Section 6

Green Stormwater Management Tools

SECTION 6

Green Stormwater Management Tools

ANDREW HILLMAN

QUEENS, NEW YORK: A simple and colorful stormwater planter along a sidewalk.

Section 3.5 of this guide illustrates ways to design sites to maximize spatial efficiency and create room for potential stormwater practices. Combining site design philosophy and the full toolbox of stormwater management strategies that are most applicable to conditions in Vermont, optimizes the potential for stormwater management in urban conditions.

Green stormwater tools can be classified based on their dominant functional mechanism: **1. Conveyance and Treatment**, **2. Infiltration/Filtration,** and **3. Evapotranspiration**. Understanding the function of stormwater tools can help to prioritize the most appropriate options for your site conditions.

CONVEYANCE AND TREATMENT

Conventional conveyance structures primarily perform the function of moving stormwater from one place to another. The green versions of this functional group differ from conventional conveyance systems because vegetated structures also provide some filtration through plant structure, infiltration as water from the surface moves through the soil profile, and evapotranspiration as plants take up water in the channel. Open vegetated conveyance structures provide more water quality benefit - in terms of quantity and quality - than closed piped systems which solely provide water movement conduits without treatment. In downtown areas where space is limited, treatment at the source of stormwater is not always possible. The following conveyance tools can be applied where water needs to be moved from one location to another before treatment or discharge. Many green practices rely on a combination of mechanisms; here, they are categorized based on dominant functional type.

INFILTRATION / FILTRATION

Infiltration is the action of water moving vertically through soil media and into groundwater. This removes pollutants from the water and eliminates excess surface runoff by providing a conduit for water to enter subsurface channels. Filtration is a similar mechanism initially, but results in a surface discharge of cleaner water rather than its infiltration underground. Infiltration practices are best suited in well-drained soils where stormwater can readily move into the ground. They are most appropriate in areas where there are no hazardous materials either in the soil media or being transported in stormwater runoff. Filtration practices are more flexible in their appropriate application because they do not function by the movement of water throughout a soil profile and therefore do not require highly infiltrative soils or extreme caution to protect groundwater quality.

EVAPOTRANSPIRATION

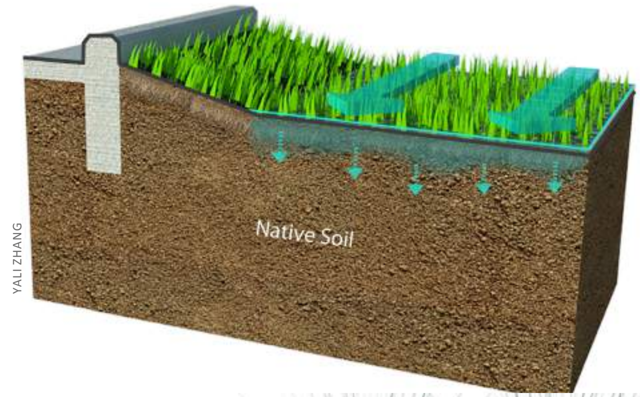
Evapotranspiration refers to the actions of evaporation (the change of water from a liquid to gaseous phase) and transpiration (water movement from a plant's roots through its vascular system). Plants move water into the atmosphere from the ground by taking up more than is required for biological processes. The excess is evaporated from aerial plant parts and returned to gaseous form. This is a critical part of the natural hydrologic cycle that is most often lacking in our downtown centers. By providing space for vegetation - most notably, large trees - to grow and thrive, evapotranspiration can be maximized.

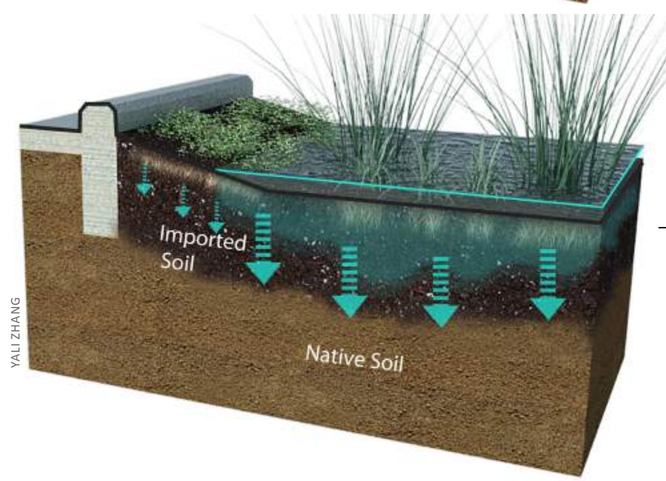
6.1 THE STORMWATER MANAGEMENT TOOLS

Green Stormwater Management Tools showcase ways that stormwater can be actively managed. This section details design parameters and examples for street and parking lot applications for the most common tools for Green Street application.

Each Tool description includes:

- How it works and common applications;
- Environmental, transportation, and community benefits;
- Constraints; and
- Typical unit cost range





HINESBURG, VERMONT: A vegetated swale along a residential street.

6.2 VEGETATED SWALES

Vegetated swales are long, narrow landscaped depressions with slight longitudinal slopes. They are primarily used to convey stormwater runoff on the land's surface while also providing water quality treatment. As water flows through a vegetated swale, it is slowed by the interaction with plants and soil, allowing sediments to settle out. Pollutants are entrapped by vegetation or broken down by microbial action, rendering the water cleaner. Some water is taken up by plants, and some infiltrates through well-drained soil. The remaining water that continues to flow downstream travels more slowly than it would through pipes in a conventional stormwater conveyance system. Vegetated swales are designed to be shallow (12 inches or less), with gently sloping sides (no more than 3:1), to transport runoff only a few inches deep in the bottom of the channel. They can be planted in with any type of vegetation, from mown grass to a diverse palate of groundcovers, grasses, sedges, rushes, shrubs, and trees. Generally, ground cover should be full and thick and maintained at a height of at least 4 inches for best water quality results.

Opportunities for Streets and Parking Lots

Swales are excellent choices for new residential and commercial development and can be retrofitted along arterial streets and within parking lots where space allows. Parking lots and certain streets that have a long, continuous space to support a functioning landscape system are excellent candidate sites for vegetated swales. The longer a vegetated swale is in relation to the volume of water it carries, the greater the time for slowing and filtering of stormwater runoff. Existing streets often have a wide right-of-way space that is underutilized. Consider removing existing buried storm sewer pipes and replacing with vegetated swales to achieve a similar conveyance purpose with greater water quality benefit.

There are many creative ways to include swales in parking lots. Oversized parking stalls can be shortened to yield a few extra feet for swale installation at the perimeter of the lot. Existing landscaping can readily be integrated into a vegetated swale design with no functional or aesthetic loss.

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

NICOLE LIMESAND

EXAMPLE VEGETATED SWALE

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●●
Supports Bikes	●●●●○
Calms Traffic	●●●●○

Can act as buffers between sidewalks, bike lanes, and vehicle travel lanes, contributing to the safety and walkability of a street.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	●●●○○
Cools Air Temperature	●●●○○

Excellent method for cleaning water prior to entering a downstream waterbody and are superior to pipe and gutter systems for this reason.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●○○
Usable Public Space	●●○○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●●●
Ease of Maintenance	●●●○○

Costs: $8-25/square foot depending on retrofit conditions or new construction.

CONSTRAINTS

Swales require long, continuous spaces which may be challenging to find in retrofit conditions without some creativity.

Swales designed to be too deep or with steep sides more closely resemble ditches and do not achieve the functional or aesthetic goals of a swale. Attention in the design and construction oversight of a project can help avoid this common pitfall.

In steeper topography conditions, swales will need frequent check dams in place to slow the movement of water.

KEVIN ROBERT PERRY

SAN MATEO, CALIFORNIA: A narrow green gutter along a residential street.

6.3 GREEN GUTTERS

Green gutters are very narrow, landscaped systems along street frontages that capture and slow stormwater flow. Typically, less than 3 feet wide, green gutters resemble planters as they are confined by vertical curbs and have a flat-bottom profile. Unlike typical planters, however, green gutters are designed to be flush with street surface, are very shallow and perform little or no water retention. While infiltration of stormwater is a possibility, the primary purpose of using green gutters is to filter out pollutants and slow the flow of water using only a narrow strip of landscaping – like a swale but possible in highly space-constrained areas where the sloping sides of a swale are not feasible.

Opportunities for Streets and Parking Lots

Green gutters introduce green space along streets that lack landscaping, provide a landscape buffer between vehicular traffic and pedestrians, and create desirable and safe street conditions for people.

Green gutters are useful along wide streetscapes. In many cases, simply narrowing the travel lanes along a residential or commercial street can yield enough space for green gutter installation. Similarly, for small parking lots, shortening parking stall lengths can provide space at the front of parked cars for a narrow green gutter application around the perimeter of the lot.

STORMWATER FUNCTION

✔ Conveyance & Treatment

✔ Infiltration/Filtration

✔ Evapotranspiration

NICOLE LIMESAND

EXAMPLE GREEN GUTTER

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●○
Supports Bikes	●●●○○
Calms Traffic	●●●○○

Can act as buffers between sidewalks, bike lanes, and vehicle travel lanes, contributing to the safety and walkability of a street.

URBAN ECOLOGY

Manages Stormwater	●●●○○
Enhances Habitat	●●●○○
Cools Air Temperature	●●●○○

Excellent method for cleaning water prior to entering a downstream waterbody and are superior to pipe and gutter systems for this reason.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●○○
Usable Public Space	●○○○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●●○
Ease of Maintenance	●●●○○

Costs: $8-25/square foot depending on retrofit conditions or new construction.

CONSTRAINTS

Require a long, continuous space to effectively slow and filter pollutants.

With heavy snow accumulation, it may be difficult for both drivers and snowplow operators to see the width of the green gutter. Adequate markings or grating at the road surface is necessary to overcome this constraint.

In steeper topography conditions, green gutters will need frequent check dams in place to slow the movement of water.

WAITSFIELD, VERMONT: A rain garden within a parking lot island.

6.4 RAIN GARDENS (BIORETENTION)

Rain gardens (also known as bioretention) are shallow vegetated depressions in the landscape. They can be any size or shape, and are often molded to fit leftover spaces in parking lots, along street frontages, and in spaces where streets intersect at odd angles. In retrofit conditions, rain gardens can add significant vegetation to spaces that would otherwise be covered by asphalt. Like stormwater planters, they are typically designed to be flat-bottomed without any longitudinal slope to maximize storage potential for stormwater.

Rain gardens retain stormwater, attenuating peak flows and reducing overall stormwater volume. They can also allow for infiltration, depending on the capacity of the native soil. Although rain gardens can share certain characteristics with swales, their primary function is to maximize stormwater storage and infiltration, not conveyance to another location. As a result, they are located where they can collect and treat stormwater from adjacent impervious surfaces.

Their versatility in size and shape make rain gardens a flexible option for application in space-constrained downtown areas. In well-drained soils, rain gardens can maximize infiltration. However, where infiltration capacity is limited, rain gardens can also be designed as flow-through filtration systems with an underdrain to facilitate drainage in high flow events. Simple rain garden designs that do not use extensive hardscape or pipe infrastructure can be very cost effective to install.

Opportunities for Streets and Parking Lots

Rain gardens can be retrofitted in a variety of street applications. Large areas of unused or inefficiently used spaces are prevalent throughout town centers, industrial areas, and residential neighborhoods. These leftover landscape and asphalt spaces are prime candidates for rain gardens to increase stormwater storage and infiltration as well as green space.

Rain gardens are effective in large parking lots (i.e., shopping malls, big box stores) because they can be designed to manage large amounts of stormwater runoff when sized appropriately. For retrofits, several parking stalls can be converted into one large rain garden to capture sheet flow from parking areas.

Green Stormwater Management Tools

STORMWATER FUNCTION

- ✔ Conveyance & Treatment
- ✔ Infiltration/Filtration
- ✔ Evapotranspiration

NICOLE LIMESAND

EXAMPLE RAIN GARDEN

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●●
Supports Bikes	●●●●○
Calms Traffic	●●○○○

Allow for separation between sidewalks and vehicular travel lanes creating a safer and more walkable environment.

URBAN ECOLOGY

Manages Stormwater	●●●●●
Enhances Habitat	●●●●●
Cools Air Temperature	●●●●●

Provide additional stormwater storage and flow reduction as well as pollutant filtration which helps prevent damage to downstream waterbodies.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●●○
Usable Public Space	●●●●○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●○○
Ease of Maintenance	●●○○○

Costs: $8-50/square foot depending on retrofit conditions or new construction and if the rain garden has landscaped side slopes or vertical planter walls.

CONSTRAINTS

Require maintenance similar to perennial gardens which may be outside the regular scope of municipal public works staff. Identifying a suitable maintenance plan and appropriate town staff to manage is critical for success.

Rain gardens collecting large amounts of road runoff are prone to clogging without pretreatment. Space for settling particles (either in a catch basin sump or a forebay structure) is critical to avoid excess sediment build-up in the garden itself.

BURLINGTON, VERMONT: A simple green street retrofit along Decatur Street.

6.5 STORMWATER CURB EXTENSIONS

Stormwater curb extensions (or curb bump-outs) are landscaped areas that extend into the street and capture stormwater runoff. Conventional curb extensions (a.k.a. bulb outs, chokers, chicanes) are commonly used to increase pedestrian safety and help calm traffic. A stormwater curb extension shares these same elements, adding the benefit of stormwater management by allowing water to flow into the space for treatment though soil media and vegetation. This landscape space can be designed with the physical characteristics of vegetated swales, planters, or rain gardens depending on the available space and specific site conditions.

Stormwater curb extensions are particularly advantageous in retrofit situations because they can be added to existing streets with minimal disturbance and added benefit to meet other municipal goals of safety and traffic calming. Where existing curb extensions are already in place, adding stormwater treatment benefits within the same space is possible by removing curb sections to allow water to flow through and modifying ground cover to allow water retention and infiltration.

Stormwater curb extensions can be used in any type of street, from low-density residential routes to highly urbanized commercial streetscapes. Curb extensions are excellent to use in steep slope conditions because they can act as a backstop for upstream flow.

Opportunities for Streets

Existing residential streets offer some of the best opportunities for conversion of a portion of the street's parking zone into stormwater curb extensions. In Vermont, many low-density residential streets have unused on-street parking zones that could capture stormwater with no negative impact to residents. Stormwater curb extensions in low-density residential areas can often be installed with minimal impact to existing infrastructure. In some cases, the curb extensions can be designed so that the existing street curb and stormwater inlets remain intact.

In areas where on-street parking is fully utilized, smaller stormwater curb extensions, spaced more frequently, can be used to minimize parking losses. In many urban examples, there are streets striped with "no parking" zones that could be converted into stormwater curb extensions without any loss of parking. Additionally, parking is generally not allowed within 20 feet of an intersection. These areas may be good candidates for stormwater curb extensions.

Green Stormwater Management Tools

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

NICOLE LIMESAND

EXAMPLE STORMWATER CURB EXTENSION

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●●
Supports Bikes	●●●○○
Calms Traffic	●●●●○

Can narrow intersection crossing distances, slow traffic, and create a safer and more walkable environment.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	●●●●○
Cools Air Temperature	●●●●○

Provide additional stormwater storage and flow reduction as well as pollutant filtration which helps prevent damage to downstream waterbodies.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●●○
Usable Public Space	●●●○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●●○
Ease of Maintenance	●●●●○

Costs: $25-50/square foot depending on retrofit conditions or new construction and if the stormwater curb extensions has landscaped side slopes or vertical planter walls.

CONSTRAINTS

Sometimes requires the removal of on-street parking.

Can conflict with bike travel if adequate space is not allowed between edges of curb extension and a street’s travel lane.

Can conflict with snow removal equipment maneuverability.

SECTION 6

Green Stormwater Management Tools

BURLINGTON, VERMONT: Concrete pervious pavers in a parking lot.

6.6 PERVIOUS PAVING

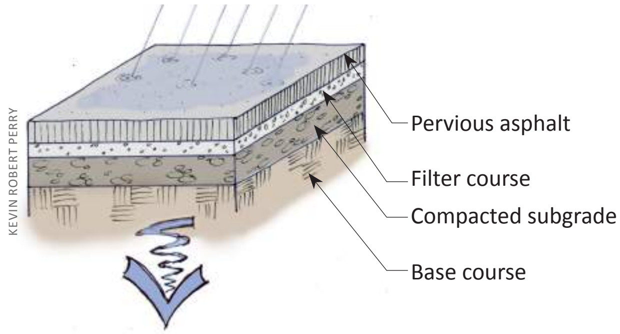
Pervious paving systems allow rain water to pass through their surface and soak into the underlying ground, reducing areas of imperviousness on a site and providing huge inlet areas to facilitate infiltration. There are generally three types of pervious paving options: concrete, asphalt, and pavers. Consider use patterns of a site to determine application of one over another.

Pervious concrete in its current mix formation has been determined to be ill suited for cold climate application on driving surfaces due to Vermont's multiple freeze thaw cycles and the deleterious effects of road salt application that cannot be eliminated from driving or parking surfaces as a result of vehicle tire tracking. On walkways porous concrete can be effective if they are managed without salt or sand addition.

Pervious asphalt is effective in Vermont's cold conditions and several installations in the state have performed well over multiple years. The mix looks very similar to conventional asphalt but has larger aggregate pieces and cures with pore spaces to allow water movement through the material. Regular inspections and maintenance of pervious asphalt surfaces is required for the long-term viability of the paving system. For preventative maintenance, vacuum cleaning on a yearly basis, preferrably in late fall, is imperative to limit the amount of sediment clogging the pore spaces and to retain permeability, for areas that do not receive significant sediment, debris, leaf litter year-round.

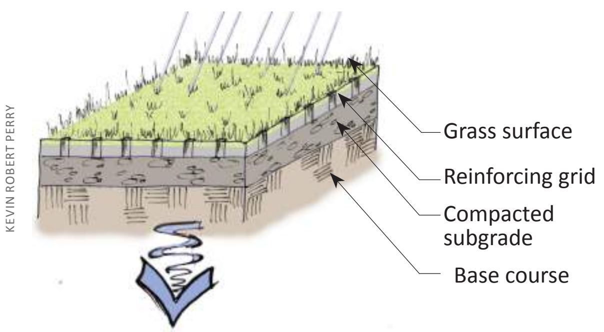
Permeable pavers come in a variety of materials and shapes. All use a sand and gravel mix between the pavers to provide permeability – the pavers themselves lack pore spaces. Reinforced grass and gravel grid systems also allow rainwater to soak into open pore spaces in the soil while providing a rigid driving surface for travel and vehicle parking.

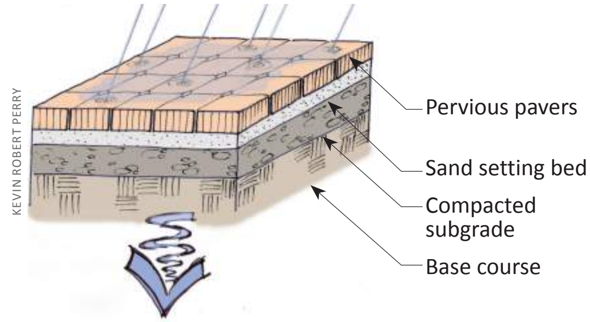
Pervious paving is primarily used on parking lots and roadways with low-traffic speeds and volumes, but there are successful examples of pervious asphalt employed on high-traffic streets throughout the United States. Pervious paving should not be used in situations with known soil contamination or high groundwater tables as the stormwater entering the subsurface could migrate pollutants. Generally, soil infiltration rates that exceed or meet the accepted standard of 0.5"/hour are suitable for pervious paving systems. However, several limitations for pervious pavement in a northern climate are discussed in Section 6.3 under Winter Climate Constraints.



Pervious Asphalt

The difference between pervious asphalt production and standard asphalt production is the omission of fine particles in the added aggregate. This results in small holes within the paving that allows water to drain through the surface. When installing pervious asphalt, the subgrade must be properly prepared, and the surface material must be poured following temperature, humidity, and curing protocols specific to the material. As with conventional paving, if pervious asphalt is not properly installed, it is prone to failure. Seek an experienced contractor for installation of pervious hardscape material. Periodic inspections are imperative; at least once or twice a year to determine whether any changes in the maintenance schedule is required. Vacuuming is especially encouraged in late fall (after the leaf drop) and before winter to remove any clogged materials prior to freezing temperatures. In addition to visual inspections, performing an infiltration assessment will gauge the need for more frequent vacuuming.





Pervious Pavers

Permeable pavers include a surface layer of interlocking bricks made of either fired clay or concrete. The space in between the pavers is filled with stone aggregate that allows water to move through and into the bedding surface which consists of gravel material with pore space sufficient to hold water as it slowly percolates into the native soil. This system is widely applicable to both small and large paving projects and is easily repaired because small sections can be removed and replaced. Permeable pavers offer flexibility in color, style, joint configuration, and paving pattern. It is important to note that permeable pavers (as with any brickwork) along pedestrian walkways must be ADA-compliant and not create tripping hazards. When installing permeable pavers, care should be taken to assure that the base and subgrade are properly constructed to minimize the potential for differential settling. Regular vacuuming and cleaning of the paver joints aggregate will help prevent clogging and extend the longevity of the system.

Reinforced Grass Paving

In areas needed for intermittent load-bearing use (such as overflow parking), grass paving or other paving/ planting hybrids, can be used to provide structural support while allowing plant growth and stormwater infiltration. These systems may be appropriate in areas of low use and where soil, drainage, sunlight, and other conditions are conducive to plant growth. Salt application should be avoided on grass paving sites as excess chloride is toxic to plant life.

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●○
Supports Bikes	●●○○○
Calms Traffic	●●○○○

Can reduce local flooding and icy conditions by allowing water to infiltrate rather than collect on the pavement surface.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	○○○○○
Cools Air Temperature	●●○○○

Reduces the size of other stormwater treatment measures and provides additional perviousness within the urban context.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●●○
Usable Public Space	●●●●○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●○○
Ease of Maintenance	●●●○○

Costs: $15-30/square foot depending on the type of pervious paving material and the amount of gravel subbase needed.

CONSTRAINTS

Requires well-drained native soil or underground gravel storage layers.

Needs special maintenance (that may include new equipment purchases) to keep pavement from clogging over time.

Has limited infiltration effectiveness on street slopes over 5%.

KEVIN ROBERT PERRY

PORTLAND, OREGON: Stormwater planters along SW 12th Avenue.

6.7 STORMWATER PLANTERS

Stormwater planters are narrow, flat-bottomed, often rectangular, landscape areas used to treat stormwater runoff. They are a popular choice for urban environments. Their most distinguishing features are the vertical side walls that create greater storage volume in less space than a swale.

Stormwater planters are easily incorporated into retrofit conditions and in places where space is limited as they are highly versatile in shape and size. They can be built to fit between driveways, utilities, trees, and other existing site elements and can be planted with a simple palate of sedges or rushes, or with a mixture of trees and shrubs. Because planters have no side slopes and are contained by vertical curbs, it is best to use plants that will grow at least as tall as the planter’s walls to help soften the edges. Planters can be used in both relatively flat conditions and in steep conditions if they are appropriately terraced. Because they tend to have small footprints, they are best used to control small volumes of water and should not be installed where heavy runoff flows are likely.

Opportunities for Streets and Parking Lots

Stormwater planters are good candidates for main streets due to flexibility with siting and shape and a small footprint. They can fit between driveway curb cuts, utilities, trees, and street furnishings commonly found along urban streets. Planters can be a very good choice for streets that require on-street parking, but thoughtful design must accommodate pedestrian circulation.

Planters can also be an effective design tool for parking lot applications. Parking lot planters can be designed to take the place of a few parking spots or they can fit in the long, narrow space between the front ends of parking stalls. Due to their tidy architectural appearance, stormwater planters are excellent choices to flank the front access doors to a commercial or retail location.

◀ *This stormwater planter along a residential street captures and conveys runoff slowly on the ground surface.*

STORMWATER FUNCTION

- ✓ Conveyance & Treatment
- ✓ Infiltration/Filtration
- ✓ Evapotranspiration

**Image courtesy of the 2014 Philadelphia Green Streets Design Manual*

EXAMPLE STORMWATER PLANTER

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●○
Supports Bikes	●●●○○
Calms Traffic	●●●○○

Can provide separation between sidewalks and vehicular travel lanes, which help provide a safer and more walkable environment.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	●●●○○
Cools Air Temperature	●●●●○

Stormwater planters provide filtration and treatment of road and parking lot runoff, improving the quality of water flowing to downstream waterbodies.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●○○
Usable Public Space	●●●○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●○○
Ease of Maintenance	●●●●○

$35-50/square foot depending retrofit conditions or new construction.

CONSTRAINTS

Planters are generally more expensive than swales due to the increased hardscape infrastructure.

Are contextually appropriate in urban settings rather than in residential or rural communities where stormwater planters may appear overbuilt or out-of-place.

BURLINGTON, VERMONT: Church Street trees during autumn.

6.8 URBAN STREET TREES

Soils in downtown areas are often compacted by transportation surfaces and are lacking the physical and chemical characteristics needed by vegetation. Street trees are conventionally planted in small rigid cubes - tree pits filled with soil. The size of tree pits is often insufficient for large tree growth and results in reduced life span and stunted canopy size of street trees. Because large healthy trees provide a number of environmental and social benefits, ensuring they can thrive in downtown areas is a critical component of Green Streets. Several innovative approaches to provide adequate soil quality and rooting space have emerged in recent years. Suspended pavements and structural soils give support to pavement while allowing roots to move through an extensive and loose soil profile. Suspended pavement systems utilize an underground scaffolding to support the weight of infrastructure without compacting soils. Engineered structural soils combine stone, soil, and a binding agent to hold the soil to the stones. This provides a similar service to suspended pavements without a rigid scaffolding. Structural soil supports pavement while allowing tree roots to move through pore spaces. Engineered soil does not appear to be susceptible to frost heaves in decade-long applications in Vermont and neighboring New York.

Where there is interest in preserving existing trees in urban areas, suspended pavement, structural cells, and engineered soils can be used to create a ‘bridge’ between a vegetative strip along a road and a green space. The ‘bridge’ entails removing paving and compacted subbases in between the tree pit and the green space and replacing the subbase with structural soil and then repaving. Practices that allow for full maturation of a tree will see larger benefits over the long-term than trees that are planted in areas that limit their growth. Designing sidewalks for the anticipated use will benefit street trees by increasing the potential rooting space underneath the surface. If given room to grow, trees can be a stand-alone stormwater system.

◀ *These urban trees provide not only shade but also habitat in this dense area of town. Trees can also spatially “narrow” a street, encouraging motorists to slow down and perceive a gateway into a more urban area.*

STORMWATER FUNCTION

✓ Conveyance & Treatment

✓ Infiltration/Filtration

✓ Evapotranspiration

**Image courtesy of the 2014 Philadelphia Green Streets Design Manual*

EXAMPLE URBAN STREET TREE

ACTIVE TRANSPORTATION

Supports Pedestrians	●●●●○
Supports Bikes	●●●○○
Calms Traffic	●●●○○

Can provide a visual trigger to reduce traffic speeds in downtown areas, making a safer and more walkable environment.

URBAN ECOLOGY

Manages Stormwater	●●●●○
Enhances Habitat	●●●○○
Cools Air Temperature	●●●●○

Provide shade, stormwater benefits through interception on leaves and evapotranspiration, and habitat for native species.

NEIGHBORHOOD ENHANCEMENT

Placemaking	●●●○○
Usable Public Space	●●●○○

COSTS TO IMPLEMENT/MAINTAIN

Cost Effective	●●●○○
Ease of Maintenance	●●●●○

$150-600/tree depending on size and species of tree. Total cost of tree depends on caliper and whether structural soil or suspended soils are utilized. It is common for structural soil to be used more now in urban environments, with a line item for the tree and a separate volume for structural soil.

CONSTRAINTS

Require regular, skilled maintenance to ensure long term growth and health.

Contributes leaf fall to street surfaces, increasing need for regular street sweeping efforts.

Species selection is limited by above-ground infrastructure and utilities – making larger varieties ill-suited where overhead power lines may conflict.

RICHARD AMORE

ST. ALBANS, VERMONT: Vermont's first Main Street with stormwater planters.