Sussex County Green Infrastructure Seminar Series
Seminar 4

Tuesday, November 30, 2010
1:00–3:00PM
Sussex County Administrative Center

Green Infrastructure Planning, Design & Implementation: Training for Design Professionals

Rutgers Cooperative Extension Water Resources Program

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Green Infrastructure & Low Impact Development

- Principles of sustainable site design for water management
- Discussion of water management methods and technologies
- Overview of LEED and New Jersey regulatory requirements and performance standards for sustainable site design and stormwater management

Low Impact Development (LID)

- LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible.
- LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product.
- Practices include bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements.
- Through LID practices, water can be managed in a way that reduces the impact of built areas and promotes the natural movement of water within an ecosystem or watershed.
- Applied on a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions.
- Sustainable stormwater practice.

LID and Green Infrastructure

- EPA intends the term **"green infrastructure"** to generally refer to systems and practices that ***use*** or ***mimic*** **natural processes** to infiltrate, evapotranspirate or reuse stormwater or runoff on the site where it is generated. Green infrastructure can be used at a wide range of landscape scales in place of, or in addition to, more traditional stormwater control elements to ***support*** the principles of LID.

Low Impact Development Principles

- **Protect Soils**
  - Minimize clearing
  - Minimize grading
  - Save good soils
  - Limit lot disturbance
- **Promote Vegetation**
  - Reforestation
  - Mimic ecological systems
  - Use native species
- **Maintain Hydrology**
  - Reduce impervious surfaces
  - Disconnect impervious surfaces
  - Reduce pipes, curbs, and gutters
- **Manage Materials**
  - Reduce energy use
  - Minimize waste
  - Alternative surfacing

Water Management in the Landscape

- Treat water (and stormwater) as a resource
- Maintain existing “natural” hydrology patterns where possible and/or design management systems that promote water quality and healthy aquatic habitats
- Develop and install strategies which include structural and/or nonstructural stormwater best management practices (BMPs) incorporating these strategies into the site planning and design process:
  - **Structural BMPs:** storage practices, infiltration practices, and vegetative practices
  - **Nonstructural BMPs:** include sound planning procedures (master plans and zoning plans can guide the growth away from sensitive areas), riparian zone preservation, minimization of disturbance and impervious areas, maximization of open space
- IMPLEMENT GREEN INFRASTRUCTURE TECHNIQUES

Guides for Green Infrastructure

- Implement water capture, reuse, and infiltration practices
- Address not only the **quantity** of storm water runoff from site development projects but also the **quality**
- Focus water quality controls on smaller, more frequent storms (first flush)
- ***Disconnect*** impervious surfaces (separate rooftop runoff from impervious land areas)
- Use multiple capture and treatment systems
- Stage, schedule, and install to minimize impacts from construction activities on filtering media, infiltration systems, and plantings
- Vegetate with native species (minimize turf and lawn)

Why LID & Green Infrastructure

- Storm Water Regulations
  - Federal Phase II Storm Water Permitting (Municipal Separate Storm Sewer System (MS4))
  - New Jersey Storm Water Regulations
- New Jersey Highlands
- Executive Order 109
  - Issued by Governor Whitman in January 2000
  - Requires nonpoint source analysis for all water quality management plan amendments
- Protect / Restore Environment
  - Point sources used to control instream water quality. With advances in wastewater treatment, nonpoint sources often dominate the health of the waterbody.
  - 40 –70% of existing NJ water quality problems attributed to storm water (NJDEP, 2003)
- Municipal stormwater management plans and ordinances
- Residential Site Improvement Standards - Stormwater Management
- Total Maximum Daily Loads (TMDLs)
- Reduce Replacement and Maintenance Costs for Existing/New Infrastructure

Components of Successful Green Infrastructure Projects

- Rainwater harvesting
- Permeable paving
- Green roofs
- Bioswales
- Bioretention/Rain gardens
- Infiltration systems
- Native plant materials

Unilever/Parker Urban Greenscapes.

GREEN INFRASTRUCTURE PLANNING, DESIGN & IMPLEMENTATION

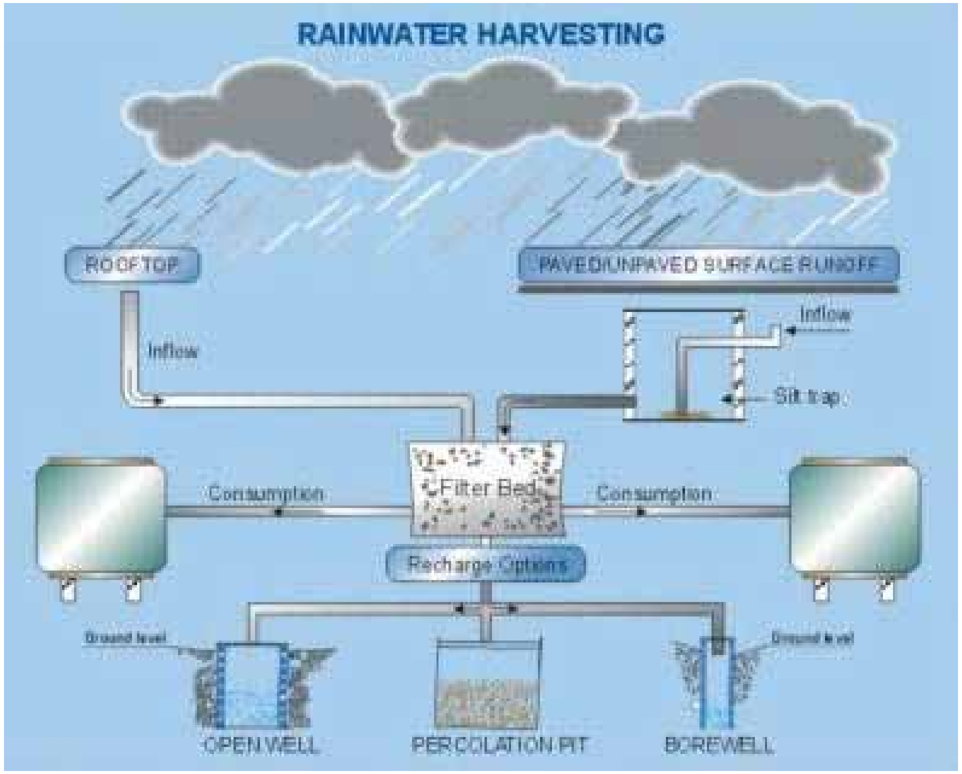
HOW DO WE DO THIS?

Rainwater Harvesting

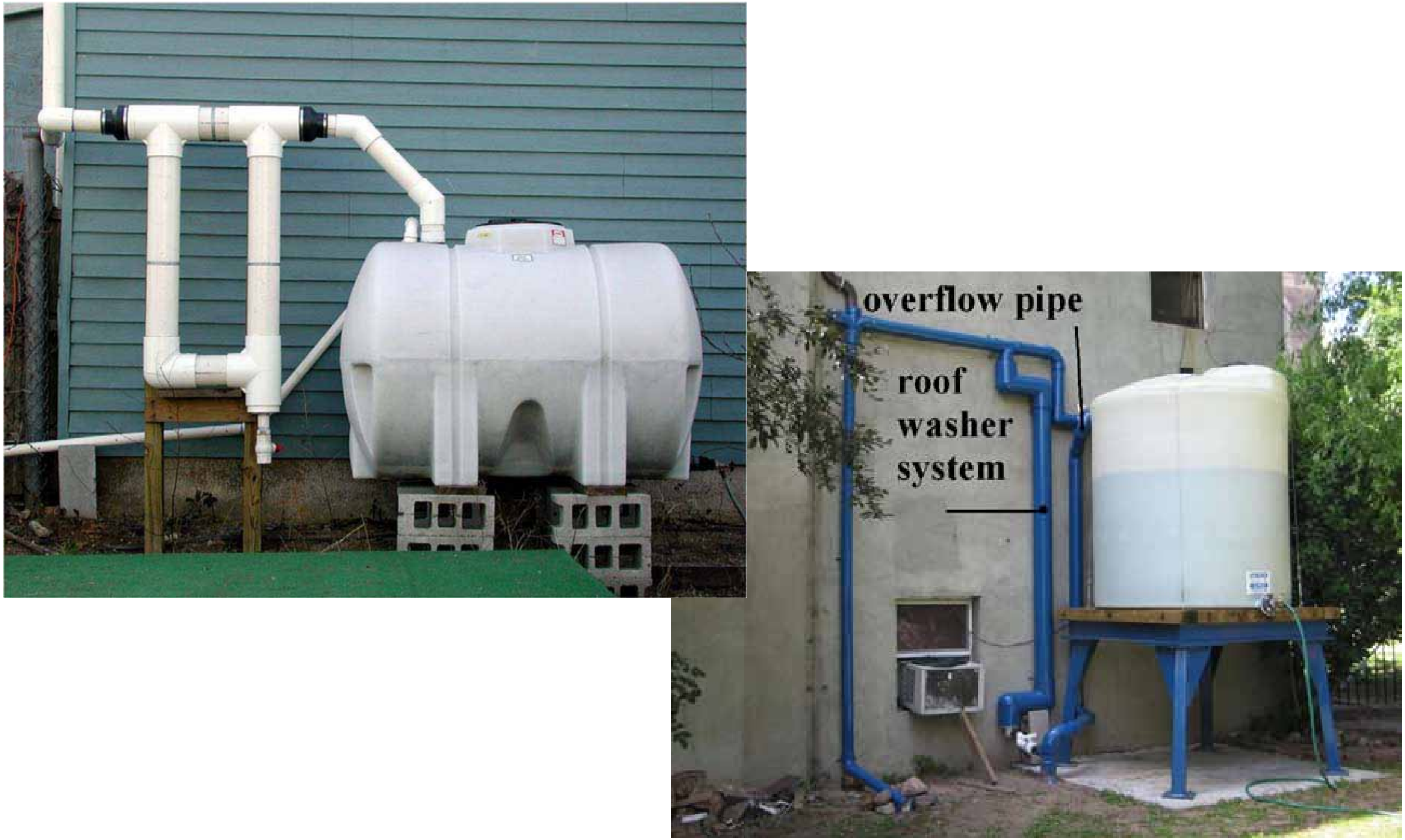
FUNCTIONS

- Collecting, filtering and storing water from roof tops, paved and unpaved areas for multiple uses.
- Harvested water can be used for nonpotable or potable purposes after testing and treatment.
- Surplus water after usage can be used for recharging ground water.
- Systems can range in size from a simple PVC tank or cistern to a contractor designed and built tank/sump with water treatment facilities.

COMPONENTS



Rainwater Harvesting



Sizing

- The rule of thumb is 600 gallons of water per inch of rain per thousand square feet of catchment area.
- Not all the rain that falls can actually be collected. Efficiency is usually presumed to be 75% depending on system design and capacity.

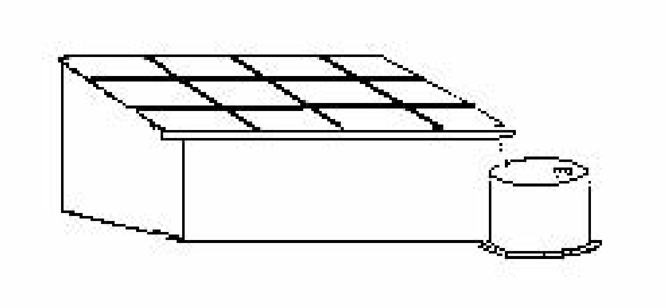
Sizing Formula

Here is the basic formula for calculating the potential amount that can be collected:

$$\frac{\text{(Catchment area) x (inches of rain) x (600 gallons) x (.75)}}{\text{1000 square feet}}$$

Design Example

The sample roof shown below has a catchment area that is 40 feet wide and 30 feet long. Hence, it has a 1200 square feet roof (40 feet wide x 30 feet long). Assume that it rains 2 inches. We can now plug this information into our general formula (see equation above).



Catchment Area = 1200 square feet

Amount of Rain = 2 inches

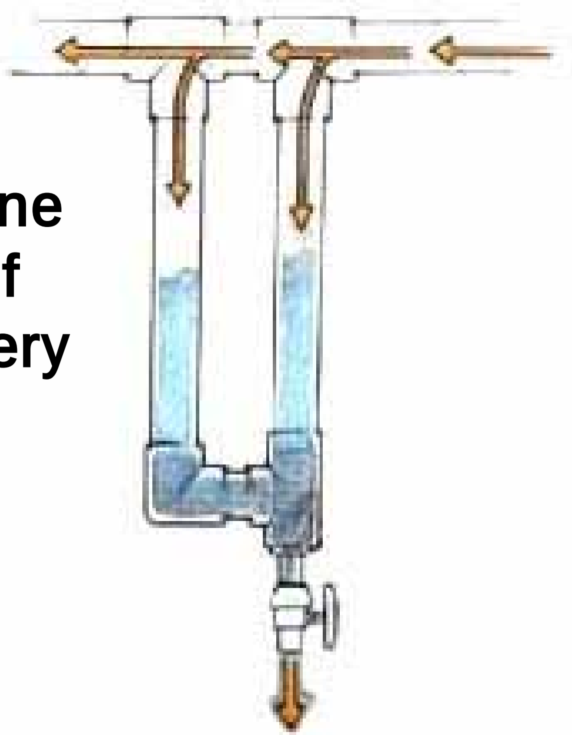
Gallons of water collected per inch of rain per 100

Percent Efficiency = 75% or .75

$$\frac{(1200 \text{ square feet}) \times (2 \text{ inches of rain}) \times (600 \text{ gallons}) \times (.75)}{1000 \text{ square feet}} = 1080 \text{ gallons}$$

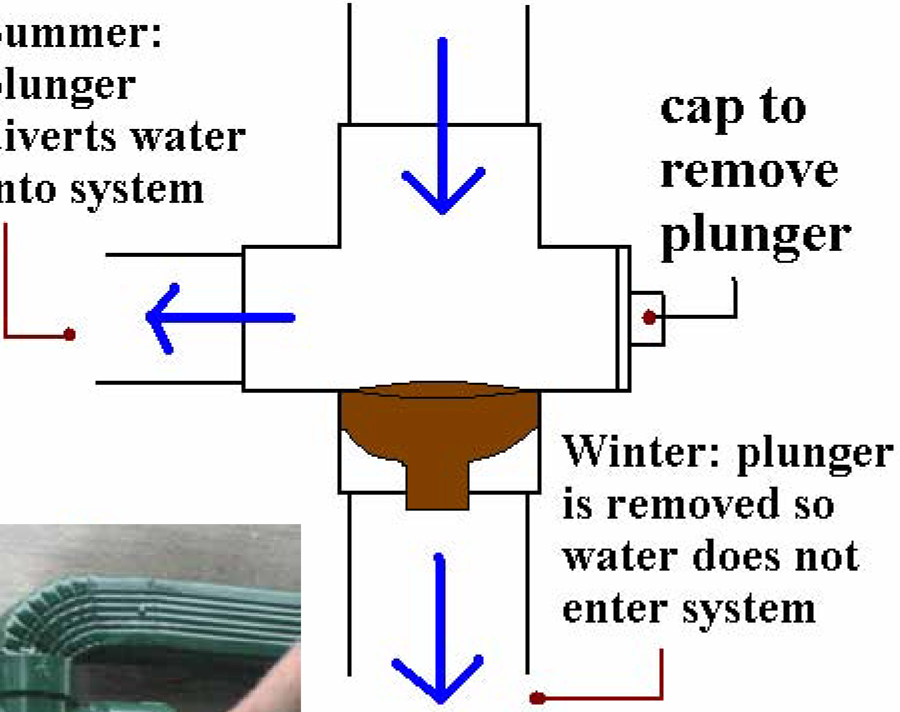
First Flush Diverter or Roof Washer

The rule of thumb is one to two gallons of roof washer capacity for every 100 square feet of catchment area.



- A 1 foot length of 6 inch diameter PVC pipe holds 1.5 gallons.
- A 1 foot length of 4 inch diameter PVC pipe holds 0.66 gallons.

Diverting Rainwater to Cistern



Summer: plunger diverts water into system

cap to remove plunger

Winter: plunger is removed so water does not enter system

Construction

- The most stable place to position the cistern is against a stable wall on level ground as close to the downspout as possible.
- Gravity moves water downhill. Be sure there is available space for a downward pitch in all pipes.
- The cistern on its platform is the highest point of the garden but the lowest point of the system.
- The overflow pipe should be directed toward a rain garden not toward pathways or structures.
- The overflow pipe should flow from the cistern’s highest point.
- The spigot should be at the cistern’s lowest point.


roof washer system
overflow pipe

Rainwater Harvesting

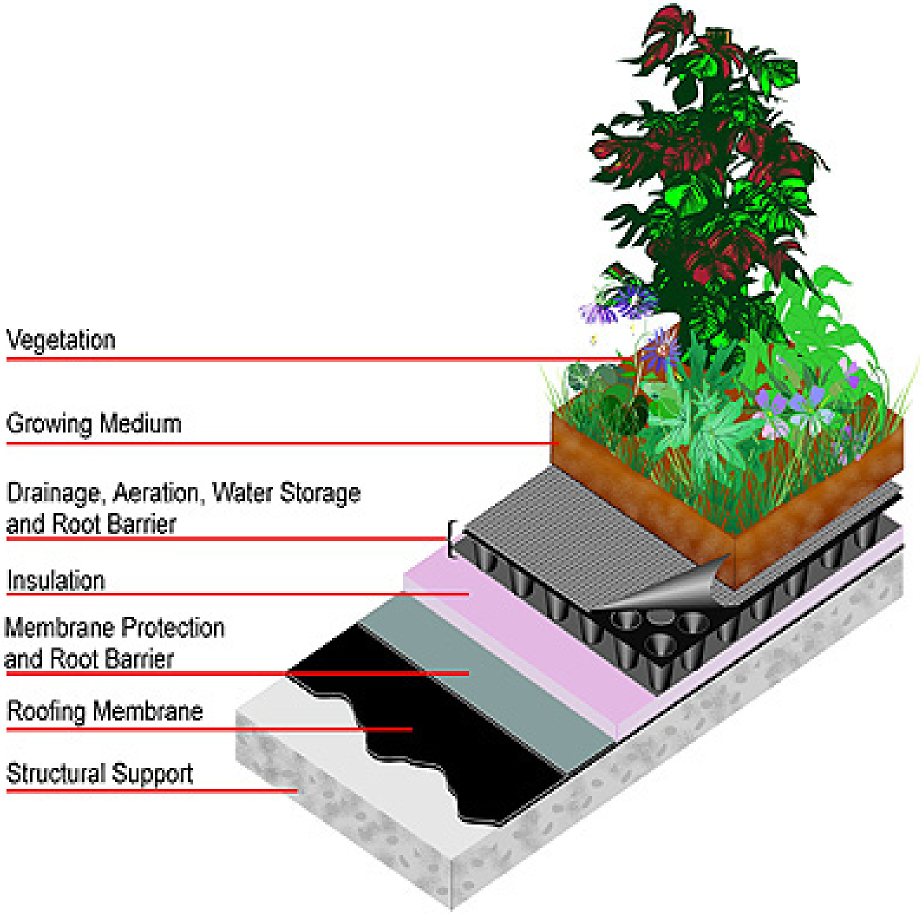
Samuel Mickle School Rainwater
Harvesting System

Green Roofs

FUNCTIONS

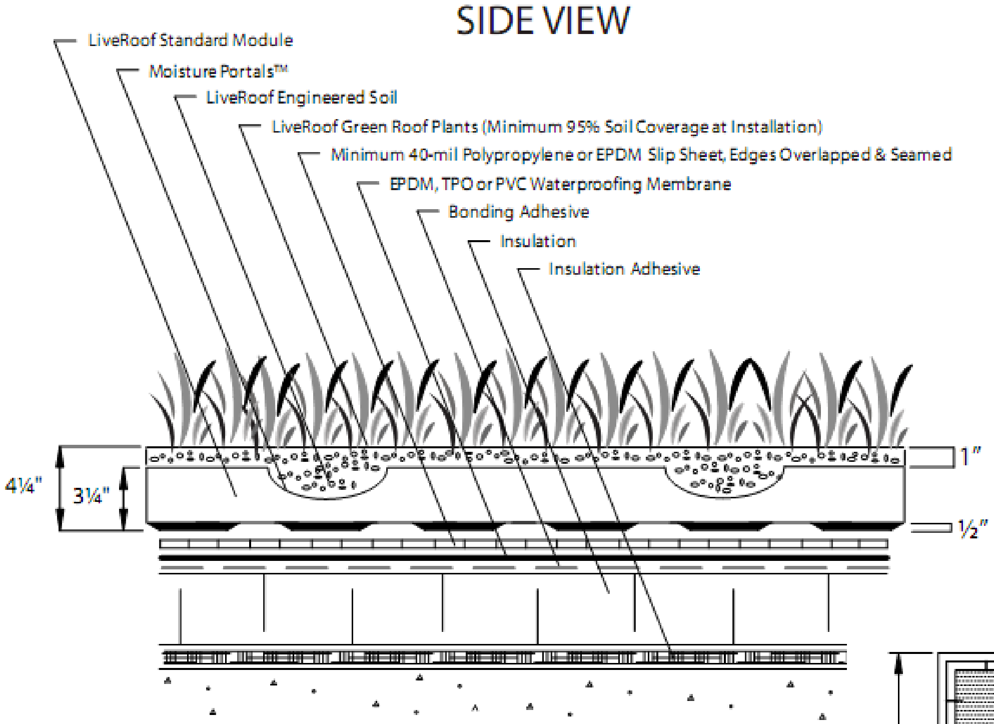
- Improves stormwater management
- Improves air quality
- Temperature regulation (moderation of Urban Heat Island Effect)
- Carbon dioxide/oxygen exchange
- Increased urban wildlife habitat

COMPONENTS

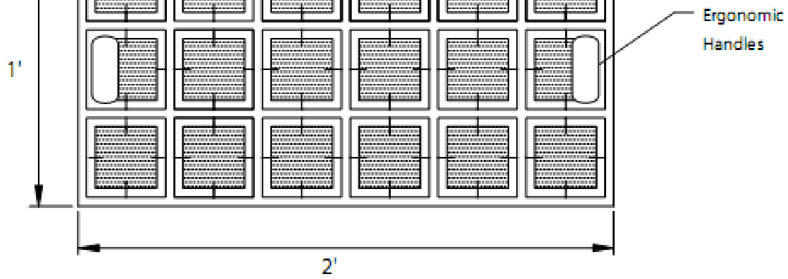


Green Roof Design

Modular System Specifications:




Parker Urban Greenscapes.

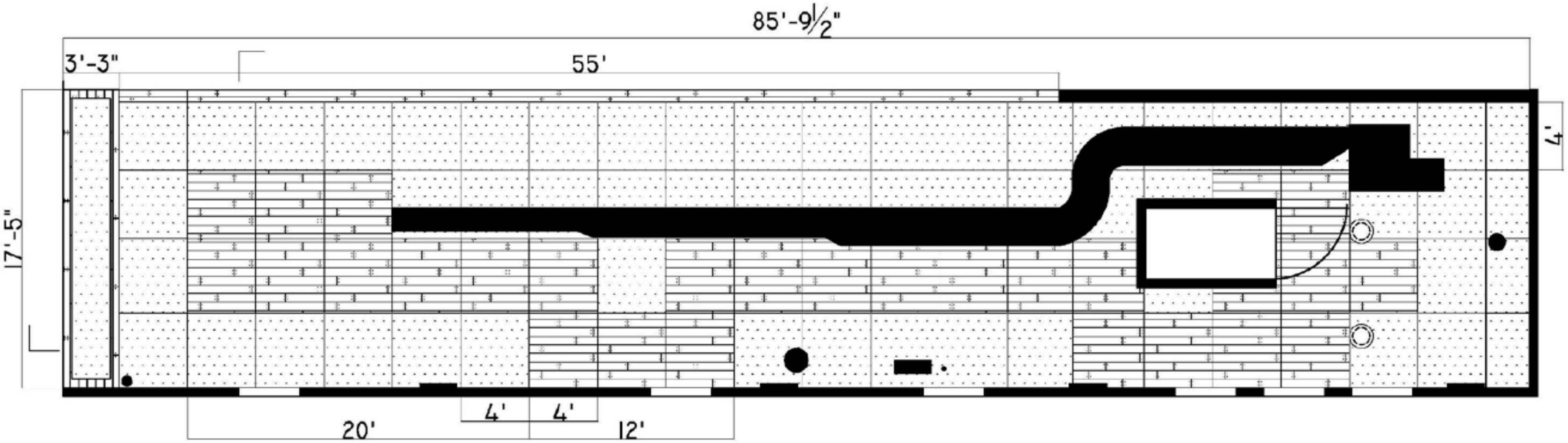


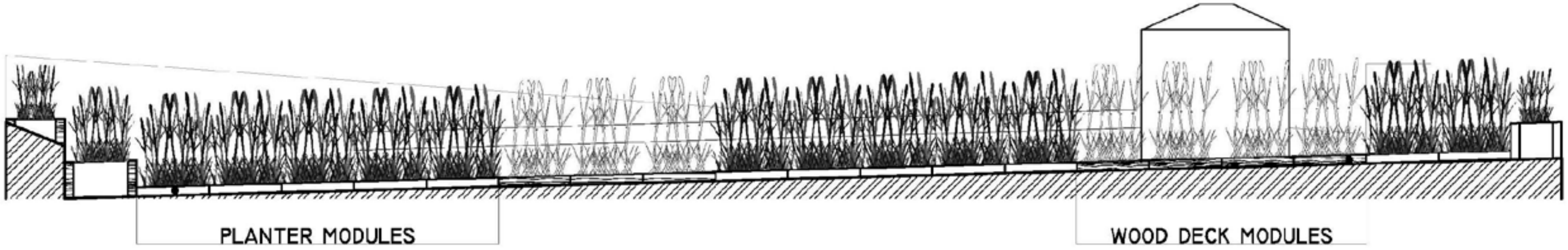
Green Roofs


Parker Urban Greenscapes. 2009.

- Engineered systems which address all critical aspects of design, including: the saturated weight of the system and load bearing capacity of the underlying roof deck; moisture and root penetration resistance of the waterproofing membrane; resistance to wind shear; management of drainage; and the suitability of the proposed plant material
- Green roofs are the result of a complete underlying roof build-up system, providing continuous, uninterrupted layers of protection and drainage.
- New technologies have advanced the properties of greenroofs, making them lighter, more durable and better able to withstand the extreme climatic conditions of the rooftop

Hackensack Riverkeeper Green Roof





Hackensack Riverkeeper Green Roof

Green Roof

PROS

- Extend life of roof base
- Sound insulation
- Provides ecosystem services in urban areas
- Amenity space and aesthetics
- Sound insulation

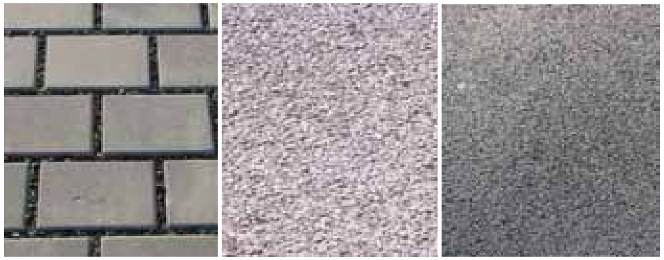
USEPA, 2009. Green Infrastructure Case Studies.

CONS

- Complex drainage systems
- More costly repairs and fixings
- Restrictions involving climate and weather conditions
- Stronger roof beams required to support weight of planting material

Pervious Pavements

- Permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before infiltrating into the subsoil
- Porous asphalt and pervious concrete appear the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration
- Grass pavers are concrete interlocking blocks or synthetic fibrous grid systems with open areas designed to allow grass to grow within the void areas
- Ideal application for porous pavement is to treat a low traffic or overflow parking area

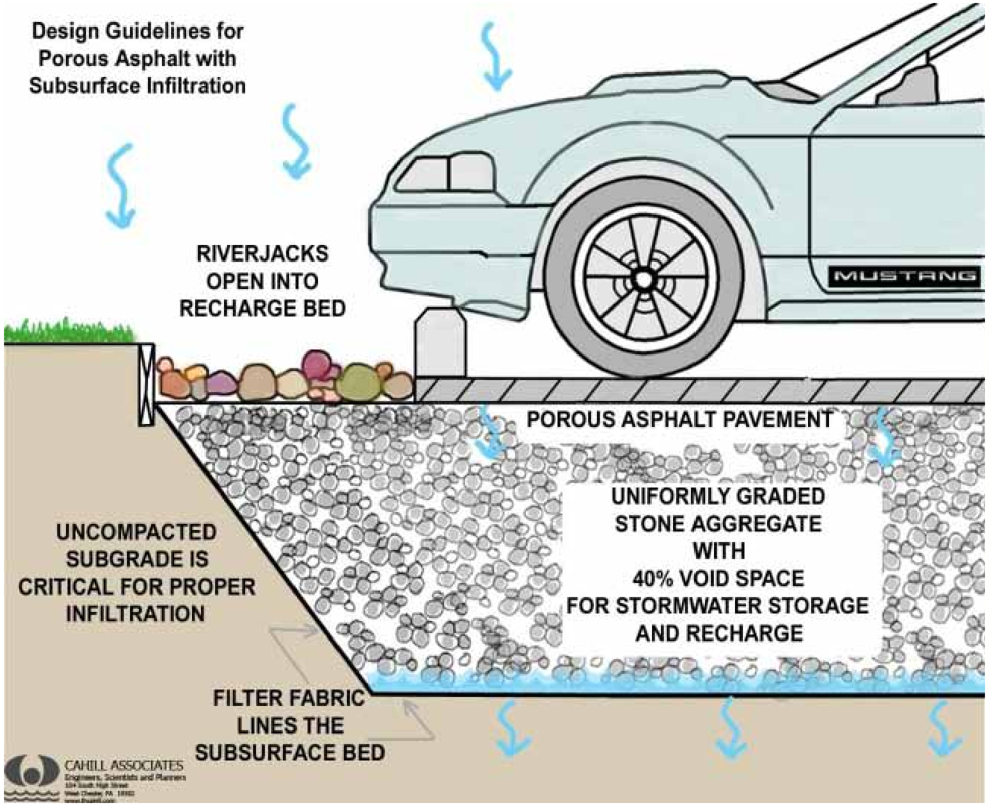


Pervious Pavements

FUNCTIONS

- Manage stormwater runoff
- Minimize site disturbance
- Possibility of groundwater recharge
- Low life cycle costs, alternative to costly traditional stormwater management methods
- Mitigation of urban heat island effect
- Contaminant removal as water moves through layers of system

COMPONENTS



Pervious Pavement

Benefits and Uses of Porous Asphalt

Porous Asphalt can be used in replace of traditional stormwater management measures given the proper conditions. Porous Asphalt's primary advantages are:

1. Quantity and Flood Control
2. Water Quality Treatment
3. Recharges Groundwater to Underlying Aquifers
4. Allows for Reduction of Stormwater Infrastructure (Piping, Catch-Basins, Retention Ponds, Curbing, etc.)
5. Suitable for Cold-Climate Applications, Maintains Recharge Capacity When Frozen
6. Allows for Reduced Salt and Sand Usage Due to Low/No Black Ice Development
7. Maintains Traction While Wet
8. Reduced Spray from Traveling Vehicles, Reduced Roadway Noise
9. Extended Pavement Life Due to Well Drained Base and Reduced Freeze-Thaw

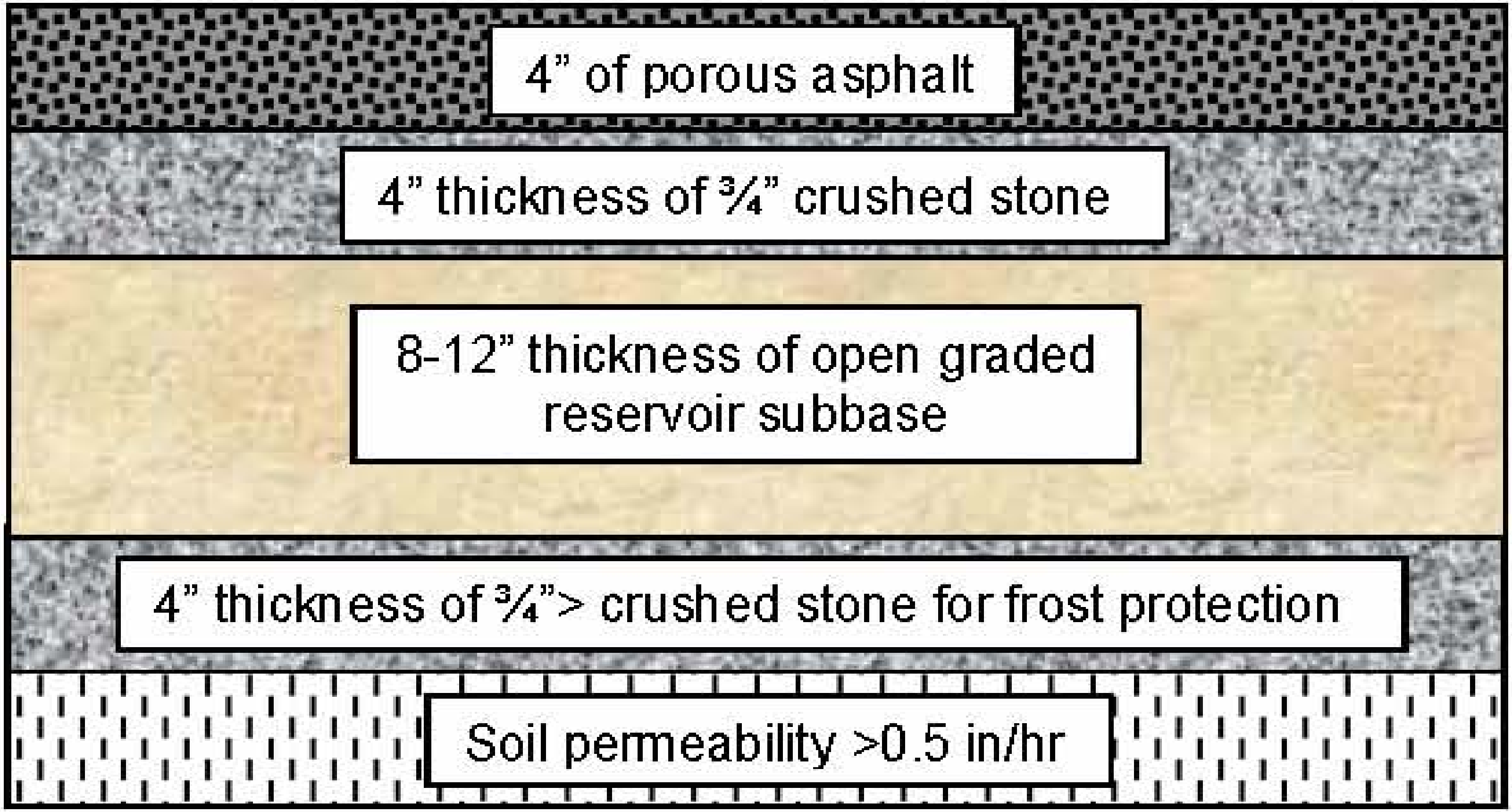
Disadvantages

1. Requires Routine (Quarterly) Vacuum Sweeping (Vac-Assisted Dry Sweeper Only)
2. Proper Construction Stabilization and Erosion Control are Required to Prevent Clogging
3. Quality Control for Material Production and Installation are Essential for Success
4. Accidental Seal-Coating or Similar Surface Treatment Will Cause Failure

Design Criteria

- Soil Permeability is Recommended Between 0.25-3.0 Inches Per Hour
- Recommended Drainage Time of 24-48 Hours
- Sub-Drains Should be Used Where Proper Drainage May be an Issue to Minimize Frost Damage
- Most Appropriate for use with Low-Use Roadways and Parking Lots—Without a Modified Asphalt Binder
- 3-5 Feet of Vertical Separation is Needed from Seasonal High Groundwater

Porous Asphalt Cross-Section



4" of porous asphalt

4" thickness of ¾" crushed stone

8-12" thickness of open graded reservoir subbase

4" thickness of ¾"> crushed stone for frost protection

Soil permeability >0.5 in/hr

Advantages of Porous Concrete

1. Quantity and Flood Control
2. Water Quality Treatment
3. Recharges Groundwater
4. Reduction in Stormwater Infrastructure (Piping, Catch-Basins, Ponds, Curbing, etc.)
5. Suitable for Cold-Climate Applications, Maintains Recharge Capacity When Frozen
6. No Standing Water or Black Ice Development During Winter Weather Conditions
7. Maintains Traction While Wet
8. Reduced Surface Temperatures; Minimizes the Urban Heat Island Effect
9. Extended Pavement Life Due to Well Drained Base and Reduced Freeze-Thaw
10. Less Lighting Needed Due to Highly Reflective Pavement Surface

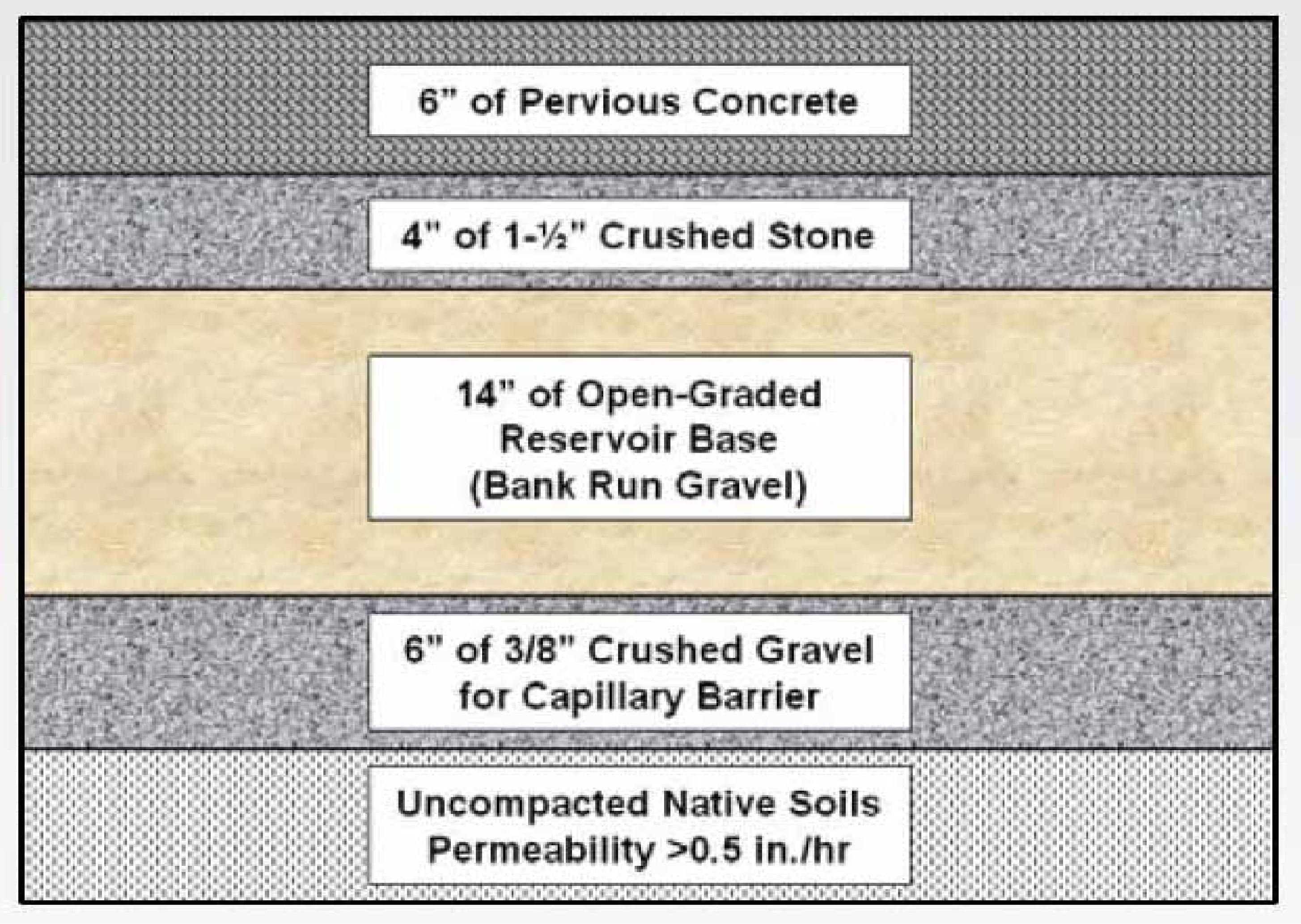
Disadvantages

- Requires Routine (Quarterly) Vacuum Sweeping (Vacuum-Assisted Dry Sweeper Only)
- Requires a Certified Pervious Concrete Craftsman On-site During Installation
- Proper Soil Stabilization and Erosion Control are Required to Prevent Clogging
- Quality Control for Material Production and Installation are Essential for Success
- Concrete Must Cure Under Plastic for 7-Days After Installation

Design Criteria

- Soil Permeability is Recommended Between 0.25-3.0 Inches Per Hour
- Recommended Drainage Time of 24-48 Hours
- Sub-Drains Should be Used Where Proper Drainage May be an Issue to Minimize Frost Damage
- Most Appropriate for use with Parking Lots, Low-Use Roadways, and Sidewalks
- 3-5 Feet of Vertical Separation is Needed from Seasonal High Groundwater

Porous Concrete Cross-Section



6" of Pervious Concrete

4" of 1-½" Crushed Stone

14" of Open-Graded
Reservoir Base
(Bank Run Gravel)

6" of 3/8" Crushed Gravel
for Capillary Barrier

Uncompacted Native Soils
Permeability >0.5 in./hr

Cost and Maintenance

- Total Project Cost is Comparable for Porous Asphalt and Porous Concrete with Reduced Stormwater Infrastructure VS. Standard Pavement Applications where Stormwater Infrastructure is Required
- Materials cost is ~20-25% more than traditional asphalt or concrete
- Long-term maintenance is required by routine quarterly vacuum sweeping
- Sweeping cost may be off-set by reduced deicing costs
- Asphalt repairs can be made with standard asphalt not to exceed 10% of surface area
- Concrete Repairs can be made with standard concrete not to exceed 10% of the surface area

Winter Conditions

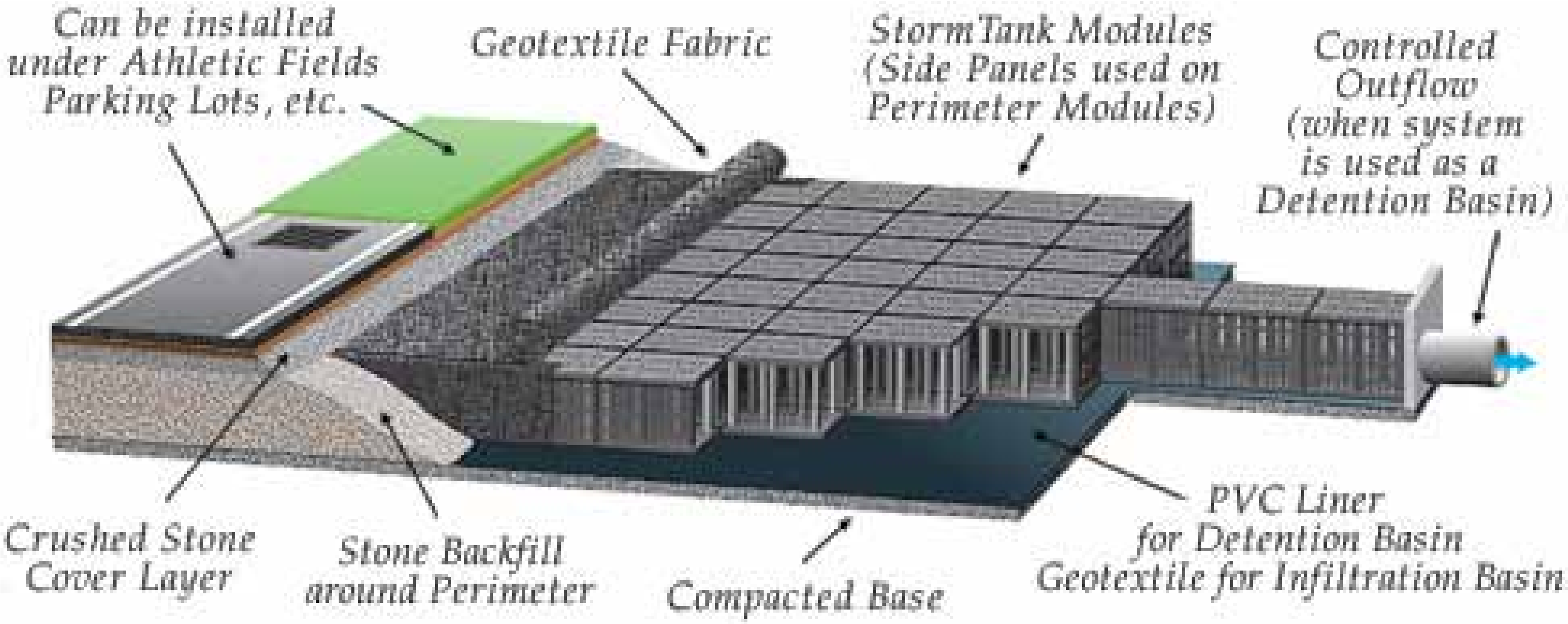
- Findings from the porous asphalt study conducted by UNH Stormwater Center have demonstrated the functionality exceeds conventional practices.
- When compared to conventional asphalt, salt application can be reduced by 75%.
- Porous asphalt can withstand routine plowing of snow.

Pervious Pavements

Underground Detention

- Provides usable surface space while promoting stormwater infiltration; used in place of detention ponds
- New technologies can support large loads
- Boasts 97% void space providing more storage than most competitors (Brentwood)
- Underground perforated pipe systems collect stormwater and slowly release it to a stone media, with a 40% void space
- A 100 ft by 420 ft system can provide storage for nearly 100,000 cubic feet of water storage by utilizing 4,900 ft of 48-inch-diameter Advanced Drainage Systems N-12 HDPE pipe.

Underground Detention Design



Underground Detention

Applications

- Provides peak flow and water quantity control
- For use in sites with limited space
- Can be installed under parking lots and other developed spaces
- Useful in retrofit applications to provide additional storage and attenuate peak flows
- Useful in combination with pretreatment devices and other water quality or recharge practices

Limitations

- Provides limited water quality treatment
- Typically provides less than 24 hour detention time
- Susceptible to re-suspension of settled materials by subsequent storms
- Does not reduce runoff volume or promote groundwater recharge
- Costs and maintenance

Site Selection and Planning

- Check with **local authorities** regarding their design requirements and necessary permits for construction of underground storage. There is great variability between localities in requirements and permissible construction materials.
- The use of **experienced** engineers, suppliers (if using a proprietary system) and installers is strongly recommended.
- Placement of underground stormwater storage is **site specific**. During early site inspections, special note should be made of site size, shape and physical characteristics of the landscape. These factors will help determine basic structure of the detention system and what materials are best used in construction.
- The suggested maximum area of stormwater drainage to be collected for one underground storage system is **25 acres**.
- If underground stormwater storage is one part of a series (or train) of a comprehensive stormwater plan, the storage system can be first or last in line and positioning in train is usually dictated by local authorities. Other components of a development’s stormwater plan should be expected to improve water quality and the storage system should be expected to slow the flow of cleaned water into native systems.

Materials

- Site-specific conditions that can influence material selection:
  - **Depth and area** of excavation- deeper and larger excavated areas require more fill for maintaining the integrity of plastic or metal pipe.
  - **Shape** of space- continuous space allows the use of concrete, while angular spaces favor the use of pipe systems. However:
    - Pipes store less water than square concrete vaults per cross sectional area.
    - Pipes require more fill than concrete structures, thus using more excavated area.
    - Use the largest pipe diameter possible. Doubling pipe diameter quadruples capacity and only doubles cost.
  - Depth of **water table** – a high, close to system water table can cause plastic pipe to float upwards.
  - **Construction costs** – locality will influence costs of materials and labor

Design

- **Capacity and discharge** rate will depend on local government stormwater requirements. Typical design requirements include:
  - System to result in reduction of stormwater flow rates to a rate that mimics pre- development conditions – no net increase in runoff for a design storm event in a newly developed area.
  - System required to handle a particular size storm event over a particular length of time
- **Pipes and floors** of vaults should be designed with a maximum of two percent slopes to facilitate drainage of water.
- An **Emergency overflow system** should be designed to convey flows larger than can be handled by the storage system or to divert water in case system becomes inoperable for any reason.
- Sufficient personnel **access points** (man holes) should be incorporated in design to facilitate easy maintenance. Placement should, at a minimum, occur near the intake and another at the outlet end of the system. The number depends on maintenance methods used.
- **Rip-rap** at the outflow is required to reduce erosion.

Maintenance

- Periodic inspections of the inlet and outlet areas to ascertain **correct operation** of system and to clean materials trapped on grates protecting catch basins and inlet area should be required monthly.
- The primary maintenance concerns are **removal of floatables** that become trapped and removal of accumulating sediments within the system; this should be done at least on an annual basis. Proprietary traps and filters associated with stormwater storage units should be maintained as recommended by the manufacturer.
- Any **structural repairs** required to inlet and outlet areas should be addressed in a timely manner on an as needed basis.
- Local authorities may require annual inspection or require that they carry out **inspections and maintenance**.

Costs

- Underground stormwater facilities are more expensive than surface stormwater treatment methods. However in areas where land is expensive or in short supply underground storage is cost effective.
- Cost is highly variable depending on:
  - Materials used
  - Storage volume required
  - Construction and labor costs
  - Site location
  - Physical conditions of site location
- Reported price ranges of three ($3) dollars per cubic foot of water storage to $10 per cubic foot of water storage in plastic and metal pipes reflect price variability based on scale of projects, size of pipes that could be used, amount of excavation, fill amounts required and construction/labor costs.

Underground Detention Systems

- Commercially Available StormChamber™ Offered by HydoLogic Solutions Inc.
  Source: HydroLogic Solutions Inc; http://www.stormchambers.com/index.html

- Commercially Available Prefabricated Plastic Stormwater Storage Units Designed to be used Beneath Structures and Other Amenities. Individual, Stackable Units are 1 meter x 1 meter x 0.1 meters (h) and Store around 25 gallons of Water per Unit.
  Source: Invisible Structures, Inc.; http://www.invisiblestructures.com/rainstore3.html

- Corrugated Metal Pipe System for Underground Stormwater Storage;
  Supplied by Contech Construction Products, USA.
  Source: Contech Construction Products, USA; http://www.contech-cpi.com/Products/StormwaterManagement/SubsurfaceInfiltration/CMPDetentionandInfiltrationSystem.aspx

Bioretention Systems & Rain Gardens

Traditional Approach

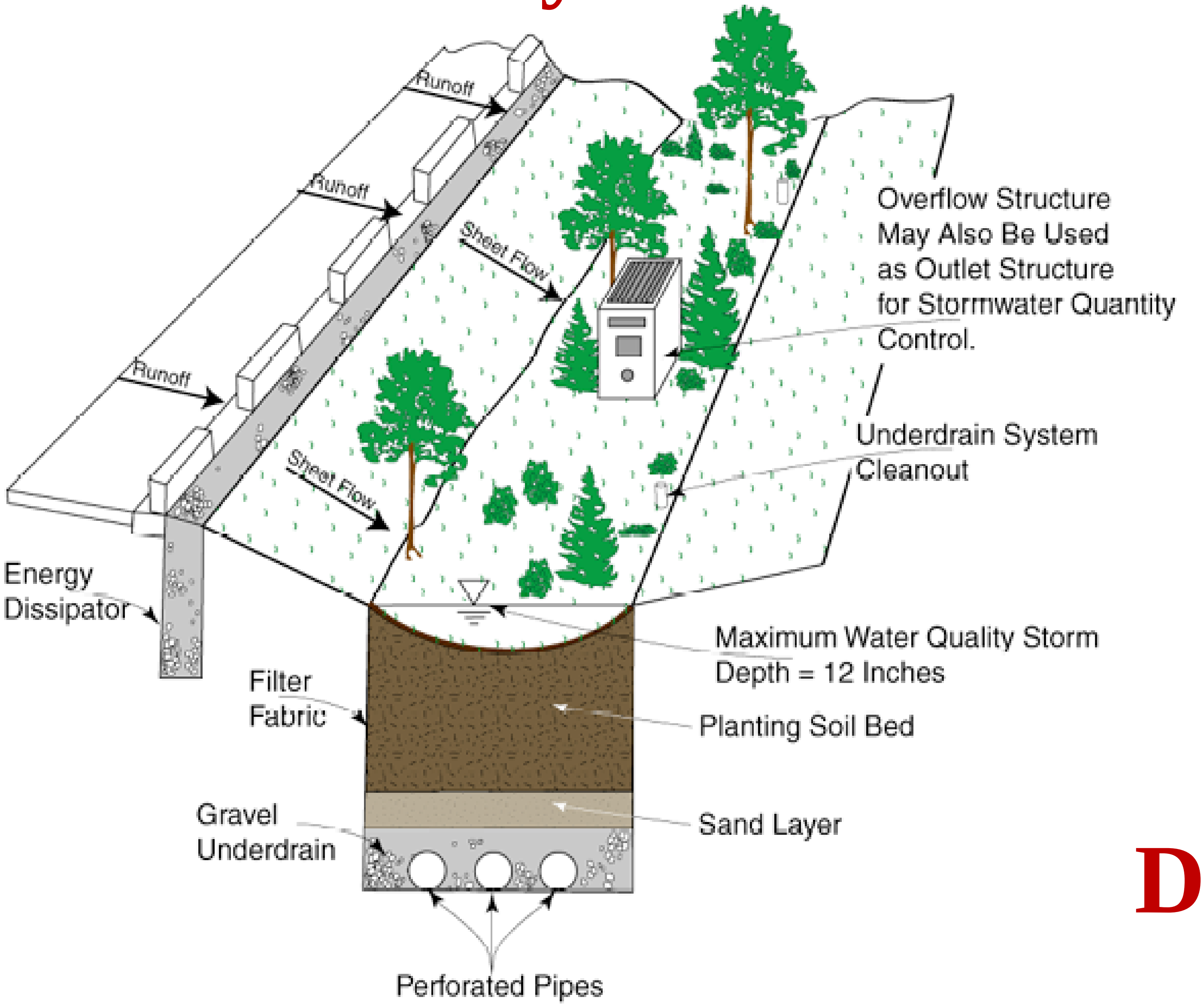
Design Dry Detention Basin:

- Treat Water Quality Storm (1.25” rain over 24 hours)
- Detain for 18 hours (residential) or 36 hours (commercial)
- Minimum outflow orifice = 3 inches
- Use Concrete Low Flow Channels to Minimize Erosion

New Approach

- Combines settling of detention basin with physical filtering and absorption processes
- Provides very high pollutant removal efficiencies
- More aesthetically pleasing than conventional detention basins
- Can be incorporated into the landscapes of individual homes

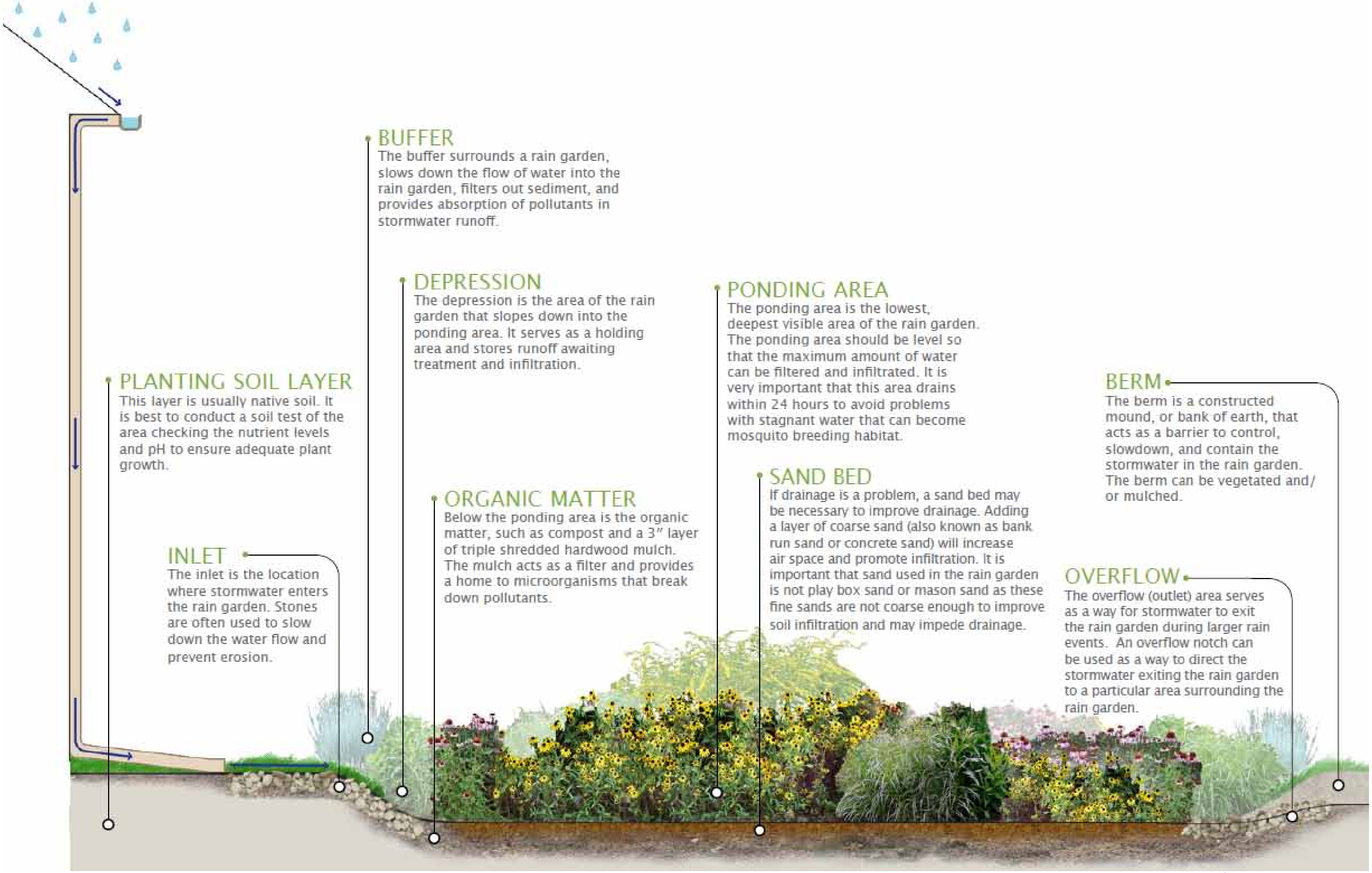
Bioretention Systems & Rain Gardens



Design

NJDEP. 2004. NJ Stormwater BMP Manual.

Bioretention Systems & Rain Gardens



PLANTING SOIL LAYER

This layer is usually native soil. It is best to conduct a soil test of the area checking the nutrient levels and pH to ensure adequate plant growth.

INLET

The inlet is the location where stormwater enters the rain garden. Stones are often used to slow down the water flow and prevent erosion.

BUFFER

The buffer surrounds a rain garden, slows down the flow of water into the rain garden, filters out sediment, and provides absorption of pollutants in stormwater runoff.

DEPRESSION

The depression is the area of the rain garden that slopes down into the ponding area. It serves as a holding area and stores runoff awaiting treatment and infiltration.

ORGANIC MATTER

Below the ponding area is the organic matter, such as compost and a 3″ layer of triple shredded hardwood mulch. The mulch acts as a filter and provides a home to microorganisms that break down pollutants.

PONDING AREA

The ponding area is the lowest, deepest visible area of the rain garden. The ponding area should be level so that the maximum amount of water can be filtered and infiltrated. It is very important that this area drains within 24 hours to avoid problems with stagnant water that can become mosquito breeding habitat.

SAND BED

If drainage is a problem, a sand bed may be necessary to improve drainage. Adding a layer of coarse sand (also known as bank run sand or concrete sand) will increase air space and promote infiltration. It is important that sand used in the rain garden is not play box sand or mason sand as these fine sands are not coarse enough to improve soil infiltration and may impede drainage.

BERM

The berm is a constructed mound, or bank of earth, that acts as a barrier to control, slowdown, and contain the stormwater in the rain garden. The berm can be vegetated and/or mulched.

OVERFLOW

The overflow (outlet) area serves as a way for stormwater to exit the rain garden during larger rain events. An overflow notch can be used as a way to direct the stormwater exiting the rain garden to a particular area surrounding the rain garden.

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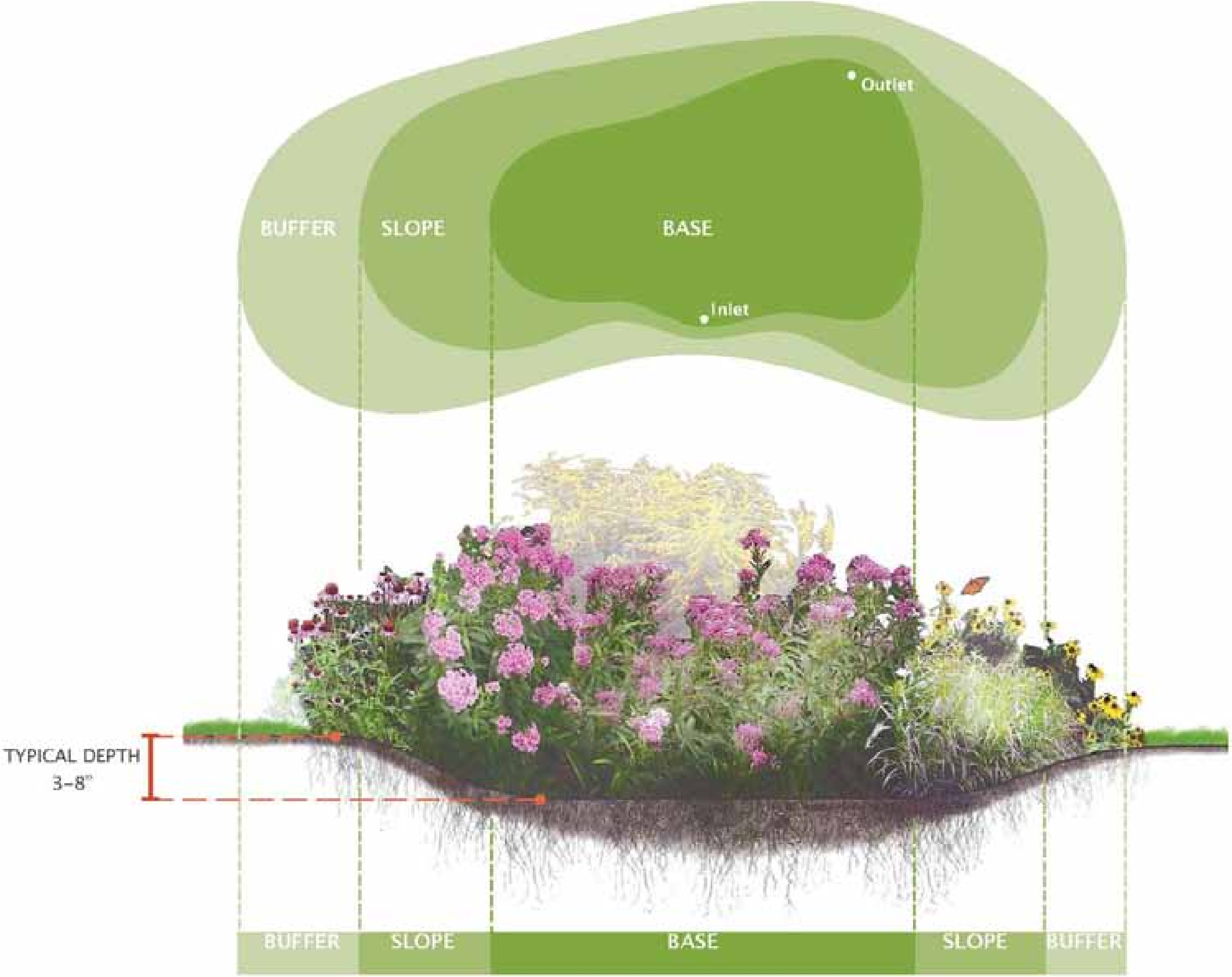
Bioretention Systems & Rain Gardens



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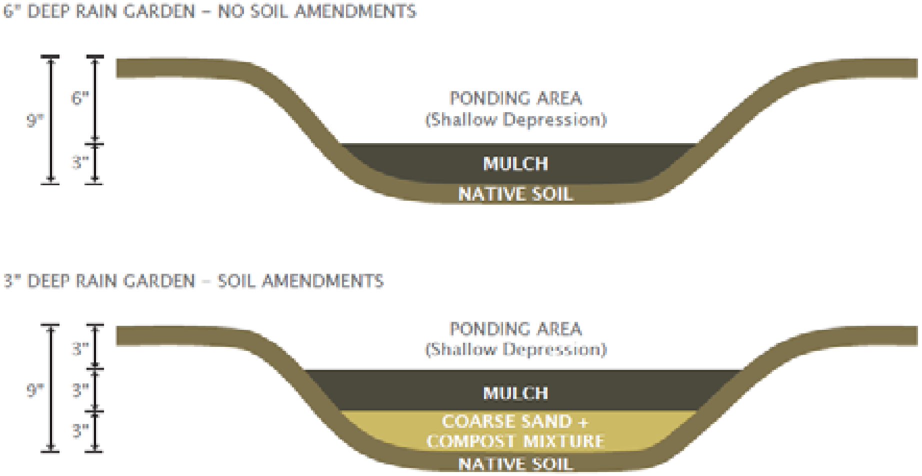
Design Criteria

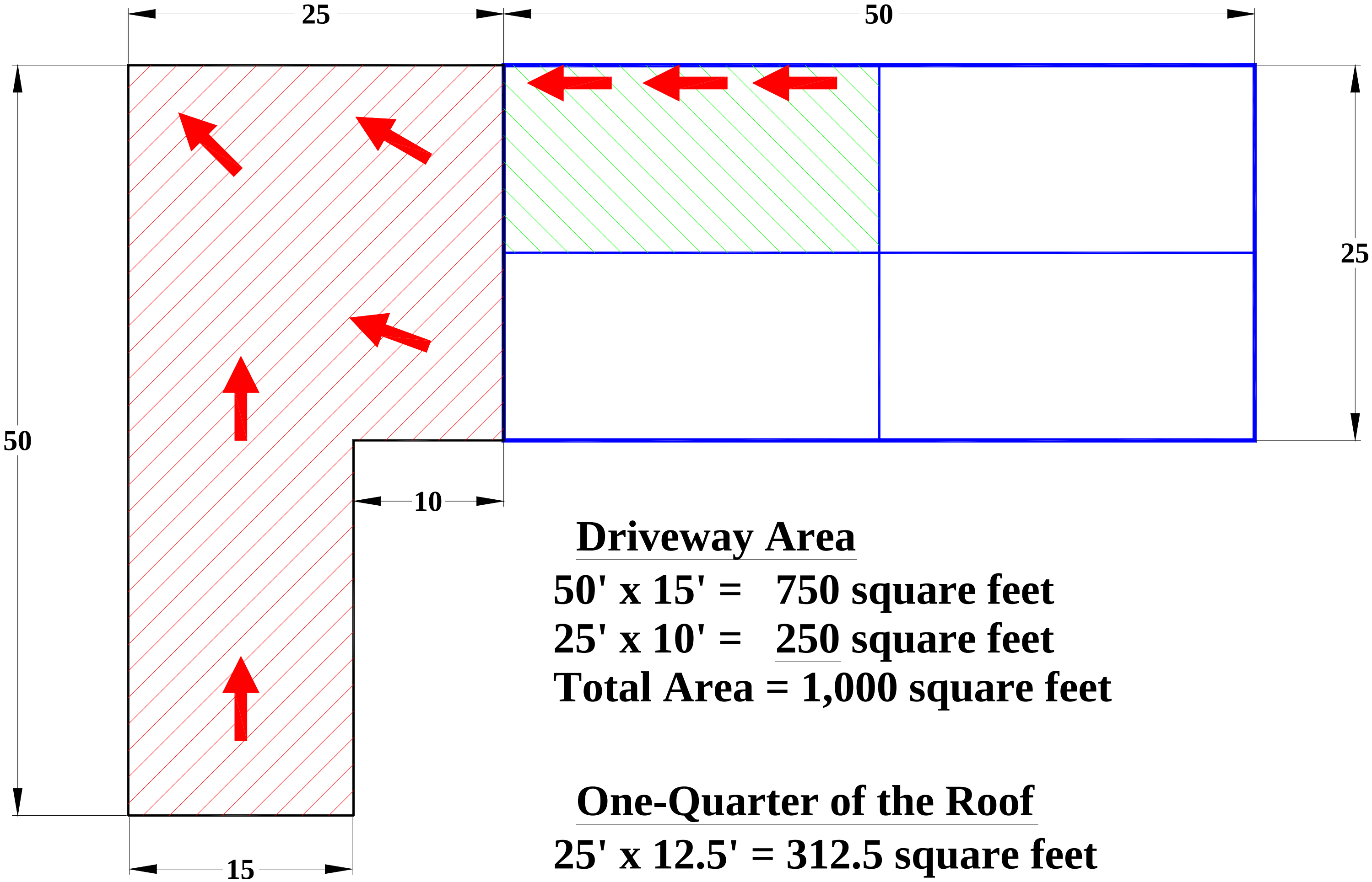
- The size of the rain garden is a function of volume of runoff to be treated and recharged.
- Typically, a rain garden is sized to handle the water quality design storm: 1.25 inches of rain over two hours.
- A typical residential rain garden ranges from 100 to 300 square feet.



Design Problem

How big does a rain garden need to be to treat the stormwater runoff from my driveway?

Design Problem



Driveway Area

50' x 15' = 750 square feet

25' x 10' = 250 square feet

Total Area = 1,000 square feet

One-Quarter of the Roof

25' x 12.5' = 312.5 square feet

Design Problem

- Drainage Area = 1,000 square feet
- 1.25 inches of rain = 0.1 feet of rain
- 1,000 sq. ft. x 0.1 ft. = 100 cubic feet of water for the design storm
- Let's design a rain garden that is 6 inches deep

Answer:

10 ft wide x 20 ft long = 200 square feet

Rain Garden Sizing Table for NJ’s Water Quality Design Storm

Area of Impervious Surface to be Treated (ft^2)	Size of 6” deep Rain Garden (ft^2) or [w x d]	Size of 12” deep Rain Garden (ft^2) or [w x d]
500	100 or 10’x10’	50 or 10’x5’
750	150 or 15’x10’	75 or 10’x7½’
1,000	200 or 20’x10’	100 or 10’x10’
1,500	300 or 30’x10’	150 or 15’x10’
2,000	400 or 20’x20’	200 or 20’x10’

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Water Resources Program

How much water does this treat?

- 90% of rainfall events are less than 1.25”
- New Jersey has approx. 44” of rain per year
- The rain garden will treat and recharge:

  0.9 x 44” = 40”/year = 3.3 ft/year
- The rain garden receives runoff from 1,000 sq.ft.
- Total volume treated and recharged by the rain garden is 1,000 sq. ft. x 3.3 ft. = 3,300 cubic feet, which is 25,000 gallons per year
- **Build 40 of these and we have treated and recharged 1,000,000 gallons of water per year!**

Pollutant Removal Mechanisms

- Absorption to soil particles
  - – *Removes dissolved metals and soluble phosphorus*
- Plant uptake
  - – *Removes small amounts of nutrients*
- Microbial processes
  - – *Removes organics and pathogens*
- Exposure to sunlight and dryness
  - – *Removes pathogens*
- Infiltration of runoff
  - – *Provides flood control, groundwater recharge, and nutrient removal*
- Sedimentation and filtration
  - – *Removes total suspended solids, floating debris, trash, soil-bound phosphorus, some soil-bound pathogens*

NOTE: 90% of all storm events produce less than 1 inch of rain. Therefore, the key to reducing pollutant loads is to treat the runoff associated with the first 1 inch of rain (Claytor & Schueler, 1996).

Pollutant Removal Comparisons

Detention Basin – (Detain 1.25” storm for 12 hours)

Bioretention Basin - (exfiltrate 1” runoff volume/impervious acre)

PARAMETER	DETENTION BASIN(1) PROBABLE RANGE	BIORETENTION BASIN(2) PROBABLE RANGE
Suspended Solids	70% to 90%	90%
Total Phosphorus	10% to 60%	70% to 83%
Total Nitrogen	20% ato 60%	68% to 80%
BOD	30% to 40%	60% to 80%
Lead	20% to 60%	93% to 98%
Zinc	40 % to 60%	93% to 98%
Hydrocarbons	60% to 77%	90%

REF: (1) NJDEP, 1994; (2) USEPA, 1999

Stormwater Wetlands

FUNCTIONS

- Used to remove a wide range of pollutants from land development sites
- Provide wildlife habitat
- Provide aesthetic features
- Reduce peak runoff rates
- The adopted removal rate for constructed stormwater wetlands is 90 percent

COMPONENTS

- Forebay - promotes settling of large particles
- Permanent pools and ponds
  - Promote diverse aquatic communities
- Heavily vegetated swales between pools
  - Slow flows, inhibit resuspension
  - Maximize contact with vegetation
- Inlet and outlet water control structures
- Diverse vegetation-aesthetics and nuisance control

Stormwater Wetlands

- Stormwater wetlands improve water quality
  - Detention time
  - Presence of plants
- Proper sizing of wetland system is critical
- Water budget/desired retention time
- Urban areas present special constraints
  - Flashy hydrology, first flush
  - Lack of space
- Importance of aesthetics

Stormwater Wetlands
General Design Principles

- KISS-complexity invites failure
- Design for minimal maintenance
- Use natural energies and processes
- Design with the landscape-integrate
- Mimic natural systems and forms
- Give the system time to develop/establish
- Design for function and form/aesthetics

Mother Nature’s Wastewater Treatment System

- Physical settling of suspended solids
- Filtration and chemical precipitation
- Adsorption and ion exchange-surface
  - plants, substrate, sediment, litter
- Chemical transformation
- Breakdown and transformation by microbes
- Uptake and transformation by microbes and plants
- Predation and die-off of pathogens

Design Considerations

- Hydrology
  - Need minimum 10-25 acres of contributing drainage area
  - Total storage volume = design runoff volume
  - Must be able to maintain a permanent pool water level
- Soils
  - Subgrade -hydrology
  - Substrate –biology
- Plants
  - Native species supported by obligate, facultative, and upland conditions
  - Natural distribution (clumps, microtopography)
- Location, location, location
  - Should not be located in existing natural wetlands
  - Almost but not quite
  - Used to be

Design Elements

- Pool Zone
  - Forebay- promote settling of large particles
  - Permanent pond 4-6 feet in depth for primary water quality/quantity controls
  - Micropond provides final treatment near the outlet
- Marsh Zone
  - Heavily vegetated swales between pools
    - High Marsh = maximum standing water depth of 6 inches
    - Low Marsh = maximum standing water depth of 6-18 inches
  - Slow flows, inhibit resuspension of sediments
  - Maximize contact with vegetation
- Semi-Wet Zone
- Inlet and outlet water control structures
- Diverse vegetation-aesthetics and nuisance control

Limitations in Urban Areas

- Lack of space
- Flashy Hydrology
    - rapid time of concentration
- High first flush pollutant load
    - dust, metals, oil and grease, nutrients, fecal coliform
- Aesthetics
- Nuisance wildlife, especially geese
- Mosquito control

4 ½ Acres Rahway Project Site

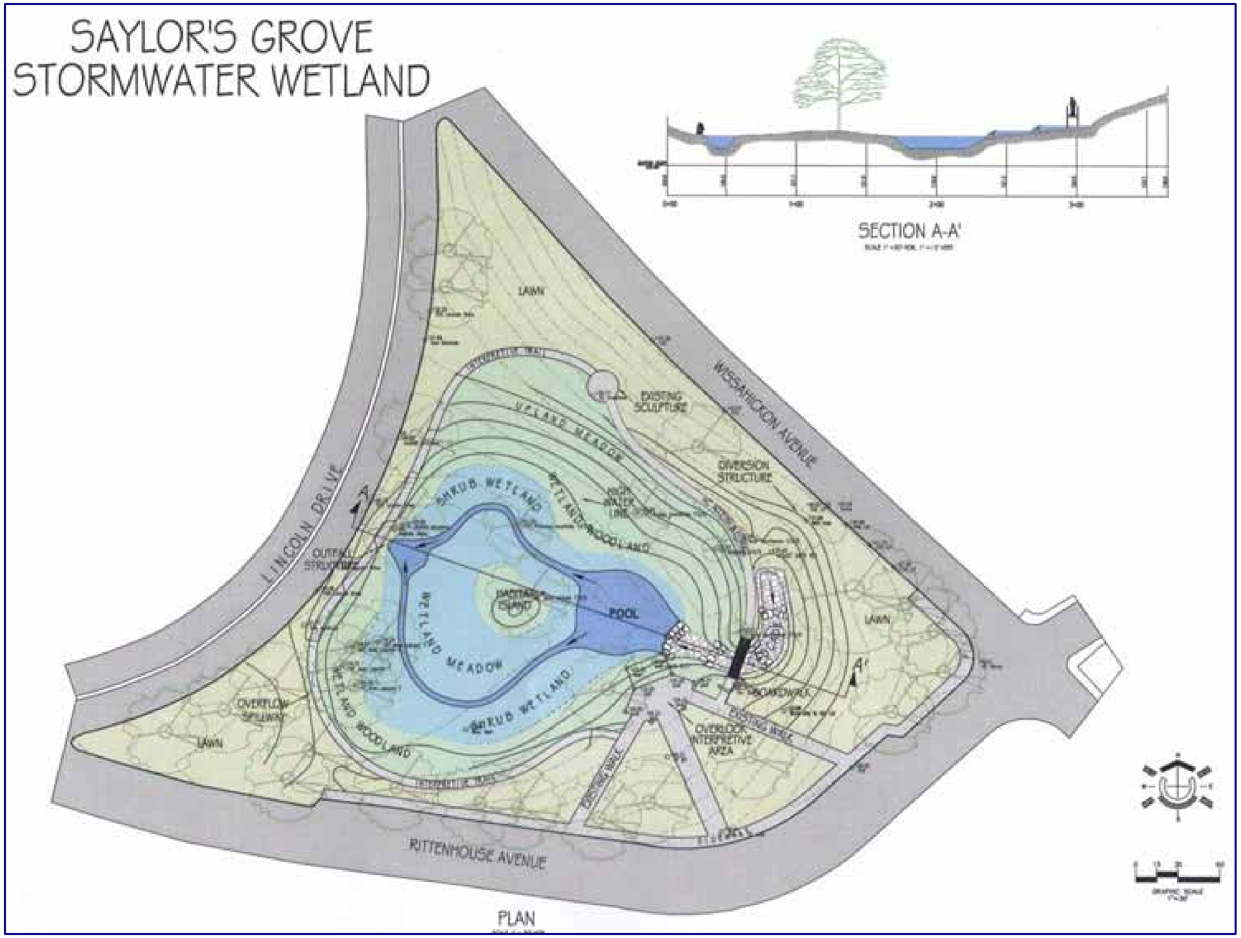

ALLEN ST
5. 3. 2002


RAHWAY RIVER
FLOOD PLAIN RESTORATION
MASTER PLAN
ISLAND
WOODED AREA
WOODED AREA
WET POND
WETLAND
WETLAND
TURN AROUND
UNION STREET
NORTH BRANCH OF THE RAHWAY RIVER
FUTURE PEDESTRIAN BRIDGE TO COUNTY PARK
APPROX. LOCATION OF EXIST. BIKE PATH
BOARDWALK OVERLOOK
TURN AROUND
ALLEN STREET
PARK PARKING
UPLAND MEADOW
TRANSITION WETLAND
WET POND
APPROX. LOCATION OF EXIST. TREELINE
CULVERT
APPROX. LOCATION OF RIVER BANK
PASSIVE RECREATION AREA
WEST GRAND STREET
BOARDWALK OVERLOOK
TRAIL ENTRANCE
BAYKEEPER
The Reynolds Group Inc.
peter bender
ENVIRONMENTAL CORPORATION
RAHWAY RIVER
FLOOD PLAIN RESTORATION
SITE PLAN
SP-1


5. 22. 2002

6. 21. 2002

Stormwater Wetlands

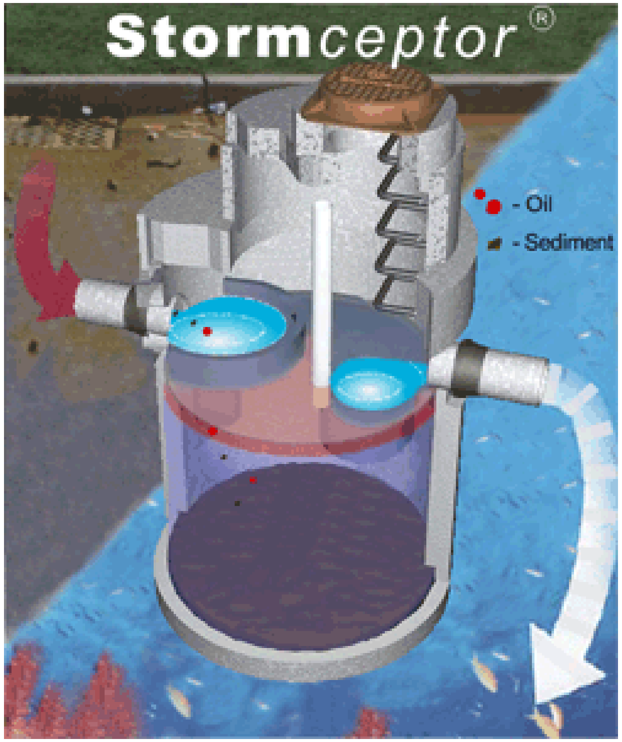


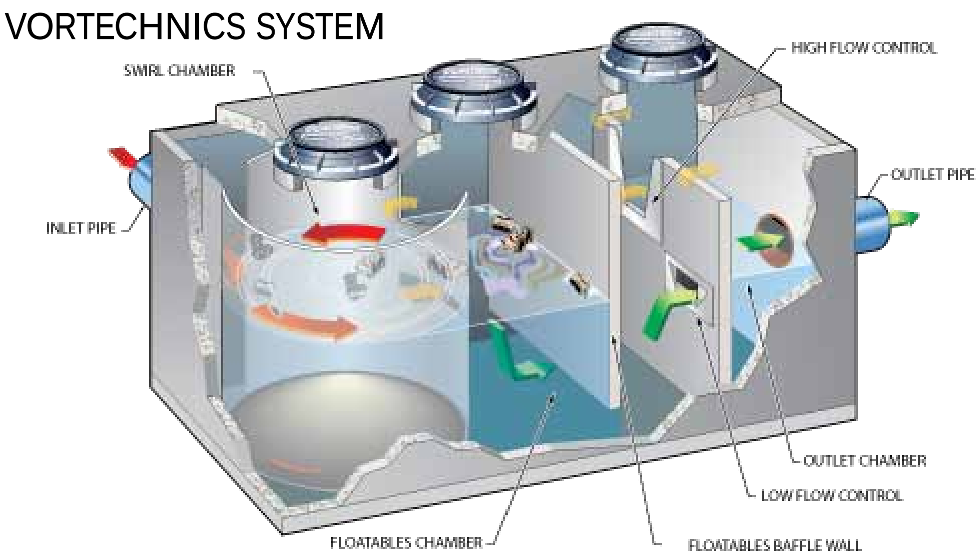
Manufactured Treatment Devices

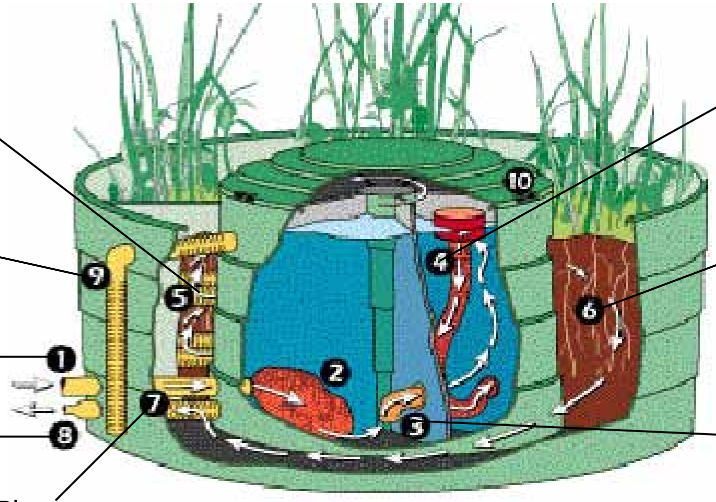
- Manufactured treatment devices are intended to **capture sediments, metals, hydrocarbons, floatables**, and/or other pollutants in stormwater runoff before being conveyed to a storm sewer system, additional stormwater quality treatment measure, or waterbody.

- A manufactured treatment device is adequate for **small drainage areas** that contain a predominance of impervious cover that is likely to contribute high hydrocarbon and sediment loadings, such as small parking lots and gas stations. For larger sites, multiple devices may be necessary. Devices are normally used for **pre-treatment** of runoff before discharging to other, more effective stormwater quality treatment facilities.

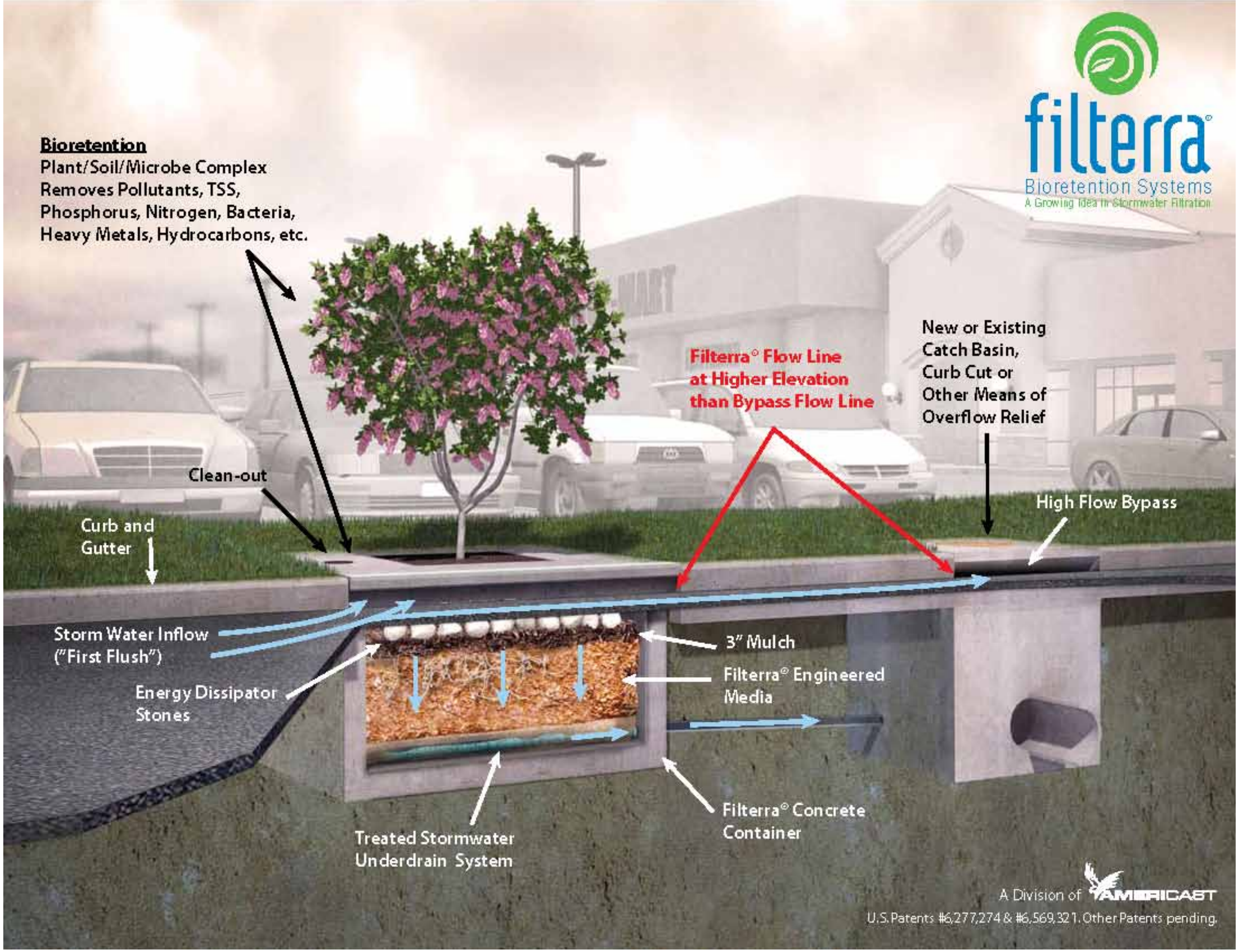
Manufactured Pre-Treatment Systems







Manufactured Pre-Treatment Systems

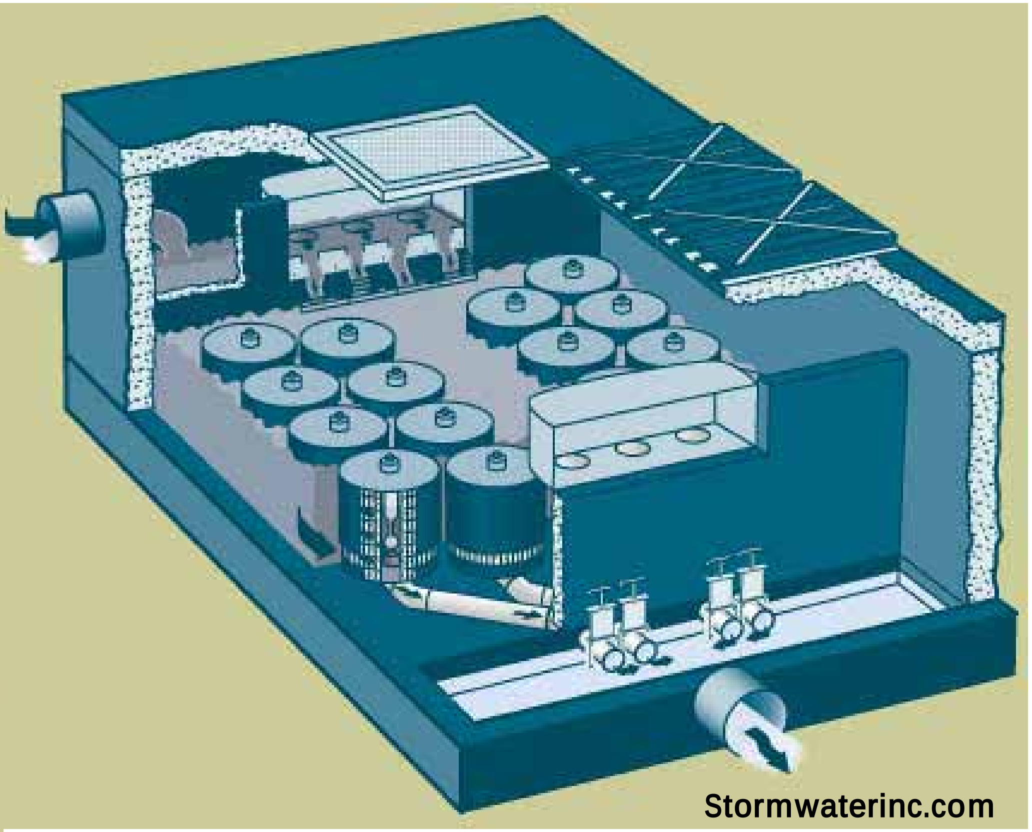


Manufactured Pre-Treatment Systems

The StormFilter System

Major Components
- Precast Vault
- Filter Cartridges

Considerations
- Sizing
- Optional Filter Media
- 2.5’ of Head needed
- Maintenance



Stormwaterinc.com

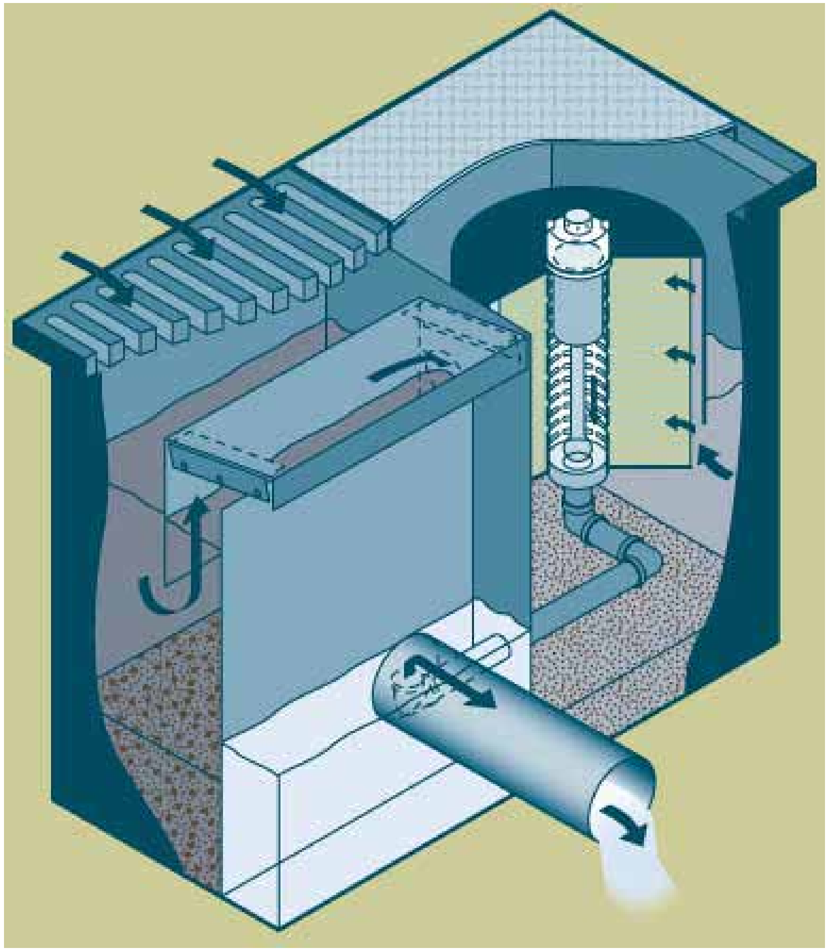
NOTE: Has received preliminary approval from NJ Office of Innovative Technology & Market Development

Manufactured Pre-Treatment Systems

The Catchbasin StormFilter System

System Features and Benefits

- Targets site-specific pollutants
- Low cost, heavy gauge, all steel construction (Concrete units also available)
- Internal bypass that minimizes re-suspension of trapped pollutants



General Specifications

- StormFilter capacity - 15 gpm/cartridge (up to 4 cartridges)
- Peak hydraulic capacities:
  Standard Steel Units -- 1.0 cfs
  Deep Steel Units - 3.0 cfs
  Concrete Units - 2.0 cfs
- Hydraulic drop (Rim to Invert): -
  Standard Steel Unit - 2.3'
  Deep Steel Unit - 3.3'
  Concrete Unit - 2.75' to 2.9' "
- Outlet pipe diameter - up to 12"
- Load-bearing capacities:
  Concrete Units - H-20
  Steel Units - H-20 with concrete collar

Stormwater…Infrastructure or Amenity

Categories of Green Infrastructure Design

- **Run-off storage practices**
  - Parking lot, street, and sidewalk storage
  - Rain barrels and cisterns
  - Depressional storage in landscape islands and in tree, shrub, or turf depressions
  - Green roofs
- **Run-off conveyance practices**
  - Eliminating curbs and gutters
  - Creating grassed swales and
  - grass-lined channels
  - Roughening surfaces
  - Creating long flow paths over landscaped areas
  - Installing smaller culverts, pipes, and inlets
  - Creating terraces and check dam

Categories of Green Infrastructure Design

- **Infiltration practices**
  - Porous pavement
  - Disconnected downspouts
  - Rain gardens and other vegetated
  - treatment systems
- **Filtration practices**
  - Bioretention/rain gardens
  - Vegetated swales
  - Vegetated filter strips/buffers

Categories of Green Infrastructure Design

- **Conservation designs**
  - Cluster development
  - Open space preservation
  - Reduced pavement widths (streets, sidewalks)
  - Shared driveways
  - Reduced setbacks (shorter driveways)
  - Site fingerprinting during construction to
  - document its unique characteristics

- **Low-impact landscaping**
  - Planting native, drought-tolerant plants
  - Converting turf areas to shrubs and trees
  - Reforestation
  - Encouraging longer grass length
  - Planting wildflower meadows rather than turf along medians and in open space
  - Amending soil to improve infiltration

Leadership in Energy and Environmental Design (LEED)

- What is LEED?
  - Nationally accepted benchmark
  - Universally understood and accepted tools and performance criteria
  - Promotes whole-building approach to sustainability
  - Encourages and accelerates adoption of sustainable green building and development

LEED

What is LEED?

What does LEED deliver?

www.usgbc.org

Certification Levels

40-49 50-59 60-79 80+

POINTS

LEED 2009 for New Construction and Major Renovations

Project Checklist

Project Name

Date

Sustainable Sites — Possible Points: 26

Y	?	N			
Y			Prereq 1	Construction Activity Pollution Prevention	
			Credit 1	Site Selection	1
			Credit 2	Development Density and Community Connectivity	5
			Credit 3	Brownfield Redevelopment	1
			Credit 4.1	Alternative Transportation—Public Transportation Access	6
			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Roon	1
			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Ve	3
			Credit 4.4	Alternative Transportation—Parking Capacity	2
			Credit 5.1	Site Development—Protect or Restore Habitat	1
			Credit 5.2	Site Development—Maximize Open Space	1
			Credit 6.1	Stormwater Design—Quantity Control	1
			Credit 6.2	Stormwater Design—Quality Control	1
			Credit 7.1	Heat Island Effect—Non-roof	1
			Credit 7.2	Heat Island Effect—Roof	1
			Credit 8	Light Pollution Reduction	1

Water Efficiency — Possible Points: 10

Y			Prereq 1	Water Use Reduction—20% Reduction	
			Credit 1	Water Efficient Landscaping	2 to 4
			Credit 2	Innovative Wastewater Technologies	2
			Credit 3	Water Use Reduction	2 to 4

Energy and Atmosphere — Possible Points: 35

Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
			Credit 1	Optimize Energy Performance	1 to 19
			Credit 2	On-Site Renewable Energy	1 to 7
			Credit 3	Enhanced Commissioning	2
			Credit 4	Enhanced Refrigerant Management	2
			Credit 5	Measurement and Verification	3
			Credit 6	Green Power	2

Materials and Resources — Possible Points: 14

Y			Prereq 1	Storage and Collection of Recyclables	
			Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
			Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Element	1
			Credit 2	Construction Waste Management	1 to 2
			Credit 3	Materials Reuse	1 to 2

Materials and Resources, Continued

Y	?	N			
			Credit 4	Recycled Content	1 to 2
			Credit 5	Regional Materials	1 to 2
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1

Indoor Environmental Quality — Possible Points: 15

Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
			Credit 1	Outdoor Air Delivery Monitoring	1
			Credit 2	Increased Ventilation	1
			Credit 3.1	Construction IAQ Management Plan—During Construction	1
			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Product	1
			Credit 5	Indoor Chemical and Pollutant Source Control	1
			Credit 6.1	Controllability of Systems—Lighting	1
			Credit 6.2	Controllability of Systems—Thermal Comfort	1
			Credit 7.1	Thermal Comfort—Design	1
			Credit 7.2	Thermal Comfort—Verification	1
			Credit 8.1	Daylight and Views—Daylight	1
			Credit 8.2	Daylight and Views—Views	1

Innovation and Design Process — Possible Points: 6

			Credit 1.1	Innovation in Design: Specific Title	1
			Credit 1.2	Innovation in Design: Specific Title	1
			Credit 1.3	Innovation in Design: Specific Title	1
			Credit 1.4	Innovation in Design: Specific Title	1
			Credit 1.5	Innovation in Design: Specific Title	1
			Credit 2	LEED Accredited Professional	1

Regional Priority Credits — Possible Points: 4

			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1

Total — Possible Points: 110

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

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Water Resources Program

Sustainable Sites

SS Credit 5.1: Site Development – Protect or Restore Habitat

1 Point

Intent

To conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

SS Credit 5.2: Site Development – Maximize Open Space

1 Point

Intent

To promote biodiversity by providing a high ratio of open space to development footprint.

Sustainable Sites

SS Credit 6.1: Stormwater Design – Quantity Control

1 Point

Intent

To limit disruption of natural hydrology by reducing impervious cover, increasing on-site infiltration, reducing or eliminating pollution from stormwater runoff and eliminating contaminants.

SS Credit 6.2: Stormwater Design – Quality Control

1 Point

Intent

To limit disruption and pollution of natural water flows by managing stormwater runoff.

Sustainable Sites

SS Credit 7.1: Heat Island Effect – Nonroof

1 Point

Intent

To reduce heat islands to minimize impacts on microclimates and human and wildlife habitats.

SS Credit 7.2: Heat Island Effect – Roof

1 Point

Intent

To reduce heat islands to minimize impacts on microclimates and human and wildlife habitats.

Water Efficiency

WE Credit 1: Water Efficient Landscaping

2-4 Points

Intent

To limit or eliminate the use of potable water or other natural surface or subsurface water resources available on or near the project site for landscape irrigation.

WE Credit 3: Water Use Reduction

2-4 Points

Intent

To further increase water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

LID/Green Infrastructure – Performance Standards

Water Quantity

- Demonstrate that post-development 2, 10, and 100-year storm event hydrographs do not exceed pre-development hydrographs

or

- Demonstrate that hydrograph peaks will not increase and that increase in volume or change in timing won't increase flood damage downstream

or

- Design BMPs so 2, 10, and 100-year hydrographs are reduced by 50%, 75%, and 80%, respectively

SOURCE: NJ Stormwater Management Rules and BMP Manual

LID/Green Infrastructure – Performance Standards

Groundwater Recharge

- Maintain 100% of average annual groundwater recharge volume

or

- Infiltrate increase in the post development runoff volume for the 2-year storm

SOURCE: NJ Stormwater Management Rules and BMP Manual

LID/Green Infrastructure – Performance Standards

Water Quality

- Install BMPs to reduce at least 80% of total suspended solids (TSS) loads
- Install BMPs to provide nutrient removal to maximum extent feasible

BMP	Removal Rate
Bioretention	90%
Constructed Wetlands	90%
Forested Buffers	70%
Extended Detention Basin	40-60%
Infiltration Structure	80%
Sand Filter	80%
Vegetative Filter Strip	50%
Wet Pond	60-90%
Manufactured Treatment Devices	50-80%

SOURCE: NJ Stormwater Management Rules and BMP Manual

10 Keys for Success

1. Connectivity is the key.
2. Context matters.
3. Green infrastructure should be grounded in sound science and land-use planning theory and practice.
4. Green infrastructure can and should function as the framework for construction and development.
5. Green infrastructure should be planned and protective *before* development.
6. Green infrastructure is a critical public investment that should be funded up front.
7. Green infrastructure affords benefits to nature and people.
8. Green infrastructure respects the needs and desires of landowners and other stakeholders.
9. Green infrastructure requires making connections to activities within and beyond the community.
10. Green infrastructure requires long-term commitment.

(from Benedict, M.A. and E.T. McMahon, 2006 Green Infrastructure: Linking Landscapes and Communities. Island Press, Washington, D.C., pp37.)

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QUESTIONS?

Rutgers Cooperative Extension Water Resources Program

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Upcoming Seminars

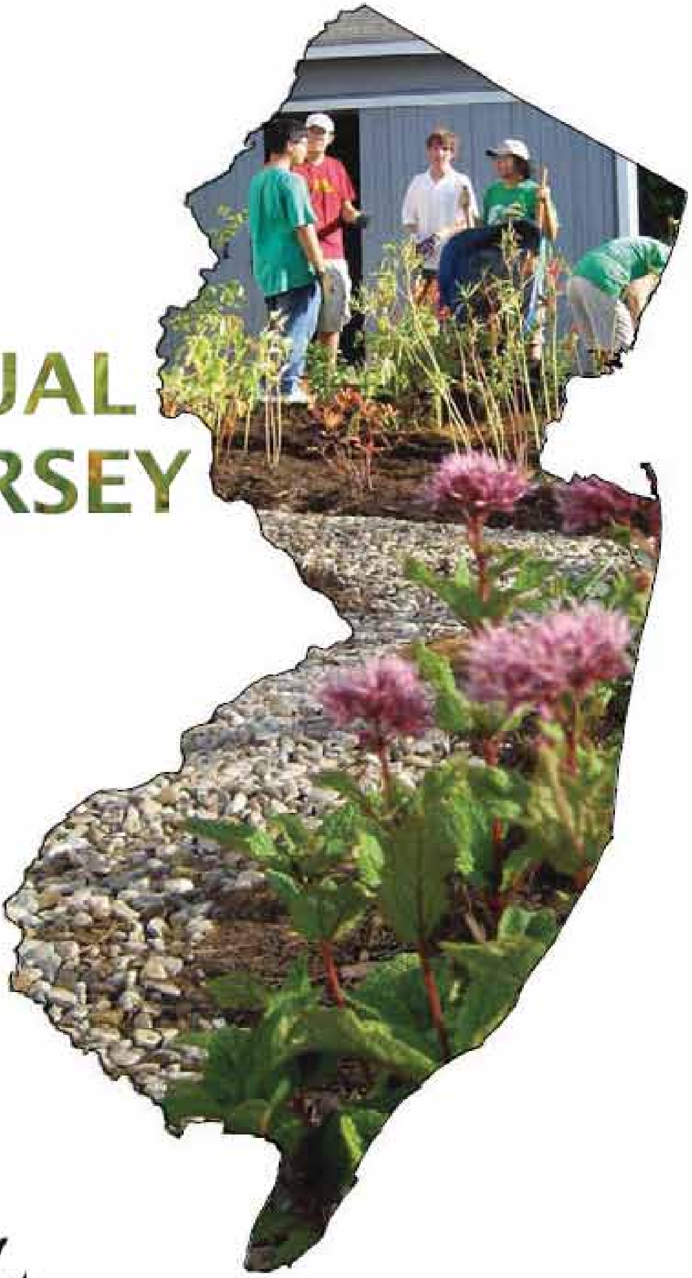
Spring Seminars

Details and schedule to come. Topics to include:

1. *Streamside living and open space management*
2. *Green alternatives and opportunities for homeowners*
3. *Green alternatives and opportunities for commerce/business/industry*
4. *Build-Your-Own Rain Barrel Workshop*
5. *Rain garden training and certification*

Visit www.water.rutgers.edu to register for each seminar.

RAIN GARDEN MANUAL OF NEW JERSEY



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