United States Environmental Protection Agency

2013 GREEN INFRASTRUCTURE TECHNICAL ASSISTANCE PROGRAM
City of Spartanburg and Northside Development Corporation
Spartanburg, SC

Northside Neighborhood Green Infrastructure Master Plan

Integrating Green Infrastructure into a Neighborhood Redevelopment Plan in Spartanburg, South Carolina

Rendering credit: JHP Architects and Tetra Tech, Inc.

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About the Green Infrastructure Technical Assistance Program

Stormwater runoff is a major cause of water pollution in urban areas. When rain falls in undeveloped areas, soil and plants absorb and filter the water. When rain falls on our roofs, streets, and parking lots, however, the water cannot soak into the ground. In most urban areas, stormwater is drained through engineered collection systems and discharged into nearby water bodies. The stormwater carries trash, bacteria, heavy metals, and other pollutants from the urban landscape, polluting the receiving waters. Higher flows also can cause erosion and flooding in urban streams, damaging habitat, property, and infrastructure.

Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, *green infrastructure* refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water. These neighborhood or site-scale green infrastructure approaches are often referred to as *low impact development*.

The U.S. Environmental Protection Agency (EPA) encourages using green infrastructure to help manage stormwater runoff. In April 2011 EPA renewed its commitment to green infrastructure with the release of the *Strategic Agenda to Protect Waters and Build More Livable Communities through Green Infrastructure*. The agenda identifies technical assistance as a key activity that EPA will pursue to accelerate the implementation of green infrastructure. In October 2013 EPA released a new Strategic Agenda renewing the Agency's support for green infrastructure and outlining the actions the Agency intends to take to promote its effective implementation. The agenda is the product of a cross-EPA effort and builds upon both the 2011 Strategic Agenda and the 2008 Action Strategy.

EPA is continuing to provide technical assistance to communities working to overcome common barriers to green infrastructure. Selected communities received assistance with a range of projects aimed at addressing common barriers to green infrastructure, including code review, green infrastructure design, and cost-benefit assessments.

For more information, visit *water.epa.gov/infrastructure/greeninfrastructure/gi_support.cfm*.

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1 Executive Summary

The Northside Community near downtown Spartanburg, South Carolina is home to one of the most ambitious revitalization efforts in the City's history. Known as the Northside Initiative, the project aims to redevelop approximately 400 acres of an economically distressed, old textile mill neighborhood into a vibrant, diverse community. At the core of the initiative is the draft Northside Redevelopment Plan (Redevelopment Plan). The Redevelopment Plan was cultivated through public input and includes affordable housing, mixed-use commercial development, urban agriculture, innovative school programs, community recreation facilities, health care, social services, and restored parks and green space.

The goal of this effort is to help incorporate green infrastructure into the Redevelopment Plan. Green infrastructure can help realize the vision of a more vibrant, livable Northside by promoting many community objectives, including:

- Improving and protecting water resources;
- Enhancing potable and non-potable water supplies;
- Increasing enjoyment, aesthetics, and overall well-being in the neighborhood;
- Promoting urban agriculture and a community-supported local food system;
- Increasing safety and reducing crime; and
- Raising property values

Based on feedback from Northside's residents during a public workshop, a set of green infrastructure goals was prioritized. The Northside neighborhood residents indicated that they wanted more green space, access to fresh food, more opportunities to recreate outdoors, and more walkable neighborhoods. To accomplish these overall goals, the community selected five site-specific transformational projects to be designed and implemented in the redevelopment area. Each of these projects will incorporate green infrastructure principles such as green space, street trees, urban agriculture, and a riparian greenway.

Given the early phase of the overall redevelopment project, this effort developed a set of conceptual green infrastructure recommendations to advance the community's vision. Recommendations are presented at two scales. First, the Stormwater Management Toolbox (Section 3) discusses a suite of nonstructural and structural practices that apply to the block densities and streetscape styles proposed for the Northside redevelopment area. Second, the Conceptual Designs (Section 4) develop green infrastructure scenarios for two land use typologies characteristic of the proposed Redevelopment Plan.

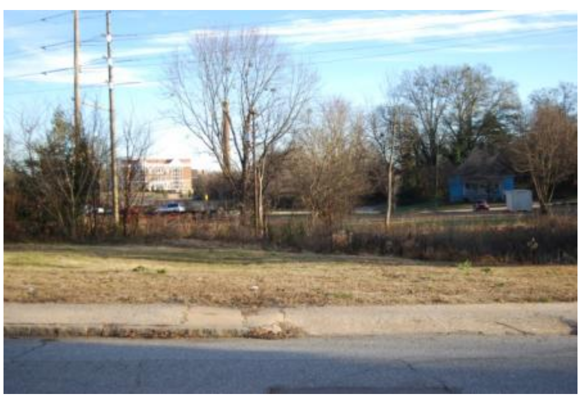
This report describes key findings that can be applied to the Northside neighborhood and to similar redevelopment projects, demonstrating how green infrastructure can support and enhance infill, mixed use development.

2 Introduction

2.1 Northside Neighborhood

The Northside neighborhood of Spartanburg, South Carolina (referred to as "the City" throughout this document) was once a regional transportation hub and viable, thriving mixed-income community with retail shops and community amenities. The economic downturn and a decline in manufacturing left the neighborhood severely distressed, suffering from deteriorated and dilapidated homes, overcrowding, and vacant lots. Figure 1 and Figure 2 show street views of the neighborhood, and Figure 3 provides an aerial view of existing conditions. The following are some of the basic challenges facing the Northside neighborhood:

- Almost 1,000 residents moved out of the greater Northside area between 2000 and 2010, a 19 percent drop in population, according to census data.
- Nearly one in every two houses is vacant.
- The Northside was the hardest-hit neighborhood in the City by the mortgage crisis.
- Unemployment in the neighborhood was 26.1 percent in 2012.
- For many years, parts of the Northside community had the highest crime rates in the City.[1]
- The Spartanburg County School District 7, which serves the neighborhood, had a graduation rate of only 65.8 percent in a recent year.[2]



Source: Tetra Tech, Inc.

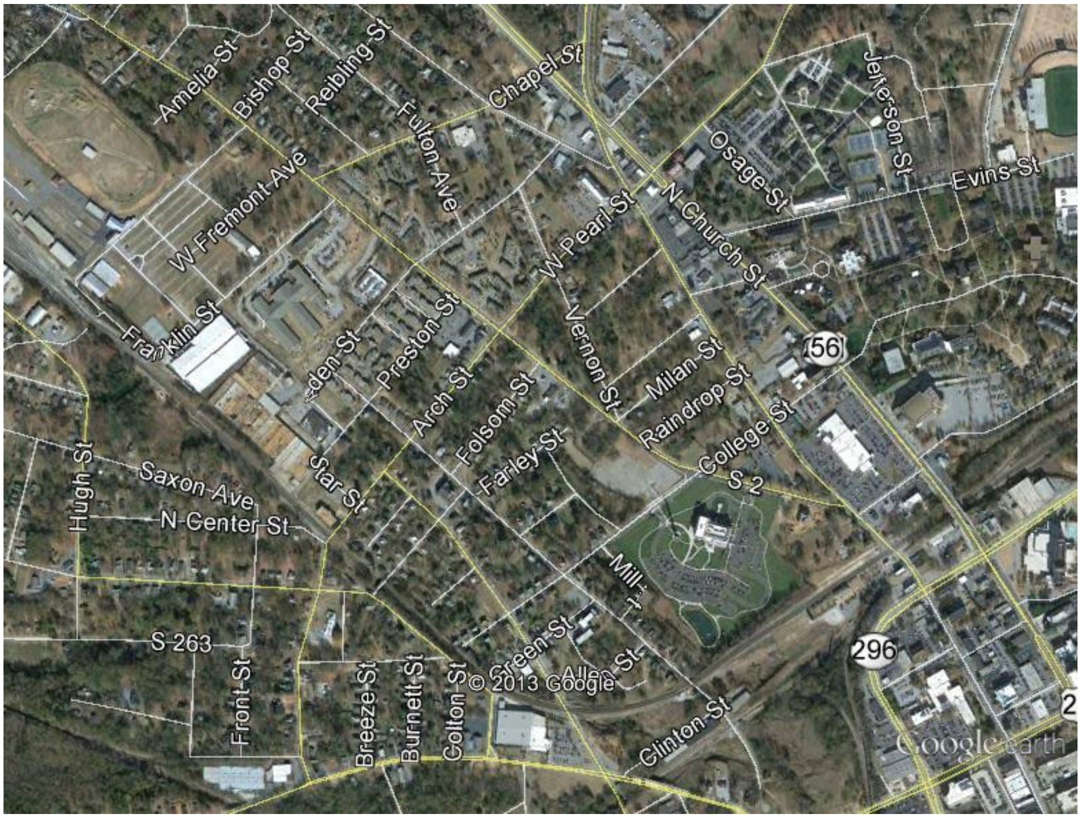
Figure 1. View from Folsom Street looking southeast.

Source: Tetra Tech, Inc.

Figure 2. View of Brawley Street looking northwest.

[1] purposebuiltcommunities.org/success-stories/spartanburg/

[2] portal.hud.gov/hudportal/documents/huddoc?id=FY12CNPlangGrantSummaries.pdf



Source: Google Earth

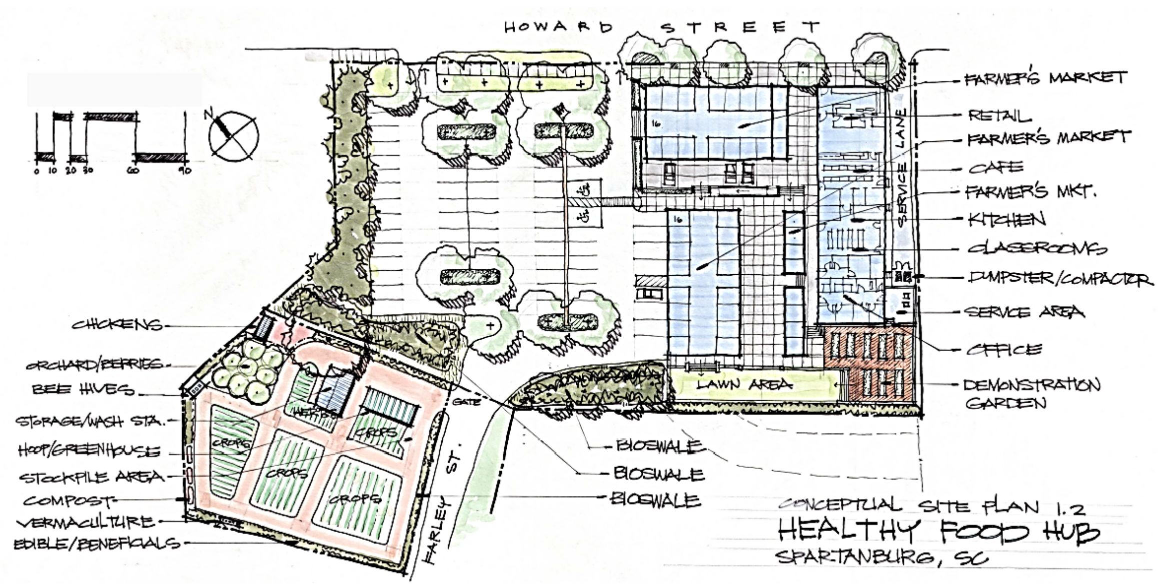
Figure 3. Existing conditions.

The Northside neighborhood is also home, however, to one of the most ambitious revitalization efforts in the City's history. Known as the Northside Initiative, the project aims to redevelop approximately 400 acres of the economically distressed, old textile mill neighborhood into a vibrant, diverse community. One of the initiative's greatest strengths is the committed support of diverse private and public organizations, businesses, and citizen groups in the City and beyond. At the foundation of the initiative is the Northside Development Corporation (NDC), a nonprofit started in 2010 to lead the revitalization project. The purpose of the NDC is to acquire vacant, foreclosed, or distressed properties in the area. NDC has raised more than $2.5 million dollars through grants and private and public funding avenues, and acquired nearly 100 parcels of vacant and distressed property in the area. The City has used federal dollars to purchase almost 50 properties. These properties, outlined in Figure 4, have been acquired for the purpose of enabling cost-effective additions of new housing and other area amenities.

Source: JHP Architects

Figure 4. Northside Redevelopment Plan properties.

Although the NDC is spearheading the initiative, the project has gained momentum from many local and federal players' contributions. The Northside community is anchored by multiple institutions—Edward Via College of Osteopathic Medicine (VCOM), Wofford College, Cleveland Academy of Leadership, and Spartanburg Regional Medical Center—all of which bring people and energy to initiate community-driven, sustainable redevelopment. In addition, when it opens in the Northside neighborhood in May 2014, the Healthy Food Hub (see Figure 5) will become home to the Hub City Farmer's Market, the Butterfly Foundation and its culinary arts program, and a community garden and café. The Healthy Food Hub will bring many benefits to the Northside, including increased access to healthy foods and fresh fruits and vegetables among a "food desert" community, new jobs and vocational training, productive green space, and a safe place for community interaction and recreation.



Source: City of Spartanburg

Figure 5. Site plan for Healthy Food Hub on Howard Street.

2.2 Northside Redevelopment Goals

In 2012 the City secured a $300,000 Choice Neighborhoods Program planning grant through the U.S. Department of Housing and Urban Development to develop a Transformation Plan for the community. Up to this point, no such planning effort had been conducted in the Northside. As a part of the planning effort, NDC and the City hosted a public planning and design workshop in January 2014 to solicit citizen and stakeholder input for developing the overall master Redevelopment Plan. NDC and the City invited EPA to participate in this effort to educate participants on the multiple benefits of incorporating green infrastructure into the redevelopment project.

During the 3-day charrette, facilitators recorded the desires of the community and conceptualized five transformative projects described by participants, which will comprise the community's Redevelopment Plan:

1. Transforming the awkward Asheville Highway/Church Street/Magnolia Street intersection into a striking new gateway (Figure 6) into the Northside and the City. The plan would require the

closure of Magnolia Street between Pearl Street and Asheville Highway, and would replace it with a green space highlighted by public art.

Source: JHP Architects

Figure 6. Artist's rendering of new gateway into the Northside.

2. Extending Evins Street across Church Street, creating a new artery into the heart of the Northside that would dead-end at the new Healthy Food Hub on Howard Street. The Evins Street extension would accomplish one of the major goals identified by the workshop participants—helping people get across Church Street, thereby creating new and better connections between the Northside, Wofford College, and Spartanburg Regional Medical Center.

3. Transforming Pearl Street into the "Main Street" of the Northside by widening it; adding bike lanes, on-street parking, wider sidewalks, street trees, and other landscaping; and zoning it for multi-use development, with retail and office space on the bottom floor and residential units on the upper floors of the three- to four-story buildings to come.

4. Creating a multipurpose, educational, recreational, and community services campus on and adjacent to the current Cleveland Academy of Leadership. Students at Cleveland Academy voiced their desire for their school—which currently houses kindergarten through 5th grade—to be expanded to include grades 6–8. Spartanburg School District 7 is considering the idea. In addition to the expansion required by that move, if it were to happen, planners identified the area around Cleveland as the logical destination for the new T.K. Gregg Community Center (which City Council has already committed to building by 2017), a new Early Childhood

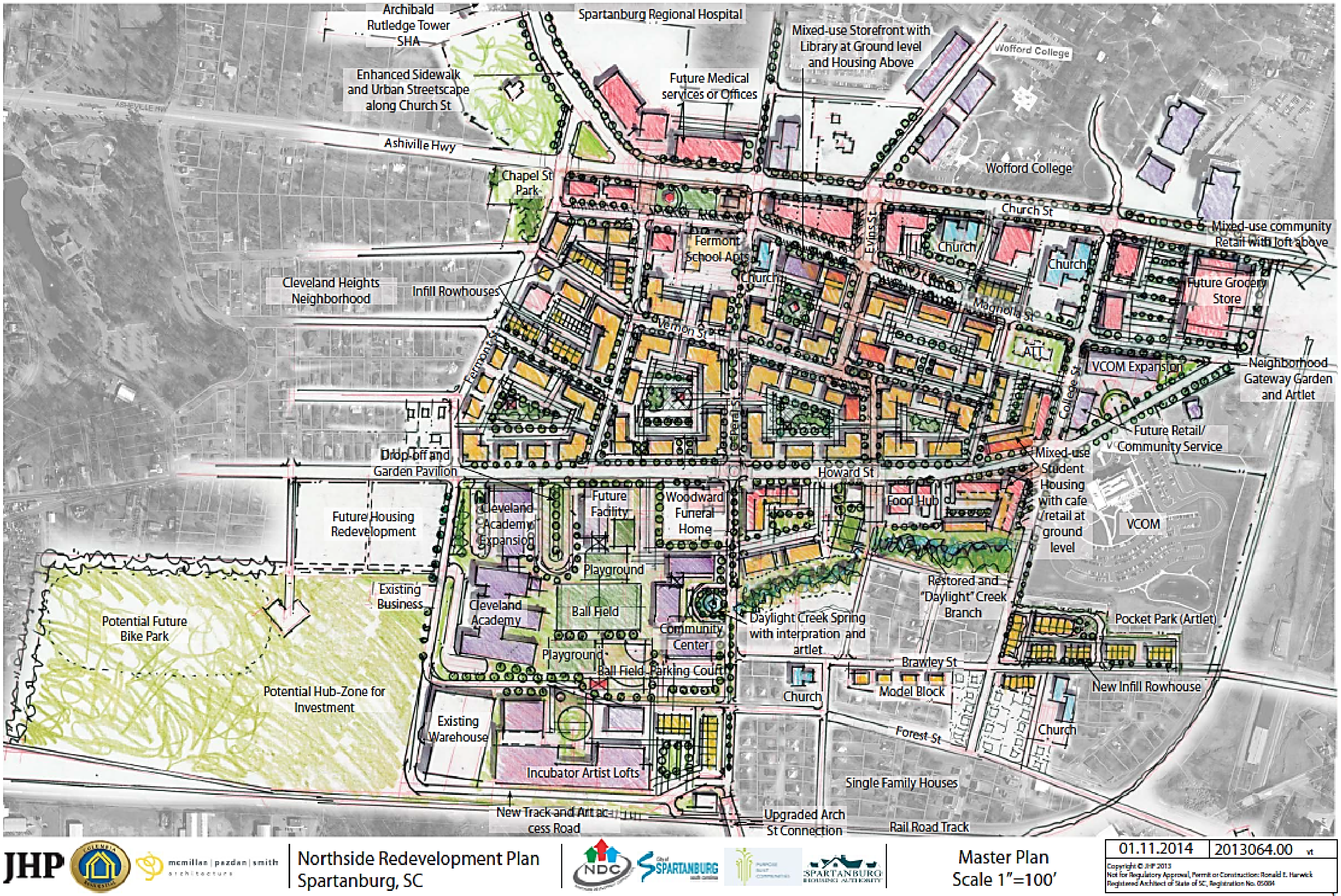
Education Center (which has $1.5 million in funding committed through the Mary Black Foundation), and new ball fields.

5. Daylighting a neighborhood creek that has been paved over and covered up for decades. Locals call the creek the "Nasty Branch," but it will be renamed Butterfly Creek. The daylighted creek and adjoining greenway on either side (Figure 7) would be not just the central feature of the new Northside, but a significant new environmental asset for the City.

Source: JHP Architects

Figure 7. Artist's rendering of the daylighted creek.

The master Redevelopment Plan diagram (Figure 8) shows the approximate location of buildings, sidewalks, alleys, and streets for the proposed redevelopment. For this project's purposes, the draft Redevelopment Plan is used as a framework in which to embed green infrastructure and provide multiple benefits to residents, as Section 2.3 describes. Section 2.3 also describes specific implementation options for the above transformative projects and general neighborhood development. Section 4 provides conceptual drawings to give a visual interpretation of some of these options.



Source: JHP Architects

Figure 8. Full Northside Redevelopment Plan developed at the Public Workshop.

2.3 Role of Green Infrastructure in the Northside Redevelopment

The redevelopment efforts in the City present a unique opportunity to incorporate green infrastructure into the Northside neighborhood's urban fabric, particularly when these efforts involve redeveloping vacant lots. By identifying appropriate green infrastructure techniques early in the planning process, this project seeks to seamlessly integrate green infrastructure practices into the revitalization of the Northside neighborhood, demonstrating how community-oriented infill projects can serve a wide variety of stakeholder and community needs.

Green infrastructure is most effective when the following strategies are implemented:

- Minimize effective or connected impervious area.
- Preserve and enhance the hydrologic function of unpaved areas.
- Harvest rainwater to enhance potable and nonpotable water supply.
- Allow and encourage the use of multi-use stormwater controls.
- Manage stormwater to sustain stream functions.

Green infrastructure uses vegetation and soil to manage rainwater where it falls, resulting in multiple benefits for a community like Spartanburg. Of course, one of the primary benefits is to protect and improve water quality. Green infrastructure could achieve this benefit in two different ways. First, green infrastructure will help protect the pristine water quality present in the unjustly named "Nasty Branch" (soon to be renamed Butterfly Creek). Second, implementing green infrastructure concepts within the Northside neighborhood will help protect the proposed Butterfly Creek stream restoration effort through peak flow reduction and improved water quality in the watershed, which will drain to the newly daylighted stream.

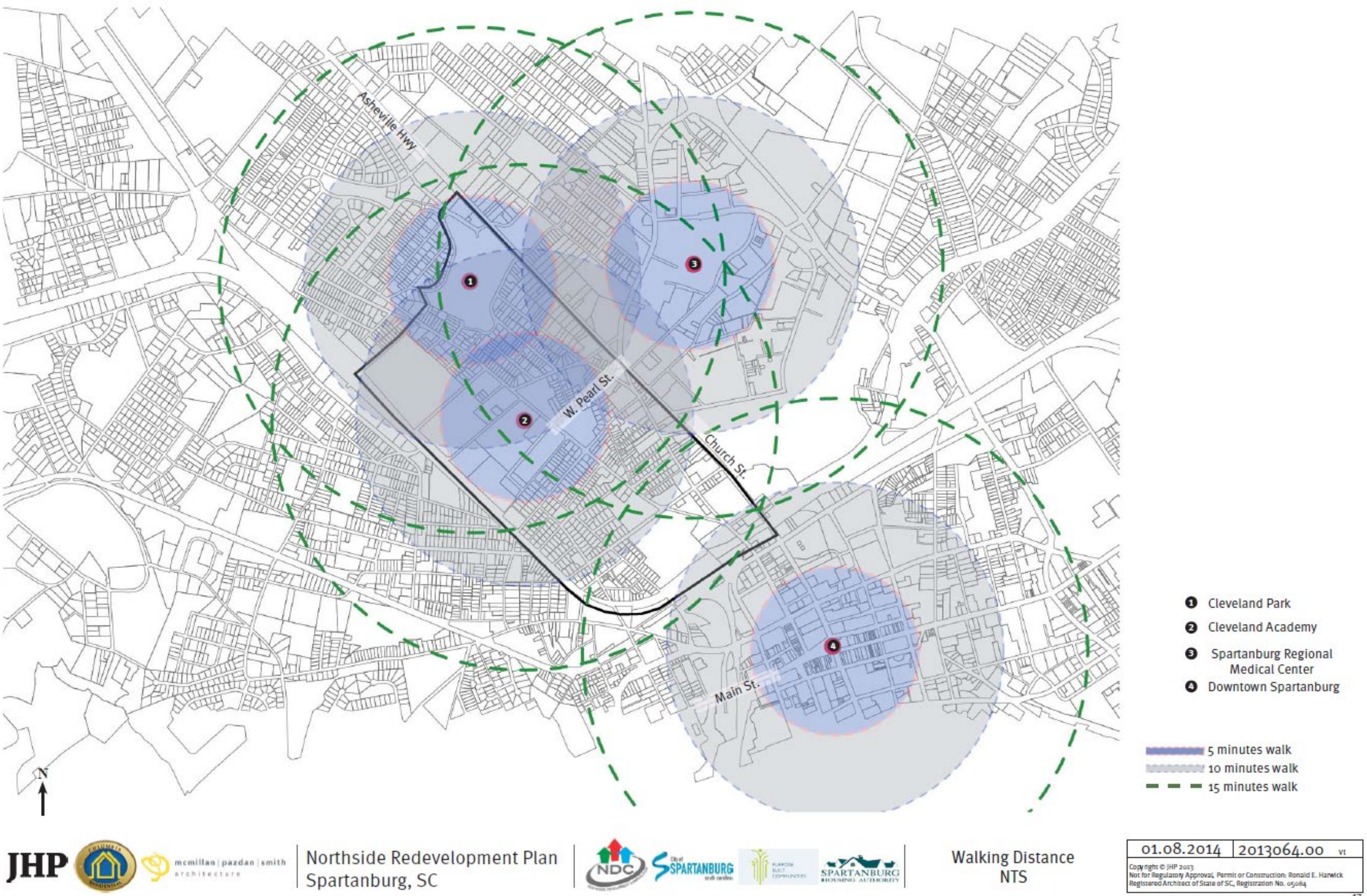
Green infrastructure not only serves as an important design strategy for protecting water quality but can also provide environmental, social, and economic benefits for the Northside community. The following are some examples of the benefits that green infrastructure can provide to the Northside residents and the City:

- **Increased enjoyment of surroundings:** Implementing green infrastructure practices that enhance vegetation within the Northside will help create a more pedestrian-friendly environment that encourages being outdoors, walking, and physical activity. This can improve the health of residents, reduce the use of cars, and encourage pedestrian traffic through residential and commercial areas (e.g., Howard Street) planned in the Northside. The Healthy Food Hub and downtown will be within walking distance (see Figure 9) of the planned residential areas within the redevelopment area and the Cleveland Leadership Academy. Incorporating the greenway and planning for greener streets will encourage people to walk and take advantage of the healthy food options coming to the area. Research suggests that people in greener neighborhoods judge distances to be shorter and make more walking trips (Wolf 2008). In addition, incorporating green space into the multi-family residential units in the Northside will encourage residents to spend more time outdoors, which benefits the heart in many ways. A large study of inner-city Chicago found that one-third of the residents surveyed said they would use their courtyard more if trees were planted (Kuo 2003). Residents living in greener, high-rise apartment buildings reported significantly more use of the area just outside their building than did residents living in buildings with less vegetation (Hastie 2003; Kuo 2003).

- **Increased safety and reduced crime:** Greener streets and housing areas in the Northside might also make the neighborhood a much safer place to live. As noted above, people generally walk more on greener streets. This increases pedestrian traffic and reduces the opportunity for crime. Also, if properly designed, narrower green streets decrease vehicle speeds and make neighborhoods safer for pedestrians (Kuo 2001; Wolf 1998). The stress-reducing and traffic-calming effects of trees are also likely to reduce road rage and improve the attention of drivers. In addition, contrary to common belief, more vegetation does not lead to more crime, and can actually be related to a decrease in crime. Researchers examined the relationship between vegetation and crime for 98 apartment buildings in an inner-city neighborhood. The study found that the greener a building's surroundings, the fewer crimes were committed (including violent and property crimes), and that levels of nearby vegetation explained 7 to 8 percent of the variance in crimes reported by building (Kuo 2001).

- **Increased sense of well-being:** There is a large body of literature indicating that green space makes places more inviting and attractive and enhances people's well-being. Increasing the green space in the Northside could improve the landscape, which is currently blighted with abandoned buildings and parking lots. People living and working with a view of natural landscapes appreciate the various textures, colors, and shapes of native plants, and the progression of hues throughout the seasons (Northeastern Illinois Planning Commission 2004). Birds, butterflies, and other wildlife attracted to the plants add to the aesthetic beauty and appeal of green spaces and natural landscaping. Attention restorative theory suggests that exposure to nature reduces mental fatigue, with the rejuvenating effects coming from a variety of natural settings including community parks and views of nature through windows. In fact, desk workers who can see nature from their desks experience 23 percent less time off sick than those who cannot see nature, and desk workers who can see nature also report a greater job satisfaction (Wolf 1998).

- **Increased property values:** Many aspects of green infrastructure could potentially increase property values in the Northside neighborhood by improving aesthetics, drainage, and recreation opportunities. These in turn can help restore, revitalize, and encourage growth in economically distressed areas. Table 1 summarizes recent studies that have estimated the effect that green infrastructure or related practices have on property values. The studies used statistical methods for estimating property value trends from observed data.



Source: JHP Architects

Figure 9. Walking distances in the Northside redevelopment area.

Table 1. Studies estimating percent increase in property value from green infrastructure

Source	Percent increase in property value	Notes
Ward et al. (2008)	3.5%–5%	Estimated effect of green infrastructure on adjacent properties relative to those farther away in King County (Seattle area), Washington
Shultz and Schmitz (2008)	0.7%–2.7%	Referred to effect of clustered open spaces, greenways, and similar practices in Omaha, Nebraska
Wachter and Bucchianeri (2006)	2%	Estimated the effect of tree plantings on property values for select neighborhoods in Philadelphia
Anderson and Cordell (1988)	3.5%–4.5%	Estimated value of trees on residential property (differences between houses with five or more front yard trees and those that have fewer), Athens–Clarke County (Georgia)
Voicu and Been (2008)	9.4%	Referred to property within 1,000 feet of a park or garden and within 5 years of park opening; effect increases over time
Espey and Owasu-Edusei (2001)	11%	Referred to small, attractive parks with playgrounds within 600 feet of houses
Pincetl et al. (2003)	1.5%	Referred to the effect of an 11% increase in the amount of greenery (equivalent to a one-third acre garden or park) within a radius of 200 to 500 feet from the house
Hobden et al. (2004)	6.9%	Referred to greenway adjacent to property
New Yorkers for Parks and Ernst & Young (2003)	8%–30%	Referred to homes within a general proximity to parks

3 Stormwater Management Toolbox

To meet the project and design goals discussed above, the team identified a set of green infrastructure practices appropriate for the Northside redevelopment. These practices manage stormwater at the source and provide neighborhood amenities by integrating planning and multifunctional stormwater practices into the planned development.

To assist the Northside developers with incorporating green infrastructure practices into the final Redevelopment Plan, the following discussion addresses constraints and opportunities associated with each stormwater management practice.

3.1 Green Infrastructure Policies, Regulations, and Incentives

Multiple green infrastructure practices can be incorporated into the Northside Development to complement and enhance the proposed layout while also providing water quality treatment and volume reduction. The following sections describe the proposed green infrastructure programmatic approaches that are well suited for the City and the Northside Development project and will help meet green infrastructure goals. It is important for the City to keep in mind when considering any of these approaches that green infrastructure is more likely to be accepted in the community and used in the Northside Development if plans encourage and the code allows such best management practices (BMPs) to be in required open space, recreation, landscaped, and right-of-way (ROW) areas.

3.1.1 Planning

The proposed Redevelopment Plan as presented in January 2014 already incorporates several key planning concepts that support green infrastructure including mixed-use development and redevelopment of brownfields, greyfields, and infill areas. Mixed-use development areas are proposed for Howard Street, Magnolia Street, and near VCOM. These areas allow for the co-locating of land uses, which decreases impervious surfaces associated with parking and decreases vehicle miles traveled—resulting in a reduction of hydrocarbons left on roadways and reduced air deposition. The Northside will also realize a significant reduction in regional runoff because the City is taking advantage of underused properties within the project area. Redeveloping already degraded sites such as the abandoned warehouses near Cleveland Academy rather than paving undeveloped sites for new development can dramatically reduce total impervious area while allowing the City to experience the benefits and opportunities associated with infill growth.

Additional municipal planning approaches could be used to support using green infrastructure within the Northside and the entire City.

The City's 2004 comprehensive plan and City parks plans could be updated to increase open space and pervious areas by incorporating a greenway park along Butterfly Creek and smaller "pocket parks" throughout the project area. The plan can also identify additional public retrofit projects that could use green infrastructure stormwater management techniques (e.g., Cleveland Academy, community center, Evins Street roundabout, fairgrounds, and artists' incubator). Open space areas contribute little pollution to stormwater and can provide large areas to infiltrate and treat stormwater. Urban tree canopy—for example, along streets or within off-street parking—can improve water quality while also providing shade, reducing the urban heat island effect, and improving air quality. Adopting a tree canopy coverage goal in the comprehensive plan could support increasing canopy cover with the Northside neighborhood. Greenways can provide community connectivity, healthy recreation, and water quality benefits. Parks can provide active and passive recreational facilities and accommodate green infrastructure BMPs.

Including a watershed protection zone in the City's comprehensive plan for the Butterfly Creek watershed would help support code changes and guide land use decisions designed to support and promote green infrastructure. Updating the City comprehensive plan to endorse context-sensitive street design with narrower streets in appropriate locations around the Butterfly Creek zone, as well as biking and walking, would provide the guidance necessary to encourage the use of green streets concepts by the City and by private developers.

In conjunction with developing a watershed protection zone for Butterfly Creek in the comprehensive plan, delineating a development overlay district in the zoning regulations for the watershed with specific development requirements or incentives for implementing green infrastructure would allow the City to institute a variety of development regulations and incentives applicable only to development within the watershed. The base zoning would not change. This could allow the City to use the Northside neighborhood as a test case for more progressive green infrastructure practices while ensuring that the restored Butterfly Creek is adequately protected. For example, Lancaster County, South Carolina, has established an overlay district to protect the Carolina Heelsplitter, an endangered species of fish in the Six Mile Creek watershed. The ordinance requires specific riparian buffers associated with the creation of impervious area as well as the required purchase of credits from the Carolina Heelsplitter Conservation Bank. Charlotte-Mecklenburg County in North Carolina has established multiple watershed overlay districts to protect potable water sources which specifies uses, buffers, density, and post-construction stormwater BMPs.

Note that the implementation options presented in the remainder of this section assume that an overlay district will be created. If the City chooses citywide adoption of a variety of the green infrastructure implementation options described below rather than just in a specified overlay district, a dedicated green infrastructure ordinance would consolidate the requirements into one document and could help developers more easily comply with and take advantage of incentives described in subsequent sections of this report.

Helpful Resources

Delaware River City Corporation. North Delaware Riverfront Greenway Design Guidelines. *www.drcc-phila.org/reports/NorthDelawareRiverfrontGreenwayDesign%20Guildelines_Final.pdf* .

This document establishes required criteria for constructing the North Delaware Riverfront Greenway in Philadelphia by providing design guidelines to developers and others who will be responsible for its implementation.

National Park Service. Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors: A Resource Book. *www.nps.gov/pwro/rtca/econ_all.pdf*.

The Rivers, Trails, and Conservation Assistance program of the National Park Service has produced this resource book to help local-level planners, park and recreation administrators, citizen activists, and nonprofit groups understand and communicate the potential economic impacts of their proposed or existing corridor project.

Town of Huntersville, North Carolina. Low Impact Development Ordinance. *ftp://ftp1.co.mecklenburg.nc.us/WaterQuality/PCO%20Ordinances/Huntersville%20Post-Construction%20Ordinance%20FINAL.pdf*.

The Town of Huntersville adopted a water quality ordinance that specifically promotes and defines green infrastructure practices and low impact development stormwater management requirements. The ordinance refers to an external water quality design manual for specific guidance.

County of Lancaster, South Carolina. Heelsplitter Overlay District Ordinance. *www.mylancastersc.org/vertical/sites/%7BA02FC01E-6C41-44F4-BE02-9B73FC0206C5%7D/uploads/%7B4B3C3CD3-1B49-4329-B754-E3652E697F81%7D.PDF*.

The County of Lancaster adopted an overlay district in 2008 to allow development within the watershed while placing restrictions and limitations on the development to protect the Carolina Heelsplitter, an endangered species.

City of Charlotte, North Carolina. Zoning Ordinance Chapter 10: Watershed Overlay Districts. *charmeck.org/stormwater/regulations/Documents/Water%20Supply%20Watershed%20Documents/CityZoningOrdChap10.pdf*.

The City of Charlotte has developed multiple overlay districts to protect potable water supplies.

3.1.2 Parking Requirements and Lot Design

Inflexible parking requirements that do not allow for alternative approaches, as well as standards that require too much parking for specific uses, could increase the amount of impervious surface in the Northside project area, which will increase overall volume and velocity of runoff into Butterfly Creek. Requiring too much parking for the need allows parking spaces to sit empty while increasing the overall imperviousness of a watershed. Greenville, South Carolina, found that 37–65 percent of City parking spaces sit empty, even during peak hours. Oversupplying parking also encourages greater vehicle use and detracts from the overall pedestrian environment. Off-street parking and driveways contribute significantly to the impervious areas on a residential lot. Reducing such dimensions can therefore minimize the effective impervious cover, reduce the amount of stormwater runoff from a site, and improve water quality. Incorporating the regulations and incentives below into parking space requirements in the overlay district will create the opportunity to meet the Northside’s parking demand with less impervious cover.

- Allow flexibility in meeting parking space requirements at municipal-owned facilities through shared parking, off-site parking, and similar approaches. For example, allow users of the proposed athletic fields and playgrounds to use the Cleveland Academy parking lots on the weekends and during the summer when school is out.
- Give credit for adjacent on-street parking, which can count for local parking requirements.

- Permit businesses with different peak demand periods to share their required parking spaces.
- Revise parking regulations to reduce minimums below standard Institute of Transportation Engineers' requirements based on analysis of actual parking demand/experience for existing and proposed commercial businesses within the overlay district.
- Create zones with reduced by-right parking requirements or waive all parking minimums in areas meant to serve pedestrian traffic (e.g., Healthy Food Hub area and Magnolia Street mixed-use area) or within the overlay district.
- Adopt maximum parking caps (e.g., 125 percent above minimum) for the planned Northside multi-family residential areas and commercial corridor along Magnolia and Church streets.
- Permit reduction in vehicle parking spaces through the provision of a minimum number of bicycle parking spaces in the mixed-use and student housing areas.

In addition, including the following green infrastructure practices into the overlay district's parking lot design standards will further reduce the environmental impact of parking required within the Northside Development, could afford additional community benefits by providing shade and, if appropriately placed, creating natural barriers between pedestrians and cars. These implementation options are recommended throughout the overlay district; however, they are specifically suited and recommended for the parking courtyards with common green space proposed for the multi-family residential housing developments proposed between Magnolia, Vernon, and Howard streets.

- Adopt standards requiring a minimum area of the parking lot to drain into landscaped areas and require the management of runoff from parking lots through green infrastructure practices including trees, vegetated islands, swales, rain gardens, or other approaches. The parking lot landscaping regulations should specify the types and sizes of shrubs and trees most appropriate for controlling and reducing stormwater runoff.
- Allow alternative or innovative landscaping solutions that provide stormwater management functions to count towards perimeter or other landscaping requirements.
- Adopt parking lot landscape regulations that require provision of trees, minimum percent of parking lot interior area to be landscaped (e.g., 10 percent), and minimum-sized landscaping areas (e.g., minimum of 25 square feet for island planting areas).
- Reduce drive aisle widths in parking lots to decrease the amount of pervious surface. For multi-family developments, drive aisles can be shared. In commercial developments, typical drive aisles can be reduced 5–10 percent.
- Create formal program offering incentives (e.g., cost sharing, reduction in street widths and parking requirements, and assistance with maintenance) for property owners who use pervious pavement elements.
- Adopt a requirement that some percentage of parking lots use pervious materials.
- Allow parking lot landscaping and green roofs on parking structures to be credited towards meeting local stormwater management requirements.

Helpful Resources

USEPA. Parking Spaces/Community Places: Finding the Balance through Smart Growth Solutions.
www.epa.gov/piedpage/pdf/EPAParkingSpaces06.pdf.

EPA developed this guide for local government officials, planners, and developers to demonstrate the significance of parking decisions in development patterns; illustrate the environmental, financial, and social impact of parking policies; describe strategies for balancing parking with other community goals; and provide case studies of places that are successfully using these strategies.

Metropolitan Transportation Commission. Developing Parking Policies to Support Smart Growth in Local Jurisdictions: Best Practices.
www.mtc.ca.gov/planning/smart_growth/parking/parking_study/April07/bestpractice_042307.pdf.

This report explores approaches to parking policies that support infill, transit-oriented development, and downtown development and provides examples of best practices and innovations from the Bay Area and beyond.

Maryland Governor's Office of Smart Growth. Driving Urban Environments: Smart Growth Parking Best Practices.
contextsensitivesolutions.org/content/reading/parking_md/resources/parking_paper_md/.

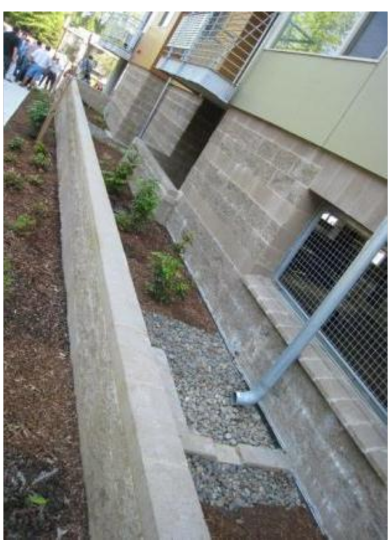
This study presents an overview of parking strategies that meet the challenges that projects face in the context of smart growth.

Metropolitan Area Planning Council. Eliminating Minimum Parking Requirements.
www.mapc.org/resources/parking-toolkit/strategies-topic/eliminate-minimum-reqs.

3.1.3 Street Design

Source: Tetra Tech

Source: Tetra Tech



Source: Tetra Tech

Figure 10. Examples of bioretention incorporated into rights-of-way.

Streets, sidewalks, and other hard surfaces contribute a large portion to Butterfly Creek watershed's total imperviousness. Making these impervious surfaces more permeable will protect the creek's pristine water quality, reduce flooding, and can help with recharging ground water. The width of street travel lanes, parking lanes, and sidewalks should be tailored to the Northside neighborhood. Where appropriate, narrowing travel lane width to 10–11 feet, rather than the standard 12–13 feet, can significantly reduce the total amount of impervious surfaces. Including vegetative green infrastructure practices (see Figure 10) in the median and ROW also can improve conditions for walking, biking and transit use, which reduces automobile use and overall demand for parking spaces, and will encourage walking around the Northside neighborhood and perhaps improve the pedestrian connection with surrounding amenities such as Wofford and downtown shopping areas. Applying an appropriate and feasible combination of all of the implementation approaches described below to create green streets at key locations can yield multiple benefits in the Northside Development.

- Incorporate green streets concepts into all new and realigned streets in the Northside such as bioretention in medians and bump-outs as well as using roadside planters, green features, and street trees in ROW.
- Revamp the City's street design specifications to allow context-sensitive, innovative street design with narrower travel lanes in appropriate circumstances—for example, residential streets within the project area.
- Allow street-side swales to replace conventional curb and gutter for managing stormwater and for separating sidewalks from street traffic in appropriate circumstances.
- Adopt technical specifications and design templates for green infrastructure practices, such as bioretention, in private and public rights-of-way.
- Adopt technical street specifications which allow pervious paving materials in appropriate circumstances.
- Adopt a requirement that some percentage of alleys or roads within the overlay district use pervious materials.

Helpful Resources

Institute of Transportation Engineers. Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities.
www.ite.org/css/.

USEPA. Stormwater Guidelines for Green, Dense Redevelopment: Stormwater Quality Solutions for the City of Emeryville.
www.epa.gov/dced/pdf/Stormwater_Guidelines.pdf

San Mateo County, California Water Pollution Prevention Program. Sustainable Green Streets and Parking Lots Design Guidebook.
www.flowstobay.org/documents/municipalities/sustainable%20streets/San%20Mateo%20Guidebook.pdf.

Portland Metro. Green Streets: Innovative Solutions for Stormwater and Stream Crossings.
www.oregonmetro.gov/tools-partners/guides-and-tools/guide-safe-and-healthy-streets.

This handbook describes basic stormwater management strategies and illustrates street designs with features such as street trees, landscaped swales, and special paving materials that allow infiltration and limit runoff. The handbook also provides guidance on balancing the needs of protecting stream corridors and providing access across those streams.

Canadian Institute of Transportation Engineers. Promoting Sustainable Transportation through Site Design: An Institute of Transportation Engineers Proposed Recommended Practice.
www.cite7.org/resources/documents/ITERP-PromotingSustainableTransportationThroughSiteDesign.pdf.

This report recommends site design practices that can be applied through the land development process to promote using more sustainable modes of passenger transportation such as walking, cycling, and transit.

USEPA. Managing Wet Weather with Green Infrastructure: Green Infrastructure Municipal Handbook – Green Streets.
water.epa.gov/infrastructure/greeninfrastructure/upload/gi_munichandbook_green_streets.pdf.

This handbook is a series of documents to help local officials implement green infrastructure in their communities.

3.1.4 On- and Off-site Stormwater Controls

Design standards should be in place that replicate the predevelopment hydrology of the site (to the extent practicable), maintain the water quality functions of the watershed, and minimize channel erosion and downstream flooding. As described in the *Spartanburg County Storm Water Management Design Manual* (Spartanburg County 2009), the City currently requires that projects disturbing more than 5,000 square feet meet both water quantity and quality standards as follows:

- The water quantity standards require that a developer provide extended detention of the first inch of runoff over the entire site and release it over a period of 24 to 72 hours; that post-development discharge rates from the entire development area must not exceed predevelopment discharge rates for the 2- and 10-year frequency 24-hour duration storm events; and that post-development discharge velocities in receiving channels must be nonerosive flow velocities and must be equal to or less than the predevelopment 2-year 24-hour storm event flow velocities.
- The water quality standards require that projects meeting the threshold install permanent controls. Detention structures must be designed to store and release the first half inch of runoff from the site over a minimum period of 24 hours; retention water quality structures must be designed to store and release the first inch of runoff from the site over a minimum period of 24-hours; and permanent water quality infiltration practices must be designed to accommodate, at a minimum, the first inch of runoff from impervious areas on the site.

These standards do not require or indicate a preference for on-site infiltration, reuse, or evapotranspiration on-site through implementing green infrastructure. As Figure 11 indicates, green infrastructure can closely mimic predevelopment streamflows.

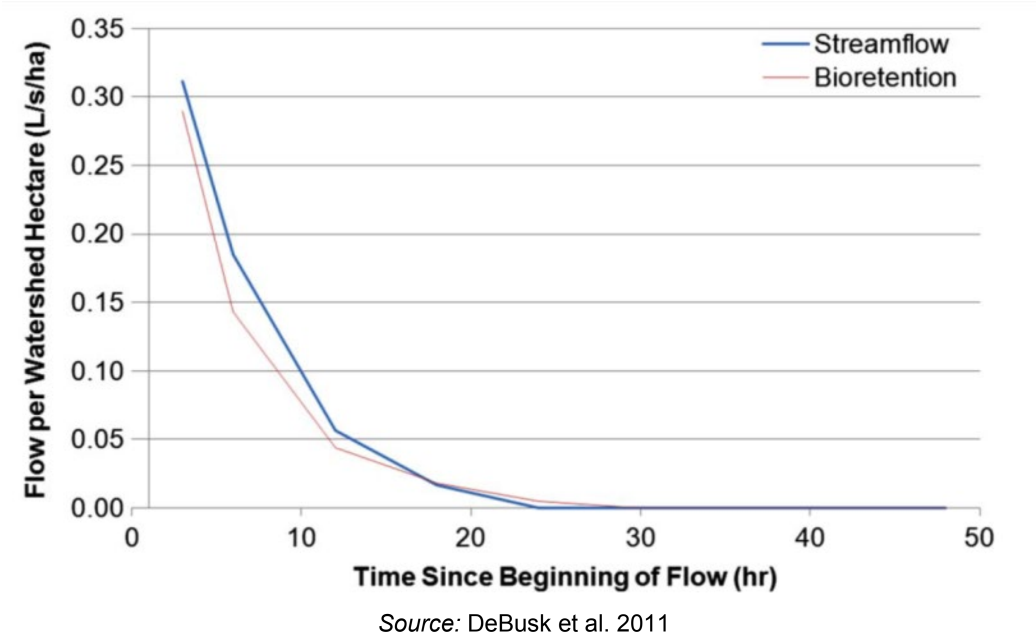
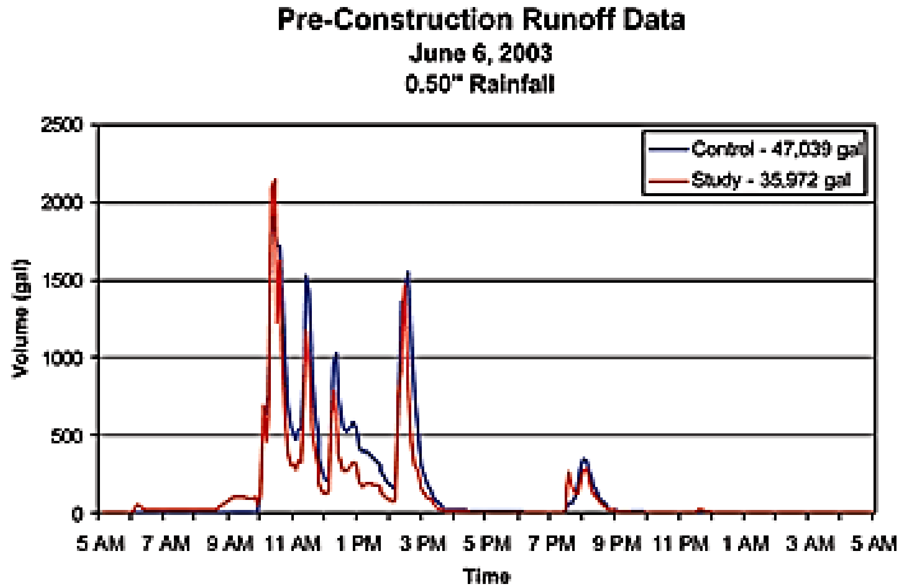
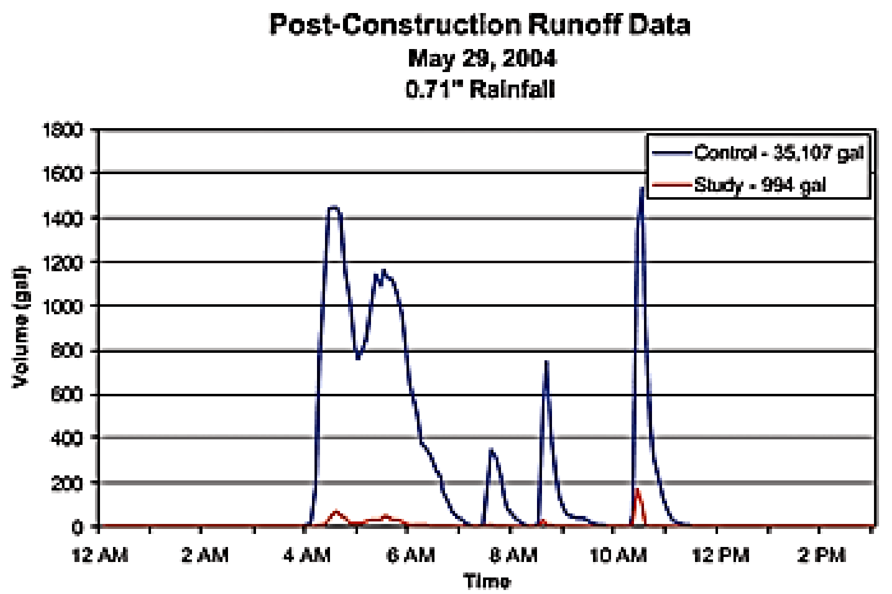


Figure 11. Comparison of bioretention discharge and predevelopment streamflow.

Furthermore, retrofitting existing sites with infiltration practices—such as the rain gardens used in the controlled study described in Figure 12—can result in a dramatic reduction in flow volumes from developed sites. A paired watershed study conducted in Burnsville, Minnesota, demonstrated that retrofitting a residential subdivision with rain gardens reduced the runoff volumes by approximately 90 percent (Barr Engineering Company 2006).

In many instances, on-site green infrastructure approaches are more effective and cost-efficient than conventional stormwater management practices. The American Society of Landscape Architects (ASLA) conducted a study in April 2012 that looked at 479 case studies around the United States of developments where the costs of using green infrastructure projects were compared to using grey infrastructure. The study found that using green infrastructure raised costs in about a quarter of projects. In about 31 percent the costs were projected to be the same, and in more than 44 percent using green infrastructure actually brought costs down. This can be explained, in part, because green infrastructure reduces built capital (equipment and installation) costs, operation costs, land acquisition costs, repair and maintenance costs, external costs (off-site costs imposed on others),and infrastructure replacement costs over grey infrastructure. Table 2 provides a comparison of typical green and grey infrastructure control measures.





Source: Barr Engineering Company 2006

Figure 12. Rainfall/runoff response before and after retrofitting of rain gardens in an existing development.

Table 2. Comparative volumetric unit costs of stormwater control measures

Stormwater Control Measures	Construction Cost per Volume of Water Stored within Cross-Section of Practice ($/CF)
Green Infrastructure	
Bioretention	$7
Planter Box	$9
Permeable Pavement	$22
Green Roof	$200
Tree Box	$67
Gray Infrastructure	
Underground Detention/Retention	
Subsurface Pipe Storage (Triton Stormwater Solutions)	$9
Interlocking Plastic Blocks (Cudo cube)	$15
Cast-in-Place Concrete Tank[a]	$26
Precast Concrete Vault[b]	$28

Source: American Rivers et al. (2012).
Notes:
a. The cast-in-place concrete tank cost and the precast concrete vault cost are based on engineering estimates for construction of a 6,400-cubic-foot storage unit.
b. The cost of a precast unit varies depending on how closely the storage capacity of the manufactured product matches the storage need.

Mitigation and In-Lieu Options

The City's standards also do not appear to provide for any alternative means of complying if meeting the standards on-site is not feasible. Allowing mitigation or in-lieu options to facilitate off-site green infrastructure implementation might be a way to increase the use of green rather than grey infrastructure within the Butterfly Creek watershed. There could be opportunities for regional green infrastructure practices within the greenway proposed along the Butterfly Creek daylighting project or in the headwaters of the watershed.

In addition to amending post-construction stormwater controls performance standards and methods of complying with the standard, the following implementation options will also support and promote green infrastructure in the overlay district:

- Amend plumbing and building codes to support opportunities for residential and commercial rainwater harvesting. For example, downspout disconnection/redirection, rain barrels, and cisterns can be used for outdoor water supply purposes such as irrigation and indoor uses such as toilet flushing.
- Create development incentives for green roofs (e.g., increased floor area ratio bonus, additional building height).

- Allow green infrastructure practices to count towards open space requirements (including green roofs).
- Allow additional open space credits for green infrastructure, which also has public recreational purposes (e.g., sports fields).
- Reduce stormwater management facility requirements for developments employing comprehensive rainwater harvesting.

It is important for the City to remember that green infrastructure practices must be maintained properly to operate as designed for the anticipated life span of the controls (see Table 12 and Table 13 for typical maintenance activities for select green infrastructure practices). Requirements for long-term maintenance agreements that allow for public inspections of the management practices and account for transfer of responsibility in leases or deed transfers or both are necessary to ensure proper maintenance. It is advisable to conduct inspections—either by City staff or certified self-inspections by property owners—every 3 to 5 years, prioritizing properties on the basis of risk to water quality and inspecting at least 20 percent of approved facilities annually.

Helpful Resources

USEPA. Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices.
water.epa.gov/polwaste/green/costs07_index.cfm.

This report provides information to cities, counties, states, private sector developers, and others on the costs and benefits of using low impact development strategies and practices to help protect and restore water quality and provides information on the cost savings and benefits that can be achieved by implementing low impact development practices versus conventional stormwater practices.

American Rivers, the Water Environment Federation, the American Society of Landscape Architects, and ECONorthwest. Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide.
www.asla.org/uploadedFiles/CMS/Government_Affairs/Federal_Government_Affairs/Banking%20on%20Green%20HighRes.pdf.

This report looks at the most cost-effective options for managing polluted runoff and protecting clean water, and finds that green infrastructure solutions save taxpayer money and provide community benefits by managing stormwater where it falls.

EcoNorthwest. The Economics of Low Impact Development: A Literature Review.
www.econw.com/media/ap_files/ECONorthwest-Economics-of-LID-Literature-Review_2007.pdf.

Santa Clara Valley Urban Pollution Prevention Program. Operations and Maintenance of Treatment Best Management Practices.
www.scvurppp-w2k.com/om_workproduct_links.htm.

Stormwater Center Maintenance Agreements Guidance and Case Studies.
www.stormwatercenter.net/Manual_Builder/Maintenance_Manual/4Maintenance_Agreements/Maintenance%20Agreements%20Introduction.htm.

USEPA. Managing Wet Weather with Green Infrastructure: Green Infrastructure Municipal Handbook – Rainwater Harvesting Policies.
water.epa.gov/infrastructure/greeninfrastructure/upload/gi_munichandbook_harvesting.pdf.

This municipal handbook is a series of documents to help local officials implement green infrastructure in their communities.

3.1.5 Buffer Requirements

Section 501.15 of the City's General and Supplemental Regulations specifies the requirements in the Riparian Buffer Overlay District; however, the requirements do not seem to apply to Butterfly Creek. In addition, a no-development buffer on both sides of Butterfly Creek and its tributaries would be more protective of the daylighted stream than a buffer area re-vegetated after damage during construction. The lead stream designer for the daylighting effort, Dr. Jon Calabria, recommended a 150 vegetated buffer along the daylighted reach. However, if the City allowed buffer areas to qualify for credit against local open space dedication/set-aside regulations, developers might be more inclined to comply with a buffer requirement rather than no development. Finally, if development within the buffer is allowed, a 2-to-1 mitigation requirement would provide additional protection.

Helpful Resources

USEPA. Model Ordinances to Protect Local Resources: Aquatic Buffers.
water.epa.gov/polwaste/nps/ordinance_index.cfm.

Center for Watershed Protection. Buffer Model Ordinance.
www.stormwatercenter.net/Model%20Ordinances/buffer_model_ordinance.htm.

Carl Vinson Institute of Government and the University of Georgia. Protecting Stream and River Corridors: Creating Effective Local Riparian Buffer Ordinances.
www.rivercenter.uga.edu/publications/pdf/riparian_buffer_guidebook.pdf.

This paper is a resource for local governments that plan to develop comprehensive riparian buffer ordinances. It presents scientifically based guidelines which evolved from an analysis of published scientific literature.

3.1.6 Urban Agriculture

By one definition, urban agriculture is the cultivation, processing, marketing, and distribution of food in urbanized areas, and ranges in scale from backyard or community gardens to suburban farms and resource distribution pathways between city and rural area. The existing field of research regarding soil and water interactions with ecologically based food production systems supports the assertion that large-scale implementation of urban agriculture can significantly help restore urban hydrology and water quality. Converting compacted soils or impervious rooftops to productive ecosystems can cause the following impacts to urban environments:

- Restore compacted urban soils to retain more rainwater through infiltration or soil absorption or both.
- Create a demand and end use for rainwater harvesting systems from rooftops.
- Change public perception of rainwater runoff to that of a resource that better serves their direct needs.
- Engage the public in management of on-site stormwater runoff.
- Recycle nutrients from municipal solid waste streams and atmospheric deposition.
- Cost-effectively covert unused rooftops (see Figure 13 and Figure 14) and vacant lots (see Figure 15 and Figure 16) to productive and beneficial systems.

Community members clearly expressed their desire for community gardens and access to fresh food at the January 2014 Public Workshop. Fortunately, the green infrastructure aspects of urban agriculture are gaining attention across the United States as a means to provide a larger set of benefits to communities. Urban agriculture also provides food security to densely populated areas, improves public health and fresh food access (especially in urban communities considered "food deserts"), and supports local economies (including new job opportunities). Although the Healthy Food Hub in the Northside (and its urban microfarm) will become a significant amenity to community health and well-being, the planned integration of urban agriculture and green infrastructure design can further meet the needs and goals of all stakeholders.

Source: Brooklyn Grange

Figure 13. Brooklyn Navy Yard rooftop farm.

Source: National Public Radio

Figure 14. Chicago Botanical Rooftop Garden.

Source: The Anthropik Network

Figure 15. Detroit Urban Farm on a previously vacant lot.

Source: CCC Food Policy Coalition

Figure 16. Ohio City Farm.

By integrating urban agriculture into green infrastructure initiatives, the Northside neighborhood could turn a perceived problem into a potential solution. For example, the green infrastructure goal to harvest stormwater to enhance both potable and nonpotable water supplies can help urban farmers solve one of their biggest challenges—reliable access to water (and nutrient inputs). Likewise, the embedded nutrients, higher oxygen content, and lower cost of stormwater runoff can make it a more ideal source of irrigation water compared to potable municipal or well water supplies.

A significant asset for promoting the benefits associated with urban agriculture within the Northside neighborhood is through the new community-supported Healthy Food Hub. Not only will this facility host multiple food-related entities (e.g., a local farmer's market, a small urban farm, a café, and a culinary training program), it can also serve as an important hub for engaging the public and creating a pathway to solicit the City's support and guidance to effectively expand urban agriculture. The following are examples of where various forms of urban agriculture can be cultivated throughout the Northside redevelopment:

- Education gardens at Cleveland Academy or other public institutions.
- Resident gardens throughout residential parking/courtyards.
- Edible perennial forest gardens along the restored Butterfly Branch stream corridor and greenway.
- Community gardens (or private microfarms) on existing vacant lots slated for later phases of development.
- Rooftop gardens (using intensive green roof design) on multi-story residential buildings.
- Commercial aquaponic, hydroponic, or mushroom operations at existing warehouses or the adaptive reuse artist incubator loft site.

The following implementation options might be necessary to support and promote urban agriculture in the Northside community:

- Amend the City's comprehensive plan to explicitly support using urban agriculture in residential and commercial areas and on municipal properties.
- Amend plumbing and building codes to support opportunities for residential and commercial rainwater harvesting and irrigation of urban agriculture.
- Review zoning regulations to ensure no barriers exist to using residential or commercially zoned land for urban agriculture.

Helpful Resources

Seeding the City: Land Use Policies to Promote Urban Agriculture. 2012.
www.NPLAN.org.

EcoDesign Resource Society. Urban Farming Guidebook.
www.refbc.com/sites/default/files/Urban-Farming-Guidebook-2013.pdf.

Fresh Water Society. Urban Agriculture as a Green Stormwater Management Strategy.
www.arboretum.umn.edu/UserFiles/File/2012%20Clean%20Water%20Summit/Freshwater%20Urban%20Ag%20White%20Paper%20Final.pdf.

Urban Design Lab. The Potential for Urban Agriculture in New York City.
www.urbandesignlab.columbia.edu/sitefiles/file/urban_agriculture_nyc.pdf.

Liebman, M.B., O.J. Jonasson, and R.N. Wiese. 2011. The Urban Stormwater Farm.
www.ncbi.nlm.nih.gov/pubmed/22053481.

3.2 Structural Green Infrastructure Practices

Many of the land use planning concepts discussed in Section 3.1 are useful to establish a foundation and framework for implementing a comprehensive green infrastructure strategy. Thoughtful land use and site-specific planning to minimize runoff can considerably decrease the size (and cost) of structural practices required to meet regulatory requirements or minimize water quality impacts. Once a site's configuration is optimized to reduce stormwater and pollutant sources, runoff from the remaining impervious surfaces should be intercepted and treated by structural green infrastructure practices which treat runoff using one or more of three basic elements: (1) infiltration, (2) retention/detention, and (3) biofiltration.

Although green infrastructure can fulfill both water quality and peak flow requirements on sites with adequate open space (and thus avoid the cost of separate detention facilities), urban redevelopment projects often pose space constraints that limit the application of green infrastructure. For infill projects with limited open space such as the Northside, green infrastructure can reduce the size and cost of required detention facilities, but might not be able to eliminate the need for detention facilities entirely.

The following sections briefly describe several structural green infrastructure practices that are proposed for the Northside redevelopment. These practices are well suited to higher density urban areas and helping mitigate the peak flow and volume reduction goals for the Butterfly Creek watershed. Refer the *South Carolina Department of Health and Environmental Control (SCDHEC) Stormwater BMP Handbook* for more detailed design information (SCDHEC 2005) unless otherwise noted.

3.2.1 Bioretention Facilities

Bioretention facilities are shallow, depressed areas with a fill soil and vegetation that infiltrate runoff and remove pollutants through a variety of physical, biological, and chemical treatment processes. The depressed area is planted with small- to medium-sized vegetation including trees, shrubs, grasses, and perennials, and may incorporate a vegetated ground cover or mulch that can withstand urban environments and tolerate periodic inundation and dry periods. Bioretention may be configured differently depending on the site context and design goals. This section summarizes general design considerations for bioretention facilities, and then describes two configurations designed for dense urban areas such as the Northside redevelopment area—planter boxes and tree boxes. Note that using these practices within the public ROW along streets in the Northside will require prior approval from the City.

Bioretention is well suited for removing stormwater pollutants from runoff, particularly for smaller (water quality) storm events, and can be used to partially or completely meet stormwater management requirements on smaller sites. Bioretention areas can be incorporated into the Northside to capture roof runoff and parking lot runoff on private property such as the multi-family residential units proposed in the Northside and within rights-of-way to capture sidewalk and street runoff (Figure 17 and Figure 18). These types of bioretention areas can also serve to green streets hoping to attract pedestrian traffic such as Howard Street.

The following is general bioretention design guidance to consider for the Northside area:

- For unlined systems, maintain a minimum of 5 feet between the facility and a building and at least 10 feet with a basement.

- A planting mix with a minimum hydraulic conductivity or permeability of 0.5 inches per hour (in/hr), either through infiltration with soils of sufficient percolation capacity or with an underdrain system and outlet to a drainage system. Although the soils in the Northside area are classified as having moderately low runoff potential (Hydrologic Soil Group [HSG] B classification), SCDHEC requires that all bioretention areas contain an underdrain system to ensure adequate drawdown times.
- Planted with native and noninvasive plant species that have tolerance for urban environments, frequent inundation, and the City's hot and temperate climate. For more information, refer to the following rain garden planting guide from Clemson University Public Service Activities (Clear and Giacalone 2009): *www.clemson.edu/psapublishing/pages/HORT/IL87.PDF*.
- Inclusion of an overflow structure with a nonerosive overflow channel to safely pass flows that exceed the capacity of the facility or design the facility as an off-line system.
- Inclusion of a pretreatment mechanism such as a grass filter strip, sediment forebay, or grass swale upstream of the practice to enhance the unit's treatment capacity.

Source: Tetra Tech, Inc.

Figure 17. Bioretention incorporated into a right-of-way.

Source: Biological and Agricultural Engineering Department, NCSU

Figure 18. Bioretention incorporated into traditional parking lot design.

Planter Box

Planter boxes are bioretention facilities contained within a concrete box, allowing them to be incorporated into tighter areas with limited open space. Runoff from a street or parking lot typically enters a planter box through a curb cut, while runoff from a roof drain typically enters through a downspout. Planter boxes are often categorized either as flow-through planter boxes or infiltrating planter boxes. Infiltrating planter boxes have an open bottom to allow infiltration into the underlying soils. Flow-through planter boxes are completely lined and have an underdrain system to convey flow that is not taken up by plants to areas that are appropriate for drainage away from building foundations. Planter boxes are well suited to narrow areas adjacent to streets and buildings (Figure 19).

Source: Tetra Tech, Inc. *Source:* Tetra Tech, Inc.

Figure 19. Planter box within the street right-of-way (top) and flow-through planter box attached to a building (bottom).

Tree Box

Tree boxes are bioretention facilities configured for dense urban areas that use the water-uptake benefits of trees. They are generally installed along street corridors with curb inlets (Figure 20). Tree boxes can be incorporated immediately adjacent to streets and sidewalks with the use of a structural soil, modular suspended pavement, or underground retaining wall to keep uncompacted soil in place. Tree boxes typically contain a highly engineered soil media to enhance pollutant removal while retaining high infiltration rates. The uncompacted media allows urban trees to thrive, providing shade and an extensive root system for water uptake. For low to moderate flows, stormwater enters through the tree box inlet and filters through the soil. For high flows, stormwater will bypass the tree box if it is full and flow directly to the downstream curb inlet.

Source: Tetra Tech, Inc.

Figure 20. Tree box using grate inlets in street.

3.2.2 Permeable Pavement

In contrast to traditional pavements, permeable pavements contain small voids that allow water to drain through the pavement to an aggregate reservoir and then infiltrate into the soil beneath impervious surfaces. Permeable pavement can be developed using modular paving systems (e.g., concrete pavers, grass pavers, or gravel pavers) or pour-in-place solutions (e.g., pervious concrete or permeable asphalt). Permeable pavements are most often used in constructing pedestrian walkways, sidewalks, driveways, low-volume roadways and parking areas of office buildings, recreational facilities, and shopping centers (Figure 21). However, composite designs using conventional asphalt or concrete in high-traffic areas adjacent to permeable pavements along shoulders or in parking areas can provide a more cost-effective solution for achieving both transportation and stormwater management goals.

The general native soil conditions in the Northside area (HSG B classification) are relatively well suited for permeable pavements because the higher percolation capacities increase infiltration and reduce the requirements for underdrains or excessive sub-base depths. Site-specific design criteria for permeable pavement are included in pages 150–151 of SCDHEC (2005) and in the following publication from Clemson University (Young 2013): (*www.clemson.edu/extension/hgic/water/resources_stormwater/introduction_to_porous_pavement.html*).

Source: Tetra Tech, Inc.

Source: Tetra Tech, Inc.

Figure 21. Pervious concrete (above) and permeable interlocking concrete paver (below) parking stalls.

Some additional guidelines for applying permeable pavement in the Northside area are as follows:

- Porous pavements are a good option in ultra-urban areas of the redevelopment because they are dual-purpose and consume no pervious area. One of the best applications of porous pavement for retrofits is on individual sites where a parking lot is being resurfaced.
- Although the Northside area soils are classified HSG B, soil borings to 4-inch depth need to be conducted at each site to determine if low-permeability soils, bedrock, or high water tables will require an underdrain system in the sub-base reservoir.
- An impermeable liner can be installed between the sub-base and the native soil to prevent water infiltration when clay soils have a high shrink-swell potential or if a high water table or bedrock layer exists.

- The minimum soil infiltration rate must be 0.3–0.5 in/hr.
- Measures should be taken to protect permeable pavements from high sediment loads, particularly fine sediment, to reduce maintenance. Typical maintenance includes removing sediment with a vacuum truck (SCDHEC 2005). See Table 13 for operation and maintenance activities for porous pavement.

3.2.3 Green Roofs

Green roofs introduce vegetation and soil media onto sections of rooftops to reduce imperviousness and absorb and filter rainfall. At a minimum, a green roof consists of a waterproof membrane and root barrier system to protect the roof structure, a drainage layer, filter fabric, a lightweight soil media, and vegetation that filter, absorb, and retain/detain the rainfall. Rainfall that infiltrates into the green roof is lost to evaporation or transpiration by plants, or, once the soil has become saturated, percolates through to the drainage layer and is discharged through the roof downspouts. Typically, a green roof is part of a treatment train with the green roof draining to another stormwater control measure such as a bioretention cell, bioswale, or cistern. They are fairly expensive compared to other green infrastructure practices, but might be a worthwhile asset if designed to allow human access.

Green roofs can cover large sections of a roof while maintaining access for utilities, maintenance, or recreation. The intended use for the space dictates the green roof design. The intended use can range from serving solely a water quality treatment mechanism (i.e., extensive green roof), to serving as a recreational space for building tenants (Figure 22). The soil media of extensive green roof systems is typically shallow (i.e., 2 to 6 inches) while the soil media for intensive systems is deep (i.e., more than 6 inches). Green roofs are most often applied to buildings with flat roofs, but can be installed on roofs with slopes using mesh, stabilization panels, fully contained trays, or battens. Alternatively, detention on roofs without vegetation (i.e., blue roofs) might be an option as long as the water drains through a biological filter, such as at ground level.

SCDHEC (2005) does not include green roofs; therefore, further design details should reference Chapter 19 of the North Carolina BMP Manual (NCDENR 2007).

General guidelines and components for installing green roofs are as follows:

- The building roof must be designed to safely support the saturated weight of the green roof, which varies depending on the green roof design and manufacturer.
- Extensive green roofs, with soil depths of 2 to 6 inches, are most commonly used for stormwater management.
- The soil media for green roofs should be light-weight and largely inorganic.
- Plants selected for green roofs should be hardy, self-sustaining, drought-resistant plants able to withstand daily and seasonal variations in temperature and moisture on rooftops. Typical plants used for extensive roofs are from the genera *Sedum* and *Delosperma*, or other succulents and hardy native perennials.
- At a minimum, a temporary irrigation system should be used to establish plants and ensure success during drought.
- A drainage layer installed beneath the green roof routes excess runoff from the roof to the downspouts.

- A root barrier installed below the drainage layer prevents plant roots from damaging structural roof membranes.
- A waterproof membrane is used to prevent transmission of moisture from the green roof to the structural roof.
- An insulation layer between the green roof and structural roof can improve the system's thermal qualities.
- An optional leak detection membrane can be used to assess the integrity of the waterproof membranes.

Source: Tetra Tech, Inc.

Source: Upstate Forever

Source: Green Roof Outfitters

Figure 22. Furman Company, Greenville, South Carolina (top left), Riverside High School, Greer, South Carolina (bottom left), Charleston VA Medical Center, Charleston, South Carolina (right).

3.2.4 Rainwater Harvesting

Cisterns or their smaller counterpart, rain barrels, are containers that capture runoff and store it for future use (Figure 23). With control of the timing and volume, the captured stormwater can be more effectively released for irrigation or alternative grey water uses between storm events. Rain barrels tend to be smaller systems, less than 100 gallons. Cisterns are larger systems that can be self-contained aboveground or belowground systems generally larger than 100 gallons. Belowground systems often require a pump for water removal. Cisterns and rain barrels primarily provide control of stormwater volume; however, water quality improvements can be achieved when cisterns and rain barrels are used for landscape irrigation or discharged to bioretention areas. Water in cisterns or rain barrels can be controlled by permanently open outlets or operable valves depending on project specifications. Cisterns and rain barrels can be a useful method of reducing stormwater runoff volumes in urban areas where site constraints limit the use of other BMPs. Table 3 outlines the advantages and limitations of rainwater harvesting.

Source: Tetra Tech, Inc.

Source: Tetra Tech, Inc.

Figure 23. Belowground cistern (left) and wood-wrapped cistern (right).

Cisterns are typically placed near roof downspouts so that flows from existing downspouts can be easily diverted into the cistern. Runoff enters the cistern near the top and is filtered to remove large sediment and debris. Collected water exits the cistern from the bottom or can be pumped to areas more conducive to infiltration. Cisterns can be used as a reservoir for temporary storage or as a flow-through system for peak flow control. Cisterns are fitted with a valve that can hold the stormwater for reuse, or they release the stormwater from the cistern at a rate below the design storm rate. Regardless of the intent of the storage, an overflow must be provided if the cistern's capacity is exceeded. The overflow system should route the runoff to a BMP for treatment or safely pass the flow into the stormwater drainage system. The overflow should be conveyed away from structures. The volume of the cistern should be allowed to slowly release, preferably into a BMP for treatment or into a landscaped area where infiltration has been enhanced.

Cisterns have been used for millennia to capture and store water. Droughts in recent years have prompted a resurgence of rainwater harvesting technology as a means of offsetting potable water use. Studies have shown that adequately designed and used systems reduce the demand for potable water and can provide important hydrologic benefits (DeBusk et al. 2012; Vialle et al. 2012). Hydrologic performance of rainwater harvesting practices varies with design and use; systems must be drained between rain events to reduce the frequency of overflow (Jones and Hunt 2010). When a passive drawdown system is included (e.g., an orifice that slowly bleeds water from the cistern into an adjacent vegetation bed or infiltrating practice), significant runoff and peak flow reduction can be achieved (AECOM Technical Service, Inc. 2011; DeBusk et al. 2012).

Table 3. Advantages and limitations of rainwater harvesting

Advantages	Limitations
• Provides peak flow mitigation for frequent and infrequent storm events • Aids in infiltration by delaying runoff • Variable configurations to meet site constraints • Can reduce the size of infiltration BMPs • Can be designed for high visibility to raise stormwater awareness or can be hidden from view • Effective where underground utilities or other constraints preclude use of surface/subsurface storage BMPs • Can be designed to supplement or replace nonpotable water supplies (for nonresidential uses) or for irrigation (residential or nonresidential)	• Requires regular maintenance of inlet filters and mosquito control screens • Can require structural support • Reuse systems might require filtration and disinfection per intended use and local plumbing codes

3.2.5 Infiltration Basins

Infiltration basins are shallow depressions filled with grass or other natural vegetation that capture runoff from adjoining areas and allow it to infiltrate into the soil (Figure 24). Using the soil's natural filtering ability to remove stormwater pollutants, infiltration facilities store runoff until it gradually discharges through the soil and eventually into the water table. This practice has high pollutant removal efficiency and can also help recharge ground water, thus helping to maintain low flows in stream systems.

Source: www.stormwaterpa.org

Figure 24. Infiltration basin as recreation area.

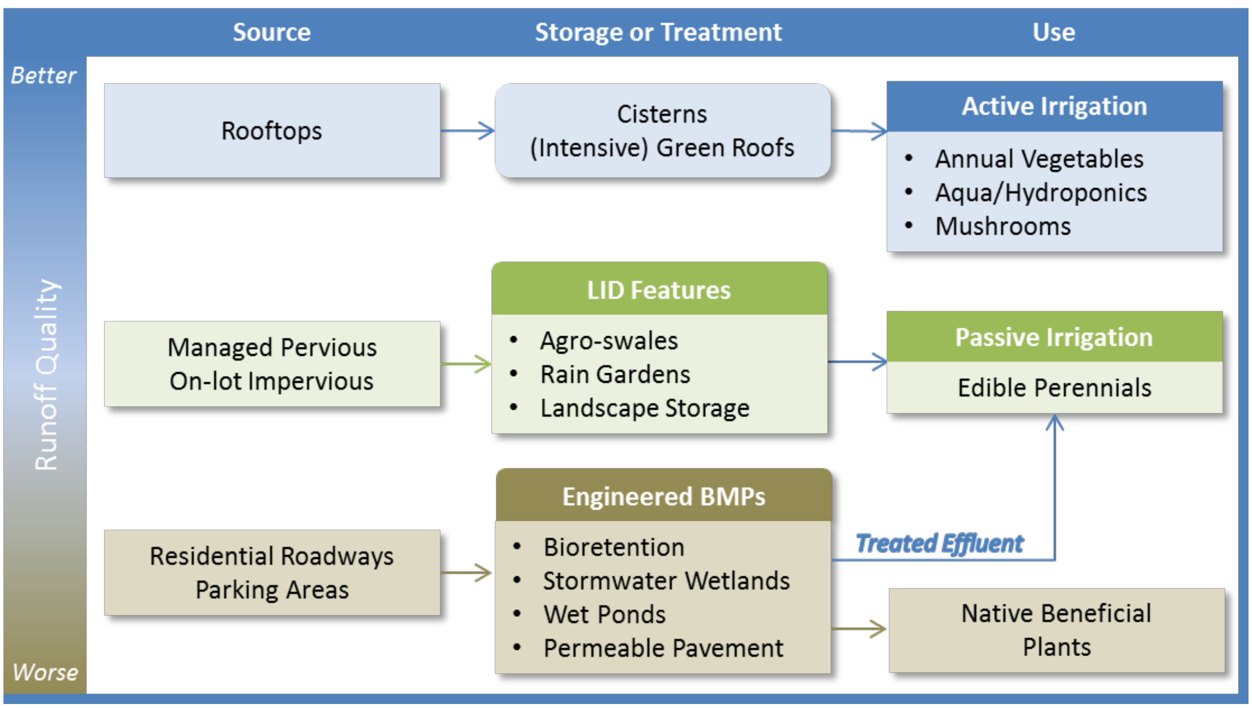
Infiltration basins can provide a useful BMP for the Northside redevelopment for several reasons. Although soil conditions often limit implementation of infiltration basins, the Northside area's HSG B soil classification indicates that recommended minimum infiltration rates (0.5 in/hr) would be met. However, the soil structures observed in the Northside area are fine enough to prevent ground water contamination from excessive stormwater infiltration. Also, because infiltration basins can be designed as a dual-purpose BMP with turf cover for recreation, this green infrastructure practice would be ideal for the common green space areas proposed for the residential courtyard blocks.

SCDHEC (2005) does not include infiltration basins as described above; however, further design guidance can be found in Chapter 16 of the North Carolina BMP Manual (NCDENR 2007). Some of the design considerations for infiltration basins include the following:

- Infiltration basins are not suitable on fill sites or steep slopes.
- Soils should have a minimum 0.52 in/hr infiltration rate.
- Basin should be a minimum of 15 feet downgradient of any structure.
- Upstream drainage area should be completely stabilized before construction.
- Pretreatment devices should be provided to prevent clogging.

3.2.6 Urban Agriculture Integration

The safe and effective integration of green infrastructure practices with urban agriculture in the Northside neighborhood is outlined in Figure 25 and further described below. Although these linkages are only a guideline and can vary from site to site, the outline demonstrates how the source and associated water quality of stormwater runoff can be matched with a management practice and beneficial reuse.



Source: Tetra Tech, Inc.

Figure 25. Stormwater reuse concept for urban agriculture in the Northside.

The cleanest source of urban stormwater runoff is typically from rooftops. However, access to open space for soil or reservoir storage can be limited in some of the higher density blocks. As a result, aboveground or belowground cisterns become viable options for preserving the quality of rooftop runoff and storing it for subsequent irrigation of higher value food crops. Annual vegetables, commercial mushroom operations, and aquaponic or hydroponic systems—all of which require both a relatively clean and constant water supply—are ideal uses for cistern water. From a stormwater management perspective, these proposed revenue-generating, beneficial end uses establish a reliable incentive for stormwater volume and nutrient load reductions. Note that intensive green roofs are included because rooftop vegetable farms provide additional production area for cistern water demand and create economic incentive for implementing this other green infrastructure BMP.

Although often discredited, urban soils, vacant land, and managed open space can contribute significant volumes of stormwater runoff and nutrient and sediment loads. Soil compaction, low organic matter contents, minimal vegetative cover, and improper or over-application of soluble fertilizers, among other things create stormwater runoff conditions from pervious areas that are more characteristic of impervious surfaces. These managed open space areas can be transitioned from mono-cultured lawns or compacted vacant lots to more productive ecosystems. From installing raised vegetable production beds on contour to building multifunctional swales and rain gardens planted with useful perennial species, urban agricultural practices can capture and infiltrate stormwater and build soil organic matter. Off-site runoff from impervious roadways and parking areas needs to be treated before the water is used for urban agriculture.

As the demand for urban agriculture continues to increase in U.S. cities, publicly owned open space can become a unique opportunity for public-private synthesis. By one scenario, if community gardens (or publicly supported microfarms) are integrated onto these public open space areas along with the stormwater practices listed in Figure 25, a mutually beneficial relationship can be created. Although the stormwater BMPs and management practices can provide irrigation supply and improved site ecology for urban agriculture systems, the renewed public perception towards BMPs as a resource to their community can help instill responsibility and ownership in BMP maintenance and operation—a popular concern of distributed stormwater practices among municipalities.

4 Conceptual Designs

One of the purposes of this report is to provide a conceptual stormwater management design for incorporation into the Redevelopment Plan. Because the final Redevelopment Plan will not be completed until late 2014, the conceptual green infrastructure practices presented here are template examples that apply to the block densities, streetscape styles, and typical development patterns selected during the Public Workshop held in January 2014. However, several redevelopment ideas discussed in Section 2 are conclusive enough to develop conceptual, site-specific green infrastructure designs. This report presents conceptual designs for both a typical residential block and a secondary street corridor. For these examples, the conceptual green infrastructure practices are designed, as much as possible, to meet the City's stormwater design criteria. A stormwater management professional should complete the final green infrastructure designs in conjunction with the final design of specific blocks, buildings, and street layouts.

The design professionals responsible for the final design of green infrastructure features will need to account for the final site/building layout, soil infiltration rates, and detailed survey information, which will dictate the final layout, sizing, and outlet control of the proposed stormwater control measures. The scenarios demonstrate how green infrastructure can complement and enhance the proposed layout while also providing water quality treatment and volume reduction.

4.1 Design Assumptions and Methodology

The overall conceptual design goal was to optimize the implementation of several green infrastructure scenarios into two proposed site plans while considering both the City's stormwater standards and available footprint areas. Each scenario (2–4 for each site) incorporates a unique collection of green infrastructure practices working collaboratively to address the site's stormwater management needs. Based on the *Spartanburg County Storm Water Management Design Manual* (Spartanburg County 2009) and discussions with City stormwater staff, much of the future redevelopment may qualify for a waiver from the City's runoff quantity requirements so long as there is adequate capacity in the downstream conveyance system to prevent flooding. Because predevelopment conditions are similar in impervious area compared to proposed conditions, it is anticipated that much of the Northside redevelopment may qualify for the waiver. City stormwater quality requirements, however, dictate the capture, treatment, and 24- to 72-hour extended detention of runoff from the 1-inch runoff event.

Although lower density areas of redevelopment within the Northside may be exempt from stormwater quantity control, the proposed higher density blocks will likely require control of the 2- and 10-year, 24-hour peak flow event to meet predevelopment discharge rates. In absence of detailed site information necessary to estimate peak flow rates for the conceptual designs, annual runoff volume was used as the preliminary design criterion to quantify the hydrologic impacts of the proposed green infrastructure practices. Where space was available based on the Phase I site plans, the BMPs were sized to capture and treat the 1-inch runoff event per the City's design standard. Otherwise, the BMP footprint was maximized within the available open space area depicted in the Phase I concept plans. As specified in the *Spartanburg County Storm Water Management Design Manual* (Spartanburg County 2009), the Composite Natural Resources Conservation Service (NRCS) Curve Number Method was used to determine the required water quality volume for each conceptual site.

Although local stormwater regulations might not explicitly require green infrastructure controls for most of the Northside redevelopment, the mitigation of watershed impervious area and hydrologic impacts necessary to protect the restored Butterfly Creek is also an important objective for community stakeholders. Green infrastructure controls can help reduce effective impervious surface in the drainage area to meet target thresholds. According to the reformulated Impervious Cover Model (ICM) (Schueler 2008), 25 percent watershed impervious area is considered the threshold when streams transition from “impacted” to “non-supporting.” Beyond 25 percent impervious area in a watershed, receiving water bodies become conduits for stormwater flows and can no longer support a diverse stream community; stream instability causes bank erosion, incision, and loss of important morphological features. The stream restoration professional advocating for the restoration of Butterfly Branch, Dr. Jon Calabria, verified this objective during the Northside redevelopment charrette.

In addition to the planning and zoning tools discussed in Section 3, the 25 percent ICM threshold can be achieved through a runoff reduction approach using structural green infrastructure practices. *Runoff reduction* can be defined as the total annual runoff volume reduced through canopy interception, soil infiltration, evapotranspiration, rainfall harvesting, engineered infiltration, or extended filtration at small sites. Depending on watershed impervious cover and ICM classification (i.e., sensitive, impacted, non-supporting, urban drainage), the annual runoff reduction target varies. For streams in “non-supporting” watersheds (more than 25 percent impervious area), the proposed runoff reduction target is the 90 percent or water quality event (Schueler 2008). The green infrastructure practices proposed for the conceptual designs and discussed in Section 3.2 were identified as having the highest runoff reduction rates compared to other BMPs (see Table 4).

Table 4. Annual runoff reduction rates for selected BMPs (Hirschman et al. 2008)

BMP	Annual Runoff Reduction Rate
Infiltration	50%–90%
Bioretention	40%–80%
Pervious Pavers	45%–75%
Green Roof	45%–60%
Cisterns	40%

EPA’s Stormwater Calculator was used to evaluate site hydrology and annual runoff reduction for each concept plan and scenario. The calculator estimates the total annual stormwater runoff, infiltration, and evapotranspiration generated for a particular site under different development and control conditions over a long-term period of historical rainfall. The tool accounts for soil conditions, topography, local meteorology, and land cover, and it can simulate a variety of structural low impact development practices with custom modifications.

Model inputs for soil and topographic information were the same for both concept plan sites. Based on the U.S. Department of Agriculture’s Soil Web Survey data (directly accessed through the calculator), Table 5 presents the model input for both concept plan sites. Meteorological input data used for the long-term simulation were derived from the Spartanburg 3 SSE location for years 1983–2006.

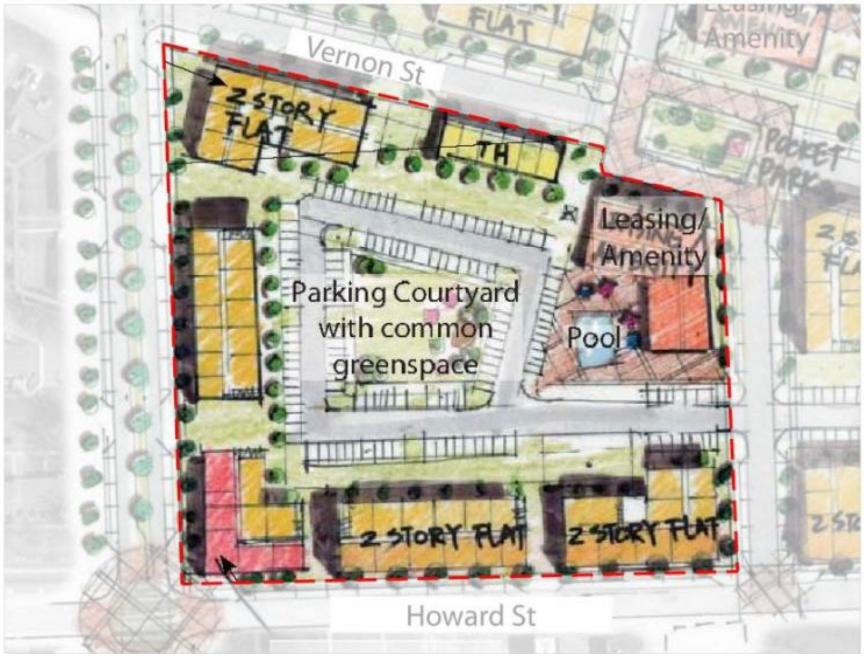
Table 5. Site and soil information used in EPA's Stormwater Calculator

Land Cover	Residential Block Concept	Green Street Concept
Site Area (ac)	6.0	0.4
Soil Series	Cecil-urban land complex	Cecil-urban land complex
Soil HSG	B	B
Soil Drainage (in/hr)	0.336	0.336
Topography	Moderately Steep (10% slopes)	Moderately Steep (10% slopes)

One of the derivatives within the calculator used to size the low impact development practices is capture ratio, which is the ratio of BMP footprint area to the impervious drainage area it collects. Capture ratio can be automatically calculated within the model for a specified design storm, or it can be manually entered if a BMP is undersized or oversized. This design factor, which is referred to in the conceptual design descriptions below, will be useful to future developers when determining the relative amount of open space required for green infrastructure practices and their associated hydrologic impacts.

4.2 Residential Block

One of the proposed residential blocks surrounding the pocket park on Vernon Street was selected to represent the residential land use typology. This block was selected because it is representative of the mixed-use development types that could be used throughout the Northside and draining directly to Butterfly Creek, and it is part of a multiblock area initially targeted as Phase I of the redevelopment activities. As depicted in Figure 26, the block consists of a mixture of two-story flats, town houses, and several public services buildings encircling a parking courtyard with common green space. The block, which does not include the adjacent publicly owned ROW, occupies approximately 6 acres and is characterized by the land use composition shown in Table 6. The land use characterization is based on the concept plan sketches developed during the Northside redevelopment charrette. The proposed land cover composition yields an impervious percentage for the site of approximately 61 percent and a composite Curve Number value of 88.6. Based on the NRCS method, a water quality volume of approximately 65,200 gallons of runoff from the 6-acre block will need to be detained and treated to meet the City's stormwater requirements.



Source: JHB Architects

Figure 26. Residential block used for concept plan.

Table 6. Proposed land cover for typical residential block

Land Cover	Percent of Total Site Area
Building	28%
Parking	17%
Sidewalk	5%
Roadway	11%
Lawn	39%
Total Impervious	61%

Four green infrastructure scenarios were developed for the residential block, with each scenario applying a different suite of structural green infrastructure practices selected as appropriate for the proposed site conditions and preferred by the Northside community. For each scenario, the proposed practices were evaluated to meet the volume reduction criterion described above, and conceptual drawings were produced to demonstrate how the proposed practices could be integrated into the site layout.

- **Scenario 1:** Includes a 5,064 sq. ft. infiltration basin in the courtyard that treats all of the internal roadway and parking areas. Internal roadway and parking areas account for approximately 45 percent of the total site impervious area, or 30 percent of the total site area. The infiltration basin was designed with **6-inch ponding height** and an assumed infiltration rate of 0.336 in/hr based on the native soil characteristics. Using the maximum available area within the parking courtyard, the proposed infiltration basin footprint yields a capture volume of 18,940 gallons, which is 29 percent of the required water quality volume for the site.

- **Scenario 2:** Same as Scenario 1, but with a **12-inch ponding height** for the infiltration basin yielding a capture volume of 37,890 gallons (or 58 percent of the water quality volume for the site). Similar to Scenario 1 the infiltration basin maximizes the available area in the courtyard but does not meet the design criteria.

- **Scenario 3**: Same as Scenario 2, but also includes rain gardens that treat all of the rooftops on the site, which account for 46 percent of the total impervious area (or 28 percent of the total site area). Collectively, the infiltration basin and rain gardens treat 92 percent of the total site impervious area. Using default parameters in the model, the rain gardens were assigned a **6-inch ponding height**, a **12-inch soil media thickness**, and **soil media conductivity of 10 in/hr**. The rain garden footprint areas, which were designed into the available open space around the proposed building footprints according to the Redevelopment Plan, yield a capture volume of 27,800 gallons. Combined with storage and treatment from the infiltration basin with 12-inch ponding depth, the Scenario 3 concept design treats 100 percent of the required water quality volume.

- **Scenario 4:** Same as Scenario 2, but used rainwater harvesting for all of the rooftops. The cisterns were designed to capture the 1-inch runoff water quality volume for the City (or roughly 1.2 inches of rainfall), which equates to 46,120 gallons of runoff. As part of the water balance calculations, the emptying rate (gal/day) was based on an assumed landscape irrigation rate of 1 inch of water per week that covered 50 percent of the open space on the site. Combined with the infiltration basin with 12-inch ponding depth, Scenario 4 exceeds the City's water quality standard and treats 129 percent of the required capture volume.

Table 7 shows the hydrologic results from EPA's Stormwater Calculator for all four green infrastructure scenarios, including the baseline condition. Compared to the baseline scenario (i.e., the proposed redevelopment land cover conditions without stormwater controls), Scenarios 3 and 4 reduce long-term annual runoff volumes by more than 50 percent and increase annual infiltration by approximately 70 percent. Most importantly, the captured water quality volume provided by each of the design scenarios is also shown, indicating that both Scenario 3 and 4 either meet or exceed the required target.

Table 7. Hydrologic results from EPA's Stormwater Calculator for residential block concept plan

Scenario	Runoff	Infiltration	Evapotranspiration	% of WQ Volume
Baseline	55%	38%	7%	**0%**
Scenario 1	40%	53%	7%	**29%**
Scenario 2	36%	57%	7%	**58%**
Scenario 3	27%	66%	9%	**100%**
Scenario 4	29%	62%	9%	**129%**

An additional analysis was also conducted with EPA's Stormwater Calculator to determine the equivalent impervious area for the site that would yield the same hydrologic impact as the proposed land cover with green infrastructure controls. Using the hydrologic results from Scenarios 3 and 4, which were statistically identical in regards to their impact on annual site hydrology, the calculator estimated that the proposed residential block with Scenario 3 or 4 green infrastructure controls is equal to a site with only 26 percent total impervious area, which is nearly equivalent to the 25 percent impervious watershed threshold recommended to protect the restored Butterfly Branch.

Figure 27 shows a site layout for the Scenario 4 concept plan, which includes the infiltration basin in the common courtyard and an underground cistern for landscape irrigation. The infiltration basin can contain turf grass or landscaped vegetation or both, and will only have ponded water during or immediately after significant storm events. Otherwise, this stormwater practice can also provide area for recreation and green open space. The 1,250 sq. ft. footprint area for the underground cistern represents the total area required to store the water quality volume from the rooftops (46,124 gallons) in a 5-foot-deep vault. Depending on final site conditions, several smaller cisterns would be distributed throughout the block to more effectively capture and reuse throughout the landscape.

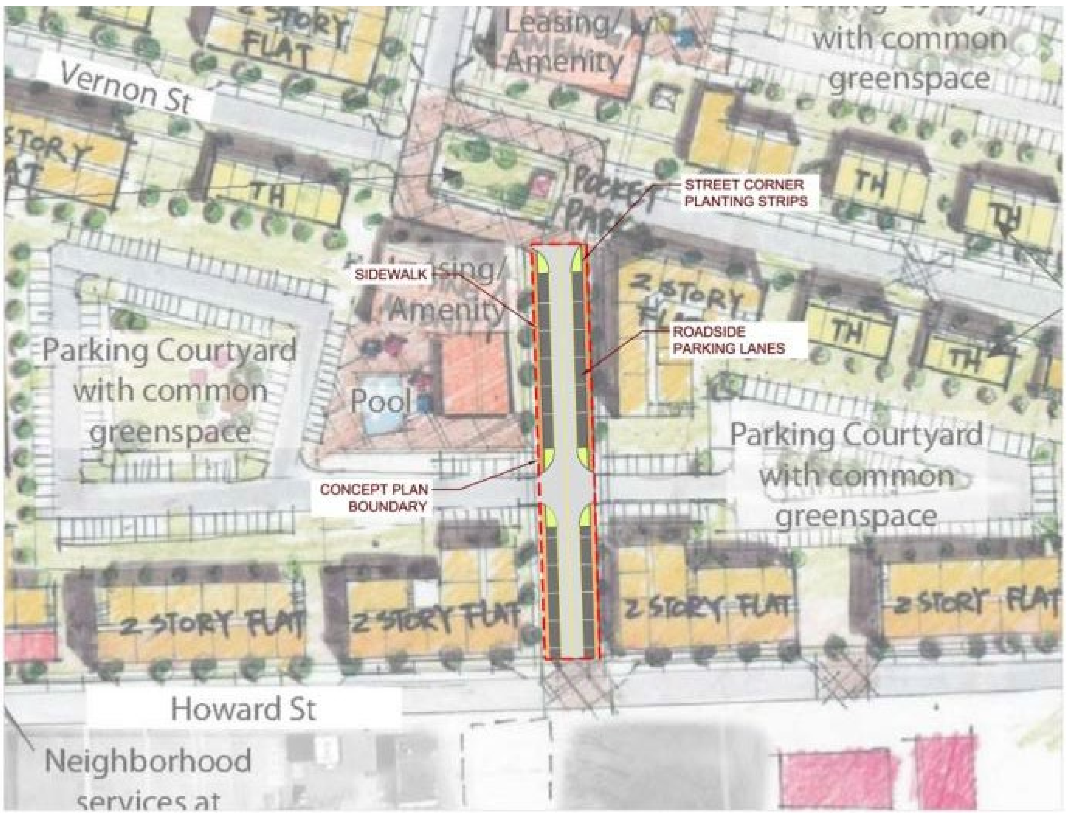
Source: JHB Architects and Tetra Tech, Inc.

Figure 27. Scenario 4 concept plan with equivalent BMP footprint areas.

4.3 Green Street

The second concept plan involved a green street design for a proposed road extension of Evins Street that will connect with Howard Street, directly east of the residential block used for the first concept plan. As mentioned during the January 2014 Public Workshop, the intent for extending Evins Street was to provide better pedestrian connectivity between Wofford College and central Northside (particularly the Healthy Food Hub and farmer's market).

Figure 28 shows the extent of the green street plan for the Evins Street expansion. Based on the proposed Redevelopment Plan and general secondary road standards for the City, a 50-foot-wide ROW was used for the green street. For the purposes of the concept plan, it was assumed that the ROW would contain 5-foot-wide sidewalks on both sides of the street, two 10-foot-wide parking lanes (including curb and gutter), and two 10-foot travel lanes. Approximately 5 percent of the ROW was allocated as street corner planting strips. Using the NRCS method and a composite Curve Number of 97.5, the proposed green street section will require a water quality treatment volume of 10,950 gallons of runoff.



Source: JHB Architects and Tetra Tech, Inc.

Figure 28. Section of Evins Street extension used for green street concept plan.

Two green street scenarios were developed and evaluated for the concept plan.

- **Scenario 1:** Uses street planters (i.e., bioretention planter boxes) to treat 100 percent of the impervious area in the ROW, including sidewalks, parking lanes, and travel lanes. The street planters were designed to capture the 1-inch runoff water quality volume using **6 inches of ponding height, 18-inch media depth**, a **12-inch gravel bed thickness**, and an assumed **soil conductivity of 10 in/hr**. The required capture ratio (ratio of street planter area to total treated impervious area) was approximately 5 percent.
- **Scenario 2:** The second scenario used permeable pavement in the parking lanes to treat 81 percent of the ROW impervious area (excluding sidewalks). This configuration yields an oversized capture ratio of 38 percent, although permeable pavement is often recommended with a 1-to-1 capture ratio. The permeable pavement was simulated with a **6-inch pavement thickness** and an **18-inch gravel thickness**.

Table 8 shows the hydrologic results from EPA's Stormwater Calculator for the two green street scenarios. Both the street planter and permeable pavement scenarios reduce the annual baseline runoff volumes by approximately 400 percent. With regards to the City's water quality standard, Scenario 1 treats 100 percent of the required capture volume while Scenario 3 stores and treats more than three-times the target.

Using a similar equivalent impervious area analysis for Scenario 1, the hydrologic impact from treating the 1-inch runoff volume with street planters is equal to the same street ROW with 17 percent impervious area and no stormwater control practices.

Table 8. Hydrologic results from EPA's Stormwater Calculator for green street concept plan

Scenario	Runoff	Infiltration	Evapotranspiration	% of WQ Volume
Baseline	84%	5%	11%	**0%**
Scenario 1	18%	67%	15%	**100%**
Scenario 2	17%	75%	8%	**345%**

Figure 29 shows the Scenario 1 green street plan with the relative areas of the street plants represented. The required area for the street planters to treat the water quality volume is equal to about four parking stalls, which would be lost to implement the proposed green infrastructure.

Source: JHB Architects and Tetra Tech, Inc.

Figure 29. Scenario 1 green street concept plan with street planters.

Figure 30 shows a sectional view of the planter box with an optional permeable pavement lane overlaid on one of the residential block renderings developed at the January 2014 Public Workshop.

Source: JHB Architects and Tetra Tech, Inc.

Figure 30. Section view of green street concept plan with street planters.

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5 Preliminary Opinion of Probable Costs

The purpose of this section is to provide guidance on the likely cost of implementation for the green infrastructure components identified for each project site and scenario described in Section 4 and representative of costs associated with green infrastructure throughout the Northside redevelopment area. Given the preliminary nature of the Northside master plan and the level of uncertainty regarding final site features, site conditions, and green infrastructure practice configurations it is not appropriate or possible to develop cost estimates based on a construction/bid item quantities and unit costs. Rather, the cost estimates reported below are based on unit area or unit treatment costs available from relevant published sources. Although the level of uncertainty in these cost estimates might be relatively high they provide a representative level of cost for implementing green infrastructure, which can be applied throughout the Northside redevelopment area where site conditions are similar to the two project sites.

5.1 Unit Cost Data

The cost estimates provided in Table 9 are based on planning level unit cost values published for each of the respective green infrastructure practices recommended as part of the project site scenarios detailed in Section 4. King and Hagen (2011) reported unit cost data for a variety of stormwater practices including both traditional and green infrastructure as well as nonstructural practices. Although these unit cost estimates are based on projects in Maryland, they are appropriate for use throughout the mid-Atlantic and southeast given the similar climate and practice design standards and are appropriate for use in the South Carolina Upstate.

Table 9. Green infrastructure planning level unit costs per acre treated (King and Hagen 2011)

GI Practice	Preconstruction	Construction	Annual O&M	Total 20-yr
Infiltration	$17,500	$43,750	$906	$4,219
Bioretention, Urban	$52,500	$131,250	$1,531	$10,869
Permeable Pavement	$21,780	$217,800	$2,188	$14,167

Unit cost data for rainwater cistern systems is highly variable and dependent on cistern configuration and the rainwater utilization system. Unit construction cost was estimated at $1 per gallon of storage based on similar project installations in North Carolina (Hunt 2013) and an additional $1 for utilization system based on professional judgment. Other unit costs were based on best professional judgment and experience in implementing rainwater cistern applications in similar settings.

5.2 Typical Residential Block

Table 13 summarizes preliminary implementation costs for the typical residential block project site. Published unit construction costs for the infiltration basin in scenarios 2, 3, and 4 were escalated by 2 percent to account for the additional excavation depth necessary to accommodate the additional 6 inches of storage depth relative to the infiltration basin configuration evaluated under scenario 1. Rain garden costs were assumed to be approximated by published bioretention unit costs for rural or suburban settings.

Table 10. Preliminary implementation cost estimates for the typical residential block project site

Scenario	Acres treated/ storage	Preconstruction	Construction	Annual O&M	Total 20-yr
Scenario 1					**$157,946**
Infiltration (6-in storage)	2	$34,825	$87,063	$1,803	$157,946
Scenario 2					**$158,643**
Infiltration (12-in storage)	2	$35,522	$87,063	$1,803	$158,643
Scenario 3					**$290,385**
Infiltration	2	$34,825	$87,063	$1,803	$158,643
Rain garden	1.7	$15,938	$63,750	$2,603	$131,742
Scenario 4					**$291,063**
Infiltration	2	$34,825	$87,063	$1,803	$158,643
Cistern	46,120*	20,000	$92,420	$1,000	$132,420

*gallons of cistern storage.

5.3 Green Street

Table 11 summarizes preliminary implementation cost estimates for the green street site. Unit costs for the planter boxes were assumed to be represented by bioretention in highly urban settings given the necessary curbing and other hardened infrastructure adjacent to the planter box.

Table 11. Preliminary implementation cost estimates for the green street project site

Scenario	Acres treated	Preconstruction	Construction	Annual O&M	Total 20-yr
Scenario 1					
Planter Boxes	0.43	$22,532	$56,438	$658	$92,136
Scenario 2					
Permeable Pavement	0.33	$7,187	$71,874	$722	$93,502

6 Operations and Maintenance

Maintenance activities should focus on the major system components, especially landscaped areas and permeable pavement. Landscaped components should blend over time through plant and root growth and organic decomposition, and should develop a natural soil horizon (Table 12). The biological and physical processes over time will lengthen the facility's life span and reduce the need for extensive maintenance. The primary maintenance requirement for permeable pavement consists of regular inspection for clogging and sweeping with a vacuum-powered street sweeper (Table 13).

Irrigation for the bioretention systems might be needed, especially during plant establishment periods or in periods of extended drought. Irrigation frequency will depend on the season and type of vegetation. Native plants will likely require less irrigation than nonnative plants.

The following tables outline the required maintenance tasks, their associated frequency, and notes to expand upon the requirements of each task.

Table 12. Bioretention operations and maintenance considerations

Task	Frequency	Maintenance notes
Monitor infiltration and drainage	1 time/year	Inspect drainage time (12–24 hours). Might have to determine infiltration rate (every 2–3 years). Turning over or replacing the media (top 2–3 inches) might be necessary to improve infiltration (at least 0.5 in/hr).
Pruning	1–2 times/year	Nutrients in runoff often cause bioretention vegetation to flourish.
Mowing	2–12 times/year	Frequency depends on the location, plant selection, and desired aesthetic appeal.
Mulching	1–2 times/ year	Recommend maintaining 1- to 3-inch uniform mulch layer.
Mulch removal	1 time/2–3 years	Mulch accumulation reduces available water storage volume. Removing mulch also increases surface infiltration rate of fill soil.
Watering	1 time/2–3 days for first 1–2 months; sporadically after establishment	If drought conditions exist, watering after the initial year might be required.
Fertilization	1 time initially	One-time spot fertilization for first year vegetation (optional).
Remove and replace dead plants	2 times/year	Within the first year, 10% of plants can die. Survival rates increase with time.
Inlet inspection	Once after first rain of the season, then every 6 months	Check for sediment accumulation to ensure that flow into the retention area is as designed. Remove any accumulated sediment.
Outlet inspection	Once after first rain of the season, then monthly during the rainy season	Check for erosion at the outlet and remove any accumulated mulch or sediment.

Task	Frequency	Maintenance notes
Underdrain inspection	Once after first rain of the season, then yearly during the rainy season	Check for accumulated mulch or sediment. Flush if water is ponded in the bioretention area for more than 72 hours.
Miscellaneous upkeep	12 times/year	Tasks include trash collection, plant health, spot weeding, and removing mulch from the overflow device.

Table 13. Permeable pavement operations and maintenance considerations

Task	Frequency	Maintenance notes
Impervious to pervious interface	Once after first rain of the season, then monthly during the rainy season	Check for sediment accumulation to ensure that flow onto the permeable pavement is not restricted. Remove any accumulated sediment. Stabilize any exposed soil.
Vacuum street sweeper	Twice per year as needed	Portions of pavement should be swept with a vacuum street sweeper at least twice per year or as needed to maintain infiltration rates.
Replace fill materials (applies to pervious pavers only)	1-2 times per year (and after any vacuum truck sweeping)	Fill materials will need to be replaced after each sweeping and as needed to keep voids with the paver surface.
Miscellaneous upkeep	4 times per year or as needed for aesthetics	Tasks include trash collection, sweeping, and spot weeding.

7 Conclusions

The conceptual stormwater management design developed for the Northside redevelopment project demonstrates how green infrastructure approaches can complement smart growth principles—providing innovative stormwater management while accommodating and supporting infill, mixed-used development and affordable housing.

The Northside neighborhood residents indicated that they wanted more green space, access to fresh food, more opportunities to recreate outdoors, and more walkable neighborhoods. To accomplish these overall goals, the community selected five site-specific transformational projects to be designed and implemented in the redevelopment area. Based on input from the project team, each of these projects will incorporate green infrastructure principles such as green space, street trees, urban agriculture, and a riparian greenway per the desires expressed by the residents. In addition, the City project team expressed an interest in the development of generic conceptual designs that could be incorporated throughout the redevelopment area. Due to the early phase of the overall redevelopment project, these conceptual designs were not based on a specific location; rather, they were developed based on certain basic design assumptions incorporating bioretention, permeable pavement, green roofs, rainwater harvesting infiltration basins, and urban agriculture. Both the Residential Block and Green Street design can be used in multiple locations throughout the redevelopment area—including the transformation projects described during the public workshop—and will support the vision of the master Northside Redevelopment Plan.

In addition, the City project team expressed an interest in revising existing plans, codes, and ordinances to better support the implementation of green infrastructure during the redevelopment of the Northside neighborhood and throughout the City. This report also provides specific guidance regarding how City planning documents and regulations can be revised to remove barriers and integrate the use of green infrastructure into the development ideology of the City.

As cities and towns seek to revitalize historic neighborhoods and redirect growth into existing urban areas, green infrastructure can complement redevelopment efforts. In addition to meeting stormwater management goals, this project illustrates how green infrastructure can help create a more attractive and livable landscape that weaves functional natural elements into the built environment.

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