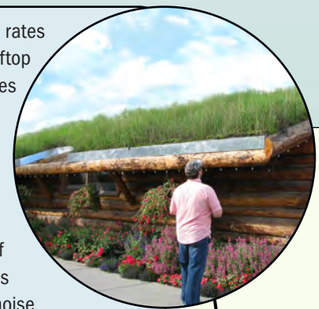
OPTIONS FOR GREENING RALEIGH

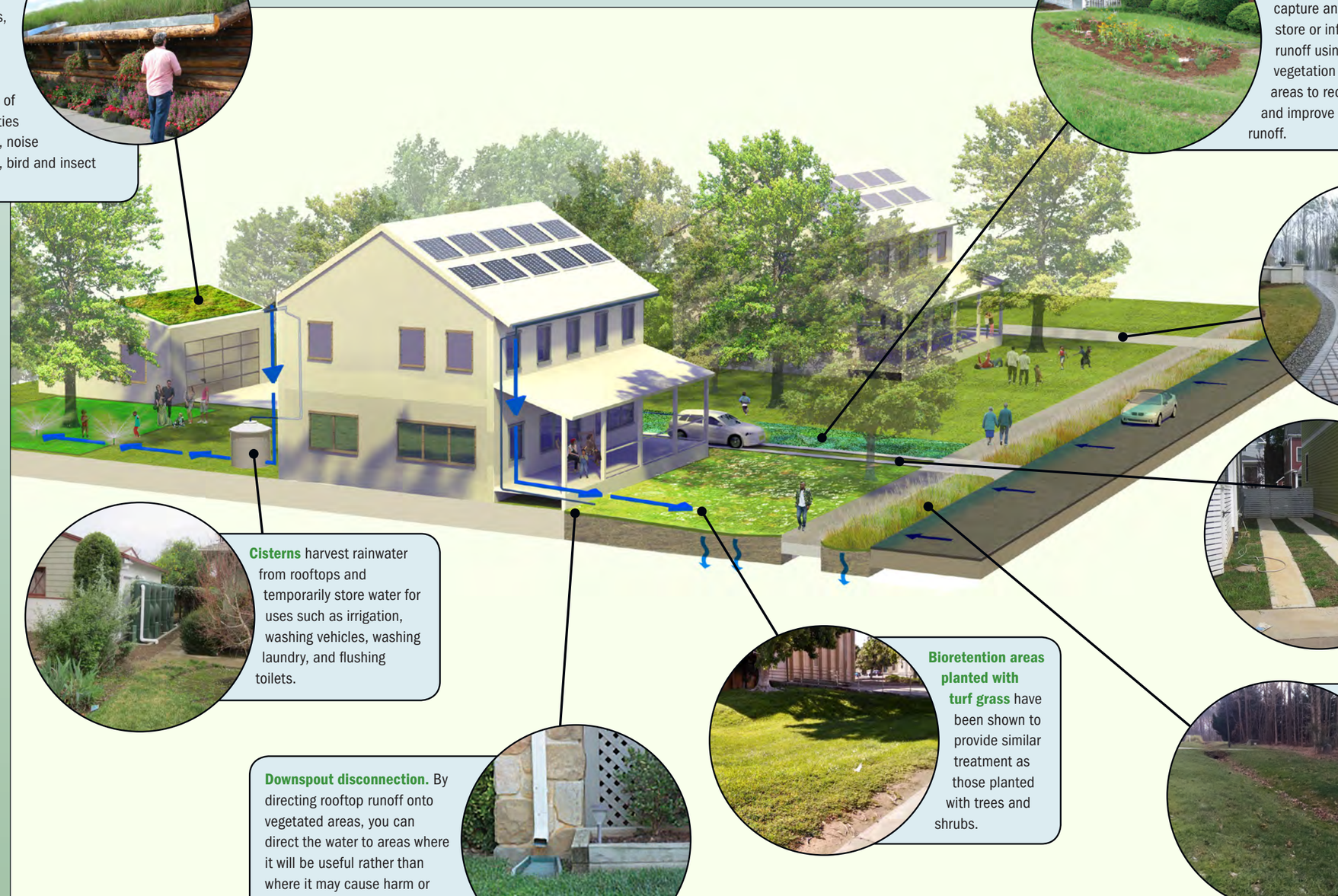
Low-Density Residential Development Stormwater Management

March 2016



Green roofs reduce runoff volume and rates by intercepting rainfall in a layer of rooftop growing media that is typically six inches (extensive) or deeper (intensive). Green roofs offer an array of benefits, including extended roof lifespan (due to additional sealing, liners, and insulation), improved building insulation and energy use, reduction of urban heat island effects, opportunities for recreation and rooftop gardening, noise attenuation, air quality improvement, bird and insect habitat, and improved aesthetics.

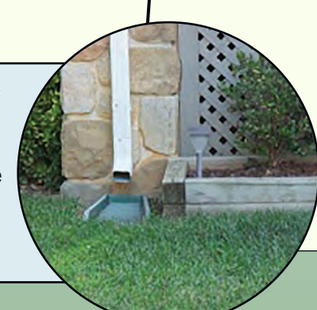
Bioretention areas, or rain gardens, are structural stormwater controls that capture and temporarily store or infiltrate stormwater runoff using soils and vegetation in landscaped areas to reduce the volume and improve the quality of runoff.



Permeable pavement in driveways allows runoff from the driveway, and potentially the rooftop, to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Cisterns harvest rainwater from rooftops and temporarily store water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets.

Bioretention areas planted with turf grass have been shown to provide similar treatment as those planted with trees and shrubs.



Downspout disconnection. By directing rooftop runoff onto vegetated areas, you can direct the water to areas where it will be useful rather than where it may cause harm or overload pipe systems.

Vegetated swales are shallow, open grass channels that can be an alternative to traditional curbs and gutters. Vegetated swales are designed to convey runoff while providing limited pollutant removal by sedimentation and horizontal filtration through vegetation.

Green Infrastructure practices use vegetation, soils, and natural processes to manage stormwater runoff by mimicking nature to absorb and store water. Integrating these practices into a site can reduce the area required for conventional stormwater management by incorporating treatment within landscaping features and surfaces that would otherwise be impervious. This can be a cost-effective approach to treating stormwater by making more efficient use of a site with the potential for reduced construction costs, increased property values, and greater revenue generation from the additional space made available.

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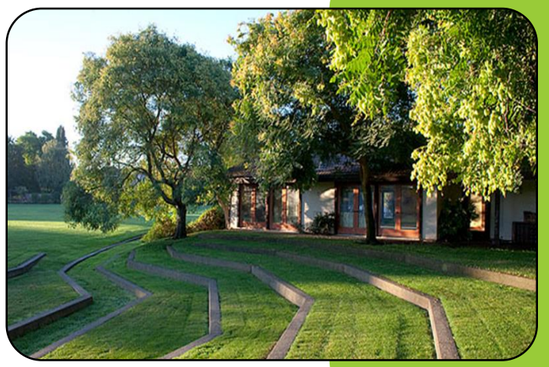
Cost Savings for Low-Density Residential Green Stormwater Management

Boulder Hills Development

- Pelham, NH
- Porous asphalt instead of conventional pavement
- Saved $50,000 (6%) by avoiding curbing, outlet control structures, large stormwater detention ponds



Village Homes Development

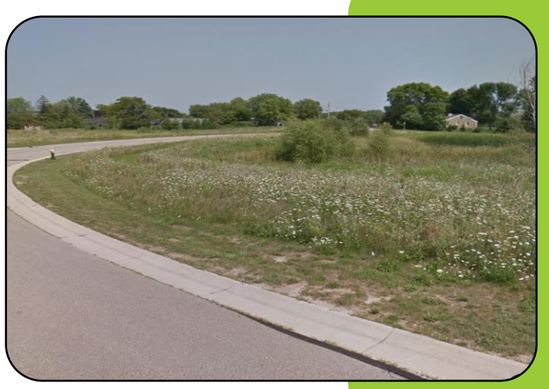
- Davis, CA
- Vegetated swales, rain gardens, open space, narrow streets, clustered lots
- Saved $800 per lot, $192,000 for entire neighborhood compared to conventional development

2nd Avenue Neighborhood

- Seattle, WA
- Bioswales, added vegetation, wetlands, reduced impervious area
- Saved $217,255 (25%) compared to conventional retrofits

Gap Creek Subdivision

- Sherwood, AR
- Preserved natural drainage areas, traffic-calming circles, reduced street width
- Saved $4,800 per lot, $678,500 (15%) total compared to conventional development



Auburn Hills Subdivision

- Racine, WI
- 40% of site preserved as open space with wetlands, green space, added open swales, bioretention
- Saved $761,396 compared to conventional development

Downspout Disconnection Program

- Portland, OR
- City offers financial incentives for disconnections ($13-$53 per downspout)
- Estimated reduction = 1 billion gallons of stormwater annually, $250 million reduction in construction for underground pipes citywide (based on 44,000 homeowners participating)

OPTIONS FOR GREENING RALEIGH

Medium-Density Residential Development Stormwater Management

March 2016

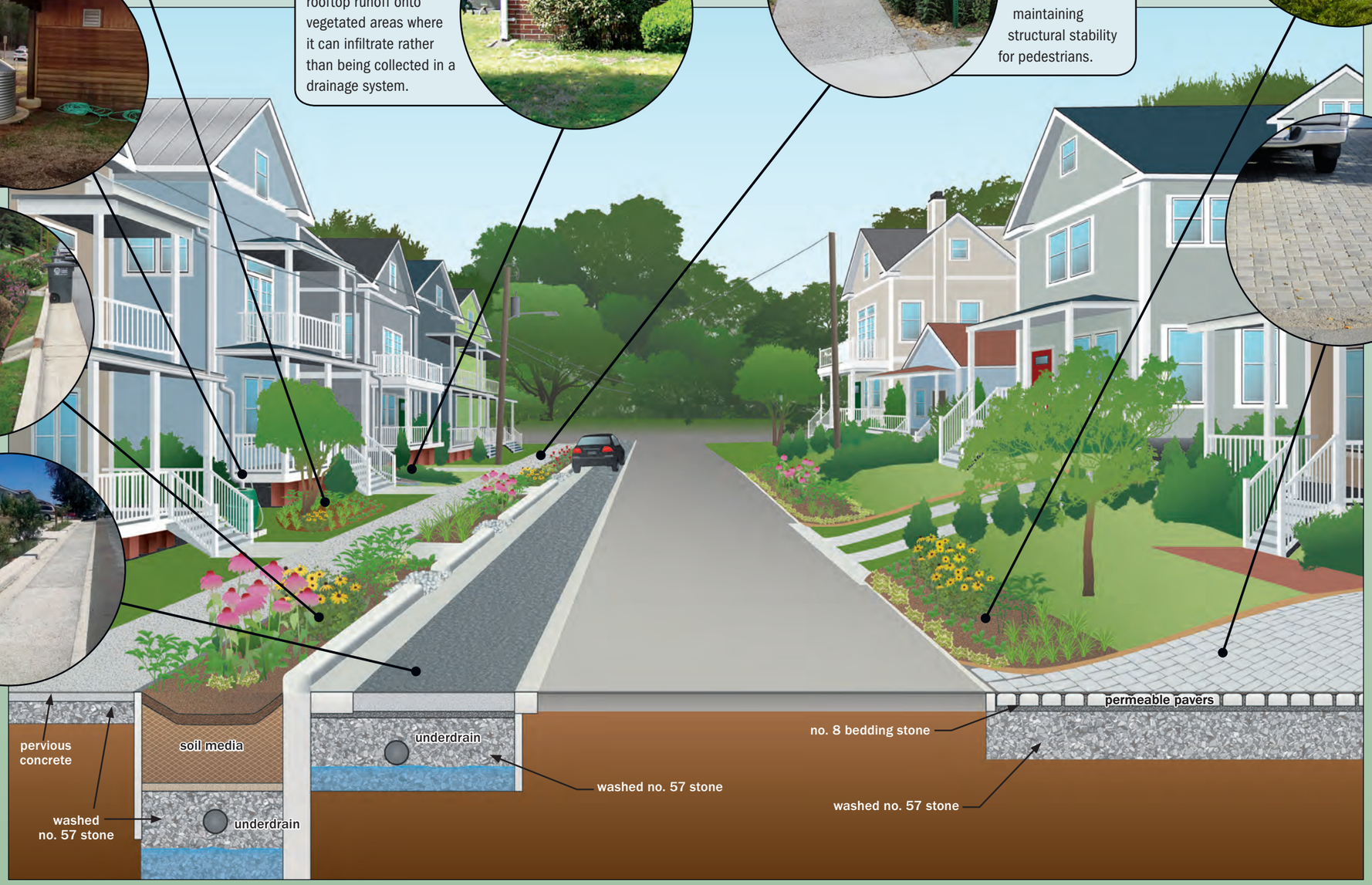
Bioretention areas, or rain gardens, are structural stormwater controls that capture and temporarily store or infiltrate stormwater runoff using soils and vegetation in landscaped areas to reduce the volume and improve the quality of runoff.

Rain barrels and cisterns harvest rainwater from rooftops temporarily storing water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets reducing the volume and improving the quality of runoff and delaying the peak flow.

Bioretention areas located between the curb and sidewalk can treat runoff from the street or adjacent parcel.

Permeable pavement in the parking lanes allows street runoff to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Downspout disconnection can reduce runoff volumes by directing rooftop runoff onto vegetated areas where it can infiltrate rather than being collected in a drainage system.



Permeable sidewalks reduce the volume of runoff by allowing infiltration while maintaining structural stability for pedestrians.

Bioretention located in the right-of-way can treat runoff from the street or rooftops.

Permeable pavement in driveways allows runoff to infiltrate, reducing runoff volume and improving water quality, while providing a structurally stable surface for parking and reducing the overall impervious area.

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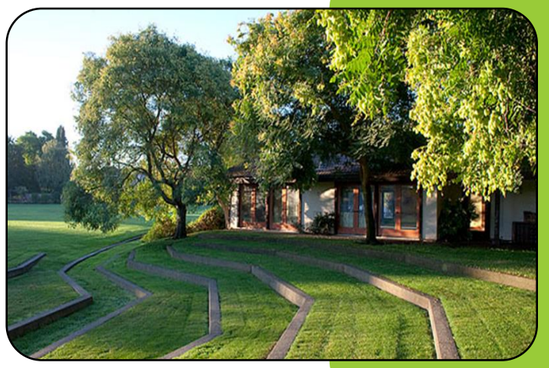

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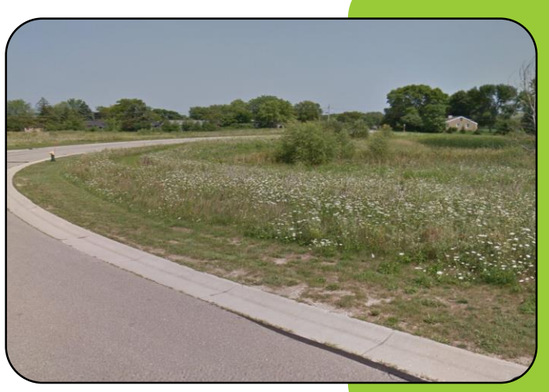

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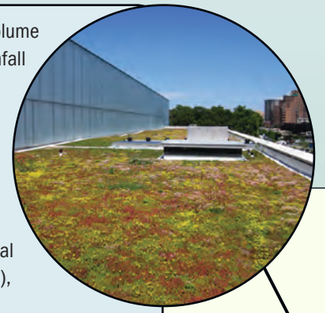
OPTIONS FOR GREENING RALEIGH

High-Density Residential Development Stormwater Management

March 2016



Green roofs reduce runoff volume and rates by intercepting rainfall in a layer of rooftop growing media that is typically six inches (extensive) or deeper (intensive). Green roofs offer an array of benefits, including extended roof lifespan (due to additional sealing, liners, and insulation), improved building insulation and energy use, reduction of urban heat island effects, opportunities for recreation and rooftop gardening, noise attenuation, air quality improvement, bird and insect habitat, and improved aesthetics.

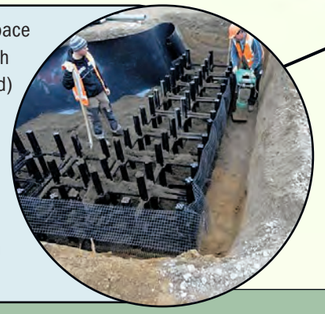
Urban agriculture is the cultivation, processing, marketing, and distribution of food in urbanized areas. Research regarding soil and water interactions with ecologically-based food production systems indicates that large-scale implementation of urban agriculture can help restore urban hydrology and water quality.

Cisterns harvest rainwater from rooftops and temporarily store water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets.

Permeable pavement in the parking lane allows rain that falls on the parking lane and the street to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Permeable pavement sidewalks allow rain that falls on the sidewalk and, potentially, the rooftops to infiltrate, reducing the volume and improving water quality, while providing a structurally stable surface.

Pervious plazas. Incorporating permeable pavement in plazas, sidewalks, or open space area can reduce impervious area and provide additional opportunities for treatment and infiltrating stormwater runoff.



Suspended pavement maintains void space underneath paved areas that is filled with high-quality soil media (often engineered) and prevents compaction in heavily paved environments allowing for treatment below the surface to reduce the volume and improve the quality of runoff. Suspended pavements are ideal for urban areas and promote tree health by keeping soils loose.

Bioretention areas, or rain gardens, are structural stormwater controls that capture and temporarily store or infiltrate stormwater runoff using soils and vegetation in landscaped areas to reduce the volume and improve the quality of runoff. Street trees can be incorporated into bioretention areas to maximize stormwater treatment and meet landscaping requirements.

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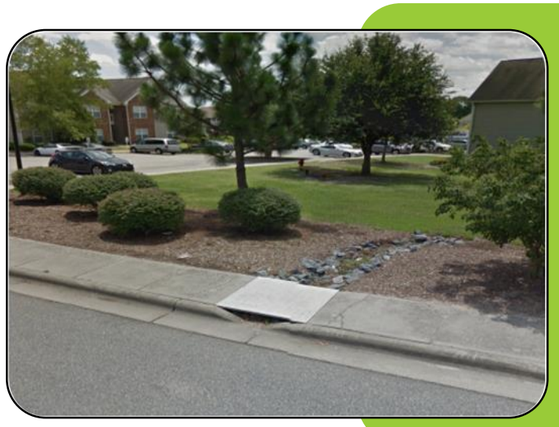
Cost Savings for High-Density Residential Green Stormwater Management

Bronx River Houses

- New York, NY
- Blue and green roofs, rain gardens, perforated pipes, subsurface stormwater chambers
- NYC Green Infrastructure Plan expected to save $2.4 billion in avoided conventional stormwater infrastructure construction

Panther Hollow (Study, not implemented)

- Pittsburgh, PA
- Analysis of green roof cost-saving potential for high-density residential: $260/year/roof saved in conventional stormwater drainage infrastructure



Poplar Street Apartments

- Aberdeen, NC
- 270-unit apartment complex
- Bioretention, channels, swales, stormwater basins
- Saved $175,000 (72%) compared to conventional development

The Natural Resources Defense Council (NRDC) estimates that, using green roofs, strategic tree planting, bioswales, and rain gardens can save $43,500/year for a single building (study assumes 34,000 square feet and 4 stories). This includes: energy cost reduction, tax credits, avoided conventional roof replacement, increased property values, increased rental income, and stormwater fee reduction.

Silver Creek Watershed Area

- Toledo, OH
- Highly developed downtown area, subject to flooding
- Blue roofs, bioswales, permeable pavement
- Estimated benefits, including reduced flooding, exceeding $39,500 annually

OPTIONS FOR GREENING RALEIGH

Mixed-Use Development Stormwater Management

March 2016

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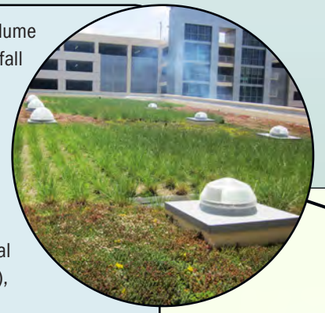

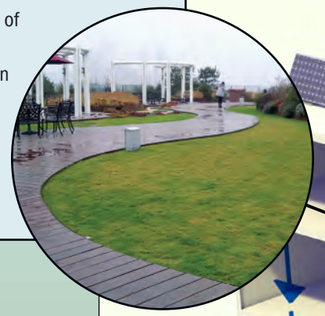

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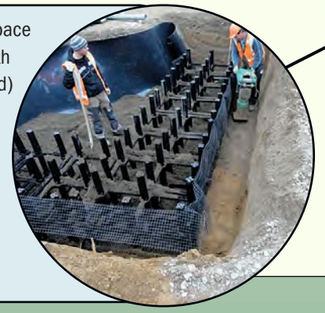
Permeable pavement in the parking lane allows rain that falls on the parking lane and the street to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Cisterns harvest rainwater from rooftops and temporarily store water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets. Cisterns in highly impervious areas can be installed in parking garages or under buildings and can store a significant amount of water.

Suspended pavement maintains void space underneath paved areas that is filled with high-quality soil media (often engineered) and prevents compaction in heavily paved environments allowing for treatment below the surface to reduce the volume and improve the quality of runoff. Suspended pavements are ideal for urban areas and promote tree health by keeping soils loose.



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Cost Savings for Mixed-Use Development Green Stormwater Management

Mill Creek

- Kane County, IL
- 1,500 acre mixed-use community with conservation design principles. 45% open space reduces stormwater costs and increases natural beauty.
- Saved $3,411 per lot (27%)

Green Downtown Area

- West Union, IA
- Implementing permeable pavers rather than traditional pavement results in long-term cost savings
- Estimated cumulative savings of a 57-year period of about $2.5 million compared to traditional pavement options with typical maintenance

Capitol Region Watershed District

- St. Paul, MN
- Rain gardens, stormwater planters, infiltration trenches, tree trenches
- Estimated $500,000 saved (20%) compared to conventional stormwater drainage infrastructure

Panther Hollow (Study, not implemented)

- Pittsburgh, PA
- Area is 9.6% commercial, 30% high density residential, 60.4% low density residential
- Estimated $295/year saved in stormwater drainage costs per green roof

City Sidewalks

- Olympia, WA
- City-wide sidewalk analysis determined traditional sidewalks costs $101 per square yard and pervious sidewalks cost $54 per square yard
- Considered construction and long term maintenance costs and the cost for conventional stormwater management required with traditional sidewalks.

OPTIONS FOR GREENING RALEIGH

Commercial Development Stormwater Management

March 2016

Permeable pavement in the parking stalls allows runoff from the parking lot to infiltrate, reducing the volume and improving water quality, while providing a structurally stable parking surface.

Subsurface storage can be an option on sites were space is a constraint. Below ground systems can be configured to store water for use on site or for treatment through infiltration.

Cisterns harvest rainwater from rooftops and temporarily store water for uses such as irrigation, washing vehicles, washing laundry, and flushing toilets.

Pervious plazas. Incorporating permeable pavement in plazas, sidewalks, or open space area can reduce impervious area and provide additional opportunities for treatment and infiltrating stormwater runoff.

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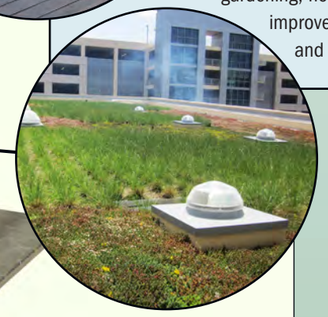

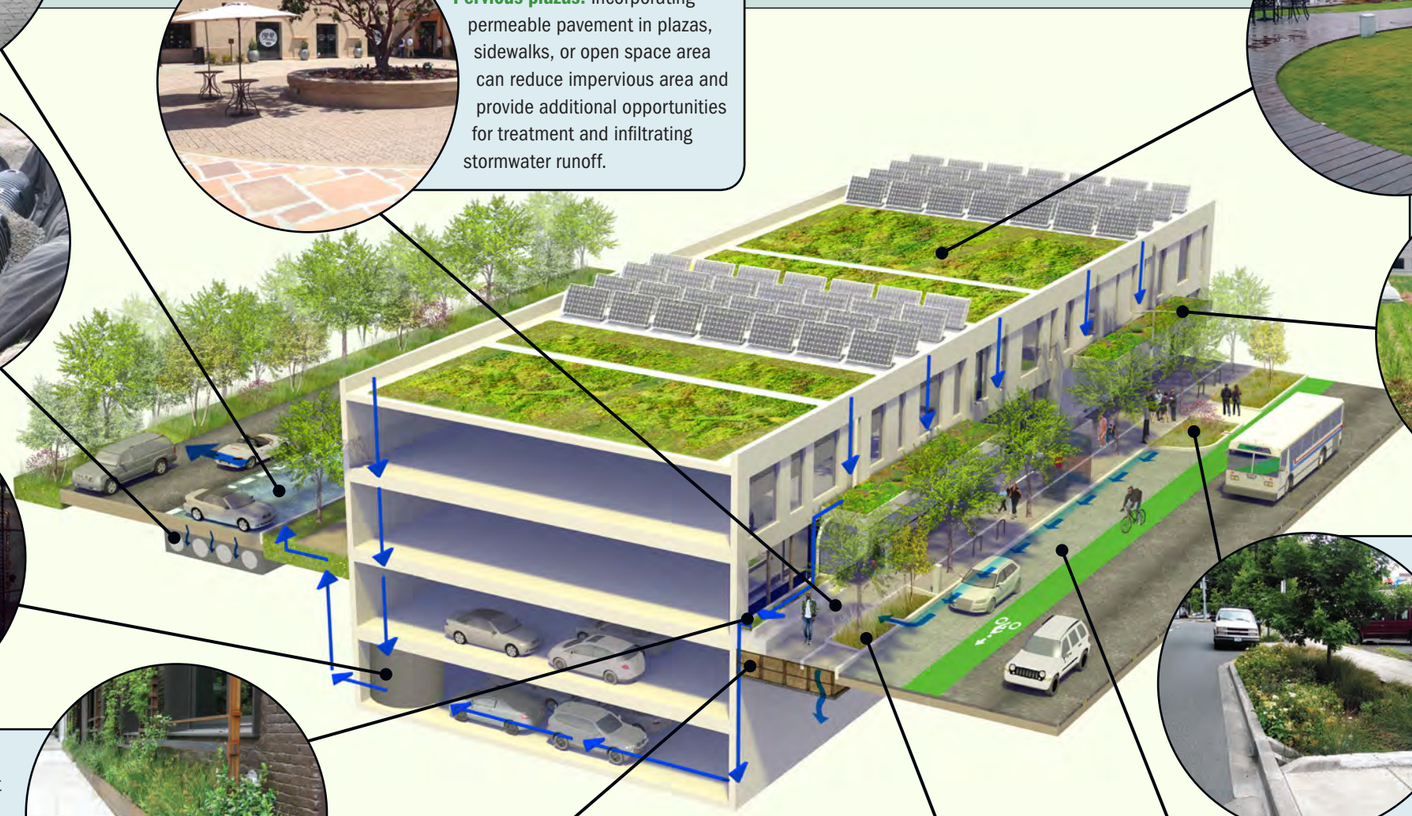

Curb bump out bioretention areas can be integrated into traffic calming measures to treat stormwater runoff from the street and meet landscaping requirements.

Planter boxes use bioretention functions, including filtration and plant uptake, to treat runoff directly adjacent to structures and foundations without impacting the structural stability of surrounding infrastructure.

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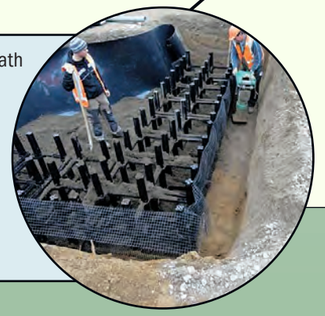

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Cost Savings for Commercial Development Green Stormwater Management

US EPA Building

- RTP, NC
- Grassy swales, water quality ponds, bioretention, preserved natural areas, 100-ft lake buffer established
- Saved $500,000 by avoiding curb and gutter and oil-grit separators

Greenland Meadows Retail

- Greenland, NH
- 4.5 acres of porous asphalt, catch basins, sand filter, sub-surface crushed stone reservoir
- Saved $930,000 compared to conventional stormwater management

Vancouver Island Tech Park

- Saanich, British Columbia
- Constructed wetlands, grassy swales and open channels, ponds, permeable pavement, native plants
- Saved $530,000 compared to conventional stormwater management

Tellabs Corporate Campus

- Naperville, IL
  - 330,000 sq ft office space
  - Preserved natural wetlands and drainage, bioswales
  - Saved $461,510 (14%) compared to conventional stormwater retrofits

Oregon Museum of Science and Industry

- Portland, OR
- 6-acre parking lot retrofit with vegetation and bioswales
- Saved $78,000 compared to conventional stormwater management

City Hall, Bloedel Donovan Park

- Bellingham, WA
- Parking lot rain garden retrofits. City Hall converted 5% of parking lot, and Park converted 550 square feet to rain gardens
- Saved $22,000 (80%) and $40,000 (76%) respectively