A CONTINUED EFFORT FOR STORMWATER CONTROL MEASURES

IN THE TRAIL CREEK WATERSHED

by

KILEY EB AGUAR

(Under the Direction of Jon Calabria)

ABSTRACT

Amidst rapid urbanization and stream impairment across the world this thesis analyzes how a landscape-based approach to stormwater management can expand the scope of nonpoint source pollution prevention to incorporate ecosystem rehabilitation. A mixed-methods approach (research-through-design) informs the process of working between the problem and solution through analysis, synthesis, and evaluation. This process is applied to Trail Creek in Athens, Georgia, as a case study to address the stream rehabilitation. Stream rehabilitation is a watershed-scale project, often limited to support from local governments and volunteer organizations. In this thesis, the Clean Water Act Section 319(h) Implementation Grant is presented as a vehicle for watershed rehabilitation. This community-based project sought to identify sites in the Trail Creek watershed for the implementation of stormwater control measures and green infrastructure as demonstration projects that address issues associated with stormwater runoff and nonpoint source pollution.

INDEX WORDS: Landscape architecture, nonpoint source pollution, stormwater, watershed rehabilitation, green infrastructure, research design

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DEDICATION

I would like to dedicate this Masters Thesis to my family and friends, without whose love and support this would not have been possible.

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CHAPTER 1

INTRODUCTION

The concept of a watershed is much more than a region of land; it is a complex web of connections through nature, culture, history and the future. Echoing the holistic perspective of a watershed presented by John Wesley Powell, it is a way about seeing the land, water, and society as parts of an interconnected ecological system - beyond property or political boundaries. (Robison 2020). In 1773, the now well-known naturalist, William Bartram, traveled through present-day Athens-Clarke County, Georgia, and described the North Oconee River, which runs through Athens, as “that beautiful river [where] the cane swamps, of immense extent, and the oak forests, on the level lands, are incredibly fertile; which appears from the tall reeds of the one, and the heavy timber of the other” (Bartram 1958). Nearly 250 years later, the North Oconee River continues to flow and provide for the nature and community of Athens, Georgia. However, the river and landscape have drastically changed. Centuries of land abuse, pollution, and urbanization have taken a toll on the health and appearance of "that beautiful river" (Bartram 1958).

Context

As populations grow, cities expand and land uses change. What were once rural landscapes and natural green spaces have become urban centers, neighborhoods, commercial developments, and industrial complexes. Along with land-use changes come increased impervious surface covers, such as asphalt, concrete, and rooftops, making stormwater runoff a particular management challenge in transitional and urban watersheds as it is largely due to the greater land use complexity. When it rains, stormwater no longer has an opportunity to soak into the ground where it falls. The additional runoff drains quickly, transporting with it a myriad of nonpoint source pollutants (NPS) as it rushes downstream, further degrading water quality and destabilizing stream ecosystems in the receiving waters (GADNR 2016).

Urban stormwater and agriculture runoff are the leading sources of NPS, the leading source of water pollution in the United States, and the largest obstacle in regulating water quality in the country (EPD 2014). While progress has been made in the protection and enhancement of water quality, innovative approaches are needed to identify NPS management strategies that are sustainable, effective, and loyal (Subramanian 2017). The federal Clean Water Act (1973 and amendments) has led to the development of water-quality standards to rehabilitate and maintain the chemical, physical, biological health of the nation's surface waters. Under the Clean Water Act, communities have a responsibility to rehabilitate rivers and streams that are listed as “impaired" – or else, the community would be violating water quality standards (GADNR 2014). Delisting a stream is a watershed-scale project, often limited to support from local governments and volunteer organizations (Mika 2017).

Stormwater is a useful resource. However, due to the magnitude and complexity of centralized stormwater infrastructure, traditional management practices fail to reclaim its value from its full potential (Subramanian 2017). Decentralized stormwater control measures, such as green infrastructure, are an integral component of sustainable communities (WERF 2007). In addition to reducing stormwater and NPS runoff, it is a way of protecting water quality while achieving co-benefits that can help achieve other social, economic, public health, and environmental goals (Rissman, et al. 2015).

Purpose

This thesis develops a creative approach for stormwater-control measures (SCM) and green-infrastructure (GI) application in an impaired watershed in coordination with the Clean Water Act Section 319(h) NPS Implementation Grant criteria. Through design exploration, this research develops an approach that can be used by communities who wish to implement sustainable design practices to address NPS pollutants and improve water quality in their local streams and rivers (see Figure 2.1). This plan incorporates SCMs and GI as demonstration projects on public lands within an impaired watershed, Trail Creek, Athens, Georgia, (see Figures 1.1 and 1.2). The demonstration projects, once implemented, will capture and treat stormwater runoff before it enters nearby waterways. This approach aims to improve degraded water quality, reduce risks to human health, and preserve and enhance ecological resources.

The term *ecosystem rehabilitation* is used to describe the means in which to repair and replace the essential or primary ecosystem structures and functions that have been altered or eliminated by disturbance. In this case, ecosystem rehabilitation includes the entire watershed, and it emphasizes the reestablishment of important missing and altered processes, and leads to the reduction or elimination of stressors, such as external NPS loading (Cooke 2009). To rehabilitate water quality and ecological function of an impaired waterbody and its tributaries, sustainable stormwater management practices must be extended across the watershed and onto privately owned lands (see Appendix A). Most importantly, demonstration projects test and measure the effects of program changes in real-world situations, and promote the concept as an alternative method for the potential future of Northeast Georgia's watersheds, streams, and rivers, which differs from how they have been treated in the past - out of sight and out of mind.

In doing so, this thesis seeks to answer the following question: *How can a landscape-based approach to stormwater management expand the scope of nonpoint source pollution prevention to include ecosystem rehabilitation?* Furthermore, this thesis addresses the following sub-question: *What might be the recommendations for the Trail Creek watershed associated with the Clean Water Act Section 319(h) NPS Implementation Grant application?*

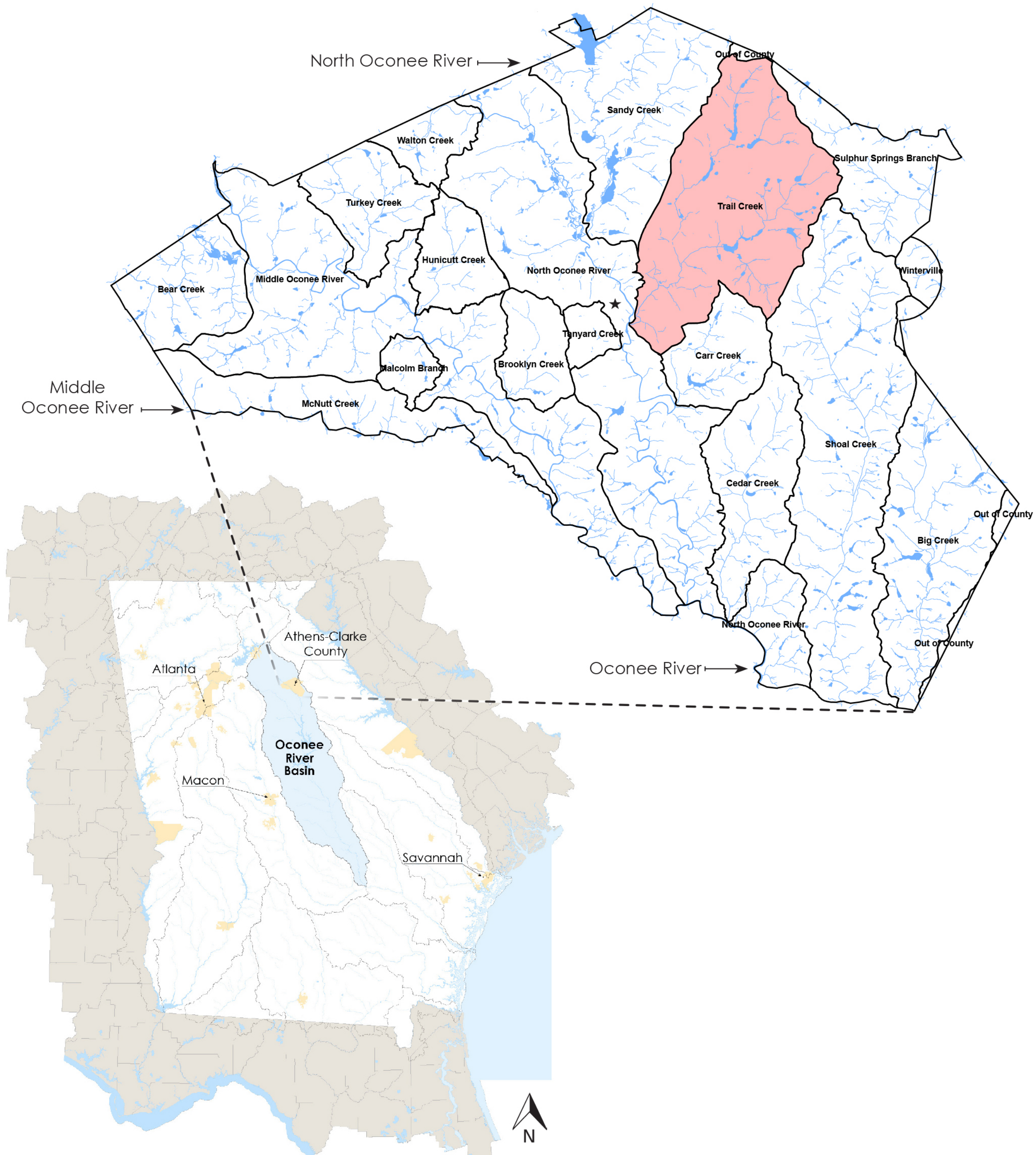

Figure 1.1. River Basins in Georgia and Watersheds in Athens-Clarke County, Georgia (2018)
Data Sources: ARC, ACC, FEMA

Figure 1.2. Trial Creek Watershed, Impaired Stream Segments (2018)
Data Source: ACC, FEMA, EPA

The importance of this research lies in its ability to be applied to the landscape architecture and planning professions as other communities seek alternative and sustainable methods to manage stormwater, improve water quality, and delist impaired bodies of water. Amidst rapid urbanization and substantial stream impairment across the world, this research is vital in developing new strategies to implement sustainable stormwater management and stormwater control measures, such as GI into the public realm, and establishes an alternative future for how we manage stormwater and live with nature. This thesis builds on nearly twenty years of watershed planning documents and water quality monitoring data. If successful, this approach will be one step closer to rehabilitating and delisting Trail Creek. The project could serve as a model for communities across the Southeastern region, as well as the country.

Goals, Aims, and Objectives

The Athens-Clarke County Unified Government (ACC) is committed to maintaining and improving the quality of local waterways and has taken a collaborative approach to watershed protection activities (Watershed UGA 2016). The goals of this thesis are to work with project partners, a group of local stakeholders, to develop a management approach that addresses NPS pollution in the Trail Creek watershed, and to identify priority candidate sites where SCMs and GI can be installed to mitigate stormwater runoff and fecal bacteria from entering nearby waterways. Project partners encourage the adoption of stormwater control measures and green infrastructure that are coupled with educational outreach. Specific practices include cattle exclusion from Trail Creek tributaries in agriculture areas, SCMs, and GI on public lands to reduce NPS pollutants from entering Trail Creek. In Chapter 5, in accordance with the Clean

Water Act Section 319(h) NPS Implementation Grant, site recommendations, analysis and siting of implementation projects will be presented.

Methods

Because of the complex nature of human-altered landscapes, such as urban watersheds, this study used a mixed methods approach: research through design (RTD) (Nijhuis and Vries 2020). In landscape architecture education and research in the academic context, as well as in practice, spatial design is increasingly used as a form of research (Nijhuis and Vries 2020). In this context, design is a means to achieve goals and not the goal itself. It is a strategy for working in a manner to achieve a particular goal or to address a research question through design exploration (Simon 1981). An adapted approach from Nijhuis and Vries's contribution to the research design discussion is used in this thesis and helped inform its strategies (see Figure 2.1). Evaluation strategies such as rubrics are used to define parameters to improve decision-making (Table 5.1) (Deming, et al. 2011). The gestalt method of suitability analysis is used to work between different scales such as watershed-scale and site-scale to evaluate optimization of a site for a particular program (Deming, et al. 2011).

Scope and Delimitations

Due to rapid urbanization and poor land use practices, Northeast Georgia's environment has been severely degraded resulting in significant watershed impairment (Peters 2009). This research prioritizes efforts directed at rehabilitating water quality as well as ecosystem function through the use of SCMs and GI (Prudencio, et al. 2018). In addition, landscape services are an important part of sustainable design as a means of shifting public opinion about stormwater management and watershed awareness (Yang, et al. 2013). Watershed rehabilitation affects a large array of factors: ecological, economic, cultural, and sociopolitical (Hilden 2001). By activating these sites for human interaction, they will serve as assets and amenities for the community, as well as a protective mechanism (Cooke 2009).

This project focuses on an impaired Hydrologic Unit Code (HUC) 12 watershed, Trail Creek, located in Athens, Georgia. It is listed as impaired for fecal coliform (FC) and is indeed threatened by other effects from stormwater that are common among urban streams (GAEPD 2016 and Siragusa, et al. 2007). Trail Creek was selected by a group of stakeholders: Athens-Clarke County Unified Government (ACC), The University of Georgia Research Foundation, The University of Georgia River Basin Center, Natural Resource Conservation Service (NRCS), Upper Oconee Watershed Network, The Carl Vinson Institute of Government, Stroud Elementary School, Chicopee Dudley Neighborhood Association, The Oconee River Land Trust, and the Athens Land Trust. The lack of SCM and stormwater runoff are the dominant factors in nutrient loading in the watershed (ACC 2010). This project's guidelines were limited to the Clean Water Act Section 319(h) NPS Implementation Grant criteria, as well as the priorities of and limitations set by the primary partners, ACC.

Clean Water Act Section 319(h) NPS Implementation Grant

Through Section 319(h) of the Clean Water Act, the U.S. Environmental Protection Agency (USEPA) awards a Nonpoint Source Implementation Grant to the Georgia Environmental Protection Division (GAEPD) to fund projects in support of Georgia’s Nonpoint Source Management Program. This particular grant requires a 40% non-federal match that can be met through local funds, in-kind services, or other non-federal sources. Funding is distributed via a competitive process to proposals that will lead to direct reduction in pollutant loads and measurable water quality improvements (See Appendix B, C) (GAEPD 2018). Many professionals are inclined toward structural controls such as centralized stormwater systems or certain stormwater control measures. But in reality, comprehensive watershed protection often requires SCMs combined with public education, economic incentives, and, in some cases, regulation, land use controls, or habitat rehabilitation (USEPA 1995). The following list covers the Clean Water Act Section 319(h) NPS Implementation Grant Criteria.

Eligible applicants are public entities such as city or county governments with Qualified Local Government status; regional and state agencies; authorities that operate public service or delivery programs; regional commissions; resource conservation and development councils; county extensions; and local school systems and state colleges and universities. All applicants are required to attend a webinar with GAEPD Grants Unit Staff to discuss the application process. Project partners, consultants, or other parties may attend, but the lead organization must be in attendance (GAEPD 2018). Project applications must meet all three of the following minimum requirements:

- implement an existing watershed-based plan that adequately meets USEPA's Nine Elements of Watershed Planning or implement an alternative to a watershed-based plan in the form of a Summary of Nine Elements compiled from planning documents; and
- locate the project in a watershed or drainage area equal in size to a single 10-digit Hydrologic Unit Code (HUC-10) or smaller; and,
- commit to a minimum 40% non-federal match that can be accomplished through local funds, in-kind services, or other non-federal sources.

Key Ranking Criteria

- Specify the nonpoint sources of pollution to be addressed and propose the activities best suited to prevent, control, and/or abate the identified nonpoint pollution sources
- Demonstrate cost effectiveness
- Support the milestones and/or implementation activities described in the 2014 revision of the Georgia Nonpoint Source Management Program as documented in Georgia's Statewide Nonpoint Source Management Plan
- Include an appropriate component to evaluate the effectiveness of the project (e.g., water quality monitoring, beneficial use assessment, environmental indicators)

If implementing Best Management Practices (BMPs), the project must include:

- schedules of BMPs operations and maintenance, or manuals describing Standard Operating Procedures, which cover the expected lifespan of the practice and in accordance with commonly accepted standards;
- estimates of load reductions in nitrogen, phosphorous, and sediment.

Additional Selection Priorities - Proposals will be given priority consideration if they meet minimum requirements and key ranking criteria, and also:

- Target Georgia's Section 305(b)/303(d) List of Waters in order to improve water quality in impaired (non-supporting) waters; or, restore impaired (non-supporting) waters so that they are meeting water quality standards and supporting their designated uses; or, protect water quality in Category 1 (supporting) waters by incorporating USEPA's Healthy Watersheds Initiative.

- Implement structural and/or nonstructural BMPs recommended in a watershed-based plan that will lead to measurable improvements in water quality.
- Support a watershed management approach utilizing cooperating partnerships and/or multi-governmental agencies, especially in conjunction with other nonpoint source management activities within the watershed as well as across jurisdictional boundaries.
- Target water bodies impaired for violating water quality standards and/or for water quality issues related to Pathogens, Dissolved Oxygen, Sediment, and/or Nutrients (Phosphorous & Nitrogen).
- Propose implementing management practices identified within the appropriate Regional Water Plan.
- Address waters with finalized Total Maximum Daily Loads (TMDLs).
- Demonstrate that the project results in environmental benefits beyond addressing nonpoint source impairments (benefits may include, but are not limited to: environmental justice, air quality, water or energy conservation, stream flow profile, habitat connectivity, and others).
- Commit to a match of 50% or higher.
- Locate the project area(s) in priority watershed(s) as demonstrated by GAEPD and USEPA, and focus proposed activities on watershed-based implementation and/or restoration.
- Include administrative and/or managerial improvements that prevent and/or correct the adverse hydrologic impacts of increased impervious surfaces. In order to receive consideration for this priority ranking, applications must propose/develop/implement items such as local or regional development ordinances, stream buffer protections wider

than state minimums, or other local mechanisms to ensure long-term success in minimizing the potential future impacts of hydrological modifications.

- Qualify as a WaterFirst Community or locate the project within the jurisdiction of a WaterFirst Community that has committed to participate as a partner in the project.
- Partner with local non-profit watershed groups that were established prior to the submittal of the application.
- Carry out specific activities that address and/or implement management measures, enforceable policies, and mechanisms identified in Georgia's Coastal Nonpoint Source Management Program.

To develop the grant proposal under a designated timeframe, this study limited the research of items that are identified as outside of the scope of this thesis but are considered essential to its future exploration. This includes items such as detailed site designs, identifying potential funding other than the Section 319(h) grant, candidate sites on private lands, and water quality monitoring. Instead, this thesis relies upon literature review, watershed analysis and characterization from previous studies, site analysis, stakeholder meetings, and the resulting approach that will suggest the transformation of selected sites in the watershed (Table 5.1). Communities, watershed groups, educators, as well as landscape architects and planning professionals, may use this research as a resource in promoting informed local decision-making. Detailed design plans were not developed, however recommendations for SCMs and GI practices, and siting of these practices are presented in Chapter 5. Other elements or approaches are discussed, but do not result in specific designs, implementation plans, and construction documents, or detailed planting plans.

Lastly, GIS and AutoCAD software were used to perform detailed site analysis, such as slope and drainage studies, in order to appropriately site and size SCMs. These representations serve as place holders for future projects. The boundaries for the selected sites are limited to the parcel edges; however, because when dealing with stormwater, they do factor in adjacent parcels that may be publicly or privately owned. Potential sites were given priority if they were on agriculture land, public land, or land owned by ACC. Moreover, sites were given priority if an adaptive reuse approach, public engagement, and/or educational component could be applied. Further discussion of the approach will be addressed in later chapters.

CHAPTER 2

USING A MIXED METHOD RESERCH DESIGN STRATEGY

Research Through Design

The research through design method presented by Nijhuis and Vries explains that: "Design is a process of discovery and invention. There are three phases associated with the design process: analysis, synthesis, and evaluation. These phases are interconnected and the process is nonlinear. In research through design, these phases are preceded by a design problem (the objective) and are concluded with a design solution [see Figure 2.1]. The analysis phase involves collecting and interpreting information. It seeks an enhanced understanding of the context of the design and identifying viable possibilities. In the synthesis phase, partial solutions are developed and brought together as resolutions for the problem as a whole. Synthesis entails a cycle of emergence and development. Emergence involves the creative translation of latent, half-formed internal imaginations in the mind of the designer within an "embryonic" design model, in which initial ideas take on tentative shape based on an intuitive idea or concept developed during the analysis phase. The development cycle concerns future refinement of the initial idea, thereby achieving a greater extent of completeness, coherence, and specificity. The evaluation phase entails assessing integral solutions according to the objective and identification of alternative problem solutions. Research through design can be understood as dialogue between a problem and a solution through comprehension, analysis, synthesis, and evaluation."

"Imagination, creativity, and innovation play important roles in all phases of a design process. The combination of these three elements and their usage make design a powerful heuristic research strategy in which the content evolves from action. In search of a design solution, the process is targeted. As the search unfolds, the solution is constantly adjusted by the process of design. Idea generation begets its representation in draft form, which is then evaluated according to original design goals. In turn, evaluative feedback generates new ideas. This interaction yields new knowledge whose production can be documented."

"The research process is reflexive, with analytic thinking and design thinking going hand in hand [see Figure 2.1]. In this context, analytical thinking aims at data translation and interpretation into knowledge (discovery), and design thinking aims at the development of new knowledge through synthesis and spatial translation (invention). Given this interaction, visual representations (mapping studies, design concepts, and models) are not by-products. Rather, they play central roles in the process of thought production and representation."

Design as Process: Analysis, Synthesis, and Evaluation

Collecting and interpreting research for design is the most common relationship between the acts of research and design, aimed at acquiring knowledge and fact-finding. This includes quantitative research methods that are measured and objective such as, watershed studies, watershed management plans, and water quality assessments, as well as qualitative methods such as observations, site investigations, and stakeholder knowledge. Thus, the data collected may be generated from the researcher or may be secondary research that was previously published by an outside source. Gathering supporting literature, conducting site analysis, and stakeholder meetings, as well as collecting all other data deemed necessary generates knowledge through the research process. Thus, the goal of this research phase was to collect abundant information and interpret it in a manner that generated new knowledge benefiting the development of the approach and the subsequent designs that were to be presented to the stakeholder group (see Figures 5.2 - 5.9). The specific strategies taken during this phase included literature review and landscape analysis.

During the synthesis phase of the design process, information gathered from the analysis and research portion was processed and interpreted. All relevant data was then translated and presented in the form of mapping studies to the stakeholder group (see Figures 5.2 - 5.9). These designs helped visualize and comprehend all of the data into a coherent plan. Based off of the criteria of the Section 319(h) grant and interests of the stakeholders, we began to identify candidate sites in the watershed. The specific strategies taken during this phase include site identification and classification, and the gestalt method of ecological planning and watershed analysis.

At this point, the evaluation phase, candidate sites were assessed using multiple design tools such as prioritization matrix, site visits, mapping studies, and site inventory and analysis (see Figures 5.2 - 5.9 and Table 5.1). The objective through this design process was to test and narrow potential candidate sites and landscape treatments that would be best suited to prevent, control, or lessen NPS pollutant sources, specifically urban runoff and fecal coliform, and meet multiple community needs in the watershed. The design process, site criteria, candidate sites, as well as the accompanying stormwater control measures (SCMs) and green infrastructure (GI) projects are presented in Chapter Five.

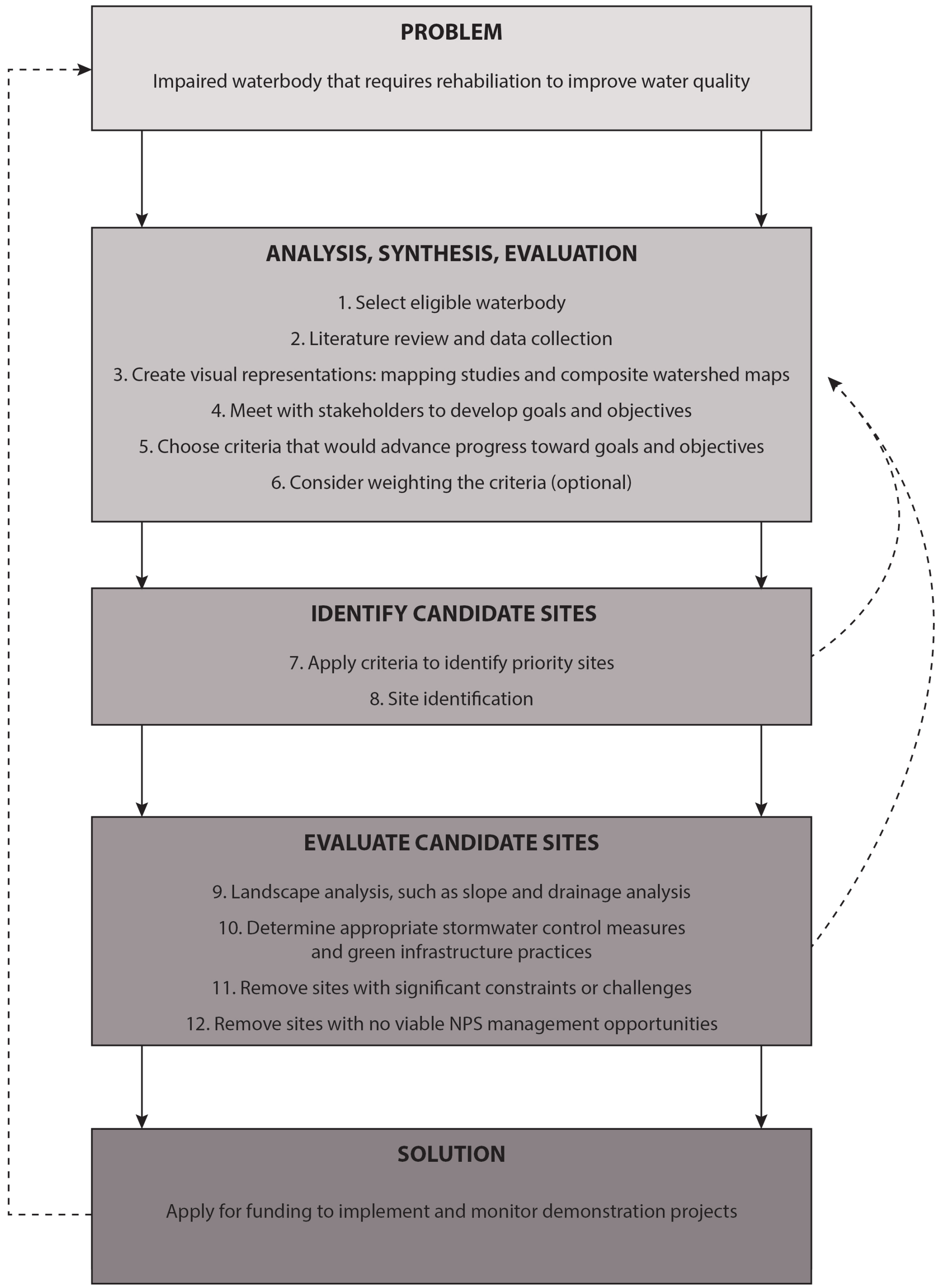

Figure 2.1. Design as Process (adapted from Nijhuis 2020)

Literature Review

The literature review strategy investigates the multiple layers and components attached to the research questions and are shown in Chapter Three and Chapter Four. Chapter Three examines urban stormwater management issues in the United States as a result of human development, specifically NPS pollution. This human-nature relationship is then used to present the Clean Water Act Section 319(h) NPS Implementation Grant as a means to fund an alternative approach to stormwater management and promote watershed rehabilitation. The section that follows introduces sustainable design practices such as SCMs and GI, a landscape-based approach to mitigate urban runoff and nonpoint source pollution. Chapter Four discusses Georgia's water resources and the importance of clean water. This information is then narrowed and analyzes an impaired watershed, Trail Creek, in Athens, Georgia, as it is facing threats similar to other urbanizing watersheds across the Southeast United States.

Evaluation Strategies

Evaluation strategies used during site identification and landscape analysis strategies are seen at different stages throughout the thesis as they were critical in understanding the conditions of the watershed as well as providing relevant context of each candidate site, opportunities and constraints, and addressing the design goals and objectives. Because most of the information gathered was not created by the researcher but by other sources, after data collection, the information was interpreted and translated into meaningful design directives applicable to the research.

The information generated from these strategies was produced using a number of resources including Geographic Information Systems (GIS) software, EagleView Pictometry

Imagery, Google Earth imagery, personal observations and photographs, and reports generated by ACC or other agencies. Using this new knowledge, an in-depth watershed inventory was performed to develop composite maps and imagery that was presented at stakeholder meetings (see Figures 5.2 - 5.10). Then the researcher and stakeholders analyzed the maps to identify candidate sites. A screening technique was used for identifying potential SCMs and GI sites that meet multiple community needs. The process used mapping and GIS software to analyze sites and select areas best suited for SCMs and GI implementation. It then set priorities, using a prioritization matrix as a decision-making tool for the remaining parcels. Because of the nature of this community-planning project, the study evolved as new knowledge was gained and as stakeholders interacted. The researcher and stakeholders further investigated potential candidate sites by site visits, local knowledge, and mapping suitability analysis.

Landscape characteristics collected include topography, floodplains, elevation, slope, sewer lines and septic tanks, stormwater lines, water quality monitoring, vegetation, digital elevation models, hydrology, public lands, land owned by ACC, impervious surfaces, land-use, and existing structures (see Figures 5.2 - 5.9). These characteristics were chosen based on knowledge gained through the evidence provided in the literature review. Again, the goal of this inventory and analysis was to comprehensively consider all relevant factors and collect any and all information that would inform or support the research and design process.

The Gestalt Method

Gestalt thinking is a method of problem solving. Typically, there are four fundamental steps or phases of activity (Rowe 1987). Peter Rowe states that the steps are "(1) preparation for the task at hand or situation at hand, (2) incubation, (3) illumination or inspiration, and (4) verification, involving the testing of proposed solutions." The illumination phase occurs when the investigator becomes aware of potential solutions to the problem. It can happen from sudden intuition or as a result of sustained efforts of exploration (Rowe 1987).

The gestalt method is a holistic practice of ecological planning used in making elemental judgments on suitability. It involves understanding the landscape as a whole through field observation and/or aerial imagery rather than examining individual components, such as slope, hydrology, and vegetation. When the cost of data collection and time are limiting factors, designers may decide to use this method as a first step in establishing suitability (Ndubisi 2002). This method of analysis is beneficial when working between different scales such as watershed-scale and site-scale to understand context and to evaluate optimization of a site for a particular program (Deming, et al. 2011).

CHAPTER 3

TREATING URBAN STORMWATER RUNOFF

Introduction

Urban stormwater is both a challenge and a resource. The current stormwater paradigm must be driven by multiple objectives in order to minimize the negatives and maximize the positives of this valuable resource. Cities have attempted to mitigate flood risks by building complex storm-sewer systems, but this urban-drainage infrastructure has exacerbated other water quality problems, radically altered natural hydrology, and separated the public understanding of the value of stormwater and natural waterways (Schuetze, et al. 2013). Some of the central problems related to urban stormwater runoff, such as NPS pollution, flooding, increased flow, and velocity of flow, are a direct result of the imperviousness of urban pavements (Subramanian 2017). This history sheds light on the problem of single-purpose management and suggests that a more integrated approach is needed.

A landscape-based approach is about balancing land-use demands in a way that is best for human well-being and the environment (Lovell, et al. 2009). The watershed management field is, in many ways, still in its infancy, and many acknowledge that each watershed plan or management action is its own experiment (Mika 2017). Watershed management approaches are becoming more focused on local participation and the complex relationships between water resources, ecology, biology, and environmental health (Subramanian 2017). The Environmental Protection Agency, environmental organizations, and stormwater managers are pointing to GI as a preventative measure that could greatly improve the ways that the urban landscape interacts with stormwater (Subramanian 2017).

Urban Stormwater

Urban stormwater and agriculture runoff are the leading sources of NPS pollution, the leading source of water pollution in the US, and the largest obstacle in regulating water quality in the United States (GADNR 2014). Urban land is about 3% of the land in the US, but a 2004 National Water Quality Inventory showed that urban runoff contributes to the impairment of 22,559 miles of streams, 701,024 acres of lakes, and 867 square miles of estuaries in the US (USEPA 2009). It important to note that in the 2004 Report to Congress, only 16% of the nation’s rivers and streams, 39% of the lakes, and 29% of the estuaries were assessed (USEPA 2009). "Impaired waters" become part of the total maximum daily loads (TMDL) program, which requires states to achieve a certain water quality criterion based on designated uses of the water body, establishing a limit on how many pollutants a stream can process daily without jeopardizing its ecological function (AECOM 2016). Stormwater control measures and GI are adaptive strategies that can be used to address issues of NPS stream impairment, stormwater runoff, and the projected impacts of climate change (USEPA, 2016). Because climate change may cause more frequent and intense storms, these problems may worsen in the future (WERF 2007). These trends continue to compound and remain unchecked, such as in Northeast Georgia, as land uses change and urban sprawl consume the landscape.

Water quality monitoring and regulatory measures are focused on the presence of pathogens, such as viruses, bacteria, and protozoans that can lead to public health problems from waterborne diseases. Direct testing for pathogens is expensive and impractical (USEPA 2009).

Instead, monitoring for pathogens uses indicator species because their presence indicates that fecal contamination may have occurred (USEPA 2006). The four indicators most commonly used are total coliforms, fecal coliforms, *Escherichia coli (E. coli)*, and enterococci. These bacteria are normally prevalent in the intestines and feces of warm-blooded animals, including wildlife, farm animals, pets, and humans (Saintil 2018). It is important to note that *E. coli* is just an indicator organism and that the other pathogens and pollutants associated with untreated sewage discharges are likely to persist longer and farther downstream and pose a serious human health risk (Siragusa, et al. 2007).

Land use is a driving factor to understand the dynamics of point and non-point sources of fecal coliforms in a watershed (Bradshaw, et al. 2016). Fecal coliforms are the leading causes of impairment of streams and rivers throughout the United States (GAEPD 2014). In rural and urban watersheds, pathogens can enter waterways from multiple inputs (Saintil 2018). Those inputs include stormwater runoff, pre-existing and aging infrastructure, municipal discharges, raw sewage, manure applications, landfill leachate, pets and wildlife waste, and leaking septic tanks (Crim, et al. 2012). While fecal coliforms are ubiquitous in streams across the country, concentrations of bacteria can increase as a result of the higher density of potential pollutant sources and decreased stormwater filtration and treatment from population growth and development (Ahmed 2019).

Obtaining Funding

Identification and discussion of dedicated funding is important in determining the economic feasibility of the sustainable management strategies to further rehabilitation efforts (Mika 2017). As a whole, pollution control measures benefit society but often do not provide an economic benefit to the individual or organization that installs them (USEPA 1995). Therefore, many watershed projects rely upon voluntary implementation of SCMs and GI, and few watershed projects come complete with sufficient federal and state funding (Rissman, et al. 2015). Fundraising is a time-consuming activity, and each type or source of funds has its own application criteria, procedures, and deadlines. Although implementation of NPS management practices is ultimately the responsibility of local governments and landowners, grant program funding is available for a wide variety of practices that directly address NPS (Tetra Tech, et al. 2018). These grants provide funding for SCMs and other water quality improvement efforts, such as GI. The following section presents an annual grant that offers funding for projects that directly address NPS pollution.

Stormwater Control Measures and Green Infrastructure

Stormwater control measures are designed to mitigate harmful effects of urbanization on stream ecosystems by reducing storm volumes and peak discharges (Bell, et al. 2016). Green infrastructure is still considered a new approach to stormwater management and is referred to by a variety of names, including water-sensitive urban design and low-impact development (Subramanian 2017). Essentially, it captures rain where it falls in the landscape and uses natural retention and treatment processes to improve water quality, as well as reduce the flow and volume of stormwater, thereby, minimizing damage to the biological, physical, and chemical integrity of receiving waters (Holm, et al. 2014). Key elements of the Georgia State Water Plan to manage NPS pollution is the promotion and implementation of long-term monitoring, GI, SCMs, and low impact developments that mimic natural hydrology and provide multiple benefits for a variety of management objectives (AECOM 2016).

Green infrastructure is a sustainable practice that introduces ancillary benefits into the community that extend beyond runoff volume reduction (Subramanian 2017). For example, it helps prepare for drought, lowers building energy demands, reduces air pollution and air temperature through evotranspiration, and helps to minimize the urban heat island effect. It also serves as habitat for wildlife and even contributes to greater property values (Wolf 2003). Examples of GI include rain gardens, permeable pavement, green roofs, floodplains, wetlands, and bioswales (Holm, et al. 2014). This sustainable approach to stormwater management can range from large-scale projects, such as city parks and stream buffer enhancement to small-scale projects, such as planter beds and cisterns.

The use of decentralized source controls in conjunction with redeveloping land in urban regions creates opportunities, over time, to develop sustainable communities that will achieve higher levels of ecological and receiving water protection (Subramanian 2017). Though not yet quantified, GI could be a cost-effective solution for pollution control and flooding, and may even be more cost-effective in the long-term when considering other benefits such as groundwater recharge, improved water quality and air quality, greenhouse gas emissions reductions, climate resiliency, and local water supply (USEPA 2016). Nonpoint source pollution controls must be tailored to factors such as hydrology, geology, topography, soils, and management capability of landowners (USEPA 1992). If implemented properly, GI allows communities the flexibility to respond to ever changing economic, social, and environmental conditions (WERF 2007). However, due to the nature of managing stormwater, SCMs and GI are subject to severe loss of effectiveness if they are not properly installed or maintained (USEPA 1992).

Conclusion

In sum, SCMs and GI are multipurpose solutions to stormwater management, but are not currently being implemented at a large scale. The best stormwater management practices address the impacts of stormwater across an entire watershed, including problems with water quality, flow, climate resiliency, and groundwater recharge (USEPA 2016). To that end, GI and SCMs need to be specifically designed at the site scale and implemented to contribute to these multiple benefits. The stormwater control can be integrated into many common urban, suburban, and rural land-uses on both public and private property, which enhances flexibility in siting stormwater runoff control measures and GI (Subramanian 2017). Because these controls can be constructed on an individual basis, or in conjunction with other projects, a variety of funding options is possible (Schuetze, et al. 2013). Most importantly, these practices allow for management strategies to be targeted at specific sites rather than requiring the planning and construction of large-scale, capital-intensive centralized control systems (Wolf 2003). If managed properly, stormwater is one unifying resource that can rehabilitate watershed health. Designing with nature can also be seen, in a larger sense, as land development that is more sustainable economically, environmentally, and socially (Rissman, et al. 2015).

CHAPTER 4

SAVING WATER RESOURCES IN GEORGIA

Introduction

The background presented in Chapter Three shows some of the problems stormwater runoff and centralized management practices amplify. The Section 319(h) grant is a vehicle to implement SCMs and improve water quality, thus creating opportunities for multipurpose methods, such as, GI to rehabilitate water bodies and influence social change. The goal of Chapter Four is to discuss water resources in the state of Georgia and the importance of rehabilitating watersheds. Next, this thesis will examine an impaired (HUC-12) watershed, Trail Creek, as it will be used as a case study in the following chapters.

Georgia's Water Resources

Georgia is one of the fastest growing states in the United States (GADNR 2014). At the current estimate of 10.66 million, Georgia is the 8th most populated state (US Census Bureau 2018). However, the population growth is not evenly distributed. Nearly three-fourths of Georgia residents live in the northern half of the state, primarily in the Piedmont and in the Ridge and Valley regions around metropolitan Atlanta. The growth and development of Georgia’s towns, cities, and suburbs have profoundly altered natural drainage systems and water resources in the state (Peters 2009). The configuration of typical rural agricultural watersheds has rapidly evolved into mixed land-use watersheds due to urbanization and population growth (McGrane 2016). As the number of Georgians increases, demands placed on natural systems and water resources become significantly greater.

The wise use and management of water is critical to support the state's economy, to protect public health and natural systems, and to enhance the quality of life for all citizens. Georgia's abundant water resources are shared natural resources, streams and rivers which run through many political jurisdictions (AECOM 2016). Nonetheless, it is not an unlimited resource and must be carefully and sustainably managed to meet long-term water needs (GAEPD 2010).

For centuries, the land in Georgia was used for intensive farming that led to physiochemical and morphological changes in Southern Piedmont waterways (Mukundan, et al. 2011). Over time, the habit of using rivers and streams as open sewers and waste dumps severely degraded the beauty and health of the watersheds. During the 20th century, the widespread adoption of the automobile fueled urbanization, and economic development was valued over preserving the natural environment, leading to the impairment of streams and rivers (Crim 2007). Southern Piedmont streams, recovering from legacy sediments, are particularly vulnerable to land-use changes due to their proximity to agricultural and urban nutrients, and fecal bacteria sources (Saintil 2018).

Within the state of Georgia are 14 major river basins, HUC-6, further broken into 52 sub-basins, HUC-8, amounting to approximately 70,150 stream and river miles (GAEPD 2010). The USEPA estimates that Georgia has 44,056 miles of perennial streams, 23,906 miles of intermittent streams, and 603 miles of ditches and canals. Georgia has 4.8 million acres of wetlands, 425,382 acres of public lakes and reservoirs, 854 square miles of estuaries, and 100 miles of coastline. While only 20% of the streams and rivers have been assessed, 59% are listed as impaired for violating federal TMDLs (GADNR 2014).

The Oconee River Basin is one of the 14 major river basins in Georgia (see Figure 1.1). The river flows to its confluence with the Ocmulgee River to form the Altamaha River before draining to the Atlantic Ocean just north of Little St. Simons Island on the Georgia coast (MNGWPD 2016). In the Oconee River Basin, there are approximately 108 rivers and streams listed on the 2012 integrated 305(b)/303(d) list as waters not supporting the designated uses (GAEPD 2012). These impaired waters include roughly 786 miles of the basin.

The Oconee River Basin is divided into two sub-basins (HUC 8), the Upper Oconee River Basin and the Lower Oconee River Basin. The main tributaries of the Upper Oconee River Basin are the North Oconee River, Middle Oconee River, Mulberry River, Little Mulberry River, and Apalachee River. Almost 50% of the assessed streams in the Upper Oconee River Basin do not meet water quality standards for FC bacteria as a result of NPS (MNGWPD 2016). Fecal coliform typically is found in both developed and undeveloped watersheds, and monitoring programs in Georgia have found levels that exceed state standards in urban, agricultural and forested areas (GAEPD 2010). Just over 40% of the streams assessed were found not to be supporting of biota, specifically benthic macro invertebrates, which typically indicate high sediment loads in streams, thereby decreasing habitat quality (MNGWPD 2016). Sediment sources include runoff from disturbed land and construction sites, as well as from streambank erosion due to accelerated streamflow velocities from impervious cover associated with urbanization (McGrane 2016).

The degradation of overall stream health is linked with an increase in urban development and other anthropogenic activities (Manning, et al. 2015). However, urban stormwater is more than a water pollution problem; urbanization changes not only the physical, but also the chemical and biological conditions of natural hydrologic systems, limiting the ability of people and wildlife to depend on the rivers and streams (AECOM 2016). Therefore, it is imperative that developments on public and private lands prioritize and implement SCMs and GI in order to mitigate the negative effects of urbanization and improve water quality (Prudencio, et al. 2018).

Trail Creek Watershed

Trail Creek is located in Athens-Clarke County, Georgia. The city of Athens is experiencing an expansion of urban development and aging wastewater infrastructure, affecting water quality similarly to other Georgia cities near Atlanta (CH2M 2017). Reflective of water quality issues throughout the southeast, approximately 114 miles of streams are located within ACC, 96 mi of which are listed on the 303(d) list for violating their TMDLs for fecal coliforms, pH, fish and macro invertebrate assessments (Tetra Tech, et al. 2018). Fishing and drinking water are the designated uses assigned to these streams (GAEPD 2016). However, 84% of the impaired streams are considered impaired due to FC, which are a public health concern as well as a loss in recreational opportunities (Siragusa, et al. 2007).

The Trail Creek basin is urbanizing rapidly for residential, commercial, and industrial land uses (Tetra Tech, et al. 2018). The watershed is one of 17 HUC-12 watersheds draining ACC (see Figure 1.1). It is a tributary of the North Oconee River, where, at the confluence, it meets the river near the edge of downtown Athens. Trail Creek is a second order stream, with a designated use classification of Fishing, and the drainage basin covers approximately 13 square-miles in the Upper Oconee Watershed (ACC 2010). The land cover of the watershed is 41% forest, 38% urban, and 21% pasture (see Figures 5.3) (Watershed UGA 2016). Due to the nature of this mixed-land use watershed, there could be multiple contributors of fecal bacteria including failing septic systems, broken sewer lines, wildlife, dogs, and cattle (see Figures 5.7, 5.8) (ACC

2016). Agricultural use where cattle have access to streams may have contributed to fecal coliform counts during the monitoring periods, but the remaining agricultural use is expected to be phased out in the future because of land use changes (see Figure 5.13, 5.14) (Tichy, 2003).

A TMDL covering the entire watershed was completed for FC in 2007. The TMDL required a 61% reduction in FC for East Fork Trail Creek, a 40% reduction for West Fork Trail Creek, and a 75% reduction for Trail Creek (Siragusa, et al. 2007). While the stream branches are impaired due to FC, as listed in the TMDL, stormwater runoff is identified as the cause of impairment in all three branches at densities high enough to suggest a potential health risk (Tichy 2003). The watershed is indeed threatened by other effects from urban stormwater runoff. Urban and suburban land uses and the lack of stormwater control measures have been identified as the dominant factors in nutrient loading from NPS in the watershed (ACC 2010). Therefore, there is an increasing need for sustainable stormwater management practices.

A 2018 water quality study found that cattle, wildlife, canine, and leaking sewer lines were the main FC contributors, and that bacteria were increased by more than tenfold during storm events. Later, the author confirmed through microbial source tracking (MST) that the sources were mainly humans, ruminants, and canines. In the same study, watershed modeling indicated that urban lands contribute 79%, pasture lands 19%, and forested lands 3% to the annual *E. coli* loads (see Figures 5.7, 5.8) (Saintil 2018). This study confirmed the need of using multiple approaches, including physio-chemical parameters, fecal indicator bacteria, MST and watershed-scale modeling to assess urban stream water quality (Saintil 2018).

Although Trail Creek is listed only for FC, continually increasing urbanization is resulting in other impacts on the stream (Siragusa, et al. 2007). The stream has become severely incised in some locations with undercut stream banks (Tetra Tech 2018). While the stream has not been listed for sediment at this time, there may be a threat of future listing for sediment, especially with continued development in the upper reaches. The impacts of sedimentation are at least as significant an ecological concern as FC, and some consideration should be given to addressing these impacts. It is important to note that *E. coli* is just an indicator organism and that the other pathogens and pollutants associated with untreated sewage discharges are likely to persist longer and farther downstream and pose a serious human health risk (Siragusa, et al. 2007).

Conclusion

While FC is a county-wide management issue, the Trail Creek Watershed was selected by stakeholders for this project before the author was included. In the Trail Creek watershed, urban lands are the primary contributors with 79% of the annual load, followed by pasturelands adding 19%, and forested lands adding just 3%. Potential NPS sources in the watershed include stormwater runoff, failing septic systems, broken sewer lines, wildlife, canine, and cattle (Saintil 2018). In order for Trail Creek to meet the TMDL water quality standards, it would involve conservation of wetlands; stream buffer preservation and enhancement; implementation of low-impact development and stormwater control measures; and continuous fecal bacteria monitoring coupled with MST (see Appendix A) (ACC 2016, and Saintil 2018).

Athens-Clarke County and local stakeholders selected Trail Creek for the Clean Water Act Section 319(h) NPS Implementation Grant because sections of streams in both branches and the main stem are listed on the 303(d)-list of impaired streams (see Figure 1.2) (GAEPD 2016). It is imperative that Trail Creek and other tributaries of the Upper Oconee River Basin are rehabilitated. The rehabilitation and delisting of Trail Creek could serve as a model for other communities across the Southeastern region.

CHAPTER 5

RESULTS AND RECOMMENDATIONS

Introduction

The recommendations follow ACC's watershed management plans for the Trail Creek Watershed (see Appendix A). An array of specific tasks has been selected to address water quality concerns and to serve as the basis for the 2019 Section 319(h) grant proposal. The specific goals of this project are to implement SCMs and GI as demonstration projects that will reduce NPS pollutants, minimize impairments to surface waters, and improve the health of the watershed (see Figure 5.11). In addition to ecological improvements, this landscape-based approach incorporates the economic and social aspects of sustainable design by introducing projects that are coupled with educational outreach in highly visible and public sites to demonstrate alternative approaches to current stormwater management practices.

This thesis can serve as a guide to other groups who wish to address watershed impairment in their community and apply for the Section 319(h) Implementation Grant in the future (see Figure 2.1). Not only does this research offer a sustainable approach to managing stormwater, but it promotes stewardship and resiliency, and supports the mitigation of anthropogenic impacts across the watershed. If successful, this project would serve as a model for the rehabilitation of other streams and watersheds in the Southern Piedmont. The following chapter presents the site-specific treatments for implementation in the Trail Creek watershed using the Section 319(h) grant and match funds. Drainage analysis and sizing for SCMs and GI projects demonstrate how NPS pollutants will be prevented from entering nearby waterways.

Meeting with Project Partners

Stakeholders or project partners are individuals and organizations that have an interest in identifying and solving water quality problems (USEPA 1995). The EPA encourages communities to give stakeholders appropriate opportunities for meaningful input during the identification, evaluation and selection of alternatives (USEPA 2009). Because of the nature of this community-planning project, the study evolved as new knowledge was gained and as stakeholders interacted. In the case of this thesis, stakeholders were already selected prior to the author's involvement with the project. Future watershed planning projects may choose to include homeowners, businesses, the Chamber of Commerce, and taxpayers. However, as part of this grant, public education and volunteer activities were proposed that could include stakeholders not involved in this project's planning process.

Over the course of three months, a group of stakeholders met five times to process, analyze, strategize, develop a plan, and evaluate the 2019 Section 319(h) Grant Proposal for Trail Creek Watershed. Stakeholders of this project include: Georgia Environment of Protection Department, Athens-Clarke County Unified Government, The University of Georgia Research Foundation, The University of Georgia River Basin Center, Natural Resource Conservation Service (NRCS), Upper Oconee Watershed Network, The Carl Vinson Institute of Government, Stroud Elementary School, Chicopee Dudley Neighborhood Association, The Oconee River Land Trust, and the Athens Land Trust.

Site Prioritization and Screening Process

The method to identify potential sites can be prioritized and refined on the basis of local preferences and priorities. Stakeholders are typically involved throughout the process to both identify relevant criteria and apply criteria to potential projects. The perceived importance of evaluation criteria will vary between stakeholders. To help prioritize projects, a community can assign weights to reflect the relative importance of each criterion. In the case of this project, an option for no weighting was selected to allow stakeholders to provide feedback on the best way to prioritize criteria (see Table 5.1).

The site selection process was used to identify, assess, and prioritize potential parcels for SCMs and GI practices in Trail Creek watershed. Throughout the prioritization and screening process, the stakeholder's input and priorities provided key guidance into how the parcels were selected and which parcels were included on the priority list. The method to identify potential sites can be prioritized and refined on the basis of local preferences and priorities. Although the prioritization tools were developed as this project unfolded, they were useful for facilitating site identification and stakeholder's decision-making process. In general, decision-making processes include the following steps:

1. Ensure upfront and continuing involvement of stakeholders
2. Develop goals and objectives
3. Identify projects that would advance progress towards these goals
4. Choose criteria for evaluating projects
5. Consider weighting the criteria (optional)
6. Apply criteria to identify projects

After the first stakeholder meeting, in order to better understand the watershed, a comprehensive review of watershed management plans and spatial data using GIS software was conducted to identify potential sites for watershed improvement measures. Watershed characteristics were selected based on available spatial data and through the evidence provided in the literature review. The following data layers were refined to the watershed's boundaries and used to create an initial mapping exercise: parcels, land cover, hydrology, floodplains, wetlands, sewer lines, septic tanks, stormwater lines and outfalls, water quality data, topography, vegetation, digital elevation model, elevation, slope, impervious surfaces, and existing structures. Water quality data was translated from previous monitoring reports and manually input to the mapping studies (see Figures 5.7, 5.8).

Watershed inventory was presented at the following stakeholder meeting as a series of mapping studies (see Figures 5.2 - 5.8). Then, spatial data was overlaid to create a composite map (see Figures 5.9, 5.10). An inventory of the watershed helps to ensure that project team members have a consistent knowledge base and helps to focus their attention on the most significant problems, ecosystem threats, and NPS management measures. The mapping studies enabled stakeholders to study the context of candidate sites, landscape characteristics, opportunities and constraints, and to address the goals and objectives.

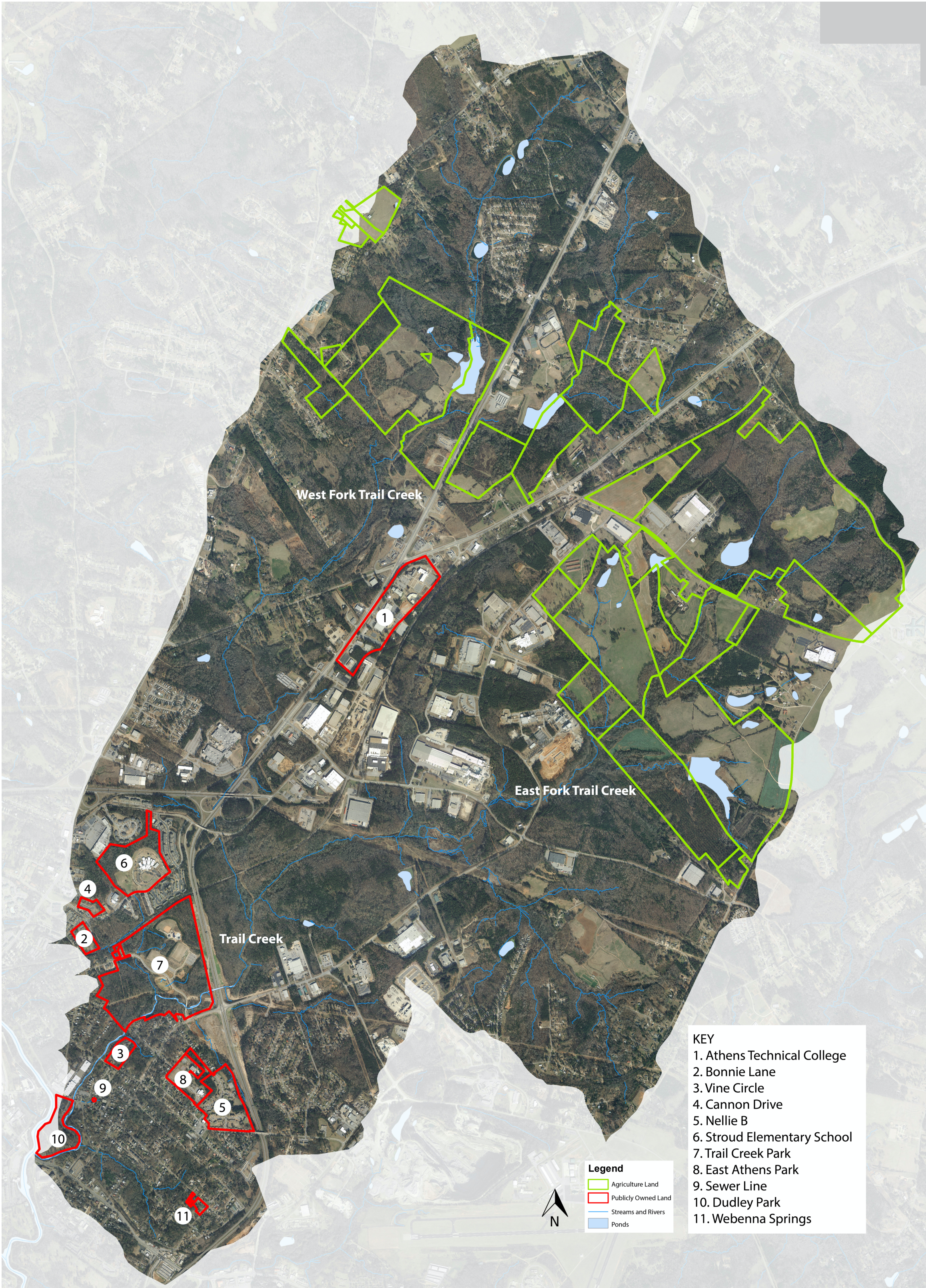

Figure 5.1. Priority Parcels on Agriculture and Public Lands, Trail Creek Watershed. (2018)

Data Source: ACC, FEMA

Hydrology Overview

- Urban runoff is identified as the cause of impairment in all three streams (ACC, 2018)
- Trail Creek is a second-order stream in Athens, Georgia, with a flashy hydrograph due to 38% urban development (Saintil, 2018).
- Southeastern Piedmont streams, recovering from legacy sediments, are particularly vulnerable to land-use changes due to their proximity to agricultural and urban nutrients and fecal bacteria sources (Crim, 2007; Fisher et al., 2000).
- The presence of fecal coliform and E. coli is highly correlated with the conversion of forested lands into urbanized landscapes covered by impervious surfaces (Chelsea Nagy et al., 2012; Crim et al., 2012).

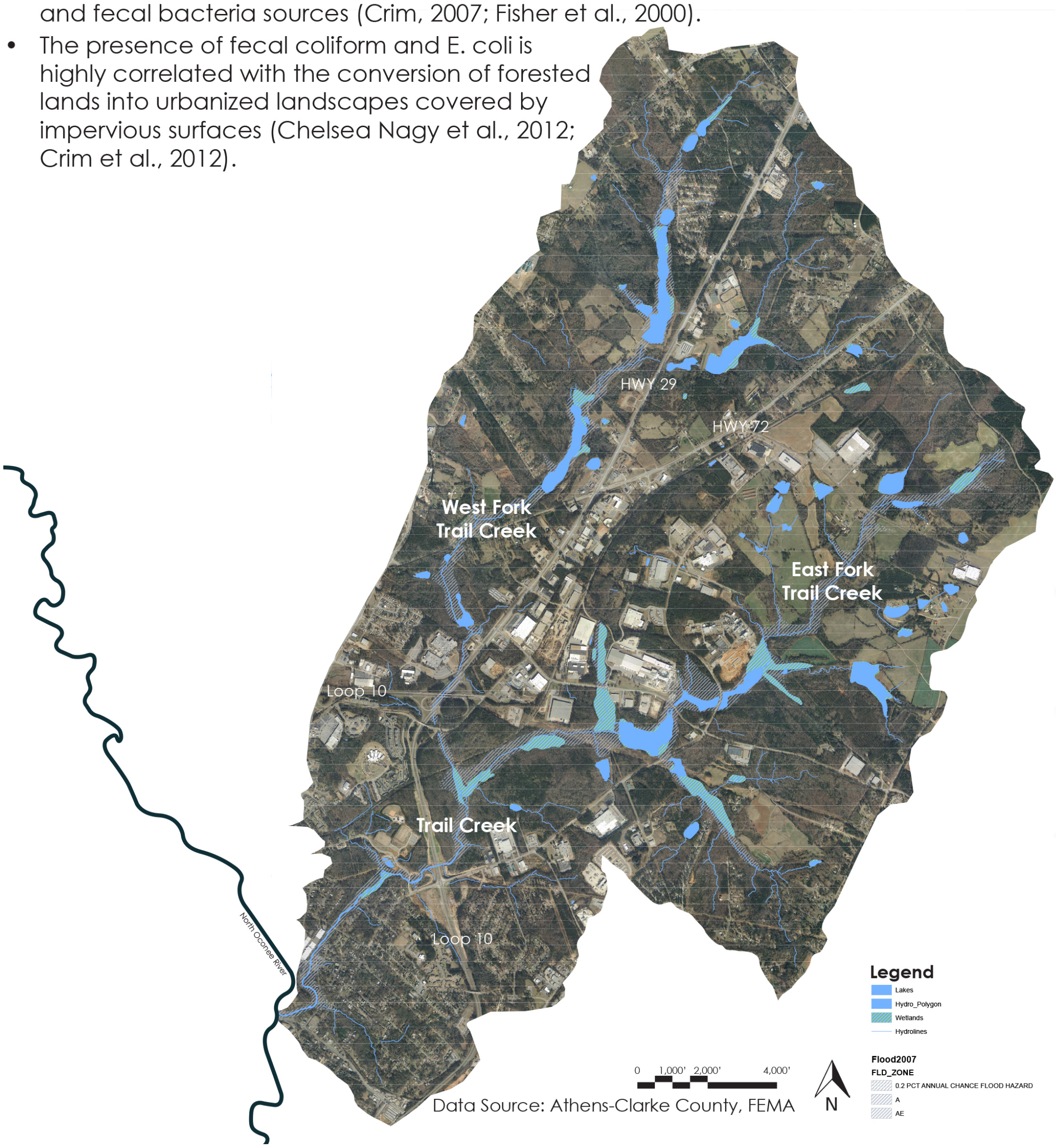

Figure 5.2. Floodplains, Wetlands and Hydrology Map

Trail Creek Watershed. (2018)

Land Use Characteristics

- The watershed is 41% forest, 38% urban and 21% pasture.
- Trail Creek is a small urban stream with tributaries forming a main stem discharging into a highly urbanized segment of the North Oconee River. The upper reaches of Trail Creek meander through forests, industrial areas and pasture operations. The main stem crosses high- to low-density residential and urban areas going south toward downtown Athens (ACC, 2018).
- The Trail Creek watershed is 38% urban land use and 79% of the E. coli loads originate from these areas (Saintil, 2018).
- Forested areas account for 41% of the land, but only 3% of E. coli loads are generated from forested lands (Saintil, 2018).
- Based on the land use information, the watershed is likely to see increased rates of land conversion and redevelopment that will further impair water quality.

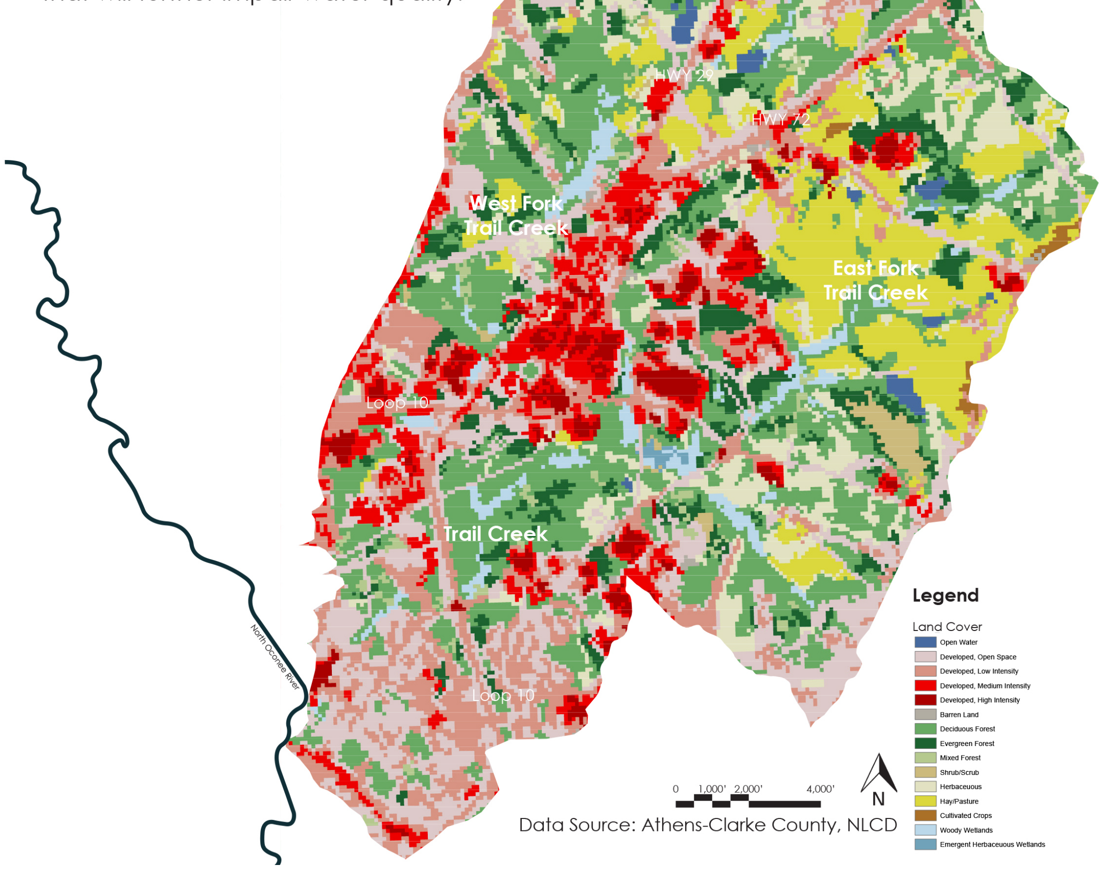

Figure 5.3. Land Use Characteristics
Trail Creek Watershed. (2018)

Elevation Map, Impervious Surface and Hydrology

- Impervious surfaces in the forms of roads, parking lots, rooftops and buildings act as vectors of fecal bacteria during storm events (Stumpf et al., 2010).
- approximately 14 percent of the watershed is covered with impervious surface (ACC,2010).
- Stormwater control measures and agriculture BMPs aim to improve watershed health by reducing storm flows and harmful pollutants in stormwater runoff.

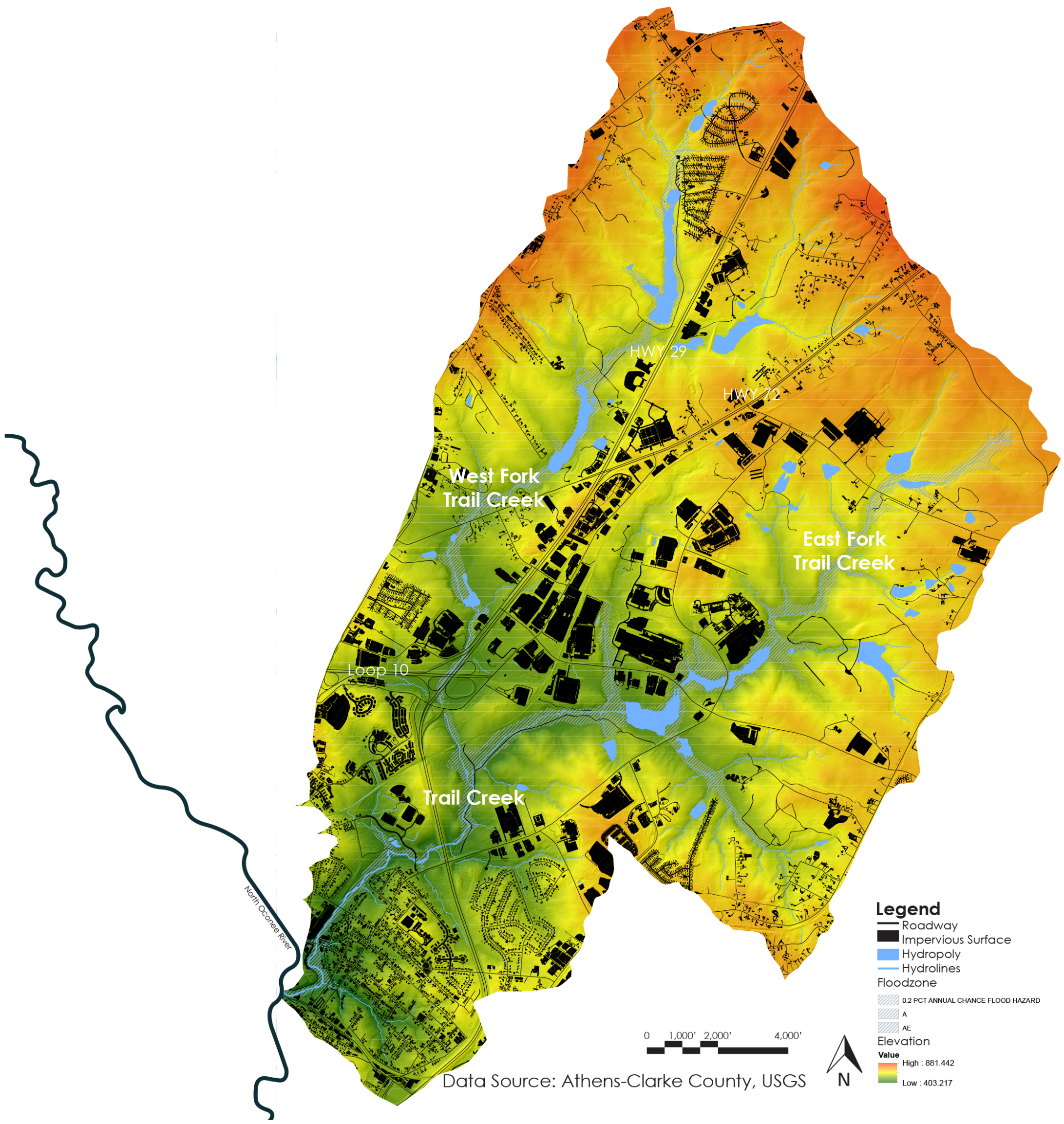

Figure 5.4. Elevation, Impervious Surface Cover and Hydrology Map
Trail Creek Watershed. (2018)

Sewer Lines and Septic Tanks

- ACC uses a centralized wastewater treatment system that heavily relies on the maintenance of sewer line networks throughout the city (Saintil, 2018).
- In the past, Trail Creek has been subject to fecal pollution by major sewer leaks (ACC,2010).
- The lower reaches of Trail Creek have a higher density of sewer lines, which are by design installed alongside streams within 23-m stream buffers required by the County (ACC, 2018).
- A previous 319 grant assisted ACC in developing a database of septic systems in Trail Creek and an extension of sewer resulted in the removal of several failing treatment pond systems for large trailer parks in the watershed.

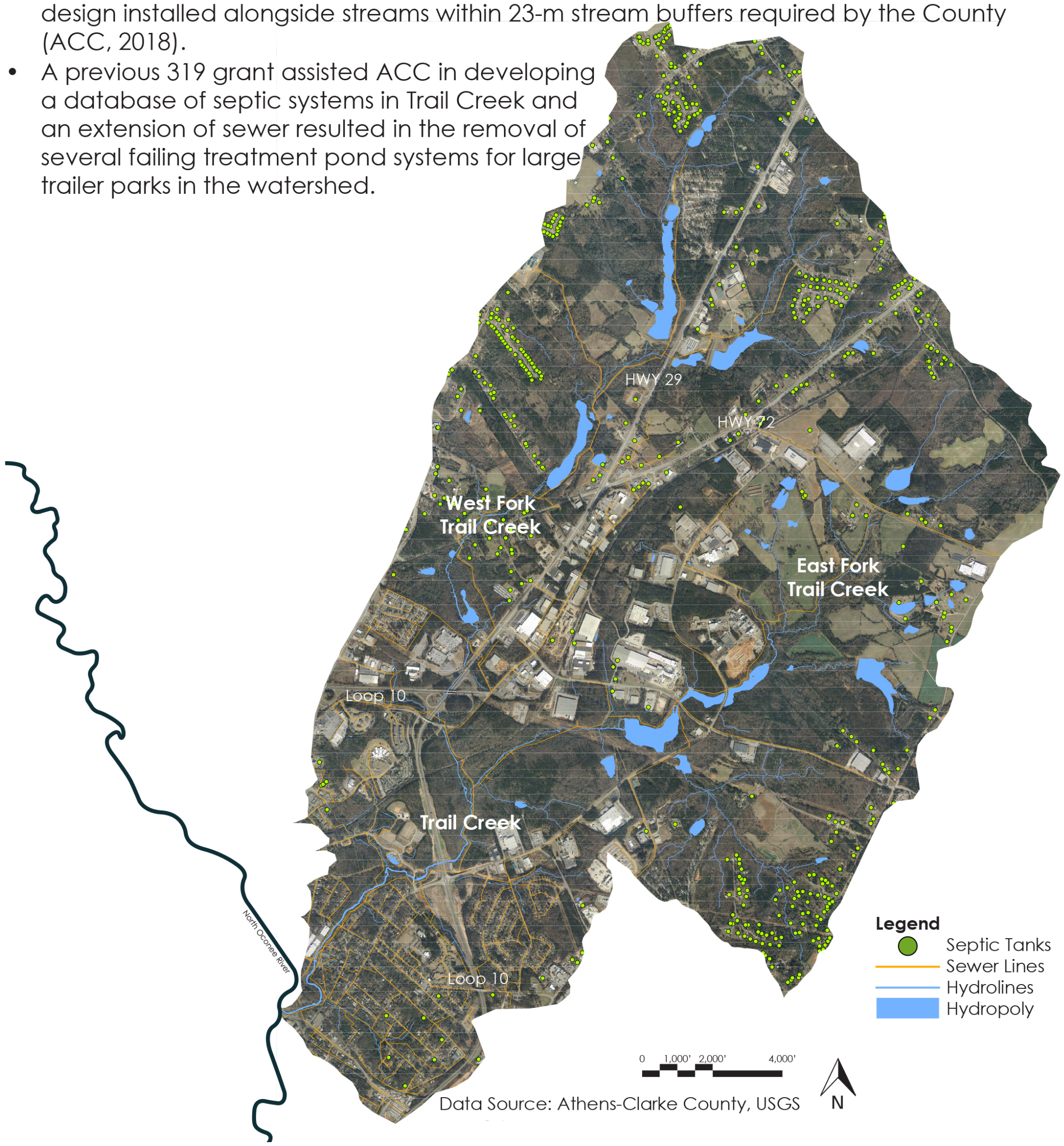

Figure 5.5. Sewer Lines, Septic Tanks and Hydrology Map
Trail Creek Watershed. (2018)

Stormwater Lines

- Urban runoff is identified as the cause of impairment in all three streams.
- Trail Creek is affected by stormwater runoff, and has increased levels of nutrients, TSS, organic matter, and metals during wet-weather events. Potential sources of nutrient impacts include runoff from rural, residential, industrial, and commercial areas (ACC, 2016).
- Flashy hydrograph patterns, varying from 0.1 to 12 cm, were observed at the watershed outlet monitoring station (Saintil, 2018).
- Bacteria increased by more than 10 folds during storm events (Saintil, 2018).
- Manure application is also a common agricultural practice to fertilize fields and might runoff to streams during rain events (Saintil, 2018).

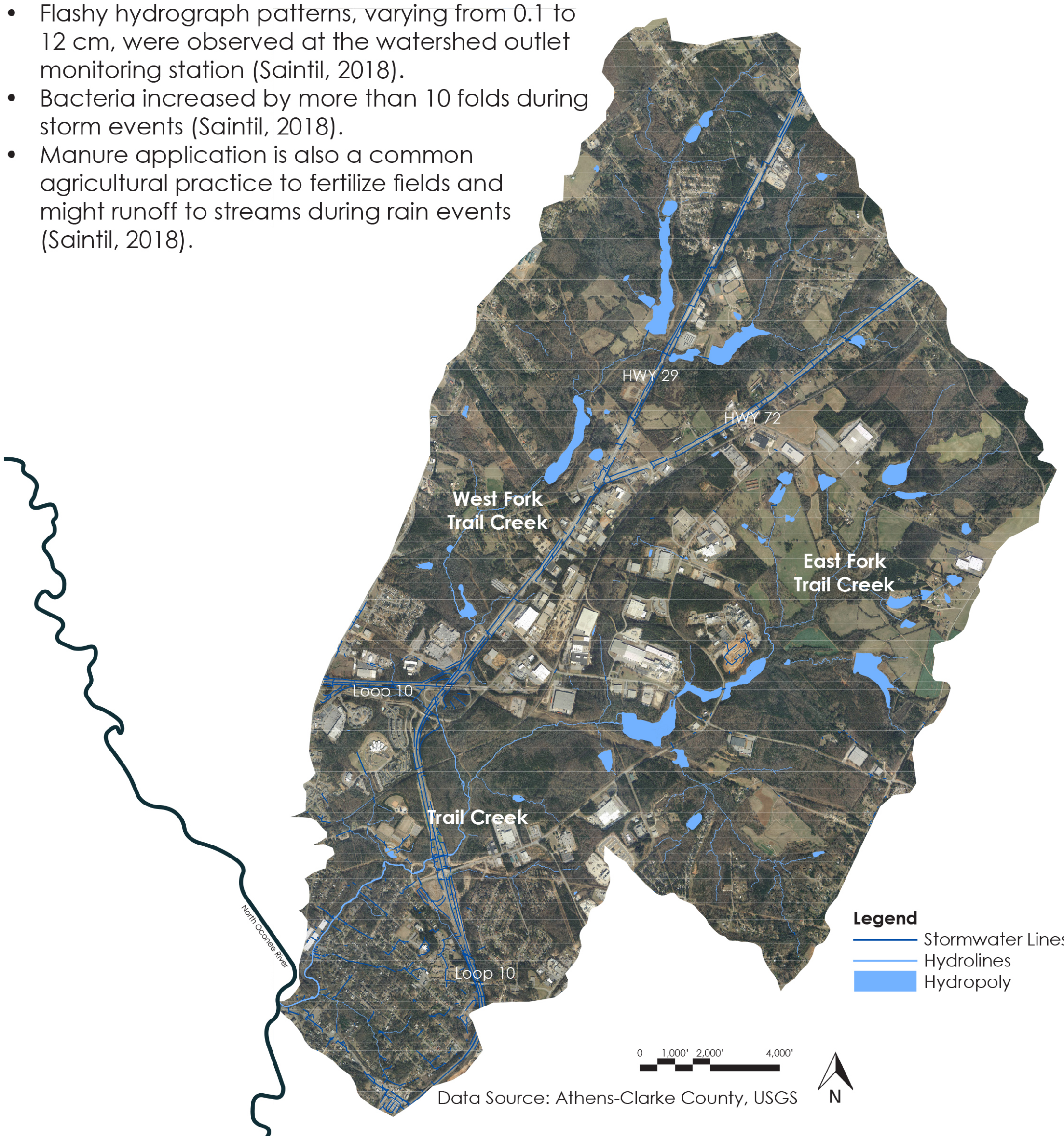

Figure 5.6. Stormwater Lines and Hydrology Map
Trail Creek Watershed. (2018)

Water Quality Monitoring !

- The Upper Oconee River Network (UOWN) has sponsored several stream sampling initiatives throughout the main watersheds. With over 17 years of UOWN's volunteer monitoring program, negative responses to stream biota and overall stream health were associated with an increase in urban development and other anthropogenic activities (Manning et al., 2015).
- A 2018 study focused on identifying the sources of fecal bacteria. Sampling results found that dogs, humans and ruminants are the main sources from fecal indicator bacteria and microbial source tracking analysis. The presence of ruminant was found in 70 to 100 % of the samples, human in 10 to 60%, and dog markers in 10 to 40% during base flow (Saintil, 2018).
- Bacteria increased by more than 10 folds during storm events (Saintil, 2018).
- Dissolved nitrate and particulate phosphorus are the predominant nutrient forms (Saintil, 2018).
- The targeted water quality sampling program proposed will help determine the efficacy of this project.

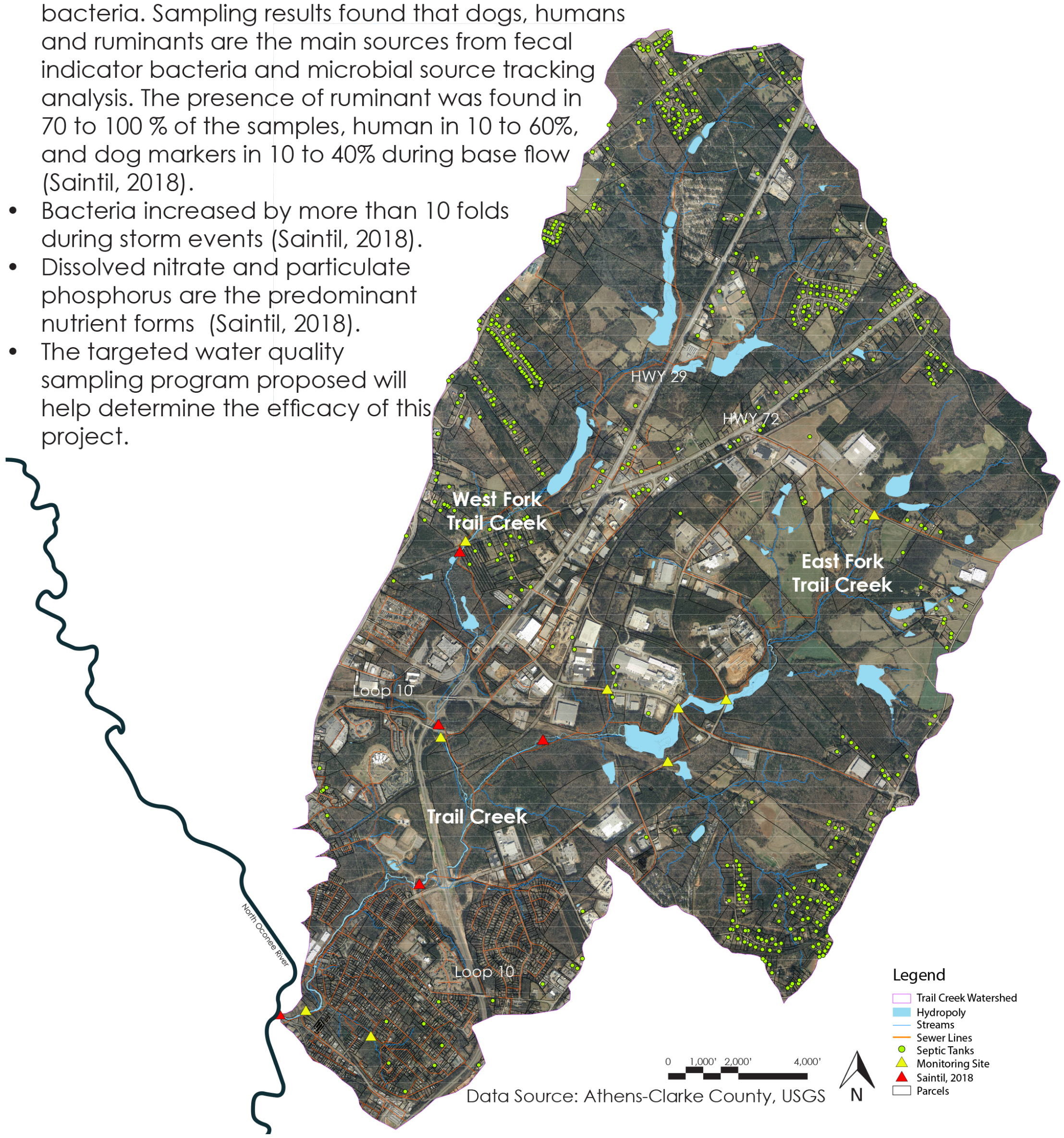

Figure 5.7. Water Quality Monitoring Map 1
Trail Creek Watershed. (2018)

Water Quality Monitoring II

- At Trail Creek, most water quality parameters were elevated during wet weather, with levels of orthophosphorus, total phosphorus, BOD, and COD being among the highest on average of the sites. Fecal coliform concentrations varied throughout the Trail Creek Watershed.
- Chemical, biological and physical monitoring are ongoing on several reaches in the Trail Creek Watershed by a variety of partners (UOWN, UGA River Basin Center, ACC).
- Fecal indicator bacteria and microbial source tracking results (Saintil, 2018)

1 40% human, 70% rumnant, 10% dog

2 40% human

3 20% human, 90% rumnant,

4 60% human, 70% rumnant, 10% dog

5 10% human, 90% rumnant, 20% dog

6 100% rumnant

- UOWN Sample Trends

  NORO 519 - historically high levels of E. coli
  NORO 514 - occasionally high levels of E. coli
  NORO 513 - elevated levels of E. coli
  NORO 501, 505, 512 - freq. high levels of E. coli
  NORO 504 - historically high nitrate
  NORO 503 - chronically high levels of E. coli

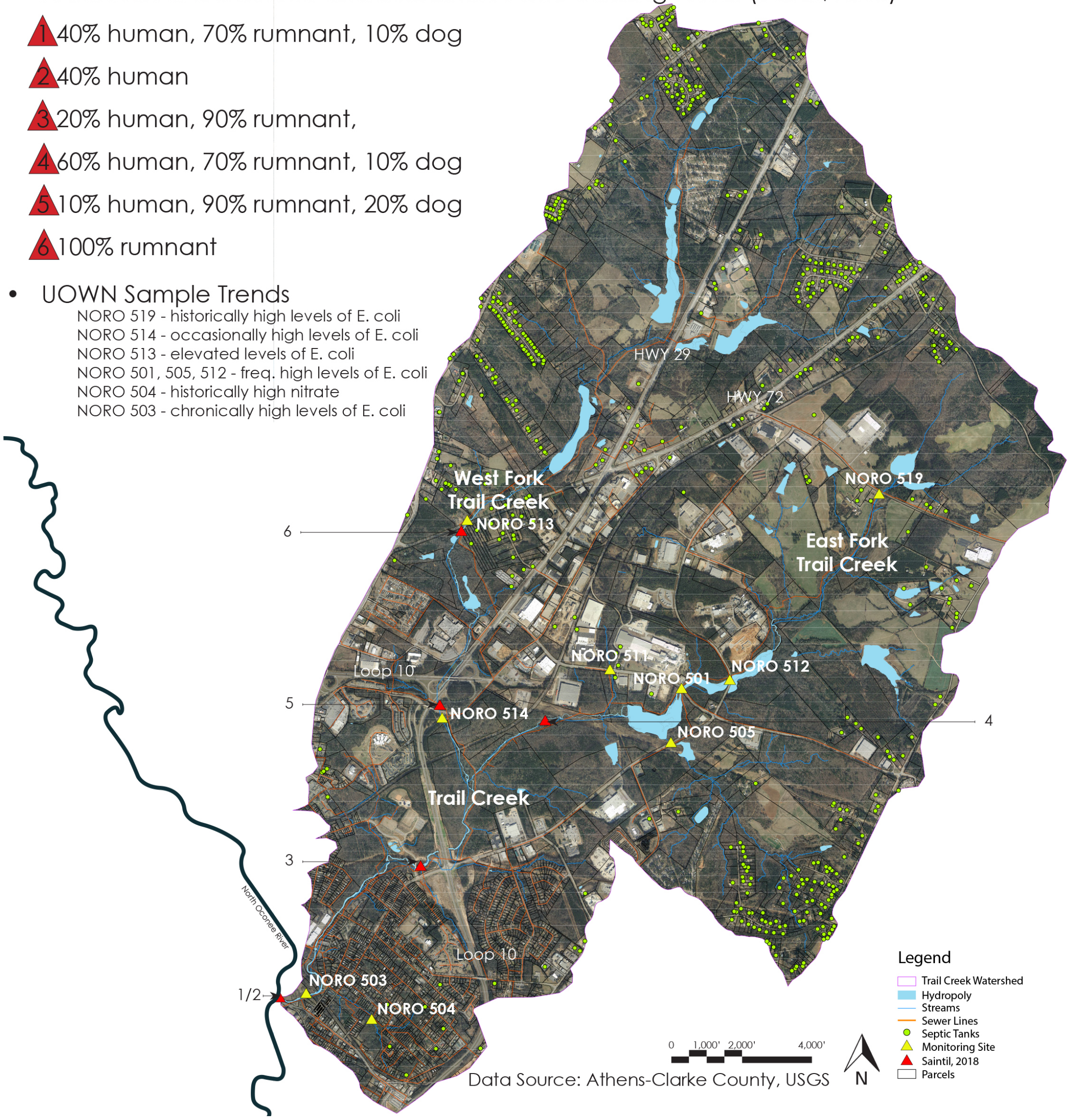

Figure 5.8. Water Quality Monitoring Map 2
Trail Creek Watershed. (2018)

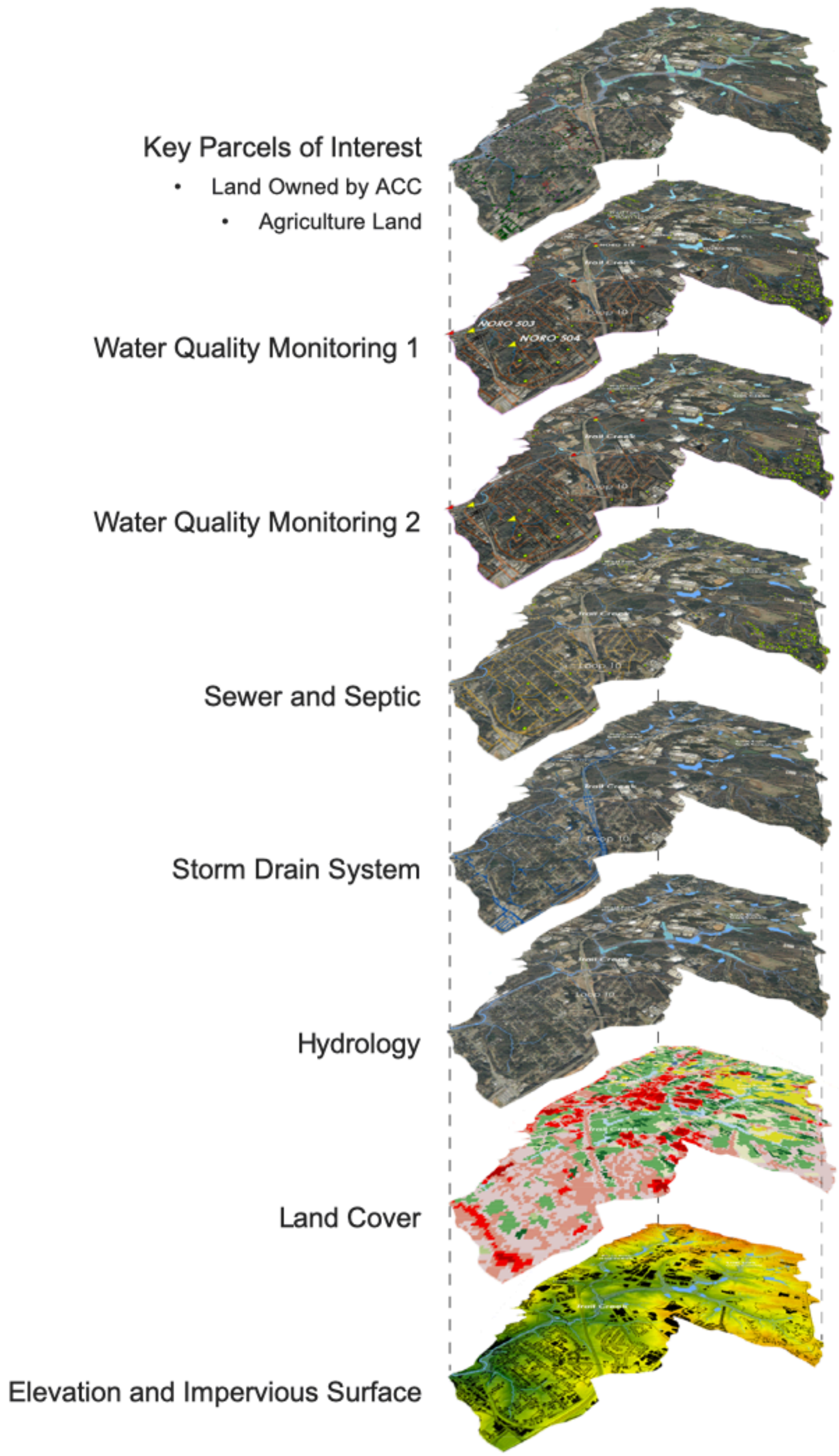

Figure 5.9. Map Layers Graphic, Trail Creek Watershed. (2018)

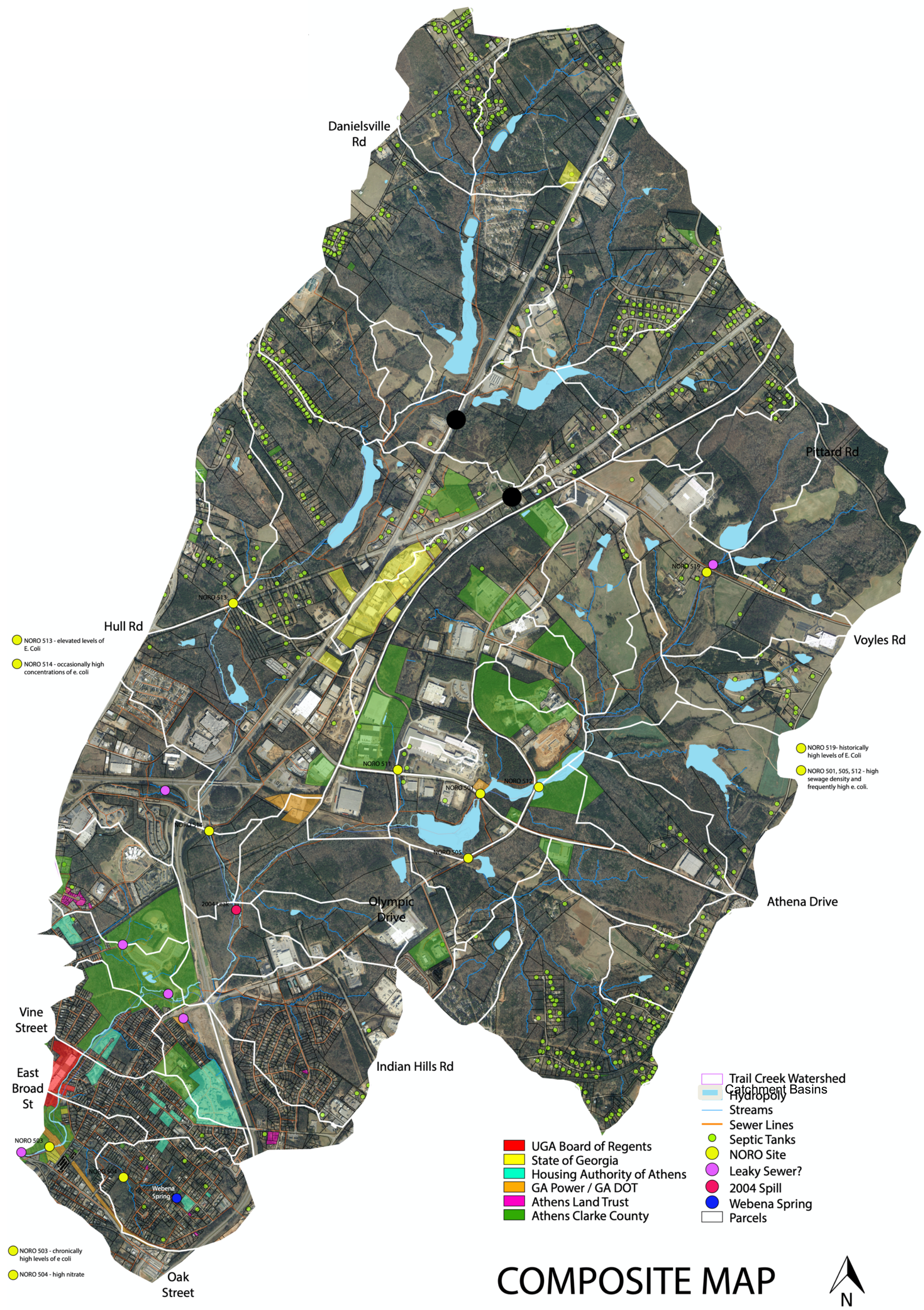

Figure 5.10. Composite Map, Trail Creek Watershed. (2018)

The screening process has two main steps:

1. A primary screening to eliminate unsuitable parcels based on physical and jurisdictional characteristics.
2. A site prioritization table of the remaining parcels to identify sites that met multiple community needs.

Unsuitable parcels were removed from further consideration if opportunities were constrained by ownership information, existing land use, position in the watershed, access constraints, and other factors. As shown on the composite map, parcel data was refined to include only agriculture lands, and properties owned by ACC, Athens Land Trust, State of Georgia, Georgia Power, Georgia Department of Transportation, Housing Authority of ACC, and University of Georgia Board of Regents (see Figure 5.10).

Additional sites were added to the list of places to investigate after meeting with stakeholders who already identified as having stormwater management concerns and other potential management opportunities. Other sites were added based on opportunities identified from personally exploring the watershed or from visual scans of the watershed using Google Earth, EagleView Pictometry, and GIS. The visual scan helped identify sites that might have been overlooked in previous studies or not identified as opportunities in computer models. Candidate sites were studied and ground-truthed by the researcher and stakeholders to evaluate the potential for stormwater management opportunities on these parcels. Following the field assessments, sites that had no viable management opportunities and those that had significant constraints or challenges were removed from further consideration.

Through stakeholder discussion and consensus, it was determined that to meet multiple community needs, priority demonstration project sites would be: owned by ACC or otherwise considered public lands; offered an educational opportunity; offered a public amenity potential; near surface waters within 150-foot buffer; direct environmental benefits, such as storm flow control, runoff reduction, or habitat enhancement (see Table 5.1).

	Agriculture SCMs	Athens Tech	Bonnie Lane	Vine Circle	Cannon Drive	Nellie B	Stroud Elementary School	Trail Creek Park	East Athens Park	Sewer Line	Dudley Park	Webenna Springs
Public ownership		●	●	●	●	●	●	●	●	●	●	●
Environmentally sensitive area	●			●		●	●	●		●	●	
Impervious surface area				●	●	●	●	●	●			
Space requirements	●	●	●	●	●		●	●			●	●
Existing GI improvements			●		●			●			●	
Proximity to park / school		●					●	●	●		●	
Multi-benefit use		●	●	●	●	●	●	●	●		●	●
Watershed Management Plan "Priority Site"			●	●			●				●	
Stakeholder Preference	●						●			●		●
Education Potential		●		●	●	●	●	●	●		●	●
Public Amenity Potential		●		●	●	●	●	●	●			●
Public Housing			●	●	●	●						
Runoff Reduction		●	●	●		●	●		●		●	
Nutrient Reduction	●				●		●	●		●	●	
Sediment Reduction	●	●	●	●		●	●		●		●	

Table 5.1. Site Prioritization Goals and Objectives (2018)

A gestalt approach in watershed planning aids to interpret representations and identify opportunities that may have not appeared in previous studies that relied on computer models for analysis. Models are widely misunderstood as “truth machines" in environmental policy and they are incomplete representations of managed systems (Rissman 2015). Debates over the validity of model predictions are long-standing because it is difficult to account for NPS (Chin et al. 2009). When there are multiple land uses it becomes difficult from a modeling standpoint, and because of this limitation, fewer studies are able to focus on mixed-land use and urban watersheds (Bradshaw et al. 2016). While analysis of model findings continues to reveal some of their limitations, models are critical for regulatory policy and will continue to be used and improved in the absence of alternatives. Regardless of these shortcomings, policy makers and local governments trust and rely on computer models when it comes to NPS management projects, such as the Section 319(h) Implementation Grant proposal.

Sites that were ultimately chosen emerged through stakeholder priorities and defining site criteria to inform the screening process. The selection of site-specific opportunities was based on using remote spatial data analysis, such as slope and hydrology evaluation. Then followed on-site review of opportunities and constraints to determine appropriate SCM and GI projects to address NPS pollution. It is important to mention that near the end of this entire process, ACC agreed to sponsor projects listed in the 2018 East Fork Trail Creek Watershed Management Plan (Tetra Tech, et al. 2018). Therefore, these projects were added to the prioritization table (Table 5.1). This particular development was unforeseen and should have been stated in the beginning of the project as it affected the analysis and approach taken by the researcher and stakeholder group. Therefore, the project's approach suffered because ACC was a primary stakeholder. Ultimately the reality of politics, funding, project implementation and maintenance responsibilities eventually influenced the site selection process.

However, in the end, ACC did endorse site-specific SCM and GI as experimental and demonstration projects. Because of traditional stormwater management practices, these landscape treatments were not recommended as potential opportunities in the 2018 East Fork Trail Creek Watershed Management Plan (Tetra Tech, et al. 2018). The following section presents the projects that were selected for the 2019 Section 319(h) NPS Implementation Grant proposal.

Selected Sites and Proposed Stormwater Control Measures

The selected sites and stormwater control measures were developed in close coordination with the ACC-Stormwater Department so that they reflect the priorities of ACC and their watershed management plans. The following SCMs are proposed to enhance GI and reduce harmful constituents from entering surface waters in agricultural, institutional, recreational, and residential areas on public lands (see Figure 5.11). Once implemented, targeted water quality monitoring will evaluate the effectiveness of the stormwater control measures.

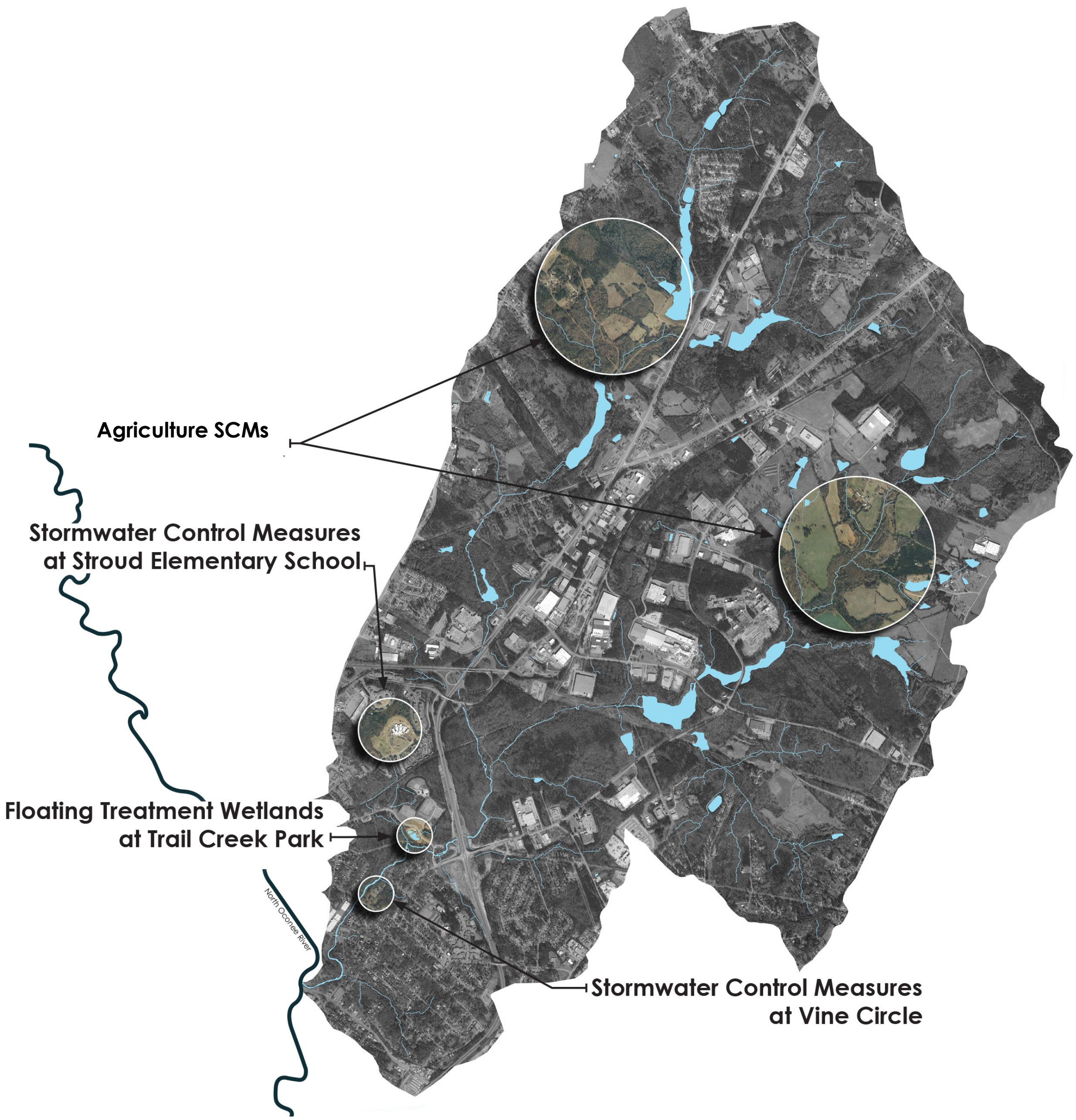

Figure 5.11. Proposed Stormwater Control Measures, Trail Creek Watershed. (2018)
Data Source: ACC, FEMA

Project Location: Upper reaches of Trail Creek Watershed on Agriculture Land

Given that the need in this watershed overwhelms allocated NRCS funding, the Section 319(h) grant would supplement prioritized practices. Cattle farms are ongoing in the headwaters of East Fork Trail Creek and West Fork Trail Creek (see Figure 5.12). The cattle population was estimated at 928 using the total land area and Natural Resource Conservation Service cattle density recommendation (NRCS 2009). However, as land is sold for urban development, cattle farms are expected to phase out in the future (Tichy 2003). During stream walks, manure was found on the banks where cattle had access to the stream (see Figure 5.13, Figure 5.14) (ACC 2010, and Tetra Tech, et al. 2018). A 2018 study focused on identifying the sources of fecal bacteria. Sampling results found that canines, humans, and ruminants are the main sources from fecal indicator bacteria and microbial source tracking analysis. The presence of ruminant markers was found in 100% of the samples from monitoring site number six in the West Fork Trail Creek (see Figure 5.7, 5.8, 5.12) (Saintil 2018).

The following stormwater control measures are best management practices for cattle farms from the United States Department of Agriculture and the Natural Resource Conservation Service. If successful, these practices could significantly reduce ruminant fecal coliforms from entering nearby surface waters. Benefits from this project may include stream buffer protection, reduced soil erosion, sedimentation, pathogen contamination and pollution from dissolved, particulate, and sediment-attached substances. The following practices are:

- Riparian buffer enhancement to establish streamside vegetation to filter stormwater runoff, stabilize streambanks and provide habitat for wildlife.
- Permanent livestock exclusion fencing to prevent livestock from entering streams and areas not intended for grazing.

- Alternative watering systems to provide water to animals rather than directly from streams, rivers and lakes. Several options are available; the best type will depend on many factors, including site layout, water requirements, availability and cost of utility water and electricity, and the location and type of water source.
- Armored stream crossing is a stabilized area or structure constructed across a stream to provide a travel way for people, livestock, equipment, or vehicles. This practice applies where an intermittent or perennial watercourse exists and a ford, bridge, or culvert type crossing is needed.
- Heavy use area protection is used to stabilize a ground surface that is frequently and intensively used by people, animals, or vehicles. Surface treatments include concrete and other cementitious materials, aggregate, mulches, and vegetation. Site specific treatments are beyond the scope of the Section 319(h) Implementation Grant. Surface treatments would be determined by project partners from the NRCS who will work with land owners to implement prioritized practices.

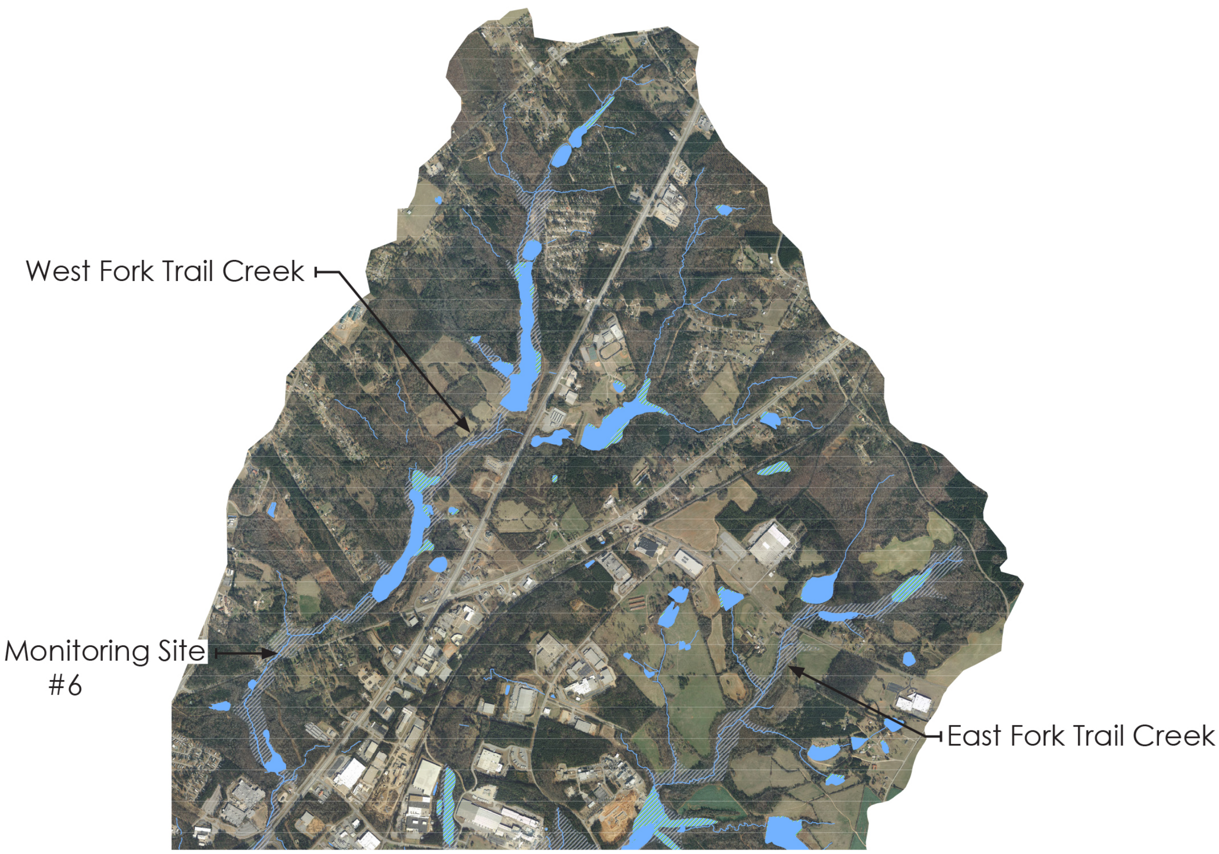

Figure 5.12. Headwaters of Trail Creek Watershed. (2018)
Data Source: ACC, FEMA

Figure 5.13. View looking toward East Fork Trail Creek. Source: Pictometry 2014

Figure 5.14. View looking toward West Fork Trail Creek. Source: Pictometry 2014

Site Location: Upper reaches of Trail Creek Watershed at Stroud Elementary School

An unnamed tributary of Trail Creek flows through the forested hillside behind Stroud Elementary School, parcel identification 164 015. Currently the stream receives overland runoff from forested areas and industrial parcels to the north and northwest (see Figures 5.15, 5.16, 5.17). Stormwater control measures of this project includes a flow splitter to direct stormwater to a constructed stormwater wetland in order to capture, retain, and improve the quality of runoff before it enters the waterway (see Figures 5.18, 5.19, 5.20). Benefits from this project may include peak flow attenuation, nutrient uptake, sediment removal, public education, and beautification.

A flow splitter is an engineered structure used to divide water flow into two or more parts, and divert these parts to different places. In this case, the structure would direct overland flow to a constructed stormwater wetland. Constructed stormwater wetlands are designed to maximize the removal of pollutants from stormwater runoff through settling and both uptake and filtering by vegetation. Shallow pools temporarily store runoff and support conditions suitable for the growth of wetland plants. While providing some habitat and aesthetic values, constructed stormwater wetlands are designed primarily for pollutant removal, erosion and flood control (USEPA 2009). A series of multi-stage treatment areas would greatly benefit this site; however, because of limited funding, this approach was not considered.

Five potential catchment areas were studied to determine the optimal location for the recommended SCMs (see Figures 5.18, 5.19, 5.20). In order to site the stormwater wetland, treatment zones were sized between 3% and 5% of the area in each catchment basin (Calkins 2012). Of the five drainage areas studied, two were beyond the scope of the implementation grant as these projects would require significant tree removal, grading, and rerouting of stormflow. The selected project location would treat 4.9 acres of overland flow (see Figures 5.18, 5.19, 5.20).

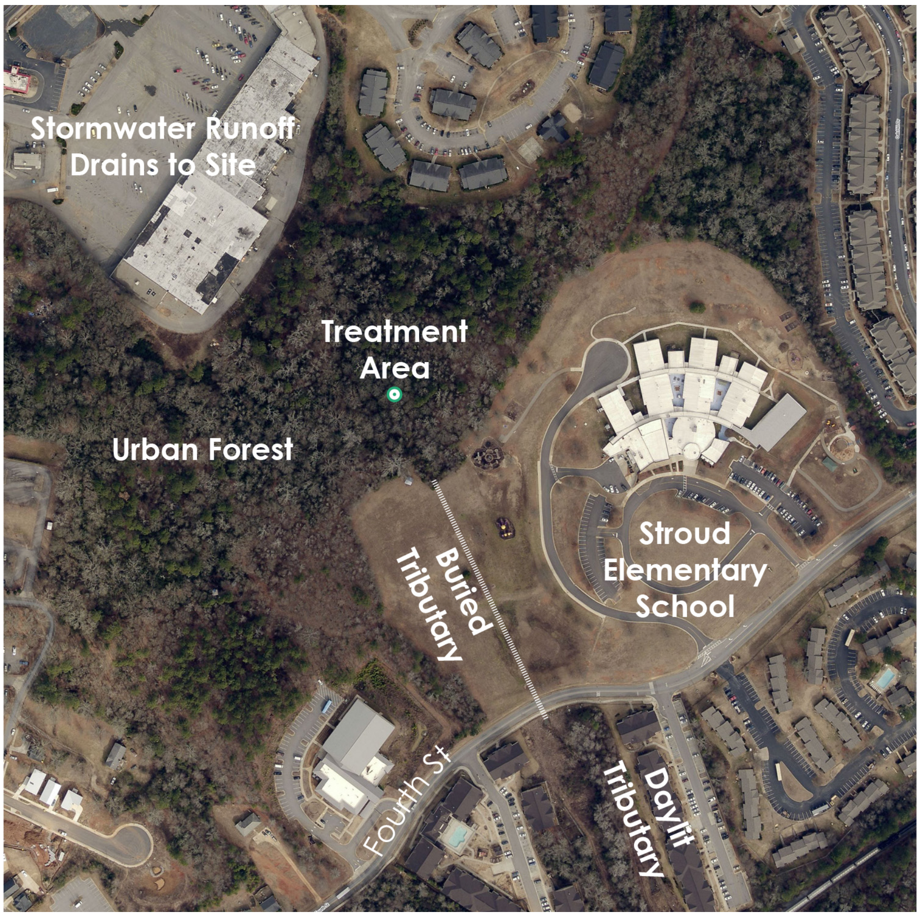

Figure 5.15. Stroud Elementary School Potential SCM Area.
Source: Pictometry 2014

Figure 5.16. View looking south toward Stroud Elementary School.
Source: Pictometry 2014

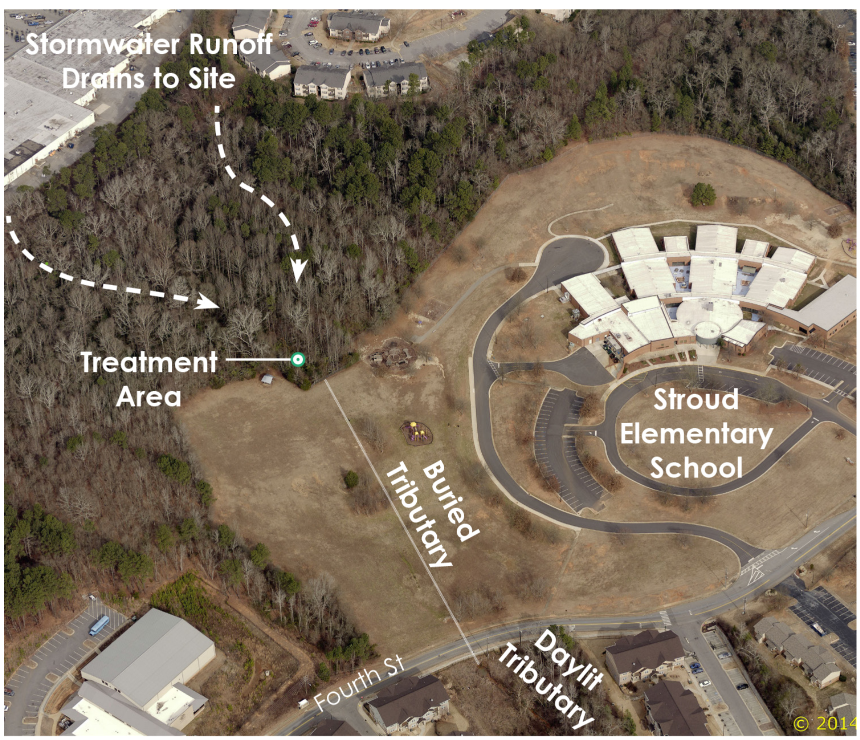

Figure 5.17. View looking north toward Stroud Elementary School.
Source: Pictometry 2014

Figure 5.18. Aerial Image, Drainage Analysis and Potential SCM Areas. (2018)
Data Source: ACC

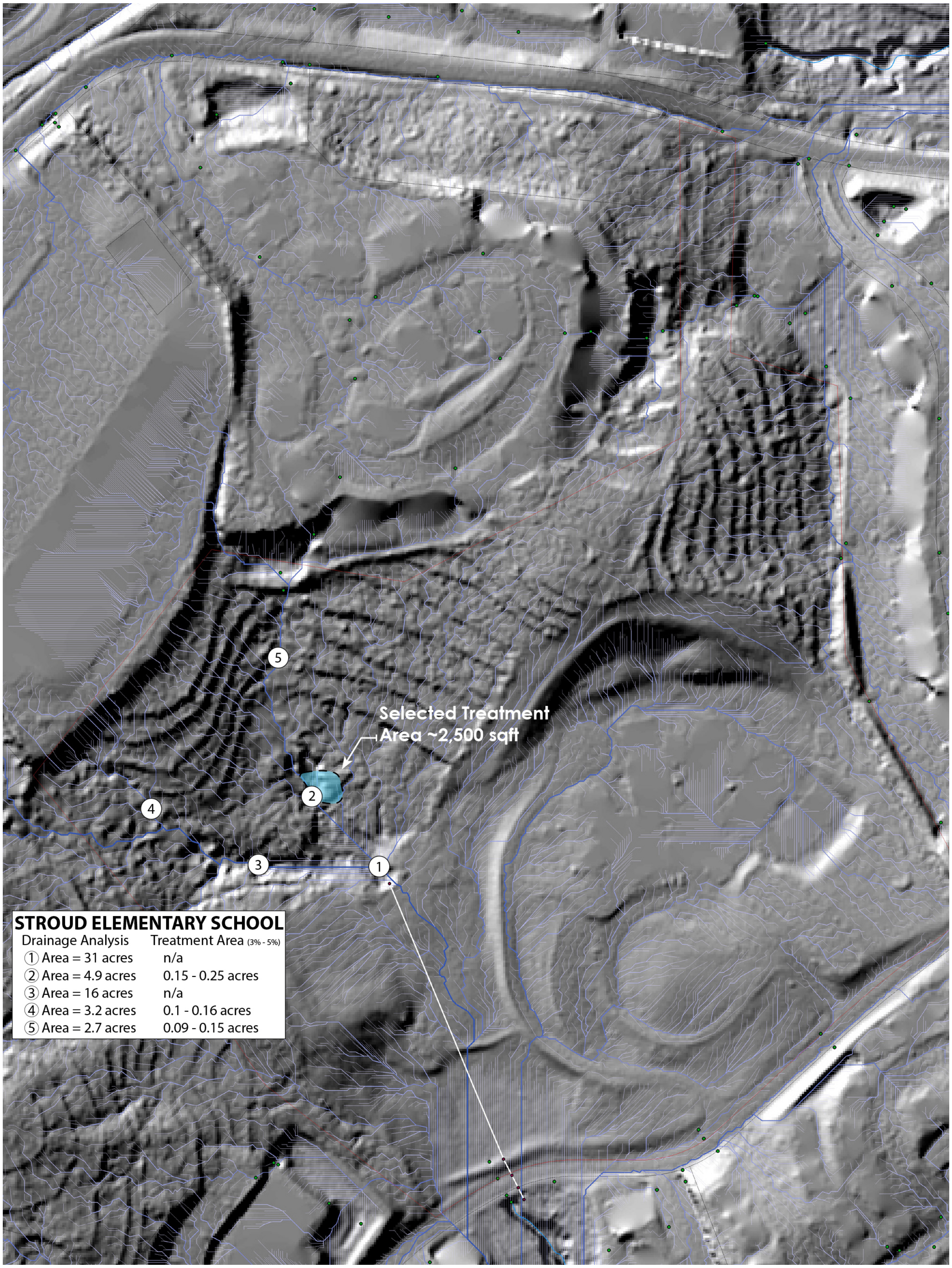

Figure 5.19. Hillshade Map, Drainage Analysis and Potential SCM Areas. (2018)
Data Source: ACC

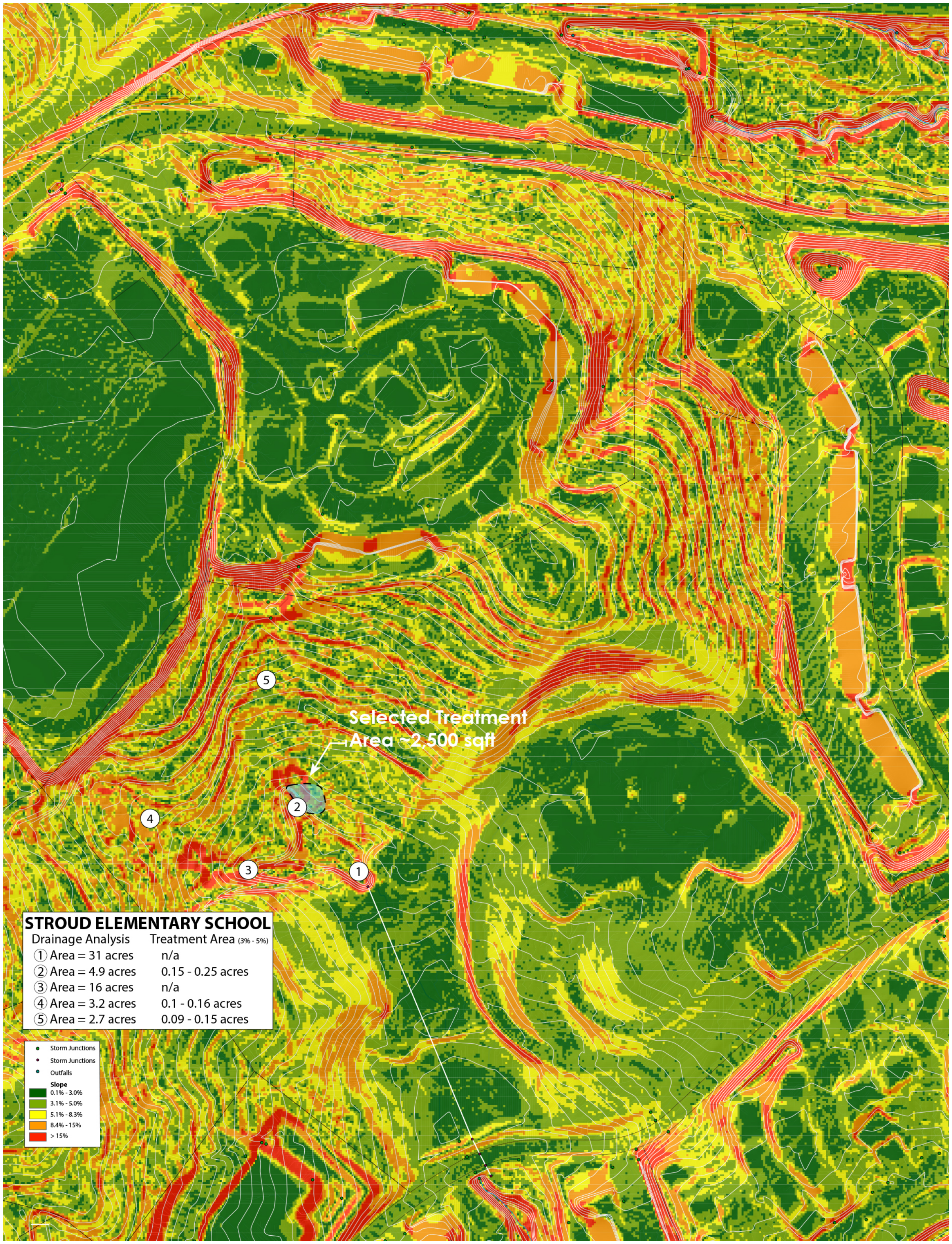

Figure 5.20. Slope Study and Potential SCM Areas. (2018)
Data Source: ACC

Site Location: Upper Reaches of Trail Creek Watershed at Trail Creek Park

Downstream and South of Stroud Elementary School is Trail Creek Park, parcel identification 164 023 (see Figure 5.21). The 113-acre park is an ideal site to demonstrate green stormwater infrastructure and highlight innovative research and community partnerships. This project will retrofit a stormwater retention pond with floating treatment islands (FTI) (see Figures 5.21, 5.22, 5.23). The existing pond receives stormwater from the impervious surfaces on-site: the parking lot, roadway, and picnic area. Benefits of this retrofit project may include nutrient uptake, sediment removal, beautification, and public education.

Floating treatment islands are an emerging innovation in green technology that are low-cost and have demonstrated significant potential for stormwater management (USEPA 2009). Floating treatment islands are designed to float on the surface of a wet pond, providing a growing medium for emergent wetland plants. Floating mats or rafts are built in a way to support vegetation grown hydroponically. Plant stems are held above water level with the roots submerged below the surface, which enables plants to draw in nutrients from the water (WEF 2015). They are a particularly attractive retrofit option because these devices do not require additional land to be dedicated to stormwater treatment. Research shows that stormwater retention ponds retrofitted with FTIs were more efficient at reducing total suspended solids, particulate zinc, particulate copper, dissolved copper, and nitrogen and phosphorus (Borne et al. 2013). Depending on the reason listed for impairment, FTIs could provide a means for meeting TMDL reductions, but quantifying an appropriate nutrient reduction value is still difficult (WEF 2015).

This site emerged based on opportunities identified from personally exploring the watershed and from visual scans of the watershed using Google Earth, EagleView Pictometry, and GIS. Additionally, the site is a public park and may achieve multiple objectives listed in the rubric (see Table 5.1). Because of traditional stormwater management practices, FTI and retention pond retrofits were not recommended as potential opportunities in the 2018 East Fork Trail Creek Watershed Management Plan (Tetra Tech, et al. 2018). To research the potential for FTIs in the watershed, future studies could create an inventory of existing retention ponds for retrofit projects.

Figure 5.21. Trail Creek Park Potential GI Area.
Source: Pictometry 2014

Figure 5.22. View looking south toward Trail Creek Park, Potential GI Area.
Source: Pictometry 2014

Figure 5.23. View looking north toward Trail Creek Park, Potential GI Area.
Source: Pictometry 2014

Site Location: Lower reaches of Trail Creek Watershed at Vine Circle Community

Further downstream, Trail Creek flows alongside a small neighborhood named Vine Circle (see Figures 5.24, 5.25, 5.26). The Athens Housing Authority manages the property, parcel identification 172A1 A001A. A concrete flume that receives runoff from adjacent properties, the road, and parking lot provides current stormwater drainage. The flume directs stormwater towards Trail Creek, which comprises the northwest border of the property (see Figures 5.27, 5.28) (Tetra Tech 2018).

This parcel emerged in the list of candidate sites because the project is on land owned by ACC and it may achieve multiple objectives listed in the rubric (Table 5.1). However, this site was selected because it was a priority project for ACC as it was recommended in the 2018 East Fork Trail Creek Watershed Management Plan (Tetra Tech, et al. 2018). That said, because of traditional stormwater management practices, the 2018 East Fork Trail Creek Watershed Management Plan recommended a dry detention pond to reduce peak flows and remove sediment (Tetra Tech, et al. 2018). While this approach may treat most of the impervious surfaces on the parcel, it fails to achieve multiple community benefits as listed in the rubric (Table 5.1). Therefore, an alternative stormwater control measure that proposes construction of a bioretention basin (see Figures 5.29, 5.30, 5.31).

Dry detention ponds differ from bioretention basins in several ways. Many dry detention ponds are designed with the single purpose of providing flood control. Over the last 30 years, detention basins have been commonly used in suburban developments to provide flood control during storm events. Particularly in urban areas, it has been suggested that this style of basin could be improved to contribute to GI goals (Haberland 2012). Bioretention basins are landscaped depressions or shallow basins used to slow and treat on-site stormwater runoff.

Stormwater is directed to the basin and then percolates through the system where it is treated by a number of physical, chemical and biological processes (Calkins 2012). Dry detention basins typically have turf grass cover and poor draining soils. In contrast, bioretention basins are installed with engineered soils and planted with vegetation that can reduce maintenance costs and can improve the infiltration and filtration of stormwater runoff (Winer 2000). Additionally, this alternative approach to stormwater management can allow a site to serve as a place for environmental education while providing the local community with increased ecosystem diversity (AECOM 2016).

Five potential catchment areas were studied to determine the optimal location for the recommended SCM (see Figures 5.29, 5.30, 5.31). In order to site the bioretention basin, treatment zones were sized to 10% of the area in each catchment basin (see Figures 5.29, 5.30, 5.31) (Calkins 2012). Of the five drainage areas studied, two bioretention areas would encroach on the outdoor living space of the residents and require significant tree removal. Additionally, the other two bioretention areas would not treat significant amounts of runoff to warrant implementation. That said, future projects should address capturing and treating all runoff from impervious surfaces. This could be achieved using GI practices, such as bioretention basins, rainwater harvesting, etc. However, because of limited grant funding for implementation the recommended project that may provide the greatest benefit and achieve multiple community objectives was selected. The selected project location would capture 4.9 acres of overland flow and is sited in central area of the community housing complex. The bioretention basin would treat sheet flow from most of the impervious surface of the parcel and stormwater directed by the concrete flume (see Figures 5.29, 5.30, 5.31). It is similar in location as the recommended dry detention pond on the northwest side of the parking lot (Tetra Tech, et al. 2018). Benefits of this alternative project may include nutrient uptake, peak flow attenuation, sediment removal, public education, and beautification.

Figure 5.24. Vine Circle Potential SCM Area. Source: Pictometry 2014

Figure 5.25. View looking northwest toward Vine Circle Potential SCM Area.
Source: Pictometry 2014

Figure 5.26. View looking southwest toward Vine Circle Potential SCM Area.
Source: Pictometry 2014

Figure 5.27. Looking toward concrete flume at Vine Circle Community. (2018)

Figure 5.28. Looking toward concrete flume at Vine Circle Community. (2018)

Figure 5.29. Aerial Image, Drainage Analysis and Potential SCM Areas. (2018)
Data Source: ACC

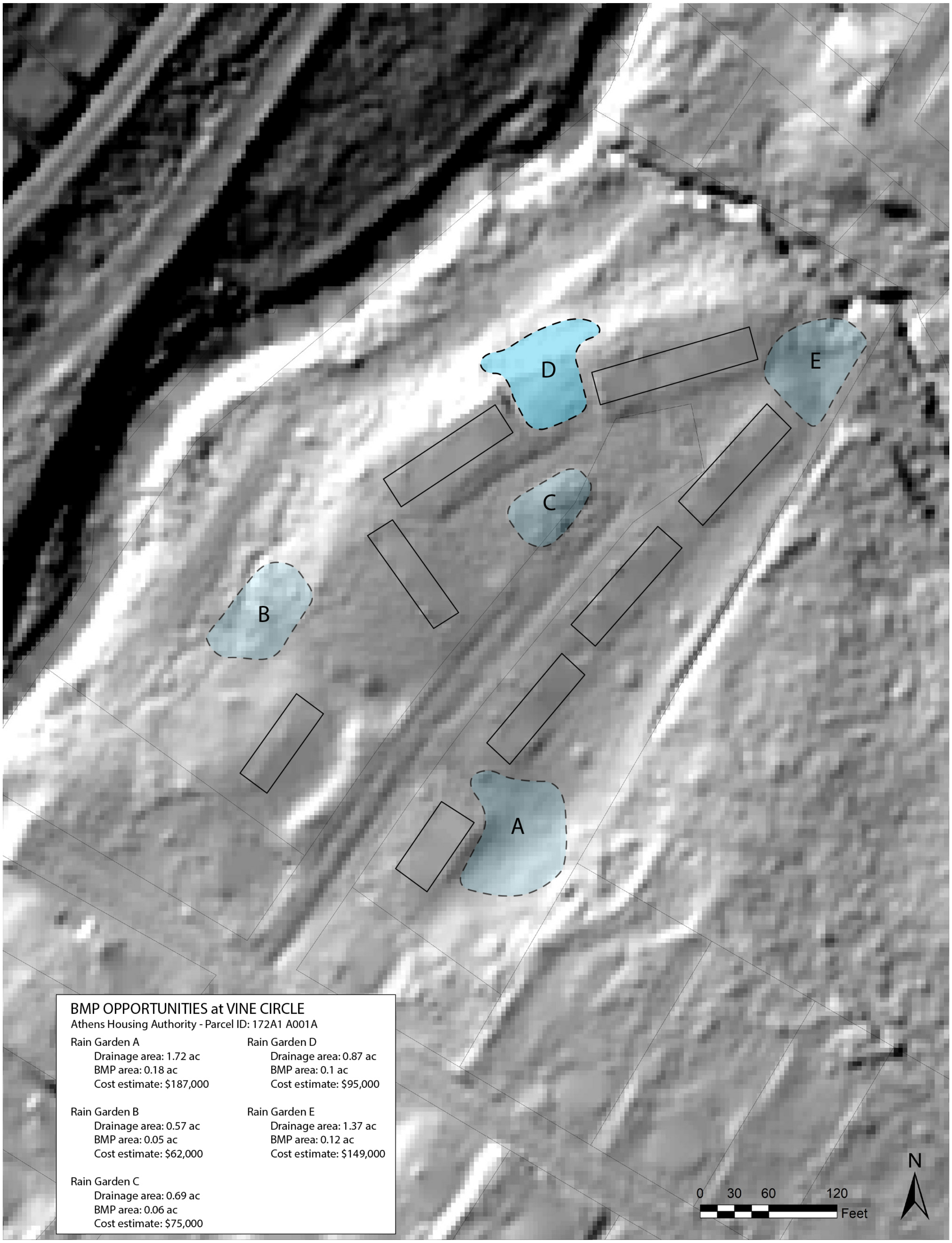

Figure 5.30. Hillshade Map, Drainage Analysis and Potential SCM Areas. (2018)
Data Source: ACC

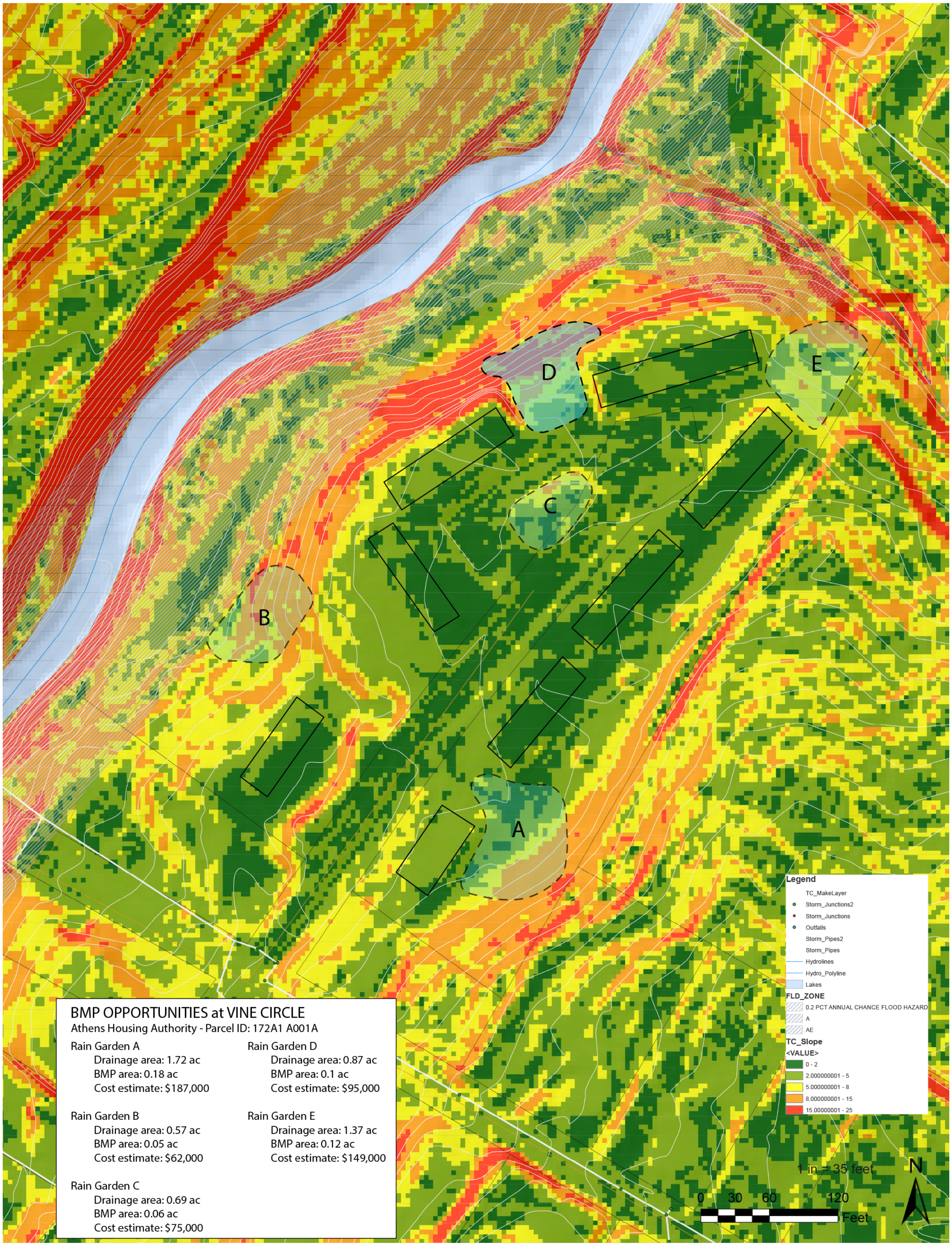

Figure 5.31. Slope Study and Potential SCM Areas. (2018)
Data Source: ACC

CHAPTER 6

DISCUSSION

This research was collaborative effort and made possible by many individuals who shared a common goal of rehabilitating surface waters. The author served as a facilitator, investigator, and participant who directly engaged with the team of stakeholders to develop a grant proposal. In the case of this thesis, stakeholders were already selected prior to the author's involvement with the project. The group was largely members of ACC government and local watershed organizations. Over the course of three months the group of stakeholders met five times to process, analyze, strategize, develop a plan, evaluate and apply for the 2019 Section 319(h) Grant Proposal for Trail Creek Watershed.

This study began on the basis that the approach to stormwater management has shifted from a focus on closed drainage systems to examining the use of a decentralized approach and SCMs, such as GI. These practices are coupled with a strong interest in addressing stormwater runoff and NPS water quality issues, strategic investment decisions, ecological impacts, creation of wildlife habitat, and increased human well-being. Through the development of the proposal, stakeholder goals were to protect water resources, improve community livability, and mitigate possible future effects of climate change. While site-specific interventions can be effective, watershed-scale and big-picture thinking are necessary to make substantive changes in the management of watersheds and to improve water quality across the Trail Creek watershed and the Oconee River basin.

Demonstration projects could prevent harmful constituents and stormwater runoff from entering surface waters, and display how innovative management strategies provide multiple community benefits. Generally, the majority of the population see high risks in change (Rogers 2003). Therefore, rather than persuading individuals to change, the evolution or reinvention of stormwater management strategies is about how these practices can supersede current methods and better fit the needs of individuals and society. The easier it is for individuals to understand the results of an innovative project, the more likely they are to adopt it (Rogers 2003). Because improvements in water quality take time, results must be translated in terms that matter to individuals and society, like economic benefits, social prestige, and amenity potential. Most importantly, promoting innovative stormwater management practices as demonstration projects is the first step in the process of social change and the adoption of SCMs and GI on public and private lands through the watershed, so that eventually the stream meets TMDL limits and is removed from the 303(d) list. Confidently, these approaches and recommendations are a step in the right direction for maintaining and rehabilitating water resources throughout the state.

An approach that actively involves the community and stakeholders in the planning process can improve design quality, create a sense of ownership, and help ensure that recommendations adequately meet the community's needs (Rogers 2003). However, in this study the program was adapted as it progressed, and more interactive techniques were introduced to engage the participants and present information more effectively. After the first stakeholder meeting, in order to better understand the watershed, a comprehensive review of watershed management plans and spatial data using GIS software was conducted to identify potential sites for watershed improvement measures. Watershed inventory was presented at the following stakeholder meeting as a series of mapping studies and composite map (see Figures 5.1 - 5.10).

Interactive techniques included facilitating stakeholder meetings, watershed mapping studies and group discussion, developing site criteria and project goals, and group site visits. Throughout the prioritization and screening process, using an option for no weighting allowed stakeholders to provide feedback on the best way to prioritize criteria and projects. Their input provided key guidance as to how parcels were selected and which parcels were included on the priority list.

Although the prioritization tools were developed as the project unfolded, they were useful for facilitating site identification and stakeholder's decision-making process. However, knowing what we know now, this process could be expedited if stakeholders understand the purpose of the grant and participate in the process; if watershed mapping studies are performed and presented at the beginning of the study; if a rubric identifying the goals of the stakeholders and benefits of each project is created during the first meeting; and, if the rubric weights selected criteria.

During the design process, our team did experience setbacks, communication problems, and misdirection. As in many cases, social and environmental forces interact to create complex patterns. The impact of local politics on planning and design, such as competing viewpoints on community problems, methods of implementation, maintenance and economic concerns, affects both conditions and outcome of planning watershed rehabilitation activities. In this case, the group met approximately every two to three weeks as people were volunteering their time, but was limited by accommodating members' schedules. However, not everyone was able to attend each meeting and contribute their expertise. In the end, I believe this was a hindrance as meeting times were spent catching others up and redirecting the focus of the meeting. Additionally, the decision making process was slowed by the number of meetings and by blurred lines of leadership between the stakeholders and the facilitator. Perhaps this reflects my role as I did struggle to manage and direct the group of stakeholders. Too much time was spent going back and forth at meetings, discussing opportunities of potential projects and organizing site visits with stakeholders. Part of this was due to a lack of understanding the purpose of this particular grant, i.e. projects that directly address NPS pollution and achievable water quality results rather than removal of invasive vegetation and creating public park space. Other setbacks included issues of responsibility or lack of commitment from some stakeholders to undertake implementation and maintenance of the proposed demonstration projects. Perhaps it is because the proposed projects are relatively new approaches to stormwater management rather than traditional practices that were recommended in previous watershed management plans.

This approach may not be feasible in areas that lack resources, such as precedent watershed studies, water quality monitoring data, or detailed spatial data. Looking back, rather than reinventing the wheel and looking at the entire watershed anew, our team could have addressed projects on agriculture lands and proposed or modified projects from the 2018 watershed management plan for East Fork Trail Creek (Tetra Tech, et al. 2018). A University of Georgia Environmental Practicum class developed a 319-grant application for Trail Creek in 2016 that addressed agriculture lands and implementation projects at Stroud Elementary School, but was not awarded funding. Unfortunately, we were unable to obtain a copy of the previous grant proposal and stakeholders were not familiar with the earlier submission enough to inform this project. Additionally, it is important to mention that near the end of this entire process, ACC agreed to sponsor projects listed in the 2018 East Fork Trail Creek Watershed Management Plan (Tetra Tech, et al. 2018). This particular development was unforeseen and should have been stated in the beginning of the project as it affected the analysis and approach taken by the researcher and stakeholder group. Therefore, the project's approach suffered because ACC was a primary stakeholder.

Ultimately the submitted grant proposal did include several modified projects from the 2018 East Fork Trail Creek Management Plan, but because of our focus on SCMs and GI we identified and proposed demonstration project that had been not considered or listed in previous planning documents. These projects were a constructed stormwater wetland at Stroud Elementary School; floating treatment islands to retrofit the stormwater detention pond at Trail Creek Park; and, a bioretention basin at Vine Circle Community. We believe coupling SCMs and GI as demonstration projects would create a competitive grant application.

Future Directions

As we move forward, it is important to remember that a factor in achieving sustainable watershed management practices is educating the public to understand the multiple benefits associated with sustainable stormwater management. Because stormwater typically remains out of sight and out of mind, and traditional hard infrastructure has been the accepted standard across the United States for decades, communities must experiment with and incentivize innovative techniques and projects that seek to set a new standard and change the way the public thinks about stormwater. Although it is common for policies to require low impact developments and SCMs on new developments, too often, developers decide to only achieve minimum design standards that do not consider the social or ecological aspects of sustainable watershed management. Implementing inventive solutions, evaluating, monitoring the successes and failures of those solutions, and reporting those outcomes allow for others to learn from and adapt to those techniques (Subramanian 2017). The application of SCMs and GI projects that exceed policy standards as demonstration projects that focus on educational opportunities and celebrate stormwater can assist in spreading the word to change public perceptions about watersheds and stormwater management.

To better understand the implications of this research, future studies could create an inventory of existing GI projects in the watershed or county to understand the percentage of who has already adopted the innovative approach. Additionally, future research could address retrofitting stormwater detention ponds with floating treatment islands; canine and human fecal contamination issues; water quality monitoring and MST tracking; investigate areas where sewer lines are near or intersect with Trail Creek; and, study areas where clusters of septic tanks may be failing.

Considering the rivers in Athens, Georgia, were dumping grounds for raw sewage until 1962, we have come a long way, but we still have a long way to go. The overall health of a watershed reflects a society's cultural values. As rapid urbanization continues, especially near the headwaters, increased impervious cover in the watershed is likely to degrade overall stream health, possibly leading to greater impairment.

CHAPTER 7

CONSLUSION

It is not always easy to document or measure the success of a watershed project. Watersheds are dynamic systems that require years to restore equilibrium after controls are implemented, and monitoring for environmental success is technically difficult and resource intensive (Cooke 2006). Nonetheless, it is important to address pollution concerns sooner than later, and communities want to know if water quality has improved in a relatively short time period. While society relies on the ecosystem services provided by natural systems, the impact which human population growth has on aquatic ecosystems continues to be overlooked. Across the country, large-scale watershed rehabilitation projects will be needed in order to assure adequate and sustainable freshwater resources in the future.

Sustainable stormwater management is about building healthy communities by balancing land-use demands that are best for human well-being and the environment. If implemented properly, SCMs and GI allow communities the flexibility to respond to ever changing economic, social, and environmental conditions. Site-specific SCMs and GI are holistic and multipurpose solutions to manage stormwater runoff and nonpoint source pollution. Projects that celebrate stormwater and ecosystem rehabilitation serve as assets and amenities for communities, as well as a protective mechanism for long-term rehabilitation projects. If managed properly, stormwater is one unifying resource that can rehabilitate watershed health.

This research used the Trail Creek watershed as a case study to develop an effective strategy and screening process that may be applied by communities, who wish to achieve multiple community benefits, rehabilitate ecosystems, and improve water quality in their local streams and rivers. In this case, the Section 319(h) Implementation Grant is a vehicle to implement decentralized SCMs thereby creating opportunities for multipurpose methods such as SCMs and GI to rehabilitate water bodies, and perhaps influence social change, stricter policies, and encourage these types of projects on private lands and across the watershed. This landscape-based approach incorporates ecological, economic, and social aspects of sustainable design by introducing projects that are coupled with educational outreach in highly visible and public sites, demonstrating alternative approaches to current stormwater management practices. This research is vital in developing new strategies for the implementation of sustainable stormwater management and SCMs, such as incorporating GI into the public realm, and establishes an alternative future for how we manage stormwater and live with nature.

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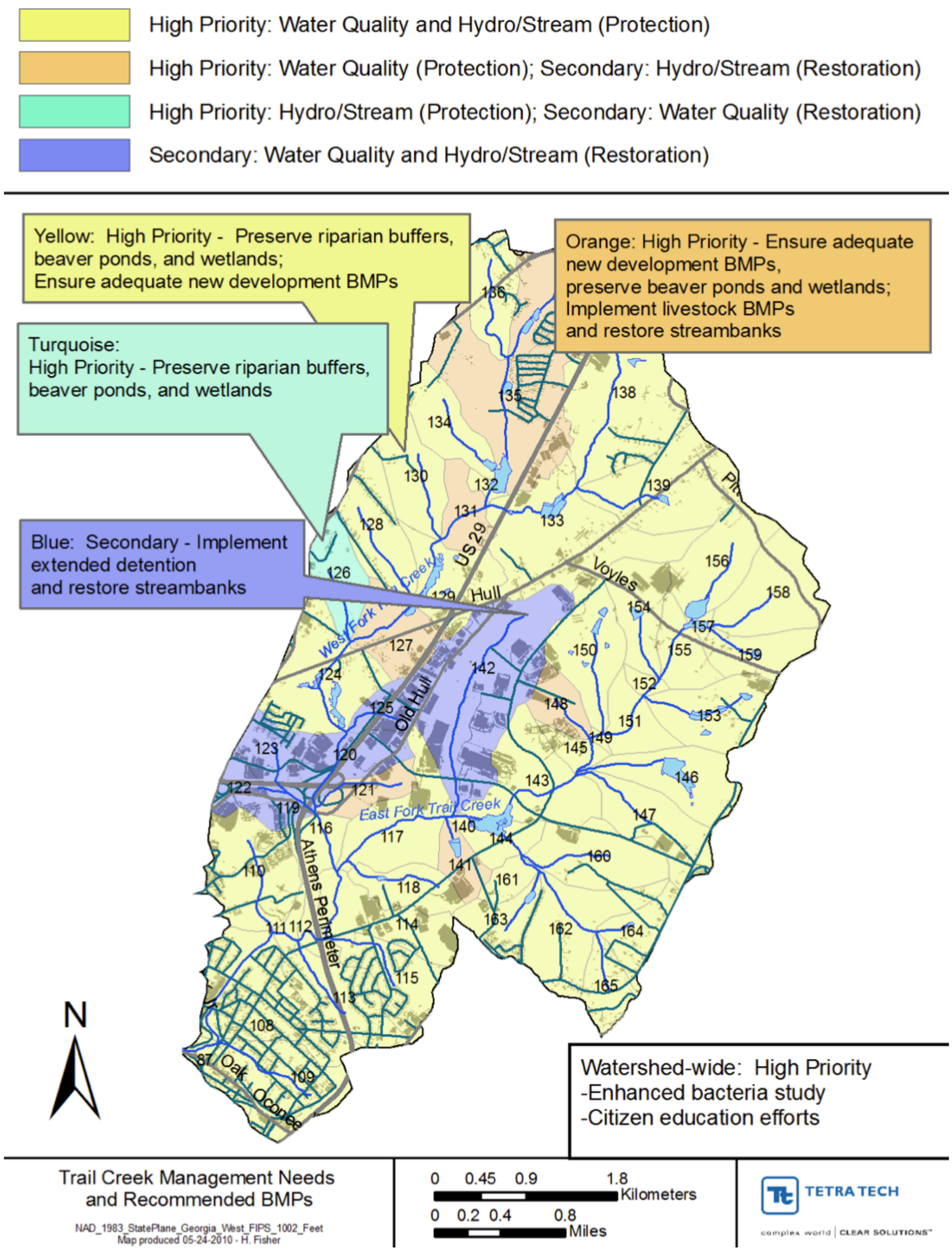
APPENDIX A



Trail Creek Management Needs and Recommended BMPs

Source: West Fork Trail Creek Management Plan (2016)

APPENDIX B

Section 319(h) Example Score Questions
(Subject to Change)

Project Title ______________________________

Project Applicant ______________________________

1) General Criteria **Score**

a. Is this application proposing one of the following?

i.	Implement a complete Nine-Element Watershed-Based Plan or an "Alternative" Plan compiled from multiple documents	40 pts.	
iii.	Implement a project-specific Supplement	30 pts.	
iv.	None of the above	0 pts.	

b. For implementing a project-specific Supplement, is the incomplete/partial plan as well as the Supplement document included with the application? Yes - 10 pts. [ ] No - 0 pts. [ ]

c. Does the application clearly and concisely describe what the project proposes to accomplish, including how and why? 0 - 50 pts. [ ]

d. Does information contained in the application fulfill grant criteria and requirements as well as convey an understanding of the 319(h) program goals and priorities as described and defined in the General Guidelines? 0 - 25 pts. [ ]

e. IF APPLICABLE, has this applicant demonstrated an **inability** to properly administer and manage prior grant-funded projects? Up to -200 pts. [ ]

2) Complete Watershed-Based Plan (WBP) or "Alternative" Plan (AP) Compiled from Multiple Documents or Project-Specific Supplement

a. Has the applicant identified sections and summarized content specific to each of the Nine Elements in the WBP or AP or Supplement to be implemented? 0 - 30 pts. [ ]

b. Score the WBP or AP or Supplement submitted by the applicant for each of the Nine Elements below:

1	Identify the contributing sources	0 - 40 pts.	______
2	Estimate of load reductions expected	0 - 10 pts.	______
3	Describe the NPS management measures	0 - 40 pts.	______
4	Estimate sources of funding needed	0 - 20 pts.	______
5	Information/education component to be used	0 - 20 pts.	______
6	Schedule for implementing management measures	0 - 30 pts.	______
7	Description of measurable milestones	0 - 30 pts.	______
8	Criteria to determine substantial BMP progress/success	0 - 30 pts.	______
9	Tracking component to evaluate plan implementation	0 - 30 pts.	
		Total Plan Points / 250	[ ]

c. *Was the complete WBP (single document that meets Nine Elements) to be implemented developed with grant funds? *20 pts. [ ]

3) Project Activities – Implementation of a WBP or an AP or a Supplement Submitted by Applicant

a. For implementing a WPB or an AP or a Supplement

   i. Do the proposed activities correspond appropriately to the overall project objectives as described in the application? — 0 - 130 pts. [ ]

   ii. Do project activities described in the application directly link to the WBP or AP or Supplement and its priorities relative to water quality? — 0 - 150 pts. [ ]

   iii. Do the project activities in the application address impervious surfaces related to causes of water quality impairment and/or improvement? — Yes - 25 pts. [ ] No - 0 pts. [ ]

   iv. *Do the project activities described in the application implement management measures of the Coastal NPS Program under CZARA? — *50 pts. [ ]

b. Are the criteria to evaluate project success (What and How to measure) appropriate, clearly articulated, and showing numeric value? — 0 - 60 pts. [ ]

4) Relevant Partners

a. How many partners provided letters of commitment describing activities or resources they will be contributing to the project and the dollar values of their donations?

i.	Six (6) or more	30 pts.
ii.	Four (4) – Five (5)	20 pts.
iii.	Two (2) – Three (3)	10 pts.
iv.	Only one (1)	0 pts.

5) Project Location

a. How does the proposal describe the watershed or jurisdictional scale of the project?

i.	One HUC 10 or smaller watershed boundary	100 pts.
ii.	Targeted watershed the size of one or more connected HUC 12s	75 pts.
iii.	Restricted to local political or jurisdictional boundary (city or county)	50 pts.
iv.	Does not apply	0 pts.

b. Will the project area be located in a priority watershed? — Yes - 100 pts. [ ] No - 0 pts. [ ]

6) Water Quality/Monitoring

a. Does the project directly address the following impairments? *(Select up to four)*

i.	Pathogens	25 pts.
ii.	Low Dissolved Oxygen	25 pts.
iii.	Sediment	25 pts.
iv.	Nutrients	25 pts.

b. Are the impairments listed as the following: *(Must correlate to 6) a. above)?*

   i. Category 4a *(25 pts. per impairment)* 25 pts. x 1 ______ = [ ]

   ii. Category 5 *(15 pts. per impairment)* 15 pts. x 2 ______ = [ ]

   iii. Not listed, but there is documented evidence of water quality conditions, issues or concerns that pose a problem or have the potential to cause impairment *(10 pts. per concern)* 10 pts. x ______ = [ ]

EXAMPLE

c. If applicable, evaluate the monitoring component based on the Monitoring Plan submitted with the application:

   i. Is monitoring proposed for an appropriate parameter and purpose? 0 - 20 pts. [ ]

   ii. Does the applicant show an understanding of the appropriate monitoring methodology for the identified parameter and purpose? 0 - 20 pts. [ ]

7) Budget / Cost Effectiveness

a. Do the budget and justification contain sufficient detail to determine how the funds will be spent? 0 - 20 pts. [ ]

b. Do the Federal Dollars for each line item seem to be reasonable as they relate to the project activities and objectives? 0 - 50 pts. [ ]

c. Are the Match Dollar sources appropriate and reasonable, and include sufficient support documentation? 0 - 50 pts. [ ]

d. What percentage of Federal Dollars pays for Direct Costs? 1 - 100 pts. [ ]

e. Do the budget and justification convey an efficient use of funds? 0 - 50 pts. [ ]

f. *Does the applicant commit to Match beyond 50%? *1 - 40 pts. [ ]

8) Value Added

a. Could the project activities achieve results beyond water quality improvements and /or protection? 0 - 40 pts. [ ]

b. * Water First Communities:

   i. Is the applicant a Water First Community? *20 pts. [ ]

-OR—

   ii. Is the project taking place in a Water First Community that is not the applicant, but an active partner? *10 pts. [ ]

c. Does the project propose leveraging existing water quality efforts within the project area? (Up to 7 at 5 pts. each) 0 - 35 pts. [ ]

Base Score: (1575)	0
*Bonus Points: (130)	0
Total Score: (1705)	0

Overall Comments: ____

Source: Georgia Environmental Protection Division (2018)

APPENDIX C

SECTION 319(h) FY2019 GRANT PROPOSAL

PROJECT COVER PAGES

Project Information

Project Title: Trail Creek Green Infrastructure Watershed Plan Prioritized Enhancements
Applicant: University of Georgia (College of Environment & Design and River Basin Center)
Primary Contact: Jon Calabria and Laurie Fowler
Did you attend the Pre-application Webinar: YES _X_ NO ___

Watershed-Based Plan

1. Is the project proposal implementing an existing, completed watershed-based plan that addresses USEPA's Nine Elements of Watershed Planning?

   YES _X_ NO __

   If YES, identify the title of the plan:

   TITLE: Trail Creek Nine Key Element Plan

2. Is the project proposal implementing an alternative to a watershed-based plan in the form of a Summary of Nine Elements compiled from planning documents?

   YES ___ NO _X_

   If YES, identify the title(s) of the planning document(s) and provide copies as attachments to the application or include a link to the electronic location. Also, attach a copy of the Summary of Nine Elements.

   TITLE: ____________________
   TITLE: ____________________
   TITLE: ____________________
   TITLE: ____________________

3. Was either the existing, completed watershed-based plan or one or more of the planning documents developed using Section 106, 604(b) or 319(h) Grant funds?

   YES _X_ NO ___

4. Insert in the template below the page numbers and section headings/subheadings in the existing watershed-based plan or Summary of Nine Elements where content addressing each of the Nine Elements of Watershed Planning can be found:

ELEMENT (A): IDENTIFICATION OF POLLUTANT & IMPAIRMENT CAUSES & SOURCES
Pages: 4; Section: Pollutant Source Identification

ELEMENT (B): POLLUTANT LOAD REDUCTION ESTIMATES EXPECTED FROM BEST MANAGEMENT PRACTICES (BMP)
Pages: 6; Section: Pollutant Load Reduction

ELEMENT (C): NONPOINT SOURCE (NPS) BEST MANAGEMENT PRACTICES (BMP) & CRITICAL TARGET AREAS FOR BMP INSTALLATION
Pages: 7; Section: Conduct Targeted Water Quality Monitoring and Modeling

ELEMENT (D): FINANCIAL & TECHNICAL ASSISTANCE TO IMPLEMENT BMP, ASSOCIATED COSTS & SOURCES OF FUNDS

Pages: 6; Section: Financial and Technical Assistance

ELEMENT (E): EDUCATION & OUTREACH TO ENCOURAGE PUBLIC PARTICIPATION IN PLAN IMPLEMENTATION

Pages: 19; Section Essential Management Measures

ELEMENT (F): BMP IMPLEMENTATION SCHEDULE

Pages: 16; Section: Appendix

ELEMENT (G): INTERIM MILESTONES TO DETERMINE PROGRESS OF BMP IMPLEMENTATION

Pages: 13; Section Appendix

ELEMENT (H): SET OF CRITERIA TO MONITOR AND ASSESS BMP

Pages: 13; Section Conduct Targeted Water Quality Monitoring and Modeling

ELEMENT (I): COMPONENT TO DETERMINE PLAN IMPLEMENTATION EFFECTIVENESS

Pages: 13; Section Conduct Targeted Water Quality Monitoring and Modeling

SECTION 319(h) FY2019 GRANT PROPOSAL

MATCH DISCLAIMER AND AUTHORIZATION

Disclaimer: Match contributions are from non-Federal sources and do not overlap current or future projects funded by either 319(h) or other Federal grants.

Signed: ______________________________ **Title:** ____________________ **Date:** ________

Organization: ____

Authorization: The individual signing below hereby represents and warrants that s/he is duly authorized to execute and deliver this Application on behalf of Lead Organization.

Signed: ______________________________ **Title:** ____________________ **Date:** ________

Organization: ____

SECTION 319(h) FY2019 GRANT PROPOSAL

PROJECT DESCRIPTION

1. **Project Title:** Trail Creek Green Infrastructure Watershed Plan Prioritized Enhancements

   Project Type: (Check all that apply)
   X **Urban** X **Agricultural** X **Monitoring** _ **Other**

2. **Lead Organization:** Dr. Jon Calabria, ASLA, Associate Professor
   Jackson St Building, 285 Jackson St, Athens, GA 30602
   706 542 0903, FAX 706 542 4485
   jcalabr@uga.edu

   Primary Contact: The University of Georgia Research Foundation, Inc.
   310 E Campus Rd, 409 Tucker Hall, University of Georgia
   Athens, GA 30602
   706-542-5939, Fax: 706-542-5946
   Email: sponprog@uga.edu

Project Start Date: After Award and Notice to Proceed (NTP on or about October, 2019)
Project End Date: Three Years after NTP with BMPs installed in first two years

Federal Amount Requested:	**$ 269,967**
Match Amount to be Contributed:	**$ 273,166**
Total Project Amount:	**$ 543,133**

3. **Project Goals:**
   Watershed-Based Plan or Summary of Nine Elements
   This project builds on nearly twenty years of watershed planning documents and water quality monitoring data. Water quality impairments exist in Trail Creek Watershed, located in Athens-Clarke County, GA. Trail Creek is listed on the draft Georgia 2016 Integrated 305(b)/303(d) List of Streams, as not supporting their designated use due to fecal coliform bacteria (FC). The impaired reaches include East Fork Trail Creek, West Fork Trail Creek, and Trail Creek from the confluence of the East and West Forks downstream to the North Oconee River. While stream reaches are impaired due to fecal coliform and sediment as listed in the TMDL, stormwater runoff is identified as the cause of impairment in all three streams. The specific goal of this project is to implement green infrastructure (GI) and Best Management Practices (BMPs) to reduce nonpoint source pollutants (NPS), minimize impairments to surface waters, and improve the overall health of the watershed.

   The Athens-Clarke County Unified Government (ACC) is committed to maintaining and improving the quality of local waterways and has taken a collaborative approach to watershed protection activities. This approach will improve degraded water quality, reduce risks to human health, and preserve ecological resources. In compliance with its National Pollutant Discharge Elimination System (NPDES) wastewater discharge permit, ACC completed a Watershed Assessment in 2005, including water quality and biological monitoring at sites throughout its wastewater service area. In 2009, ACC submitted to the Georgia Environmental Protection Division (GAEPD) its Watershed Protection Plan (WPP), based on results of the Watershed Assessment, which outlined best management practices (BMPs) to improve and protect water quality in its service area.

Where the Project Will Implement the Plan
The Nine Key Element Plan addresses rural and urban catchments within the HUC 12 watershed that prioritizes preservation opportunities and improvements to reduce pollutants. Rural and Urban implementation work that is above and beyond any municipal requirements is proposed as part of this grant. As part of the first phases of implementation, NRCS will continue to evaluate needs and recruit landowners to implement agricultural BMPs. Given that the need in this watershed overwhelms allocated NRCS funding, this grant will supplement prioritized practices such as: riparian buffer enhancement with exclusion fencing; alternative watering and heavy use areas; pasture renovation and/or nutrient management plans that are supported by conservation or management operation and management plans. In the urban areas, several stormwater control measures are proposed to enhance green infrastructure and reduce constituents from entering surface waters in institutional, recreational and residential areas on public lands. Project partners include a land trust with experience in working with agricultural landowners to protect water quality, the watershed's only known neighborhood association and an advocacy organization with over 20-years of experience of water quality sampling in Trail Creek. A town-gown collaborative of UGA faculty, students and Athens-Clarke County staff operating under the rubric of "Watershed UGA" shows the local commitment. This assistance is particularly invaluable in a community such as Athens-Clarke County where there are a number of impaired waters and many pressing needs facing government. This partnership will serve as a model for the restoration of other streams in our community and others.

How the Project Will Implement the Plan
Project partners will encourage the adoption of agricultural practices and stormwater control measures (SCMs) that are coupled with educational outreach. Specifically, practices include cattle exclusion from Trail Creek tributaries in rural areas and SCMs and GI on public lands to reduce pollutants from entering Trail Creek. The targeted water quality sampling program proposed will help determine project efficacy. Project summaries will be presented to other stakeholders in Georgia and surrounding states at professional meetings and will be used in the campus wide Watershed UGA Curriculum.

4. Project Background:

This grant is a catalyst to improve water quality and address high priority areas in the Trail Creek watershed; by installing agricultural BMPs, and Stormwater Control Measures (SCMs aka BMPS) in highly visible public sites to demonstrate alternative approaches to ineffective previous stormwater management. As part of this grant, monitoring and modeling will more precisely identify sources of pollutants and measure the efficacy of the BMPs and SCMs employed.

Many organizations and levels of government are keenly interested in addressing water quality issues in Trail Creek Watershed as evidenced by the fact that 141 people attended the community meeting to review the draft of the Trail Creek 9-Element Watershed Management Plan on October 20th, 2017 and the commitment letters of support attached to this application. Funding this project would assist with targeted monitoring for nutrients and fecal, adoption of agricultural BMPs and urban SCMs, and community outreach and education.

Reasons for Water Quality Impairments and Concerns

Sources of impairments stem from legacy impacts and changing land use in the watershed (p 41, Ch 4, Identification of Management Needs). Elevated fecal coliform levels exceed state standards and are indicators of threats to health, safety and welfare. Past work within the last decade has identified threats to water quality and cites agricultural BMPs and Urban SCMs and wetland and buffer protection as strategies and practices to reverse degradation. Based on the land use information, the watershed is likely to see increased rates of land conversion and redevelopment that will further impair water quality. However, a project like this with broad support can foster ameliorations in the watershed and educate stakeholders about reducing impacts. This project can be a catalyst and attract external funding to improve water quality.

Staff, Partners and Volunteers

Many partners are interested in reducing loading pollutants in the watershed. ACC, UGA, UOWN, Chicopee-Dudley Homeowners Association and the Athens Land Trust will continue or launch coordinated efforts to reduce pollutants. Partners honed project goals based on citizen input sessions and are ready to improve water quality.

Supporting Multi-Phase Projects

Chemical, biological and physical monitoring are ongoing on several reaches in the Trail Creek Watershed by a variety of partners (UOWN, UGA River Basin Center, ACC). By adding strategic monitoring sites, we will build on this ongoing monitoring with a goal of identifying specific sources of impairment. A previous 319 grant assisted ACC in developing a database of septic systems in Trail Creek and an extension of sewer resulted in the removal of several failing treatment pond systems for large trailer parks in the watershed.

Supporting Other On-going Projects

This project provides the opportunity for a variety of partners to address water quality in this watershed by fortifying and expanding existing relationships formed in this and other watersheds near Athens, GA. Several NPS projects have been implemented in the watershed such as monitoring, agricultural BMPs and required urban stormwater management for new development.

Addressing Adverse Hydrologic Impacts of Impervious Surfaces

ACC has a riparian buffer ordinance that exceeds the state's standards and encourages infiltration and storage on retrofit projects. This project will address buffer incursion that occurred prior to the adoption of that ordinance.

Environmental Benefits in Addition to Addressing Nonpoint Source Impairments

Associated benefits that accrue if this project were funded include enhancing ecosystem services, environmental equity issues (SCMs and education in underserved community and school systems), water conservation (SCMs and education), corridor connectivity linkages (cattle exclusion and buffer planting) and protection of wetlands (conservation easements and purchase of development rights program).

Implementing Management Practices Identified in an Appropriate Regional Water Plan

N/A

5. **Project Activities:**
Nonpoint source pollution is contributing to impair water quality in Trail Creek and can be addressed by implementing agricultural and green infrastructure practices and increasing the awareness of landowners and stakeholders about the issues and possible solutions.

<u>Project Activity:</u> Install Agricultural BMPs to reduce constituent loading

Task 1: Introduce Project Partners
Listserve and notices
Deliverables:
Schedule and invite participants and stakeholders interested in installing agricultural BMPs; urban SCMs or preserving lands.
Measures of Success:
Contact known partners within watershed.

Task 2: Introduce Project Partners
Convene Meetings
Deliverables:
Notices, agenda, presentations and sign in sheets.
Measures of Success:
Stakeholders attend meeting.

<u>Project Activity:</u> Install Agricultural BMPs

Task 3: Install Ag BMPs to reduce loading. GA's Statewide NPS Mngt Plan, Ag Nonpoint, Long term Goal 3, p 45: Facilitate Activities to reduce NPS pollution.
Meet with interested landowners; Coordinate with NRCS and prioritize landowners interested in Ag BMPs
Deliverables:
Meeting summary notes and prioritization scores for interested landowners
Measures of Success:
Agreement from landowners to proceed with implementation

Task 4: Install Agricultural BMPs
GA's Statewide NPS Mngt Plan, Ag Nonpoint, Longterm Goal 3, p 45: Facilitate Activities to reduce NPS pollution.
Install Ag BMPs on willing producer's land
Deliverables:
Install BMPs on producer's land that may include riparian buffer enhancement with exclusion fencing; alternative watering and heavy use areas; pasture renovation or nutrient management plans; conclude with Demonstration Field Day.
Measures of Success:
Fully executed contract to install BMPs

<u>Project Activity:</u> Conduct outreach meetings, implement Stormwater Control Measures above and beyond NPDES requirements in public sites. Install and monitor stormwater control measures to demonstrate change in loading.
Task 5: Install Urban BMPs - stormwater control measures. GA's Statewide NPS Mngt Plan, Urban Nonpoint, Short term Goal 3.5, p 60: Encourage/Incentivize GI retrofits to reduce NPS pollution.

Install SCM practices on public property at Stroud Elementary School and Vine Circle of Athens Housing Authority. Install floating treatment islands on public property at Trail Creek Park.

Deliverables:

SCMs on selected sites (rain gardens, bioretention, stormwater wetlands, vegetated swales, floating treatment islands, etc.) to reduce constituents from entering Trail Creek.

Measures of Success:

Built SCMs

<u>Project Activity:</u> Conduct Workshops

Task 6: Conduct CVIOG Workshops

Program will consist of 2 workshops

Deliverables:

Each program session will consist of a mix of taught content and interactive workshops.

Measures of Success:

Workshops and training completed

<u>Project Activity:</u> Targeted Water Quality Monitoring. GA's Statewide NPS Mngt Plan, Water Quality Monitoring, p 79: Identify Corrective Action

Task 7: Targeted Monitoring

Sample and Calibrate SWAT model

Deliverables:

Sample results and targeted monitoring opportunities.

Measures of Success:

Report results in final 319 report and disseminate to stakeholders.

<u>Project Activity:</u> Prepare and submit quarterly, final reports and invoices. GA's Statewide NPS Mngt Plan, Ag Nonpoint, Long term Goal 13, p 99: Effectively Manage 319 Funding

Task 8: Quarterly Reports

Quarterly Reporting

Deliverables:

Submit Quarterly Reports and invoices during grant period.

Measures of Success:

Quarterly Report and Invoices accepted by grantor; documentation of progress according schedule.

Task 9: Final Invoice and Report

Final Reporting

Deliverables:

Submit Final Reports at end of grant period.

Measures of Success:

Final Report accepted by grantor; Document completion and evaluation of project activities on schedule and within budget.

6. Roles and Responsibilities of Participating Organizations: (attached)

Is either of the following certified as a WaterFirst Community?

- Lead Organization. YES X NO___
  If YES, Year of Certification: 2013
- Local government in the HUC-10 watershed and listed as a partner in the project. YES X NO___
  If YES, Year of Certification: 2013

Organization Name	Specific Responsibilities
UGARF	• Contribute to at least 40%, if not more than 50% of total project costs in matching funds or in-kind services • Pay funds to appropriate contractor(s) and vendor(s) • Request reimbursements from GAEPD on a quarterly basis • Track the progress of project activities completed, grant funds expended, and match values provided in accordance with the drawdown & implementation schedule • Complete and submit quarterly progress reports and invoices to GAEPD by January 15th, April 15th, July 15th, and October 15th of each project year • Complete & submit close-out report at conclusion of project
GAEPD	• Provide 60% of total project costs • Review and approve project deliverables • Participate in meetings, as appropriate • Review and assist as needed with 319(h) Grant protocols • Provide project oversight and contract management • Provide monitoring guidance and training
Other Invited Partners	**Specific Responsibilities**
Stroud Elementary School	• Serve on Project Advisory/Steering Committee • Serve as demonstration site for select SCM
Chicopee Dudley Neighborhood Association	• General Stakeholder • Identify other stakeholders and help host workshops
Athens-Clarke County Unified Govt: Stormwater Services	• Serve on Project Advisory/Steering Committee • Render in-kind services to Match as described in attached Letter of Commitment
NRCS	• Technical Support to Landowners to implement Ag BMP's such as Streamside Management Areas, Alternative Water and Heavy Use Areas
Upper Oconee Watershed Network	• Technical Support and Monitoring
Oconee River Land Trust	• Aggressive Exotic Control
Athens Land Trust	• Aggressive Exotic Control

7. Project Location and Watershed Characteristics:
Geographic Location: North East Athens, GA in City: Athens in County or Counties: Clarke
Latitude (decimal degrees): 33°58'24.37"N_Longitude (decimal degrees): _ 83°21'9.09"W_

a) Project Area Description and Map:
The project is located on UT to Trail Creek, adjacent to the West Fork Trail Creek catchment area.

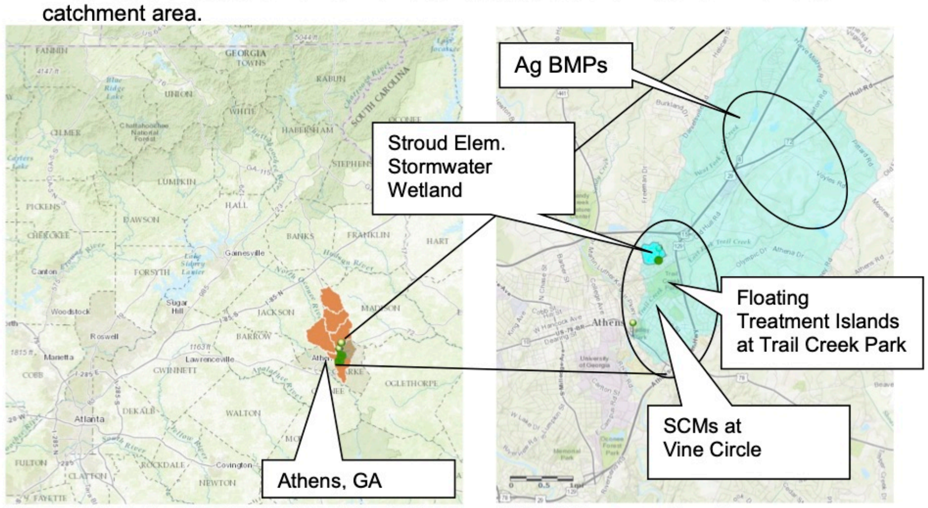


Figure 1: Left Panel: Vicinity Map (North Oconee HUC 10 in orange) and Right Panel: Stroud Elementary (Catchment in Dark Cyan embedded in HUC 12). Data Source (ESRI Online: http://arcg.is/2cD2XUY).

b) Size of Watershed(s) or Drainage Area (Acres): 8,129.8 acres
Size of Watershed Area (if not entire watershed): ___________

Vine Circle: 1.6 acres
Stroud Elementary: 4.9 acres
Rural Ag BMPs: ~20 acres

c) Land Uses within the Watershed(s) or Project Area (Percentages):

Residential-Low Density--> URLD	19.11
Residential-Medium Density - -> URMD	13.94
Forest-Deciduous--> FRSD	33.29
Range-Grasses--> RNGE	7.68
Septic Area--> SEPT	0.16
Hay--> HAY	12.13
Range-Brush --> RNGB	1.63
Forest-Evergreen --> FRSE	4.48
Wetlands-Forest ed--> WETF	0.26
Residential-High Density--> URHD	6.42
Industrial--> UIDU	0.90
Total	100.00

Data Source & Date: SWAT2012 and ArcMap 10.3.1;DEM, land use and soil GIS files from NRCS Geospatial Data Gateway 10-meter National Elevation Dataset, State of Georgia National Landcover Dataset and Soil Survey Spatial and Tabular Data (SSURGO 2.2), Weather data from 1999-2004 was Climate Forecast System Reanalysis (CFSR)

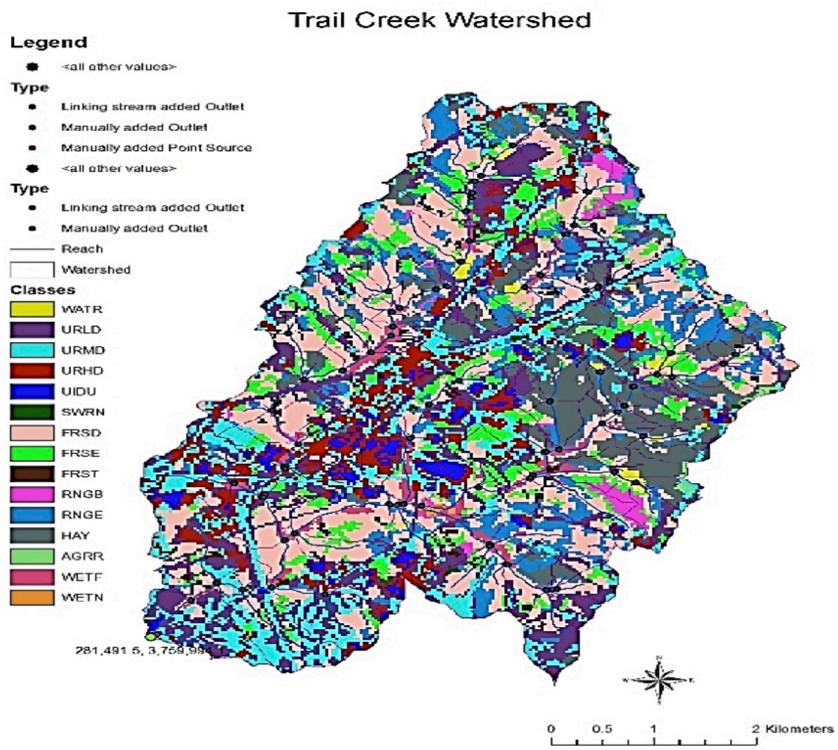


Figure 2: SWAT Model of Land Cover (analysis by Stantil 2016).

d) Hydrologic Unit Code(s), Watershed Name(s) and Priority Watershed(s):
HUC #: 030701010505 Name: Trail Creek Priority: No

8. Nonpoint Source Pollution Impairments and Healthy Waters:
a) Section 305(b)/303(d) List of Waters:

Segment Name/Length (Miles)	Reach Description from Section 305(b)/303(d) List of Waters	County	Criterion Violated, Healthy Water or Documented Water Quality Impairment	Listing Status Category 1, 2, 3, 4 (a-c), or 5
3 Miles	Headwaters East Fork of Trail Creek	Clarke	Fecal Coliform	4a
3 Miles	Headwaters West Fork of Trail Creek	Clarke	Fecal Coliform	4a
2 miles	Trail Creek to the North Oconee River	Clarke	Fecal Coliform	4a

b) TMDL Name, *Revised TMDL Implementation Plan, HUC 0307010105 Trail Creek and North Oconee River, April 2003*

c) Known Impairments not on the 305(b)/303(d) List of Waters:
Water quality parameters were elevated during wet weather, with levels of orthophosphorus, total phosphorus, BOD, and COD being among the highest on average of the sites. Trail Creek is affected by stormwater runoff, with increased levels of nutrients, TSS, organic matter, and metals during wet-weather events. Potential sources of nutrient impacts include runoff from rural, residential, industrial, and commercial areas. Fecal coliform concentrations varied throughout the Trail Creek Watershed, with the highest bacteria levels in East Fork Trail creek and the lowest levels in West Fork Trail Creek. In both the West Fork and East Fork Trail Creek Watersheds, there was evidence of livestock access to the streams. In West Fork Trail Creek, livestock waste was observed in the stream in the far upper reaches. In East Fork Trail Creek, evidence of livestock was noted from Olympic Drive to the headwaters. More information is presented in the Appendices.

9. Post-BMP Water Quality Monitoring:

X QA/QC Water Quality Monitoring Plan Attached *(listed in Section 12)*
_____ Targeted Monitoring Plan to track trends in water quality improvement or
_____ Sampling Quality Assurance Plan (SQAP) to qualify data for listing assessments

☐ Project Will Not Include Water Quality Monitoring

10. Project Budget:

Item	Item Class Category	319(h) Grant Funds (60% Maximum)	Non-Federal Matching Funds (40% Minimum)	Total
A	Personnel One (1) Graduate Assistant - 0.0 FTE ($12,500/year) for 3 years Description of Duties: Monitoring	$37,500		$37,500
	One (1) Summer Salary - 0.0 FTE ($12,000) for 1 month / 3 years Description of Duties: Project Management	$36,000		$36,000
	(2) CVIOG Workshop(s) Description of Duties: Education	$10,000		$10,000
	(80) PSO Day of Service Volunteers Description of Duties: Education		$1,975.20	$1,975.20
	(50) UOWN Volunteers Description of Duties: Monitoring		$1,234.50	$1,234.50
	(150) Rivers Alive Volunteers Description of Duties: Education		$3,703.50	$3,703.50
	UGA Salary Match (Calabria, Bledsoe, Pippin, Fowler) Description of Duties: In kind match from UGA research		$197,253	$197,253
	Sub Total:	$83,500	$204,166.20	$287,666.20
B	Fringe Benefits One (1) Staff Position - 0.0 FTE at 00% for x years	n/a	n/a	n/a
	Sub Total:	n/a	n/a	n/a
C	Travel Staff Position: Design Development and Construction Oversight Purpose of Travel: On site travel and disseminate research in GA/SE States Miles x Mileage Rate ($.54/mile)	$7,500		$7,500

Item	Item Class Category	319(h) Grant Funds (60% Maximum)	Non-Federal Matching Funds (40% Minimum)	Total
	Sub Total:	$7,500		$7,500
D	Equipment Equipment: Purpose/Use:	n/a	n/a	n/a
	Sub Total:	n/a	n/a	n/a
E	Supplies Supplies: Monitoring Purpose/Use: Monitoring Stream Sample Analyses	$27,000		$27,000
	Sub Total:	$27,000		$27,000
F	Contractual Contractor Name: Description of Duties: Design Development, Construction Oversight, Install Urban BMP, Monitoring Number and Type of BMP: Bioretention Vine Circle Between Housing	$9,000	$69,000	$78,000
	Contractor Name: Description of Duties: Design Development, Construction Oversight, Install Urban BMP, Monitoring Number and Type of BMP: Floating Treatment Islands	$21,500		$21,500
	Contractor Name: Description of Duties: Design Development, Construction Oversight, Install Urban BMP, Monitoring Number and Type of BMP: Stormwater Wetland Stroud Elementary School	$57,500		$57,500
	Contractor Name: Description of Duties: Install Ag BMP Number and Type of BMP: Heavy Use Areas	$6,682.50		$6,682.50
F	Contractor Name: Description of Duties: Install Ag BMP Number and Type of BMP: Cattle Exclusion, HU-Woven Wire	$3,762.50		$3,762.50
	Contractor Name: Description of Duties: Install Ag BMP Number and Type of BMP: Stream Crossing, HU-Rock armored low water crossing	$5,220		$5,220
	Contractor Name: Description of Duties: Install Ag BMP Number and Type of BMP: Alternative Watering, HU-4 Ball Freeze Proof	$1,467.19		$1,467.19
	Contractor Name: Description of Duties: Install Ag BMP Number and Type of BMP: Alternative Watering, PVC Line	$412.50		$412.50
	Sub Total	$105,544.69	$69,000	$174,544.69
	Other:			
G	**Sub Total**	$105,544.69	$69,000	$174,544.69
H	Total Direct Charges: (Sum of A-H)	$223,544.69	$273,166.20	$496,710.69
I	Indirect Charges:	$46,422		$46,422
J	**Total:** (Sum of I and J)	$269,966.69	$273,166.20	$543,132.89

Narrative Justification for Item Class Categories (Federal, Match or Both):

- **Personnel Narrative Justification (A):**

Graduate Students and Faculty will implement the project deliverables. Graduate assistant salary to coordinate Grant and associated projects; prepare and submit quarterly and final reports and accounting summary to the level EPD requires; coordinate educational programming; contract administration for construction and educational outreach projects; disseminate research-based information. CED faculty to assist graduate students. Description of duties: assist Graduate Assistant with associated project management; assist staff person with preparation and submission of quarterly and final reports; CVIOG to host two educational for workshops; travel to trainings or presenting findings at professional conferences. Monitoring person to perform sample collection.

- **Fringe Benefits Narrative Justification (B):**

Benefits are required in addition to personnel at various rates of 32 or 36%.

- **Travel Narrative Justification (C):**

Travel is for project partners to travel to sites, meetings and trainings in GA or adjacent states.

- **Equipment Narrative Justification (D): n/a**

- **Supplies Narrative Justification (E):**

Supplies include 450 samples at $60 each for TSS and nutrients and some bacteria.

- **Contractual Narrative Justification (F):**

Contracts include the design, permitting and implementation of ag BMPs, residential SCMs, water quality monitoring setup and workshops.

- **Other Narrative Justification (G):** n/a

- **Indirect Charges Narrative Justification (I):**

Indirect Charges are for offsite public service university involvement.

11. Project Schedule: See attached EXCEL form

12. Project Attachment(s):

- Draft QA/QC Water Quality Monitoring Plan
- Letter of Commitment from Athens Clarke County Stormwater Division
- Signed Match Disclaimer and Authorization
- Signed Letter of Assurance
- References
  - Trail Creek Green Infrastructure Watershed Plan Prioritized Enhancements
  - Trail Creek Watershed Fecal TMDL (1998)
  - West Fork Trail Creek Fecal Coliform TMDL (1998)
  - TMDL Revised Implementation Plan: North Oconee River - Trail Creek (2003)
  - West Fork Trail Creek TMDL Implementation (2007)
  - Trail Creek West Fork - Watershed Management Plan (2010)
  - Nine Element Watershed Management Plan Trail Creek (2016)
  - Unified Government of Athens-Clarke County Watershed Protection Plan (2017)
  - Watershed Management Plan for East Fork Trail Creek (2018)
  - Watershed Assessment of Streams in the Trail Creek Watershed (Saintil, 2018)

APPENDIX D

Project Schedule

	Initial	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter	5th Quarter	6th Quarter	7th Quarter	8th Quarter	9th Quarter	10th Quarter	11th Quarter	12th Quarter	Final
Federal Drawdown Amount		$118,422	$10,450	$10,413	$6,683	$124,000								$269,967
Percent Federal Remaining	100%	56%	52%	48%	46%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Match Amount	$0	$197,253				$75,913								$273,166
Percent Match Accrued	0%	72%	72%	72%	72%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Milestones/Tasks

- Execute Contract
- Task 1: Introduce Project Partners - Listserve and notices
- Task 2: Introduce Project Partners - Convene meetings
- Task 3: Ag BMPs - meet with landowners; coordinate with NRCS
- Task 4: Install Ag BMPs to reduce loadings
- Task 5: Urban BMPs - Install Stormwater Control Measures
- Task 6: Conduct 2 CVIOG Workshops
- Task 7: Water Quality Monitoring
- Task 8: Submit Quarterly Invoices & Status Reports
- Task 9: Submit Final Close-Out Report

Key

- Meetings & Outreach
- Monitoring
- Ag BMPs
- Septic BMPs
- Urban BMPs
- Contract & Reports

Section 319(h) FY 2019 Project Proposal Implementation Schedule