



NEW JERSEY DEVELOPERS' GREEN INFRASTRUCTURE GUIDE



New Jersey
Builders Association



Special thanks to the Developers' Green Infrastructure Task Force and the Green Infrastructure Guide Review Committee for their insight, constructive input, time and assistance in the preparation of this Developers' Green Infrastructure Guide.

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This Guide has not been reviewed or endorsed by NJDEP. All permit applicants are encouraged to consult directly with NJDEP staff and/or NJDEP regulations and guidance documents regarding compliance issues.

NEW JERSEY DEVELOPERS' **GREEN** **INFRASTRUCTURE** **GUIDE**

PREPARED FOR:



**New Jersey
Builders Association**

APRIL 2017

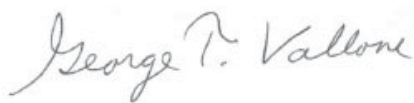
When our two organizations formed a partnership called the Developers' Green Infrastructure Task Force, the need for information tailored to developers quickly became clear. Like all good business people, developers need to understand the impact of decisions on the bottom line. Innovation is great; it drives progress. But it also has to benefit the bottom line.

This Developers' Green Infrastructure Guide addresses basic questions about green stormwater infrastructure: what it is, how it works, what are its costs and benefits, and why it makes good business sense. Green infrastructure has its limits. It is not the perfect solution for every setting or every project, but it is versatile, powerful and the future of stormwater management.

Our aim is to help you answer the questions, "Why should I do this?" and "Where and how will it be most beneficial?" We hope you find this Guide – with basic information, case studies, side-by-side site plan comparisons and interactive decision-making tools – to be helpful in doing just that.

This is a dynamic and evolving field and we want your feedback. Tell us what you like about the Guide and what questions you still need answered. As you begin using green stormwater infrastructure, share your experiences with us. We'd love to learn from your trials and highlight your successes.

MESSAGE FROM THE DEVELOPERS' GREEN INFRASTRUCTURE TASK FORCE CO-CHAIRS



George Vallone

President, Hoboken Brownstone Company
Chairman, Board of Directors
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Task Force Purpose

The Developers' Green Infrastructure Task Force helps New Jersey's developers and their design professionals learn about, finance, and build high-quality, cost-effective green stormwater infrastructure.

About New Jersey Future

New Jersey Future is a nonprofit, nonpartisan organization that brings together concerned citizens and leaders to promote responsible land use policies. The organization employs original research, analysis and advocacy to build coalitions and drive land-use policies that help revitalize cities and towns, protect natural lands and farms, provide more transportation choices beyond cars, expand access to safe and affordable neighborhoods and fuel a prosperous economy.

About NJBA

The New Jersey Builders Association (NJBA) is the leading trade association for the shelter industry in New Jersey. Members include residential and commercial builders, developers, remodelers, subcontractors, suppliers, engineers, architects, consultants and other professionals. NJBA serves as a resource for its members through continuing education and advocacy. NJBA and its members strive for a more vibrant, greener and affordable housing market in New Jersey.

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NEW JERSEY DEVELOPERS'

GREEN INFRASTRUCTURE GUIDE

Answering the question, "Why should I do this?"

PAGE 9



OVERVIEW

OF GREEN STORMWATER INFRASTRUCTURE PRACTICES

What is green stormwater infrastructure and how does it work?



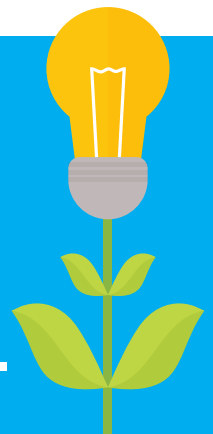
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CASE STUDIES

GAIN INSIGHT

into decision-making, project value, competitive advantage, challenges and keys to success.





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DEVELOPER BENEFITS

LEARN OPTIONS

to create value and reduce costs.



PAGE 42

MEASURING BENEFITS

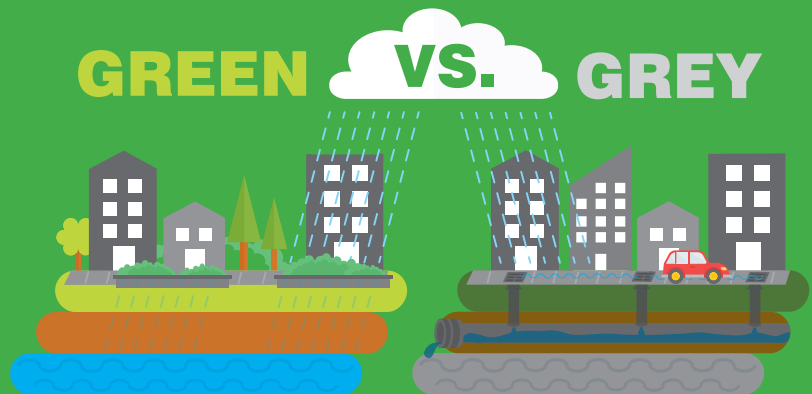
USE **BENEFIT CALCULATORS** TO COMPARE
PERFORMANCE, COSTS AND BENEFITS
of various GI practices for your own project.

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SIDE-BY-SIDE COMPARISONS

LEARN HOW

a project designed with
grey infrastructure
can be improved with
green infrastructure.



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FAQS

FREQUENTLY ASKED QUESTIONS

GET THE FACTS: clear, simple,
and sometimes surprising.



FACT ☒
MYTH ☐





OVERVIEW OF **GREEN INFRASTRUCTURE PRACTICES**

OVERVIEW OF GREEN INFRASTRUCTURE PRACTICES

WHAT IS GREEN INFRASTRUCTURE?



Source: Upstream Matters

Stormwater is “managed” when it is captured, stored, and filtered of pollutants using a variety of different engineered systems or land grading techniques. The image above shows stormwater being “managed” through infiltration through the soil and into the ground.

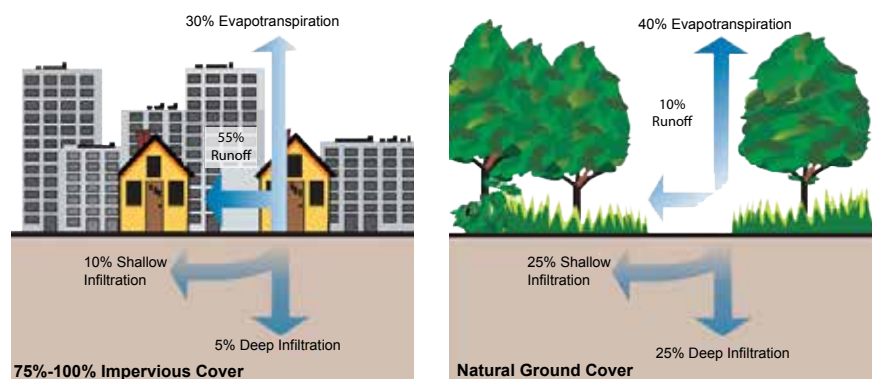
Developers understand that land development projects in New Jersey must be designed to “manage” stormwater runoff. NJ DEP regulations require that stormwater management standards be met through the use of “nonstructural strategies,” to the “maximum extent practicable.” Green infrastructure helps you, the developer, to do just that. **This Developers’ Green Infrastructure Guide is meant as a resource to help you incorporate green infrastructure into your projects for maximum benefit.**

The term “green infrastructure” or “green stormwater infrastructure” refers to a set of stormwater management practices that use or mimic the natural water cycle to capture, filter, absorb and/or re-use stormwater. Unlike traditional gray infrastructure, green infrastructure uses high performance landscaping and hardscaping to meet stormwater requirements while also improving the appearance and value of your project. Though most commonly understood as garden-like landscapes, green infrastructure can also be installed on roofs or in paved areas.

Green infrastructure can provide financial, regulatory and community benefits over the traditional approach, often at the same or lower cost to the developer. These practices can increase property value, lower operational costs, decrease permitting headaches and, by providing environmental and aesthetic benefits, can help attract community support.

Effect of Impervious Cover on Stormwater Runoff

In a natural environment, rainfall is cycled through the process of evaporation, uptake by plants, and infiltration into the ground. Development (roofs, pavement, etc.) disrupts this process and leads to runoff and water pollution.



Source: Environmental Protection Agency, Washington D.C.

When selecting which type of green infrastructure to use in different settings, it is important to understand the financial, regulatory, and community benefits of each type. These benefits are described in detail in the Benefits of Green Infrastructure (page 31). The following icons are used to call out the benefits afforded by specific green infrastructure practices:

TYPES OF GREEN INFRASTRUCTURE



This section of the Guide provides definitions, photos, diagrams, and permitting considerations for different types of green infrastructure practices. The majority of system types fall within the general category of “landscape practices,” which include a number of different designs at different scales but generally are systems that incorporate plantings at the ground level. Descriptions of landscape practices are grouped for small-scale and large-scale practices in the pages that follow. In addition, non-landscape practices (such as cisterns, subsurface tanks, and green roofs) are also presented.

Green infrastructure can be designed using a variety of different designs that incorporate plants, soil, stone, pipes, and more to fit into different site designs and achieve different types of benefits based on the needs of the development or redevelopment project. The following green infrastructure practices are divided by type and described in further detail in this section:

Small Landscape Practices

- Bioretention Basin
- Rain Garden
- Curb Bumpout
- Vegetative Filter Strip
- Grass Swale
- Downspout Planter
- Tree Trench / Tree Box

Large Landscape Practices

- Naturalized Detention Basin
- Constructed Wetlands / Subsurface Gravel Wetlands
- Surface Infiltration Basin
- Wet Pond (naturalized edge and water re-use)

Pervious Pavement

Dry Well

Cistern / Rain Barrel

Green Roof / Blue Roof

Subsurface Infiltration Basin

GREEN INFRASTRUCTURE'S PLACE IN THE REGULATORY FRAMEWORK

The New Jersey Stormwater Best Management Practices Manual (NJ BMP Manual) includes a list of approved structural stormwater control measures, all of which are considered green infrastructure for the purpose of this Guide. In addition, this Guide provides descriptions of eight GI practices—curb bumpout, downspout planter, tree trench/tree box, naturalized detention basin, cistern/rainbarrel, green roof/blue roof—that are not included in the NJ BMP Manual. While not yet named as BMPs in the NJ BMP Manual, these can be valuable for managing stormwater.

New Jersey's stormwater rule and NJ BMP Manual require that stormwater management standards be met by incorporating nonstructural stormwater management strategies to the "maximum extent practicable" (NJAC 7:8). Nonstructural strategies are low-impact site design techniques that preserve or mimic natural hydrologic function; examples include designing paved areas that are "disconnected" to allow stormwater to flow over natural surfaces and soak into the ground. There are nine nonstructural strategies listed in the NJ DEP's stormwater rule.

Some structural stormwater management measures—including most of the green infrastructure practices described in this Guide—can be used to support or satisfy nonstructural strategies requirement. In the pages that follow, for the GI practices that help to satisfy the nonstructural strategies requirement, you will see a checkmark icon with a reference to the nonstructural strategy number(s), like this:



The nine nonstructural stormwater management strategies are as follows:

#1	Protect areas that provide water quality benefits or areas particularly susceptible to erosion and sediment loss.
#2	Minimize impervious surfaces and break up or disconnect the flow of runoff over impervious surfaces.
#3	Maximize the protection of natural drainage features and vegetation.
#4	Minimize the decrease in the pre-construction time of concentration.
#5	Minimize land disturbance including clearing and grading.
#6	Minimize soil compaction.
#7	Provide low maintenance landscaping.
#8	Provide vegetated open-channel conveyance systems.
#9	Provide preventative source controls.

Green infrastructure can also be used to support NJ DEP regulatory requirements for the reduction of Total Suspended Solids (TSS) in stormwater, with a target reduction of 80% overall. In the following pages, the assumed TSS reduction capacity assigned to each green infrastructure practice by the NJ BMP Manual is denoted using an icon:

TSS %



Rain garden planted with native grasses at an urban playground.

Image Credit: AKRF, Inc.

SMALL LANDSCAPE PRACTICES

Features:

- Flexible
- Distributed
- Drain a small area
- Provide water quality benefits
- Native vegetation
Especially salt-tolerant species for right-of-way practices

“These are the go-to practices for meeting regulatory requirements while adding aesthetic value.”

- Edward Confair, RLA, PE
Engineering and Land
Planning Associates

What are they?

Small landscape practices are garden-like systems designed to capture, store, and infiltrate stormwater on a small scale, often in yards or parking lots, next to buildings, in the right-of-way, or in other locations where space is constrained. They offer flexibility in terms of overall site design and may in some cases offer the opportunity to increase the site's developable area by locating stormwater management areas in the same footprint as planned landscape areas.

Pollutants are removed by settling and filtration through plants, soil, and in some cases stone layers. These systems may be connected to sewer systems through an overflow structure or an underdrain, but usually are designed to infiltrate the collected stormwater runoff within a short period after the storm has ended. Some shallow ponding (six inches or less) may briefly occur on the surface during that time. In addition to reducing the volume of stormwater runoff, small landscape practices remove pollutants and improve water quality. Mulch and soil can trap certain contaminants, while soil microorganisms and plants reduce organic pollutants like nitrogen and phosphorus. When planted with native grasses and shrubs, these systems can provide micro-habitats for birds and other pollinators like bees and butterflies.

When are they used?

Small landscape practices can be designed to create visual appeal and enhance passive recreational opportunities in your development project. They are flexible in terms of site design and are often located in public-facing or high traffic areas and are often planted with a dense and colorful plant palette to maximize visual appeal.

What are some key considerations?

- Planting design as well as location and structural elements dictate appearance, which can range from meadow-like to ultra-formal with structured landscaped beds.
- These types of practices tend to be susceptible to sedimentation from roads and parking areas, and should not be designed to manage very large drainage areas.

The following small landscape practices are described in further detail in this section:

- Bioretention Basin
- Rain Garden
- Curb Bumpout
- Vegetative Filter Strip
- Grass Swale
- Downspout Planter
- Tree Trench / Tree Box

Further information on green infrastructure design standards can be found in the NJ BMP Manual.

Rain garden in a public park, planted with grasses and flowers. Image Credit: AKRF, Inc.



Bioretention Basin

💰 🌱 ✅ #2 #4 #7 #8 TSS 80-90%

Bioretention basins are small landscape practices that may infiltrate stormwater into the subsoil, and/or hold it for a period of time to settle out pollutants and allow some uptake by plants. They are normally constructed as a simple depression in an existing landscape. They may be designed with meadow-type plantings or more formal beds, depending on their location. Bioretention basins can be sited in a wide range of different locations and settings and are commonly used as a high-performance alternative to traditional landscaped gardens or planting beds. By co-locating stormwater management with visually appealing landscaped areas, designers may be able to maximize the remaining area available for building.



Image Credit: Bluegrass Landscaping & Maintenance



Image Credit: Canyon Region Water Authority

Rain Garden

💰 🌱 ✅ #2 #4 #7 #8 TSS 80-90%

“Rain garden” is a simple term that is commonly used to refer to bioretention basins but may in some cases be used to describe other types of small landscape practices. This term may have somewhat different design implications in different regions and regulatory jurisdictions. It is commonly used in public-facing and non-technical documents.



Image Credit: Rutgers NJ Water Savers

Myth: Green infrastructure breeds mosquitoes.

Fact: Since mosquitoes can go through their life cycle in less than one week, green infrastructure practices are typically designed to drain within 72 hours or less, which will prevent completion of their life cycle.



Image Credit: NJ BMP Manual



Image Credit: AKRF, Inc.

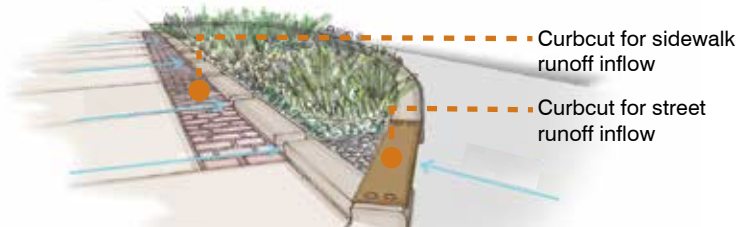


Image Credit: AKRF, Inc.

Curb Bumpout



A curb bumpout is an extension of the curb along a sidewalk that extends into the roadway, creating a small area that accepts stormwater runoff from the sidewalk and street, and manages the stormwater as a rain garden would. Because a curb bumpout works much like a rain garden, it may provide the same nonstructural strategies and TSS removal objectives as a rain garden. However, curb bumpout does not currently appear in the NJ BMP manual. When located at intersections, bumpouts can improve the appearance of your development project by creating a highly-visible, attractive looking streetscape. When located at intersections, bump-outs can help slow traffic and improve pedestrian safety by reducing the street crossing distance and by providing a barrier for pedestrians waiting at cross walks.



Image Credit: Adams County Stormwater BMPs

Vegetative Filter Strip



A vegetative filter strip is a gently sloping landscaped area that provides pretreatment to an adjacent stormwater management facility through sheet flow. The slow runoff rate reduces the risk of erosion and allows for quicker infiltration before the water leaves the site. The vegetative strip adds a visual buffer from impervious areas such as parking lots. The key here is that the runoff must be flowing in the form of sheet flow (not concentrated flow like in a swale or pipe) across the vegetative filter strip in order for this green infrastructure practice to be effective.

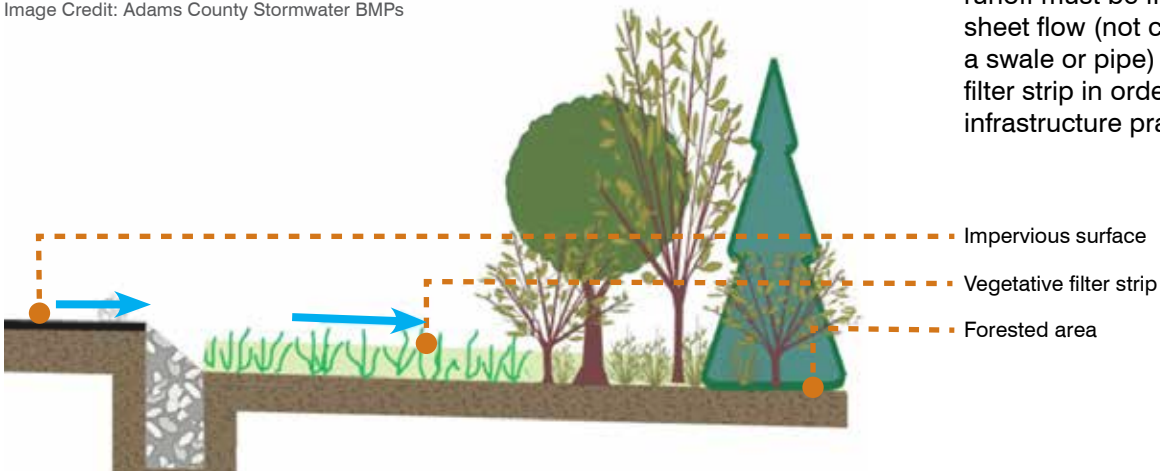


Image Credit: NJ BMP Manual

Grass Swale



A grass swale is a long, narrow grassy channel used to carry stormwater to a downstream green infrastructure practice or storm drain. Grass is typically kept to a height of about three to six inches to slow down the runoff and allow any debris or sediment to settle out without interfering with the direction of flow. Grass swales can be used to make your streetscapes greener and to save your project money on traditional piping.



Image Credit: Keltic Engineering, Inc.

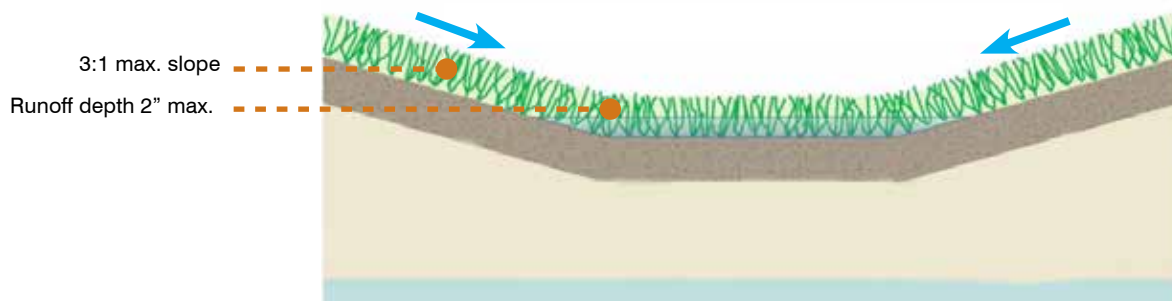


Image Credit: NJ BMP Manual

Downspout Planter



A downspout planter is a containerized landscape bed that utilizes rainfall from roof runoff for irrigation and manages the stormwater as a rain garden would. Because a downspout planter works much like a rain garden, it may provide the same nonstructural strategies and TSS removal objectives as a rain garden. However, downspout planter does not currently appear in the NJ BMP manual. The downspout planter is typically placed alongside the building where water from the downspout can flow into the planter, infiltrate through the soil mix and gravel layer and can drain out through an underdrain pipe. Alternately, stormwater may flow directly into the soil mix layer, allowing the water to infiltrate down into the subsoils instead. Structural components include the roof downspout, an underdrain and overflow structure if warranted. Downspout planters can create visual appeal and are often used as a high-performance alternative to traditional landscape planters.



Image Credit: AKRF, Inc.

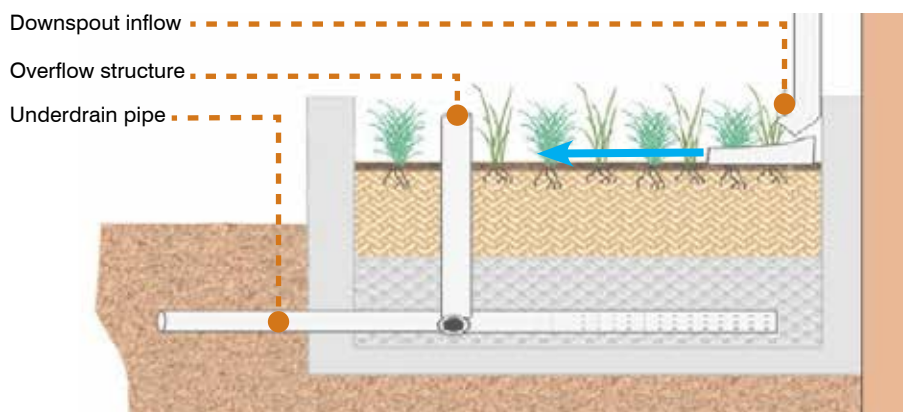


Image Credit: NY Film Finance



Image Credit: American Society of Landscape Architects

Tree Trench / Tree Box



A street tree trench is a linear stormwater management feature, typically placed along sidewalks, that combines tree pits with an underground stormwater management system. A tree trench is a type of bioretention system, but does not currently appear in the NJ BMP manual.

Although street tree trenches may appear like conventional tree pits, they are designed with piped connections and underground stormwater storage systems that capture runoff, provide additional storage and allow slow release of stormwater. Street tree trenches can be used effectively in tight spaces such as along footways and parking lots due to their small aboveground footprints.

Most tree trenches incorporate infiltration through a soil layer. Stormwater runoff is diverted to the trench by a curb cut, storm drain or permeable concrete sidewalk pavers. The soils typically provide treatment for the runoff before it enters a storage area, where the water is available to the tree roots for uptake. Tree trenches can position trees below grade, as pictured here, or at grade, like the rendering below.

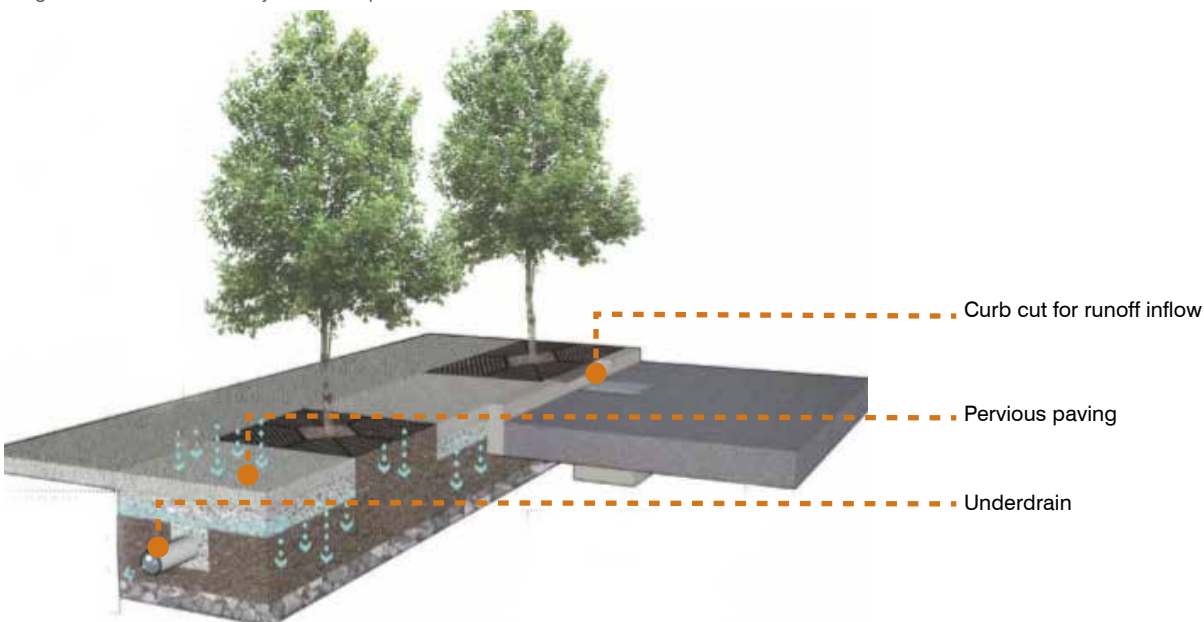


Image Credit: Jersey Water Works Green Infrastructure

What are they?

Large landscape practices are designed to capture, store, and/or infiltrate significant quantities of stormwater using basin-like depressions in the ground. Unlike flood control basins, which quickly release water from all but the largest storms, these types of practices may be designed to drain down slowly over a period of one to three days. In some instances, they may be designed as permanent wet ponds or wetland systems to provide nutrient cycling and water filtration through natural chemical processes. Drainage stones, piping and sand layers can be engineered into these systems to optimize their functionality. During large storms, overflow from these practices may be piped into the storm sewer system or discharge directly via overflow structures into nearby waterbodies. During dry periods, the appearance of these features – planted with trees, shrubs and grasses – approximates low lying meadows or woodlands. These naturalized systems can provide significant habitat for birds and pollinators like bees and butterflies.

When are they used?

Large landscape green infrastructure practices can be used to manage large volumes of stormwater, for example from a neighborhood development project or a large commercial site. They may be designed to extend or accentuate existing natural features in recreational areas along bike trails or walking paths, or simply to enhance the natural character of the development. These types of systems are most likely to be incorporated into a landscape plan along edge areas, slightly offset from walkways and roads. They are most often planted with naturalistic meadow-type grasses, trees, and shrubs.

What are some key considerations?

- Subsurface components need to be cleaned occasionally, so it is important that these systems be designed with safe and easy maintenance access.
- For settings in wooded areas, protection of plants from wildlife is important during the early stages of establishment. Deer fencing (to protect small trees in particular) and muskrat trapping (for ponds and wetlands) can help to prevent wildlife damage.

The following large landscape practices are described in further detail in this section:

- Naturalized Detention Basin
- Constructed Wetlands / Subsurface Gravel Wetland
- Surface Infiltration Basin
- Wet Pond (naturalized edge and water re-use)

Further information on green infrastructure design standards can be found in the NJ BMP Manual.

LARGE LANDSCAPE PRACTICES

Features:

- Drains a large area
- Meets volume requirements
- Generally low maintenance
- Native vegetation



Image Credit: AKRF, Inc.

Typical infiltration basin.

Naturalized Detention Basin



A conventional detention basin is widely used to manage stormwater from development, but it has important limitations in terms of water quality, ecology, and community benefits. Detention basins usually capture stormwater using a series of inlets and pipes that collect drainage from nearby hardscapes, but are normally designed to manage runoff from only the largest storms and are less effective at reducing pollution. Turf-covered detention basins can be converted to native meadows through a variety of turf stripping and seeding methods. This can offer a cost effective option for meeting regulatory requirements if your project includes redevelopment areas, but note that naturalized detention basin does not currently appear in the NJ BMP Manual. Naturalized detention basins may look similar to infiltration basins or constructed wetlands, but are dry except during storms and do not include an engineered sand/soil bed.



Image Credit: Princeton Nature Notes

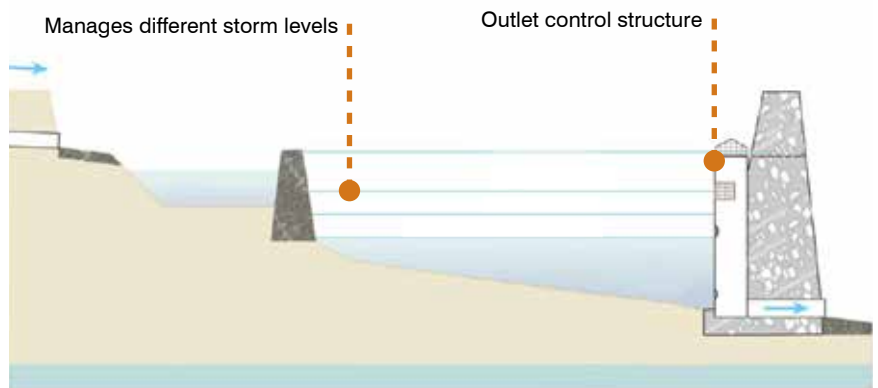


Image Credit: NJ BMP Manual

Constructed Wetland/ Subsurface Gravel Wetland



A constructed wetland is a combination of a surface marsh and underground gravel bed, commonly used to manage large amounts of stormwater. In the surface marsh, pollutants in runoff are treated through filtration and biological function. Runoff flows vertically from the surface marsh into the subsurface gravel bed which acts as a second form of pollutant removal. Constructed wetlands differ from naturalized detention basins and infiltration basins in that soils remain saturated in the lower zones and water ponds permanently in some areas. Unlike wet ponds, most wet areas are planted with a variety of water-loving plant species.



Image Credit: MSU Infrastructure Planning

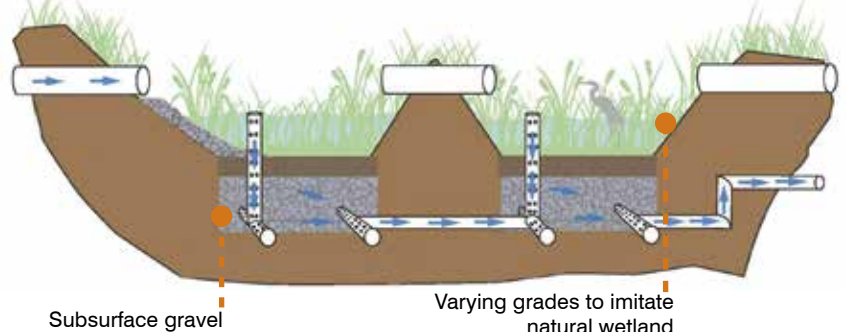


Image Credit: University of New Hampshire



Image Credit: AKRF, Inc.



Image Credit: Susdrain, Inc.

Surface Infiltration Basin



An infiltration basin is an above ground practice that captures stormwater and infiltrates it into the ground. Although an infiltration basin can appear fundamentally no different than a large depression in the ground, it can be designed to have varying topographic features. Highly permeable components are used in the design of infiltration basins to promote pollutant removal and groundwater recharge. The soil media in these systems treat pollutants through settling, filtration and transformation through biological processes. Vegetation planted in these basins, especially if they are native grasses, perennials, and shrubs can facilitate these processes while providing added aesthetic and wildlife habitat benefits. These practices can be incorporated into the overall site design of a development so that they are inconspicuous as stormwater control features but appear instead as part of the landscaping.

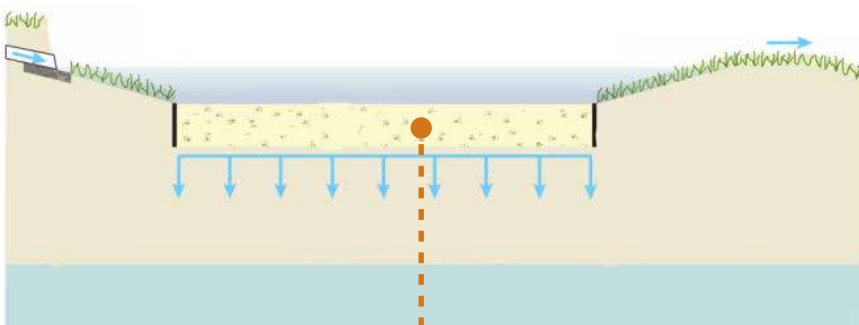


Image Credit: NJ BMP Manual

Highly permeable soil

Wet Pond



TSS 50-90%

A wet pond, also known as a retention basin, is a permanent pool where stormwater is captured and held by an elevated outlet structure. The system can be designed as a multi-stage, multi-function system; extended detention above the permanent pool; detention and prolonged infiltration through higher elevation outlets. Wet ponds are used to accommodate runoff and provide stability from larger design storms. They can also be used when wildlife habitats, recreational benefits, or water supply for irrigation or fire protection need to be enhanced. They should not be located within natural areas because they will not have the same range of ecological function. Wet ponds may look similar to constructed wetlands, but their plantings, soil, and subsurface systems are very different.



Image Credit: Native Plant Solutions



Image Credit: Master Consulting P.A.

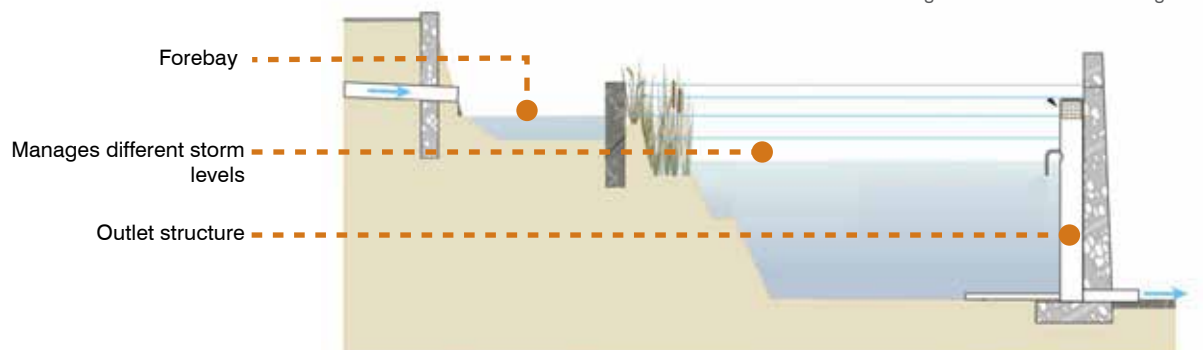


Image Credit: NJ BMP Manual

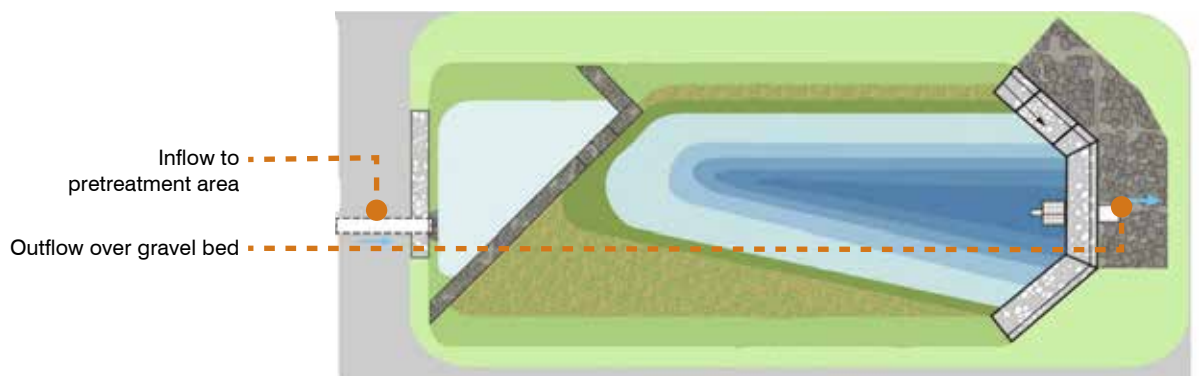


Image Credit: NJ BMP Manual

Pervious Pavement



What is it?

Pervious pavement is a hardscape surface that allows water to pass directly through the surface and infiltrate into the ground. Pervious pavement materials can include poured asphalt, concrete, and interlocking concrete pavers installed over a supporting base of crushed stone that helps to store and infiltrate stormwater. Pervious pavements can offer a simple means of integrating green infrastructure if your development footprint is tightly constrained.

The key difference between conventional and pervious surfaces is:

- **Poured pavements** - the smallest stones are left out of the mixture during manufacturing, allowing water to infiltrate through the vacant spaces.
- **Interlocking pavers** - the joints are filled with sandy material that also allows water to infiltrate.

When is it used?

Pervious pavement can be used effectively in hardscape areas designed for foot and bicycle traffic (such as sidewalks and greenways) as well as alleys, parking stalls, and basketball courts. It should not be used for areas of heavy car or truck traffic, or where nearby industrial, agricultural, or landscape operations may lead to heavy sediment or organic material accumulation that could clog the system.

What are some key considerations?

- Construction should not take place during rain or snow, when the subsoil is frozen, or when there is significant accumulation of sediment or debris. These conditions can permanently clog the pervious pavement.
- Snow and ice, especially from areas treated with sand, should not be stockpiled on a pervious pavement system.

Myth: Pervious pavement doesn't work in cold weather climate.

Fact: Pervious paving is not negatively affected by freezing; this pavement remains porous and does not become clogged from frozen runoff. Furthermore, pervious paving requires less deicing throughout the winter season, and is more resistant to frost heave than standard pavement, thus reducing maintenance costs and salt use.



Image Credit: Clark Township Town Hall



Image Credit: Glassboro Town Square designed by Clarke Caton Hintz



Image Credit: TecEco

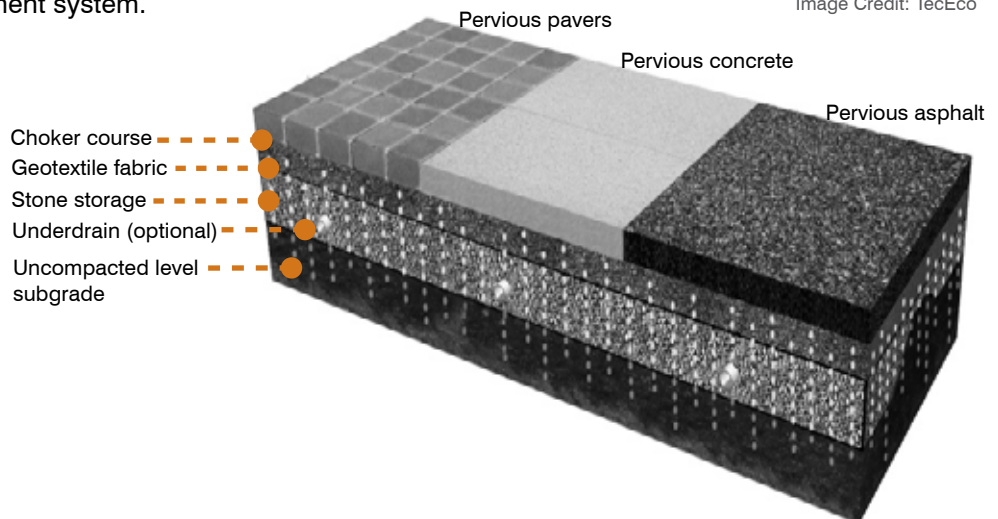


Image Credit: Philadelphia Water Department Plan Review



Image Credit: R Brigante Excavating Inc.



Image Credit: Earth Stone and Water



Image Credit: Montgomery County, Maryland

Dry Well



What is it?

A dry well is a subsurface stormwater facility consisting of either a structural chamber or an excavated vault that is only used to collect and temporarily store stormwater runoff from rooftops. The dry well inflow is connected by an exposed pipe alongside a building that runs down into the ground. The sides and top of the dry well are completely lined with filter fabric to avoid fines clogging the system. The rate of infiltration from the subsurface layers is an important component, since these layers provide outflow from the system.

When is it used?

A dry well may be used to comply with groundwater recharge design and performance requirements. Also, it may also be used to reduce the volume of clean roof runoff.

What are some key general considerations?

- The dry well is only intended for small storm events, and all excess water must be designed to flow around the structure.
- Subsurface layers must be sufficiently checked and maintained to ensure minimum permeability rates.

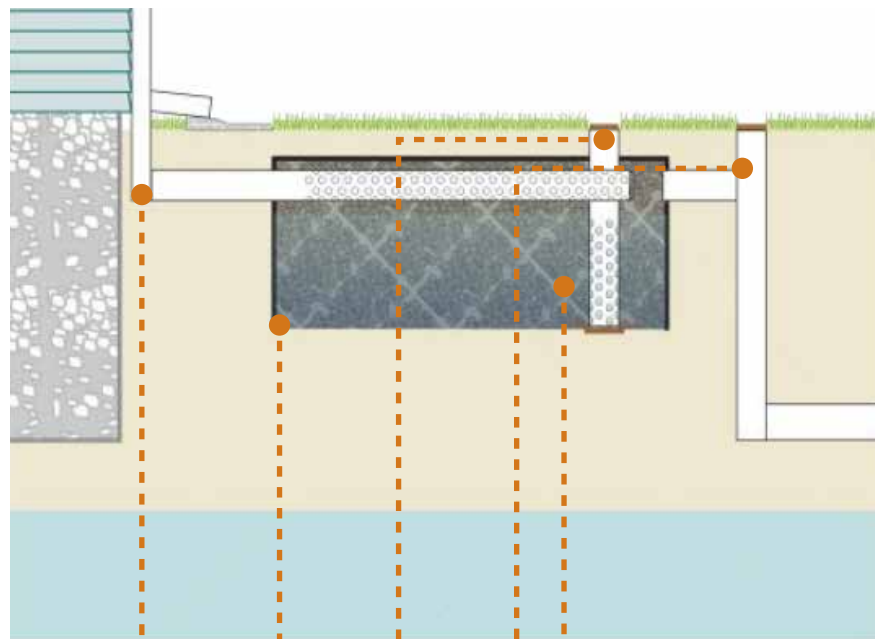


Image Credit: NJ BMP Manual

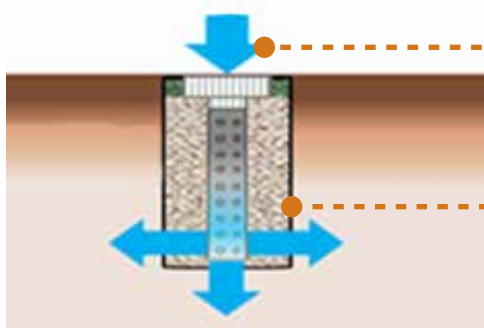


Image Credit: City of Elk Grove

Stormwater
Inflow

Stormwater
Inflow

Dry Well

Inspection
port

Stone fill to
infiltrate runoff

Maintenance access

Cistern/Rain Barrel



What is it?

Cisterns and rain barrels are storage tanks designed to capture and store stormwater for non-potable uses such as irrigation, toilet flushing, or industrial processes. Stormwater runoff is typically carried from roof areas to rain barrels or cisterns through roof gutters, downspouts, drains, and/or pipes and from parking areas through storm drains. Screens on gutters, downspouts, and in inlets filter large sediment and debris from stormwater runoff before it enters the rain barrel or cistern. Depending on their size, these systems can provide a significant opportunity to use recycled rainwater in place of potable water, which can help save on your project's long-term water use costs.

When is it used?

Rain barrels are typically located adjacent to buildings at single downspout locations, whereas cisterns may be located above or below ground and usually receive stormwater runoff from larger rooftops or ground-level impervious areas.

What are some key general considerations?

- Consideration should be taken to ensure a stable path for overflows since cisterns are not typically designed for large storms.
- Underground cisterns may need special permits and the location for overflows may also need approvals. Check with your local municipality.
- A number of pollutants can be deposited on roofs and in parking lots through air deposition, bird droppings, other chemicals used to treat roof tiles, and oils from automobiles; therefore, it is important to never consume water collected without proper treatment in cisterns/rain barrels or use it to wash anything that will later be consumed.

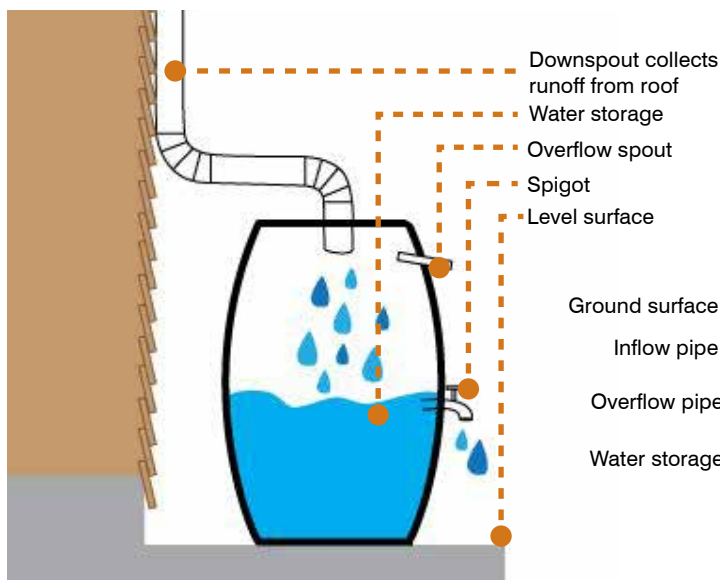


Image Credit: Conservation Conversations



Image Credit: Environmental Finance Center



Image Credit: AKRF, Inc.



Image Credit: Metropolitan St. Louis Sewer District

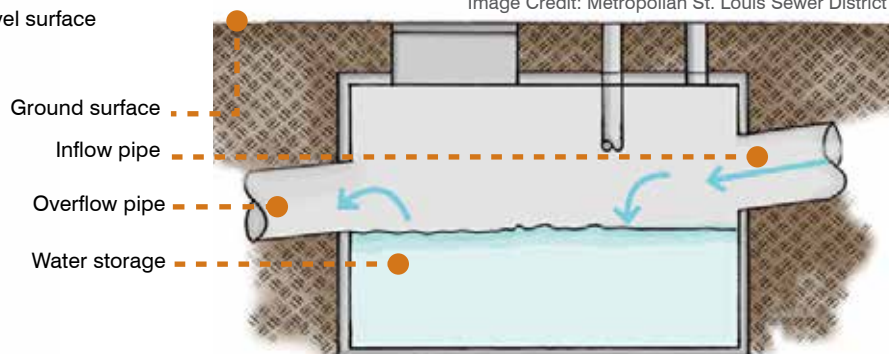


Image Credit: AKRF, Inc.

Green Roof/Blue Roof



What is it?

A green roof is a system of lightweight soil mix and plants. The plants absorb some of the rain that falls on the roof, and any excess is stored in a soil layer below. Layers of soil and plants are as thin as just a few inches, or as thick as several feet depending on the structural capacity of the building and the types of plants that are used. Roofs with a thin soil layer are lighter and easier to install, and are usually planted with succulent plants that need minimal water and nutrients to survive. Thick green roofs can support a greater variety of plants, including grasses and flowering perennials, but tend to be more expensive.

Blue roofs are non-vegetated systems that hold stormwater. They can be designed as modular trays with loose stones, specialized permeable pavers, or just a waterproof membrane. The infrastructure for this system is less costly than a green roof, but does not have any aesthetic value.

Benefits include:

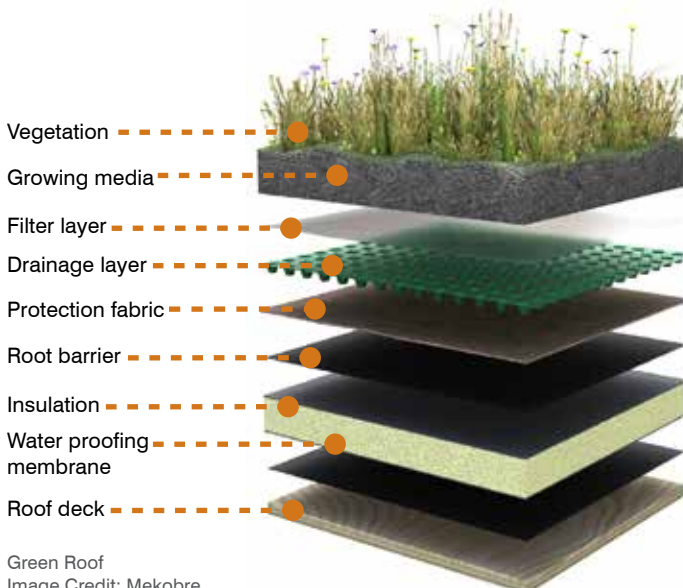
- Better temperature regulation on the roof surface
- Lower heating and cooling costs
- Recreational and public space areas for a project with a tight footprint

When is it used?

Green roofs may sometimes be installed on slightly sloped roof surfaces, while blue roofs are only suitable for flat roofs. Both systems can be built during new construction or modified onto an existing roof.

What are some key general considerations?

- Rooftops must be evaluated for structural considerations before a green or blue roof can be installed.



Green Roof
Image Credit: Mekobre

Types of Green Roofs

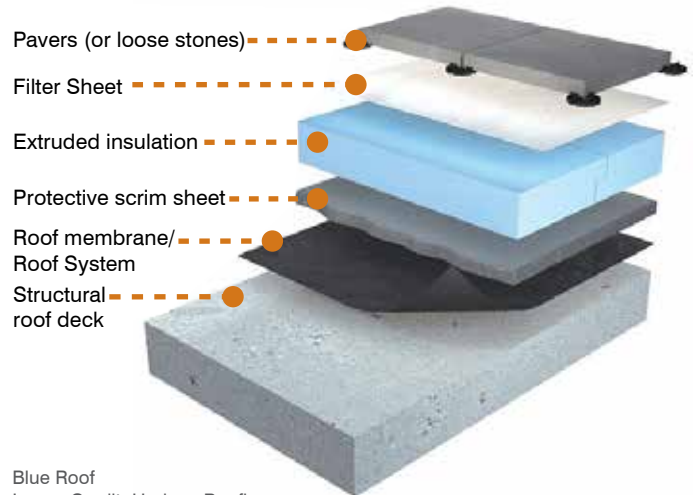
Name	Vegetation	Media Depth
Intensive	Supports trees and shrubs	10 or more inches
Semi-intensive	Grasses, herbaceous perennials and shrubs	6-10 inches
Extensive	Succulents, herbs and grasses	3-6 inches



Blue Roof
Image Credit: NYC Department of Environmental Protection



Green Roof
Image Credit: Rutgers University Business School designed by Roofmeadow



Blue Roof
Image Credit: Hudson Roofing

Subsurface Infiltration Basin

✓ #2 TSS 80%

What is it?

A subsurface infiltration basin is a below ground system that captures stormwater and infiltrates it into the ground. Subsurface infiltration basins use a system of pipes, stone, and/or underground storage chambers to store stormwater at a shallow depth underground until it fully infiltrates into the underlying soils.

When is it used?

They are used to manage stormwater under impervious surfaces, recreational areas (e.g., basketball courts, athletic fields), or other open areas. These can help you to meet stormwater requirements for development projects where available space for landscaping is limited; however, they do not provide many of the benefits that are typically associated with green infrastructure since they have no plant components.

What are some key general considerations?

- Consideration should be taken to ensure a stable path for overflows since subsurface infiltration basins are not typically designed for large storms.
- Underground systems may need special permits and the location for overflows may also need approvals. Check with your local municipality.
- Subsurface systems need to be cleaned occasionally, so it is important that these systems be designed with safe and easy maintenance access, especially for enclosed components of subsurface systems.

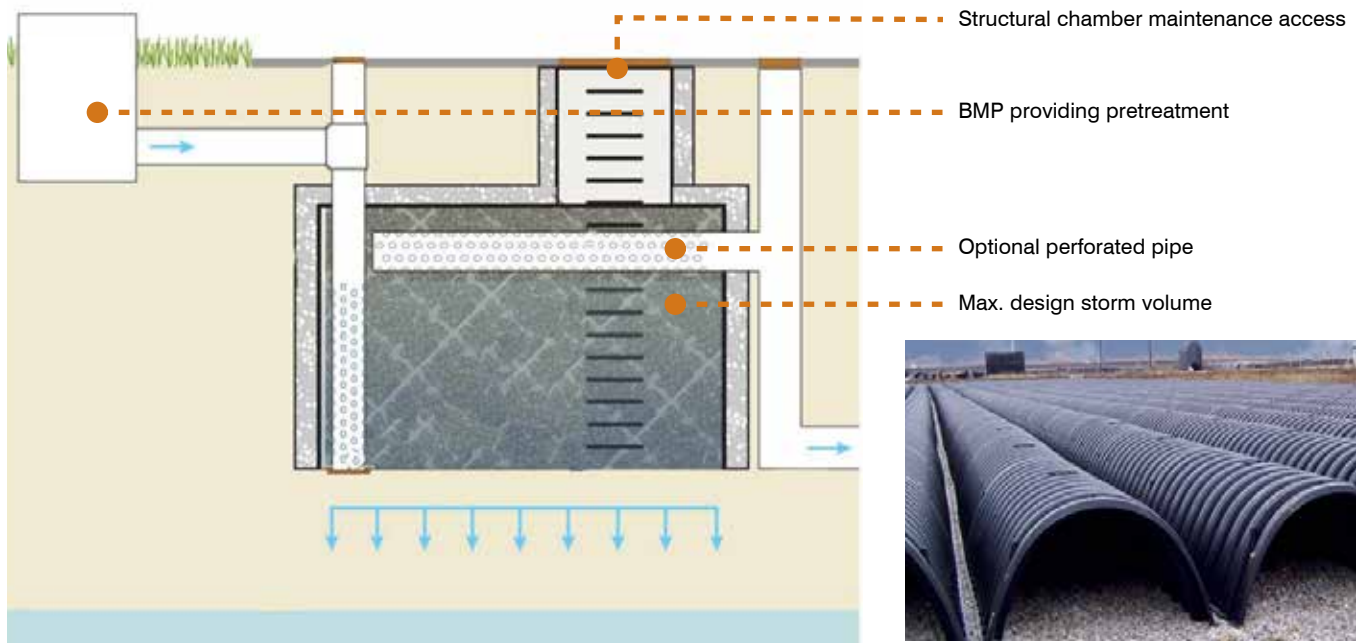


Image Credit: NJ BMP Manual



Image Credit: Philadelphia Water Department



Image Credit: Contech Engineered Solutions



Image Credit: Contech Engineered Solutions



Pervious pavement used in an alley like this one can absorb up to 3-5 gallons per minute per square foot (*Huffman, 2008*).

Image Credit: AKRF, Inc.



BENEFITS OF **GREEN** INFRASTRUCTURE



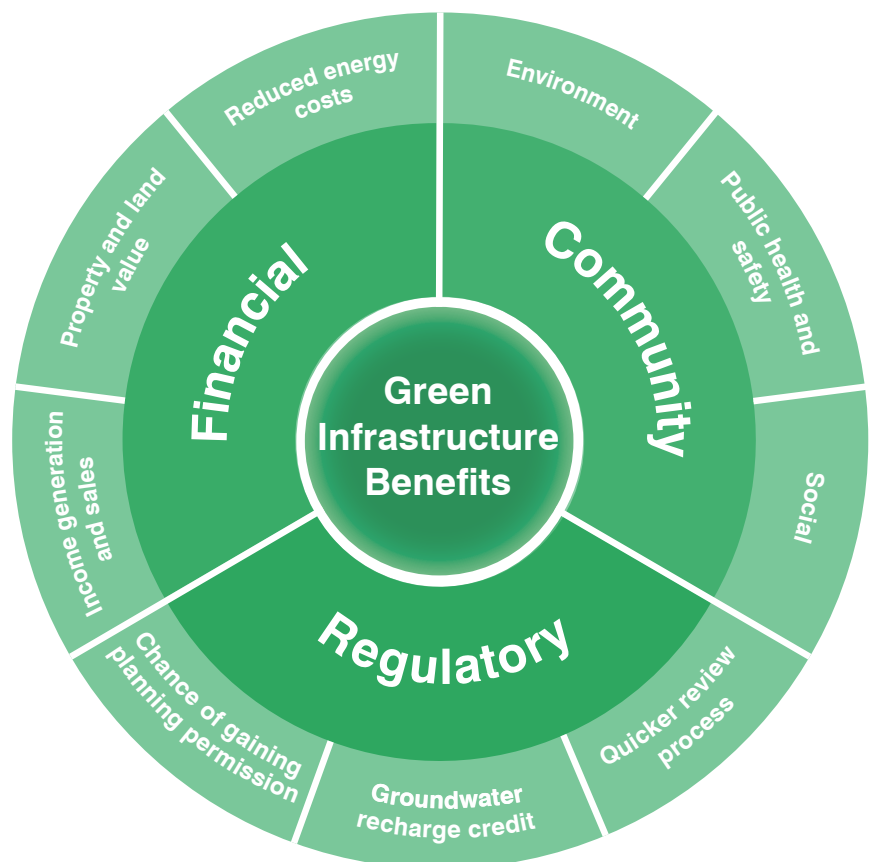
BENEFITS OF GREEN INFRASTRUCTURE

“Green infrastructure is always introduced as a headache, not as an Advil. We need to change that.”
 - Stephen Santola, General Counsel, Woodmont Properties

Green infrastructure can offer distinct benefits over traditional “gray” infrastructure. It can help save costs, speed permitting, and differentiate your business in the marketplace. It can also improve the marketability of a project and help draw a sophisticated clientele, which can directly improve your bottom line.

Studies have found that green infrastructure can be associated with higher property values, lower crime rates, and even increased spending in commercial areas. It may also lead to lower operating expenses and higher rates of public acceptance and, if implemented extensively, could in some cases result in faster permit approval for proposed developments. These opportunities create a powerful argument for incorporating green practices holistically into the overall site design, rather than simply adding in stormwater management to an existing design to meet regulations.

This chapter summarizes benefits of green infrastructure and shows developers how to incorporate these benefits. In addition to this general information, this section provides tools and frameworks for evaluating costs and benefits for a specific development project.





A green infrastructure streetscape enhancement in Portland, Oregon uses planters, trees, and permeable concrete pavers to capture and manage stormwater from the street and gutter. Photo credit: City of Portland, Environmental Services

FINANCIAL BENEFITS

“Compared to the original gray infrastructure approach, using a bioretention basin eliminated significant installation and long term maintenance costs, while providing a much more aesthetically pleasing stormwater facility. The client found both to be cogent justifications to authorize a design change, and the green infrastructure approach was well received by the Township.”

- Jeromie Lange, P.E.
Senior Principal, Maser Consulting

Myth: Green infrastructure costs more to maintain than traditional infrastructure.

Fact: In most cases, green infrastructure can be maintained as part of a routine landscape maintenance program at little or no additional cost to the owner. In fact, green infrastructure requires less mowing, and eliminates expenses for fertilizer, pesticides and herbicide.

Green infrastructure can offer numerous financial benefits that are real and quantifiable. Depending on the type of practice used, financial benefits may include:

- Operational cost savings associated with lower maintenance needs and lower building heating and cooling costs.
- Increased property values associated with more appealing landscape elements and improved opportunities for recreation.
- Improved public perception of the project and thus a faster public review phase (and less money spent on carrying costs).
- Potential (in some cases) for decreased review periods and fewer design revisions for projects requiring NJ DEP permits.
- Marketing “stories” related to landscape and recreational appeal, better social and environmental conditions, and LEED and sustainability metrics.

Operational Cost Savings

Many studies have shown that green infrastructure can help you save on long-term operations costs through savings in building energy use (specifically for green roofs), landscape maintenance, and potable water use.

- **Energy cost savings.** For buildings with a green roof installed, there are cost savings associated with reductions in heating and cooling needs due to better insulation (*General Services Administration, 2011*). When estimating the exact value of energy savings for a specific green roof, it is helpful to think of the roof’s layer of plants and soil as simply insulation. Opportunities vary based on the size and type of your building, the overall site design, and the intended use.
- **Landscape maintenance cost savings.** Landscape maintenance costs can be reduced because green infrastructure practices require little or no mowing, fertilizing, liming, dethatching, and aeration, and significantly less weeding compared to typical lawns or planting beds. In addition, green infrastructure practices don’t need to be watered as frequently.
- **Potable water cost savings.** Green infrastructure that incorporates rainwater harvesting for irrigation, toilet flushing, or industrial processes can significantly reduce costs associated with potable water service fees (*CNT, 2010*).

Increased Property Values

Green infrastructure can improve the appearance of the landscape, and thus increase property value. Both home prices and commercial spending have been linked to the presence of green amenities, which can improve the character, visual quality, and overall “feel” of your development. This has tremendous implications if you are weighing the costs of “green” stormwater management versus the costs of a subsurface system.

Multiple studies have linked public green space and street trees with increased property value and spending:

- **An analysis of residential property in Philadelphia found a ten percent increase in the value of residences that were located near green infrastructure practices** (*Sustainable Business Network, The Economic Impact of Green Cities, Clean Waters, 2016*).
- On commercial property, the presence of green infrastructure-related plantings is associated with 5-7 percent higher rents (*Wolf, City Trees and Property Values, 2007*).
- Research on consumer behavior in shopping districts has found that customers are willing to pay significantly more for goods—up to 8-12 percent—to shop in landscaped areas with mature tree canopy (*NRDC, 2013*).
- A study of apartment building rental rates in New York City found that buildings with a green roof can charge 16 percent higher rents after other factors have been controlled (*Ichihara & Cohen, New York City Property Values: What Is the Impact of Green Roofs on Rental Pricing? 2011*).

Put simply, green infrastructure can help make your site a place where people want to spend time—to live, shop, relax outdoors, or take a morning walk. This increased foot traffic and curb appeal can lead to direct financial benefit.

“In Philadelphia, green infrastructure is associated with a 10% increase in property values, a 7% increase in commercial office rents and a 5% increase in apartment rents.”
(GSI Partners / Econsult Solutions, 2016)



Image Credit: Live Roof

Allowing access to a green roof is a way to increase customer demand and add value to the property.

Marketing Opportunities

There are several ways in which developers can use green infrastructure to add value to projects and differentiate their brand in the marketplace. **Financial benefits can be marketed as value-added amenities (for example, lower operating costs) that create a competitive advantage.** Indirect benefits can be leveraged to align the project with a social and environmental purpose that can resonate with like-minded customers. In some cases, customers may even be willing to pay a premium for these types of services, as evidenced by the ongoing popularity of “green building” products, and LEED developments.

Another way of marketing green infrastructure is through the use of landscape photography to document the visual aesthetic of the site, such as the aerial photo below used to represent the appearance and character of a cutting-edge park designed for the Philadelphia Navy Yard.

Philadelphia Navy Yard photograph capturing the organization of various recreational activities arranged within the circular pods.



Image Credit: Halkin Mason Photography

Reduced Project Carrying Costs

The NJ DEP requires that nonstructural green infrastructure be implemented “to the maximum extent practicable.” However, that standard is open to interpretation, and this uncertainty can lead to longer review periods. As the saying goes, “time is money.”

Site designs that incorporate green infrastructure as an integral part of the landscape can help ensure that the “maximum extent practicable” standard is met up-front in any jurisdiction without extensive deliberation and revisions during the permit review phase. The section that follows provides further detail on how different types of green infrastructure can be used to meet the requirements and thus speed the permit process and reduce overhead expense.

“The highest cost in redevelopment is the cost of money over time. Whatever helps me get my building permits faster is money in the bank.”

- George Vallone, President, Hoboken Brownstone Co., and Chairman, Board of Directors of the New Jersey Builders Association

Incorporating green infrastructure as an integral part of the landscape can help developers to quickly meet permit requirements, as noted earlier, which reduces the overall time spent on permitting and plan revisions. **But, not all green infrastructure is created equal in terms of permitting benefits.**

The types of green infrastructure systems listed in the Overview of Green Infrastructure section are defined by the New Jersey Stormwater Best Management Practices Manual (NJ BMP Manual) as structural stormwater management measures. The NJ DEP requires that *non-structural* stormwater management strategies be used “to the maximum extent practicable” to meet stormwater management requirements. **However, as specified in the NJ BMP Manual, certain structural measures can be used to satisfy nonstructural strategies.** Table 1 outlines ways that structural green infrastructure can be used to satisfy nonstructural strategies, which can help speed permitting.

Using green infrastructure to satisfy permitting standards while also providing key value-added benefits allows developers to leverage intersecting regulatory, financial, and outreach benefits to save money and improve the quality of the development.

REGULATORY BENEFITS

Myth: Many people assume that there are no regulatory benefits for choosing a green infrastructure approach to stormwater management.

Fact: NJ DEP regulators and many local jurisdictions are eager to work with developers who demonstrate a commitment to maximizing nonstructural measures as a part of the overall site design.



Image Credit: Philadelphia Green Roofs

Green roofs such as these installed at North Hope Street, Philadelphia can be used to obtain stormwater credit in locations with limited open space. In New Jersey, green roofs are not yet included in the Stormwater BMP Manual, but can offer financial benefit in the form of energy savings and, in some cases, higher property value.

Table 1: Matrix of Structural Stormwater Strategies that Help Satisfy Nonstructural Stormwater Management Requirements

Green Infrastructure System	NJ DEP's Nonstructural Stormwater Management Strategies								
	#1. Protect areas that provide water quality benefits or areas particularly susceptible to erosion and sediment loss	#2. Minimize impervious surfaces and break up or disconnect the flow of runoff over impervious surfaces	#3. Maximize the protection of natural drainage features and vegetation	#4. Minimize the decrease in the pre-construction time of concentration	#5. Minimize land disturbance including clearing and grading	#6. Minimize soil compaction **	#7. Provide low maintenance landscaping	#8. Provide vegetated open-channel conveyance systems	#9. Provide preventative source control **
Bioretention Systems		X		X			X	X	
Constructed Stormwater Wetlands							X		
Dry Wells		X							
Extended Detention Basins*									
Infiltration Basins		X							
Manufactured Treatment Devices*									
Pervious Paving Systems		X							
Blue Roofs*									
Sand Filters*									
Vegetative Filter Strips	X		X	X	X		X		
Wet Ponds*									
Grass Swales				X				X	
Subsurface Gravel Wetlands							X		

* These systems do not support any nonstructural stormwater management strategies, but rather support other stormwater management requirements.

** These nonstructural stormwater management strategies are not supported by the systems listed at left but can be supported by other low-impact development techniques.

Source: This table is a graphic representation of information from the NJ BMP Manual.

Municipal Incentives

Some municipalities may occasionally offer incentives for development projects that incorporate a significant amount of green infrastructure. **These kinds of incentives are not common practices and do not relieve the developer from NJ DEP requirements. Possible incentives vary by municipality, but could include the following:**

- **Density bonuses.** In some cases development projects may be allowed to exceed municipal density limits if green infrastructure is incorporated in a certain quantity or configuration.
- **Tax abatements.** Municipalities may offer multi-year tax abatements for projects that incorporate green infrastructure, especially if the benefit to the community and/or municipality can be demonstrated.
- **Municipal connection fee credits.** In some cases, it may be possible to cost share the price of the project's sewer connection with the municipality, if the proposed development can support municipal stormwater management goals.
- **Redevelopment area bonuses.** Municipalities may offer a one-time tax credit for development projects that incorporate green infrastructure in a way that benefits the local community.

In addition to the direct benefits green infrastructure can offer to developers and property owners, there are numerous benefits to communities associated with public greening, better air, and green jobs opportunities. **The benefits green infrastructure offers to a community can help build stakeholder support for the development project and can sometimes ease the process of planning or zoning board review.** Many of these benefits can be quantified using the online calculator tools presented in the following pages. Other benefits may be more difficult to quantify, but are no less important. The table on the opposite page summarizes the types of community benefits that can be leveraged to build consensus and improve public perception of a development through the use of green infrastructure.

COMMUNITY BENEFITS



Green infrastructure workers installing geotextile matting to control erosion in a bioretention system.

Image Credit: AKRF, Inc.

Beautification of Public Spaces	Generally a green infrastructure approach is associated with more green space as well as better landscape design. Public spaces will look and feel more “green,” a quality that studies have found can drive positive feelings about a place. This is evidenced by people’s willingness to pay more for properties with more greenery, as noted earlier (see “Increased Property Values” section on page 36).
Opportunities for Recreation	Greening public spaces creates more opportunities for outdoor activities like walking, jogging, and bird watching.
Public Safety	Studies have shown that where there is green infrastructure in public spaces, there is often a reduction in crime. In Philadelphia, narcotics possessions were 18-27 percent lower in areas within a half mile of a green infrastructure practice (Kondo, 2015). Green infrastructure may also help to slow traffic when used in certain configurations in the right-of-way.
Green job creation	Green infrastructure development requires specialized skills in design, construction, and maintenance, quickly becoming an engine for job creation regionally. In New York and Philadelphia, specialized training programs have been developed to transition service providers from the landscaping and construction industries into green infrastructure construction and maintenance.
Habitat	If designed using native plant species, green infrastructure can provide habitat for a variety of beneficial animals such as birds and pollinators. Habitat values can be difficult to quantify and easy to overlook, yet are nonetheless an important consideration.
Energy Conservation	Shade trees located around buildings help regulate outside temperature, slow wind, and reduce temperatures in warm weather. Likewise green roofs help reduce the amount of solar heat that enters a building in summer, and provide insulation year-round. These benefits have a public effect of reducing overall energy usage and thus, the carbon footprint of the development. As noted earlier, energy conservation also makes these buildings more cost effective to operate in the long term.
Public Health and Welfare	• <i>Water Quality and Supply</i> - Green infrastructure removes sediment, nutrients, and other pollution from runoff, and can also help increase groundwater reserves through infiltration. Certain types of green infrastructure can also reduce flooding damage to property and to streams. It can also be a cost-effective alternative to traditional water treatment infrastructure. • <i>Air Quality</i> - Green infrastructure systems that increase the number of plants, especially trees, in a development will help to keep the air clean by absorbing air pollution. Improved air quality reduces the rate of respiratory illnesses like asthma. In addition to direct pollution removal, green infrastructure can help reduce energy costs as noted earlier, which can help reduce fossil fuel need and reduce the carbon footprint of the site. • <i>Heat Mitigation</i> - Plants and trees can decrease temperatures in the immediate vicinity, which in summer can have a measurable effect on heat-related illnesses. Even porous pavement can reduce heat stress in summer by allowing water to evaporate and by reducing radiant heat.

Cyclist enjoys a ride through a recreational area benefiting from green infrastructure practices that achieve maximum on-site retention and water quality, as well as high aesthetic value.

“Improvements like this create a derived benefit for the residents of a community.”

- Kevin Kernahan, Sr. Vice President - Land Development, Toll Brothers, Inc.



Image Credit: The Global Grid

There are a number of different tools available to support decision-making for cities, developers, and property owners that want to evaluate costs and benefits of different green infrastructure practices. Most exist in the form of proprietary models, free online calculators, or simple calculation methodologies. **For the purposes of this Guide, two tools have been identified that help to simplify evaluation of green infrastructure benefits at the site scale.** These tools use site-specific conditions as input within proven analytic frameworks to estimate green infrastructure costs and benefits that accrue to the property owner, manager, or developer.

“Green Infrastructure Co-Benefits Calculator”

The Green Infrastructure Co-Benefits Calculator was designed to estimate costs and benefits using user-input project details. The calculator is intended to be used as a tool to calculate and compare the social, economic, and environmental benefits of green infrastructure against the costs. This calculator uses some of the newest research findings available to date on green infrastructure costs and benefits, and although geared to some extent toward the New York City region it is generally applicable to medium and high density developments in New Jersey.

The calculator uses predictive equations developed through analysis of New York City monitoring data (such as field measurements of temperature, observed insects/pollinators, bloom periods, plant coverage, and soil sampling) as well as an extensive literature review of over 100 quantitative studies and a life-cycle evaluations of energy and materials needed for construction and maintenance.

Specific cost and benefit estimates are provided for different types of green infrastructure. Costs are separated into construction costs and annual maintenance costs. Users may create and compare portfolios of different green infrastructure projects using different input tabs. In addition to cost information, the following benefit data is calculated for each project:

Economic benefit

- Property value increase
- Savings (to municipality) in stormwater treatment cost
- Inferred economic benefits associated with decreased pollution

Social benefit

- Annual jobs supported
- Social benefits score (associated with aesthetic improvement and educational opportunities)

Environmental benefit

- Pounds of pollution produced and removed by building the green infrastructure practice
- “Ecosystem services” score, which is an index of the environmental benefit of the project

In order to estimate these costs and benefits, users must input a variety of site-specific variables such as the footprint, planting density, location, visibility, and more. The calculator is available for use online at:

www.nycgicobenefits.net

MEASURING BENEFITS: DECISION MAKING TOOLS

“If it makes my project achieve higher rents and renewal rates, and happier residents, that’s what makes the numbers work, and I’m all for it.”

- George Vallone, President, Hoboken Brownstone Company, and Chairman, Board of Directors of the New Jersey Builders Association

Save/Open Mode Compare Mode v File Load Control Store Control View Comparison Start Tutorial

Save Location: ROWB 1 ROWB 2 ROWB 3 Slot 3 Slot 4 Slot 5 Slot 6 Slot 7 Slot 8 Slot 9 Slot 10 Help Enabled

-Introduction- ROW Bioswale Greenstreet Large Bioretention Porous Pavement Constructed Wetland Green Roof Blue Roof -Tool Setup-

Co-Benefits Provided

- Carbon Sequestration
- Urban Heat Island Mitigation
- Reduced Energy Demand
- Improved Ecosystem Services
- Improved Air Quality
- Improved Quality of Life
- Increased Property Value
- Reduced Treatment Needs
- Green Jobs

Co-Benefit Details

Carbon Sequestration

Description:

By supporting plant growth, green infrastructure can provide carbon sequestration. Carbon is taken from the atmosphere and integrated into above and below ground biomass. When plant material is decomposed, some of this carbon can return to the atmosphere. Soil within the green infrastructure control also serves as a

Calculator Inputs

Save Name: ROWB Name

ROWB Footprint (ft²)

Managed Impervious Area (ft²)

25 Anticipated Lifespan (yrs)

Shrub and Herbaceous Cover (%)

Number of Trees

Flowering Vegetation 0%

Native Vegetation 0%

Plant Species 1-2

Visible Greenspace None

GI Accessibility Accessible

Calculator Outputs

Environmental

Total Per ft² GI Per ft² Man. Per Gal.

Gallons Managed (gal/yr)

Net CO₂ Produced (lb/yr)

CO₂ Produced (lb/yr)

CO₂ Sequestered (lb/yr)

Urban Heat Island Reduction

Ozone Removed (lb/yr)

PM10 Removed (lb/yr)

NO₂ Removed (lb/yr)

SO₂ Removed (lb/yr)

CO Removed (lb/yr)

Ecosystem Services Score

Ecosystem Score Detail

Pollinator Support

Native Habitat Support

Biodiversity Support

Green Corridor Support

Economic

Construction Cost

Maintenance Cost (\$/yr)

Treatment Savings (\$/yr)

Inferred Economic Benefit (\$/yr)

Potential Property Value Increase

Calculator Outputs

Social

Jobs Supported (job-yr)

Social Benefits Score

Social Score Detail

Aesthetic Potential

Impact of New Greenspace

Educational Opportunity

Community Based Needs

Community District Unknown

Location Based Need Ratings:

0 100%

Ozone Levels

Asthma Incidents

Heat Stress Incidents

Lack of Greenspace

School Aged Population

Click on the bar to see description and rating details.

Clear Inputs / Outputs Calculate



A sample view of the Green Infrastructure Co-Benefit Calculator interface showing the different data fields that can be inputted to calculate the cost of a green infrastructure practice.

“National Green Values Calculator”

The National Green Values Calculator is a stormwater management calculator developed by the Center for Neighborhood Technology as a tool for quickly comparing the performance, costs, and benefits of green infrastructure or low impact development to conventional green infrastructure practices. The tool is intended for a non-technical audience to evaluate the environmental improvement that can be achieved with green infrastructure. In addition, the calculator provides users with planning-level cost estimates.

The calculator uses a simple web interface to walk the user step-by-step through a planning process to identify the right combination of green infrastructure practices to meet stormwater management goals in a cost-effective way. Users can enter a stormwater runoff volume reduction goal (typically a standard established by the regulating government agency) to tailor results to local requirements. Inputs to the calculator consist of the following:

- Project location (used for rainfall input data)
- Lot size
- Predevelopment conditions (land cover)
- Runoff reduction goal (for New Jersey, select 1.25 inches to comply with current regulations [NJAC 7:8])
- Proposed development characteristics (roof size, parking lot size, etc.)
- Proposed green infrastructure improvements
- Advanced options (such as life cycle length, discount rate, etc.)

The calculator determines cost and benefit results based on the pre- and post-development site conditions and what types of green infrastructure were selected. Costs of green and traditional infrastructure are presented side-by-side for comparative purposes. Stormwater management, pollution reduction, energy savings, and groundwater replenishment values of green infrastructure are also presented. The calculator is available online at:

greenvalues.cnt.org/national/calculator.php

GREEN VALUES[®]
NATIONAL STORMWATER MANAGEMENT CALCULATOR

Calculator | Get Information | Predevelopment | Runoff Measurement Goal | Green Infrastructure Development | Advanced Options | Results Values

Runoff Reduction Goal: 42.9% | Impervious Area: 10,000 sq ft | Total Volume: 1,250 cu ft

Get Information | Predevelopment | Runoff Measurement Goal | Green Infrastructure Development | Advanced Options | Results Values

Get Information | Predevelopment | Runoff Measurement Goal | Green Infrastructure Development | Advanced Options | Results Values

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Get Information | Predevelopment | Runoff Measurement Goal | Green Infrastructure Development | Advanced Options | Results Values

CALCULATOR

Getting Started

Getting Started

The National Green Values™ Calculator is a tool for quickly comparing the performance, costs, and benefits of Green Infrastructure, or Low Impact Development (LID), to conventional stormwater practices. The GVC is designed to take you step-by-step through a process of determining the average precipitation at your site, choosing a stormwater runoff volume reduction goal, defining the impervious areas of your site under a conventional development scheme, and then choosing from a range of Green Infrastructure Best Management Practices (BMPs) to find the combination that meets the necessary runoff volume reduction goal in a cost-effective way.

A few important points to keep in mind:

- The National GVC is currently focused on runoff volume reduction; it does not produce any peak flow results. Volume reduction in this context implies infiltration, evapotranspiration and reuse, and does not include detention in ponds or tanks. All runoff volume captured in BMPs is assumed to be kept on site.
- The National GVC is meant for a single lot or a campus of buildings contained on a single site. If you are interested in looking at the performance and cost/benefit analysis of Green Infrastructure BMPs applied on a neighborhood or suburban locale, consider using the original GVC, and/or some of the other stormwater tools provided below.

To get started, select a tab at the top to enter site information. Default values (that can always be changed by the user) are provided throughout the calculator, so you can begin on any step. However, we recommend starting on the Lot information page and proceeding through each step. Below is a brief description of the information you can provide on each page:

- Lot Information
- Predevelopment
- Runoff Reduction Goal

RESULTS

The Green Stormwater BMP(s) applied in this scenario decrease the site impervious area by **42.9%** and capture **300%** of the runoff volume required. Compared to conventional approaches, the green practices in this scenario will decrease the total life-cycle construction and maintenance costs by **8%** (in net present value).

Volume Control

Required Volume Capture from 2.5" over impervious Surface (ft³)	417
Volume Captured by current BMPs (ft³)	1,250
Excess Volume (ft³)	1,250
Percentage of Required Volume Captured by Current BMPs (%)	300
Decrease in Impervious Area (%)	43

Photo courtesy of [unreadable]

National Green Values Calculator
interface developed by The Center for
Neighborhood Technology's Green
Values®.



SIDE-BY-SIDE COMPARISONS



SIDE-BY-SIDE COMPARISONS

Green infrastructure can help you meet stormwater management requirements while providing financial and community benefits and in some cases lessening the permitting effort. The sample projects presented in this section compare development plans, costs and benefits of two hypothetical scenarios. One option (Option 1) shows green infrastructure being implemented extensively as an integral component of the landscaping plan; and another option (Option 2) shows a more traditional “gray” approach, with green infrastructure implemented minimally or through a subsurface approach.

The three sample development projects represent commercial, residential and urban infill development project scenarios. Each scenario is approximately one acre in size. The Option 1 approach maximizes the use of green infrastructure practices such as rain gardens, blue roofs, green roofs, planters, and pervious pavement across the site to meet stormwater management water quality and quantity requirements. The Option 2 approach uses techniques such as an underground extended detention facility and a manufactured treatment device to demonstrate regulatory compliance. In all three scenarios, a subsurface management system would most likely be required to meet regulatory requirements for the green approach. However, the size of the system required for the green approach would be much smaller than for the gray approach.

For each sample scenario, there is no difference in useable development area (building area and parking spaces) between the green approach and the gray approach. A summary table is provided for each scenario that compares cost and other performance metrics. Performance metrics for sequestered carbon dioxide (CO₂), urban heat island reduction and potential increase in property value were all calculated using the Green Infrastructure Co-Benefits Calculator described in the Benefits of Green Infrastructure section. The green approach also includes the additional aesthetic, permitting and economic benefits associated with green infrastructure described in the Benefits of Green Infrastructure section.

Maintenance activities associated with surface green infrastructure are mainly geared toward landscaping and include weeding, watering, sediment and trash removal. Subsurface systems may require sediment removal. Maintenance for manufactured treatment devices include sediment removal and periodic cartridge replacement. It is assumed that the cost to maintain green infrastructure is offset by the maintenance cost associated with a manufactured treatment device.

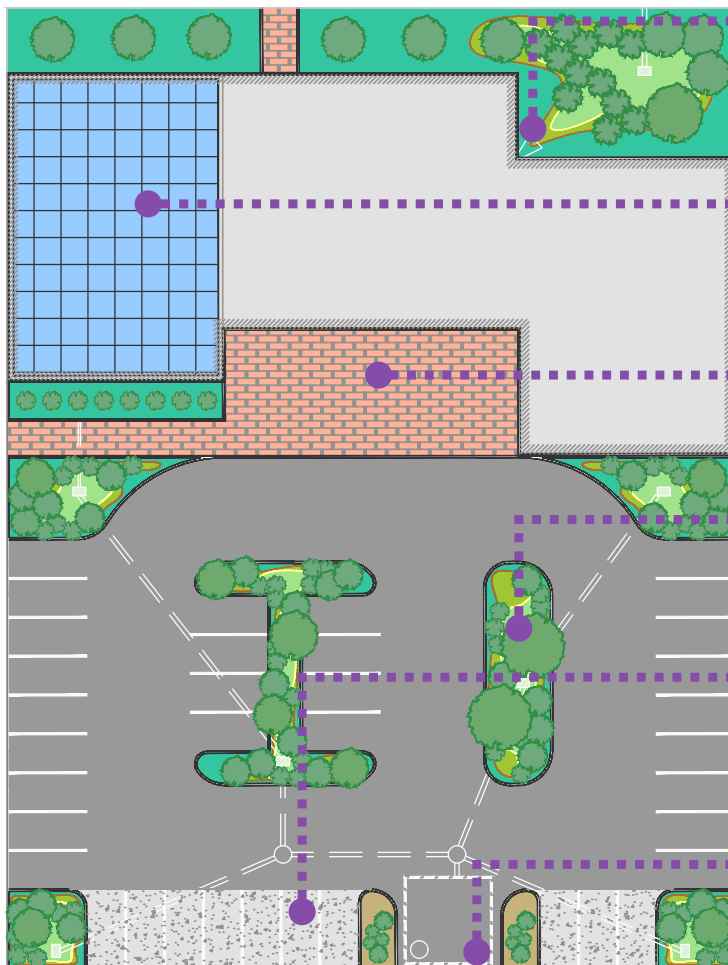
The estimated costs included in the summary tables are only provided for the design elements that differ between the green and gray scenarios. For example, no building costs or underground piping costs were included as these items were assumed to be the same for both approaches. Capital cost assumptions included the following:

- No additional cost was added for a blue roof versus the cost of a conventional roof.
- Porous pavement cost was calculated as the difference between porous pavement and standard impervious asphalt.
- Pervious paver cost was calculated as the difference between pervious pavers and standard concrete.
- Rain garden cost was calculated as special soil media, additional landscaping, and underdrains and was calculated as the difference between rain gardens and basic landscaping with trees and mulch.
- Underground detention/retention facility cost was calculated as the difference in size between the gray and green infrastructure approaches and includes a manufactured treatment device for water quality control for the gray approach.

COMMERCIAL PROPERTY

Option 1 — Maximum Green Infrastructure

The sample development project shown here includes a typical commercial building with associated parking spaces. Green infrastructure is implemented throughout the site to the maximum extent practicable. This sample project represents a green approach to stormwater management and includes a blue roof that discharges to a planter adjacent to the building, rain gardens to manage runoff from most of the parking lot and a portion of the roof area, pervious asphalt pavement and pervious concrete paver sidewalk areas, and an underground stormwater detention/retention system.



Roof downspout drains to a rain garden.

Blue roof provides extended detention with low flow connection to planters for water quality treatment.

Pervious pavers provide means for infiltration adjacent to hardscape areas.

Rain gardens with curb cuts provide water quality treatment of parking lot runoff.

Pervious asphalt pavement provides means for infiltration adjacent to hardscape areas.

Connection to existing sewer provides for safe overflow during large storm events.



Image Credit: VNH Princeton



Image Credit: VNH Capital Health



Image Credit: VNH Princeton

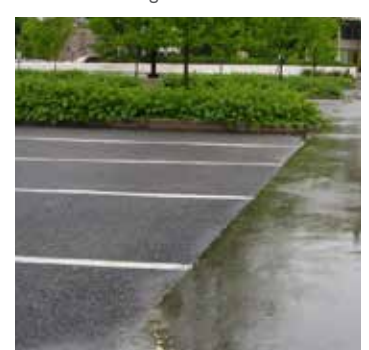


Image Credit: Asphalt Pro

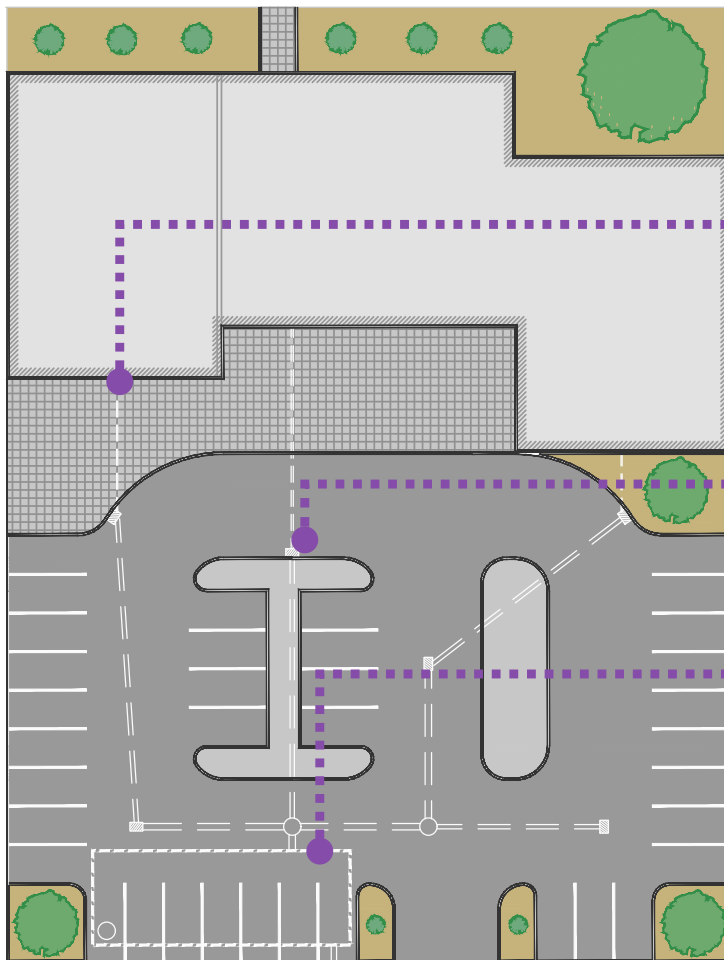
Green Stormwater Management Comparison Table

	Construction Cost	Nonstructural Strategies Addressed	Performance		
			CO ₂ Sequestered (lb/yr)	Urban Heat Island Reduction	Potential Property Value Increase
Green Option	\$44,000	#2, #4, #7, #8	1,218	61%	9%

COMMERCIAL PROPERTY

Option 2 — Minimal Green Infrastructure

The sample development project shown here includes the same typical commercial building and associated parking spaces as option 1. This approach uses an underground stormwater detention/retention system with a manufactured treatment device to meet regulatory requirements.



Downspout connects directly to underground piping.

Parking lot runoff drains directly to underground piping.

Subsurface extended detention system with manufactured treatment device provides water quality treatment of parking lot runoff and connection to existing sewer provides safe overflow during large storm events.



Image Credit: Concrete Fastening



Image Credit: Al's Asphalt Paving



Image Credit: AKRF, Inc.



Image Credit: Water World

Gray Stormwater Management Comparison Table

	Construction Cost	Nonstructural Strategies Addressed	Performance		
			CO ₂ Sequestered (lb/yr)	Urban Heat Island Reduction	Potential Property Value Increase
Gray Option	\$82,000	None	117	8%	0%

RESIDENTIAL PROPERTY

Option 1 — Maximum Green Infrastructure

The sample development project shown here includes two typical medium-density residential buildings with associated parking spaces. Green infrastructure is implemented throughout the site to the maximum extent practicable. This sample project represents a green approach to stormwater management and includes rain gardens to manage runoff from the roof areas and some of the parking area, pervious asphalt pavement, pervious concrete paver sidewalk areas and an underground stormwater detention/retention system.

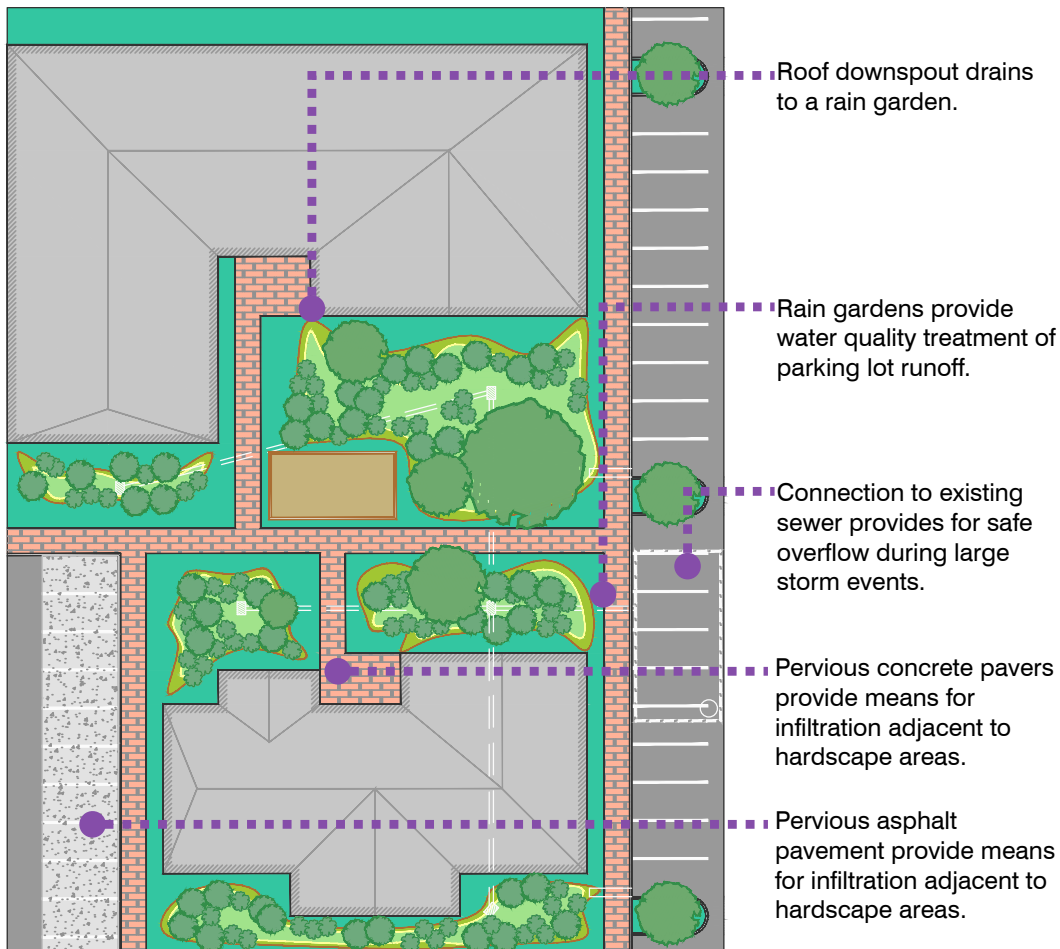


Image Credit: SPUR



Image Credit: Creating Sustainable Landscapes, LLC



Image Credit: Stormwater Report



Image Credit: Farland Corp.

Green Stormwater Management Comparison Table

	Construction Cost	Nonstructural Strategies Addressed	Performance		
			CO ₂ Sequestered (lb/yr)	Urban Heat Island Reduction	Potential Property Value Increase
Green Option	\$24,000	#2, #4, #7, #8	1,052	61%	9%

RESIDENTIAL PROPERTY

Option 2 — Minimal Green Infrastructure

The sample development project shown here includes the same two typical medium-density residential buildings and associated parking spaces as option 1. This approach uses an underground stormwater detention/retention system with a manufactured treatment device to meet regulatory requirements.

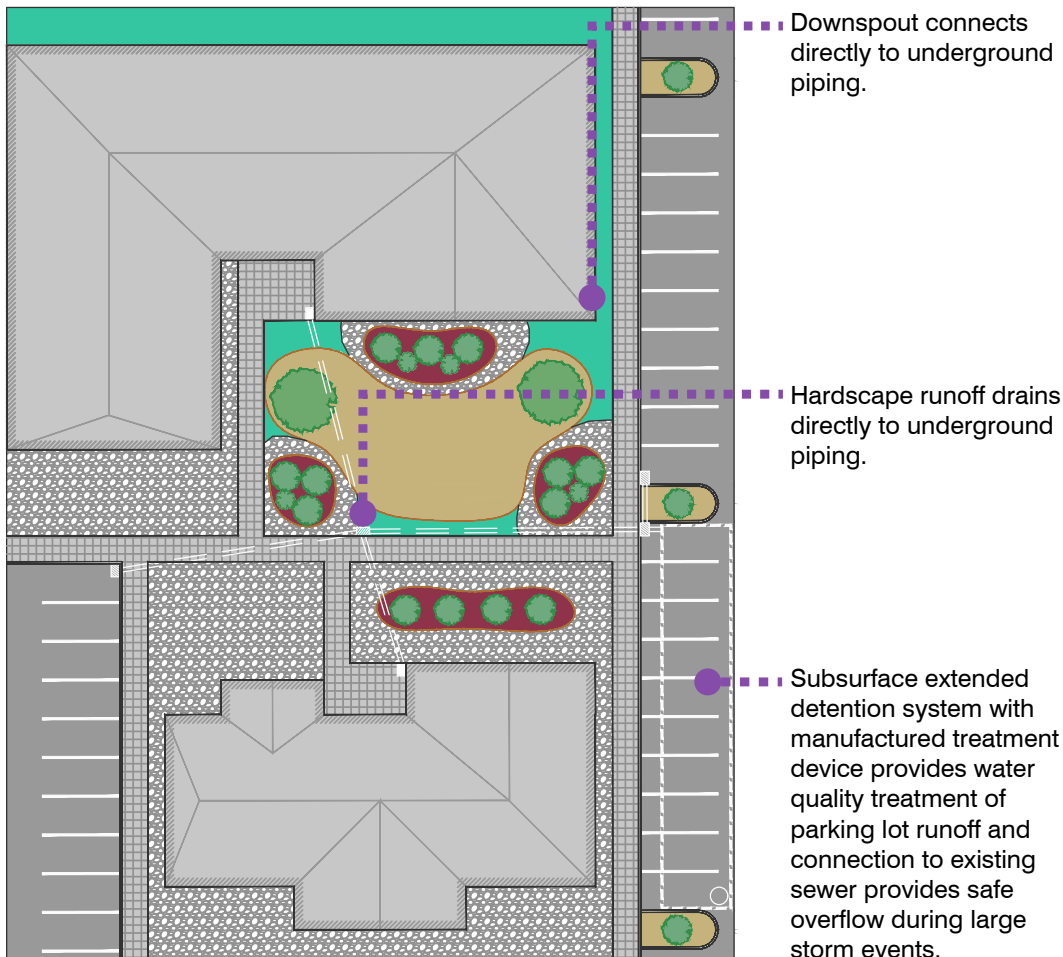


Image Credit: YouTube



Image Credit: KC Drainage Solutions



Image Credit: Relator.com



Image Credit: Advanced Foundation Repair

Gray Stormwater Management Comparison Table

	Construction Cost	Nonstructural Strategies Addressed	Performance		
			CO ₂ Sequestered (lb/yr)	Urban Heat Island Reduction	Potential Property Value Increase
Gray Option	\$94,000	None	147	8%	0%

URBAN INFILL

Option 1 — Maximum Green Infrastructure

The sample development project shown here includes a typical high-density residential building with associated parking spaces. Green infrastructure is implemented throughout the site to the maximum extent practicable. This sample project represents a green approach to stormwater management and includes blue roofs that drain to planters at the rear of each unit, green roofs at the front of each unit, a rain garden to manage runoff from a portion of the parking area, pervious asphalt pavement, pervious concrete paver sidewalk areas and an underground stormwater detention/retention system.

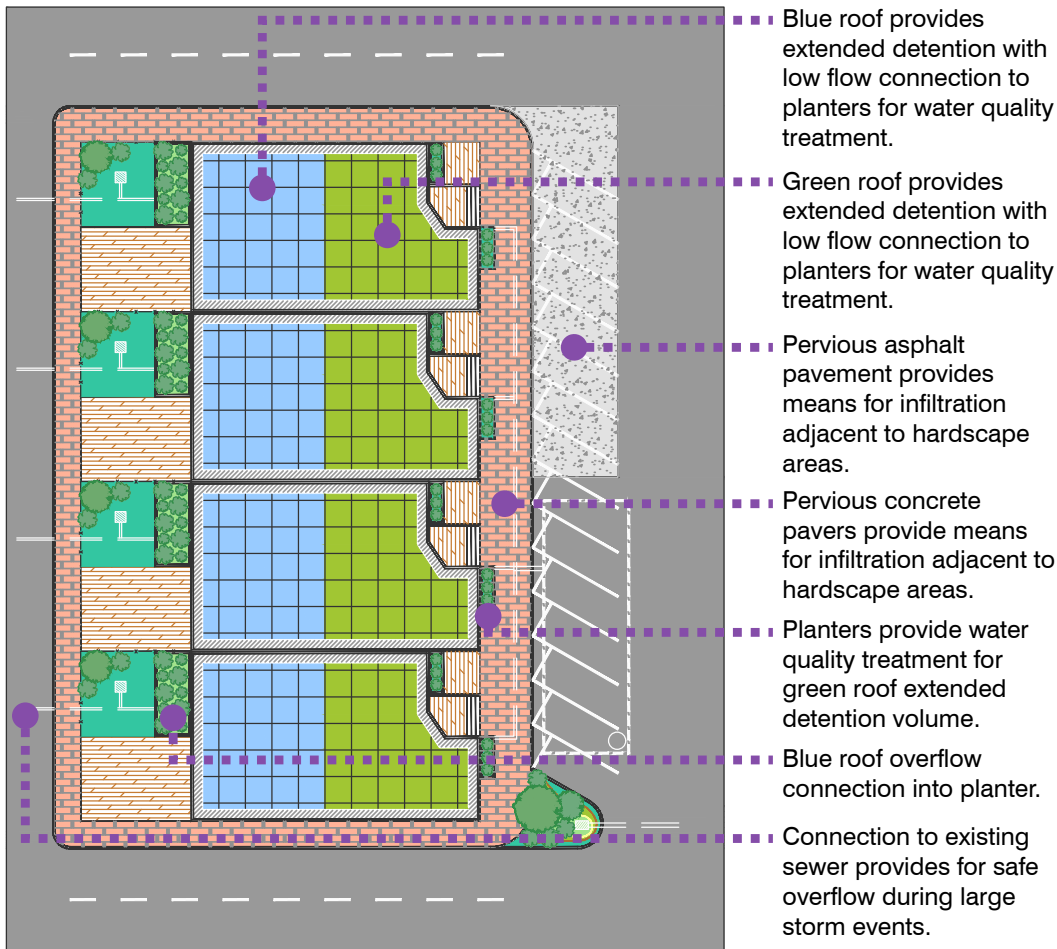


Image Credit: Zelen Architecture



Image Credit: Near Say



Image Credit: NYC.gov



Image Credit: EPA

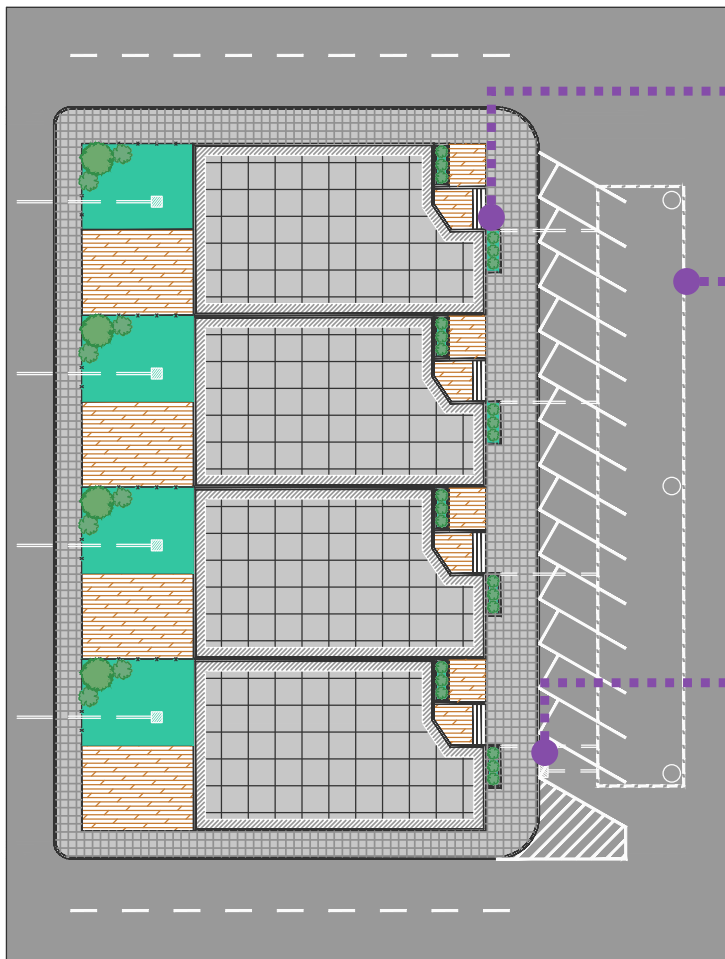
Green Stormwater Management Comparison Table

	Construction Cost	Nonstructural Strategies Addressed	Performance		
			CO ₂ Sequestered (lb/yr)	Urban Heat Island Reduction	Potential Property Value Increase
Green Option	\$41,000	#2, #4, #7, #8	616	61%	9%

URBAN INFILL

Option 2 — Minimal Green Infrastructure

The sample development project shown here includes the same typical high-density residential building and associated parking spaces as option 1. This approach uses an underground stormwater detention/retention system with a manufactured treatment device to meet regulatory requirements.



Downspout connects directly to underground piping.

Subsurface extended detention system with manufactured treatment device provides water quality treatment of parking lot runoff and connection to existing sewer provides safe overflow during large storm events.

Parking lot runoff drains directly to underground piping.



Image Credit: Small Backyard



Image Credit: PJT Green Plumbing



Image Credit: Philly's Homes



Image Credit: Blogfinger

Gray Stormwater Management Comparison Table

	Construction Cost	Nonstructural Strategies Addressed	Performance		
			CO ₂ Sequestered (lb/yr)	Urban Heat Island Reduction	Potential Property Value Increase
Gray Option	\$92,000	None	117	8%	0%



CASE STUDIES





Landscaped rain gardens at the front entrance of Paseo Verde. Image Credit: Urban Land Institute

CASE STUDIES

CASE STUDY 1 PASEO VERDE

DEVELOPMENT TYPE:

Urban Infill

LOCATION:

1900-1950 North 9th Street,
Philadelphia, PA 19122

MUNICIPALITY//

NEIGHBORHOOD:

North Philadelphia, adjacent to Temple
University and the Regional Rail

DEVELOPER//

DESIGN TEAM:

The Asociación Puertorriqueños en
Marcha (APM)
Jonathan Rose Companies
WRT, LLC - Architect
WRT, LLC - Landscape Architect
Urban Engineers, Inc. - Civil Engineer
David Chou & Associates, Inc. -
Structural Engineer
CSA Group - Mechanical, Plumbing,
Fire Protection and Electrical Engineer

SEWER TYPE:

Combined sewer

COMPLETION DATE:

August 2013

Project Overview

Paseo Verde is a mixed use/mixed income development on an urban infill site in the ethnically diverse, low-income neighborhood of North Philadelphia, Pennsylvania. The development consists of 67 units of market rental housing, 53 units of LIHTC affordable rental housing, and 30,000 square foot of commercial space that houses a Federally Qualified Health Center, pharmacy, and APM's headquarters and program offices. The project was built by a partnership between an established community development corporation and an experienced developer committed to affordability and sustainability. **Paseo Verde achieved three Leadership in Energy and Environmental Design (LEED) Platinum certifications and incorporated extensive green infrastructure practices to demonstrate compliance with local stormwater management requirements and create an attractive development project that achieved full occupancy in less than one year.** The Asociación Puertorriqueños en Marcha (Association of Puerto Ricans on the March, or APM), one of Philadelphia's most prolific community development corporations, along with Jonathan Rose Companies, orchestrated the development.

The property had been a city-owned parking lot leased to the local gas utility for decades. It was desolate and unwelcoming, described as an "open wound" in the neighborhood. The 1.9-acre site sits less than two miles north of Center City Philadelphia in a densely populated and highly impervious area. The site is immediately adjacent to Temple University and has direct access to a regional rail system, several bus lines and the Broad Street subway.

Paseo Verde was realized through a close collaboration between the APM community organization with deep roots in its neighborhood, the Jonathan Rose Companies developer with a deep commitment to meeting the highest standards of triple-bottom-line (social, environmental, and financial) sustainability, many designers committed to integrating a green building into a green neighborhood, and public officials who saw the perfect symbol for a resurgent, forward-thinking city. **Above it all, this remarkable transformation was built for an enviably low price, using strictly off-the-shelf technologies.**



Design Summary

The design team incorporated high performance green features that required additional planning but no additional construction costs.

The green approach helped to avoid costly delays in getting local approvals since the green stormwater management program met regulators' expectations. The stormwater management approach includes the capture of 3 inches of stormwater managed through the use of blue roofs (37,600 SF), green roofs (15,600 SF), rain gardens (4,000 SF), and porous paving (80 SF). Stormwater from the blue roofs, green roofs, and rain gardens is sent to subsurface infiltration basins and overflow is discharged back to the city sewer system.

- **Blue roofs** (actually white) atop Paseo Verde North and South's apartments collect water during storms of up to a 100-year return interval, and then slowly release it afterwards. The blue roofs are equipped with standard waterproofing and include outlet control devices on the roofdrains. The blue roofs were sized to store up to 3 inches of stormwater for up to 72 hours and can hold up to 3 feet of snow (the equivalent of 3 inches of ponded water) to meet code requirements. The construction means and methods to add additional structural strength were the same as those for conventional roofs, therefore, no additional cost was incurred. This was accomplished using a typical roof design that includes open web wood trusses and Batt insulation, plywood sheathing, 2 inches of rigid insulation, and a TPO (thermoplastic polyolefin) waterproofing membrane.
- **Green roofs** were placed above a podium structure so no additional support was required. The green roof system includes 4 inches of growing media and prefabricated green roof trays that were delivered to the site with mature, drought tolerant sedum plants. Large tree planters were placed directly above load bearing supporting columns.
- **Rain gardens** include infiltration soil media with a variety of native plantings (grasses, perennials, and trees) – roughly 25 to 30 different species.
- **Subsurface infiltration basins** provide additional stormwater storage capacity beyond what is provided in the blue roofs, green roofs, and rain gardens and consist of perforated HDPE pipe surrounded with varying sizes of stone and a geotextile fabric.
- **Porous pavement** design includes Hanover concrete blocks with gravel in between. Stormwater passes through the gravel and infiltrates into the soil below.

“If you can do this here, you can do this anywhere.”

- Rose Gray,
Sr. Vice President of Community
and Economic Development with
APM



A bird's-eye view of the Paseo Verde project. The first-floor retail/parking podium supports three landscaped courtyards or green roofs and the three wings of Paseo Verde South have blue roofs. Photo Credit: Urban Land Institute

Decision-Making

The project team consisting of APM, Jonathan Rose Companies, and WRT did not need to incorporate green infrastructure into the design to the extent they did. For example, including nearly 16,000 square feet of green roof into the design was not specifically required in order to meet the local stormwater management requirements, but other measures would have been necessary if not a green roof. The small rain gardens and the porous pavement were not required either. **The project development team elected to include accessible green roofs and the rain gardens for the residents. The visually appealing features function as a usable amenity for the residents, while adding stormwater management benefits.** The pervious pavement was included to “disconnect” more impervious area and promote additional groundwater recharge. The stormwater management requirements could have been met using a more robust subsurface infiltration system. That approach would have left the residents without a rooftop amenity and would not have provided the community with the added environmental and aesthetic benefits that come with the surface green components.

Key to Success

Working within the Regulatory Framework

By incorporating green infrastructure in the development, Paseo Verde helps the City meet its regulatory obligations under the Clean Water Act by minimizing stormwater runoff and improving water quality. Meeting these obligations within a combined sewer area also helps the City reduce stormwater management and wastewater treatment costs. Sustainable developments like Paseo Verde can be instrumental to marketing the City as a forward thinking, green destination.

- Blue roofs were chosen as a cost-effective way to manage stormwater without the need for additional infrastructure. The cost and price points for construction had to be reasonable for affordable housing. To achieve these dual—and sometimes competing—goals, the project development team looked for efficiencies in every green design element it pursued and chose features that would simultaneously provide multiple benefits. For example, green roofs were selected as a way to reduce the amount of impervious cover on the site while also providing an amenity for the residents. By using a podium design approach for the supporting structure, no additional construction costs were incurred, which helped justify the decision to install green roofs.
- Many of the building’s sustainability measures were selected to meet multiple objectives that include adding amenities to help market the building and provide stormwater management to meet local regulations. The building’s green infrastructure not only manages stormwater in accordance with local requirements but also adds visual appeal.
- The design supports the city of Philadelphia’s nationally recognized stormwater management strategy, which processes stormwater through green infrastructure rather than through pipes, and helps tie the site into a neighborhood known for its tree-lined streets. The project development team wanted the project to blend in with the surrounding community. Neighboring developments have helped to enliven and green the sidewalks.
- The project development team worked closely with regulators during the planning stages to come up with a collaborative solution to stormwater management that met the goals of all parties. A common goal was to incorporate visible, surface green infrastructure components. Neither the project development team nor the city representatives wanted to build a large underground detention basin. Blue roofs, green roofs, rain gardens, and porous paving all provided above-ground, cost-effective, and visible stormwater management solutions.

- Green spaces were envisioned from the beginning during concept design, and stormwater management was integrated later in the design process. The decision to include rain gardens and porous pavement was driven by stormwater management requirements. Blue roofs and green roofs alone could not provide enough stormwater storage volume to meet the requirements, so the project development team decided to convert planned landscaped areas into rain gardens and install pervious pavement in a small sidewalk area. Designers viewed this as a way to combine stormwater management with aesthetic improvements.

Challenges

Paseo Verde has taught the development team a lot about design and stormwater management. The developers were glad they had made LEED certification and green design a top priority from the very beginning. In the case of Paseo Verde, that meant pursuing low-cost green features and achieving sustainability through multiple efficiencies.

“People say LEED and green infrastructure are expensive. But put it in your budget up front, and you find a way to pay for it.”

- Rose Gray,
Sr. Vice President of Community
and Economic Development with
APM



The Paseo Verde Green Roof provides stormwater management as well as a cost-effective amenity for the residents. The landscaping is primarily comprised of low-maintenance, hardy sedum plants. Photo Credit: Philadelphia LISC

In order to meet stormwater management requirements, a large quantity of stormwater had to be captured. To overcome this challenge, the project development team used innovative green stormwater infrastructure to demonstrate compliance, which also provided environmental and aesthetic benefits for the developers, the residents and the community.

It is very difficult to separate the cost of green infrastructure facilities that are incorporated into a larger development project. In the case of Paseo Verde it is particularly difficult because there was no extra cost. The stormwater management cost is primarily attributed to the subsurface infiltration basins and amounts to approximately \$134,000. This could have been twice as much had the development team elected not to incorporate green infrastructure. Below is a cost breakdown of the green infrastructure elements of the project:

Key to Success

Economic Uplift

The Paseo Verde development shows that smart design can be accessible to everyone. The green infrastructure components have helped to create a healthy and respectful environment within the community - less crime, less noise and no graffiti. As a result, it took less than 1 year to achieve full occupancy after opening, revitalizing the local area.

- **Blue roof** – No additional cost to the traditional roofing system was required. Custom PVC roof drains that extend 3 inches above the roof deck and that included drilled perforations added a negligible cost. No additional insurance was required.
- **Green roof** – The design included a podium roof deck and tree planters strategically placed above supporting columns, which did not incur additional structural reinforcement cost. The cost to install the vegetated tray systems and trees was part of the overall project landscaping cost of approximately \$42,000.
- **Rain gardens** – The rain gardens were incorporated into areas that were already planned as landscaped areas so there was no extra cost beyond the total landscaping cost of \$42,000.
- **Pervious concrete pavers** – The pervious concrete paver element was a very small component of the project and was completed by the main concrete contractor. The cost for the porous pavement was included in the overall concrete cost for the project.

Incorporating green infrastructure into the construction of the Paseo Verde development allowed for costs to be much more affordable. Photo Credit: Hidden City Philadelphia



Maintenance Overview

- APM maintains the green infrastructure at Paseo Verde, which takes the responsibility away from the residents.
- Maintenance for the blue roofs is minimal and includes regular inspections to ensure the roof drains are not clogged and are functioning properly. Since maintenance is needed for a conventional roof, there is no additional maintenance cost associated with the blue roofs.
- The building management company currently maintains the green roofs and the rain gardens in-house and does not rely on specialty contractors. Maintenance activities include traditional landscaping services such as weeding, plant replacement, and initial establishment-phase watering. Now that the trees, native species, and sedums are fully established, no regular watering is required. The cost to maintain the green roofs and rain gardens is no higher than traditional landscaping. In fact, the maintenance cost is reduced by installing native, hardy species that don't require regular watering. Regular lawn mowing services are not required either.
- The only maintenance required for the porous pavement is to keep the gravel area free and clear of debris. This is done as part of the normal housekeeping activities so no additional cost is required.



A green roof at Paseo Verde. The green roof is landscaped with plants that absorb stormwater. Photo Credit: Urban Land Institute



Landscaping with native plants is used at the entrance to Paseo Verde. Photo Credit: Urban Land Institute

Key to Success

Triple Bottom Line

The decision to incorporate green infrastructure into the project was made to expedite permitting, reduce cost, and provide an amenity to make the Charlotte Wilson Complex a highly desirable housing option.



The Charlotte Rachel Wilson Student Housing with a porous paving parking lot and landscaping to minimize impervious area. Photo Credit: ACT Engineering, Inc.

CASE STUDY 2 PRINCETON THEOLOGICAL SEMINARY

DEVELOPMENT TYPE:

Student Housing

LOCATION:

Faber Road, West Windsor Township, NJ 08540

MUNICIPALITY// NEIGHBORHOOD:

Mixed Use

DEVELOPER// DESIGN TEAM:

Princeton Theological Seminary;
ACT Engineers, Inc.

SEWER TYPE:

The project is served by public sewers through West Windsor Township with treatment by the Stony Brook Regional Sewerage Authority.

COMPLETION DATE:

2013

Project Overview

Located in the West Windsor Campus of Princeton Theological Seminary (PTS), the 54-acre Charlotte Rachel Wilson Student Campus was originally made up of 25 buildings dating back to the 1950's. The surrounding area can be characterized as Mixed Use, bounded by the Delaware and Raritan Canal State Park to the north, a condominium complex to the east, a shopping complex to the south and Princeton Country Club to the west.

Since their original construction, buildings aged poorly and required extensive maintenance. Nevertheless, the complex provided needed housing that accommodated graduate students and their families. After extensive planning, PTS chose to redevelop a 23-acre portion of the complex as a LEED accredited campus, with three garden style apartment buildings containing 204 units and green infrastructure to manage stormwater. **The aesthetically pleasing new units have upgraded the school's housing stock and enhanced the living environment for prospective students.**

The project's proximity to the Delaware and Raritan Canal, as well as freshwater wetlands and flood plains associated with nearby Stony Brook, meant that special attention to stormwater management and water quality control was needed. The development also had to be sensitive to aesthetic and historical concerns raised by the Delaware and Raritan Canal Commission (DRCC). **The use of green infrastructure to manage stormwater helped to meet NJ DEP, local and regional regulatory requirements. By utilizing green infrastructure, the designers and PTS were able to provide a conservation minded, low impact development that preserved the wooded character of the site.**



Preserving mature trees creates a sense of permanence for the development. In addition, mature trees add property value, cool the air, reduce ground-level ozone and absorb a large volume of water.
Photo Credit: Princeton Theological Seminary

Design Summary

The design team utilized green infrastructure to support a holistic vision of the development project, which sought to integrate naturalized stormwater management areas adjoining the existing wetland buffers. Natural areas dominated by hardwood trees around and within the project area were retained as much as possible.

- Two **infiltration basins** with extended detention were installed to provide primary water quality management and stormwater detention. The basins were designed to manage stormwater in accordance with NJ DEP and local requirements. The basins were carefully sited to minimize disturbance to adjacent woodlands while their naturalized landscaping visually tied them into the surroundings. **The infiltration basins located at the perimeter of the site help to transition the carefully manicured landscape around the buildings to the more natural landscape beyond.** The decision to send overflow from the infiltration basins to the nearby canal using existing swales rather than stormdrain piping was made to reduce cost and to provide additional water quality benefits through a surface vegetated conveyance system.
- Approximately 10,700 square yards of **porous bituminous pavement** were installed in parking lots and driveways where adequate separation to the seasonal high groundwater table could be achieved. The porous pavement served as water quality pretreatment for an underground extended detention system. An open bottom design provides some infiltration capacity.

“Wetland buffers, floodplains and wooded areas were left largely undisturbed to provide a visual connection to the Delaware and Raritan Canal State Park and to protect valuable wildlife habitat adjacent to the nearby stream corridor.”

- Walter Bronson,
Project Engineer



Infiltration basin immediately after a storm event (Left). Installation of subsurface detention cell (Right).
Photo Credits: ACT Engineering, Inc.

Key to Success

Inter-agency Coordination

Close collaboration with DRCC was instrumental in obtaining approval from NJ DEP regarding the siting of an infiltration basin on a pre-existing manmade wetland. While disturbance of the isolated wetlands was a cause for concern with NJ DEP, the DRCC was able to make the case that clearing existing woodland was the more detrimental choice.

Decision Making

- The presence of sandy, highly permeable soils coupled with relatively deep seasonal high groundwater levels was one of the primary drivers for installing infiltration basins. One of the basins is an expansion and retrofit of an existing basin on site, which helped to minimize cost. The siting of the newly constructed basin repurposed an existing disturbed area to reduce the need for further encroachment into existing woodlands.
- The design utilized porous pavement at a cost of approximately \$550,000 for an added level of water quality protection to satisfy the concerns of the DRCC. Porous pavement also provides the 80% Total Suspended Solids (TSS) removal required by NJ DEP prior to stormwater entering the underground detention system. The design team decided to use porous pavement rather than a manufactured treatment device to achieve TSS removal out of concern for cost, and/or long-term maintenance requirements.
- The Contractor utilized low ground pressure vehicles to minimize soil compaction during construction of the infiltration basins, underground detention systems, and landscape areas.

Challenges

- Permitting for the project was complicated due to multiple agencies having jurisdiction. Clear communication of the project's objective to minimize site disturbance was influential in obtaining approvals from different regulatory agencies.
- Construction challenges were overcome by paying careful attention to construction practices. For example, filter fabric was used to protect completed areas during infiltration basin and porous pavement installation. The fabric was carefully removed upon complete stabilization of the contributing drainage areas. Similarly, downstream discharge points were additionally reinforced to prevent erosion.

Maintenance Overview

The porous pavement requires periodic vacuuming instead of sweeping and is estimated to cost approximately \$3,500 per year. Salt is required for ice treatment rather than sand. The infiltration basins and subsurface extended detention facilities require regular inspections to ensure the facilities are working properly. Repairs are made, as necessary, and typically include minor activities such as cleaning outlet control structures. There is essentially no required maintenance of the infiltration basins other than occasional cutting of vegetation on side slopes. The use of native hardy species around the infiltration basins reduces the need for pruning or regular watering.



The Virtua Voorhees Hospital viewed across the stormwater wetland. Photo Credit: Dewberry

CASE STUDY 3 VIRTUA VOORHEES HOSPITAL

DEVELOPMENT TYPE:

Healthcare Campus

LOCATION:

100 Bowman Drive
Voorhees, Camden County
NJ 08043

MUNICIPALITY//

NEIGHBORHOOD:

Major Business District

DEVELOPER//

DESIGN TEAM:

Virtua Health
Dewberry
HGA Architects & Engineers

SEWER TYPE:

Separate Sanitary and Storm Sewer

COMPLETION DATE:

May 2011

Project Overview

Ten years in the making, Virtua Voorhees is a 120 acre healthcare campus development constructed on a greenfield site along NJ State Highway Route 73 in Voorhees Township, Camden County, NJ. The site was assembled from a number of single family, commercial and vacant lots. The project consists of a 386 bed inpatient acute care hospital and 300,000 sf health and wellness center. The initial development on the campus was built by a partnership between Virtua Health and a private healthcare real estate developer. Virtua Voorhees achieved Leadership in Energy and Environmental Design (LEED) Silver certification.

The Virtua Voorhees campus was envisioned as a state of the art healthcare development that promotes a sense of healing from the moment one arrives on the campus. This vision is supported by the presence of many green infrastructure practices throughout the development. From preservation of onsite freshwater wetlands, natural viewsheds and lush native landscape treatments that, in some cases, also manage stormwater; to site amenities such as walking trails and bike lanes, the campus allows patients, visitors, staff and the community to experience the beauty of the setting while providing the highest level of healthcare and healing consistent with Virtua's mission to 'be well, get well and stay well'.

The 120 acre site lies along Route 73 in a Major Business zone district. As part of the project approval process, a General Development Plan that lays out the long term vision for the eventual buildout of the campus was developed and approved by Voorhees Township. The surrounding areas include residential neighborhoods, retail and commercial development along the state highway, a golf course and public park. The site is served by a NJ Transit bus route with stops provided onsite.



One of the three green roof gardens used as a passive recreational element. Photo Credit: Dewberry

Design Summary

The design team incorporated green stormwater management techniques that required additional design and planning, but which nonetheless achieved compounded improvements to site water quality and aesthetics. **Green infrastructure provides multiple benefits to Virtua Health, its employees and the patients that visit the campus. The green infrastructure helped Virtua Health obtain NJ DEP and local regulatory approval, offers a beautiful place to work and visit, and provides multiple environmental benefits as well, including wildlife habitat and stormwater quality treatment.**

By incorporating green stormwater infrastructure, the project also provides benefits to the local municipality by improving the water quality of stormwater leaving the site, reducing downstream flooding, and replenishing groundwater aquifers. The campus is a testament to the fact that implementation of a sustainable approach to site development and stormwater management using green infrastructure is not only feasible but beneficial from both an environmental and economic standpoint for both the property owner and the community.

The well-integrated green infrastructure practices include a mixture of structural and nonstructural stormwater management techniques including surface and subsurface groundwater recharge basins, extended detention basins, wet ponds, constructed stormwater wetlands, vegetated swales and rain gardens. Green roof areas are also incorporated into the building design to enhance “look down” views, provide passive cooling and reduce roof runoff volumes. All site runoff is eventually either recharged or discharged to surface waterways at below pre-development rates.



Green infrastructure can enhance the landscape and become an inviting space for employees and visitors. Photo Credit : Dewberry

Studies show convincingly that views of trees, flowers and water promote healing. And the ability to be outdoors, in a naturalistic landscape with trees, benefits patients and staff alike.
(Franklin, 2012)

- **Groundwater recharge basins** provide water quality treatment, runoff rate reduction and groundwater recharge for a majority of the drainage areas at the south end of the campus. Minimal curbing on roadways and parking lots promote sheet flow and shallow flow into linear roadside swales that convey runoff into the basins. By minimizing the amount of curbing through sheet flow and by using surface swales rather than underground piping, construction costs were reduced. Through this green infrastructure approach, the first flush of runoff has greater opportunity to be completely retained on-site and infiltrated to groundwater.
- **Subsurface infiltration** was incorporated as two large fields of High-Density Polyethylene (HDPE) arched chambers installed beneath parking areas comprise a major subsurface infiltration system. These chambers collect rooftop runoff and directly recharge ground water without the need for water quality treatment.
- **A constructed stormwater wetland** was an ideal GI practice for a poorly drained area with a high ground water table located near the center of the development and flanked by two preserved wetlands. A stormwater landscape of microponds, high and low marshes and permanent pools remove a large portion of sediment carried in runoff to achieve a TSS removal rate of 90%. The constructed stormwater wetland offered an opportunity to make the most of difficult site conditions and demonstrate compliance with regulatory requirements. A meandering walkway weaves through the complex and connects the wetland to other traditional stormwater features on site, creating a holistic and connected environment.
- **Vegetated swales** are located along the perimeter of much of the surface parking and campus loop roadway areas. By directly capturing runoff from these large impervious areas, the swales eliminate the need for traditional piped infrastructure to remove runoff, which reduced construction costs. Micro-scale design elements such as check dams and intermittently spaced inlets along the channels promote infiltration, control stormwater flow and prevent ponded water.
- Three large **rain gardens** sited at the north end of the campus collect runoff from the large employee parking lot while lush planting of native trees, shrubs and colorful perennials in the rain gardens serve as an attractive visual buffer along the north entry drive.
- **Green roofs** were strategically placed at lower roof levels to be visible from patient rooms which create soothing 'look down' views which would otherwise have barren views of traditional roofscape.

Decision Making

The wide array of carefully chosen green infrastructure practices resulted in many benefits including reduced construction costs, attractive views, and expedited compliance with regulatory requirements. The decisions that were made to incorporate green infrastructure are summarized below.

- Virtua's primary objective for this project was to create a cutting edge, high quality environment in which to deliver exceptional health care services. In light of this primary objective, construction cost decisions were carefully weighed against the health system mission's statement. Accordingly, the design team elected to incorporate extensive green infrastructure practices as an opportunity to satisfy multiple needs: enhanced aesthetics, reduced construction and/or operating costs, promote a more natural landscape and achieve expedited regulatory compliance.
- The decision to eliminate curbing and traditional stormdrain piping where possible resulted in hundreds of thousands of dollars in savings.
- The project development team decided at the beginning of the project to incorporate a site sensitive stormwater design that responds to local soils, wetlands, woodlands and topographic conditions. The strategy used to meet the goal entailed a wide range of green stormwater practices to meet the regulatory and functional requirements of the project.
- Green roofs were chosen as a cost-effective way to manage stormwater without the need for additional infrastructure. The minimal added weight was easily accommodated without significant change to the structural design.
- The design team's decision to incorporate green infrastructure and their close working relationship with NJ regulatory agencies (NJ DEP, NJ DOT) during the permitting process helped to meet the stormwater management goals of all parties without delay.



Green infrastructure practices were used throughout the parking lot of the hospital to handle road runoff. Photo Credit: Dewberry

Challenges

- For a project of this scale and magnitude, the design team had to negotiate a complex regulatory environment requiring adherence to multiple agency requirements. By incorporating green stormwater infrastructure, this process did not result in permitting and approval delays.
- Difficult site constraints and development program needs made for a challenging design effort. Green infrastructure helped to overcome this challenge. Implementing distributed green infrastructure practices to manage stormwater instead of more traditional detention storage areas in underground facilities resulted in a better design. While additional underground facilities would have increased valuable area for parking, the need for expensive pretreatment systems such as manufactured treatment devices made it more cost effective to comply with water quality permitting requirements using green infrastructure.
- Incorporating green infrastructure into the construction sequence without negatively impacting the facilities was a challenge. Temporary stormwater controls such as rock check dams, temporary sediment basins, silt fence, haybale barriers, and temporary curbing were implemented prior to installing the permanent green infrastructure facilities in order to avoid damage during mass grading, earthwork, and paving operations. By using temporary controls, the vegetation in the swales and rain gardens were installed later in the construction process so they were able to establish without the risk of sedimentation and damage from heavy equipment.

Areas of green infrastructure double as a space for people to gather and enjoy the outdoors. Photo Credit: Dewberry

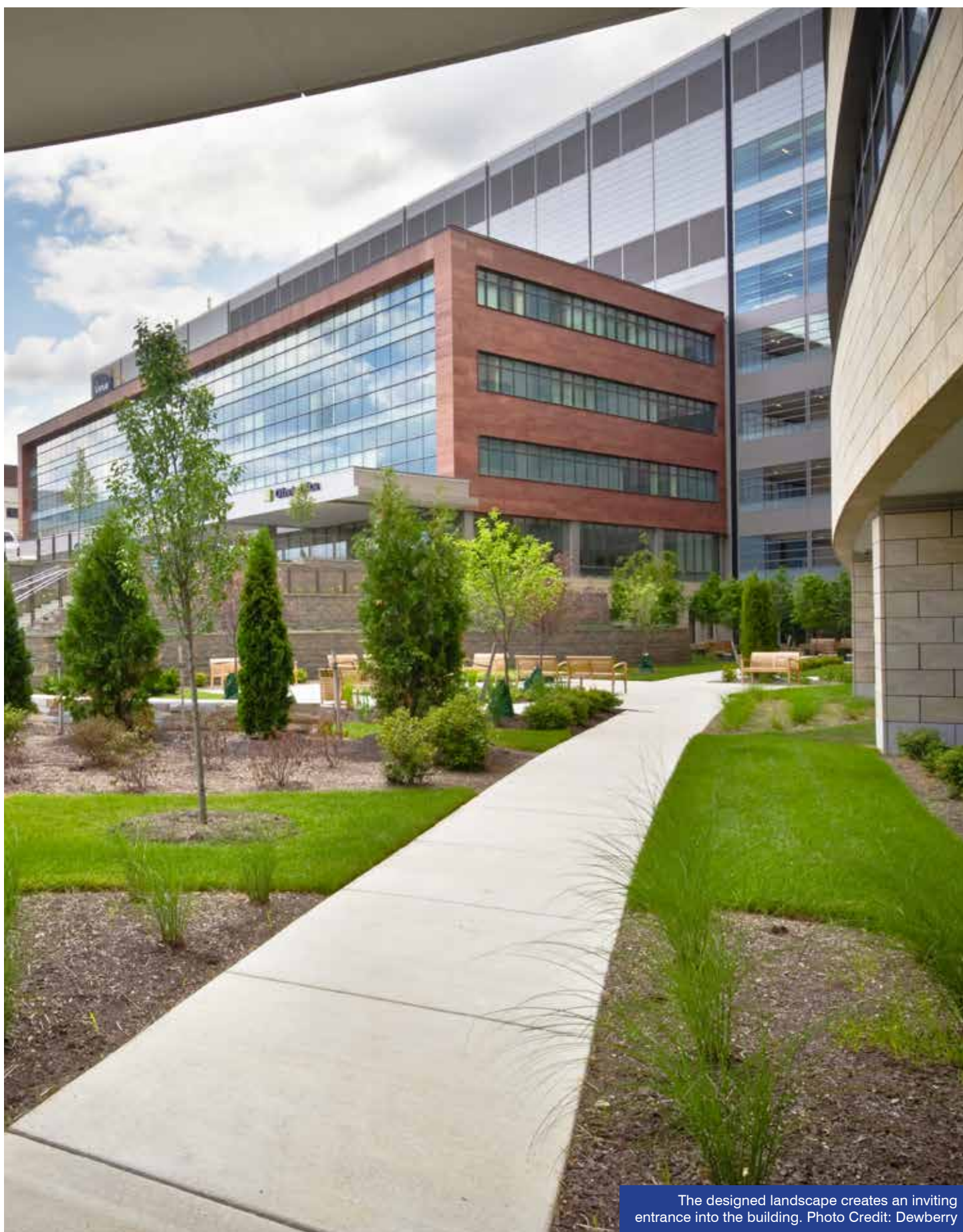


Maintenance Overview

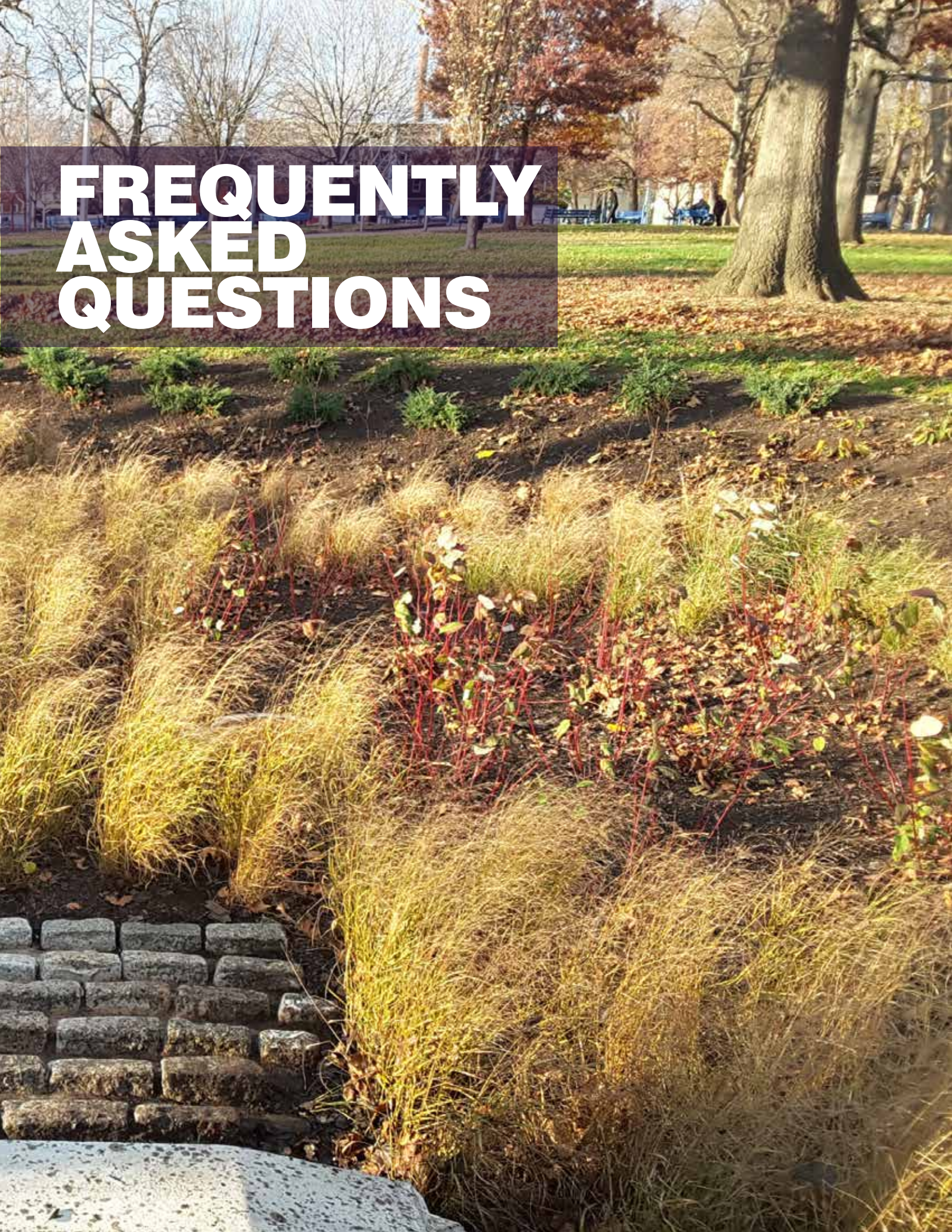
- Maintenance of the green infrastructure and stormwater management measures is undertaken by Virtua's facility management group with the assistance of contract service providers.
- Maintenance for the green roofs is minimal and includes regular inspections to ensure the plant material is in good condition and an occasional watering during extended periods of hot, dry weather.
- With extensive "no mow" meadow type landscaped areas, regular lawn mowing services are more limited than is required by traditional lawn areas.
- Water quality treatment is provided with nonstructural measures so there is no need or cost for periodic removal of oils, trapped solids, and cartridge replacement as is the case with structural manufactured treatment devices.
- The recharge basins, constructed wetlands, wet pond, and vegetated swales all require minimal annual maintenance at little cost other than would be required for any typical landscaping contract.



A dramatic view of the landscaped amenities that are nestled within the architectural components of the campus. Photo Credit: Dewberry





A photograph of a park landscape. In the foreground, there is a stone wall made of grey rectangular stones. Behind the wall, there are clumps of tall, dry, yellowish grass and some red-stemmed plants with small white flowers. In the background, there are several trees, some with autumn-colored leaves (orange, red, yellow) and some without leaves. A large tree trunk is visible on the right side. The sky is blue with some light clouds. The overall scene is a park in autumn.

FREQUENTLY ASKED QUESTIONS

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What is green infrastructure?

Green infrastructure is an approach to managing stormwater that is modeled on natural processes and systems. Unlike conventional “gray” infrastructure, which carries rainwater away from where it falls through gutters, drains and pipes, green infrastructure keeps most stormwater on site through infiltration and beneficial reuse. In urban and suburban areas, this helps restore the natural water cycle and provides many environmental benefits. Rain gardens, green roofs, pervious pavements, and other types of green infrastructure practices can save money, help satisfy permitting requirements, and increase public acceptance of your development project.

Green infrastructure practices have been installed successfully throughout New Jersey. While these practices may not prevent flooding in extreme rain events, they have proven to be as effective as gray infrastructure at managing stormwater in many settings. They offer a cost effective way for developers to comply with regulations, provide aesthetic enhancements for communities, attract customers to retail centers, and reduce long-term energy costs.

Why should I consider using green infrastructure on my project?

Green infrastructure is an important tool for meeting the nonstructural strategies requirements defined in NJAC 7:8. It can offer the same stormwater management benefits as traditional gray infrastructure, while providing a suite of other financial, permitting, and community engagement benefits to your development project at the same or lower cost. See the Green Infrastructure Benefits section of this Guide for further detail on how and why green infrastructure can serve your project. For specific examples of how some developers have leveraged green infrastructure for multiple benefits, refer to the Case Studies section of this Guide. For a side-by-side comparison of how green stacks up to gray infrastructure for a sample development scenario, refer to the Side-by-Side Comparisons.

In addition, green infrastructure can also help the local and state economy. It generates jobs for engineers, environmental scientists, and landscape architects who have technical knowledge of appropriate, site-specific practices. The installation of systems creates jobs for construction workers. The need to maintain system after construction also helps to create jobs, especially for entry-level workers. These entry level jobs can lead to higher paying jobs as workers gain experience and knowledge.

Doesn't green infrastructure require more maintenance?

No. A common misconception about green infrastructure is that it requires significantly more maintenance than traditional gray infrastructure or traditional landscaping. This is not the case. Maintenance tasks are usually very simple (such as occasional weeding, cleanup, etc.) and can be done by the property owner or the routine landscaping crew.

Maintenance varies depending on the type of green infrastructure practice. For example, recommended maintenance for pervious asphalt pavement involves biannual vacuuming to remove fine sediments. Less maintenance is required compared to regular asphalt due to superior snow melting characteristics.

(http://www.sandiegocounty.gov/reusable_components/images/dgs/Documents/Grants_Prop40_AppendIII_.pdf)

Landscape practices need regular maintenance to remove debris, replace mulch in some cases, and maintain vegetation. Inspections (e.g., for erosion and sediment accumulation, or pH testing) can be performed occasionally as needed.

(<http://www.bluewaterbaltimore.org/wp-content/uploads/RainGardenRoutineMaintenance1.pdf>)

Don't rain gardens look weedy and overgrown?

Rain gardens can be planted to look naturalistic, like a meadow, or they can be maintained with a more formal garden appearance. The plants and landscape design that are chosen will determine the appearance. If you think your customers would prefer a garden-like aesthetic over a meadow, simply communicate this need to the landscape designer or engineer. Like any garden, regular maintenance will ensure that it does not become weedy and overgrown.

Since it collects water, doesn't green infrastructure also breed mosquitoes?

Mosquitoes are one of the most common concerns that citizens tend to raise about green infrastructure, but this concern is addressed by standard design requirements. Green infrastructure practices are designed to drain within 72 hours or less, which will prevent colonization of mosquitoes since they take at about 72 hours to develop into their adult stage. Rain barrels, which may contain standing water for a bit longer, should be covered with a mosquito net or screen to prevent mosquitoes from laying their eggs.

How well does pervious pavement work? Is it durable?

The key difference between conventional concrete and asphalt pavements and pervious pavements is that the smallest stone particles, or fines, are left out of the pervious pavement mixture. This leaves small voids that allow water to infiltrate through the pavement. However, these pore spaces do slightly reduce the durability of the pavement in comparison with conventional pavements. Therefore, pervious pavements should be used strategically in areas with low vehicular traffic like parking stalls in parking lots or pedestrian and bicycle pathways. With proper design, construction and maintenance, pervious pavement works well for many years, including in winter weather. Black ice does not form on pervious asphalt, as any thawed water infiltrates; thus, pervious asphalt can help prevent slip and fall accidents.

Will a green roof work in winter?

Green roofs are still able to perform in cold weather, although not necessarily at the same level of effectiveness as during warm seasons. The soil in green roofs is porous, and therefore pervious, to some extent when frozen. Therefore, rainfall as well as snow that melts during freeze-thaw cycles can still be stored, although it will not be used by dormant plants.

(<https://www.epa.gov/green-infrastructure/winter-weather-om-green-infrastructure>)

Won't road salt kill the plants in green infrastructure practices?

Green infrastructure practices, especially those located next to streets or sidewalks, should be designed with plants that are salt tolerant. They are also designed with well-drained soil that helps flush salt through the soil more rapidly and reduce high concentrations that negatively affect plants. Thus, road salt rarely kills the plants, although it can cause stress and damage if used in large quantities. To reduce the potential for any damage, you can choose eco-friendly salt such as calcium chloride, which is safe for plants and pets, or you can reduce the amount of salt spread.

(<http://plant-pest-advisory.rutgers.edu/impact-of-road-salt-on-adjacent-vegetation/>)

(<http://www.deepproot.com/blog/blog-entries/minimizing-the-effects-of-salting-on-urban-trees>)

Will a green roof cost more because of its structure?

Green roof cost will depend on the type of roof and the amount of weight you are loading onto the rooftop. A new building can be designed to support this additional weight. For existing buildings, a structural engineer should be consulted to ensure the rooftop is able to support the additional load. In many cases, the lightweight materials used for green roof construction allow for a retrofit on an existing building.

My clients don't want a rain garden. Is that their only option?

There are many different types of green infrastructure that can be chosen to meet the specific needs of your client or project. For example, porous pavements and rain barrels can offer great alternatives in cases where a landscape practice is not the right choice for your project. Driveways and walkways can be repaved with porous pavement to infiltrate runoff from those surfaces, and downspouts can even be redirected into them to catch rooftop runoff as well. Rain barrels can be used to catch runoff from rooftops for reuse in watering plants or washing cars.

Although some homeowners have been discouraged from installing rain gardens due to misconceptions about them, many others in New Jersey have realized the functionality of green infrastructure and the benefits that rain gardens can bring to their home and community. For example, rain gardens can add to the aesthetics of a home, lower landscape maintenance costs, and can even increase property value!

Doesn't green infrastructure cost more?

Green infrastructure practices often are more cost-effective than traditional gray infrastructure. Integrating green infrastructure into development projects can reduce costs by decreasing the amount of underground drainage piping and structures needed to manage stormwater, which reduces construction costs. Green infrastructure can reduce operations and maintenance costs associated with development properties. For example, a green roof can reduce heating and cooling costs for a building. Green roofs also last longer than conventional roofs, which reduces replacement costs. Pervious pavements have been shown to cost less to maintain over the long term than conventional pavements, resulting in accumulated savings that exceed higher initial installation costs. In some cities, green infrastructure saves property owners money by reducing or avoiding stormwater fees. No city in New Jersey levies stormwater fees -- yet.

Won't using green infrastructure on my projects increase my costs to meet building codes?

If designed thoughtfully, green infrastructure should not affect your ability to meet building codes. In most cases green infrastructure can be sited far enough away from the building to avoid any potential concerns about infiltrating near foundations, etc. In the case of green roofs, these are most commonly integrated as part of the overall building design and any potential increase in structural loads are addressed through the normal design process. Before installing green infrastructure, it is always advisable to check municipal codes, design standards, and planning to determine potential impacts on the development process. There are different steps that can be taken to address issues that might arise as a result of regulations and codes. For more information, visit the US Environmental Protection Agency (EPA) website.

Does green infrastructure qualify me for any tax abatements or tax savings?

Currently, green infrastructure practices do not usually qualify for abatements or tax savings. Tax abatements or tax savings vary from municipality to municipality as each city or town decides what will or will not qualify for tax abatement or tax savings. Contact your local municipality for information about abatements or other incentives.

Will green infrastructure help me qualify for LEED certification?

Yes. The LEED rating system offers up to four points toward certification for managing rainwater on site. Points are awarded based on the percentile of regional or local rainfall events that are managed using green infrastructure. For example, managing rainfall in 80th percentile is worth one point, while the 95th percentile is worth four points. It is calculated using daily rainfall data and methodology.

(<http://www.usgbc.org/node/2611408?return=/credits/neighborhood-development-plan/v4/green-infrastructure-%26amp%3B-buildings>)

(<http://www.usgbc.org/node/2613289?return=/credits/neighborhood-development-plan/v4/green-infrastructure-%26amp%3B-buildings>)

(<http://www.usgbc.org/node/2614047?return=/credits/neighborhood-development-plan/v4/green-infrastructure-%26amp%3B-buildings>)

Where can I learn more about green infrastructure options to consider for my next project?

The Rutgers Cooperative Extension (RCE) has created the Rutgers Green Infrastructure Guidance Manual in which the different types and benefits of green infrastructure practices are described. The Rutgers manual can be found at <http://www.water.rutgers.edu/>. Other useful considerations can be provided by Georgetown Climate Center, EPA, University of New Hampshire, and the Center for Watershed Protection.

(<http://water.rutgers.edu/GreenInfrastructureGuidanceManual.html>)

(<http://www.georgetownclimate.org/>)

(<https://www.epa.gov/green-infrastructure>)

(<https://www.unh.edu/unhsc/>)

(<http://www.cwp.org/>)

Are there green infrastructure consultants?

Yes. Many engineering, landscape architecture and architecture firms in the region have professionals on staff who are knowledgeable about green infrastructure design, installation and maintenance. It is also true that some firms lack this expertise. Ask your design professional what he or she has designed or built. If they tell you green infrastructure doesn't work or that it's too expensive, get a second opinion.



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This Guide has not been reviewed or endorsed by NJDEP. All permit applicants are encouraged to consult directly with NJDEP staff and/or NJDEP regulations and guidance documents regarding compliance issues.

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