS4 permit holder, share the primary watershed management responsibilities within Forsyth County. The City represents an area of approximately 3,760 acres, almost 6 square miles, located along State Route 400 in the center of the County. Most of the City, or 97 percent, drains into the headwaters of Big Creek or to the headwaters of several tributaries to Lake Lanier (see Table 3). However, recent annexations are extending the City south into the headwaters of the Dave's Creek watershed, as well. Unincorporated communities in Forsyth County include Brookwood, Ducktown, Heardville, Hightower, Big Creek, Matt, Coal Mountain, Midway, Shakerag, and Pirkle Woods.

TABLE 3
City of Cumming by Watershed Area
Forsyth County Watershed Protection Plan

	City of Cumming	
Watershed	Acreage	Percent Coverage
Big Creek	1,988	53 %
Dave's Creek	110	3 %
Sawnee Creek / Lake Lanier Tributaries[a]	1,662	44 %
Total Incorporated Area	3,760	100 %

[a] Not a community watershed since it is outside the study area

Watershed Protection Groups

Several watershed protection groups exist for the watersheds within Forsyth County. These watershed protection groups are comprised of concerned stakeholders and, in some cases, other organizations such as universities and local governments. The groups include:

- Upper Chattahoochee Riverkeeper
- Lake Lanier Association
- Upper Etowah River Alliance
- Etowah Habitat Conservation Plan

Their mission is generally to protect the watershed through public outreach/education, coordination with political jurisdictions, and development of watershed protection strategy recommendations.

Jurisdiction of Lake Sidney Lanier

The United States Army Corps of Engineers (USACE) has Proprietary or Managerial jurisdiction on USACE-managed Federal lands. Under Section 234 of the Flood Control Act of 1970, certain project personnel may enforce Code of Federal Regulations (CFR) Title 36 part 327. Also, under Section 10 of the Rivers and Harbors Act of 1899, as amended, and Section 404 of the Clean Water Act, certain USACE personnel may enforce portions of CFR Title 33 part 200. The State of Georgia and its political subdivisions retain statutory responsibility to enforce State and local laws.

Congress authorized construction of Lake Lanier in 1946. It became the northernmost link in a series of USACE-built lakes on the Apalachicola-Chattahoochee-Flint River system. Construction was started in 1951 and completed in 1956, and the lake was fully operational in 1958. The project's purposes (the first three are specific, congressionally authorized purposes, while the latter three arise from general statutory authority) are:

- Flood control – During times of heavy rainfall, runoff waters stored in the lake protect thousands of downstream homes, businesses, and farmlands from flooding.
- Hydroelectric power production – Electricity produced by the powerhouse generators provides pollution-free energy for peak demand.
- Navigation – Water stored in Lake Lanier can be released to increase downstream river depths, allowing commercial barge navigation of the Lower Chattahoochee River.
- Water supply and water quality – Water stored in the lake is the major water source for 50 percent of the population of Georgia.
- Recreation – Millions of visitors annually enjoy the recreational opportunities provided by the lake.
- Fish and wildlife management – The USACE and GADNR work jointly to implement management plans to ensure protection and enhancement of these resources.

Code and Regulation Responsibilities

Forsyth County has followed GAEPD and District guidelines to establish local rules, plans, and procedures for effective implementation of watershed and stormwater management activities. These regulations are adjusted as guidelines from GAEPD and the District are reissued and updated. The following paragraphs review the County's local ordinances, land use plan, development approval procedures, the County's SWMP required by the MS4 permit, water and sewer upgrades, the County's Parks and Recreation program, and the Greenspace Program.

Ordinance Revisions

Since local ordinances are critical to watershed management, the District-wide WMP recommended changes to local and State laws, regulations, and ordinances that would facilitate implementation of watershed management strategies. The District Board adopted six model ordinances to help ensure consistency in watershed management practices:

- Model Ordinance for Post-Development Stormwater Management for New Development and Redevelopment
- Model Floodplain Management/Flood Damage Prevention Ordinance
- Model Conservation Subdivision/Open Space Development Ordinance
- Model Illicit Discharge and Illegal Connection Ordinance
- Model Litter Control Ordinance
- Model Stream Buffer Protection Ordinance

These District model ordinances are a key requirement of the local stormwater management program activities described in the District-wide WMP. Forsyth County revised its Code of Ordinance, identified in Table 4, to meet the intent of the six District model ordinances. County staff initiated an extensive revision process to not only complete this task but to also revise the entire Unified Land Development Code in 2004. Final revisions to ordinances noted in Table 4 were presented to the Board of Commissioners for review and adoption in June 2004.

Since adoption of the Model Stream Buffer Protection Ordinance, the County has made additional revisions to its ordinances to clarify and expand on variance procedures and definitions for stream buffers. These revisions are currently released for public comment and are expected to be adopted later in 2006. Revisions to the ordinance include updates to definitions, information about variance requests, mitigation requirements, and more specific text regarding exemptions. Details regarding the specific revisions will be reported after the ordinance has been adopted.

The District finalized revisions to the Model Floodplain Management/Flood Damage Prevention Ordinance in February 2006, including: (1) a better definition of the "future-conditions" floodplain, (2) mapping requirements for local governments, and (3) procedures for development approvals in areas that have not been mapped. Forsyth County is developing revisions to their existing floodplain ordinance to follow the recommended revisions from the District. For these revisions and others that may occur later, Forsyth County will revise corresponding ordinances to meet the updated District guidelines after the model ordinance revisions are finalized.

TABLE 4
Summary of Recent Revisions to Forsyth County Code of Ordinances and Unified Development Code
Forsyth County Watershed Protection Plan

Model Ordinance	Forsyth Reference	Comments
Model Ordinance for Post-development Stormwater Management for New Development and Redevelopment	Chapter 34, Article V. Stormwater Management (Ordinance No. 75) UDC Chapter 18-5.14, Drainage System. Tables 18.1 and 18.2. Forsyth County Stormwater Design Manual	Significant changes completed: – Adopted GSMM with Revised Forsyth County Stormwater Design Manual as an addendum – Revised applicability and added “Hot Spot” language – Revised definitions – Added requirement for Inspection and Maintenance Agreements
Model Floodplain Management/Flood Damage Prevention Ordinance	Chapter 46. Floods (Ordinance No. 55) Chapter 34, Article VI Regulated Floodplain for Big Creek (Ordinance No. 7)	Significant changes completed: – Combined two existing ordinances into one – Revised Definitions – Added requirements for plan review of the administrative (future) floodplain – Revised language to prohibit all new construction in floodplain
Model Conservation Subdivision/Open Space Development Ordinance	UDC Chapter 19, Conservation Subdivisions Ordinance No. 30, Comprehensive Zoning & Land Use	No changes necessary, met intent of model ordinance
Model Illicit Discharge and Illegal Connection Ordinance	Chapter 34 Environment, Article V. Stormwater Management. Sec. 34-187. Prohibition and illicit connections Road Drainage Code. Ordinance No. 15, Chapter 6. Material to be kept out of drainage system. Adopted 4/23/1984	No changes necessary, met intent of model ordinance
Model Litter Control Ordinance	Road Drainage Code. Ordinance No. 15, Chapter 6. Material to be kept out of drainage system. Adopted 4/23/1984 Ordinance No. 84 Article III, Litter Control	No changes necessary, met intent of model ordinance
Model Stream Buffer Protection Ordinance	Chapter 3. Definitions Chapter 18. Subdivisions and Land Development	Significant changes completed: – Revised Definitions – Added several references to the Georgia Stormwater Management Manual – Added new section (Article X) to provide additional support

Forsyth County Comprehensive Plan

The County's current Comprehensive Plan, adopted by the Board of Commissioners in February 2004, covers a time period from the present to 2025 and is designed to meet the requirements of the "Minimum Planning Standards and Procedures for Local Planning" of the Rules of the Georgia Department of Community Affairs, Chapter 110-12-1. The purpose of the Plan is to guide the intensity, location, and timing of new development and redevelopment and to ensure compatibility with existing development, future population and economic development trends, community infrastructure, and natural and cultural resources.

The plan is divided into 11 parts:

- Population
- Housing
- Economic Development
- Natural Resources
- Cultural Resources
- Community Facilities and Services
- Land Use
- Transportation
- Intergovernmental Coordination
- Implementation Program
- Capital Improvements

The intent of the land use element of the Comprehensive Plan is to guide all new development and redevelopment within the County to ensure that it is compatible with existing development. Additionally, the land use element is meant to ensure that the development is of high quality, is environmentally sensitive, and is based on the County's vision and goals. Development in Forsyth County has followed traditional development patterns of urban sprawl, moving from the City of Atlanta along major road and rail corridors. Road construction was the driving force in determining locations for land use with unrestricted development.

Table 5 shows the allocation of land uses in Forsyth County in 2003. Almost half, or 49 percent, of the County remained either undeveloped, in agricultural use, or set aside as park lands. Thirty-eight percent of the County was in residential use, while almost 5 percent was being used for commercial or industrial purposes. Forsyth County's Future Land Use Plan identifies and defines 18 land use categories that were consolidated to represent the categories in Table 5. It projects that by the Year 2025, over two-thirds of unincorporated Forsyth County, approximately 70 percent, will be in a low, medium, or high density residential use.

TABLE 5
Forsyth County Comprehensive Plan Existing and Future Land Use
Forsyth County Watershed Protection Plan

Land Use Category	Existing Percentage (2003)	Future Percentage (2025)
Residential	38.1%	70.6%
Undeveloped	27.0%	1.6%

TABLE 5
Forsyth County Comprehensive Plan Existing and Future Land Use
Forsyth County Watershed Protection Plan

Land Use Category	Existing Percentage (2003)	Future Percentage (2025)
Agriculture	16.1%	0.0%
Parks/Recreation/Conservation	6.3%	6.0%
Road Right-of-Way (ROW)	6.1%	6.1%
Industrial	2.9%	5.4%
Commercial	1.9%	6.5%
Institutional/Public	1.5%	1.3%
Transportation/Communications/Utilities (TCU)	0.1%	3.0%
Landfill	0.0%	5.0%

Source: Forsyth County Comprehensive Plan 2004 - 2025 from http://www.forsythco.com/department.asp?DeptID=53Forsyth.

Development Review

Providing adequate staff and resources for the review of new development or redevelopment and their compliance with the County's Unified Land Development Code is essential to the success of Forsyth County's WPP. The three primary departments with planning, review, and implementation responsibilities associated with watershed protection are the Planning, Engineering, and Water and Sewer Departments. Forsyth County also reviews land-disturbing activities within 2,000 feet of either bank of the Chattahoochee River for compliance with watershed protection guidelines in the Georgia Metropolitan River Protection Act (MPRA). Section 2.3 of Forsyth County's SWMP currently details the planning procedures and criteria for new development and redevelopment as follows. When the SWMP is revised, this procedure may be refined or changed depending on the County's needs to make procedures as streamlined and robust as possible:

Step 1: Plan Submittal-- All plans and supporting documents for new developments and redevelopments are submitted to the Department of Planning and Development except for initial submittals of Final Plats. Final Plats are submitted for review to the Department of Engineering along with the following supporting information:

- Dedication Stamp on Plats
- Right-of-Way Warranty Deed for all road ROWs
- Attorney's Title Certificate for all roads
- Performance Bond in the amount specified by the Department of Engineering
- Maintenance Bond on all roads in the amount specified by the Department of Engineering with an expiration date of no less than 18 months for the date of the Final Plat is approved
- Real estate transfer tax declaration
- Stormwater Facilities Inspection and Maintenance Covenant

Step 2: Plan Review Meeting-- Following Step 1, a plan review meeting is held by the Planning Department with a representative of each reviewing department present to distribute comments back to the developer and/or their agents for corrections, if necessary. The additional documentation submitted with Final Plat applications is

presented to the County's Legal Staff for review and certification. Any problems with these items will be handled between the County's Legal Staff and the developer's attorney. Once certified, the Legal Staff will return the documents to the Department of Planning and Development.

Step 3: Walk Through-- After the departmental comments have been addressed, and the corrections to the plans are made, the developer and/or their agent returns to each reviewing department to provide evidence that the required changes have been made. If the changes are satisfactory to the reviewing department, then said department may sign-off on the Application for Plan Approval and affix their departmental stamp to the plans.

Step 4: Plan Approval-- The developer and/or their agent will deliver to the Department of Planning and Development the plans approved by the other reviewing departments, with the appropriate stamps affixed, and the completed Application for Plan Approval with the signature of the respective departmental plan review personnel.

The Planning Department will verify that the reviewing departments have signed the Application for Plan Approval and stamped the plans. If any department has given conditional approval, said department must list under what conditions their approval is granted. Said conditions must be in letter-form on departmental letterhead, indicating the project and date of conditional approval, and delivered to Planning and Development prior to, or concurrent with, the sign-off of the plans granted conditional approval. In any conditional approval, the person so conditioning the plans must sign the letter of conditional approval and print their name for further clarification.

After the Department of Planning and Development has verified that all plans and supporting documents are true and correct, the Director, or his designee, will sign-off on the plans and supporting documents. In the case of subdivision construction plans and final plats, the Forsyth County Planning Commission, or their representative, must participate in the final approval. Final Plats will be ready for recording after all final approvals of the plats have been granted, and the legal documentation required has been approved by the County's Legal Staff.

After a final plat is approved and recorded, the Department of Engineering will schedule the ROW documents for the next scheduled Board of Commissioners' hearing. The Board of Commissioners will either accept or reject the ROW for County maintenance. Once the Board of Commissioners accepts the ROW, the Department of Engineering will record the deeds.

Step 5: Pre-construction Conference-- Grading permits will be issued after approvals have been granted by the appropriate reviewing departments. The permit is issued at a pre-construction conference with the Department of Engineering, the department responsible for inspection of the development site.

Step 6: As-built Policy-- An as-built is a civil drawing depicting completed commercial development and construction, as it exists in the field. As-builts are required to be submitted to the Department of Planning and Development on all commercial and industrial sites. The as-built should be submitted at around 90 percent completion of the site, sometime between the rough plumbing inspection and the final building inspection.

Upon approval of the as-built, the applicant may schedule the final building inspection. The Department of Engineering, Department of Water and Sewer, and Department of Planning and Development (including County Arborist) are responsible for reviewing the as-built application.

Stormwater Management Program

The Storm Water Phase I Rule (55 CFR 47990; November 16, 1990) requires all operators of medium and large MS4s to obtain an NPDES permit and develop a SWMP. In Georgia, GAEPD is the delegated State agency to administer the NPDES MS4 program. The program is designed to prevent harmful pollutants from being washed by stormwater runoff into the MS4 (or from being dumped directly into the MS4), then discharged from the MS4 into local water bodies.

The Environmental Protection Agency (EPA) did not develop baseline general permits for stormwater discharges from MS4s because of the wide range of conditions in different parts of the country and the varying water quality impacts on receiving waters. However, the SWMP must meet the standard of "reducing pollutants to the Maximum Extent Practicable (MEP)." EPA did not define MEP, thereby allowing flexibility in the development of site-specific permit conditions based on internal knowledge of the jurisdiction. The SWMP should include measures to accomplish the following tasks:

- Identify major outfalls and pollutant loadings
- Detect and eliminate non-stormwater discharges to the system
- Reduce pollutants in runoff from industrial, commercial, and residential areas
- Control stormwater discharges from new development and redevelopment areas.

Forsyth County's SWMP was completed and approved in 2005 and is supported by the County's use of the Georgia Stormwater Management Manual (GSMM) and recent revisions to its Code of Ordinances to meet the intent of the District Model Stormwater Ordinances. The long-term planning horizon of the District and Forsyth County's SWMP supports an adaptive management approach that allows time to evaluate options and make optimal decisions on allocation of limited resources to achieve desired results. More information regarding the SWMP activities is presented in the section of this document titled, "Best Management Practices."

Water-Supply Watersheds and Water Intake Facilities

There is one water intake facility in the Forsyth County study area. The City of Cumming facility withdraws water from Lake Lanier and some of this water is then pumped to the Forsyth County Water Treatment Facility. Prior to April 2000, the County's water was supplied almost exclusively through wholesale purchases from the City of Cumming and Fulton County. Beginning in April 2000, the Forsyth County began to produce its own potable water with the commissioning of the Forsyth County Water Treatment Facility (WTF). The County's water system consists of a raw surface water supply with a monthly average allotment of 14 million gallons per day (mgd) and a maximum daily withdrawal of 16 mgd. Current limitations at the raw water pump station restrict the amount of raw water that can be withdrawn and treated by Forsyth County to 11.9 mgd. Forsyth County's water system includes a 13.93-mgd water treatment plant and a water distribution system contain-

ing approximately 725 miles of water mains. Forsyth County and the City of Cumming are in the process of retrofitting portions of the raw water pump station to allow for raw water pumping capacity equal to the permitted treatment capacity.

All of Forsyth County drains either directly or indirectly to a water-supply watershed. These areas are governed by State Rules for Environmental Planning (Part V criteria) which were created to protect surface water supplies used for drinking water. The planning criteria vary based on the size of the water-supply watershed and proximity to the intake location.

Most watersheds in Forsyth County, including the Etowah River, Settingdown Creek, and Chattahoochee River are large water-supply watersheds (> 100 square miles) and are outside of a seven-mile radius of a water intake facility, which means that no impervious cover restrictions apply to them as a result of Part V criteria. However, the Etowah and Chattahoochee Rivers also fall under the "protected river" definition in the Part V criteria. As a result, a River Corridor Protection Plan has been adopted for the Etowah River. Part V criteria for the Chattahoochee River are superseded by MRPA, which provides regulations to manage and protect the Chattahoochee River within a 2,000-foot corridor on both sides of the river. Forsyth County is required to review all land-disturbing activities and certify that development follows guidelines for watershed protection in MRPA. Although there is a water intake facility for the City of Cumming and Forsyth County within the Lake Lanier watershed, the Part V criteria do not apply to Federal lakes.

Because the Big Creek watershed is a small water-supply watershed (less than 100 square miles), additional stream buffer requirements and impervious cover restrictions apply to this portion of Forsyth County. Moreover, the City of Roswell has a water intake facility that is located less than 7 miles from Forsyth County, requiring the County to adopt stricter restrictions for the portion of the watershed within 7 miles of the water intake facility. Depending on if the location in the watershed is within or outside 7 miles from the water intake facility, Part V criteria for the Big Creek watershed include a buffer distance of 50 or 100 feet along streambanks with an impervious and septic system setback of 75 or 150 feet from the streams. Other criteria apply to small watersheds such as Big Creek, including synthetic liners/leachate collection systems for landfills, no new hazardous waste treatment or disposal areas, limitations for existing hazardous waste treatment areas, and a limitation of 25 percent impervious cover.

Sewer Lines and Wastewater Reclamation Facilities

The majority of the County's population is still served by septic tanks and privately owned land application sites. Approximately 38 percent of Forsyth County's population (about 48,000 people) is served by private and public sewerage system. Thus, Forsyth County sewer lines are relatively new (mostly built after 1993) and are being sized so that they will be half full in 2025. The County does not have a large number of rehabilitations or upgrades to the relatively new existing sewer lines, although a contractor has been hired to inspect and address any inflow and infiltration problems. The County has ordinances in place to require public sewer as the sole sewage disposal option when any portion of the development is within 5000 feet of a public sewer line and the public sewer line can accommodate the anticipated effluent load. According to the 2005 Engineer's Report Water and Sewerage Revenue Bonds, the County's goal is to provide sewer service to 85 percent of

its new population and extend service to current private and septic tank owners at a measured pace.

Wastewater reclamation facilities (WRF) are the treatment centers and discharge points for household and industrial sewage. Wastewater is collected by gravity sewers and transported to the treatment facility via pump stations and force mains. Flow from the sewers is treated at the facilities and discharged to streams. The permitted treatment capacity of all County-operated treatment facilities is 2.01 mgd. This requires that a portion of the wastewater generated in Forsyth County be treated by private utilities, City of Cumming, and Fulton County through an intergovernmental agreement (Table 6). The City of Cumming has a WRF that discharges to Big Creek within the City limits.

TABLE 6
Intergovernmental Agreements for Water Reclamation Services
Forsyth County Watershed Protection Plan

Cooperating Agency	Date of Original Agreement	Agreement Expiration Date	Contracted Capacity (mgd)	Current Utilization (mgd)
City of Cumming				
Big Creek	1997	No expiration – purchased capacity	0.5	0.083
Fulton County				
Big Creek	February 6, 1980	February 6, 2030	1.25	0.94[a]
John's Creek	April 21, 1993	April 21, 2043	0.75	0.75[a]

[a] Based on 2004 Forsyth County meter data – average annual flow

The Forsyth County sewer system extends throughout the areas of the County adjacent to the City of Cumming and southern portions of the County, including the Big Creek, Chattahoochee, Etowah, Lake Lanier, and Settingdown Creek drainage basins. The County also owns treatment capacity in several private wastewater treatment facilities. See Table 7 for a complete list of the public and privately owned WRFs in Forsyth County. Dick's Creek WRF is located south of Old Atlanta Road and east of SR 400 on this tributary to the Chattahoochee River. The Fowler WRF, located south of Highway 9, uses membrane bioreactor technology to recycle wastewater so it can be discharged safely to irrigate agricultural fields, golf courses, and parks. If these uses are not sufficient to manage all the treated flow from the WRF, then the rest of the flow is irrigated on the Threatt Land Application System (LAS), located in the southeastern corner of the County on McGinnis Ferry Road adjacent to the Chattahoochee River. Permit limits for the Cumming WRF are presented in Table 7.

TABLE 7
Phased Forsyth County Wastewater Treatment Capacities in Chattahoochee and Etowah River Drainage Basins
Forsyth County Watershed Protection Plan

Facility/Contract	**Plant Capacities (mgd)**	**Plant Capacities (mgd)**
Year	**2005**	**2010**
Publicly Owned System operated by Forsyth County		
Shakerag WRF (proposed)	1.25[a] (Phase I)	2.50 (Phase II)
Fowler WRF	1.25	5.00
James Creek WRF	0.50 [a]	1.00
Dick's Creek WRF	0.76	0.76
Subtotal	**3.76**	**9.26**
Privately Owned System contracted by Forsyth County		
The Hampton	0.275	0.90
Hillside at Mt. Ridge	0.036	0.072
The Manor LAS	0.25	0.50
Polo Golf and Country Club	0.338	0.338
Olde Atlanta Club LAS	0.262	0.262
Parkstone	0.10	0.25
Windermere LAS	0.50	0.50
Subtotal	**1.76**	**2.82**
Publicly Owned System contracted by Forsyth County		
Fulton County Contract	2.00	2.00
City of Cumming Contract	0.50	0.50
Subtotal	**2.50**	**2.50**
TOTAL MMADF[b]	**8.02**	**14.6**
TOTAL ADF[b]	**6.42**	**11.7**
PROJECTED WASTEWATER ANNUAL ADF[c]	**6.34**	**10.3**

[a] Assumes James Creek WRF operational in 2006; Phase I Shakerag WRF will be completed between 2005 and 2010.

[b] MMADF = Maximum Month Average Daily Flow. MMADF is 1.25 times average daily flow (ADF). All flows are MMADF except where indicated.
[c] Projected flows are the combined flows from the Chattahoochee and Etowah River drainage basins, which receive flows from the Chattahoochee, Big Creek, Etowah, and Settingdown sub-basins.

Source: Sewer System Master Plan (Dec. 2002) and Etowah Basin Update (Feb. 2004) prepared for FCWSD by JJ&G.

Forsyth County is actively developing its wastewater conveyance and treatment system. However, development in the remote regions of the County is currently outpacing the County's ability to reach all potential new customers. Forsyth County has taken a proactive approach toward working with developers who wish to develop residential properties where the sewer conveyance system has not yet reached. According to this approach, new developments that want private WRFs are required to design, permit, construct, and operate state–of-the-art biomembrane treatment facilities. In some cases, Forsyth County takes over the operation of the facilities shortly after construction and in other cases the private utility operates and maintains the facility.

As older, private WRFs begin to age and the useful life expires, requiring major capital improvements, Forsyth County plans to connect the population served by the private utilities. These additional flows are accounted for in the design of new facilities and future expansion phases. For example, the new Threatt site WRF, currently in the permitting and planning stages, is earmarked as a regional reuse facility for the southern portion of Forsyth County and ultimately will allow Forsyth County to reduce reliance on Fulton County and private utility providers in that area.

The Forsyth County has received a draft Waste Load Allocation (WLA) for cold weather discharge from James Creek WRF and Fowler WRF. The permit documents are currently being finalized for this discharge. Upon award of permit, Forsyth County will be able to send reuse quality effluent to Big Creek between November 1 and April 30.

Forsyth County has also received a WLA for discharge to the Chattahoochee River for 6 mgd at the Threatt Site. This WLA serves as the foundation of the County's effort to have a combined discharge on the Chattahoochee River as recommended by the District.

The Dick's Creek WRF has been in operation since 1992. The most recent major expansion occurred in 1997, increasing the facility's rated capacity to 0.76 mgd. The WRF was privately owned and operated from 1992 to January 2005. In January 2005, the Dick's Creek WRF was purchased from a private owner/operator. The WRF currently operates under GAEPD permit number GA02-082 for land application purposes. After construction of the cold weather discharge improvements is complete, the WRF will operate under NPDES permit no. GAU0038563 which allows cold weather discharges.

Parks and Recreation

According to the Forsyth County Comprehensive Plan, approximately 7,274 acres, or 5.29 percent of the County land area are occupied by park, recreation, or conservation lands. This acreage includes both active and passive recreation facilities owned and operated by Forsyth County, the Federal government and the USACE. These areas are significant to watershed protection because they provide areas of mainly pervious land uses to promote water quality. The Forsyth County Parks and Recreation Department is responsible for programs, facilities and related public outreach. The Parks Division of the Department is responsible for the safety and maintenance of the park facilities.

Greenspace Program

Protecting undeveloped land, or greenspace, is one way to limit the amount of impervious cover within a watershed, reducing the pollutants associated with nonpoint source

pollution. The County currently has approximately 10,781 acres of permanent and non-permanently protected greenspace, including Federal, State, County, and privately owned land. Current greenspace lands in Forsyth County include the protected river corridors along the Etowah Chattahoochee Rivers, the Sawnee Mountain conservation zone, and existing parks. The permanent protection of greenspace is an objective of the Forsyth County Board of Commissioners (BOC). The County is an active participant in the Georgia Greenspace Program. Steps continue to be taken to meet the Georgia Greenspace Program goal of permanently protecting 20 percent of the County land area (that is, 29,000 acres) with activities including: identifying lands that can be properly and formally protected as greenspace, acquiring lands where feasible, and implementing other methods of land protection such as conservation easements. Due to its rapid development, the County should use multiple sources for greenspace lands such as from stream buffer areas/floodplains, conservation subdivisions, utility easements, greenways, bikeway development, agricultural land, steep slopes, scenic viewsheds, historic/archeological sites, and other categories of land that might be protected. The Forsyth County Greenspace Program is a combined effort between the Planning Department and the Parks and Recreation Department.

Funding for Implementation

Protection of water quality is an important mission, and continued implementation of watershed protection and stormwater activities will require additional funding from a variety of sources. This section describes Forsyth County's current budget as it relates to the primary departments responsible for implementation activities and provides suggestions for future implementation funding.

County Departments

Forsyth County is committed to dedicating sufficient budgets to effectively manage and control influences to the County's watersheds and stormwater systems. Forsyth County's gross budget for FY 2006 is $71,718,629. The following County departments perform activities associated with watershed protection and stormwater management:

- Engineering
- Water and Sewer
- Planning
- Keep Forsyth County Beautiful
- Board of Commissioners
- Public Information
- Sheriff's Office

These departments are supported by the General Fund, except for the Water and Sewer Department, which is supported by an Enterprise Fund. Money collected through the Enterprise Fund is used for operating costs within the Water and Sewer Department. It should be noted that revenue collected by Financial Services and Planning for site plan reviews, variances, zoning amendments, and issuance of construction permits is returned to the General Fund and does not have to be expended on related activities. The 2006 budgets for each of these departments are summarized in Table 8.

Departments provide different services to maintain watershed protection and stormwater management activities for the County. A description of the responsibilities for each Department is included in the paragraphs below.

TABLE 8
2006 Budget for County Departments
Forsyth County Watershed Protection Plan

Department	FY 2004 Actual	FY 2005 Budget	FY 2006 Budget
Engineering	$ 760,280	$ 984,915	$ 1,046,316
Water and Sewer*	$ 35,192,697	$ 4,100,766	$ 17,965,553
Planning	$ 3,268,505	$ 3,839,130	$ 4,303,877
Keep Forsyth County Beautiful	$ 168,264	$ 197,917	$ 185,635
Board of Commissioners	$ 921,770	$ 792,770	$ 888,209
Public Information	$ 67,663	$ 141,876	$ 292,962
Sheriff's Office	$ 16,664,568	$ 19,101,267	$ 20,461,707

*Water & Sewer net income, as Water & Sewer is supported by an Enterprise Fund.

Engineering

The mission of the Engineering Department is to provide safe, efficient design, construction, maintenance, and operation of the County's surface transportation for the public. The department also reconstructs existing roads and builds other road projects, coordinates contracted work, installs and maintains traffic control, striping, signs, and signals. The Department consists of the Signals Division, Stormwater Division and the Traffic Division. The Stormwater Division implements Forsyth County's Stormwater Management Program, including enforcement of the Erosion and Sediment Control Ordinance, the environmental monitoring and pollution prevention programs, inspection of detention facilities and drainage systems.

Water and Sewer

The mission of the Water & Sewer Department is to provide Forsyth County with the highest quality of water and sewer service through superior customer support, strong financial management, progressive leadership, and environmental stewardship. Our mission is to protect the environment by complying with, or exceeding, all state and federal regulations governing the operation of Forsyth County's Water Reclamation Facilities.

Planning

The function of the Department of Planning is to promote and enhance the quality of life of the residents, property owners, and businesses of Forsyth County. The Department accomplishes its mission through programs and services that encourage quality development. The Department consists of the Planning Division, Permitting Division, Building Inspections Division, Business License Division and the GIS Division. The Planning Department is also responsible for the review of stream buffer compliance.

Keep Forsyth County Beautiful

The mission of Keep Forsyth County Beautiful (KFCB) is to cooperate with government, businesses, schools, civic organizations, and citizens in a joint effort to improve beautification, litter reduction, recycling, and other public outreach/education activities. Maintaining a beautiful county is a team effort which needs to involve everyone. The mission of KFCB strives to educate the public on recycling, solid waste reduction, litter control, and how to protect natural resources as well as to offer guidance to any organization or individual with interests in these areas. The KFCB affiliate is made up of four County maintained positions. A volunteer group of Board of Directors administers KFCB as a nonprofit 501c3 organization with support from several corporate sponsors and members. The KFCB Board meets every third Thursday of the month at 3:30 pm to coordinate information regarding events, memberships, business sponsorships and volunteers.

Keep Forsyth County Beautiful maintains a Public Resource Library in their office that allows individuals such as teachers, parents and students to sign out items that serve as environmental education tools. Resources in the library include reference books, videos, CDs, posters, kits, puzzles and brochures. Items are provided free of charge through a sign out process by the Keep Forsyth County Beautiful Staff. KFCB holds over ten different programs in cooperation with local citizens and schools. The organization also facilitates environmental education programs to County students and teachers including TEAM (Teach, Encourage And Model) Recycling Environmental Educator Workshops. While public information from KFCB is available all year round, there are several annual events hosted to enhance volunteer participation and public awareness of environmental issues. Annual events include: Bring One For the Chipper Christmas Tree Recycling, The Great American Cleanup, Liberty Gardens Ceremony, Phone Book Recycling Contest, Volunteer Recognition Banquet, TEAM Recycling Educator Workshop, Adopt-A-Road Picnic, Litter Index, Rivers Alive Waterway Cleanup, annual storm drain stenciling, and America Recycles Day.

Board of Commissioners

The mission of the Forsyth County Board of Commissioners is to exercise the powers, duties and responsibilities vested in and imposed upon it as the duly constituted governing authority of Forsyth County. Forsyth County operates under the commission-county manager form of government. The Board of Commissioners is made up of five members, each living in a specific district but elected by voters countywide to serve 4-year terms. Each year in January, the five members elect one of their own to serve as chairman of the board for the coming year.

Public Information

The Public Information Office plays the pivotal role in explaining and interpreting public policy as set by the Board of Commissioners, informing citizens about the day-to-day operations of local government, promoting the County to visitors and investors and helping to shape the County's public image.

Sheriff's Office

The Sheriff's Office is charged with serving and protecting Forsyth County citizens and visitors. The Sheriff's Office enforces all laws and ordinances, protects life and property, preserves the peace, and strives to prevent crime and disorder.

Potential Funding Sources

Use of the General Fund for watershed and stormwater activities is beneficial; however, other funding sources may be appropriate due to the instability of funding due to competing General Fund demands. The following paragraphs describe funding sources that the County will investigate for use in the future to promote watershed protection and stormwater activities.

Stormwater Utility

A Stormwater Utility would provide a dedicated funding source for watershed and stormwater activities. The public would recognize stormwater management as a type of utility service, and charges would relate to stormwater contributions. As a cost of using this type of funding, the Stormwater Utility would provide public acceptance challenges and also require implementation expenditures. A study to assess the feasibility of a Stormwater Utility for the Forsyth County will be investigated. Results of the analysis will determine if the concept is feasible and the utility could generate significant funding for the implementation of a more comprehensive stormwater management program. With the new requirements for watershed management from the District and the need for implementation of the Phase I MS4 program, the County plans to assess the stormwater utility issue as soon as possible.

Sales Tax Revenues

Georgia law permits a special sales tax to be imposed by local referendum and to be collected in a defined area for defined uses. Some of the revenues may be available for infrastructure improvements as part of the WPP if it is specified in the enabling referendum. However, the legal requirements for using sales tax revenues include approval by voters through a referendum.

Cost Sharing

A government's cost of capital improvements may be shared with businesses or other governmental entities that stand to gain substantial benefits from the improvement. It is not uncommon for manufacturing enterprises to provide partial capital funding for improvements designed to provide services to their facilities. The County should continue to be alert to the potential for opportunities to share stormwater and watershed improvement costs with the City of Cumming.

State Revolving Funds

State Revolving Funds may be appropriate for watershed and stormwater management projects in Forsyth County. The Clean Water State Revolving Fund (CWSRF) is a Federal funding and loan program administered by the Georgia Environmental Facilities Authority (GEFA) for projects including a wide variety of local community improvement projects. Loans are available at a low interest rate for a maximum of twenty years. To receive funding or a loan, Forsyth County would be required to complete an application including plans, schedules, and costs.

319 Nonpoint Source Grant Funds

Congress amended the CWA in 1987 to establish the Section 319 Nonpoint Source Management Program because it recognized the need for greater Federal leadership to help focus State and local nonpoint source efforts. Under Section 319, States, Territories, and Indian Tribes receive grant money which supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific nonpoint source implementation projects. In Georgia, the State has identified the following types of projects as eligible to receive funding:

- Development, revision or implementation of TMDL or Watershed Management Plans for TMDL and 303(d)-listed streams
- Restoration, protection, and prevention activities
- BMP demonstrations
- Water quality assessment and monitoring
- Technical assistance
- Regulatory and enforcement activities
- Education information and activities

The County could use this funding to complete watershed improvement projects to meet District goals to have Watershed Improvement Plans in place according to a schedule that is currently being updated by the District.

Conservation Programs that Provide Incentives and Assistance

Many conservation programs that are federally and state funded can provide private landowners with monetary and technical assistance to promote goals that are consistent with the WPP. Forsyth County could coordinate applications with private landowners to encourage watershed management and protection activities. Programs include the Wetlands Reserve Program (WRP), Partners for Fish and Wildlife (PFW), Environmental Quality Incentives Program (EQIP), and Conservation Reserve Program (CRP). For instance, the EQUIP provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns. The program is funded through the Commodity Credit Corporation. Cost-share payments may be made to implement one or more eligible structural or vegetative practices on eligible land, such as animal waste management facilities, terraces, filter strips, tree planting, and permanent wildlife habitat. Similarly, the CRP provides cost-share incentives for farmers to convert highly erodible cropland, or other environmentally sensitive land, to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers.

Identification of Pollutant Sources

A variety of planning studies have been performed for Forsyth County and the watersheds within its jurisdiction in response to the area's continued growth. Figure 2 shows current

land use and Figure 3 shows potential pollutant sources located in the County. Some studies are described in this section to provide an overview of pollutant sources that must be controlled and managed to maintain and improve watershed integrity, including:

- The 1999 watershed assessment, which was completed to establish baseline conditions in the watersheds of the County
- Additional monitoring since the watershed assessment
- GIS mapping of land use and potential pollutant sources
- Adoption of management measures and estimated load reductions as specified in the Georgia Stormwater Management Manual (GSMM)

Watershed Assessment from the 2000 WAMP

Forsyth County completed a watershed assessment as part of the WAMP in 2000 to determine the current condition of the major tributaries within the County sewer service area, to assess the sizes and effects of various pollution sources, and to evaluate options for improving and protecting water quality. The WAMP consisted of four basic components:

- Watershed characterization was conducted to determine the health of the streams by sampling water quality, in-stream/riparian habitat, aquatic macroinvertebrate communities, and fish communities.
- Watershed modeling was performed using a computer program that uses rainfall, soil, land use, and water quality data to simulate the amount of stormwater (and the pollution carried by it) that enters a stream during a rain event. For this study, a watershed model was used to predict future changes in water quality under various land uses.
- Watershed management planning involved evaluating results of watershed characterization and modeling efforts. Recommendations were made on ways to protect and improve water resources in the County over time.
- Public involvement activities were completed to gather information used to shape the development of the WAMP.

The WAMP, which was accepted by the Forsyth County Board of Commissioners and submitted to and approved by the GAEPD in the summer of 2000, provides guidance on how the County can achieve both economic development and watershed protection. Watershed characterization results and land use are included below to document baseline conditions that were determined in 1999. Since the 1999 assessment, Forsyth County has conducted annual monitoring based on a monitoring plan that is discussed later in this document.

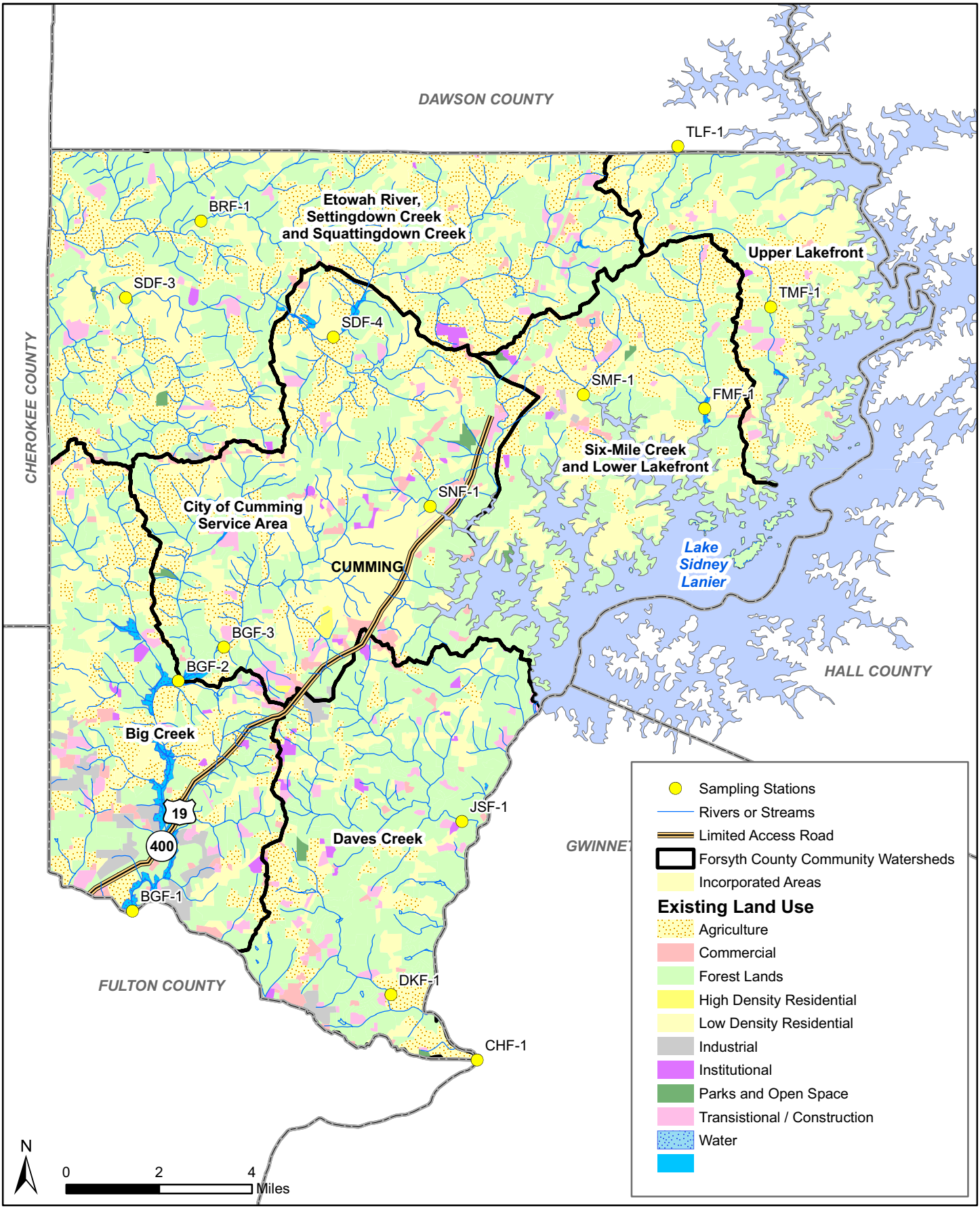


Figure 2
Land Use Characterization
Watershed Protection Plan
Forsyth County, GA

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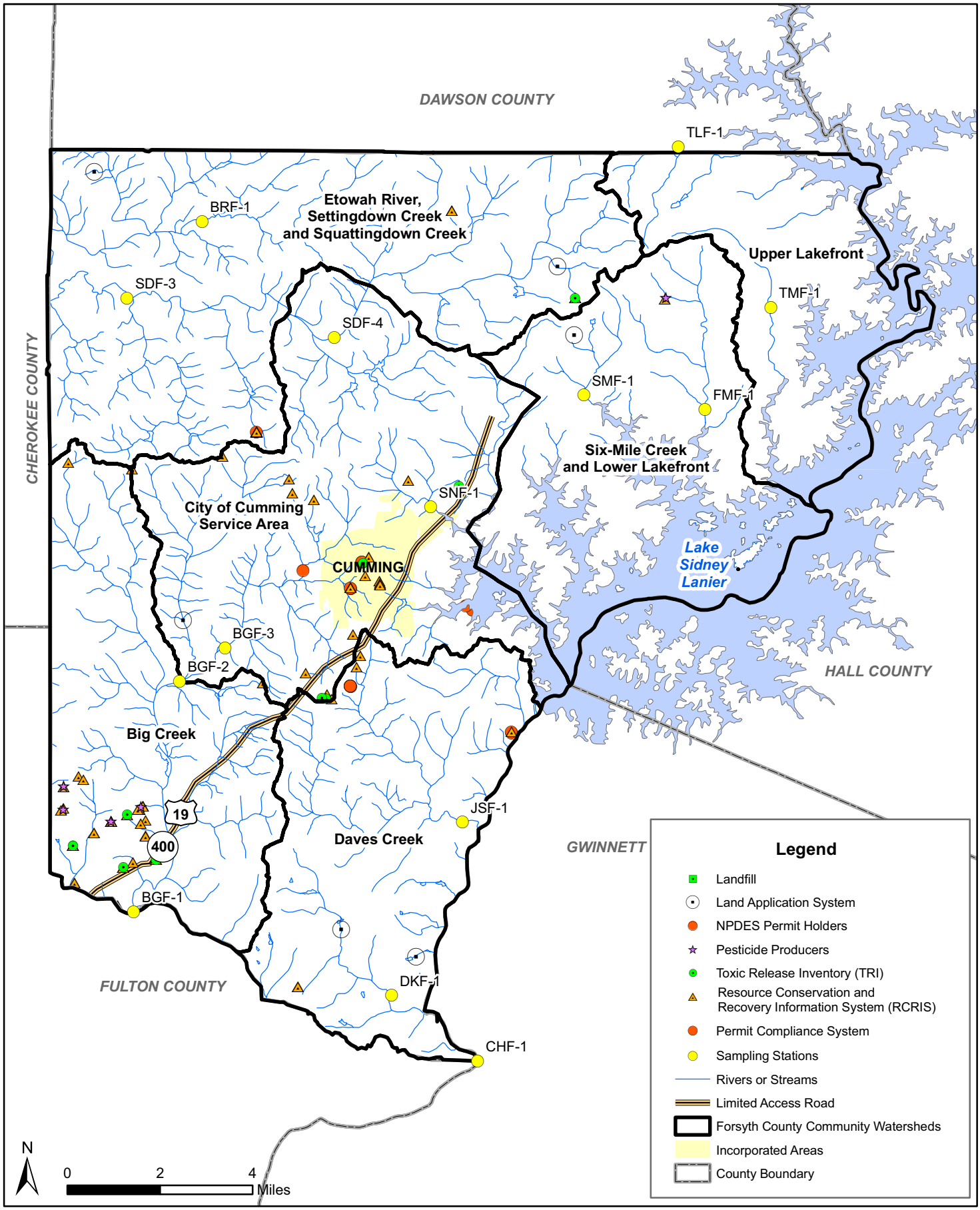

Figure 3
Sampling Station Locations and
Potential Pollutant Sources
Watershed Protection Plan
Forsyth County, GA

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Baseline Conditions from 1999 Assessment

To facilitate public communication, the study area was subdivided into five "community watersheds" for the 2000 WAMP. The creation of community watersheds narrowed the focus areas, allowing the evaluation of site-specific water quality issues and opening dialogue with residents about effective solutions for their communities. The Upper Lakefront Community Watershed and the Six Mile Creek and Lower Lakefront Community Watershed represent the small watersheds draining to Lake Lanier. Dave's Creek Community Watershed represents the small watershed that drain directly to the Chattahoochee River just south of Lake Lanier. The Big Creek Community Watershed represents the single largest watershed in Forsyth County that drains to the Chattahoochee River Basin. These four community watersheds are approximately 123.9 square miles in total area. The community watershed which drains to the Coosa River Basin is the Etowah River, Settingdown Creek, and Squattingdown Creek Community Watershed, which is approximately 89.7 square miles.

In 1999, dominant land use categories varied among the drainage basins and within the watersheds (Table 9).

TABLE 9
1999 Land Use from the WAMP
Forsyth County Watershed Protection Plan

Community Watersheds	Undeveloped (Agricultural, Forested, Parks/Open Space)	Residential (Low & High)	Urban (Commercial, Industrial, and Major Roads)	Other (CFOs, Institutional, Transitional, Water)
Chattahoochee River Basin				
Big Creek	57.0%	23.8%	15.7%	3.5%
City of Cumming Service Area	53.1%	28.8%	6.4%	11.7%
Dave's Creek	53.5%	32.6%	10.7%	3.2%
Six Mile Creek and Lower Lakefront	35.4%	23.6%	3.1%	37.9%
Upper Lakefront	40.9%	24.1%	0.8%	34.2%
Coosa River Basin				
Etowah River, Settingdown Creek, and Squattingdown Creek	79.3%	12.6%	1.9%	6.2%

Sources: BASINS (US Environmental Protection Agency [USEPA], v.2, 1993-1994); Forsyth County Planning Department hard copy maps; digital, color aerial photography (DigiAir, January 1999); and land use data from the Tennessee Valley Authority's Clean Water Initiative, Nonpoint Source Pollution Pilot Program.

Forest land use was the most prevalent land use in all community watersheds except Six Mile Creek and the Lower Lakefront. While forest land use was most prevalent, it still comprised less than the 50 percent of the land use within each of the community watersheds. Low-density residential was the second most prevalent land use in Forsyth County, except for the: (1) Six Mile Creek and Lower Lakefront Community Watershed, (2) Upper Lakefront Community Watershed, and (3) Etowah River, Settingdown Creek, and Squattingdown Creek Community Watershed. Agriculture was the second most prevalent land use in the Etowah River, Settingdown Creek, and Squattingdown Creek Community Watershed (22.6 percent). Forest and water were the second most dominant land uses in the

Six Mile Creek and Lower Lakefront and the Upper Lakefront Community Watersheds, respectively. The following paragraphs describe baseline watershed conditions using data collected in 1999.

The overall aquatic integrity (habitat, biological, and water quality) was substantially degraded in the Big Creek Community Watershed. Elevated levels of nutrients, sedimentation, copper, and habitat degradation were the primary stressors in this watershed. Fecal coliform bacteria levels were also above the State standard. Changes in land use associated with development were identified as the primary causes of habitat degradation. Water quality degradation appears to be the result of urban runoff and point sources within the headwaters of Big Creek.

In the Dave's Creek Watershed, the habitats were moderately degraded. This degradation is primarily due to sedimentation associated with ongoing construction and development in the community watershed and the resulting increases in impervious surfaces and associated increases in stream flows.

The Six Mile Creek and Lower Lakefront Community Watershed was relatively unimpacted. Sedimentation and elevated levels of nutrients were identified as the primary stressors in the Six Mile Creek watershed. The sources of sedimentation and erosion in this watershed were changes in land uses in the headwaters of the systems and the resulting changes in hydrology from increased impervious area.

In the Upper Lakefront Community Watershed, aquatic integrity was relatively unimpaired when compared to regional reference stations. In Two Mile Creek, fecal coliform bacteria was the primary parameter of concern and may be the result of poultry and agricultural operations in this watershed. As development continues, sedimentation from new construction and the impervious surfaces associated with the large tracts of unbuffered residential land located adjacent to Lake Lanier and its tributaries will become more problematic.

Conditions in the Etowah River Community Watershed ranged from good to highly degraded. Brewton Creek had the least developed watershed and overall, was the least disturbed of all the stations evaluated in the County. Settingdown Creek was significantly degraded due to sedimentation and habitat alteration. Past disturbance (channelization) and ongoing agricultural operations may be causes of this degradation.

Current Monitoring Results

This Environmental Monitoring Plan (EMP) was developed and implemented in 2003, as a result of the WAMP, to help provide an understanding of how biological and water quality is changing and to identify and characterize pollutant sources. Monitoring information is used as a basis for watershed management strategies, identification of retrofitting and restoration sites, and a determination of the success of the watershed management implementation strategies. Monitoring results since 2003 have shown some consistencies, some improvements (that is, lower nutrient levels), and some declines in water quality (that is, higher fecal coliform, sedimentation) since the 1999 assessment. These monitoring results are discussed in annual reports submitted to GAEPD in 2004, 2005, and 2006. Results will continue to be compared with the baseline 1999 assessment in future annual reports.

As reported in the 2006 annual report, water chemistry results for 2005/2006 suggested that for some streams in Forsyth County, such as Brewton, Sawnee, and Settingdown Creeks, water quality is generally being maintained as compared to previous years of sampling from 1999 and 2003/2004. For other streams, water quality results showed that several stations have changed since the 1999 assessment, although values are mostly consistent with 2004 results. When comparing water quality values between those collected in 1999 and those from the current year, it is important to note that five additional wet weather samples were collected in the 2005/2006 monitoring period compared to previous monitoring in 1999. Due to this fact, water quality averages are more likely to be higher in the 2005 monitoring period, because wet weather events tend to increase concentrations of water quality parameters. When comparing minimum and maximum values, it is also important to note that rain events in 1999 were all below 1.00 inch, which is not true for 2005/2006. The lower intensity of rainfall in 1999, due to a severe drought, led to a narrower range in water quality values, while the higher rainfall intensities in 2005/2006 led to a broader range in water quality values. However, when differences between 1999 and 2005/2006 are substantial, watershed conditions are likely to have caused the change. Identifying substantial changes will vary based on the parameter, and these substantial changes, as well as other water quality trends, are identified in the following paragraphs.

Table 10 summarizes overall results for key parameters at each station by comparing data to State standards. In addition, patterns were identified based on differences between wet and dry weather events. Other sampled parameters that were not included in the table were generally consistent at all stations and within the expected range. The water quality patterns and parameters that are emerging in Forsyth County suggest that nonpoint source pollution due to watershed land use changes may be a contributor to current stream conditions. For example, high levels of turbidity, TSS, nutrients, and fecal coliform were found at Big, Taylor, Four Mile, and Dick's Creeks mainly during wet weather sampling. These watersheds with decreased water quality are also the watersheds that have experienced the most existing or new development.

One station that had decreased water quality (due to fecal coliform concentrations) during wet and dry weather sampling was the watershed of Two Mile Creek. Water quality often changes due to storm events because greater runoff, associated with urbanization, can carry an increased level of pollutants to streams. Two Mile Creek has agricultural land use and increasing residential development, and the agricultural land use may be influencing the water quality parameters, especially nutrients and fecal coliform. The County has implemented a public education program that includes providing farmers with materials to promote sustainable farming practices, as well as informing residents of septic maintenance and other watershed protection measures. Other watersheds in the County, such as Big, Taylor, Four Mile, and Dick's Creeks, have less agricultural land use, but have a greater proportion of urbanized areas with completed and new infrastructure, which may be influencing the pattern of lowered water quality during wet weather events.

TABLE 10
Summary of Key Watershed Findings by Station for January 1, 2005 to March 31, 2006
Forsyth County Watershed Protection Plan

Stream	Water Quality Parameters					Biological Parameters		
	Turbidity and TSS	Nutrients Total P and N	Copper	TOC	Fecal Colifom	Habitat	Invertebrates	Fish
Taylor Creek at Hwy 53 (TLF-1)	Usually low, but occasionally high during only some wet events	Nutrient levels were sometimes moderately elevated	Below detectable limits	Average values are within normal range. Wet events produce some values over normal range.	Dry weather values below State standards, individual wet event values well above	Not assessed	Not assessed	Not assessed
Two Mile Creek at Wallace Wood Rd. (TMF-1)	Low during dry weather events, but high during wet events	Nutrient levels were sometimes moderately elevated	Below minimal detectable limits	Most readings within normal range. Some wet weather values over normal range	Individual wet and dry values above State standards	Comparable to Reference	"Very Good" ecological integrity, according to State protocols.	"Fair" ecological integrity, according to State protocols
Four Mile Creek at Keith Bridge Rd. (FMF-1)	Low during dry weather events, but high during wet events	Nutrient levels were usually high	Below minimal detectable limits	Wet weather values typically over normal range, two values much higher than normal	Dry values below and individual wet values above State standards	Not assessed	Not assessed	Not assessed
Six Mile Creek at Burress Mill Rd. (SMF-1)	Usually low, but occasionally high during only some wet events	Nutrient levels were usually high	Below minimal detectable limits	Most readings within normal range. Some wet weather values over normal range	Some individual wet values above State standards	Partially Similar to Reference	"Fair" ecological integrity, according to State protocols	"Poor" ecological integrity, according to State protocols
Brewton Creek at Mt. Tabor Rd. (BRF-1)	Consistently low	Nutrient levels were low, except for one isolated dry weather event	Below minimal detectable limits	Most values within normal range	Most individual values below State standards, some wet events were above	Not assessed	Not assessed	Not assessed

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Forsyth County Watershed Protection Plan

Stream	Water Quality Parameters					Biological Parameters		
	Turbidity and TSS	Nutrients Total P and N	Copper	TOC	Fecal Colifom	Habitat	Invertebrates	Fish
Settingdown Creek at Wallace Tatum Rd. (SDF-3)	Usually low, but occasionally high during only some wet events	Nutrient levels were moderately elevated during some wet events	Below minimal detectable limits	Most values within normal range	Most individual values below State standards, some wet events were above	Dissimilar to Reference	"Fair" ecological integrity, according to State protocols	"Very Poor" ecological integrity, according to State protocols
Settingdown Creek at John Burrus Rd. (SDF-4)	Low during dry weather events, but high during wet events	Nutrient levels were somewhat elevated during wet events	Below minimal detectable limits	Some wet weather values above normal range	Most individual values below State standards, some wet events were above	Not assessed	Not assessed	Not assessed
Sawnee Creek at Pilgrim Mill Rd. (SNF-1)	Usually low, but occasionally high during only some wet events	Nutrient levels were generally low	Below minimal detectable limits	Most values within normal range	Most individual values below State standards, some wet events were above	Not assessed	Not assessed	Not assessed
Big Creek at Bethelview Rd. (BGF-3)	Usually low, but occasionally high during some wet events	Nutrient levels were moderately elevated during some wet events	Below minimal detectable limits	Some wet weather values above normal range	Most individual values below State standards, some wet events were above	Not assessed	Not assessed	Not assessed
Big Creek at Majors Rd. (BGF-2)	Usually low, but occasionally high during some wet events	Nutrient levels were moderately elevated during wet events	Below minimal detectable limits	Most values within normal range	Most individual values below State standards, some wet events were above	Dissimilar to Reference	"Very Poor" ecological integrity, according to State protocols	"Very Poor" ecological integrity, according to State protocols
Big Creek at McGinnis Ferry Rd. (BGF-1)	Usually low, but occasionally high during some wet events	Nutrient levels were moderately elevated during wet events	Below minimal detectable limits	All values within normal range	Most individual values below State standards, some wet events were above	Not assessed	Not assessed	Not assessed

TABLE 10
Summary of Key Watershed Findings by Station for January 1, 2005 to March 31, 2006
Forsyth County Watershed Protection Plan

Stream	Water Quality Parameters					Biological Parameters		
	Turbidity and TSS	Nutrients Total P and N	Copper	TOC	Fecal Colifom	Habitat	Invertebrates	Fish
Chattahoochee River at McGinnis Ferry Rd. (CHF-1)	Usually low, but occasionally high during some wet events	Nutrient levels were generally low to moderate with elevated values during an isolated rain event	Below minimal detectable limits	Most values within normal range	Most individual values below State standards, some wet events were above	Not assessed	Not assessed	Not assessed
Dick's Creek at Old Atlanta Rd. (DKF-1)	Usually low, but occasionally high during some wet events	Nutrient levels were generally low with occasional moderately elevated values during heavy rain events	Below minimal detectable limits	Most values within normal range. Several wet weather values are above normal	Most individual values below State standards, some wet events were above	Dissimilar to Reference	"Fair" ecological integrity, according to State protocols	"Very Poor" ecological integrity, according to State protocols
James Creek at James Burgess Rd. (JSF-1)	Usually low, but occasionally high during some wet events	Nutrient levels were generally low with occasional moderately elevated values during heavy rain events	Below minimal detectable limits	All values within normal range	Most individual values below State standards, some wet events were above	Not assessed	Not assessed	Not assessed
Orr Creek at Jason Drive (ORF-1)	Not sampled	Not sampled	Below minimal detectable limits	Not sampled	Exceeded the summer geometric mean State standard of 200 cfu/100mL	Not assessed	Not assessed	Not assessed
Kelly Mill Branch at Kelly Mill Rd. (KMF-1)	Not sampled	Not sampled	Not sampled	Not sampled	Exceeded the summer geometric mean State standard of 200 cfu/100mL	Not assessed	Not assessed	Not assessed

P = phosphorous
N = nitrate/nitrite
TOC = total organic carbon

In addition to long-term monitoring stations, geometric means for fecal coliform that were calculated quarterly at Orr Creek and Kelly Mill Branch exceeded the summer geometric mean State standard of 200 cfu/100mL during one 30-day period for Kelly Mill Branch and two periods for Orr Creek in 2005. Fecal coliform is a notable factor in decreased water quality at the impacted sampling stations. The elevated fecal coliform values were most commonly associated with heavy storm events and were most likely caused by nonpoint source runoff due to urban and/or agricultural land uses. For instance, failing septic systems in urban and residential areas could be a contributor to nonpoint source runoff in Forsyth County. The same pattern holds true for elevated nutrient levels, many of which occurred in unison with the elevated fecal coliform values.

Five of the fourteen long-term monitoring stations were also sampled in 2005 for biotic communities. Biological monitoring parameters included fish communities, benthic macroinvertebrate communities, and physical habitat assessments. Stations representing Two Mile and Six Mile Creeks scored moderate to good in all analyses while stations representing Big, Settingdown, and Dick's Creeks generally scored lower across the three parameters (Table 10). Despite the decreased water quality parameters found at some of the study stations, biological and habitat results show that, for four of the five stations analyzed, at least one biotic integrity score was rated as fair to good. This includes sites that also exhibited poor water quality characteristics.

Although data from Two Mile Creek suggested a fecal coliform problem, biological data indicated that the watershed may still be sustaining a healthy biological community. Contrastingly, some more developed watersheds, such as Big Creek, did not show as much of a decrease in water quality in the past reporting year, but the biological community has been impacted. This indicates a decline in the physical habitat provided by these streams, most likely due to factors such as increased stormwater pulses caused by higher development in the watershed, and bank erosion. The differences in the water quality and biological datasets may represent a delay in water quality impacts or may exhibit the strong influence of stormwater runoff on the water quality data. The County has implemented watershed management activities to help manage stormwater and prevent further degradation to streams. In all watersheds, the County is committed to maintaining and improving water quality so that the biological community can be sustained and improved.

Current Land Use and Impervious Cover

Forsyth County watersheds are changing due to greater amounts of low and medium-density residential land use (Figure 2). Forsyth County has been managing for extremely rapid growth, and over the last five years the County has been one of the five fastest growing Counties in the United States. Between 2000 and 2005, the County's population grew by 44 percent from 98,407 to 140,393 (Bill Johnson--Atlanta Journal and Constitution, March 23, 2006).

To estimate the relative impact of this development in each watershed, impervious cover was compared over time. The 1999 impervious cover data from the WAMP was compared to 2003 impervious cover data, which was calculated using the 2003 land use data (and average impervious cover for each land use type) from the Atlanta Regional Commission. As impervious cover increases in a watershed, hydrological conditions of streams change leading to increased stormwater pulses, sediment transport, and bank erosion.

Impervious cover has continued to increase in the County, as shown in Table 11. From 1999 to 2003, Big Creek, Dick's Creek, and Two Mile Creek had an increase in impervious cover greater than 10 percent. Because Big Creek and Dick's Creek have watersheds with an estimated total impervious cover greater than 30 percent, they are considered to be the most developed in the County. Estimated impervious cover is positively correlated to biological and water quality results, suggesting that streams in Forsyth County are being more heavily affected by nonpoint source pollution in watersheds where development is higher.

TABLE 11
Estimated Total Impervious Cover for the Drainage Area of Each Station
Forsyth County Watershed Protection Plan

Station	1999 Impervious	2003 Impervious	Change
BGF-1	15.68%	24.64%	**8.96%**
BGF-2	14.13%	32.28%	**18.15%**
BGF-3	18.22%	33.97%	**15.75%**
BRF-1	4.44%	13.75%	**9.31%**
DKF-1	21.84%	33.01%	**11.17%**
FMF-1	5.57%	12.15%	**6.58%**
JSF-1	12.82%	23.83%	**11.01%**
SDF-3	NA	10.65%	**NA**
SDF-4	NA	20.52%	**NA**
TMF-1	5.55%	16.96%	**11.41%**
TLF-1	NA	22.85%	**NA**
SNF-1	NA	26.67%	**NA**
SMF-1	19.91%	22.37%	**2.46%**

Management Measures

Forsyth County is facing increased urbanization and more intensive land uses, and this was reflected in the samples taken downstream of the most heavily developing watersheds. Agricultural impacts due to feedlots, livestock, and row crops are still present in the County, but these types of land use are being replaced by residential and commercial land uses. Thus, the County works with the Natural Resources Conservation Service (NRCS) to continue outreach efforts aimed at low-impact farming practices (as specified in the WAMP), but the majority of the County's planning and development practices address water quality protection from more urban land uses that increase impervious cover, as discussed in the previous section. To quantify the water quality benefit of management measures, the WAMP analyzed load reductions expected for various structural management measures that could be used for new development associated with

urbanization. Total Suspended Solids (TSS) was the water quality indicator used to represent pollutant loading due to its high correlation with percent imperviousness (CH2M HILL, 2000). Table 12 provides a summary of estimated load reductions for several BMPs.

TABLE 12
TSS Removal for BMP Options
Forsyth County Watershed Protection Plan

BMP	TSS Removal (%)
Extended Wet Detention Pond	80
Extended Dry Detention Pond	50
Constructed Wetland	80
Vegetated Filter Strips	50
Sand Filters	80
Infiltration Trenches	80
Oil/Grit Separator	60
Grassed Swales (2% slope, dam)	15

Aquatic integrity can be maintained and improved by decreasing habitat alteration due to point and nonpoint source pollutants, erosion and sedimentation, flow regime modification, and riparian area degradation. In the 2000 WAMP, a water quality model (GIS Pollutant Load Model) was developed to estimate pollutant loadings to streams from nonpoint sources, based on current land use conditions, and from point source discharges. The County used this model to develop watershed and stormwater management techniques to lessen the impacts of changing land uses and potential pollutant sources on stream integrity (see the following section for more detail). In response to watershed stressors, the County has developed local ordinances related to watershed protection and implemented a public education program to increase awareness of nonpoint pollution sources. As Forsyth County faces continued urbanization and growth, the County is committed to using monitoring data as a reference by which to determine the most effective placements for watershed management and protection measures.

Forsyth County has adopted the Georgia Stormwater Management Manual (GSMM), Volumes 1 and 2 (2001) in 2004 to facilitate implementation of pollutant load reducing management measures. Estimates of load reductions from various management measures can be found in the GSMM. In addition, the County provided more specific stormwater management guidance via the development of the Forsyth County Addendum to the GSMM.

According to the GSMM, "the increase in frequency and duration of bankfull flow conditions in stream channels due to urban development is the primary cause of streambank erosion and the widening and downcutting of stream channels." Due to a fast-growing population, Forsyth County is becoming more urbanized with greater areas of

impervious cover leading to greater stresses on watersheds. To lessen the impacts of urbanization on the watershed, the GSMM provides stormwater management measures that decrease channel erosion by storing and releasing stormwater runoff from stormwater runoff events.

Best Management Practices

BMPs are implementation measures that help to maintain and improve a watershed. Implementation measures have been described in annual reports submitted to GAEPD since 2004. Many implementation measures are also required as part of the GSMM (discussed above) and the Forsyth County Addendum to the GSMM, Forsyth County's SWMP, which was approved by GAEPD in August 2005.

Structural and Source Control Measures as Listed in the SWMP

The SWMP addresses the BMPs and specific programs that are being implemented by the County to protect the watershed from harmful pollutants in stormwater runoff and uncontrolled water volumes. When the SWMP is revised, the County may revised the following list based on regulatory guidance and effectiveness of each BMP; thus, some of the following sections provide a brief summary of the information included in greater detail in the SWMP.

The SWMP addresses the various activities that affect the quantity and quality of the stormwater entering the County stormwater conveyance system, including: structural controls (such as requirements for stormwater ponds and oil/grit separators), operation and maintenance procedures for public and privately owned structures, stormwater pollution control plans (new development and redevelopment), street maintenance, flood management projects, County facilities, and pesticides, fertilizer, and herbicides application. The SWMP also describes the County's efforts to inventory and inspect industrial facilities for compliance with stormwater regulations. The SWMP also includes lists of highly visible pollutant sources to be inspected, as well as a description of the County's activities to identify highly visible pollutant sources.

Erosion and sedimentation control inspections and procedures are described in the SWMP, as well as enforcement efforts and efforts to educate local construction site operators. The Engineering Department is responsible for completing field reports for all soil erosion inspections. An order of precedence has been established whereby the most urgent cases are handled first. Therefore, complaints filed with the Engineering Department receive priority.

The SWMP describes a proactive program to identify intentional and unintentional illicit discharges into the County stormwater system. While complete elimination of illicit discharges is unrealistic, this program strives to minimize their occurrence in the County through proper management of toxic materials, public education, inspections, stream walks, dry weather outfall screening, and efficient response when they do occur.

Watershed Restoration and Retrofit

Since the WAMP, Forsyth County has investigated watershed priorities and funding sources for restoration and retrofitting activities to improve and protect streams, riparian

areas, and water quality, as described below.

Settingdown Creek Ecosystem Restoration Report

As part of a watershed assessment conducted by Forsyth County in 1999 to 2000, several watersheds were identified that needed restoration to meet their designated uses. In 2003, the County began trying to identify potential funding sources to move forward with restoration in the designated priority watersheds. Section 206 of the Water Resources Development Act of 1996 provides the USACE, Mobile District, the authority to restore degraded aquatic ecosystems. Therefore, the County approached USACE to prepare an Ecosystem Restoration Report (ERR) for Settingdown Creek and its tributaries. Forsyth County participates as the non-federal cost-share partner of USACE. The study area consists of the entire Settingdown Creek Watershed within Forsyth County. This watershed is located within the upper Piedmont province and drains a 50-square-mile area. The lower portion of Settingdown Creek enters Cherokee County to the west near the confluence of the creek with the Etowah River. The ERR will be designed to investigate planning, engineering, design, environmental, and land acquisition activities associated with developing restoration plans. The project was approved in 2004 but was delayed due to USACE funding issues. Forsyth County and USACE plan to start the project as soon as funding becomes available.

Watershed Improvement Plans

The District recommends that local governments develop watershed improvement plans to help restore streams to their designated uses, as well as support future NPDES permitting activities. The baseline watershed conditions that were established in the 2000 WAMP and subsequent monitoring efforts provide an inventory of the existing stream system condition, allowing the County to prioritize improvement efforts in each watershed. Due to the effort and costs involved, the County must use a phased approach to develop each watershed improvement plan based on the priority level. In substantially impacted watersheds (as identified by the District), watershed improvement plans are required to be submitted in 2007. For other watersheds, watershed improvement plans will be developed beginning in 2008 until eventually all watersheds in the County have a watershed improvement plan. Big Creek watershed in Forsyth County is included by the District as a high-priority substantially impacted watershed. Thus, the Big Creek Watershed Improvement Plan will be developed in 2006 and 2007.

Watershed improvement plans will be developed based on the recommendations from the WPP, 2000 WAMP, GAEPD guidance, and the District-wide WMP and its amendments. Watershed improvement plans will quantify linear feet of eroded streambank requiring stabilization and restoration and identify other measures that would decrease pollutant loading to streams. Plans will be prepared to assess the current and proposed restoration and retrofitting activities, roles, regulatory requirements, responsibilities, and schedule for implementation.

Public Education Program

Various community outreach activities are undertaken by the County, as described in the WAMP, SWMP, and annual reports. Forsyth County is involved in several efforts to

disseminate information to the public concerning watershed issues and recycling efforts. The County actively encourages residents to participate in any of several community activities to raise awareness of water pollution, littering, and water quality. Forsyth County participates in the District's Clean Water Campaign (CWC). Brochures prepared by CWC are distributed by the County and links to the CWC web site are included on the County web site. Links on the County web site also point to the Earth911 web site, which is another organization that promotes environmental awareness. Annual programs are mainly run by Keep Forsyth County Beautiful (KFCB) and include cleanup events (that is, Rivers Alive, Adopt-a-Road, and Great American Cleanup), presentations to school children and civic groups, Adopt-a-Stream training, and storm drain stenciling. In addition, the County provides informational brochures at its offices and during stormwater-related inspections.

Forsyth County retained CH2M HILL to further develop their Public Information and Education activities in response to guidance implemented by GAEPD in March 2005. The resulting plan provides a comprehensive description of existing and future mechanisms for engaging and educating the public about watershed and stormwater protection issues. In addition, the plan incorporates multiple GAEPD guidelines and comments and also to follow the guidelines established by the District. The following activities are included in the plan:

- Forsyth County promotes access to educational and informational material through its web site. Printouts from the web site and others linked to the County web site are included in annual reports.
- Adopt-a-stream workshops are advertised on the Georgia Department of Natural Resources web site. Workshops are planned to be held once a year for introductory, water chemistry, and biological training, depending on level of public interest.
- The County conducts annual storm drain marking.
- At least one river cleanup event is planned to be held every year, with prior mailings to schools and civic groups to encourage participation.
- Stormwater-related articles are published in local and regional newspapers (Forsyth County News, Atlanta Journal-Constitution). Article topics are available from the Clean Water Campaign.
- The County partners with KFCB, taking advantage of opportunities to provide speakers and literature at KFCB's events and activities to promote Forsyth County's watershed protection activities, such as Adopt-a- Road, Adopt-a-Stream, Rivers Alive Waterway Cleanup, TEAM Recycling Educator Workshop, Volunteer Recognition Ceremony, and other events.
- The County maintains continued participation in the Clean Water Campaign efforts to distribute informational literature about stormwater issues.
- Outreach efforts to school aged children through presentations made available to teachers. Information could also be made available to teachers in the Public Resource Library that is maintained by KFCB in the Engineering Department. This library

provides educational resources such as reference books, videos, CDs, posters, kits, puzzles, and brochures free of charge.

- Forsyth County may work with the local homebuilders association to conduct training sessions. The sessions would focus on methods and Best Management Practices that developers can use to control stormwater runoff and pollution.
- The County may use and expand its existing Speakers Bureau to include a series of presentations related to WAMP initiatives. Presentations may be delivered at meetings of local civic groups and organizations, such as environmental groups, Rotary clubs, church groups, the Cumming-Forsyth County Chamber of Commerce, KFCB, and affiliate groups.
- The County attempts to brief the Forsyth County Commissioners and other community leaders to provide an overall picture of the stormwater activities in the County.
- The County is investigating the development of short, informative messages to be printed on bills, bill inserts, or the outside of the mailing envelope. Through this method, virtually every household in the County may be reached.
- Pet owners often do not realize the impacts that pet waste has on local surface water quality. Because most pet owners visit a veterinarian office at least on an annual basis, the County can use this method to distribute a targeted message to a specific group of people.

Overall, these activities raise public awareness about watershed and stormwater management among various economic and demographic subsets of Forsyth County's population. Raising general public awareness will help local residents understand the role individual behaviors play in creating nonpoint source pollution and other problems (such as flooding, erosion, etc.).

TMDL Management Strategies

Section 305(b) of the CWA requires that states develop and institute a biannual (every other year) monitoring and reporting program that describes water quality conditions of state waters. This report, known as the 305(b) report, provides an assessment of surface-water quality as supporting, partially supporting, or not supporting a designated use. The report also provides information on parameters violated, causes of the violations, and actions planned to reduce the problems. The report considers both point and nonpoint source pollution issues. Long-term monitoring of these streams is essential for tracking future changes in water quality, early detection of infrastructure maintenance issues, and the long-term goal of meeting their designated uses. Table 13 illustrates the streams listed within Forsyth County. The County's watershed improvement efforts are a priority in 303(d)-listed streams. Because listed streams are spread throughout the County, water quality protection and management must be implemented on a County-wide basis.

GAEPD is required to develop segment-specific Total Maximum Daily Loads (TMDL) and corresponding implementation plans that outline the steps to be taken to restore a stream segment to its designated use. A TMDL is the amount of a pollutant that can be assimilated

by the receiving waterbody without exceeding the applicable water quality standard. A TMDL is the sum of the individual waste load allocations (WLAs) from point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body. TMDLs may be expressed in terms of either mass per time, toxicity, or other appropriate measures.

TABLE 13
Streams Listed in Georgia 305(b) Report [a]
Forsyth County Watershed Protection Plan

Watershed/Stream	River Basin	Criterion Violated[b]	Evaluated Causes[c]	Stream miles	Existing TMDL/ % Reduction
Not Supporting Designated Use					
James Creek	Chattahoochee	FC	UR	2	
Orr Creek[d]	Chattahoochee	FC, Cu	UR	3	91%
Six Mile Creek	Chattahoochee	FC	UR	2	
Partially Supporting Designated Use					
Big Creek	Chattahoochee	FC, Cu	UR	3	39%
Four Mile Creek	Chattahoochee	FC	UR	3	
Kelly Mill Branch[d]	Chattahoochee	FC	UR	2	3%
Sawnee Creek	Chattahoochee	FC	UR	2	
Taylor Creek	Chattahoochee	FC	UR	3	
Two Mile Creek	Chattahoochee	FC	UR	5	
Settingdown Creek	Etowah	Bio	UR	3	

Source: GAEPD, 2006

[a] Note that, as acknowledged in the Georgia 305(b) report, the data used to develop these lists are not rigorously screened and/or subjected to standard quality control protocol for use in this manner.

[b] FC = fecal coliform bacteria; Cu = copper; Bio = Biological Criteria

[c] UR = urban runoff/urban effects; NP = nonpoint sources/unknown sources

[d] Denotes watershed shared with the City of Cumming

According to the Georgia 2006 draft 303(d) list for stormwater permittees, TMDLs for stream segments in Forsyth County have been developed and approved for all the listed streams except Settingdown Creek. In the Chattahoochee River Basin, James Creek, Orr Creek, and Six Mile Creek are not supporting their designated uses. Urban runoff is identified as the primary cause for these waters not meeting their uses. The 303(d) list from 2006 (see Table 10) identified fecal coliform bacteria as the predominant cause of water quality violations in the County. The exceptions are Orr Creek and Big Creek in the Chattahoochee River Basin, which are also listed for copper violations. Forsyth County shares jurisdictional responsibilities with the City of Cumming for Orr Creek. These TMDLs are discussed in the following sections, along with the District TMDL strategies that provide an adaptive management approach to restoring stream segments to their designated uses.

TMDL Stream Monitoring

As part of the Environmental Monitoring Plan (EMP), the objectives of TMDL stream monitoring are to locate sources of water quality impairment in the watershed, identify

streams needing further action, and fulfill the TMDL monitoring portion of the District's guidelines. Most stream segments were included as part of the long-term monitoring plan; thus, no additional sampling was needed for these 303(d)-listed stream segments. The long-term monitoring plan is described later in this document. A study has begun for fecal coliform sampling (at Kelly Mill Branch and Orr Creek since 2004) and copper sampling (at Orr Creek since 2005) of stream segments from the 303(d) list. At these streams, 30-day geometric means are collected quarterly for fecal coliform, as described by the District-wide WMP (2003), and quarterly samples are collected for copper, as described in the District-wide WMP. The data are collected and analyzed to identify pollution sources. The data generated from the study of the listed stream segments in Forsyth County may eventually result in watershed improvements and the delisting of those segments. TMDL water quality studies are essential in managing Forsyth County's watersheds and in collecting important information for the adaptive watershed management approach being used by the County.

Fecal Coliform

In the Chattahoochee River Basin, the existing TMDL from 2003 for fecal coliform involves 79 stream segments, of which three are in Forsyth County. WLAs, shown in Table 14, have been developed for Big Creek, Kelly Mill Branch, and Orr Creek. For fecal coliform bacteria, the TMDLs are expressed as counts per 30 days as a geometric mean. The WLA established for Orr Creek requires a 91 percent reduction in fecal coliform bacteria. The TMDL projects the need for a combined reduction of 82 percent in Big Creek and 91 percent in Orr Creek for point and nonpoint sources of fecal coliform to meet water quality standards. As illustrated in Table 13, a number of stream segments are listed for fecal coliform in the 2006 draft 303(d) list, and while a specific WLA has not been developed for these segments, it is expected that the implementation plan activities will be similar.

TABLE 14
Existing Fecal Coliform Waste Load Allocations (WLAs)
Forsyth County Watershed Protection Plan

Stream Segment	Current Load (counts/ 30 days)	WLA (counts/ 30 days)	WLAsw (counts/ 30 days)	LA (counts/ 30 days)	MOS (counts/ 30 days)	TMDL (counts/ 30 days)	Percent Reduction
Big Creek – Headwaters to Cheatham Creek	7.73E+12	2.12E+11		5.34E+12	1.39E+11	1.39E+12	82%
Kelly Mill Branch	4.23E+11			3.47E+11	4.12E+10	4.12E+11	3%
Orr Creek	5.02E+12	2.56E+11		1.41E+11	4.42E+10	4.42E+11	91%

WLA = Waste load allocation
WLAsw = waste load allocations from stormwater discharges
LA = Load allocation for nonpoint sources
MOS = Margin of safety
TMDL = Total maximum daily load

Fecal coliform bacteria is the primary reason for streams being listed as "impaired" in the Georgia 305(b) report (GAEPD, 2006). Forsyth County and the Atlanta Regional Commission (ARC) are currently developing TMDLs for the listed stream segments in the Chattahoochee River. With the pending issuance of the fecal coliform TMDLs, this investigation may also serve as a reference for future studies. However, effective reduction in fecal coliform levels to meet the standard may be difficult due to the great variety of sources and the ubiquitous nature of the contamination. GAEPD has recognized the difficulty in meeting the current fecal standard and is currently developing an alternative standard (for *Escharia coli* bacteria), which represents the potential human health risks associated with pathogens in surface waters.

Point Sources

Fecal coliform permit limits for NPDES-permitted facilities are presented in Table 15 as they were listed in the TMDL plan for the Chattahoochee River Basin (GAEPD, 2003a). The City of Cumming WRF and Tyson Foods, Inc. are the only NPDES point sources that discharge directly to into one of the three studied watersheds. Table 15 compares the actual 2000 discharge from each WRF with its permit limits. Neither facility is approaching its permitted limit for fecal coliform, so based on the findings of the TMDL source assessment, NPDES point source fecal coliform loads from wastewater treatment facilities do not significantly contribute to the impairment of the listed stream segments. This is because these facilities are required to treat to levels corresponding to instream water quality criteria.

TABLE 15
NPDES Facilities Discharging Fecal Coliform in the Chattahoochee River Basin, as listed in the 2003 TMDL Plan for the Chattahoochee River
Forsyth County Watershed Protection Plan

			Actual 2000 Discharge		NPDES Permit Limits		Number of Violations
Facility	**Receiving Stream**	**Permit #**	**Average Monthly Flow** *(mgd)*	**Geometric Mean** *(No./100 mL)*	**Average Monthly Flow** *(mgd)*	**Average Monthly FC** *(No./100mL)*	*July 1998-June 2001*
Cumming WRF	Big Creek	GA0046019	0.87	2.5	2.0	200	1
Tyson Foods, Inc.	Unnamed Trib / Orr Creek	GA0001074	1.22	18.3	n/a	400 daily max	0

Data Source: GAEPD, February 2003a.
mL = milliliter

Additional sources have been on line since the TMDL was implemented in 2003. As discussed in a previous section of this document, the Fowler WRF and the Dick's Creek WRF are both NPDES permitted facilities. However, fecal coliform bacteria levels in discharges from these facilities are highly treated with advanced technologies and then discharged at land application sites. Thus, water quality impacts due to these facilities are minimal.

Nonpoint Sources

The Chattahoochee River TMDL notes that, in general, nonpoint sources cannot be identified as entering a waterbody through a discrete conveyance at a single location. Likely

nonpoint sources of fecal coliform bacteria in these watersheds include wildlife, livestock, and leaking septic and sanitary sewer systems. Fecal coliform loads from NPDES-permitted MS4 areas may be significant, but these sources cannot be segregated easily from other stormwater runoff.

Protection Plan Strategies

Forsyth County can best address the fecal coliform bacteria listings in its jurisdiction by using an adaptive management strategy that involves public participation and intergovernmental coordination to reduce the discharge of pollutants to the maximum extent practicable. Based on data from the 1999 watershed assessment and subsequent monitoring, it is not clear that fecal coliform exceedances are due to malfunctioning sewer or septic systems. Other nonpoint sources of fecal coliform include domestic and wild animals, as well as pets. Management practices, control techniques, public education, and other appropriate methods and provisions may also be employed. In addition to implementing the Long-Term Monitoring Plan, Forsyth County should proactively implement the following strategies.

- Enforce ordinance to require connection to public sewer line if an existing line is within 5000 feet of any part of a new development.
- Uphold requirements that all new and replacement sanitary sewage systems be designed to minimize discharges into storm sewer systems.
- Accelerate implementation of MS4 stormwater management program BMPs.
- Further develop and streamline mechanisms for reporting and correcting illicit connections, breaks, surcharges, and other sanitary sewer system problems.
- Continue efforts to increase public awareness and education about the impacts of human activities in urban settings on water quality, ranging from the consequences of industrial and municipal discharges to the activities of individuals in residential neighborhoods (including control of domestic animal wastes and septic system maintenance).
- Facilitate interjurisdictional coordination with the City of Cumming to maximize funding resources available to improve water quality and aquatic integrity in shared watersheds.

Copper

A copper TMDL report for the Chattahoochee River Basin was published in January of 2003. According to the 2003 report, elevated copper levels are indicative of illicit discharges, runoff from roads and bridges, and runoff from new and existing development. Dissolved copper standards for use classifications of Georgia streams are dependent on water hardness. Forsyth County currently has one stream segment, Orr Creek, listed as not supporting for copper. Forsyth County also has another stream segment, Big Creek, that is listed as partially supporting for copper. Table 16 shows the chronic and acute copper concentrations for the two listed stream segments.

Based on monitoring from the past year at Big Creek and Orr Creek, no copper levels were found to be above the reportable limit of the laboratory. However, the reportable limit is

greater than acute and chronic criteria listed in the TMDL Implementation Plan (20 ug/L). Thus, before streams can be recommended for delisting, future analysis of dissolved copper concentrations in listed streams will be performed using approved methods with lower detection limits.

TABLE 16
Allowable Instream Copper Concentrations
Forsyth County Watershed Protection Plan

	Copper (µg/L)			
Listed Stream	**Dissolved Acute Criterion**	**Dissolved Chronic Criterion**	**Allowable Total Acute Criterion**	**Allowable Total Chronic Criterion**
Big Creek	3.64	2.74	10.2	7.67
Orr Creek	4.05	3.02	8.91	6.64

Data Source: GAEPD, 2003b

Copper permit limits for NPDES-permitted facilities are presented in Table 17 as they were listed in the TMDL Implementation Plan for the Chattahoochee River Basin (GAEPD, 2003b). The City of Cumming WRF and Tyson Foods, Inc. are the only NPDES point sources that discharge directly to into one of the three studied watersheds.

TABLE 17
NPDES Permitted Facilities for Discharging Copper, as listed in the 2003 TMDL Plan for the Chattahoochee River
Forsyth County Watershed Protection Plan

Facility Name	Permit No.	Average or Permitted Flow (mgd)	Listed Watershed
Cumming WRF	GA0046019	8	Big Creek
Tyson Foods, Inc.	GA0001074	1.4	Orr Creek

Data Source: GAEPD, 2003b

Implementation Schedule of Management Measures

Forsyth County's WPP includes a suite of activities to be implemented over time by multiple departments. This section summarizes these implementation activities, discusses funding sources, and lays out a schedule for each department to reference. The WPP is a living document based on an adaptive management approach that allows time to evaluate options and make optimal decisions on allocation of limited resources to achieve desired results.

Schedule for Implementing Management Measures

Specifically identifying the "next steps" for implementation of this WPP by the various responsible departments is essential to its success. Table 18 summarizes management measures and other actions that have been or will be implemented by the County.

TABLE 18
Schedule for Watershed Implementation Activities
Forsyth County Watershed Protection Plan

Activity	Responsible Department	Frequency/ Implementation Date
Sedimentation Controls		
Conduct at least monthly erosion site certifications by certified inspector with weekly inspections for significant sites	Engineering	Ongoing
Provide certification program for developers on sedimentation and erosion control practices	Engineering	Annually
Stormwater Controls		
Develop process for monitoring issued permits and tracking compliance with permits	Engineering	2007
Stream Buffers		
Additional revisions will be adopted to clarify and expand the existing ordinance.	Planning	2006
Untrained staff should participate in District training seminars for stream buffers	Planning/ Engineering	Ongoing
Stormwater Management		
Perform GIS mapping of BMPs and impervious area	Engineering	Ongoing
Identify illicit connections through dry-weather screening and commercial/industrial inspections according to current District guidelines.	Engineering	Annually
Adopt District Post-Development Stormwater Management Ordinance and use of criteria that meet the intent of the Georgia Stormwater Management Manual	Engineering	June 2004
Implement Development Review Requirements from Ordinance and Georgia Stormwater Management Manual	Engineering	June 2004
Develop inspection and maintenance procedures for all (public and private) stormwater management ponds at new and existing developments, and submit procedures to GAEPD	Engineering	2004
Develop inspection and maintenance procedures for the County's storm sewer system and submit to GAEPD	Engineering	2005
Develop a stormwater management training program for County employees and submit to GAEPD	Engineering	2007
Continue to implement street cleaning program	Engineering	2005
Develop procedures to improve enforcement of ordinances, regulations, and maintenance of stormwater facilities, assess existing and new flood control projects for water quality impacts, require modification of those not in compliance with District guidelines	Engineering	Ongoing
Require proper disposal of storm system wastes	Engineering	Ongoing

TABLE 18
Schedule for Watershed Implementation Activities
Forsyth County Watershed Protection Plan

Activity	Responsible Department	Frequency/ Implementation Date
Watershed Improvement		
Implement an effective public education/outreach program to promote water quality awareness	Public Relations/ Engineering	Ongoing
Inspect sewer lines for inflow and infiltration, as well as inspect pumping stations	Engineering	Ongoing
Require sewer connection in appropriate areas	Engineering	Ongoing
Initiate Watershed Improvement Planning Process for Big Creek	Engineering	2006
Implement watershed improvement projects along Big Creek upon completion of planning process	Engineering	2008
Initiate Restoration Action Strategy/Ecosystem Restoration Reports for other impacted watersheds in the County	Engineering	2009 and Beyond
Total Maximum Daily Load (TMDL)		
Continue proactive implementation of stormwater management activities	Engineering	Ongoing
Facilitate interjurisdictional coordination with the City of Cumming to maximize funding resources available to improve water quality and aquatic integrity in shared watersheds	Water and Sewer	Ongoing
Continue to confirm the 303(d) listings and further isolate potential sources	Engineering	Ongoing
Long-Term Monitoring		
Conduct long-term ambient water quality monitoring according to current District guidelines	Engineering	Ongoing
Conduct biological monitoring	Engineering	Biannually
Identify specific sources of water quality problems based on monitoring data and follow-up inspections of suspect areas	Engineering	Ongoing
Reporting		
Submit Annual Progress Report to GAEPD and the District.	Engineering	Annually

The GAEPD has stated that implementation of the WPP will be coupled with regulatory permits for water and wastewater facilities. Permit holders will need to document that they have made meaningful progress in protecting water quality, as described in the guidance provided by GAEPD in 2005. In cases where a degradation trend is identified, permit holders must modify the plan to address causes of the degradation. Because environmental monitoring often does not show trends over a single year, it is proposed that implementation occur on a 5-year cycle as described in the District-wide WMP.

Schedules and budgets are tentatively proposed for programming purposes, but improving impacted areas are preliminary at this time, as many program details are undefined and must be finalized prior to action. This plan must be dynamic and flexible, because the starting dates of several proposed programs or activities may need to be staggered, and programs and activities may need to be modified as experience is gained in implementation.

Therefore, the dates, costs, and other specifics must be considered as general guidance at this time with further refinement as the WPP continues to evolve. This is particularly true with regard to the watershed restorations and retrofits, which can be quantified only after stream reconnaissance studies have been conducted for the impacted watersheds. Implementation of the program will entail the participation of several departments, including Engineering, Water and Sewer, and Planning. The successful implementation of the WPP mandates the close cooperation of County staff. Each entity participating in the coordination effort must take ownership and be responsible for the success of the program within its jurisdiction.

Long-Term Monitoring Plan

Understanding the sources and magnitudes of stream impairment is fundamental to developing effective strategies for achieving water quality improvements and restoring or maintaining biotic integrity. A monitoring program helps provide this understanding. The purpose of this section is to outline some major considerations shaping development of a long-term strategy for data collection.

Purpose and Objectives

The County's long-term goals are consistent with the GAEPD's position that all jurisdictions should implement effective nonpoint source programs to achieve and maintain beneficial uses of its waters that are regulated by the state. The purposes of a long-term monitoring program are multifaceted and involve establishing baseline conditions, identifying water quality impairments and improvements, as well as monitoring the effectiveness of the WPP and recommended BMPs. By comparing monitoring data to water quality standards and data from previous years, the County can identify any required modifications to make implementation activities more effective. Objectives are listed below:

- **Document Stream Improvement –** Implementation of BMP and land use control measures should result in measurable enhancements in water quality and the biotic integrity of streams. The monitoring program should be designed to collect the data needed to document stream improvements and any pollutant reductions that can be attributed to the WPP implementation.
- **Identify Streams Requiring Further Action –** Not all streams in the study area were sampled in the watershed assessment, and additional and continuous monitoring is needed to determine whether other stream segments may need further site-specific actions.
- **Monitor Effectiveness of the WPP –** The ultimate goal of the program is to maintain or improve existing conditions in the watersheds. The monitoring program must be designed to determine the extent to which the recommended combinations of BMPs and retrofitted stream segments are meeting this goal.
- **Monitor BMP Effectiveness –** Recommendations for BMPs and restoration projects are based primarily on literature values on pollutant-reduction efficiencies. Therefore, the effectiveness of certain groups of BMPs will be monitored by taking site-specific water quality measurements to help determine the effectiveness of the BMPs.

Environmental Monitoring Program

Forsyth County established its EMP prior to completion of the District-wide WMP; however the EMP still meets the intent of the District WMP to collect data that is representative of drainages for the entire County. Although some aspects of the EMP do not follow District recommendations exactly, the County's EMP exceeds many of the District guidelines. As appropriate, the County will modify its monitoring efforts to be more consistent with the current District guidance.

Forsyth County has an ongoing water quality program that includes long-term water quality monitoring on 14 streams in Forsyth County (Table 19), visual inspections of streams and industrial areas for water quality problems (i.e., spills, illicit discharges, etc.), and written documentation of findings. The County also performs biannual biological monitoring for fish, macroinvertebrates, and physical habitat at five locations that are also sampled for water quality. As described in a previous section, the County also performs additional TMDL monitoring for streams that are 303(d)-listed, but not included in the long-term monitoring. Forsyth County is also required to perform some of their existing monitoring protocols as they are described in the SWMP for their NPDES permit requirements and for the MS4 program, including outfall screenings for illicit discharges and commercial/industrial inspections. At least 150 MS4 outfalls are screened during dry weather for illicit discharges and maintenance issues, and 4 MS4 outfalls are screened twice annually during wet weather for illicit discharges. A more detailed description of the County's sampling protocol for 2006 is provided in the Water Quality Sampling Plan (Appendix B).

TABLE 19
Summary of Level of Effort and Station Location According to the EMP
Forsyth County Watershed Protection Plan

Program Element	Method/Frequency	Notes
Long-Term Ambient Trend Monitoring	14 stations[1]	Stations located in the Chattahoochee River Watershed, Etowah River Watershed, and the Lake Lanier Watershed (see Table 21)
Dry Weather Illicit Discharge Screening	150 dry weather discharge screenings / year[1]	Rotate sites annually as necessary based on data collected through water quality sampling.
Commercial/Industrial Inspection Program	5% of operations[1]	Inspect a minimum of 5% of relevant industrial/ commercial operations, based on standard industry classification codes, each year.
Watershed Assessment Monitoring	Completed	See Chapter 4, *Community Watershed Assessment and Management Plan* (CH2M HILL, 2000)
TMDL Implementation. Monitoring and Delisting	11 stations	See Table 13 for the list of locations described as currently not supporting, or partially supporting, their designated uses.
Biological and Habitat Assessments	5 stations/every 2 Years on a rotating basis[1]	GAEPD WRD methodology

[1] This number may change when regulatory guidelines are finalized
[2] As of the publication of this document, the District requires biological and habitat assessments every 5 years. However, based on guidelines from the GAEPD, the State will require monitoring at a higher frequency.

The water quality monitoring program required by the District is more extensive than that required by GAEPD, including long-term ambient trend monitoring, dry and wet-weather illicit discharge screening, commercial/industrial inspections, monitoring for the watershed assessment, TMDL monitoring, and biological and habitat monitoring. The District monitoring plan was designed to be a comprehensive effort that would allow for a consistent, minimum effort for monitoring across the planning area, as well as streamline monitoring efforts required for multiple regulatory efforts. The District recommendations are described in Table 20.

TABLE 20
Summary of Local Government Water Quality Monitoring Elements Required by the District
Forsyth County Watershed Protection Plan

Program Element	Frequency	Methodology/Approach
Long-Term Ambient Trend Monitoring	1 baseflow and 3 wet-weather samples (flow-weighted composite) collected during the summer (May–October) and winter (November–April) seasons.	2 stations will each be monitored at the listed frequency 1 Automated sampling – Composite hydrograph sampling triggered by data loggers 2 EWI/EDI[1] composite-grab sampling 3 Clean metals analysis (Method 1669)
Dry Weather Illicit Discharge Screening	Annual inspections	Rotation of sites as necessary based on data collected through water quality sampling
Commercial/ Industrial Inspection Program	Annual inspections	Inspection of a minimum of 5% of relevant industries/commercial operations each year
Watershed Assessment Monitoring	As needed based upon application for a new source or expansion of WTP and/or WRF discharge.	Water quality and biological monitoring watershed approach
Monitoring for Assessing TMDL Implementation and Delisting	As specified in the TMDL Implementation Plan	Sampling for 303(d)/305(b) listed constituents
Biological and Habitat Assessments	Every 5 years on a rotating basis	GAEPD/Wildlife Resources Division (WRD) methodology

[1] EWI/EDI – Equal Width Integrated and Equal Depth Integrated
[2] Sampling focused on wet-weather events and, therefore, may not be conducted monthly. A total of approximately 12 sampling events should be conducted in a year.

Source: Metropolitan North Georgia Water Planning District-wide WMP (CH2M HILL, 2003)

Long-Term Water Quality Monitoring

Fourteen locations within the County have been chosen to be sampled: Big Creek (3), Settingdown Creek (2), Four Mile Creek, Six Mile Creek, Two Mile Creek, James Creek, Dick's Creek, Taylor Creek, Sawnee Creek, Brewton Creek, and the Chattahoochee River. Current water quality monitoring locations are shown in Figure 4, and frequency of sampling are listed in Table 21. Samples are gathered on a monthly basis following storm events greater than 0.25 inches within 8 hours. During the sampling stage, height and in-

stream velocity are to be recorded, except for the Chattahoochee River. Existing local gauge information developed by the U.S. Geological Survey (USGS) is then used to estimate flow within the river.

In-situ parameters include dissolved oxygen (DO), temperature, conductivity, pH, and turbidity. Water quality samples are gathered and then sent to a certified laboratory to be analyzed for fecal coliform, total suspended solids (TSS), nitrate-nitrite, total phosphorus (TP), total organic carbon (TOC), dissolved copper, total dissolved solids, and pH. Further information about the relationship of each parameter to watershed activities is provided in the WAMP (CH2M HILL, 2000).

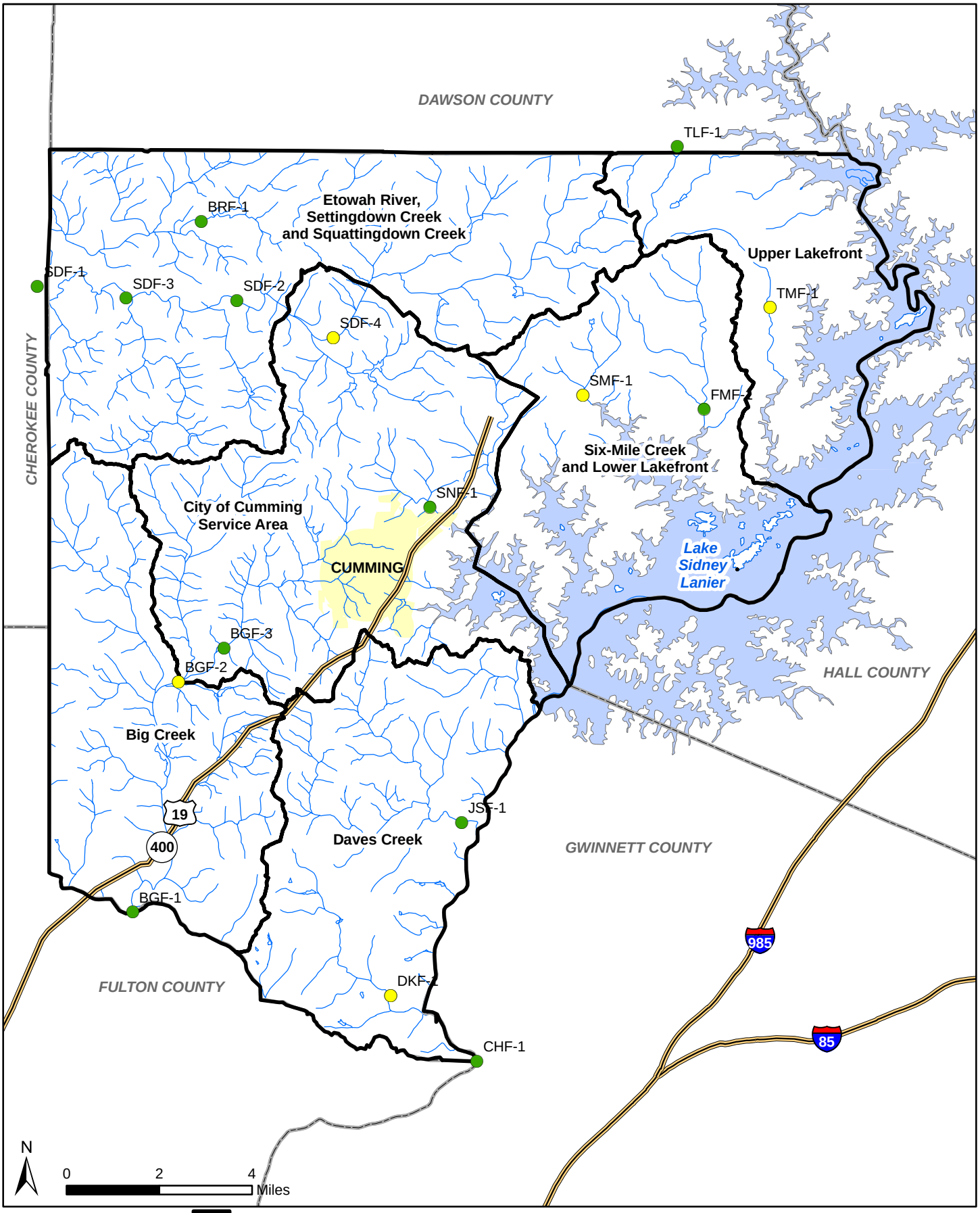
TABLE 21
Minimum Frequency of Stream Sampling
Forsyth County Watershed Protection Plan

Stream	Approximate Sampling Frequency[1]
Big Creek at McGinnis Ferry Rd (BGF-1).	Monthly
Big Creek at Majors Rd (BGF-2).	Monthly
Big Creek at Bethelview Rd. (BGF-3)	Monthly
Dick's Creek at Old Atlanta Rd. (DKF-1)	Monthly
James Creek at Burgess Rd. (JSF-1)	Monthly
Chattahoochee River near McGinnis Ferry Road (CHF-1)	Monthly
Six Mile Creek at Burgess Rd. (SMF-1)	Monthly
Four Mile Creek at Avery Bridge Rd. (FMF-1)	Monthly
Sawnee Creek at Pilgrim Mill (SNF-1)	Monthly
Taylor Creek at Highway 53 (TLF-1)	Monthly
Two Mile Creek at Wallace Wood Rd. (TMF-1)	Monthly
Settingdown Creek at Matt Hwy (SDF-3).	Monthly
Settingdown Creek at Burnt Bridge Rd. (SDF-4)	Monthly
Brewton Creek at Mt. Tabor Rd.(BRF-1)	Monthly

[1] Actual sampling frequency is dependent on storm events.

Biological Assessment

Macroinvertebrate and fish community assessments are conducted at 5 stations that are also sampled for water quality along Big Creek, Dick's Creek, Settingdown Creek, Six Mile Creek, and Two Mile Creek. The procedures will follow the most current version of the draft Standard Operating Procedures for Freshwater Macroinvertebrate Biological Assessment (GADNR, 2004) and Fish Communities in Wadeable Streams in Georgia (GADNR, 2005). Biological monitoring was performed in 1999 and 2005 by CH2M HILL. The County also conducted sampling in 2003 using a different contractor, but the sampling was redone in early 2004 with the help of CH2M HILL to better meet GADNR protocols. The County will conduct biological monitoring again in 2007.



Sampling Station
River or Stream
Limited Access Road
Forsyth County Community Watersheds
Incorporated Areas
County Boundary

Figure 4
Study Station Locations
Watershed Protection Plan
Forsyth County, GA

CH2MHILL

File Path: \\boomer\l\projects4\Forsyth_Watershed\MXD\Study_Sampling_Locations.mxd, Date: January 24, 2006, User: BBODINSO

Monitoring procedures include a habitat evaluation of the immediate watershed, substrates, stream width, and general water quality conditions. This is carried out by rating each of 10 metrics used to measure various riparian and in-stream parameters.

Fish communities are sampled using backpack electrofishing, where electricity is used to temporarily stun fish so they can be easily captured using dipnets (GADNR, 2005). Areas are also selected to use a minnow seine for further sampling if the habitat was conducive for seining. Seining is particularly effective in collecting darters, minnows, and other smaller fish generally not as vulnerable to backpack electrofishing. Index scores were derived for each station by rating 13 metrics of fish community structure in 5 broad categories: species richness, species composition, trophic function, species abundance, and physical condition. The 13 metrics integrate attributes of the entire fish community that are differentially sensitive to various levels of stream perturbation.

The procedure for macroinvertebrate collection involves collecting a composite sample from different habitats for analysis and data evaluation. The habitats sampled include coarse particulate organic matter (CPOM)/leaf pack samples, riffle kick net samples, undercut bank sweep net samples, rock and/or log wash samples, sand kick net samples, and aquatic vegetation sweeps. The macroinvertebrate samples are identified to the lowest taxonomic level practical, and the results is used to compute the community, population, and functional metrics (GADNR, 2004). Each metric or index represents a slightly different component of community structure and/or function and provides a measure of biotic integrity.

Etowah River Basin Monitoring Program

Funded by a grant from the United States Fish and Wildlife Service (USFWS), the habitat conservation planning process was triggered when three species of fish in the Etowah River Basin were listed as federally threatened or endangered under the Endangered Species Act. Five additional species are listed by the State of Georgia as rare, threatened, or endangered. As a result, any development activities requiring a USACE permit or Development of Regional Impact (DRI) review must also be coordinated with USFWS, a potentially lengthy process. The HCP proposes to expedite the review process for those projects / developments located in jurisdictions implementing the recommendations found in the final Etowah Habitat Conservation Plan (HCP), as approved by USFWS.

The draft Etowah HCP is being developed by staff from the University of Georgia, Kennesaw State University, and the Georgia Conservancy and a Steering Committee composed of representatives from counties and municipalities within the Etowah River Basin. An Advisory Committee composed of state and federal agencies, non-government organizations (NGOs), and other stakeholders also assists the Steering Committee and ad hoc Technical Committees with scientific and legal research, public education and outreach, and organization of meetings. The Etowah HCP is being developed through a series of technical papers that are presented to committee members for feedback and discussion. Completion and submittal of the draft HCP to the USFWS is projected for the fall of 2006.

Approximately 30 percent, or 70 square miles, of northwest Forsyth County drains to either the Etowah River or one of its tributaries (see Figure 1). Forsyth County is a partner in the development of the Etowah HCP with County leaders and staff members serving on

committees responsible for drafting the HCP, stormwater ordinances, development criteria, and BMP recommendations. As a County partner in the Etowah HCP, Forsyth County is also responsible for monitoring water quality and biotic integrity at 1 out of the 19 predetermined locations within the Etowah River Basin. Other monitoring locations are sampled by the additional counties that occur within the basin. The location monitored by Forsyth County is Settingdown Creek at Highway 369. On a monthly basis, the County samples water chemistry parameters including temperature, dissolved oxygen, pH, conductivity, turbidity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), hardness, total suspended solids (TSS), ammonia, total phosphorous (TP), orthophosphorous (DP), nitrate/nitrite, total nitrogen (TN), total organic carbon (TOC), fecal coliform, *Escharichia coli*, and total metals (that is, cadmium, copper, lead, zinc).

Table 22 summarizes the key points by topic area of the HCP documents published to date. These recommendations are in addition to existing District guidelines, already adopted by the County, and are still in draft format. Upon approval by the USFWS, Forsyth County will consider modifications to their ordinances, development criteria, and BMPs to meet the intent of the HCP in the portion of the County draining to the Etowah River.

In addition to participating in the HCP, Forsyth County has implemented by ordinance (Chapters 8 and 21 of the UDC), the Etowah River Corridor Protection District for the purposes of water supply protection. These measures consist of buffer protection from development, developmental type limitations, building and septic tank restrictions, and the prohibition of solid waste landfills within the river corridor. These measures apply to the 100-foot corridor running parallel to the Etowah River.

TABLE 22
Summary of Current Etowah HCP Documents (beyond Draft Reports)
Forsyth County Watershed Protection Plan

Topic Area	HCP Document Names	Key Points	Action Required by Forsyth
Better Site Design	Guidelines and Site Design Checklists BSD Ordinance (aka Stormwater Ordinance, see last row of table) Stormwater Facility Maintenance Problems and Proposed Solutions	Purpose: The goal of these site design guidelines is to reduce the volume of runoff generated by developed areas in order to protect imperiled aquatic species. Better Site Design is used to reduce the total impervious surface area of a new development and is one tool for meeting the HCP stormwater management performance criteria. Maximizes pervious area through changes in setbacks, road and sidewalk design, and parking lot regulations and infrastructure. Suggests the simplification and encouragement of regulations that allow for cluster development and green space preservation within new developments. Suggests the adoption of County ordinances that will address potential maintenance and jurisdiction issues that may arise in relation to stormwater infrastructure. Suggests the following BMP inspection frequencies and maintenance responsibilities:	TBD

TABLE 22
Summary of Current Etowah HCP Documents (beyond Draft Reports)
Forsyth County Watershed Protection Plan

<table>
<tr><th>Topic Area</th><th>HCP Document Names</th><th>Key Points</th><th>Action Required by Forsyth</th></tr>
<tr><td>Better Site Design (Continued)</td><td></td><td>
<table>
<tr><th>Owner/Type</th><th>Minimum Inspection Frequency</th><th>BMP Maintenance Responsibility</th></tr>
<tr><td>Facilities serving more than 10,000 sq. ft. impervious surface</td><td>Annual</td><td>Owner*</td></tr>
<tr><td>Facilities serving 5,001-10,000 sq. ft. impervious surface</td><td>Every 2 years</td><td>Owner or HOA*</td></tr>
<tr><td>Facilities serving less than 5,000 sq. ft. impervious surface</td><td>Every 3 years</td><td>Owner</td></tr>
<tr><td>Government-Owned BMPs</td><td>Annual</td><td>Government</td></tr>
</table>
* Government may also choose to accept maintenance responsibility, if desired.
</td><td></td></tr>
<tr><td>Conser-vation Subdivision</td><td>Technical Report

Ordinance</td><td>Purpose: Gives developers and landowners the flexibility to cluster development on a portion of the tract while permanently preserving the remaining areas as open space.

Site Analysis Map of Primary and Secondary Conservation Areas

Follow Randall Arendt’s four-step design process to preserve at least 40% of the total tract in the open space.

Must require permanent protection of open space.

If open space owned by the HOA, membership shall be mandatory for all homeowners.</td><td>TBD</td></tr>
<tr><td>Stormwater Runoff</td><td>Development Runoff Study

“BSD” Ordinance</td><td>Purpose: To manage the quantity and quality of stormwater runoff identified in the Technical Reports to be the largest threat to the imperiled fishes of the Etowah River.

Similar to District Model Ordinance, adds language for additional performance criteria in designated Priority Areas.

Additional runoff limits are defined by ordinance for those portions of the Etowah identified as either a Priority 1 or Priority 2 Areas or as a Development Node.

Priority 1 Areas would require new development to produce no net increase in stormwater runoff over a forested condition. Post development runoff limits are higher for Priority 2 Areas and predetermined Development Nodes

In these areas, the runoff limits may necessitate use of Better Site Design, nonstructural stormwater management measures, and structural stormwater management measures that allow for infiltration or evapo-transpiration in order to meet these performance standards.

The Etowah HCP Runoff Limits Manual provides technical guidance.</td><td>TBD</td></tr>
<tr><td>Erosion and Sediment-ation</td><td>Technical Report

Standard Operating Procedure for E and S Control</td><td>Purpose: To identify the best practices among the jurisdictions of the Etowah Basin and develop these into a “Standard Operating Procedure” (SOP) for all participating counties and municipalities.

Would require two pre-construction meetings, semi-monthly reporting, a bonding program, minimum inspection frequency requirements, E and S checklist for building inspectors, and designation of emergency contact for E and S at each development..</td><td>TBD</td></tr>
</table>

TABLE 22
Summary of Current Etowah HCP Documents (beyond Draft Reports)
Forsyth County Watershed Protection Plan

Topic Area	HCP Document Names	Key Points	Action Required by Forsyth
Stream Crossings and Culvert Design	Technical Report	Purpose: The goal of recommendations is to improve the placement of culverts and road crossings during new construction over streams and rivers. Road crossings and associated infrastructure can serve to fragment fish habitat and populations. Would require bridges over streams draining more than 20 square miles, Crossings over streams draining less than 20 square miles would use bottomless culverts or embedded box or pipe culverts. Perched culverts may not be installed. Channel disturbance and bank erosion would be minimized to full extent possible during installation of infrastructure Variances may be issued when proposed alternatives have no greater impact than the required provisions	TBD
Utility Line Crossings	Technical Report (Draft)	Purpose: To protect instream habitat and reduce bank erosion from utility crossings and their installation. During installation, horizontal direct drilling (HDD) shall be utilized in preference to all other methods when feasible When HDD is not feasible isolation crossings can be made if they do not create excessive erosive forces and if they do not involve the dewatering of streams Open trench construction is prohibited except when it can be shown that alternatives would produce more harm Construction activities would minimize impact of instream and adjacent habitat and all but HDD installation would be prohibited during sensitive life history periods of imperiled species.	TBD
Stream Buffers	Stream Buffer Ordinances (HCP Revisions to District Model Ordinance)	Recommends District communities continue to meet the intent of the District ordinance with minor adjustments. Clarify the definition of a stream. Remove exemption for activities in ROWs Clarify and strengthen variance procedures.	TBD

TBD = To be determined when HCP is finalized.

References

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APPENDIX A

Responsible Parties within Watersheds

TABLE A
Responsible Parties within the Same Watersheds as Forsyth County
Forsyth County Watershed Protection Plan

Responsible Party	
Cities and Counties	
City of Cumming Department of Planning and Zoning Scott Morgan 100 Main Street Cumming, Georgia 30040 770.781.2024 s.morgan@cityofcumming.net	Gwinnett County Public Utilities Frank Stephens 75 Langley Dr Lawrenceville, GA 30045 Phone: 770.822.8000 Frank.Stephens@gwinnettcounty.com
Cherokee County Engineering Department Geoffrey E. Morton 130 East Main Street Suite 106 Canton, GA 30114 678.493.6077 gmorton@cherokeega.com Cherokee County Water and Sewerage Authority 391 West Main Street Canton, GA 30114 770.479.1813 Janice@ccwsa.com	City of Canton (See Cherokee County Engineering Department and Cherokee County Water and Sewerage Authority)
City of Holly Springs Administrative Offices Anthony W. Griffin 3235 Holly Springs Parkway Holly Springs, GA 30142 770.345.5536 awgriffin@hollyspringsga.net	City of Woodstock Jarvis Middleton 103 Arnold Mill Road Woodstock, GA 30188 770.592.6036 jmiddleton@ci.woodstock.ga.net
Robert L. Brice Cobb County Water System 660 S Cobb Drive Marietta, GA 30060 770.423.1000 water@cobbcounty.org	James Wells Marietta Water 627 B. North Marietta Parkway Marietta, GA 30060 770.794.5223 jwells@mariettaga.gov
Randy Bowen Dawson County Public Works Dawsonville Business Park Hwy. 9 South 76 Howard Avenue East, Suite 120 Dawsonville, GA 30534 706.344.3501 Ext. 246 rbowen@dawsoncounty.org	City of Dawsonville Water/Sewer Department 415 Highway 53 East, Suite 100 Dawsonville, Georgia 30534 706.265.3256

City of Chamblee (See Dekalb County Water and Sewer) 770.986.5024	Miguel Valentin City of Decatur Leveritt Public Works Building, second floor 2635 Talley St. Decatur, GA 30030 404.377.6198 mvalentin@decaturga.com
City of Doraville (See Dekalb County Water and Sewer)	Marie Woody Fannin County Department of Land Development 400 West Main, Suite 101 Blue Ridge, Georgia 30513 706.632.8361 landdevelopment@fannincountyga.org
Nick Ammons Fulton County Department of Public Works-Surface Water Management Program 141 Pryor Street, S.W. Suite 6001 404.730.7400 Nick.Ammons@co.fulton.ga.us	John Moskaluk City of Alpharetta Two South Main Street Alpharetta, GA 30004 678.297.6200 jmoskaluk@alpharetta.ga.us
Stuart Moring City of Roswell Public Works Roswell City Hall-Main 38 Hill Street Roswell, GA 30075 770.641.3750 smoring@ci.rowswell.ga.us	Lamar Sudderth City of Buford Public Utilities 2300 Buford Highway Buford, GA 30518 770.945.6761
Audrey Turner City of Duluth Public Works 2450 Chattahoochee Drive Duluth, GA 30097 770.476.2454 aturner@duluthga.net	Kaipo Owana, Planning and Development Department City of Sugar Hill 4988 West Broad Street Sugar Hill, GA 30518 (770) 945-6734 Fax: (770) 945-0281
James Miller City of Suwanee Department of Public Works 373 Highway 23 Suwanee, GA 30024 770.945.7034 jmiller@suwanee.com	Betty Lathan Habersham County Water Department P.O. Box 1540 Clarkesville, GA 30523 706.754.8159 hcwsa@hemc.net
Doug Derrer Hall County Public Works and Utilities P.O. Box 1435 Gainesville, GA 30503 770.531.6800 dderrer@hallcounty.org	Adrian Niles City of Gainesville Department of Public Works 770.535.6882 publicworks@gainesville.org
Johnny Thomas City of Flowery Branch Water and Sewer Department P.O. Box 757 Flowery Branch, GA 30542 770.967.6371	Larry Sparks Planning Director City of Oakwood P.O. Box 99 Oakwood, Georgia 30566-0002 (770) 534-2365 Fax: (770) 297-3223

Dudley Owens Lumpkin County Water Authority 99 Courthouse Hill Dahlonega, GA 30533-0540 706.867.6580 dowens@lumplincounty.gov	Larry Coleman Director of Utilities Pickens County 52 N. Main Street Jasper, Georgia 30143 (706) 253-8719
David Hall Water and Wastewater Treatment Supervisor City of Jasper 200 Burnt Mountain Road Jasper, Georgia 30143 (706) 692-9101 Fax (706) 692-9104	Townes County 48 River St. Hiawassee, Georgia 30546-3219 (706) 896-2276 Fax (706) 896-1772
DeKalb County Water and Sewer 1580 Roadhaven Drive Stone Mountain, GA 30083 770.621.7200 wsmail@co.dekalb.ga.us	Clean Water Atlanta City of Atlanta Department of Watershed Management 55 Trinity Avenue Atlanta, GA 30303 404.529.9211 cleanwateratlanta@atlanta.gov
Other Pertinent Authorities and Organizations	
Curt Gervich Etowah Habitat Conservation Plan P.O. Box 287 Acworth, GA 30101 678.801.4013 curt@etowahhcp.org	Upper Etowah River Alliance Robin Dake Rt. 2 Box 104 Eastanollee, GA 30538 706-779-5756 info@etowahriver.org
Upper Chattahoochee Riverkeeper 3 Puritan Mill 916 Joseph Lowery Blvd. Atlanta, Ga 30318 404.352.9828	Lake Lanier Association 615F Oak Street, Suite 100 Gainesville, GA 30501 770.503.7757 lakeinfo@lakelanier.org

APPENDIX B

2006 Water Quality Sampling Plan

Sampling Plan

2006 Water Quality Sampling

Prepared for

Forsyth County

110 East Main Street, Suite 150
Cumming, Georgia 30040

March 2006

CH2MHILL
115 Perimeter Center Place NE, Suite 700
Atlanta, GA 30346-1278

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1.0 Introduction

As part of Forsyth County's Watershed Assessment and Management Plan (WAMP), the Environmental Monitoring Plan (EMP) was developed to identify water quality impairments and improvements, as well as to evaluate the effectiveness of the County's stormwater and watershed management activities. Multiple regulatory requirements are met by the EMP, including the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm System (MS4) program, Georgia Environmental Protection Division (GAEPD) watershed assessment and protection plan guidance, Metropolitan North Georgia Water Planning District (District) guidance, and the GAEPD Total Maximum Daily Loading (TMDL) program. The County's long-term goals are consistent with those of the GAEPD. Trends in the data provide information on the effectiveness of Best Management Practices (BMPs) toward meeting water quality standards, including any required changes.

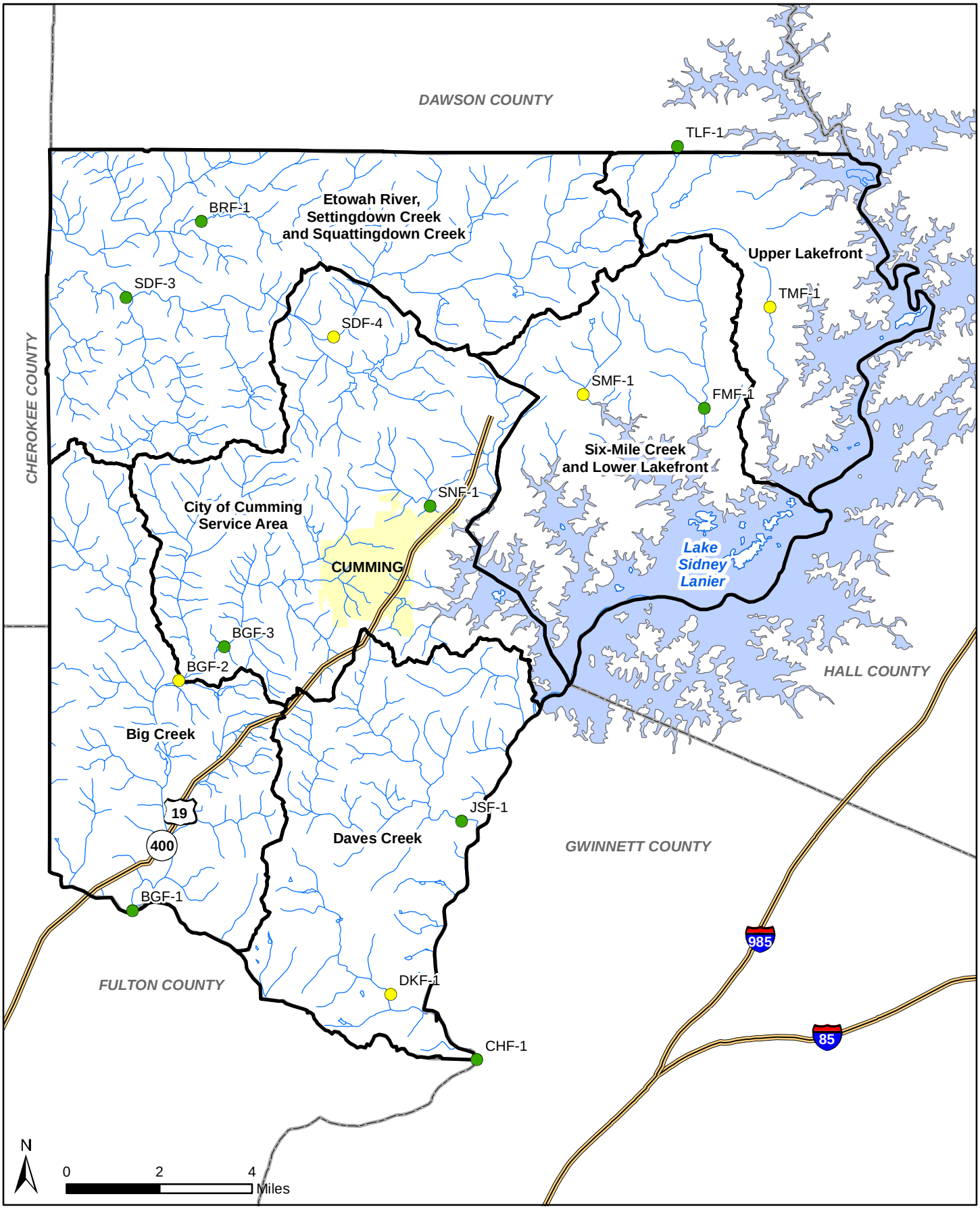
CH2M HILL assisted Forsyth County in the completion of the WAMP in 2000 by collecting physical, chemical, and biological data and conducting an assessment of representative stream locations throughout the County. The WAMP was used along with existing data about watershed characteristics to identify primary factors causing any stream impairment with respect to water quality standards and designated uses, and to support modeling efforts that examined possible options for future watershed management/protection strategies for improving water quality in Forsyth County streams. Data collected during the development of the WAMP aided in the selection of sites and strategy for future sampling efforts.

The County has conducted water quality monitoring since 2003. Biological monitoring occurred in summer 2003, but had to be repeated in spring 2004 due to inconsistent sampling methods on the part of the contractor. To remain on a biannual sampling schedule, biological monitoring occurred again in summer 2005. The next scheduled biological monitoring will occur in 2007. This year (2006), sampling will continue according to Forsyth County's WAMP and SWMP. The focus of sampling in 2006 will be on water quality and stream discharge across the County.

This field sampling plan presents the overall technical approach to water quality sampling and provides a description of field methods to be used in accordance with the WAMP. The major components of this sampling plan include multiple-stage stream discharge recordings, in-situ water quality monitoring, and water quality sampling.

Forsyth County Watersheds

Forsyth County contains portions of two major watersheds (Figure 1). The majority of the County, excluding the northwest corner is within the Chattahoochee River basin. Major streams of the Chattahoochee basin within Forsyth County include Big Creek, Taylor Creek, James Creek, Dick Creek, Two Mile Creek, Four Mile Creek, Six Mile Creek, and Suwanee Creek.



Sampling Stations

- Water Quality
- Biological and Water Quality

- River or Stream
- Limited Access Road
- Forsyth County Community Watersheds
- Incorporated Areas
- County Boundary

Figure **1**
Study Station Locations
Sampling Plan 2006
Forsyth County, GA

CH2MHILL

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Lake Lanier, which is the largest lake located entirely within the boundaries of the State of Georgia, occupies more than 38,000 acres in Forsyth County. The Etowah River is the second watershed that is located partly in Forsyth County. The major streams within the Etowah watershed and draining Forsyth County are Settingdown, Banister, and Brewton Creeks. The Etowah River itself flows through a small portion of Forsyth County.

Forsyth County Streams Listed in the Georgia 305(b) Report (TMDL Program)

Section 305(b) of the Clean Water Act requires that states develop and institute a biannual monitoring and reporting program that describes water quality conditions of state waters. This report, known as the 305(b) report, provides an assessment of surface-water quality as supporting, partially supporting, or not supporting a designated use. Table 1 provides a summary of the 305(b) report stream status for the County. The County has incorporated all listed streams into the EMP for sampling according to their listed criterion violation. In Forsyth County, three streams are identified as "not supporting" their designated use. All three creeks are listed for violating fecal coliform standards. The potential origins of the fecal coliform include urban runoff and non-point sources. Six streams in the County are listed as "partially supporting" their designated use. These streams are listed for violations of fecal coliform, copper, and State biological standards due to urban stressors and non-point sources of pollution.

TABLE 1
Forsyth County Streams Listed in Georgia 305(b) Report [a]
Forsyth County Sampling Plan 2006

Watershed/Stream	Water Use Classification	Criterion Violated [b]	Evaluated Causes [c]	Stream Miles	303(d) Status [d]
Streams Partially Supporting Designated Uses					
Big Creek (headwaters to Cheatham Creek)	Fishing	FC, Cu	UR, I2	3	3,3
Four Mile Creek (Lake Lanier tributary)	Fishing	FC	NP	3	3
Kelly Mill Branch (headwaters to Orr Creek)	Fishing	FC	UR	2	3
Settingdown Creek (Squattingdown Creek to Thalley Creek)	Fishing	Bio	NP	3	X
Taylor Creek (with Dawson County)	Fishing	FC	NP	3	3
Two Mile Creek	Fishing	FC	NP	5	3
Streams Not Supporting Designated Uses					
James Creek	Fishing	FC	NP, UR	2	3
Orr Creek	Fishing	FC,Cu	UR, I1,I2	3	3
Six Mile Creek (headwaters to Lake Lanier)	Fishing	FC	UR	4	3

Source: GADNR, January 2004.

[a] Note that, as acknowledged in the Georgia 305(b) report, the data used to develop these lists are not rigorously screened and/or subjected to standard quality control protocol for use in this manner.

[b] FC = fecal coliform bacteria; Cu = copper; Bio = biota impacted

[c] UR = urban runoff/urban effects; I2 = residual from industrial source; NP = nonpoint sources/unknown sources

[d] "3" Indicates area where a Total Maximum Daily Load (TMDL) has been developed

2.0 Technical Approach

All sampling and analysis will be completed by certified laboratories that follow Environmental Protection Agency (EPA) and GAEPD guidelines and procedures. The planned sampling for Forsyth County is as follows:

- Long-term ambient water quality monitoring at 14 stations (Figure 2) within the County and both the Chattahoochee and Etowah River basins.
- Fecal coliform monitoring (to determine geometric means) at two stations, and copper monitoring at one of these for assessing TMDL implementation and delisting (Figure 2 and Table 1).
- Commercial and industrial inspections at 20 percent of the relevant businesses or Standard Industrial Codes (SIC).
- Wet weather MS4 samples (4 outfalls) during rain events in which at least 0.25 inch of precipitation is received in a minimum of 3 hours.

Station Selection

Water sampling for chemical analysis, in-situ water quality measurements, and fecal coliform sampling will be conducted at 14 study stations in the Chattahoochee and Etowah River basins (Table 2 and Figure 2). These stations were represented a variety of land uses, nonpoint loading sources, point source discharges, and other watershed factors directly affecting water quality and aquatic biota in Forsyth County streams (Figure 3). Primary watershed criteria considered in the selection of study stations are listed in Table 3. Water quality attainment status was a selection criterion for nine stream segments in the study area (see Table 1). GAEPD (2004) rated these streams as not supporting or partially supporting their "fishing" water use classification (see previous section).

TABLE 2
Minimum Frequency of Stream Sampling
Forsyth County Sampling Plan 2006

Stream	Sampling Frequency
Big Creek Watershed	
Big Creek at McGinnis Ferry Rd.	Monthly
Big Creek at Majors Rd.	Monthly
Big Creek at Bethelview Rd.	Monthly
Daves Creek Watershed	
Dick Creek at Old Atlanta Rd.	Monthly
James Creek at Burgess Rd.	Monthly
Chattahoochee River near McGinnis Ferry Road	Monthly
Six Mile Creek and Lower Lakefront Watershed	
Six Mile Creek at Burgess Rd.	Monthly

TABLE 2
Minimum Frequency of Stream Sampling
Forsyth County Sampling Plan 2006

Stream	Sampling Frequency
Four Mile Creek at Avery Bridge Rd.	Monthly
Sawnee Creek at Pilgrim Mill	Monthly
Upper Lakefront Watershed	
Taylor Creek at Highway 53	Monthly
Two Mile Creek at Wallace Wood Rd.	Monthly
Etowah River, Settingdown Creek and Squattingdown Creek Watershed	
Settingdown Creek at Matt Hwy.	Monthly
Settingdown Creek at Burnt Bridge Rd.	Monthly
Brewton Creek at Mt. Tabor Rd.	Monthly

There are 24 permitted point source discharges to the streams of Forsyth County including the Cumming Water Pollution Control Plant (WPCP) and Forsyth County Water Reclamation Facility (WRF) (USEPA, 2006). Prevalent urban land uses include low and medium density residential units, commercial areas, industrial complexes, office parks, and transportation corridors. Long-term sample locations were selected to represent each type of land use. A reconnaissance of the proposed monitoring station locations was conducted in April 1999, as described in the WAMP.

TABLE 3
Sampling Station Selection Criteria
Forsyth County Sampling Plan 2006

Criteria	Sources of Information
Water quality attainment status	Georgia 305(b) Report
Point source discharges (WPCPs, NPDES permits, Toxic Release Inventory [TRI] sites, etc.)	Forsyth County EPA Envirofacts (2003)
Land application sites	BASINS (2001)
Solid waste facilities (landfills)	BASINS (2001)
Existing nonpoint loading sources (i.e., land uses)	BASINS (2001)
Future nonpoint loading sources (i.e., land uses)	BASINS (2001)
Sewer and septic service areas	Forsyth County
Water supply intakes	EPA Envirofacts (2003)
Comparability of physical habitats	Site reconnaissance
Perennial stream flow	U.S. Geological Survey (USGS) topographic maps

Water Quality Sampling Methods

Water quality sampling will include long-term ambient trend monitoring, stream discharge measurements, TMDL monitoring (short-term monitoring), dry weather MS4 screenings, and wet weather MS4 facility outfall sampling. Wet events will be taken within a defined sampling period during a rain event. The wet event must be preceded by 72 hours of dry weather (that is, less than 0.1 inch of rainfall per day) and will be conducted within 8 hours following a minimum of 0.25 inch of rainfall. Dry weather samples will be taken after 72 hours with less than 0.1 inch of rain. Type 1 quality assurance/quality control (QA/QC) will be used when collecting samples for chemical and fecal coliform analysis and for taking in-situ measurements (see page 11 for details). The following paragraphs specify methods for each water quality sampling technique in further detail. See Table 4 for an overview of the number of samples that will occur for each parameter.

TABLE 4
Summary of Long-term Ambient Trend Water Quality and TMDL Monitoring Parameters and Events
Forsyth County Sampling Plan 2006

Water Quality Parameters	No. of Stations	Minimum No. of Dry Events	Total No. of Dry Samples	Minimum No. of Wet Events	Total No. Of Wet Samples
In-situ Parameters [a]					
DO	16	4	64	8	128
pH	16	4	64	8	128
Conductivity	16	4	64	8	128
Turbidity	16	4	64	8	128
Temperature	16	4	64	8	128
Chemical and Bacteriological Parameters					
pH (laboratory)	14	4	56	8	112
Total Suspended Solids (TSS)	14	4	56	8	112
Nitrate-Nitrite (NO_2- NO_3)	14	4	56	8	112
Total Phosphorus [TP]	14	4	56	8	112
Dissolved Copper	14	4	56	8	112
Total Dissolved Solids (TDS)	14	4	56	8	112
Total Organic Carbon (TOC)	14	4	56	8	112
Fecal Coliform (collected with other parameters)	14	4	56	8	112
Fecal Coliform (4 grab events to calculate a geometric mean)[b]	2	4	32	12	24

[a] Additional in-situ events will occur for TMDL sampling to what is shown in this table
[b] Fecal coliform samples may coincide with the wet and dry events depending on schedule but will be based on at least four samples collected from given sampling sites over a 30-day period at intervals not less than 24 hours.

Long-term Ambient Trend Water Quality Monitoring

The long-term monitoring locations for 2006 remain unchanged from 2005. There are 14 sites located on the following streams: Big Creek (3), Settingdown Creek (2), Four Mile Creek, Six Mile Creek, Ten Mile Creek, James Creek, Dick Creek, Taylor Creek, Sawnee Creek, Brewton Creek, and the Chattahoochee River. Samples will be taken approximately monthly following storm events greater than 0.25 inches within 8 hours and during dry weather periods. During dry weather the stations will be sampled four times throughout the year and during wet events the stations will be sampled eight times. During the sampling, GPS coordinates and stage height will be recorded, except for the Chattahoochee River. Existing local gage information developed by the U.S. Geological Survey (USGS) will be used to estimate flow in the River. Water quality samples will be gathered and then sent to a certified laboratory, discussed below, to be analyzed for fecal coliform, total suspended solids (TSS), total phosphorus (TP), total organic carbon (TOC), dissolved copper, nitrate-nitrite , and pH.

Stream Discharge Measurements

At all long-term monitoring stations listed above stream discharge will be measured at varying stages and seasons. A total of six measurements will be taken at each station over the course of the sample period (1 year). Measurements will include baseflow conditions as well as elevated stages in relation to the varying severity of rain events. Streams will not be sampled if the FTL determines that flow conditions are unsafe.

TMDL Monitoring

TMDL water monitoring, also known as short-term sampling in previous years, is used to sample 303(d)-listed streams in the County that are not included in the long-term monitoring stations. The stations to be sampled include one that is currently listed on the 303(d) list for partially supporting its designated uses, Kelly Mill Creek. Orr Creek, of which Kelly Mill Creek is a tributary to, is the other stream that will be sampled and is listed as not supporting its designated use. Kelly Mill Creek is listed for fecal coliform and will be sampled for this parameter. Orr Creek is listed for fecal coliform and copper and will be sampled for both. In compliance with State standards, a 30-day geometric mean will be sampled and calculated during four separate periods during the year at both sites. Copper at Orr Creek will be sampled for once during each quarter. By monitoring these stations, Forsyth County meets monitoring requirements associated with TMDLs established by the District, and the County establishes the process for potential delisting of these stream segments.

Dry Weather MS4 Screenings

The MS4-NPDES Permit Monitoring Program identifies and prioritizes areas where illicit connections and discharges are most likely to occur by tracking dry-weather flows from the outfalls or manholes to their source.

Dry weather MS4 screenings will be performed at 150 sites selected by the County in 2006. Dry weather outfall screenings are performed to identify potential land use impacts and to monitor the effectiveness of each facility. A visual inspection of industrial discharges or local waters will be performed to determine if only stormwater is being discharged.

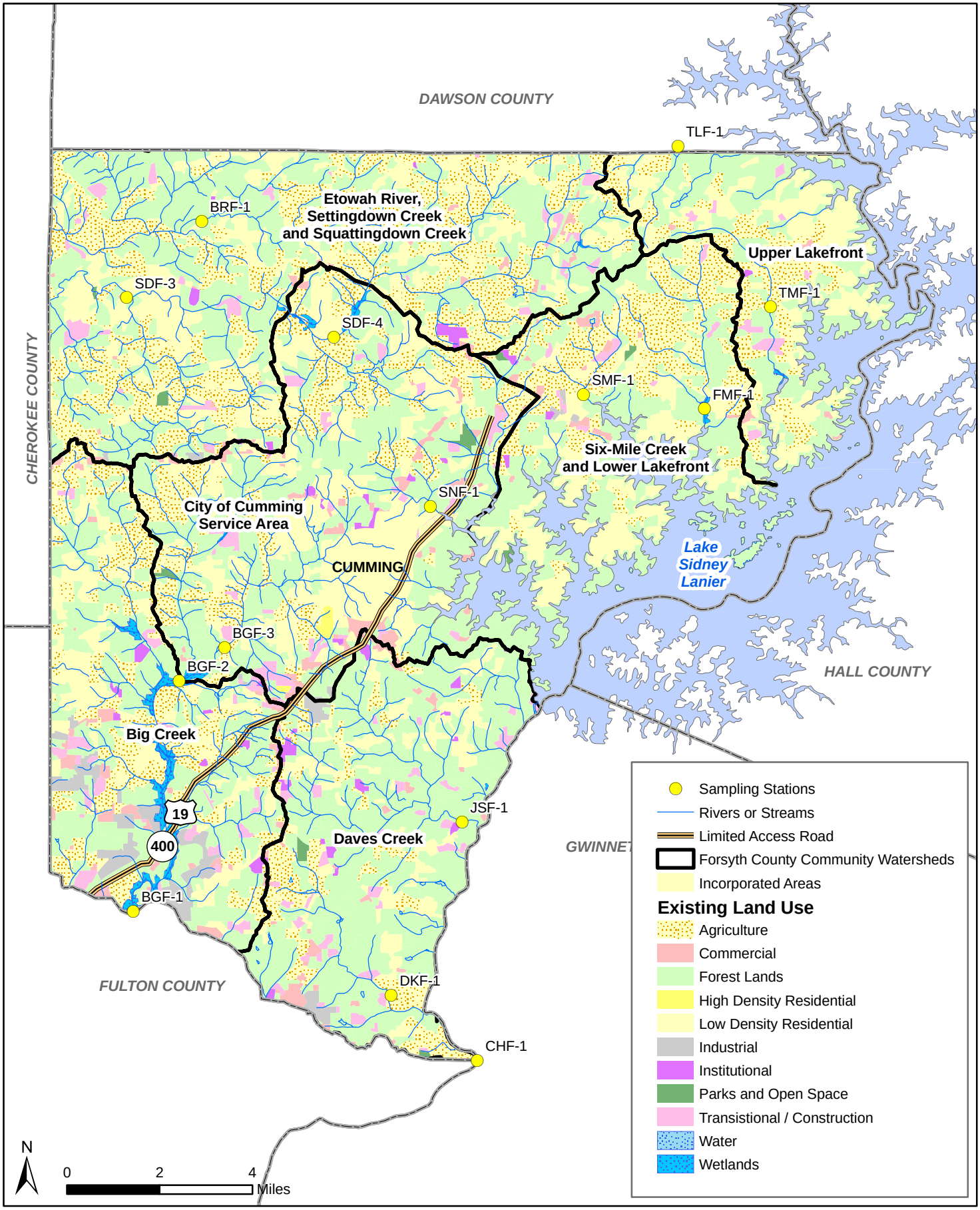

Figure 2
Study Stations and Land Use Characterization
Sampling Plan 2006
Forsyth County, Ga

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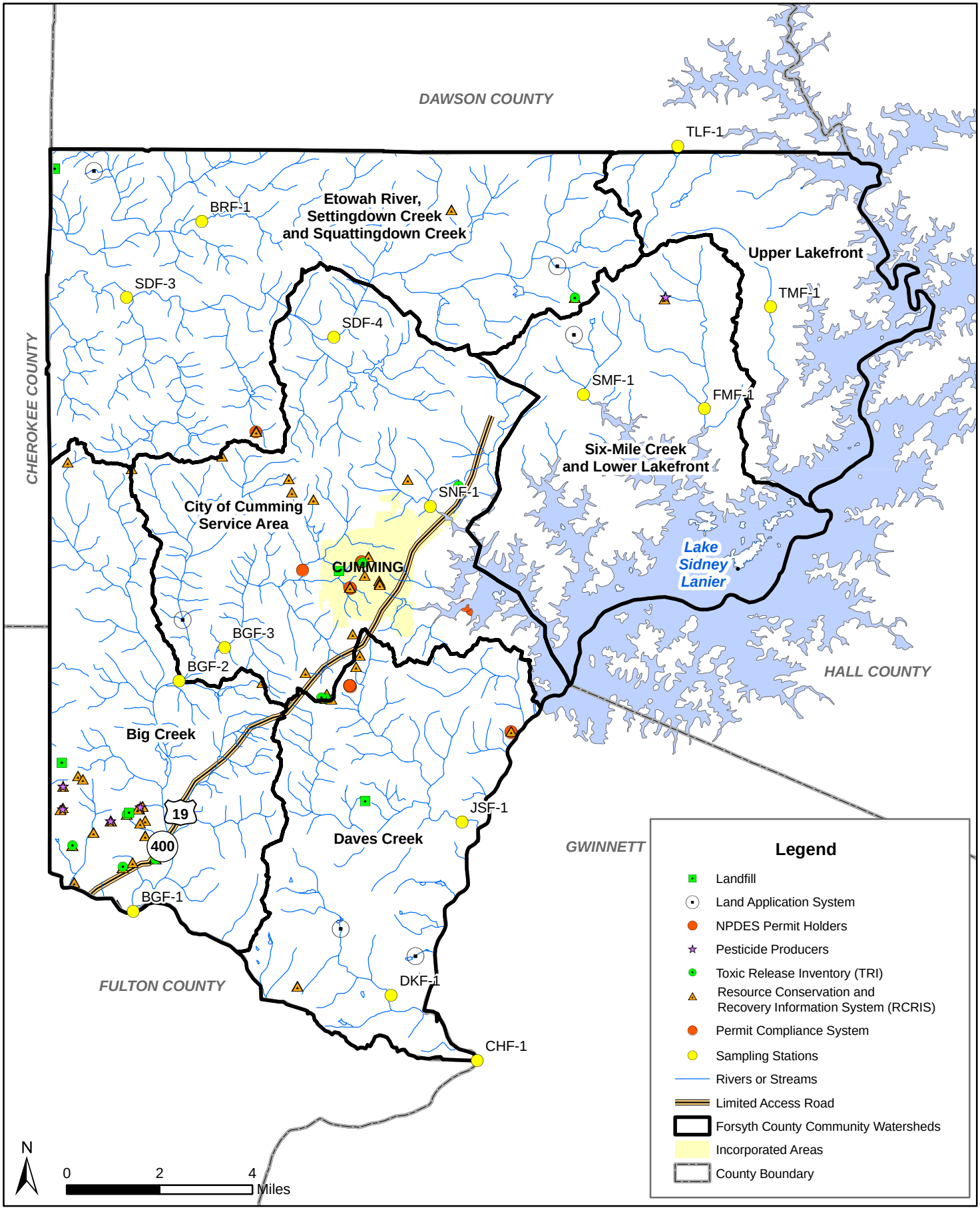

Figure 3
Sampling Station Locations and
Potential Pollutant Sources
Sampling Plan 2006
Forsyth County, Ga

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LaMotte's Storm Drain Text Kit or an equivalent kit will be used for field tests. Field screening will follow ARC guidelines (ARC, 2000). Screenings will include:

- Checking any observed discharge for color, turbidity, oil sheen, and odor
- Field and laboratory sampling of discharge for total chlorine, oil and grease, total copper, total phenol, and detergents/surfactants

Outfall sampling locations are identified by the County as pipes at least 36 inches in diameter in residential areas (or at least 24 inches for drainage basins greater than 50 acres) or at least 12 inches for commercial sites. Sampling is done during dry weather, defined as at least 72 hours after the last runoff-producing rain event, to help identify non-stormwater discharges. Dry weather screenings are done as a part of the regular monitoring program and in response to reported releases. Results of dry weather screening and any follow-up activities are documented on the Outfall Screening Report provided in Appendix A.

If dry-weather flow is present, field tests will be performed. Water is usually tested for pH, conductivity, detergents, and metals; and an investigation is initiated where readings indicate a potential pollution source. When responding to a reported release, an investigator inspects the site and water testing is carried out if needed using a LaMotte field kit. The detection kit was designed to meet US EPA requirements for field test procedures approved in the November 16, 1990 Federal Register to monitor illicit storm drain connections. Each unit includes tests for pH, Total Chlorine, Total Copper, Phenols, Detergent surfactants, Conductivity, and Turbidity. In some cases where toxic or hazardous material release is suspected, additional sampling may be performed. If the public is involved, a notice will be issued to alert the inhabitants of the affected area.

Wet Weather MS4 Sampling

Wet weather sampling will occur two times per year (the first in spring/summer and the second during fall/winter) at the following four locations in Forsyth County:

- Johns Creek (near McGinnis Ferry)
- Polo Fields
- Margate Subdivision
- Twenty West Business Park

Grab samples will be taken within the first 45 minutes of the beginning of the rain event. The storm events should be preceded by 72 hours of dry weather and at least 0.1 inch of rain must be recorded.

During the sample period a composite sample shall be collected. The composite will be made with 500 milliliter (mL) aliquot samples taken every 30 minutes during the first three hours of a rain event. The total volume of the composite sample will be between 2500 and 3000 mL total volume depending on the duration of the sample event. Samples will include:

- In-situ measurements of pH, conductivity, turbidity, temperature, and dissolved oxygen.
- Grab samples of fecal coliform, oil and grease, and pH taken from the midpoint of the sample period.

- Composite samples of total phosphorous, dissolved phosphorous, nitrate/nitrite, total organic nitrogen, total Kjeldahl nitrogen (TKN), chemical oxygen demand (COD), biological oxygen demand (BOD), total suspended solids (TSS), total dissolved solids (TDS), and metals (lead, copper, zinc, and cadmium).

In Situ Measurements

In-situ measurements of dissolved oxygen (DO), temperature, pH, conductivity, and turbidity will be made at each long-term station, TMDL station, and during wet weather MS4 monitoring events using a handheld sampler (YSI Model 6280) (Table 4). These measurements will be collected at the same time as the water quality sampling tasks.

Field Equipment

A tentative field equipment list for the water quality and discharge sampling stations includes:

- YSI Sonde (water chemistry measurements)
- Data Interrogator Cable
- Prepared bottles and labels
- Coolers and ice packs (blue ice)
- Marsh-McBirney Flowmate velocity meter
- Velocity meter sensor mount rod
- 100m meter tape
- Water quality collection bottles from the laboratory

Equipment will be gathered, checked, and loaded into the vehicles the day before each event.

Quality Assurance/Quality Control (QA/QC)

QA/QC is designed to assure the reliability and quality of the analysis and data and identify any contamination that may result from lab methods, equipment, or sample collection. Sample collection, preservation, handling and storage, and analytical procedures will be in accordance with standard methods and practices. A summary of QA/QC sampling requirements for this project is shown in Tables 5 and 6.

TABLE 5
Laboratory QA/QC Sample Frequency
Forsyth County Sampling Plan 2006

QA/QC Sample	Frequency
Method Blank	Once every 20 samples
Matrix Spike/Matrix Spike Duplicate	Once every 20 samples
Blank Spike	Once every 20 samples

TABLE 6
Parameters, Reporting Limits, and Methods
Forsyth County Sampling Plan 2006

Parameters	Detection Limit	Units	Method
pH	N/A	N/A	EPA 150.1
Turbidity	0.1	NTU	EPA 180.1
TSS	4.0	mg/L	EPA 160.2
Nitrate-Nitrite	0.05	mg/L	EPA 353.2
Total Phosphorous	0.1	mg/L	EPA 365.1
[c] Copper (Cu)	0.003	mg/L	EPA 200.7
TDS	10	mg/L	EPA 160.1
TOC	1.0	mg/L	MCAWW 415.1
Fecal Coliform	20	Colony-Forming Units (CFU)/100 milliliters (mL)	SM 9222 D

[a] Reporting limits are listed in National Environmental Methods Index. http://www.nemi.gov/.
[b] Measured in situ (in place) with field instrument
[c] Analyzed for dissolved and total concentrations

Three types of QA/QC will be performed as part of this field effort, with each type having a different amount of supporting laboratory QA/QC. Type 1 includes regular checks of water quality meters and proper documentation of sampling activities and field conditions by the field team members. Type 2 consists of sampling procedures intended to identify the type and estimate the level of contamination. Type 3 provides confirmation of the analytical procedures conducted by the laboratories. In combination, these types of QA/QC provide the equivalent of a modified Level 3 USEPA data quality objective.

Type 1—Field Surveys

Type 1 encompasses field monitoring activities and calibration of field equipment (see page 11). Field personnel for this project will be experienced in the calibration and operation of each piece of field equipment used on the project. Field instruments will be calibrated according to manufacturer's specifications and these procedures will be documented in a field notebook or on specially prepared field sheets. Type 1 activities include documenting other pertinent data concerning the sampling events such as weather conditions and time of sampling. Type 1 documentation can be summarized as follows:

- Instrument identification
- Calibration information (standards used and results)
- Date and time of calibrations and measurement

Type 2—Field Sampling

Two personnel with experience or special training in water quality sampling techniques will conduct field sampling. Type 2 activities include sample procedures designed to detect contamination from sampling equipment resulting from improper sample collection. Type 2 activities also include collection of QA/QC duplicate samples, use of trip blanks, and proper labeling of all samples. Table 6 lists the field QA/QC requirements.

Trip Blanks

Trip blanks are sample containers that are taken, as received, into the field and returned without being used. These are used to evaluate any contamination that may have taken place before the containers were received by the sampling team.

Field Duplicates

Field duplicate samples are collected to measure the precision of the sampling process. The FTL will choose at least one station per trip to collect the duplicate sample.

Type 3—Laboratory Analysis

The laboratories selected for this project assure data quality and use an internal QA/QC program. This program includes the analysis of blanks and spiked samples. The QA/QC samples are analyzed in the same manner as field samples and are interspersed with the field samples during analysis. Analytical results of the QA/QC samples are used to document the validity of the data and to control data quality within predetermined acceptance limits.

The QA/QC samples listed in Table 5 will be used to assess the validity of the analytical results.

Method Blank

A method blank is a sample of analyte-free water that the laboratory treats as a sample, undergoing the same analytical process as the corresponding field samples. Method blanks are used to monitor laboratory performance and detect contamination introduced during the analytical procedure.

Matrix Spikes/Matrix Spike Duplicate

For inorganic analyses, a single sample is split and one portion is spiked with a known amount of reference material. Spike recovery is used to evaluate potential matrix interferences as well as accuracy. The duplicate spike results are compared to evaluate precision.

Blank Spike

Analytes of interest or surrogates are spiked into blank water rather than into a sample. The blank spike goes through the same analytical procedure as the corresponding field samples, and percent recovery is calculated to measure matrix effects.

Analytical Procedures

Laboratory analysis will be conducted using EPA-approved methods published in *Standard Methods for the Examination of Water and Wastewater* (Standard Methods, 1997). The parameters and reporting limits are listed in Table 6.

Chain-of-Custody and Shipping

A required portion of any sampling and analytical program is the system for sample control from collection to data reporting. This includes the ability to trace the possession and handling of samples from the time of collection through analysis and final disposition. This documentation of the sample's history is referred to as "chain-of-custody." The components of the COC (COC record, sample labeling, custody seals, and field logs) and the procedures for their use are described below.

A sample is considered to be in a person's custody if it is:

- In the person's physical possession
- In view of the person after he/she has taken possession
- Secured by that person so that no one can tamper with the sample
- In a designated secure area

Chain-of-Custody Record

To establish the documentation necessary to trace sample possession from the time of collection, a COC record will be filled out and accompany every sample. The CH2M HILL or laboratory COC form will be used. In order to maintain COC, each person who has custody of the sample will sign, date, and note the time on the form. Samples will not be left unattended unless placed in a secured and sealed container with the COC record inside the container.

The FTL will include on the COC record special instructions for the laboratory to follow such as composite preparation or clean metal analysis. The special instructions should be consistent with the contract. If not, the FTL will inform the Project Manager about the change before the samples are analyzed. The following special instructions will be included on the COC forms:

- Water Quality: Analyze samples for the parameters listed in the contract (these parameters will also be listed on the COC form).

The FTL will include more specific instruction if needed.

2.3.1 Water Quality Sample Labeling

For each water quality sample, the following information will be clearly marked and labeled on the sample container:

- Client: CH2M HILL/Forsyth County
- Sample or Station Number:
- Location: _____River or Stream @ _____(Road Crossing)
- Analyses:
- Preservative:
- Date and Time:
- Sampled by:

During sampling, filled and labeled containers will be stored in coolers on ice to maintain a temperature of 4 ^{O}C. The coolers will remain in the custody of the FTL until the end of the sampling event. Glass containers, if used, will be wrapped in bubble-wrap to prevent breakage. Samples will be transported, in coolers on ice, by overnight courier. All coliform samples will be stored on ice and hand-delivered to the appropriate laboratory in order to meet the 6-hour holding time. If samples are collected on Friday, the laboratories will be notified for Saturday delivery.

Coolers prepared for shipping will be lined with a cooler liner and packed with ice in double-wrapped zip lock bags so that movement of samples will be minimized. Each shipping container will contain a COC form indicating the parameters to be analyzed.

A COC form will be included in each shipment container describing: the type of sample, number of containers, type and kind of analysis, QA/QC instructions and samples, and special processing and handling procedures. It is imperative that the samples taken to fulfill the QA/QC requirements to be completed by the lab are included on the COC. The FTL will keep the copy of the COC form.

Custody Seals

Custody seals are used to detect tampering with samples following collection, up to the time of analysis. When samples are packed for shipping, CH2M HILL custody seals will be placed across the latch and across the lid opening of the coolers to confirm that they arrive at the laboratory unopened. The custody seal placed across the lid opening will be secured with strapping tape. The tape will be placed over the custody seal and wrapped completely around the cooler so that it remains closed during shipping.

3.0 Additional Project Information

Project Team

Table 6 is a list of the names, addresses, and telephone numbers of the key project personnel assigned to the field sampling, data analysis, and report writing. The table summarizes the responsibilities of the each of the members listed.

TABLE 6
Project Team Responsibilities
Forsyth County Sampling Plan 2006

Team Member/Title	Contact Information	Responsibilities
Betsy Massie Project Manager	CH2M HILL 115 Perimeter Center Place Suite 700 Atlanta, GA 30346 W 770/604-9182 ext. 353	Manage team performance with regard to budget and schedule compliance.
Phillip Sacco Senior Scientist	CH2M HILL 115 Perimeter Center Place Suite 700 Atlanta, GA 30346 W 770/604-9182 ext. 506	Provide technical guidance in sampling methods and design. Serve as senior technical advisor for the field efforts and sampling techniques.
Chrissy Thom Task Leader Water Quality Sampling	CH2M HILL 115 Perimeter Center Place Suite 700 Atlanta, GA 30346 W 770/604-9182 ext. 582	Manage the overall sampling effort and deliver the task on time and on budget. Lead the sampling efforts. Organize the sampling team, lead field sampling efforts, and ensure proper sampling protocols are used in the field. Responsible for procuring, organizing, and maintaining field vehicles, field equipment, and water quality meters.
Casey Storey Project Scientist Water Quality Sampling	CH2M HILL 115 Perimeter Center Place Suite 700 Atlanta, Georgia 30346 W 770/604-9182 ext. 351	Provide technical oversight in sampling methods and field efforts. Assist with procuring and maintaining field equipment and water quality meters. Conducts field sampling and data analysis.
Kevin Barnes Subcontractor Water Quality Sampling	StreamTechs 190 Milledge Heights Athens, Georgia 30606 W 202/494-6660	Provide technical oversight in sampling methods and field efforts. Assist with maintaining field equipment and water quality meters. Conducts field sampling.

Project Schedule

The field schedule for the water quality monitoring will depend on rain and flow conditions. Sampling is scheduled to begin in January 2006. Wet weather sampling will depend on storm events, as they occur, but will also depend on laboratory availability. The detailed sampling schedule and sequence of sampling will be evaluated on a daily basis at the discretion of the sampling personnel. Scheduling decisions will take into account recent

rain events as they affect turbidity, water levels, field team safety, and station proximity in optimizing efficiency.

The water quality tasks are scheduled to be on-going. Activities to complete the water quality monitoring include: monitoring, data entry and summary, quarterly updates and assessment report (to be delivered in conjunction with one another). The project schedule will not be changed without approval from the Project Manager.

Project Contacts

All formal laboratory communications should be through the assistant project manager. There will be one primary point of contact for the Forsyth County monitoring: the general chemistry parameters, including fecal coliform. Questions concerning these analyses should be addressed to the contacts listed below.

The FTL should notify these points of contact about when to expect samples.

Laboratory, including contact names, phone/fax numbers, and addresses, are as follows:

Severn Trent Laboratories-Tallahassee

Debra Vergin
2846 Industrial Plaza Dr.
Tallahassee, FL 32301
Phone: 850-878-3994
Fax: 850-878-9504

Analytical Services, Inc.

Judy Wagner
110 Technology Parkway
Norcross, GA 33092
Phone: 770-734-4200
FAX: 770-734-4201

References

Atlanta Regional Commission (ARC). 2000. *Atlanta Region NPDES MS4 Phase I Standard Operating Procedures for Stormwater Monitoring 2000.*

Georgia Department of Natural Resources (GADNR). 2004. *Draft State 305(b)/303(d) List, January 2004.* Georgia Department of Natural Resources Environmental Protection Division, Atlanta, Georgia.

U.S. Environmental Protection Agency (EPA). 2003. *Envirofacts Database.* Washington D.C. http://www.epa.gov/enviro/

U.S. Environmental Protection Agency (EPA). 2001. *U.S. EPA BASINS Database Version 3.0.* Washington D.C. January 2001.

Appendix A

OUTFALL SCREENING REPORT
MS4 DRY WEATHER FIELD SCREEN

Structure Name and Location: _____

Access Instructions: _____
(nearest intersection or landmark)
Date/Time: _____ Observers:_____
Precipitation <72 hours? Yes/No
Flowing at outfall? Yes/No Flow Estimate:_____gpm
Dominant Land Use Type: _____Receiving Water:_____
(indicate dominant land use as residential, industrial, commercial, agricultural, mixed,)
GPS: N_____ W_____
Type of Structure, shape, material, dimensions: _____

Vegetative Growth (circle one): none normal excessive growth inhibited growth
Vegetative dominant type:

Sampling Parameters: GRAB Samples Taken? Y/ N
Total Cl2: _____ppm
Phenols: _____ ppm
Total Cu: _____ppm
Detergents: _____ppm
pH: _____
Turbidity: _____ FTU

Physical Observations:
(circle appropriate descriptors, for "other" write in description)
Oil Sheen: Y/N Color:
Deposits: None sediments oily other
Surface scum: Y/N
Odor: none musty sewage rotten eggs solvent chlorine other
Biological: none fish algae other
Estimated Air Temp:_____ Estimated Water Temp: _____

Channel/pipe Flow (provide sketch):

Water Depth: _____(in) Width: _____ (feet)

Photograph: Y/N #_____

Additional Notes

The Scientific Justification for Stream Buffers

Paul Mitchell
Spring 2006

Land Use Clinic
university of georgia
School of Law & College of Environment and Design

The **UGA Land Use Clinic** provides innovative legal tools and strategies to help preserve land, water and scenic beauty while promoting creation of communities responsive to human and environmental needs. The clinic helps local governments, state agencies, landowners, and non-profit organizations to develop quality land use and growth management policies and practices. The clinic also gives UGA law students an opportunity to develop practical skills and provides them with knowledge of land use law and policy.

For more information about the UGA Land Use Clinic contact:

Jamie Baker Roskie, Managing Attorney
UGA Land Use Clinic
110 Riverbend Road, Room 101
Athens, GA 30602-1510
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jroskie@uga.edu

This report was written for the **Initiative for Watershed Excellence: Upper Altamaha Pilot Project,** which is made possible by US EPA Clean Water Act 319 program funds, administered by the Georgia Environmental Protection Division, Non-Point Source Program.

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The author thanks Larry Kaiser, Laurie Fowler, Seth Wenger and Christine Rodick for their valuable assistance in creating this document.

The Scientific Justification for Stream Buffers

Author: Paul Mitchell

Editor: Jamie Baker Roskie
University of Georgia Land Use Clinic

Spring 2006

Stream buffers (a.k.a. riparian buffers) have been a source of controversy in Georgia. Although some say there is no sound science behind stream buffer requirements, some 890 scientific studies, articles, and books demonstrate the value of stream buffers. Stream buffers play a crucial role in promoting public health and protecting the environment.

A riparian buffer is a band of vegetation bordering a body of water; riparian buffers improve water quality, wildlife, and property value. Buffers provide a range of environmental services, including trapping and removal of sediment and other contaminants in stormwater as well as maintenance of fish and wildlife habitat. Scientific studies on buffer function demonstrate that, to provide these services effectively, buffers must be **at least 50 feet wide**. Wider buffers provide greater benefits and additional services. To be most effective, however, buffers should be coupled with on-site management of pollutants, including good stormwater management, erosion and sedimentation control, and proper agricultural and forestry practices.

Stream buffers address the following problems:

Sediment often causes more damage than any other pollutant in many streams and rivers. Vegetative buffers reduce the amount of sediment entering streams and rivers; they also reduce channel erosion.

A 100-foot buffer will trap sediments under most circumstances, but the steeper the slope, the wider the buffer must be. Buffers must extend along all streams—including intermittent and ephemeral channels—to be most effective. Both grassed and forested buffers are effective at trapping sediment, but forested buffers have other benefits as well. Finally, buffers alone are insufficient; sediment must also be managed effectively at its source. Even the best buffer can be overwhelmed by excessive sediment.

Phosphorus and **Nitrogen** threaten water quality. Vegetative buffers act as short-term sinks for phosphorus, and they also help control the amount of nitrogen and nitrates entering rivers and streams.

In most cases, 100-foot buffers should provide good control of phosphorus and nitrogen, and 50-foot buffers may be sufficient in many conditions. Although buffers help control phosphorus during the short-term, long-term management requires effective on-site control. Wetlands are especially important in controlling nitrogen.

Wildlife suffers without sufficient riparian buffers.

In order to maintain aquatic habitats, research indicates that 35-100 foot buffers of native forest should be preserved or restored along all streams. Buffers provide streams with the temperature control and woody debris and other organic matter necessary for aquatic organisms. 300-foot buffers of native forest are necessary to protect land animals that live near streams.

Trout streams need buffers that are at least 100 feet wide to maintain viable trout populations. In a sampling of 35 streams, when buffers were reduced from 100 feet wide to 50 feet wide, the percentage of streams that could support trout fell from 63% to only 9%. This translates into an 80% reduction in the number of young trout.

Buffers should consist of native forest and plants. All major sources of contamination should be excluded from the buffer, including construction that results in major land disturbance, impervious surfaces (such as roads), logging roads, mining activities, septic tank drain fields, agricultural fields, waste disposal sites, livestock, and clear cutting of forests. Application of pesticides and fertilizer should be prohibited, except as may be needed for buffer restoration.

For buffers to be most effective, efforts are needed to reduce impervious surfaces, effectively manage pollutants on-site, and minimize buffer gaps.

In summary, a stream buffer is a strip of naturally vegetated land along a stream or river that provides a range of social, economic, and environmental benefits. In addition to the above-mentioned benefits, buffers:

- Stabilize stream banks and reduce channel erosion
- Trap and remove contaminants
- Store flood waters, thereby reducing property damage
- Improve aesthetics, thereby increasing property values
- Offer recreational and educational opportunities

Sources consulted

Correll, David. *Vegetated Stream Riparian Zones: Their Effects on Stream Nutrients, Sediments, and Toxic Substances (An Annotated and Indexed Bibliography of the world literature, including buffer strips and interactions with hyporheic zones and floodplains)* (2003). Accessible on the web at: http://www.unl.edu/nac/ripzone03.htm.

Judy L. Meyer, et al. *Implications of Changes in Riparian Buffer Protection for Georgia's Trout Streams*, University of Georgia Vinson Institute (2005). Accessible on the web at: http://www.rivercenter.uga.edu/publications/pdf/buffer_science.pdf.

Seth Wenger, *A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation*, University of Georgia Office of Public Service & Outreach Institute of Ecology (1999). Accessible on the web at: http://www.rivercenter.uga.edu/service/tools/buffers/buffer_lit_review.pdf.

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RIPARIAN BUFFERS: WHAT ARE THEY and HOW DO THEY WORK?

Definition

Riparian buffers are vegetated areas next to water resources that protect water resources from nonpoint source pollution and provide bank stabilization and aquatic and wildlife habitat. The formal definition of riparian buffer is diverse and depends on the individual or group defining the term.

The USDA Forest Service defines a riparian buffer as follows:

> the aquatic ecosystem and the portions of the adjacent terrestrial ecosystem that directly affect or are affected by the aquatic environment. This includes streams, rivers, lakes, and bays and their adjacent side channels, floodplain, and wetlands. In specific cases, the riparian buffer may also include a portion of the hillslope that directly serves as streamside habitats for wildlife.

Leading experts (Lowrance, Leonard, and Sherida, 1985) on riparian buffers define them as follows:

> a complex assemblage of plants and other organisms in an environment adjacent to water. Without definitive boundaries, it may include stream banks, floodplain, and wetlands, as well as sub-irrigated sites forming a transitional zone between upland and aquatic habitat. Mainly linear in shape and extent, they are characterized by laterally flowing water that rises and falls at least once within a growing season.

Natural riparian buffers are composed of grasses, trees, or both types of vegetation. If riparian buffers are maintained or reestablished, they can exist under most land uses: natural, agricultural, forested, suburban, and urban.

What Do They Do and How Do They Work?: Introduction

Since riparian buffers in North Carolina are predominantly forested, discussion in this manual will focus on riparian forest systems. Forested riparian buffer systems in North Carolina are typically comprised of two integrated streamside riparian buffers (forest and grass or shrub) that are designed to intercept surface runoff and subsurface flow (Figure 2). Riparian buffers have been shown to be effective in controlling nonpoint source pollution by removing nutrients, especially nitrogen and sediment (USDA, 1997).

There are many factors that determine the effectiveness of riparian buffers for any given pollutant. To understand these factors, it is necessary to understand how riparian buffers work to reduce pollutant movement into surface waters. Movement of water from agricultural land through riparian buffers is illustrated in Figure 2. Sediment and sediment-associated pollutants, such as some pesticides and phosphorus, move to surface waters almost exclusively through surface runoff. Thus, to remove sediment and its associated pollutants, surface runoff water must be intercepted. **Figure 2. Schematic of the two zone Riparian Forest Buffer System (modified from Lowrance et al., 1995).**

The most important factor controlling effectiveness of riparian buffers is hydrology: how the water moves through or over the buffer. For example, removal of contaminants from surface runoff requires that runoff water be sufficiently slowed to allow sediment to settle out. If the runoff water does not spread over the buffer, it will move through the buffer in channels. Channelized water moves almost as quickly through a buffer as it does from the field, thereby making the buffer ineffective at pollutant removal (Dillaha et al., 1989).

Most nitrogen from agricultural fields reaches surface water as nitrate in the ground water below the soil surface. In order for nitrate to be removed from ground water before it reaches surface water, the ground water must enter a zone where plant roots are or have been active. These plant roots may either absorb the nitrate for use in plant growth or, more importantly, may provide an energy source for bacteria that converts nitrogen in nitrate to a gas, which then escapes to the atmosphere. This process, denitrification, occurs almost exclusively in water-saturated zones where abundant organic matter is present.

Within all of the riparian buffer sites in North Carolina that were measured, nitrate concentrations in shallow ground water were significantly reduced as the water flowed through the riparian buffer (Gilliam et al., 1997). However, it is possible for nitrate to pass below the riparian buffer at depths far enough below the root zone that very little nitrate removal occurs (Correll et al., 1994). It is also possible for ground water to move through the riparian buffer so quickly that removal is limited (Haycock and Pinay, 1993). To quantitatively predict nitrate removal in riparian buffers, it is necessary to understand the hydrology of each site (Hill, 1996). Because riparian buffers are effective in reducing nitrogen under most conditions in North Carolina, we have no hesitation in recommending their use wherever practical.

What Do They Do and How Do They Work?: Buffer Design

Scientists agree that a corridor of vegetation can be effective at buffering valuable aquatic resources from the potential negative impacts of human use of the adjacent land. The streamside vegetated buffer filters nonpoint source pollutants from incoming runoff and provides habitat for a balanced, integrated, and adaptive community of riparian and aquatic organisms (Welsch, 1991). These filtering and habitat functions are often best provided by natural vegetation such as trees and associated woodland or forest plants in the zone directly adjacent to the waterway. While there is general agreement about the benefits of buffers, the specific design criteria, such as buffer width, types of vegetation, and management, are the subject of considerable debate.

Width is considered the most important controllable variable in determining the effectiveness of buffers in reducing pollutants and protecting stream health. Buffers that are too narrow may not be sustainable or effective at protecting stream banks. Conversely, buffers that are wider than needed limit the use of adjacent land and are unpopular with landowners. Complicating the determination of design buffer widths are the effects of varying site characteristics associated with topography, hydrology, geology, and land use. Additionally, other factors, such as the value of the water resource and adjacent land, must be considered when determining widths.

The width of most existing riparian forest buffers was established by leaving the area adjacent to the stream as forest. This area was generally too wet or too steep to be used conveniently for agricultural or urban purposes. Welsch (1991) recommended a widely acclaimed riparian buffer system that was 95 feet wide on both sides of the stream. There is little debate among riparian buffer experts that the system he described is very good as an idealized stream. However, the senior author of this document does not agree that this width should be required along every stream. The width necessarily depends upon what functions are expected of the riparian buffer and the site characteristics.

Most decisions about buffer widths will be a compromise between ideal widths based on environmental goals (wildlife corridors, bank stabilization, water quality protection) and sociologic or economic constraints. Science-based criteria, for which research data may be available to support an informed decision, include the functional value of the water resource; watershed, site, and buffer characteristics; adjacent land use; and buffer function. The functional value of the water resource is important for determining buffer width in that a highly valued resource may merit a wider buffer for increased protection.

Watershed, site, and buffer characteristics are most important when evaluating pollutant-filtering effectiveness. The size and topography of the watershed determine the amount and rate of surface and ground water passing through the buffer. Site characteristics, such as soil type, slope steepness, microbial populations, and vegetation, determine the amount of pollutants that are filtered out of the water before it enters the waterway. Buffer characteristics, such as the types of vegetation and their location in the buffer, can also influence pollutant removal effectiveness.

One of the most widely recognized buffer planning models is the three-zone buffer that was developed by the USDA Forest Service (Welsch, 1991). Zone one of the model begins at the normal water level or at the edge of the active channel and extends a minimum of 15 feet along a line perpendicular to the watercourse . Dominant vegetation consists of existing or planted woody vegetation suitable for the site and intended purpose. This zone should remain undisturbed; therefore, tree removal is generally not permitted. Zone two begins at the edge of zone one and extends a minimum of 60 feet perpendicular to the watercourse. While vegetation in zone two should be similar to zone one, removal of tree and shrub products is permitted on a regular basis provided the tree and shrubs are replaced. The third zone begins at the outer edge of zone two and has a minimum width of 20 feet. Vegetation in this zone can be grazed or ungrazed grass or other plant communities as long as it facilitates sediment filtering, nutrient uptake, and the conversion of concentrated flow to uniform, shallow, sheet flow through the use of structural practices such as level spreaders (Lowrance et al., 1995).

The current proposed buffer standards in North Carolina use a two-tiered riparian buffer: forested areas near the streams and grassed areas away from the stream. The proposed buffer width is 50 feet: 30 feet of forest and 20 feet of grass (NCDEHNR, 1997). Some streams, however, may need greater and some streams need less buffer width, depending not only on site location but also on the pollutant that is being controlled. For optimal performance, riparian forest buffer systems must be designed and maintained to maximize sheet flow and infiltration and impede concentrated flow.

The design also depends on the stream order and the land area that drains the riparian buffer. The larger the drainage area, the wider the buffer width. The Neuse River Basin consists of over 4,000 miles of streams, although the Neuse River itself is only 200 miles long. Since most nonpoint source pollution enters the river system through these first order streams, it is very important to protect the smaller streams with buffers.

Stream networks are designated by using stream orders. First-order streams have no tributaries. A second-order stream starts at the confluence of two first-order streams. The confluence of two second-order streams is a third-order stream and so on (Dingman, 1994).

What Do They Do and How Do They Work?: Protect Stream Health

The most general function of riparian forest buffer systems is to provide control of the stream environment. This function includes moderating fluctuations in stream temperature and controlling light quantity and quality; enhancing habitat diversity; modifying channel morphology; enhancing food webs and species richness; and protecting water resources from nonpoint source pollutants, such as sediment and nutrients (USEPA, 1995b).

The design specifications for forested riparian buffers should provide the desired function of the buffer at the particular location – whether it is being used to control nonpoint source pollution so that downstream waters do not deteriorate or to protect aquatic organisms.

Habitat: Aquatic Organisms.(The following information on habitat was largely taken from USDA's Riparian
Organisms Forest Buffer Handbook for the Chesapeake Bay Watershed, 1997. Thanks to Al

Todd for letting us use the draft version of this document.)

The riparian buffer is an important feature of stream habitat. The vegetation of the riparian buffer affects the type and amount of organic matter food sources available for stream organisms. Streamside vegetation also affects the amount of sunlight that reaches the stream and, in turn, the temperature of the water. In addition, the physical structure of the stream, such as the extent of pools and riffles, is affected by riparian vegetation. Climate and watershed characteristics also affect aquatic life habitat. All of these factors influence species diversity and abundance.

Food. Food sources for macroinvertebrates include detritus and algae. Detritus is organic matter such as leaves, stems, sticks, and logs that falls into the stream. Because their mouth parts are adapted for a particular food source, some macroinvertebrates eat primarily detritus and others eat only algae. Two types of algae found in streams are diatoms and filamentous algae.

The vegetation in the riparian buffer affects the type and quantity of detritus that occurs in the stream. It is likely that vegetation that falls into the stream generally does not move very far away so that the food benefits are highly localized to the immediate stream corridor. Older stratified forests may provide the greatest variation in quality of detritus food for macroinvertebrates.

Vegetation also affects the amount of light that reaches the stream, but this is a function of stream order and stream width as well. For first-, second-, and third-order streams, the riparian canopy of trees can block sunlight from reaching the water. A shaded stream is likely to have more diatoms and less filamentous algae. A stream that runs through a cleared riparian buffer or one that has meadow vegetation is likely to have more filamentous algae. The detritus food source from the clearing of a riparian buffer is only temporary as detritus rapidly decays. For grassed riparian buffers, filamentous algae is likely to dominate. Also, large streams and rivers will receive a large portion of direct sunlight which encourages filamentous algal production in open areas. Nearshore areas bordered by mature vegetation are likely to have diatoms and sufficient detritus.

Temperature and light. Vegetation type, canopy development, and directional orientation of the stream controls light energy and impacts stream temperature. A north-south oriented stream is less affected by buffer canopy shading. The vegetation on the north side of an east-west oriented stream may also have little effect on light penetration. For first-, second-, and third-order streams, the majority of water flows through a shaded riparian buffer. For higher order streams, which are wide and open in cross-section, shading has less of an impact on water temperature. However, the loss of the buffer canopy on any stream, due to clearing, can increase water temperature substantially, causing a shift in macroinvertebrate and fish species.

Physical habitat (pools, riffles, etc.). Roots of riparian vegetation stabilize the stream bank and prevent stream bank erosion and sedimentation. Stabilized stream banks also help maintain the geometry of the stream, including characteristics such as the meander length and profile. Preventing excess sedimentation helps prevent silt from covering large rocks and stones in the stream bed which serve as habitat for some macroinvertebrates. Pools can be vital parts of stream habitat for fish. Excess sediment can fill pools and eliminate habitat. Tree roots and woody debris are also important habitat features for macroinvertebrates and fish. Overhanging stream banks, stabilized by tree roots and large woody debris, can be important habitat for fish.

Large woody debris provides critical macroinvertebrate habitat. Large woody debris can also create dams and trap sediment and detritus. Riparian forests may have the greatest enhancing effect on fish habitat on mid-order streams (i.e., stream order 3-6), with

sufficient large woody debris structure and flow to support diverse fish and macroinvertebrate populations.

Habitat: Wildlife Wildlife species require food, water, and cover. Well managed riparian buffers generally support larger populations of wildlife because the buffer provides many habitat requirements. In a stratified forest, different habitat zones exist vertically, including the soil-air interface, herbs and shrubs, intermediate height trees, and the canopy. Included with the leaf litter and rotting logs at the soil-water interface are insects, isopods, spiders, and mites. These organisms are a food source for reptiles, mice, and birds. The herbs and shrubs provide habitat for insects, birds, and mammals. The intermediate zone and the canopy serve as habitat for birds, bats, squirrels, opossums, and raccoons. Bird habitat may be highly stratified and birds generally show a preference for certain layers that differ in habitat characteristics and food sources.

Riparian areas may also serve as corridors linking dryer, less diverse uplands to more moist, more diverse bottom lands. The width of riparian buffers needed for wildlife is not clear. This may be a function of the type of wildlife and their vegetation requirements. Upland game birds such as pheasant and bobwhite quail benefit from grasses. A stratified forested may be needed to maintain wrens and robins in a herbaceous zone and tree-creeping birds and robins in the canopy.

What Do They Do and How Do They Work?: Reduce Nitrogen

In the Coastal Zone of North Carolina, most nitrogen, as stated previously, enters surface waters from ground water as nitrate-nitrogen. As the shallow ground water moves through the riparian buffer, microorganisms change the nitrate-nitrogen to gaseous nitrogen via a process known as denitrification (Figure 4). When the soil is poorly aerated (anaerobic conditions), some microorganisms reduce nitrates to the gaseous components of nitrous oxide, nitric oxide, or free nitrogen gas.

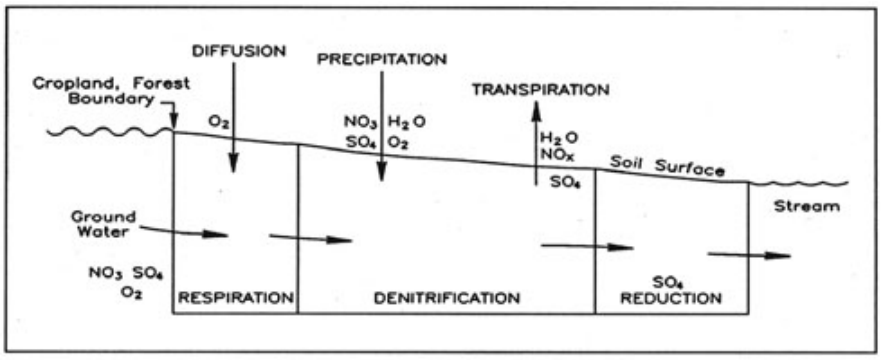
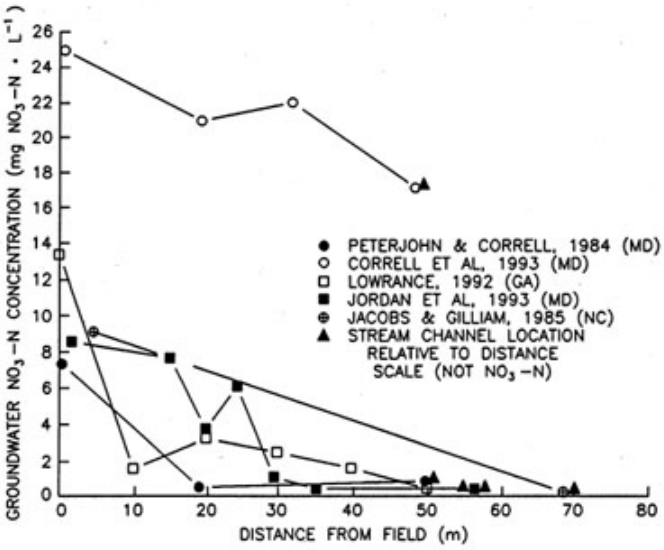


Figure 4. Conceptual model of below-ground processes affecting ground water nutrients in riparian forest (from Correll and Weller, 1989).

Denitrification is most effective in root-zone soil layers where carbon sources are available for the denitrifying bacteria. Numerous researchers have reported that it is the complex interaction between vegetation and below-ground environment that provides the appropriate conditions for denitrification to occur (Lowrance et al., 1995). The area of interaction within the riparian buffer is generally quite narrow —10 to 50 feet (or 3 to 15 meters) — from the field through the riparian buffer (Figure 5). The majority of denitrification that has been observed in riparian buffers occurred within the first 15 feet of the forested



riparian buffer.

Figure 5. Nitrate concentrations in ground water beneath riparian forests.

Denitrification has measured in Coastal Plain forested riparian buffer areas has removed as much as 263 lb N acre-1yr-1. Typically, though, denitrification rates are generally between 18 and 55 lb N acre-1 yr-1. Most studies indicate that denitrification takes place throughout the year (Lowrance et al., 1995).

Vegetation in riparian buffers also removes nitrogen and phosphorous through uptake. Some of these nutrients are sequestered in woody vegetation, whereas the nutrients absorbed into herbaceous materials, generally, are recycled as the vegetative matter dies. Several studies have indicted that uptake by above-ground woody vegetation removes various amounts of nitrogen and phosphorus, depending on the riparian conditions (Table 1).

Table 1. Above-ground woody vegetation uptake of nitrogen and phosphorus in Coastal Plain riparian forests (from Lowrance et al., 1995).

		Nitrogen		Phosphorus	
Reference	Location	Total Input	Woody Storage	Total Uptake	Woody Storage
Correll & Weller, 1989	Rhode R., MD	ND*	12 to 20	ND	3 to 5
Peterjohn & Correll, 1984	Rhode R., MD	77	12	10	1.7
Fail et al., 1986, 1987(mean)	Little R., GA	114	52	7.5	3.8
Fail, 1986 (maximum)	Little R., GA	194.4	97.6	12.6	6.9
Fail, 1986 (maximum)	Little R., GA	80	34.6	4.5	1.9

*ND =not Determined

Although nitrogen uptake by the vegetative portion of the riparian buffer buffer contributes to nitrogen reductions, denitrification is the primary process that removes nitrate from the shallow ground water that flows through riparian buffers.

What Do They Do and How Do They Work?: Reduce Sediment and Phosphorus

Riparian buffers, both the grassed and forested portions, serve to slow water velocity, thus allowing sediment to settle out of the surface runoff water. The grassed portion of the buffer functions as a grass vegetated filter strip. There is extensive research demonstrating the effectiveness of vegetated filter strips for sediment removal (Lowrance et al., 1995).

The effectiveness of well maintained grass riparian buffers for sediment may be as high as high as 90–95%. Likewise, nitrogen and phosphorus attached to the sediment and, to a lesser extent, dissolved nitrogen and phosphorus are abated. Frequently, the concentration of dissolved nutrients in the runoff passing over a grass filter does not change or may slightly increase. However, because some of the runoff water infiltrates in the buffer, less runoff water leaves the buffer than enters it. For example, we have observed that approximately half of field runoff events have no runoff that passes through a 24-foot grass filter. Thus, there is a reduction in total amount of dissolved nutrients that leaves the filters even though nutrient concentration may not change. These filter strips are not designed for high velocity flow but, rather, are used to slow flows so that sediment drops out. Because grass riparian buffers are designed to trap sediment, they **REQUIRE MAINTENANCE** to remain effective (Dillaha et al., 1989).

In experiments conducted to determine optimum width of a grass riparian buffer adjacent to a forested riparian buffer, Parsons (personal communication, 1997) determined sediment reduction for different grass riparian buffer widths. Approximately 100 data points were collected for storms that produced >1000 g of sediment loss at the edge of the field. The percent sediment reduction is calculated as 1.0 – [(grass buffer loss)/(field edge loss)]. In the Piedmont, 28 feet of buffer width retarded sediment such that there was 86–90% reduction (Table 2), whereas the narrower buffer width of 14 feet reduced sediment loss by 70%. By contrast, the difference in sediment reduction between grass buffer widths of 14 and 28 feet was not as marked at a Coastal Plain location: 86% reduction for buffer widths of 28 feet and 76.5% reduction for 14-foot grass riparian buffers (Table 3).

Table 2. Sediment reduction by grass riparian buffers on a Piedmont site.

Grass Buffer Width	Plot	% Reduction
14 ft	1	71
14 ft	2	68
28 ft	1	90
28 ft	2	86

Table 3. Sediment reduction by grass riparian buffers on a Coastal Plain site (Kinston).

Grass Buffer Width	Plot	% Reduction
14 ft	1	70
14 ft	2	83
28 ft	1	82
28 ft	2	90

Grass riparian buffers in combination with forested areas appear to do the best job of reducing both sediment and phosphorus, as can be seen from the following table. The effects of different riparian buffer widths in reducing sediment, nitrogen, and phosphorus are presented in Table 4.

Table 4. Effects of different size riparian buffers on reductions of sediment and nutrients from field

surface runoff (from Lowrance et al., 1995).

		Sediment			Nitrogen			Phosphorus		
Buffer Width	Buffer Type	Input Conc.	Output Conc.	Reduction	Input Conc.	Output Conc.	Reduction	Input Conc.	Output Conc.	Reduct
m		--mg L--		%	--mg L--					
4.6[1]	Grass	7284	2841	61.0	14.11	13.55	4.0	11.30	8.09	28.5
9.2[1]	Grass	7284	1852	74.6	14.11	10.91	22.7	11.30	8.56	24.2
19.0[2,3]	Forest	6480	661	89.9	27.59	7.08	74.3	5.03	1.51	70.0
23.6[5]	Grass/ Forest	7284	290	96.0	14.11	3.48	75.3	11.30	2.43	78.5
28.2[6]	Grass/ Forest	7284	188	97.4	14.11	2.80	80.1	11.30	2.57	77.2

[1]Calculated from masses of total suspended solids, total N, total P, runoff depth, and plot size (22 x 5 m) from Magette et al. (1989)
[2]Input concentrations from Table 2, Peterjohn & Correll (1984). Nitrogen = Nitrate-N + exch. part. ammonium + diss. ammonium + part. organic N + diss. organic N. Phosphorus = part. P + diss. P.
[3]Surface runoff concentrations at 19 m into forest reported by Peterjohn & Correll (1984). N and P constituents same as input (footnote 2).
[4]Percent reduction = 100 * (Input-Output)/Input.
[5]4.6 m grass buffer plus 19 m of forest.
[6]9.2 m grass buffer plus 19 m of forest.
conc. = concentration.

Because most phosphorus loss is so closely tied to erosion, the above discussion on riparian buffers and sediment is relevant to the control of phosphorus.

As noted previously, vegetative uptake of phosphorus is another reduction mechanism. Researchers have shown (see Table 1) that between 2 and 12 lb P acre-1 year-1 are absorbed by the above-ground woody vegetation in Coastal Plain riparian forests (Lowrance et al., 1995). Top of Page / Table of Contents / Next Section

Scientific Recommendations on the Size of Stream Vegetated Buffers Needed to Protect Water Quality

PART ONE of a Series entitled:
The Need for Stream Vegetated Buffers:
What Does the Science Say?

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Montana Department of Environmental Quality
EPA/DEQ Wetland Development Grant
Helena, Montana

June 2008

This document should be cited as:

Ellis, J.H. 2008. Scientific Recommendations on the Size of Stream Vegetated Buffers Needed to Protect Water Quality, Part One, The Need for Stream Vegetated Buffers: What Does the Science Say? Report to Montana Department of Environmental Quality, EPA/DEQ Wetland Development Grant. Montana Audubon, Helena, MT. 24 pp.

This report is available at mtaudubon.org

Scientific Recommendations on the Size of Stream Vegetated Buffers Needed to Protect Water Quality

Introduction

Montana's vast landscape and water resources are critical to the economy, public welfare, and the quality of life of the state's local communities. Each year, development modifies these resources. Riparian areas and their associated wetlands, where water and land come together, are particularly sensitive to changes from development.

As a result of increasing pressures, representatives from local and state governments are discussing ways to protect streams, rivers, and their associated riparian areas from unplanned, sprawling development. One of the main tools available to local governments interested in protecting these resources is to set back structures and protect streamside buffers of native vegetation (hereafter referred to as "building setbacks with vegetative buffers"). In order to use this tool, decision makers and citizens alike must understand the science behind buffer widths.

The vegetated buffer is the "work horse" portion of this tool because it is the area that filters out pollutants, helps prevent unnatural erosion, works to minimize the impact of floods, sustains the food and habitat of fish and wildlife, and more. As a result, relevant scientific studies focus on the vegetated buffer portion of this tool. For more information on how building setbacks relate to vegetated buffers, see page 3.

Protecting water quality is one of the important functions of vegetated buffers. Consequently, this first report in a series summarizes the scientific recommendations underlying the vegetated buffer size needed to protect water quality. Two other reports have been developed in this series on other key elements of stream protection: fisheries and wildlife:

- *Part II: Scientific Recommendations on the Size of Stream Vegetated Buffers Needed to Protect Fish and Aquatic Habitat;* and
- *Part III: Scientific Recommendations on the Size of Stream Vegetated Buffers Needed to Protect Wildlife and Wildlife Habitat.*

Each of these reports is designed to explain the science behind one of the many functions provided by vegetated buffers found along streams. Other topics for this series are currently being considered because building setbacks and vegetated buffers should also consider floodplains and seasonal water levels, stream migration corridors, density of development adjacent to the riparian corridor, and other factors.

Building Setbacks and Vegetated Buffers

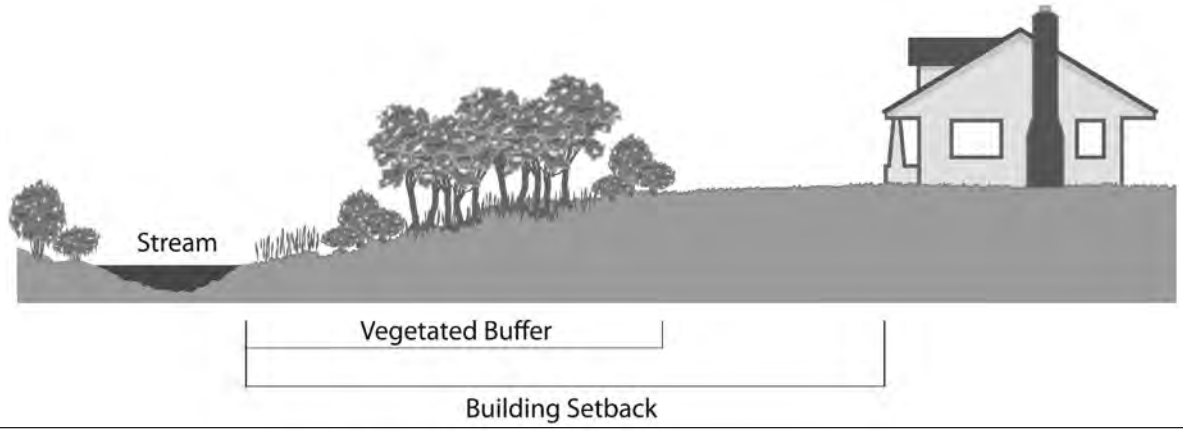
In order to understand setbacks and buffers, it is important to understand the following concepts:

Building setbacks or "no build areas" are the distance from a stream's ordinary high water mark to the area where new structures and other developments (such as highly polluting land uses—including roads, parking lots, and waste sites) are allowed.

Vegetated Buffers are not an additional area, but rather the portion of the building setback that is designated to remain undisturbed. These buffers are areas where all native vegetation, rocks, soil, and topography are maintained in their natural state, or enhanced by additional planting of native plants. Lawns should not be considered part of the vegetated buffer. With their shallow roots, lawns are not particularly effective at absorbing and retaining water, especially during heavy rains. Consequently, they do not significantly filter out water pollutants. They can also be a major source of fertilizers and pesticides—substances that should be prevented from entering our streams and rivers.

How much space should be placed between a building and a vegetated buffer? The building setback should be wide enough to prevent degradation of the vegetated buffer. As an example, most families use the area between their home and the vegetated buffer for lawns, play areas, swing sets, picnic tables, vegetable gardens, landscaping, etc. As a result, the building setback should extend at least 25–50 feet beyond the vegetated buffer (Wenger 1999). A smaller distance between a building and a vegetated buffer, such as 10 feet, will most likely guarantee degradation of the vegetated buffer. A greater distance between structures and a vegetated buffer is recommended if the:

- River has a history of meandering; the setbacks should ensure that people and homes will not unwittingly be placed too close to the river's edge, in harm's way.
- Vegetated buffer is narrower than scientific studies recommend; a deeper building setback can help protect water quality, fisheries, and aquatic habitat.
- Land is sloped and runoff is directed toward the stream (the steeper the slope, the wider a buffer or setback should be)
- Land use is intensive (crops, construction, development)
- Soils are erodible
- Land drains a large area
- Aesthetic or economic values need to be preserved
- Wildlife habitat needs to be protected
- Landowners desire more privacy



Vegetated Buffers and Clean Water

All Montanans depend upon clean water. Vegetated buffers along streams break down and/or retain nutrients, salts, sediments, chemical pesticides, and organic wastes. Buffers also act like giant sponges to filter and reduce the amount of pollutants that enter streams, groundwater, and—ultimately—drinking water, in runoff originating from sources such as city streets, lawns, construction sites, and agricultural fields.

Examples of common vegetated buffer restrictions include:

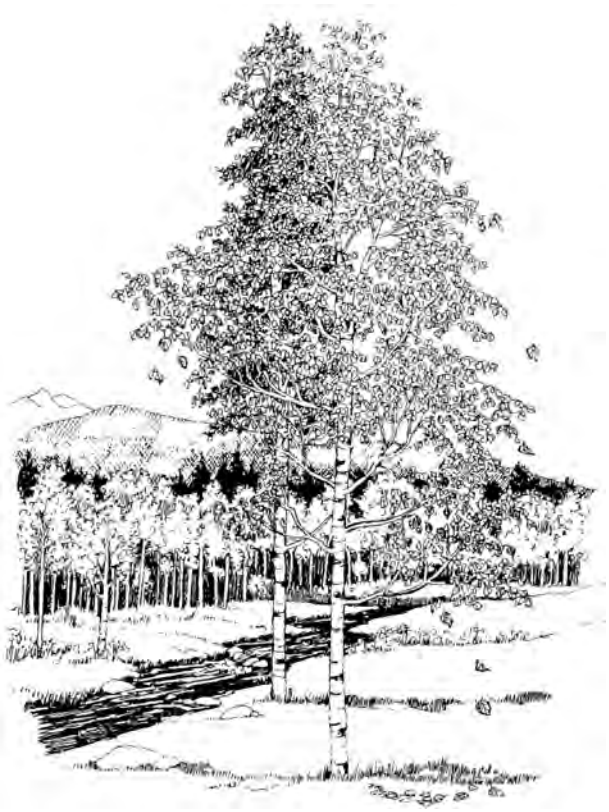
- Minimizing removal of native vegetation;
- Using native vegetation in plantings and restoration;
- Prohibiting non-native plants (including lawns);
- Prohibiting the use of pesticides and fertilizers;
- Avoiding use of heavy equipment that compacts soil; and
- Restricting mowing and managing grazing so as to avoid loss of riparian vegetation.

It should be noted that the ability of vegetated buffers to provide adequate water quality protection depends upon the slope, vegetation, floodplains, soils, and other similar factors. The following descriptions explain why these factors influence how effective a vegetated buffer is in protecting water quality:

Steep Slopes. From a water quality perspective, the most effective buffers are flat. Scientific research shows that the width of buffers should be increased when slopes are steeper, to allow more opportunity for the buffer to capture pollutants (Castelle et al 1994; Fischer et al 2000; Mayer et al 2005; Knutson and Naef 1997; and Wenger 1999). The greater the slope, the faster water flows over the surface. Researchers have noted that very steep slopes cannot effectively remove contaminants, though there is debate over what constitutes a steep slope, with ranges suggested between 10% and 40%. One model suggests that slopes over 25% should not count towards a buffer (Wenger 1999).

Vegetation. Natural vegetated buffers are important to water quality, because the longer runoff is detained in a buffer, the fewer pollutants will enter the stream. Physically, plants act as a barrier, slowing down water flow, giving sediments and other contaminants time to settle out of runoff, and allowing more water to move into the soil. Plant roots trap sediments and other contaminants in shallow groundwater, take up nutrients, hold banks in place, and prevent erosion. Runoff that seeps into shallow groundwater increases groundwater recharge and temporarily stores and slowly discharges precipitation and snowmelt to surface waters over a longer period of time.

Although vegetated buffers with woody plant species (trees and shrubs) and native grasses are both effective at trapping pollutants, those with woody plants provide the most effective water quality protection for several reasons. First, by providing a canopy, trees and shrubs reduce the velocity of raindrops and lessen runoff and soil erosion. Trees and shrubs also have longer, more complex root systems, which increase their ability to absorb nutrients and curtail erosion. Overhanging branches provide shade that reduces stream temperatures. Litter (leaves and organic debris) from trees and shrubs also increase the infiltration and pollution-absorbing ability of soil. And finally, trees and shrubs provide the most diverse fish and wildlife habitat in Montana, providing cover, nesting sites, and food. Native grasses also have complex root systems—especially compared



to the root systems of lawn grass—but they are not as deep-rooted as trees and shrubs.

As stated above, lawns—with their shallow roots—are not particularly effective at absorbing and retaining water, especially during heavy rains. Consequently, they do not significantly filter out water pollutants. Lawns can also be a major source of fertilizers and pesticides—substances that need to be prevented from entering our streams and rivers.

Surfaces without vegetation—including parking lots, compacted or paved roads, and other impervious surfaces—reduce the filtering capability of buffer areas, increase surface erosion, and lead to higher and faster storm flows in streams. As a result, restrictions on impervious surfaces should be considered in order to ensure that buffers are effective.

Floodplains. Because much pollution can enter streams during storm events caused by snowmelt or heavy rainstorms, protection of a stream or river's floodplain is important. Floodplains covered with native vegetation can significantly remove contaminants, minimize damage from floods, and reduce the amount of unnatural erosion that takes place. For these reasons, it is recommended that vegetated buffers encompass the entire floodplain whenever possible (Wenger 1999). This recommendation is particularly important in Montana's valleys, where streams and rivers meander.

Soils. Different soils have different abilities to filter out sediment and pollutants. Consequently, activities that compact soils or increase erosion (such as vegetation removal) should be avoided in vegetated buffers. The speed with which water and dissolved substances percolate through the soil depends upon the amount of organic material and the size of the spaces between the grains of soil. As an example, in fine clay soils, pollutants may take months or years to move into streams and groundwater. In porous soils (e.g. with more sand and gravel), pollutants can flow almost directly into streams or groundwater.

Contaminants Impacting Water Quality

Many of the substances covered in this report can degrade water quality. Vegetated stream buffers are an important tool that local governments can use to filter out these pollutants. Tables II and III summarize the information from scientific studies that tested how stream vegetated buffers filtered out the following contaminants (which are listed in alphabetical order, and not in order of importance):

Ammonium (NH_4) is a form of nitrogen (*see Nitrogen below*) found in human and animal waste (hence in sewage and septic field leakage) and in some fertilizers. It is toxic to fish and many other

Lawns—with their shallow roots—do not significantly filter out water pollutants. They can also be a source of fertilizers and pesticides, substances that should not enter streams and rivers. Montana Dept. of Natural Resources and Conservation photo library.

forms of stream life. Like all forms of nitrogen, ammonia can contribute to eutrophication (over-fertilization) of lakes, wetlands, and slow-moving streams (*see Nutrients below*).

Fecal coliform bacteria are found in the fecal material of humans or other animals and are used as an indicator of the likely presence of bacteria and viruses that cause a wide range of diseases. Sources of such bacteria and viruses include leaking sewer pipes, sewer overflows, failing septic systems, and areas where concentrations of animals are found, such as animal feedlots, city parks frequented by dogs, and areas with colonial nesting birds. The higher the levels of fecal coliform bacteria in water the greater the risk to human health because of the many waterborne pathogenic diseases associated with bodily wastes.

Heavy metals, such as lead, mercury, cadmium, copper, and zinc, occur naturally in streams and soils. However, many human activities increase the movement of these substances from land into water, raising the concentration of these metals to levels that are toxic to aquatic life. At very high levels, such metals may quickly kill aquatic life. Even at fairly low levels, metals may gradually accumulate in the liver or kidneys of animals, causing failure of these organs. The main sources of these contaminants are industrial and consumer waste, including power plant and other industrial emissions, old mining operations, run-

off from roads and parking areas, and fertilizers.

Nitrogen (N) is an essential nutrient for all life. Under natural conditions it is often in short supply, limiting plant growth. However, many kinds of human activity increase availability of nitrogen, stimulating growth of plants. In water, excess nitrogen is a pollutant that can cause eutrophication (over-fertilization) (*see Nutrients below*) in surface water and contamination of groundwater. As a drinking water pollutant, nitrogen is particularly dangerous for infants. Streams receive nitrogen from sources such as fertilizers, animal wastes, leaking sewer lines and septic systems, and runoff from highways. The U.S. Environmental Protection Agency considers nitrogen one of the "top stressors in aquatic ecosystems" (Mayer, et al 2005). Nitrogen occurs in many forms, including nitrates, nitrites, ammonium, and particulate nitrogen.

Nitrates (NO_3) and Nitrites (NO_2) are forms of nitrogen that occur in fertilizers, animal wastes, septic tanks, municipal sewage treatment systems, and decaying plants (see *Nitrogen above*). Nitrates/nitrites can move quickly through the soil and into groundwater and surface water. However, nitrate/nitrite levels in shallow groundwater can be reduced before reaching surface water in two main ways: (1) uptake by the roots of plants in vegetated buffers, or (2) use by bacteria that live in water-saturated soils which convert nitrates/nitrites to harmless nitrogen gas (a process called denitrification).

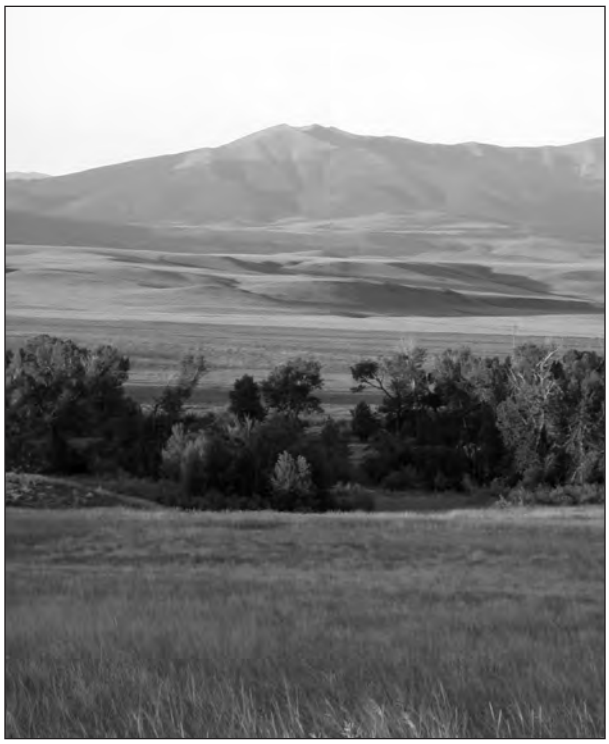
Nutrients are substances that are essential to life and include certain forms of nitrogen (*see above*) and phosphorus (*see below*). Increases in availability of nutrients may stimulate additional growth of plants. In water, excess nutrients increase the rate of eutrophication of lakes and slow-moving streams. Eutrophication can stimulate abundant plant growth in water bodies, which can lead to toxic algae blooms, excessive growth of nuisance aquatic plants, the depletion of oxygen in water, and—ultimately—the death of fish and other organisms. Hence at excessive levels, nutrients are considered water pollutants.

Pesticides, including both herbicides and insecticides, are designed to be toxic. The main sources for these chemicals include spraying of crops, weed-infested rangelands, lawns, and ornamental plants. At high enough concentrations in streams, pesticides may kill stream life outright, or weaken organisms so they die more readily from 'natural causes.' Pesticides also pose a risk to human health, especially those that biomagnify in the food chain. Biomagnification refers to the process where certain substances increase in concentration as they move from one link in the food chain to another.

Phosphorus (P) is an essential nutrient for plant growth that is found naturally in soils and streams, but exists in much higher levels in fertilizers and in human and other animal waste. It enters streams in waste water or in runoff polluted with fertilizers or animal wastes, including from leaking sewer pipes or septic drain fields. Stream vegetated buffers are typically effective at short-term control of phosphorus that is bound to sediment particles—they are *less* effective at (1) filtering out phosphorus that is dissolved in water, or (2) providing long-term storage of phosphorus (Wenger 1999). Increased levels of phosphorus can contribute to eutrophication (see *Nutrients* above).

Sediments are a common type of pollutant found in streams and rivers. Sediments come from a variety of sources, including natural and human-driven stream bank erosion, agricultural fields, exposed earth at construction sites and on dirt roads, and other activities that remove vegetation and expose soil. Excess sediment has numerous impacts, including degrading municipal water supplies and, as a result, increasing water

treatment costs and/or posing a threat to human heath when treatment is made less effective. It can also degrade habitat for fish and the aquatic life that they eat and can clog drainage ditches, stream channels, water intakes, and reservoirs.



About This Report—Methods Used

This report summarizes the recommendations of 77 scientific studies that tested how various stream vegetated buffers protected water quality (*see Appendix I*). These scientific studies were reviewed by the authors of 5 review publications. Please note that the information in this report was taken from the text and tables of 5 review publications—and that the original studies were not reviewed in this report. The 5 review publications are:

- Castelle, A.J., A. W. Johnson, and C. Conolly. 1994. Wetland and stream buffer size requirements — a review. J. Environ. Qual. 23: 878–882.
- Fischer, R.A., C.O. Martin, and J.C. Fischenich. 2000. Improving riparian buffer strips and corridors for water quality and wildlife. International Conference on Riparian Ecology and Management in Multi-Land Use Watersheds. American Water Resources Association. August 2000. 7 pp.
- Knutson, K.L. and V.L. Naef. 1997. Management recommendations for Washington's priority habitats: riparian. Wash. Dept. Fish and Wildlife, Olympia, WA. 181 pp.
- Mayer, P.M., Steven K. Reynolds, Jr., Timothy J. Caneld. 2005. Riparian buffer width, vegetated cover, and nitrogen removal effectiveness: a review of current science and regulations. U.S. Environmental Protection Agency, EPA/600/R-05/118, National Risk Management Research Laboratory, Ada, OK. 28 pp.
- Wenger, S.J. 1999. A review of the scientific literature on riparian buffer width, extent and vegetation. Athens: Institute of Ecology Office for Public Service and Outreach, University of Georgia. 59 pp.

Appendix II contains the original references cited in the 5 review publications described above, allowing individuals using Appendix I to see the full title of all original references, as well as have sufficient information to access all references, if necessary.

Summary of Scientific Recommendations

All Montanans depend upon clean water—and streamside vegetated buffers play an important role in water quality protection. These areas break down and hold nutrients, chemical pesticides, salts, sediments, and organic wastes. They reduce the amount of pollution that enters streams, rivers, groundwater, and—ultimately—drinking

water, in runoff originating from sources such as city streets, leaking sewer lines and septic systems, lawns, construction sites, and agricultural fields. As a result:

In order to protect the water quality of streams, scientific studies generally recommend that at least a 100-foot (30-meter) vegetated buffer be maintained. Steeper slopes and other local factors may require larger vegetated buffers. A minimum of a 50-foot (15-meter) buffer may be sufficient to protect certain aspects of water quality. However, for significant removal of nitrates, sediments, and pathogenic bacteria, at least 100 feet is recommended.

This recommendation is drawn from the conclusions of the 5 publications that reviewed a total of 77 separate scientific studies on water quality and stream vegetated buffers. Specific conclusions and recommendations by the 5 review publication authors are quoted in Table I.

This conclusion is also supported by the State of Montana's Nonpoint Source Management Plan, which was approved by the U.S. Environmental Protection Agency (EPA) in July 2007. It states that a "buffer of at least 100 feet is recommended for water quality protection. . . . Minimum widths for buffers should be 50 feet for low order headwaters streams, with expansion to as much as 200 feet or more for larger streams." Montana's Nonpoint Source Management Plan identifies locally-adopted water body setbacks as important "Best Management Practices" to protect and improve water quality from nonpoint source pollution. Nonpoint sources of pollution in urban areas include parking lots, streets, and roads where stormwater picks up oils, grease, metals, dirt,

Table I. A summary of the specific conclusions and recommendations of 5 review articles on vegetated buffer size and water quality protection. All authors emphasized that water quality protection depends on the slopes, soils, vegetation, floodplains, and similar factors.

Castelle et al 1994	"Based on existing literature, buffers necessary to protect wetlands and streams should be a minimum of 15 to 30 meters in width" (50–100 feet).
	Buffers less than 10 meters (33 feet) "provide little protection of aquatic resources under most circumstances."
Fischer et al 2000	Concluded that "most buffer width recommendations for improving water quality tend to be between 10 and 30 m" (33–100 feet).
Knutson and Naef 1997	Concluded that scientific studies indicated that vegetated buffers to protect water quality should be between 24 and 42 meters (78–138 feet).
Mayer et al 2005	Concluded that "wider buffers (>50 m) [167 feet] more consistently removed significant portions of nitrogen entering a riparian zone."
	[W]hile some narrow buffers (1–15 m) [3–50 feet] removed significant proportions of nitrogen, narrow buffers actually contributed to nitrogen loads in riparian zones in some cases."
Wenger 1999	To protect water quality overall, "a 100 ft [30 meter] fixed-width riparian buffer is recommended for local governments that find it impractical to administer a variable-width buffer."
	For long-term sediment control and short-term phosphorus control, a "30 m (100 ft) buffer is sufficiently wide to trap sediments under most circumstances."
	For nitrogen control, in "most cases 30 m (100 ft) buffers should provide good control, and 15 m (50 ft) should be sufficient under many conditions."
	For pesticide and heavy metal control, "the width is unclear from the existing research," with 15 meters (50 feet) seen as a bare minimum, and 50 meters (164 feet) shown to filter out much of two specific pesticides.

salts, and other toxic materials. In areas where crops are grown or in areas with landscaping (including grassy areas of residential lawns and city parks), irrigation and rainfall can carry soil, pesticides, fertilizers, herbicides, and insecticides to surface water and groundwater (Montana Department of Environmental Quality, 2007).

Several additional recommendations are worth noting:

- "The greater the minimum buffer width, the greater the safety margin in terms of water quality and habitat protection." (Wenger 1999)

- "Removal of riparian vegetation, drainage of wetlands and development of floodplains leads to larger magnitude floods that cause greater damage to property." (Wenger 1999)

- "To provide maximum protection from floods and maximum storage of flood waters, a buffer should include the entire floodplain. Short of this, the buffer should be as wide as possible and include all adjacent wetlands." (Wenger 1999)

- "Riparian buffers are especially important along the smaller headwater streams which make up the majority of stream miles in any basin." (Wenger 1999)

- "It is very important that buffers be continuous along streams. Gaps, crossings, or other breaks in the riparian buffer allow direct access of surface flow to the stream, compromising the effectiveness of the system." (Wenger 1999)

- "[E]xtensive experimental support for buffer zones <10 meters [33 feet] . . . is lacking." (Mayer et al 2005).

In order to better understand the range of scientific studies that went into the above conclusions, Appendix I contains study-specific information for all 77 scientific studies reviewed. It should be noted that many of these studies underwent extensive peer review before they were published in a peer-reviewed journal or report of a scientific government agency. The summarized studies show a range of buffer widths, because the ability of buffers to trap pollutants is affected by slope, soil type, vegetation type and density, climate, floodplains, and many more factors. It would be very costly to duplicate these studies in every situation; hence the recommendations given here are intended to be protective in most situations, based on the findings of a wide range of studies. If localized information on area conditions is available (vegetation maps, floodplain maps, etc.), this information can also be used to determine vegetated buffer sizes, ensuring that these buffers more accurately fit local conditions.

And finally, because Appendix I contains a lot of detailed information, which can be difficult to interpret, we created Table II. Table II is designed to organize the findings of the 77 scientific studies by activity (erosion and flood control) or type of pollutant (nutrients, ammonia, fecal coliform, nitrates, nitrogen, pesticides, phosphorus, and sediment)—giving readers a snapshot of the vegetated buffer width needed to control individual pollutants. As explained below, we did not use all scientific studies to create Table II—just those that reduced a specific water pollutant by 80% or more. The 80% threshold was chosen as a reasonable goal for nonpoint source pollution control; it may be insufficient for some pollutants, such as ammonia and fecal coliform. It is interesting to note that if pollutants are removed by 80% or more, it appears that stream vegetated buffers should be at least 130 feet, and not 100 feet, as recommended by the authors of the 5 review articles featured in this report.

Table II. Summary of stream vegetated buffer widths recommended to protect water quality. This table was compiled using information from the scientific studies reported in Appendix I below, as reported in the 5 review articles featured in this report. This table gives the average vegetated buffer width recommended to filter out approximately 80% of the following pollutants: ammonia, fecal coliform, nitrates, nitrogen, pesticides, phosphorus, and sediment. Desired buffer width was calculated by averaging the recommended buffer width for all studies that met or exceeded the 80% removal criteria. Where studies reported a range of values, the median of that range was used to calculate the average (mean) buffer width. In addition to an average buffer width, the range of buffer sizes from all studies meeting or exceeding the 80% reduction level is provided. Please note that nutrient reduction studies were treated slightly differently: because reviewed nutrient studies did not include a figure (e.g. 80% threshold) for the amount of pollution removed, the average buffer width for this pollutant was calculated using all scientific studies reviewed (12 studies total).

Type of Water Pollution	Average Stream Buffer Width	Number of Studies Used in Calculating Desired Buffer Width
Erosion control	100-year floodplain, but at least 100 feet	Review article conclusion (Wenger 1999)
Flood control, includes channel migration ability	100-year floodplain	Review article conclusion (Castelle et al 1994)
Nutrient	100 feet (range 33–600 feet)	12
Ammonia reduction (78% reduction)	164 feet	1
Fecal coliform	129 feet (range 100–600 feet)	4
Nitrates in surface runoff	113 feet (range 33–279 feet)	5
Nitrates in shallow groundwater	168 feet (range 3–721 feet)	31
Nitrogen	87 feet (range 5–164 feet)	4
Pesticides	182 feet (range 164–200 feet)	2
Phosphorus	106 feet (range 53–200 feet)	6
Sediment	103 feet (range 30–300 feet)	19
Average Stream Buffer Width Needed to Filter Approximately 80% of Pollutants	**132 feet**	

Appendix I.

A Summary of 77 Scientific Studies Conducted on the Size of Stream Vegetated Buffers Needed to Protect Water Quality. The information in this appendix was taken from the text and tables of 5 review articles described above. The table summarizes (1) the purpose of the vegetated buffer that was tested in a scientific study (Vegetated Buffer Function); (2) the size (in meters and feet) of the vegetated buffer(s) tested; (3) the author of the scientific study who tested the buffer's function and size; and (4) the name of the review article where the scientific study was summarized. As much as possible, the studies in this table are listed from most protective to least protective. Note that information about maintaining water temperatures, recruiting large woody debris, and maintaining microclimate influences and instream habitat appear in Part II of this report series, *Scientific Recommendations on the Size of Stream Vegetated Buffer Needed to Protect Fish and Aquatic Habitat*.

FILTER POLLUTANTS—Nutrients*
***Depends on slope, soils, etc.**

	Meters	Feet	Author of Original Scientific Study	Name of Review Article
Nutrient removal—using the multi-species riparian buffer strip system described by the authors	20	66	Schultz et al 1995	Knutson and Naef 1997
Nutrient reduction—suggested distance to protect water quality	36	118	Young et al 1980	Knutson and Naef 1997; Wenger 1999
Nutrient reduction—buffers needed in forested riparian areas	30	100	Terrell and Perfetti 1989	Knutson and Naef 1997
Nutrient reduction—buffers needed in herbaceous or cropland riparian areas	183	600	Terrell and Perfetti 1989	Knutson and Naef 1997
Nutrient reduction—improve or protect water quality	≥10	≥33	Corley et al 1999	Fischer et al 2000
Nutrient reduction—improve or protect water quality from logging	≥30	≥100	Lynch et al 1985	Knutson and Naef 1997; Castelle et al 1994; Fischer et al 2000
Nutrient reduction—improve or protect water quality	≥18	≥60	Lynch et al 1985	Fischer et al 2000
Nutrient reduction—improve or protect water quality	≥15	≥50	Woodard and Rock 1995	Fischer et al 2000
Nutrient reduction—improve or protect water quality	≥25	≥82	Young et al 1980	Fischer et al 2000
Nutrient reduction—minimum buffer size recommended	10	33	Petersen et al 1992	Knutson and Naef 1997
Nutrient reduction	4	13	Doyle et al 1977	Knutson and Naef 1997; Castelle et al 1994; Fischer et al 2000
Nutrient reduction	16	52	Jacobs and Gilliam 1985	Knutson and Naef 1997
Nutrient reduction	30–43	100–141	Jones et al 1988	Knutson and Naef 1997

FILTER POLLUTANTS—Animal Waste* *Depends on slope, soils, etc.				
	Meters	Feet	Author of Original Scientific Study	Name of Review Article
78% ammonium reduction from surface water	50	164	Peterjohn and Correll 1984	Wenger 1999
71% ammonium reduction from surface water	21	70	Young et al 1980	Wenger 1999
20–50% ammonium reduction	6–18	20–50	Daniels and Gilliam 1996	Wenger 1999
Fecal coliform removed	30	100	Grismer 1981	Knutson and Naef 1997
Fecal coliform removed	30–43	100–141	Jones et al 1988	Knutson and Naef 1997
Fecal coliform removed	30	100	Lynch et al 1985	Knutson and Naef 1997
87% of fecal coliform removed	60	197	Karr and Schlosser 1977	Wenger 1999
34–74% of fecal coliform removed	9	30	Coyne et al 1995	Wenger 1999
Feedlot waste—distance needed to filter confined animal waste	183	600	Terrell and Perfetti 1989	Knutson and Naef 1997
80% of feedlot waste removed	91–262	300–860	Vanderholm and Dickey 1978	Castelle et al 1994
92% of suspended sediment removed from feedlot waste	24	80	Young et al 1980	Castelle et al 1994
33% of suspended sediment removed from feedlot waste	23	75	Schellinger and Clausen 1992	Castelle et al 1994

FILTER POLLUTANTS—Nitrogen in various forms* *Depends on slope, soils, etc.				
	Meters	Feet	Author of Original Scientific Study	Name of Review Article
NITRATES IN SURFACE RUNOFF				
Nearly 100%' nitrate reduction	20–30	66–100	Fennesy and Cronk 1997	Wenger 1999
Nitrates removed to meet drinking water standards	30	100	Johnson and Ryba 1992	Knutson and Naef 1997
99% nitrate reduction in forested buffer	10	33	Xu et al 1992	Castelle et al 1994
79% nitrate reduction in forest buffer	70–85	230–279	Peterjohn and Correll 1984	Wenger 1999; Mayer et al 2005
78% nitrate reduction in forest buffer	30	98	Lynch et al 1985	Mayer et al 2005
27–57% nitrate reduction in grassland buffer	5–9	15–30	Dillaha et al 1989	Mayer et al 2005
20–50% nitrate reduction in grassland buffer	8–16	26–53	Vought et al 1994	Wenger 1999
16–76% nitrate reduction in grassland buffer	26	85	Schwer and Clausen 1989	Mayer et al 2005

	Meters	Feet	Author of Original Scientific Study	Name of Review Article
NITRATES IN SURFACE RUNOFF (continued)				
12–74% nitrate reduction through wetland vegetation	20	66	Brüsch and Nilsson 1993	Mayer et al 2005
8% nitrate reduction in grassland buffer	27	89	Young et al 1980	Mayer et al 2005
Nitrates *increased* across buffer	21	70	Young et al 1980	Wenger 1999
Nitrates *increased* in grassland buffer	5–9	15–30	Dillaha et al 1988	Wenger 1999; Mayer et al 2005
NITRATES IN SHALLOW GROUNDWATER				
100% nitrate reduction	30	98	Pinay and Decamps 1988	Mayer et al 2005
100% nitrate reduction	30	98	Pinay et al 1993	Mayer et al 2005
100% nitrate reduction	40	131	Puckett et al. 2002	Mayer et al 2005
100% nitrate reduction	10–20	33–66	Vought et al 1994	Wenger 1999
99% nitrate reduction	50	164	Jacobs and Gilliam 1985	Mayer et al 2005
99% nitrate reduction	10	33	Cey et al 1999	Mayer et al 2005
98% nitrate reduction	100	328	Prach and Rauch 1992	Mayer et al 2005
97–99% nitrate reduction in grass-forest area	33–66	108–216	Vidon and Hill 2004	Mayer et al 2005
97% nitrate reduction	165	541	Hill et al. 2000	Mayer et al 2005
96% nitrate reduction in clay soils	1	3	Burns and Nguyen 2002	Mayer et al 2005
96% nitrate reduction	15	49	Hubbard and Sheridan 1989	Mayer et al 2005
95% nitrate reduction	200	656	Fustec et al 1991	Mayer et al 2005
95% nitrate reduction	60	197	Jordan et al 1993	Wenger 1999; Mayer et al 2005
94–98% nitrate reduction in forest area	204–220	669–721	Vidon and Hill 2004	Mayer et al 2005
94% nitrate reduction	50–60	160–200	Lowrance 1992	Wenger 1999; Mayer et al 2005
94% nitrate reduction	85	280	Peterjohn and Correll 1984	Mayer et al 2005
91% nitrate reduction	6	20	Borin and Bigon 2002	Mayer et al 2005
91% nitrate reduction	70	230	Hubbard and Lowrance 1997	Mayer et al 2005
90–99% nitrate reduction	50	164	Peterjohn and Correll [1] 1984	Wenger 1999
89% nitrate reduction	16	52	Haycock and Burt 1993	Mayer et al 2005

	Meters	Feet	Author of Original Scientific Study	Name of Review Article
NITRATES IN SHALLOW GROUNDWATER (continued)				
84–99% nitrate reduction	16–20	52–66	Haycock and Pinay 1993	Wenger 1999; Mayer et al 2005
84–98% nitrate reduction	25–50	82–164	Hefting and de Klein 1998	Mayer et al 2005
84–97% nitrate reduction	6–15	19–50	Simmons et al 1992	Mayer et al 2005
83% nitrate reduction	55	180	Lowrance et al 1984	Mayer et al 2005
83% nitrate reduction	20	66	Schultz et al 1995	Mayer et al 2005
82–99% nitrate reduction	10	33	Schoonover and Williard 2003	Mayer et al 2005
82–95% nitrates reduction	16–39	52–128	Osborne and Kovacic 1993	Wenger 1999; Mayer et al 2005
80–100% nitrate reduction	50–70	164–230	Martin et al 1999	Mayer et al 2005
80–81% nitrate reduction	20–28	66–92	Mander et al 1997	Wenger 1999
78% nitrate reduction	30	100	Hubbard 1997	Wenger 1999
78% nitrate reduction	38	125	Vellidis et al. 2003	Mayer et al 2005
64–100% nitrate reduction	100–200	328–656	Spruill 2004	Mayer et al 2005
60–99% nitrate reduction in grassland area	25–30	82–98	Vidon and Hill 2004	Mayer et al 2005
59–94% nitrate reduction[2]	31	102	Hanson et al 1994	Wenger 1999; Mayer et al 2005
58–96% nitrate reduction	10–50	33–164	Hefting et al 2003	Mayer et al 2005
52–76% nitrate reduction	5	16	Clausen et al. 2000	Mayer et al 2005
NITROGEN				
Nitrogen removed	30	100	Muscutt et al 1993	Wenger 1999
90–99% nitrogen reduction	5–9	15–30	Madison et al 1992	Castelle et al 1994
89% nitrogen reduction	19	62	Shisler et al 1987	Castelle et al 1994; Fischer et al 2000
86% nitrogen reduction in surface water	50	164	Peterjohn and Correll [1] 1984	Wenger 1999
67–74% nitrogen reduction	5–9	15–30	Dillaha et al 1988	Wenger 1999
67% nitrogen reduction	21	70	Young et al 1980	Wenger 1999
54–73% nitrogen reduction	5–9	15–30	Dillaha et al 1989	Castelle et al 1994; Wenger 1999
38% nitrogen reduction in grassland	91	299	Zirschky et al 1989	Mayer et al 2005
28–51% nitrogen reduction in grass/forest	8–15	25–50	Schmitt et al 1999	Mayer et al 2005
17–51% nitrogen reduction	5–9	15–30	Magette et al 1987	Wenger 1999

	Meters	Feet	Author of Original Scientific Study	Name of Review Article
NITROGEN (continued)				
Buffer zones less than 10 meters (33 feet) lack extensive experimental support	>10	>33	Hickley and Doran 2004	Mayer et al 2005
Nitrogen *increased* or reduced by 48%	5–9	15–30	Magette et al 1989	Wenger 1999; Mayer et al 2005
Nitrogen *increased* in groundwater	50	164	Peterjohn and Correll [1] 1984	Wenger 1999

FILTER POLLUTANTS—Pesticides and Heavy Metals* ***Depends on slope, soils, etc.**				
	Meters	**Feet**	**Author of Original Scientific Study**	**Name of Review Article**
Pesticides—buffering distance for sediment with pesticides—ungrazed buffers	61	200	Terrell and Perfetti 1989	Knutson and Naef 1997
Pesticides—various types—almost 100% over 3 years	50	164	Lowrance et al 1997	Wenger 1999
Pesticides—various types—8–100% reduction	20	66	Arora et al 1996	Wenger 1999
Pesticides—various types—10–40% reduction	12–60	40–60	Hatfield et al 1995	Wenger 1999
Lead removal	61	200	Horner and Mar 1982	Castelle et al 1994

FILTER POLLUTANTS—Phosphorus* ***Depends on slope, soils, etc.**				
	Meters	**Feet**	**Author of Original Scientific Study**	**Name of Review Article**
100% phosphorus reduction	61	200	Horner and Mar 1982	Castelle et al 1994
80% phosphorus reduction	19	62	Shisler et al 1987	Castelle et al 1994; Fischer et al 2000
73–84% phosphorus reduction—in surface water	50	164	Peterjohn and Correll 1984	Wenger 1999
67–81% phosphorus reduction in short-term study	20–28	66–92	Mander et al 1997	Wenger 1999
83% phosphorus reduction in short-term study	21–27	70–90	Young et al 1980	Wenger 1999
66–95% phosphorus reduction in surface water in short-term study	8–16	26–53	Vought et al 1994	Wenger 1999
61–79% phosphorus reduction in short-term study	5–9	15–30	Dillaha et al 1989	Castelle et al 1994; Wenger 1999
58–72% phosphorus reduction in short-term study	5–9	15–30	Dillaha et al 1988	Wenger 1999
41–53% phosphorus reduction in short-term study	5–9	15–30	Magette et al 1987	Wenger 1999
18–46% phosphorus reduction in short-term study	5–9	15–30	Magette et al 1989	Wenger 1999

FILTER POLLUTANTS—Sediments* ***Depends on slope, soils, etc.**				
	Meters	**Feet**	**Author of Original Scientific Study**	**Name of Review Article**
Sediment removal—adequate buffer for cropland, animal waste across ungrazed buffer, and for pesticides	61	200	Terrell and Perfetti 1989	Knutson and Naef 1997
Sediment removal	30	100	Moring et al 1982	Knutson and Naef 1997
Sediment removal—to prevent impacts in logged forest	30	100	Davies and Nelson 1994	Wenger 1999
Sediment removal—based on multi-year studies	30	100	Cooper et al 1988	Wenger 1999
Sediment removal—minimum needed	30	100	Erman et al 1977	Wenger 1999
Effective sediment removal—most effective width of vegetated buffers	25	82	Desbonnet et al 1994	Wenger 1999
Effective sediment removal—adequate buffer for logging practices on steep slopes—buffer measured from edge of floodplain	61	200	Broderson 1973	Knutson and Naef 1997; Castelle et al 1994
Effective sediment removal—buffer strip width to control non-channelized sediment flow	60–91	200–300	Belt et al 1992	Knutson and Naef 1997
99% sediment reduction in short-term study (1 rainfall)	9	30	Coyne et al 1995	Wenger 1999
90–94% sediment reduction in short-term study	19–60	62–197	Peterjohn and Correll 1984	Wenger 1999
90% sediment reduction at 2% grade	30	100	Johnson and Ryba 1992	Knutson and Naef 1997
85% sediment reduction	9	30	Ghaffarzadeh et al 1992	Castelle et al 1994
80% sediment reduction	61	200	Horner and Mar 1982	Castelle et al 1994
76–95% sediment removal in short-term study	5–9	15–30	Dillaha et al 1988	Wenger 1999
75–80% sediment reduction from logging activity	30	100	Lynch et al 1985	Knutson and Naef 1997; Castelle et al 1994; Fischer et al 2000
75–80% sediment reduction from stormwater in logged areas; more effective where runoff is in sheets; less effective where surface flows are channelized	30	100	Johnson and Ryba 1992	Knutson and Naef 1997
75% sediment reduction	30–38	100–125	Karr and Schlosser 1977	Knutson and Naef 1997
70–84% sediment reduction	5–9	15–30	Dillaha et al 1989	Castelle et al 1994; Wenger 1999
66–93% sediment reduction in short-term study	21–27	70–90	Young et al 1980	Castelle et al 1994; Wenger 1999; Fischer et al 2000
66–82% sediment reduction in short-term study	5–9	15–30	Magette et al 1989	Wenger 1999
50% sediment reduction—based on muti-year studies	100	328	Lowrance et al 1988	Wenger 1999
50% sediment reduction	88	289	Gilliam and Skaggs 1988	Knutson and Naef 1997

1 NOTE: Wenger (1999) refers to two articles written by Peterjohn and Correll: one from 1984 and one from 1985. It appears that the article he cited was Peterjohn and Correll 1984.

2 NOTE: Wenger (1999) reported a 94% reduction in nitrates for this study while Mayer et al (2005) reported a 59% reduction. Both figures are presented.

Appendix II

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Acknowledgements

A special thanks goes to the following individuals who provided advice, editorial counsel, and support for this publication: Chris Clancy and Doris Fischer (FWP), Lynda Saul and Taylor Greenup (DEQ), and Dr. Vicky Watson (Univ. of Montana). Geoff Wyatt, of Wyatt Design, designed the report and developed the illustration on page 3. Rick Newby, Zadig, LLC, copyedited the text. Financial Support for this report came from the Montana Dept. of Environmental Quality (DEQ); U.S. Environmental Protection Agency; Montana Fish, Wildlife & Parks (FWP); the Liz Claiborne/Art Ortenberg Foundation; and Montana Audubon.