GREEN INFRASTRUCTURE IN PRACTICE

A Stormwater Management Case Study from Atlanta, GA

Report by Chattahoochee Riverkeeper - January 2019

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Executive Summary

The following report discusses the use of green infrastructure to reduce urban stormwater runoff in Atlanta, Georgia. In 2013, the City of Atlanta adopted an ordinance that requires all new development and redevelopment to manage the first inch of rainwater that falls on a site using green infrastructure. In the first six years after the ordinance was adopted, over 4,800 new green infrastructure practices at commercial and residential sites in the city were permitted. Since then, the Georgia Environmental Protection Division has adopted green infrastructure requirements similar to Atlanta's for all other Georgia cities and counties who operate Municipal Separate Storm Sewer Systems. Using the City of Atlanta's experience as an example, this report provides an introduction to green infrastructure, outlines the city's approach to implementing the new requirements, and presents three recent developments as examples of typical projects that meet the new requirements. The objective of this publication is to provide a resource for anyone interested in green infrastructure, especially municipalities enacting policies that promote its use as a stormwater management strategy.

About Chattahoochee Riverkeeper

Chattahoochee Riverkeeper's (CRK) mission is to advocate and secure the protection and stewardship of the Chattahoochee River, including its lakes, tributaries and watershed, in order to restore and conserve their ecological health for the people and wildlife that depend on the river system.

Established in 1994, CRK has kept watch over the Chattahoochee for 25 years, and is supported by more than 8,600 members. CRK was the 11th licensed program of the global Waterkeeper Alliance, now more than 300 organizations strong.

Acknowledgements

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Introduction

The Challenge of Stormwater

When it rains in a city, impervious surfaces, like rooftops and asphalt prevent rainwater from soaking into the soil. The resulting stormwater runoff collects litter, chemicals, and sediment as it flows across the ground and is generally treated as a liability to be managed. Cities have traditionally dealt with stormwater runoff using a system of drains, underground pipes, and culverts. Often referred to as 'gray infrastructure,' this approach to stormwater management is typically designed to provide the single benefit of draining the urban landscape as quickly as possible, discharging large volumes of stormwater into nearby streams and rivers. In a highly impervious urban area like Atlanta, the amount of runoff generated in even a small rainstorm is a major source of pollution and erosion in waterways. Larger storms can produce enough water to overwhelm a city's stormwater system as well as its sewers, causing flooding of streets and homes and hazards to public health.


Stormwater runoff poses significant harm to streams and rivers.

The more pavement and rooftops that a city has, the more stormwater that it produces. Most municipalities have policies to reduce the stormwater impacts of new development, which helps protect residents, waterways, and municipal infrastructure. Typically, developers are required to ensure that new and redeveloped properties are designed to address both the volume and quality of stormwater runoff that occurs after construction is complete, or 'post-construction'.

How We Manage Post-Construction Stormwater

The post-construction stormwater requirements that a developer must meet are set through both local and state policy. In Georgia, any local government that owns and operates infrastructure designed to convey stormwater must have a Municipal Separate Storm Sewer System (MS4) permit with the Environmental Protection Division (EPD). Based on a municipality's size, EPD issues one of three MS4 general permits (Phase I Large, Phase I Medium, or Phase II Small), which are updated and renewed every 5 years. The MS4 permit sets guidelines that include post-construction stormwater management requirements that a local jurisdiction must set for any development or redevelopment within a MS4 area. Local jurisdictions can also adopt additional ordinances that set stormwater requirements for development outside of their MS4 area.

Post-construction stormwater requirements generally include standards for both reducing the volume of runoff and for improving the water quality of stormwater before it leaves a site. Up until recent MS4 permit updates, most municipalities in Georgia have required newly developed or redeveloped properties to include stormwater management practices that provide:

- **Channel protection for downstream waterways** – A development's stormwater practices must be equipped to detain the 1-year storm, 24-hour storm event, releasing it over a 24 hour period.
- **Flood protection** – The peak discharge of stormwater from a development must not exceed the site's pre-development peak discharge for the 25-year, 24-hour storm event.
- **Stormwater treatment** – A development's stormwater management system must remove 80% of the average annual post-development total suspended solids load from the 1.2 inch rainfall event.

Improving Our Stormwater Management Standards

The requirements discussed above have set the standard for post-construction stormwater management in Georgia since 2001. However, EPD and the development community have determined several aspects of the regulations that needed an update. The most common approach for developers to meet the above requirements has been to utilize over-sized detention ponds, underground vault systems, and costly, proprietary water quality devices. Each of these can present problems after construction is complete. Single purpose detention ponds often become eyesores in a development and create a feeling of wasted space.


Detention ponds often become unsightly and require a significant amount of space.

Meanwhile, underground vaults and proprietary devices stay out of sight and require special tools to maintain, leading to inadequate upkeep and subsequent failure. Developers have also found the flood protection component of the old requirements problematic because pre-development stormwater discharge volumes vary widely depending on whether a site was forested or highly impervious.

Fortunately, EPD has taken steps to improve the way we manage stormwater. During the agency's most recent round of permit renewals, EPD revised the post-construction stormwater requirements for all Phase I Large, Phase I Medium, and Phase II Small MS4 operators. Under the new rules, municipalities must revise their post-construction stormwater ordinances and require new development or redevelopment within their MS4 to retain the first inch of rainfall on site using green infrastructure. EPD has provided a phase-in period for the new requirements, which, depending on the size of the MS4, must be implemented by the end of 2020. To view the new permit requirements, visit: epd.georgia.gov/storm-water.

What is Green Infrastructure?

In contrast to the conventional approach to managing stormwater, green infrastructure (also called low impact development) manages rainwater where it falls and restores the natural flow of water through a landscape. Green infrastructure often uses plants, engineered soils, and other technologies to capture and reuse stormwater, infiltrate water into the soil, and increase stormwater uptake by plants. This approach can be implemented in tandem with conventional gray infrastructure approaches, and provides added benefits of removing pollutants present in stormwater runoff and improving water quality. By slowing and infiltrating stormwater, green infrastructure can also recharge base flows in creeks and rivers.

Many city managers around the country have come to realize that in addition to improving stormwater management, green infrastructure maximizes the impact of municipal investments by providing multiple community benefits at once. Trees and plants incorporated into green infrastructure help improve air quality by filtering airborne pollutants like ozone and nitrogen oxides and trapping particulates. These vegetated areas also help counteract urban heat and can be used to buffer noise and provide traffic calming. In addition, beautification associated with increased green infrastructure can improve property values and residents' quality of life.

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Common Types of Green Infrastructure

Bioretention

Photo by Atl Dept of Watershed Mngmt

A planted area designed to receive and infiltrate stormwater and promote uptake by plants. These often incorporate a specialized soil mix and an underdrain or outlet structure to control ponding.

Permeable Pavement

An alternative to conventional paved surfaces that allows stormwater to drain through the surface to a layer of stone beneath. The water then infiltrates into the soil or slowly flows into the stormwater system through an underdrain.

Bioswale

A linear bioretention area that conveys stormwater while slowing its flow and promoting water uptake by plants and infiltration into the soil.

Stormwater Planter

Photo by Atl Dept of Watershed Mngmt

Specialized planters that receive stormwater runoff from an adjacent roadway or sidewalk. Planters often contain layers of gravel and soil to store stormwater, and allow it to infiltrate into soil, evaporate, or be taken up by plants.

Green Roof

A layer of vegetation planted atop a waterproof membrane on a building's roof. Precipitation is captured within the growing medium, decreasing and slowing runoff. Green roof systems reduce a building's impervious area and can reduce climate control costs.

Rainwater Harvesting

Cisterns and rain barrels collect runoff from rooftops or other impervious areas, storing water for irrigation, non-potable building uses, or for slow release into an infiltration system after a storm.

Underground Infiltration

Systems such as modified French drains, dry wells, and open-bottom infiltration chambers below the soil surface. Stormwater runoff enters these systems through piped connections and is detained and allowed to infiltrate into the subsurface soil.

Preservation of Natural Areas

Preservation of natural areas such as forests, wetlands, and stream buffers is considered the most effective green infrastructure strategy for stormwater management. These ecosystems slow the flow of stormwater and reduce runoff through evapotranspiration and soil infiltration.

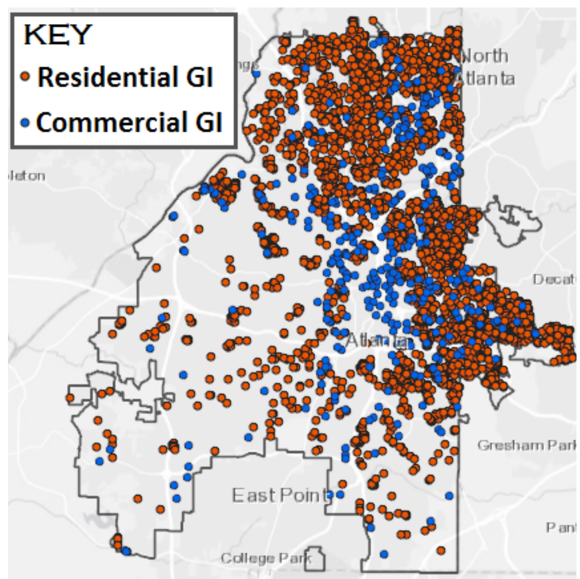
Green Infrastructure in Atlanta

The Revised Post-Construction Stormwater Ordinance

Georgia's new MS4 requirements mean that some municipalities may be looking at green infrastructure as an approach to stormwater management for the first time. Fortunately, the City of Atlanta provides an excellent local case study for implementing the new requirements. Atlanta revised its post-construction stormwater ordinance to prioritize green infrastructure in 2013, six years in advance of Georgia's recent MS4 permit updates. The city's experience serves as an example of both the strategy and the results of implementing the new requirements.

Among the revisions included in Atlanta's post-construction stormwater ordinance, elements that have spurred new and effective green infrastructure practices include:

- **Runoff Reduction Requirement** – Developments must capture and manage the first inch of stormwater runoff using green infrastructure strategies that allow the water to infiltrate, be taken up by plants, or to be reused on site. This requirement is newly applied to single family residence construction and renovations adding more than 1,000 ft^2 of impervious surface. As a revision from the previous ordinance, this new requirement reduces the need for over-sized detention ponds while addressing the most polluted runoff that occurs during a rainstorm's 'first flush.'



Newly permitted green infrastructure practices in Atlanta from 2013-2017
Source: Atl Dept of Watershed Mngmt

- **Stormwater Concept Plan Meeting Requirement** – Developers must meet with Watershed Management staff to review site plans and discuss improved green infrastructure design practices before submitting a building permit.

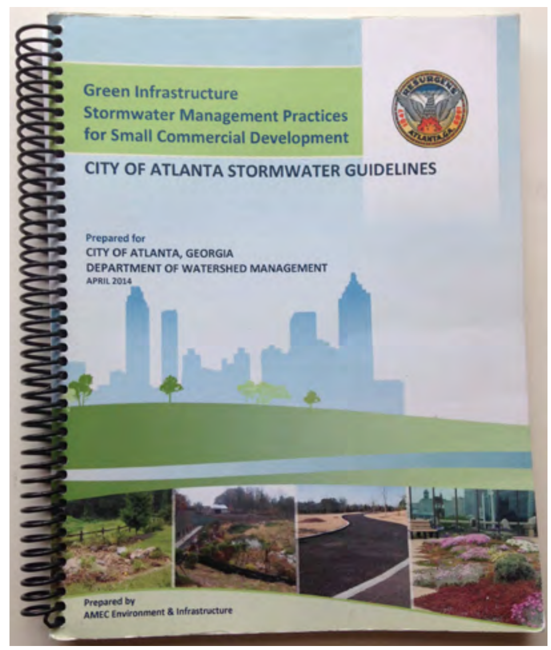
The changes have already made a big difference. In the first six years after the new requirements were instituted, Atlanta permitted over 4,800 construction projects that employ green infrastructure, reducing the volume of polluted runoff entering the city's stormwater and combined sewer systems by 950 million gallons each year.

| ***Read Atlanta's complete ordinance at: www.atlantawatershed.org/stormwaterordinance*** |

Strategies for Implementing the Ordinance

To facilitate effective implementation of its new post-construction stormwater management ordinance, the City of Atlanta took steps to engage relevant stakeholders before and during the revision process and conducted significant outreach after the ordinance was adopted. City staff met with engineering companies early on in the revision process to discuss the implications of potential changes and learn from the experience of the firms operating under the existing ordinance. The city also convened a technical advisory committee to inform the ordinance revision process. The committee was comprised of engineers and development practitioners, planning agencies, clean water advocacy organizations, and other relevant stakeholders. In addition, Department of Watershed Management staff maintained regular contact with other city agencies that would be affected by the new ordinance to provide updates and gather feedback.

Once the new ordinance was adopted, Atlanta's Department of Watershed Management implemented trainings about the new requirements for the development community, city staff, and the general public. Trainings included bringing city plan reviewers and inspectors up to speed on the new requirements and providing resources to practitioners for design, construction, and maintenance of different green infrastructure practices.



Atlanta has published multiple resources to help developers meet the new ordinance requirements.

During the roll-out period for the new ordinance, Atlanta developed several resources to aid developers when designing green infrastructure practices. Among these, the city published in-depth guidance manuals for implementing green infrastructure at single family residences and small commercial developments. These manuals provide thorough information on the post-construction ordinance requirements and they walk developers through the steps of selecting, sizing, and designing appropriate green infrastructure practices.

Among Atlanta's public projects that incorporate green infrastructure, the city retrofitted four miles of public roadway with permeable brick pavers in 2015-2016 to provide combined sewer capacity relief and address localized flooding.

Constructed in 2014, the city's McDaniel Branch wetlands manage 180,000 cu ft of stormwater from a 176 acre drainage area. The site has been designated a wildlife sanctuary, providing habitat for birds, fish, beavers, pollinators while managing urban stormwater.

In the years since Atlanta revised its post-construction ordinance, the city has been widely recognized as a leader in green infrastructure. Building on the success of its ordinance, Atlanta has incorporated green infrastructure into numerous public projects to manage urban stormwater. To date, these projects include constructed wetlands, permeable roadways, green roofs, street-side stormwater planters, and world class city parks.

The city has also developed a Green Infrastructure Task Force comprised of city departments and external nonprofit partners to help drive its green infrastructure success. The Task Force improves interdepartmental communications and has developed a coordinated strategy for advancing green infrastructure through its 2018 Green Infrastructure Strategic Action Plan. The plan sets a goal for Atlanta to reduce its stormwater runoff volume by 225 million gallons each year with green infrastructure. The Task Force has also developed informational resources for public and stakeholder outreach including a website and an interactive map of example sites which can be found at www.atlantawatershed.org/greeninfrastructure.

Green Infrastructure in Practice

This section details three recent development projects in Atlanta that meet the requirements of the city's post-construction stormwater ordinance. The developments include a parking lot, a public school, and a small retail facility. These projects have been selected as representative examples of commonplace developments constructed in most jurisdictions. Each example includes information about construction costs, post-construction runoff reduction requirements, green infrastructure utilized, and a description of the runoff reduction measures that would have been implemented prior to the new green infrastructure requirements. Discussion of special considerations for green infrastructure design and construction are included in Appendix A.

Site #1 – The Parking Lot

Project: GA Tech, Tech Parkway, Marietta Street Improvements, Phase I
Summary: 44 stall parking lot for student/staff parking

Project Description: As part of a larger project aimed at improving circulation and transportation on the Georgia Tech campus, the university constructed a new parking lot on a previously undeveloped parcel. The project included grading, curb work, paving with pervious concrete and asphalt, installation of lighting, and landscaping. To manage stormwater runoff in exceedance of City of Atlanta's requirements, the parking lot features pervious concrete parking stalls and an underground infiltration system.

Date Completed: April 2018

Property Owner: Georgia Tech

Design/Engineering Firm:
Breedlove Land Planning

Lead Contractor: JHC Corporation

Subcontractors: Chattahoochee Group, Smith Concrete

Prior Conditions: Undeveloped dirt lot

Impervious Area: 0.37 acres (16,117 sq ft)

Runoff Reduction Required: 1,345 cu ft (10,061 gal)

Total Project Cost: $845K

Construction Cost: $790K

Watershed: Tanyard Creek (combined sewer area), Chattahoochee River

Green Infrastructure Practices:
Pervious concrete parking stalls without underdrains integrated with an underground detention/infiltration area

Likely Alternative if Constructed Prior to Atlanta's Ordinance Revisions: Underground detention using non-perforated corrugated metal pipe. The footprint of the underground detention area would need to be greatly increased because the parking stalls would have been paved with asphalt which means more impervious area. Water quality requirements would have been met using a proprietary gravity separator upstream of the underground detention area.

Pervious concrete parking stalls reduce the impervious surface area and allow stormwater to percolate into subsurface layers of stone.

Photo by JHC Corporation

Excess water that overflows from the pervious concrete parking stalls enters an underground infiltration area made of perforated metal pipe surrounded by stone. The water is retained and slowly infiltrates into subsurface soil.

| Detailed photos of the pervious concrete construction proccess are included in Appendix B |

Site #2 – The Elementary School

Project: E. Rivers Elementary School

Summary: Renovation/redevelopment of a public elementary school

Project Description: One of Atlanta's oldest public schools, the E. Rivers Elementary School buildings and grounds were significantly renovated and expanded through this project. The renovation involved demolition of some existing structures and expanding the school into a three-story, 112,000 square foot facility able to accommodate 900 students in 56 classrooms. The project also included traffic circulation and parking improvements and newly established outdoor learning areas. Stormwater management requirements were met through implementation of multiple green infrastructure practices including a permeable paver parking lot, multiple bioretention areas surrounding the school, an underground infiltration area, pervious concrete, and cisterns that collect rainwater for reuse.

Photo by Atl Dept of Watershed Mngmt

Downspouts in the school courtyard empty into a collection channel that routes stormwater into a central bioretention area.

Date Completed: January 2015

Property Owner: Atlanta Public Schools

Design/Engineering Firm: Breedlove Land Planning

Lead Contractor: Parrish Construction

Prior Conditions: An existing elementary school on 8.7 acres including buildings, parking lots, driveways and sidewalks

Impervious Area: 3.5 acres (152,460 sq ft)

Runoff Reduction Required: 5,046 cu ft (37,747 gal)*

Total Project Cost: $28.2M

Construction Cost: $23.8M

Watershed: Peachtree Creek, Chattahoochee River

Green Infrastructure Practices: Multiple bioretention areas, permeable pavers, underground detention/infiltration area, pervious concrete, rainwater cistern.

*The development received credits for secondary conservation, reduced clearing and grading, and soil restoration, which reduced the site's runoff reduction requirement

Likely Alternative if Constructed Prior to Atlanta's Ordinance Revisions: Stormwater detention would have been provided in two underground detention facilities. Water quality requirements would have been met using a proprietary gravity separator upstream of the detention facilities.

A traffic circle utilized for bus circulation at the school was designed as a bioretention area for stormwater management.

Photos by Atl Dept of Watershed Mngmt

Permeable pavers within the parking area reduce impervious surface and allow stormwater to infiltrate into the ground and an adjoining underground detention facility

| ***Detailed photos of the traffic circle and paver construction process are included in Appendix B*** |

Site #3 – The Retail Facility

Project: Family Dollar

Summary: 9,100 sq ft retail facility with 18 stall parking lot

Photo by LeCraw Engineering

Project Description: This redevelopment project included demolition of two buildings and an existing parking lot prior to construction of a medium-sized retail store. To meet the requirements of the Atlanta post-construction stormwater management ordinance, the developers incorporated an underground detention facility beneath the parking lot and driveway area paved with permeable pavers. A landscaped bioretention area was also included adjacent the building.

Photo by Atl Dept of Watershed Mngmt

Stormwater runoff from the building's roof is directed into a landscaped bioretention area sized to manage 855 cu ft of stormwater.

Date Completed: May 2015

Property Owner: Garrard Group

Design/Engineering Firm:
LeCraw Engineering, Inc.

Lead Contractor: Garrard Group

Prior Conditions: Fully developed site with two buildings and a parking lot (approximately 83% impervious) with no stormwater detention

Impervious Area: 0.73 acres (43,560 sq ft)

Runoff Reduction Required: 1,873 cu ft (14,011 gal)

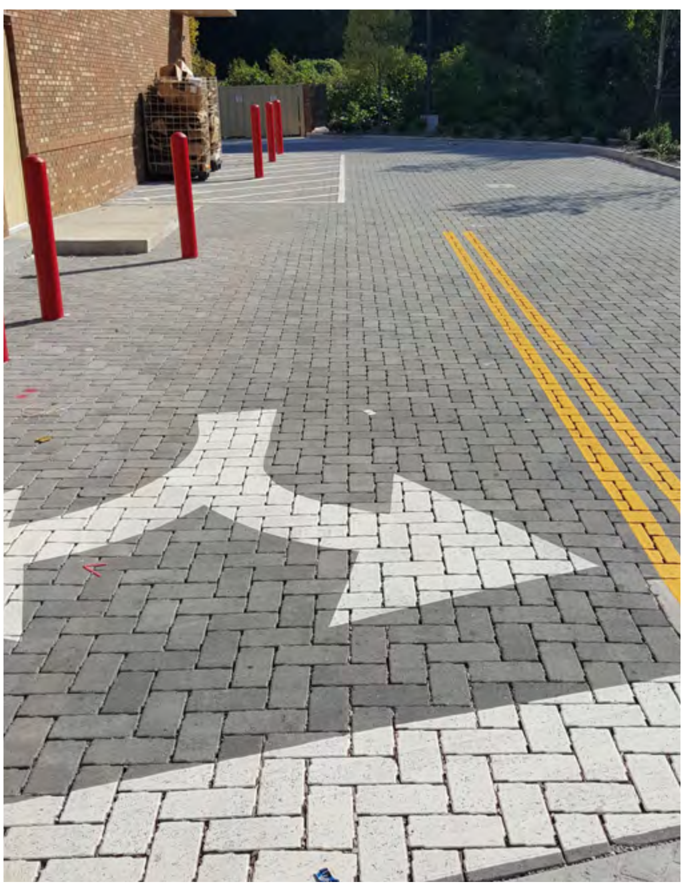
Total Project Cost: $1.5M (estimated)

Watershed: Camp Creek, Chattahoochee River

Green Infrastructure Practices:
Bioretention area, permeable pavers throughout parking and driveway area with underground detention/infiltration facility beneath

Likely Alternative if Constructed Prior to Atlanta's Ordinance Revisions:
Site would have utilized an underground detention area with oversized pipes and conventional piped stormwater system. Water quality requirement would have been met using a proprietary separator device.

Photos by LeCraw Engineering



The site's 10,225 sq ft parking lot and driveway area is paved with permeable pavers, allowing rainwater to infiltrate into the ground and an integrated underground detention facility.

Conclusion

The challenges associated with stormwater runoff will only increase as our communities grow. Green infrastructure strategies provide an opportunity to augment our existing stormwater management systems to address those challenges. As evidenced from the example projects discussed in this report and the 4,800+ new green infrastructure projects permitted in Atlanta since 2013, developers are equipped to adopt new green infrastructure techniques and the results are overwhelmingly positive. Implementation of policies that promote green infrastructure significantly reduces the volume of polluted stormwater runoff that cities must manage while simultaneously providing numerous co-benefits.

In contrast to conventional strategies for stormwater management, green infrastructure provides an opportunity to maximize the impact of municipal investments by going beyond stormwater. Trees and vegetation integrated into bioretention, bioswales, and green roofs improve community welfare through improved air quality, urban cooling, aesthetic and economic benefits. The associated improved protection of our waterways preserves wildlife and natural spaces downstream and yields associated benefits for recreation.

Atlanta's revised post-construction ordinance has demonstrated the potential for advancing green infrastructure implementation in our communities. The city's experience provides a tested blueprint for other cities and counties to follow as Georgia's new MS4 permit requirements take effect. Integrating green infrastructure into other cities throughout the state will be a pivotal step toward improving the quality of life in our communities and helping guarantee a clean water future for all.

Photo by Breedlove Land Planning

Appendix A: Special Considerations for Design and Construction

Most aspects of green infrastructure construction should already be familiar to experienced engineers, landscape architects, and contractors. For those less familiar with this approach, some new details should be taken into account to ensure effective installation of these practices. Below is a discussion of some special considerations.

Construction Sequencing

One of the most important things to plan for when incorporating green infrastructure into a development is the sequencing of when various phases of construction will occur. Installing a green infrastructure feature too early during construction can lead to damage later on from silt or heavy construction equipment. Whenever possible, green infrastructure should be installed towards the end of a construction process, after the soil on the site has been stabilized. If sequencing in this way is not feasible, developers should take special precautions to protect green infrastructure features with erosion and sediment controls and barriers to prevent damage from construction and landscaping equipment. Similarly, green infrastructure practices should not be used for temporary sediment storage during construction.

Top: In the example above, contractors constructed a large bioretention area at the start of construction for a ten-acre housing development. Erosion and sediment controls were not installed to protect the feature, and the site was not stabilized for over a year.

Bottom: The bioretention area became saturated with silt, making it incapable of infiltrating stormwater. The City of Atlanta later required the developer to excavate and reconstruct the bioretention area.

Design for Maintenance

Green infrastructure features typically have different maintenance requirements than conventional stormwater infrastructure. Thoughtful design can reduce the frequency and time required for maintenance. Often green infrastructure maintenance can be managed alongside regular landscaping tasks that include watering, weeding, mulching, and removing trash. Removing sediment deposited into green infrastructure is an important aspect of maintaining the function of these runoff reduction features. In most cases, green infrastructure should incorporate some form of pretreatment to remove sediment. This can include elements such as a vegetative or stone filter strip or a pretreatment catch basin or forebay that be easily emptied of sediment during a regular maintenance schedule.

Protecting Trees and Natural Green Infrastructure

Existing trees, established native vegetation, healthy stream buffers, and healthy soil are some of the most effective and beneficial types of green infrastructure. When planning for and designing a development, special care should be taken to identify and prioritize preservation of these resources which add significant value to a project post-construction. Many jurisdictions like Atlanta allow developers to receive credits for reduced clearing and grading on a site and reduce their post-construction stormwater management volume and water quality requirements. Best management practices to protect mature trees during construction are well known and can be easily implemented during construction. These strategies include protecting natural green infrastructure with barriers during construction and avoiding soil compaction, trenching, and grade changes within the critical root zone.


Photo by Atl Dept of Watershed Mngmt

During redevelopment of E. Rivers Elementary School, mature trees were incorporated into the site design and preserved, reducing the site's post-construction stormwater runoff requirements.

Appendix B: How It Was Built

Parking Lot – Pervious Concrete

Photo by JHC Corporation

1) Subsurface storage area is excavated and compacted; **2)** Geotextile fabric is placed followed by washed stone to create void space for water storage; **3)** Stone layer is compacted to appropriate density; **4)** Pervious concrete is poured and hand spread, then smoothed and compacted with a roller screed; **5)** Pavement is cross rolled; **6)** Edges are touched up with hand floats; **7)** Joints are created using joint roller; **8)** Curing compound is applied and concrete is allowed to cure; **9)** Finished concrete is inspected and a core sample is removed to certify that concrete thickness and density are correct.

Elementary School – Bioretention and Permeable Pavers

Traffic Circle Bioretention Area

The bioretention area has been excavated, filled with a 1 ft deep gravel bed and plumbed with underdrains. Geotextile fabric covers the gravel bed and lines the bottom of the subsurface area.

Notches in the curb will allow stormwater to flow into the bioretention area from the driveway. A stone filter strip will provide pretreatment to remove sediment.

The sides of the bioretention area have been lined with impermeable material to prevent undercutting the roadway. A 4 ft deep layer of soil, mixed to promote infiltration, is used to fill the remainder of the belowground area.

Permeable Paver Parking Lot

The parking area has been graded, compacted, lined with geotextile fabric, layered with 10 inches of stone and plumbed with underdrains.

Additional layers of stone in varying sizes are spread and compacted to the appropriate density. In total, 2 ft of stone will rest beneath the pavers to retain stormwater.

A slab laying machine is used to place the interlocking permeable concrete pavers.

All Photos by Parrish Construction