Developed by the
Central Shenandoah
Planning District Commission

Phase III Watershed Implementation Program

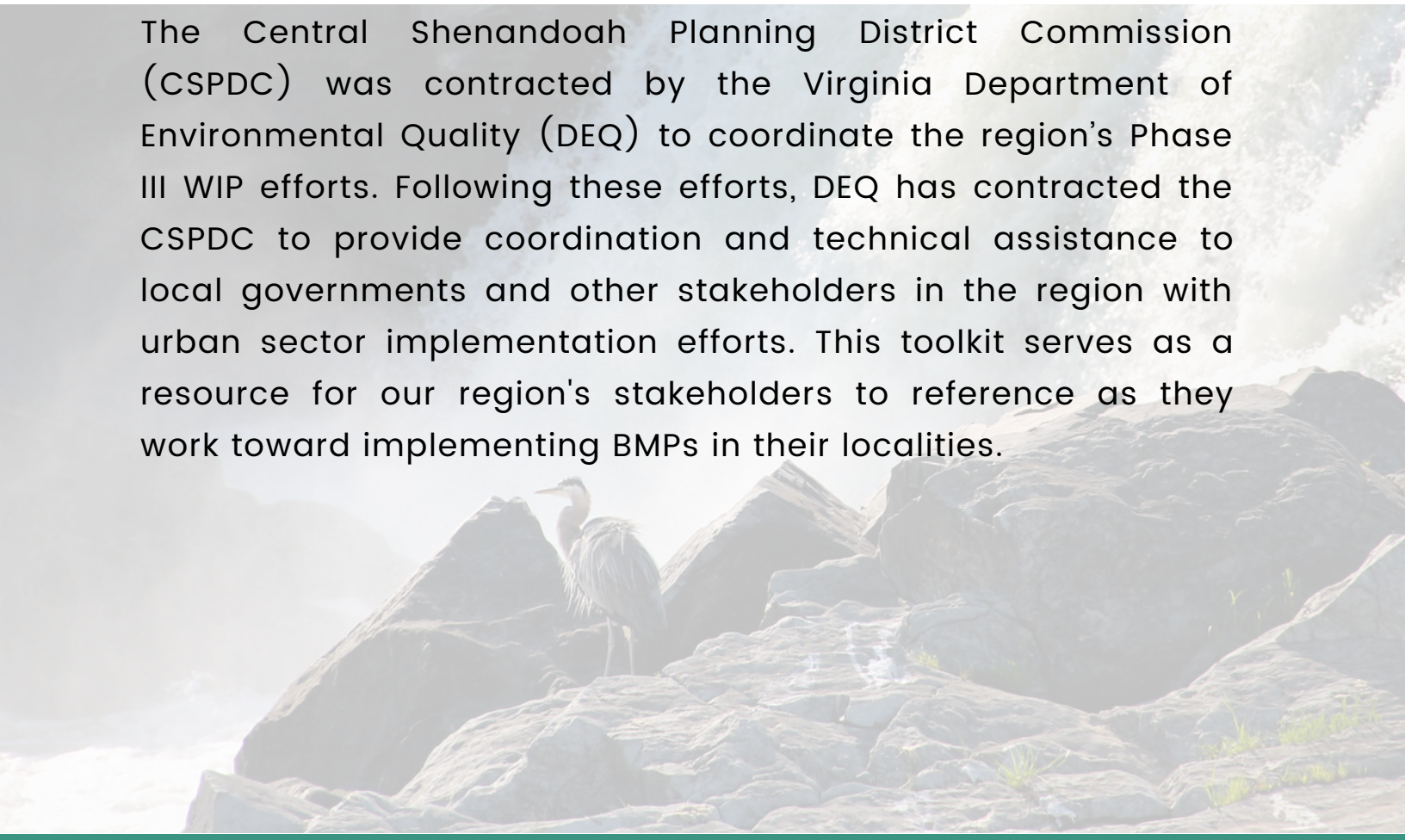
STORMWATER MANAGEMENT BEST PRACTICES TOOLKIT

2021

PHASE III WATERSHED IMPLEMENTATION PLAN (WIP III)

Watershed Implementation Plans (WIPs) are roadmaps for how Chesapeake Bay states and the District of Columbia, in partnership with federal and local governments, will attain the Bay Total Maximum Daily Load (TMDL). In Virginia, the TMDL calls for a 20.5% reduction in nitrogen, 25.2% reduction in phosphorous and 20.8% reduction in sediment delivered to the Bay. The objective is to have clean up practices, known as best management practices or BMPs, in place by 2025 to reach the goal of a clean Chesapeake Bay and local waterways that meet water quality standards.

The Central Shenandoah Planning District Commission (CSPDC) was contracted by the Virginia Department of Environmental Quality (DEQ) to coordinate the region's Phase III WIP efforts. Following these efforts, DEQ has contracted the CSPDC to provide coordination and technical assistance to local governments and other stakeholders in the region with urban sector implementation efforts. This toolkit serves as a resource for our region's stakeholders to reference as they work toward implementing BMPs in their localities.



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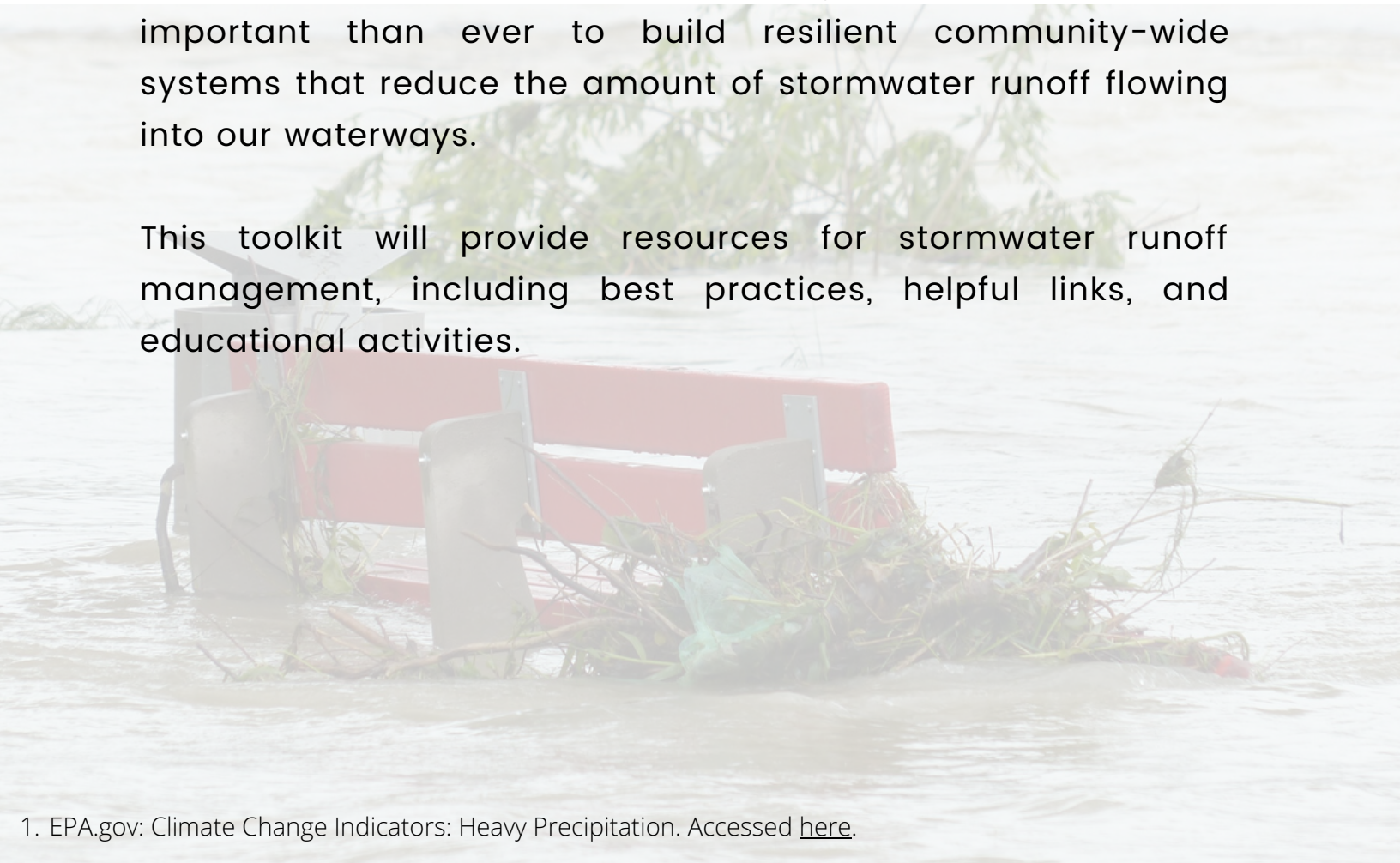
WHY SHOULD WE CARE ABOUT STORMWATER?

Stormwater runoff is a major contributor of water pollution in our natural waterways. As localities develop, the amount of impervious surface, or surfaces that cannot absorb stormwater, increases. Consequently, stormwater runs through our built infrastructure and directly into natural water sources, carrying harmful pollutants and waste along with it.

Compounding this issue, the United States is experiencing more frequent heavy rains, with nine of the top ten years for extreme one-day precipitation events occurring since 1996.[1] As heavy rains and subsequent flooding increase, it is more important than ever to build resilient community-wide systems that reduce the amount of stormwater runoff flowing into our waterways.

This toolkit will provide resources for stormwater runoff management, including best practices, helpful links, and educational activities.



1. EPA.gov: Climate Change Indicators: Heavy Precipitation. Accessed here.

GREEN INFRASTRUCTURE

The Clean Water Act defines green infrastructure as "...the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters." Green infrastructure is also referred to as low impact development (LID), and emphasizes systems that use and/or mimic natural stormwater management systems. Localities, businesses and organizations, and families can implement green infrastructure/LID practices that are both cost-effective and beneficial to community resilience.

GREEN INFRASTRUCTURE BEST MANAGEMENT PRACTICES (BMPS)

1. Downspout Disconnection

Rooftop drainage pipes can be disconnected from storm sewers and re-routed to drain into rain barrels, cisterns, or permeable surfaces. This prevents massive influxes of water from flowing into sewer systems during heavy rain events, reducing the risk of basement flooding and sewer overflows.[2] This practice can be implemented for individual buildings, or at a community-wide level.

Example of Downspout Disconnection
Source: ResearchGate. Accessed here.

Examples:

The Milwaukee Metropolitan Sewerage District (MMSD) has a community-wide Downspout Disconnection Program. The program requires downspout disconnection at eligible residential properties of four units or less in the city's combined sewer service area, which prevents excess water from overwhelming sewers. MMSD works on an individual basis with residences to ensure that properties are suitable for downspout disconnection.

The District of Columbia's DC Clean Rivers Project (DCCR) is implementing a free Downspout Disconnection Program, using the tagline "Drain the Rain" to raise awareness about the benefits of downspout disconnection. DCCR will cut downspouts and attach extensions to re-direct stormwater free of charge for areas within D.C.'s combined sewer system.

2. Milwaukee Metropolitan Sewerage District: Downspout Disconnection. Accessed here.

Resources for Downspout Disconnection:
Alliance for the Bay: Downspout Disconnect.
Mid-America Regional Council: Get the most of out of rain – ideas for creating a rain-friendly yard.
Portland Bureau of Environmental Services: How to Disconnect Downspouts (Youtube).
Reduce Runoff: Downspout Disconnection.
Syracuse University and Cornell University: Developing a Municipal Downspout Disconnect and Green Infrastructure Program.

2. Rainwater Harvesting

Rainwater harvesting systems collect rainwater and store it for future use. Rainwater harvesting is dually beneficial in that it both reduces stormwater runoff and conserves water for a wide-range of uses, including irrigation, pond/fountain filling, toilet flushing, car washing and more. [3] Individuals can install simple rainwater harvesting systems, such as rain barrels and cisterns, to collect water from disconnected downspouts. Localities can encourage rainwater harvesting by promoting or subsidizing rain barrel programs.

Source: Rivanna Conservation Alliance. Accessed here.

3. Energy.gov: Water Efficient Technology Opportunity: Rainwater Harvesting Systems. Accessed here.

Examples:

New York City initiated a Rain Barrel Giveaway Program to reduce the number of sewer overflows. Elected officials organized rain barrel distribution events, providing free rain barrels to homeowners, as well as instructions and installation kits.

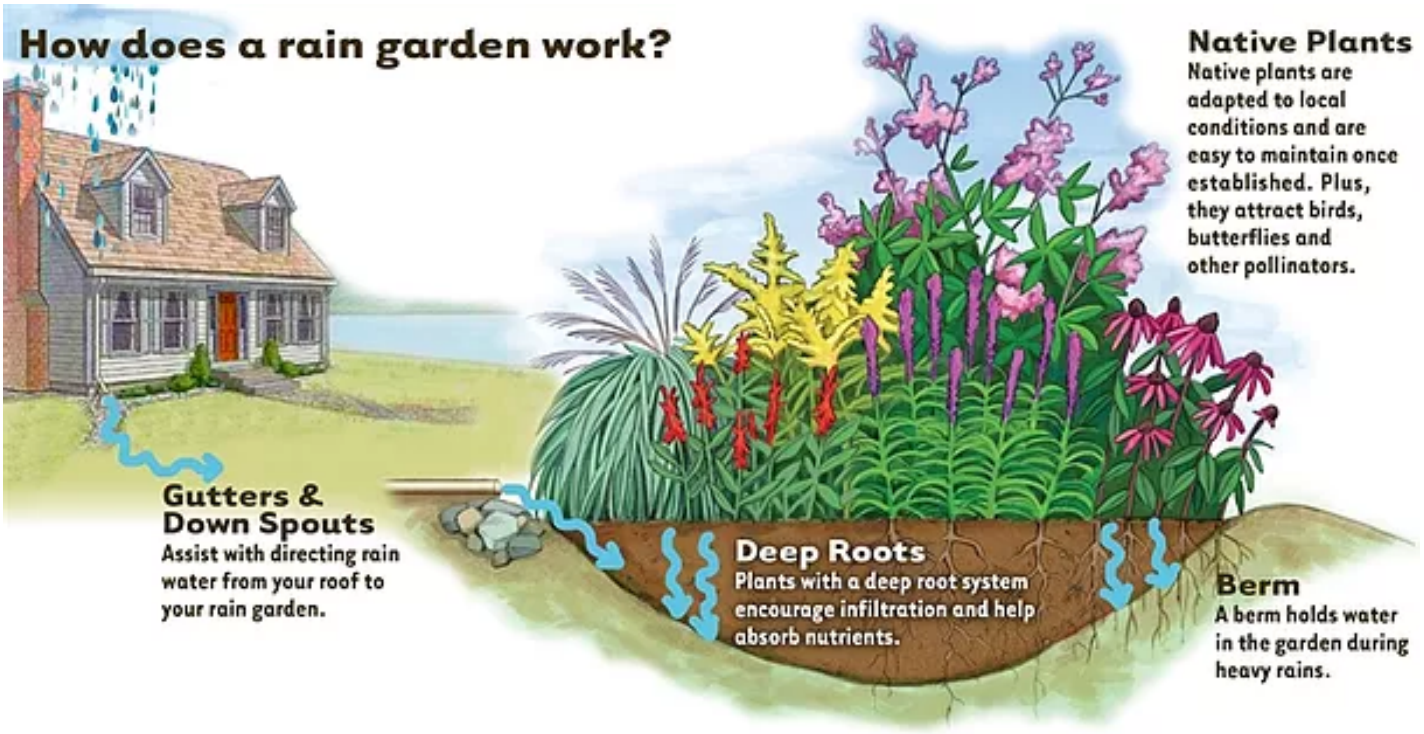
The City of San Francisco Public Utilities Commission (SFPUC) Rainwater Harvesting Program enables residents, businesses, and schools to receive deep discounts on rainwater barrels and cisterns. Participants also receive installation kits and can purchase discounted downspout diverters. SFPUC also provides rebates permitting fee rebates for participants that need to disconnect their downspout.

Resources for Installing Rainwater Harvesting Systems:

American Rainwater Catchment Systems Association: Rainwater Harvesting.
Mid-America Regional Council: Conserve water with rain barrels.
North Carolina State University Extension: Rainwater Harvesting – Guidance for Homeowners.
Texas Water Development Board: Rainwater Harvesting Training.
University of Nebraska Lincoln: Stormwater Management – Rainwater Harvesting in Residential-Scale Landscapes.

3. Rain Gardens and Bioswales

Rain gardens and bioswales are versatile stormwater management systems that can be installed on most unpaved spaces. The EPA defines rain gardens as "shallow, vegetated basins that collect and absorb runoff from rooftops, sidewalks, and streets." Rain gardens are sometimes referred to as bioretention filters or bioretention ponds. These passive systems absorb stormwater runoff and filter out harmful pollutants. Rain gardens typically include native vegetation that can easily grow and attract biodiversity. Similarly, bioswales are vegetated channels that help to filter stormwater runoff. Bioswales differ slightly from rain gardens in that they are long and narrow, and are typically suitable between streets and sidewalks or within parking lots.



Source: General Lansing Regional Committee for Stormwater Management. Accessed here.

Examples:

Charlottesville's Rivanna Conservation Alliance (RCA) launched the Residential Rain Garden Program in 2020. The year-long program offered funding and technical assistance for Charlottesville residents to install residential rain gardens. RCA conducted site visits, selected projects based on compatibility, and funded selected projects using grant funding.

Washington State University Extension and Stewardship Partners recently launched the 12,000 Rain Gardens campaign with the goal of installing 12,000 rain gardens around the Seattle/Puget Sound Region. If completed, 12,000 rain gardens would absorb 160 million gallons of stormwater runoff in the region. The campaign aims to educate residents about the benefits of rain gardens, and partner with localities to provide rain garden project grants for households, businesses, and non-profits.

Resources for Installing Rainwater Harvesting Systems:
Alliance for the Bay: Rain Gardens.
Clemson Cooperative Extension: An Introduction to Bioswales.
GrowNYC: Bioswales.
Mid-America Regional Council: How to Build your own Rain Garden.
Northern Virginia Soil and Water Conservation District: Rain Garden Design and Construction – A Northern Virginia Homeowner's Guide.
Plant Virginia Natives: Home Page.

4. Planter Boxes

While rain gardens are integrated into pervious surfaces, planter boxes/beds are 'urban rain gardens' - rain gardens with vertical walls that collect stormwater runoff from sidewalks, parking lots, and other impervious surfaces. Planter boxes are ideal for use in downtown areas where unpaved space is limited, and can be installed in and around parking garages, office buildings, residential units, streetscapes, etc.

Source: Main Street Ann Arbor. Accessed here.

Examples:

The James River Association (JRA) partnered with the City of Richmond and various private partners to launch the Bellemeade Green Street Project, a 0.4 mile segment that includes several stormwater runoff measures, including eight large planter beds. With the help of a large bioretention filter and hundreds of native trees and shrubs, these eight planter beds will remove harmful nutrient pollution from stormwater before it enters nearby Albro Creek.

The City of Lansing, Michigan installed 27 planter boxes along Michigan Avenue. The project aimed to reduce sewer overflow and flooding occurring along Michigan Avenue, and to remove harmful nutrients and heavy metals from stormwater flowing into the Grand River.

Resources for Installing Planter Boxes:

Charles River Watershed Association: Stormwater Planter.
Clemson University: Downspout planter boxes reduce urban water pollution (Youtube).
Oregon State University Extension Service: Low Impact Development Fact Sheet – Stormwater Planters.
Seattle Department of Transportation: Gardening in the Planting Strip.

5. Permeable Pavements, Green Parking & Green Streets

Standard pavement used for streets and parking lots is impermeable, meaning that all stormwater runoff flows from pavement directly into our sewer systems. Permeable pavements provide a green alternative, catching storwmater runoff at the source and filtering harmful pollutants. Common materials for permeable pavement include pervious concrete, porous asphalt, and permeable pavers. In addition to absorbing stormwater runoff, permeable pavement can also reduce ice and pooled water on roadways, improving traffic safety.[4]

4. Minnesota Transportation Research: Permeable Pavements Reduce Slippery Conditions During Winter Thaw. Accessed here.

Green parking infrastructure utilizes permeable pavement in addition to other elements (i.e. rain gardens, bioswales, etc.) to absorb stormwater runoff from parking lots. Green parking also reduces the urban heat island effect, in which structures such as building and parking lots absorb the sun's heat and emit higher temperatures than natural landscapes. [5]

Left: permeable pavers (Source: Alliance for the Chesapeake Bay. Accessed here).
Right: Green parking infrastructure (Source: Building Construction Design. Accessed here).

Combining permeable pavement and green parking practices with other stormwater runoff best practices, such as bioswales, planter boxes, and rain gardens, can create more holistic 'green streets' [6] that maximize stormwater retention.

Examples:

Minneapolis-St. Paul has been implementing permeable pavement practices since 2007 to absorb stormwater and reduce snow and ice accumulation on roadways. Officials have found that the use of permeable pavement is highly cost-effective in reducing snow and ice accumulation – comparatively, the cost of road salts on bridge and car erosion is estimated at $1,400 per ton. [7] In some Twin Cities neighborhoods, permeable pavement has removed the need for complex stormwater systems to absorb stormwater runoff completely.

5. EPA.gov: Heat Island Effect. Accessed here.
6. EPA.gov: Green Infrastructure. Accessed here.
7. Nextcity.org: How a Twin Cities Suburb Has Led the Way with Permeable Pavement. Accessed here.

Examples:

In May 2020, the City of New Orleans mandated that all new construction of parking lanes and sidewalks use permeable pavement. The mandate stems from a recognition of the heavy burden on the city's sewer system from stormwater runoff. Though permeable pavement will cost the city nearly twice as much as a traditional sewer system upfront, the city recognizes the long-term financial benefits of flood mitigation and states that the improved infrastructure will "improve resiliency and reduce flooding."

The Los Angeles Department of Sanitation has administered several Green Street Projects aimed at integrating permeable pavement with other green infrastructure projects. Past projects include bioswales, permeable pavement, rain gardens, water quality monitoring systems, and drought tolerant vegetation.

Resources for Permeable Pavements, Green Parking & Green Streets:

City of Austin, Texas: Green Streets – An Introduction.
Metropolitan Area Planning Council: Fact Sheet – Permeable Paving.
River Network: Green Streets Resources.
United States Environmental Protection Agency: Green Parking Lot Resource Guide.
United States Environmental Protection Agency: Green Streets Handbook.
United States Environmental Protection Agency: Learn About Green Streets.
United States Environmental Protection Agency: Urban Runoff – Low Impact Development.
Virginia Soil & Water Conservation District: Permeable Paver Installation.

6. Nitrogen-Reducing Septic Systems

Conventional septic systems are not designed to remove nitrogen from water waste. Nitrogen leads to harmful environmental effects, such as algal blooms and fish kills. Nitrogen-reducing septic systems can reduce nitrogen discharges by up to 90%, significantly improving stormwater quality.[8] However, large-scale adoption of advanced septic systems is difficult due to prohibitive costs.

8. EPA.gov: Supporting Innovations to Reduce Nitrogen Pollution from Septic Systems. Accessed here.

In 2017, the EPA, the Nature Conservancy, and the U.S. Geological Survey launched the Advanced Septic System Nitrogen Sensor Challenge, inviting participants to design low-cost nitrogen sensors for advanced septic systems. In 2020, the EPA provided funding to commercialize the winning design.[9] These nitrogen sensors could be installed on a large-scale by both governments and residential properties, and would allow users to monitor their septic tanks and ensure they are not leaching nitrogen.

Examples:

In 2014, Suffolk County, New York initiated an Innovative & Alternative Onsite Wastewater Treatment Systems (IA/OWTS) demonstration project to address excess nitrogen flowing into local waters. Since then, Suffolk County has formalized this demonstration project through its Reclaim our Water Initiative. The initiative's Septic Improvement Program provides grants of up to $30,000 for residents to purchase and install nitrogen removal septic systems. Homeowners can also qualify for a low-interest loan for up to $10,000 to cover the remaining costs, such as maintenance.[10]

In June 2021, the Maryland Board of Public Works announced approximately $20 million in grant funding aimed at improving water quality. $15 million of the funding will be dedicated exclusively to counties to upgrade septic systems. All 23 Maryland counties will receive septic system improvement funding. The remaining $5 million will go to fund an advanced nutrient removal facility at one of the state's wastewater treatment plants. The upgrades will reduce nitrogen discharge by 83%.

Resources for Nitrogen-Reducing Septic Systems:

Onsite Installer: An Installer's Guide to Nitrogen.
Reclaim Our Water: Home Page.
United States Environmental Protection Agency: Innovative/Alternative Septic Systems.

9. EPA.gov: Advanced Septic System Nitrogen Sensor Challenge. Accessed here.
10. Reclaimourwater.info: Septic Improvement Program. Accessed here.

7. Green Roofs

Green roofs - or rooftop coverings made of native vegetation - can also be used to reduce urban heat island effects and absorb stormwater runoff. The EPA found that green roof temperatures can be 30-40 degrees cooler than conventional roofs and reduce building energy use by 0.7%.[11] Green roofs are particularly useful for existing built environments, and can be retro-fitted to roof structures. Green roofs are similar to permeable pavement in that they catch rainwater at the source.

Source: The Water Network. Accessed here.

Examples:

In 2020, Congresswoman Nydia Velázquez (D-NY) introduced legislation for a Green Roofs for Public School Buildings initiative. This $500 million proposal merges environmental and educational goals, providing students with opportunities for green learning while reducing impacts on stormwater systems. An economic analysis of the project estimates that it will have a rate of return of 7.3% over a 50-year period.

11. EPA.gov: Using Green Roofs to Reduce Heat Island Effects. Accessed here.

Examples:

In Lancaster, Pennsylvania, city officials opted to construct a green roof for their new fire department facility using a perennial plant that is resistant to both extreme heat and cold. The 4,000 square foot green roof is expected to capture more than 375,000 gallons of water annually. The city plans to demolish and re-construct another fire station in town using the same green roof techniques.

Resources for Green Roofs:

Greenroofs.com: Project Database.
Green Roofs for Healthy Cities: Green Roof and Wall Policy in North America.
Green Roofs for Healthy Cities: Policy Resources.
Library of Congress: Green Roofs and Living Walls.
National Public Radio: How Green Roofs Can Help Cities (Youtube).
Whole Building Design Guide: Extensive Vegetative Roofs.

8. Urban Tree Canopies

Localities can make community-wide efforts to reduce stormwater runoff by increasing urban tree canopy: "the layer of leaves, branches, and stems that cover the ground when viewed from above."[12] A robust urban tree canopy helps to manage stormwater runoff during major weather events by slowing the flow of precipitation, while tree roots slow runoff long-term by absorbing a greater amount of stormwater as trees grow. Healthy tree canopies also reduce urban heat island effects by shading impervious surfaces. Urban tree canopy can be increased through individual actions, such as neighborhood tree planting initiatives, or by local governments that set urban tree canopy goals through comprehensive plans or government-sponsored initiatives.

12. Chesapeake Bay Program: Urban Tree Canopy Goal Setting. Accessed here.

Examples:

The City of Albuquerque, New Mexico is making a multi-party effort to increase its thinning tree canopy. In 2020, Albuquerque's mayor launched the "Let's Plant ABQ" initiative, which aims to plant 100,000 new trees over the next ten years. The initiative will sponsor community tree plantings, educate the public about the importance of urban tree canopies, and provide rebates of up to $100 for residents' water bills to cover the cost of tree maintenance.

The City of Dallas finalized their Urban Forestry Master Plan in 2021 to formalize a comprehensive strategy around maintaining existing tree canopy and planting new trees. The plan lays out the numerous benefits of a robust tree canopy, from stormwater management to human health to reducing global temperatures. The plain aims to "create a healthy, equitable, and resilient urban forest," and achieve 37% tree canopy coverage in the city by 2040.

Source: Tree Pennsylvania. Accessed here.

Resources for Urban Tree Canopies:

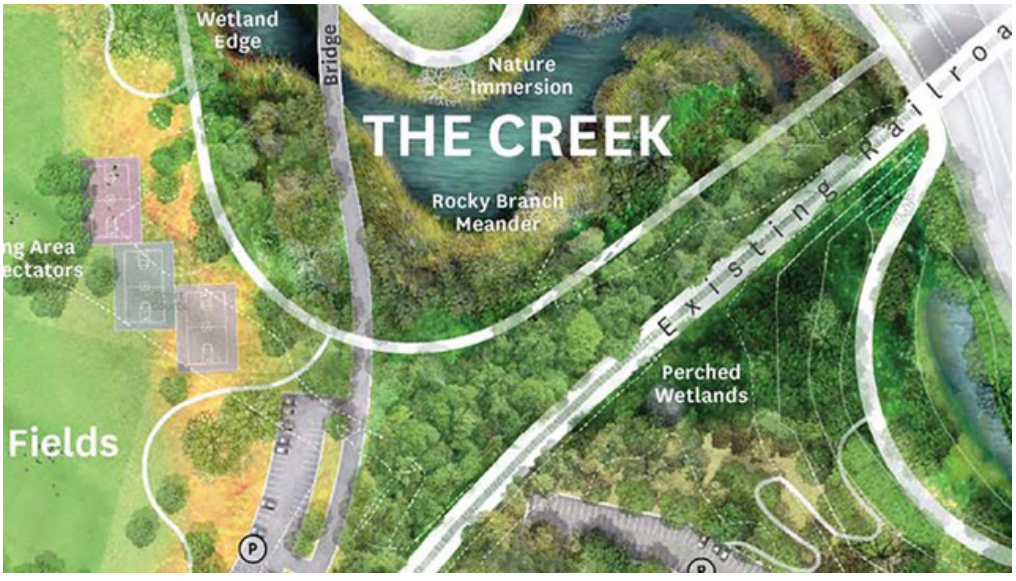
Planit Geo: How to Set Effective, Evidence-Based Urban Tree Canopy Goals.
The Environmental Finance Center at the University of Maryland: Financing Urban Tree Canopy Programs – Guidebook for Local Governments in the Chesapeake Bay Watershed.
The Lancet Planetary Health (Michelle Kondo et. al): Health Impact Assessment of Philadelphia's 2025 tree canopy cover goals.
United States Department of Agriculture. Urban Tree Canopy Assessment – A Community's Path to Understanding and Managing the Urban Forest.
Vibrant Cities Lab: A Source of Tree and Canopy Maps and Data.

9. Land Conservation

On a broad scale, localities can reduce stormwater runoff by preserving open spaces and sensitive natural areas such as riparian zones, wetlands, and hillsides. Conserving land is perhaps one of the most effective strategies for managing stormwater runoff due to the sheer quantity of stormwater that can be absorbed. A 2011 study found that only 5% of stormwater from conserved land leads into waterways, compared to 95% of stormwater from impermeable surfaces.[13] Local and state governments can acquire land or establish land use management ordinances to both reduce stormwater runoff and preserve natural assets for their localities.

Examples:

In 2017, the City of Raleigh, North Carolina partnered with the Dorothea Dix Park Conservancy to create a bold vision for a public park in the center of downtown Raleigh. The land was previously used as the headquarters for the Department of Health and Human Services, and is now being reimagined as a park conservancy project that brings in public-private partnerships to expand recreational opportunities and preserve public space. Dorothea Dix Park will feature stormwater catchment ponds, pervious parking gardens, and restoration of a wetland habitat along a creek.



Visioning for Restoration of Creek at Dorothea Dix Park – Raleigh, NC
Source: Dorothea Dix Park. Accessed here.

13. World Resources Institute: Forests for Water – Exploring Payments for Watershed Services in the U.S. South. Accessed here.

Examples:

In 2020, the New Jersey Department of Environmental Protection designated a former industrial site in Millville, NJ as a permanent recreation and open space. The acquisition was completed by a state-conservation initiative, and aims to restore and preserve habitats of local endangered species across the 1,400 acre property.

Resources for Land Conservation:

Land Trust Alliance: Conserve Your Land.
Piedmont Environmental Council: Intro to Conservation Easements.
The Conservation Fund: State and Local Conservation Programs.
Virginia Department of Recreation and Conservation: Local Government Tools to Protect Land.

INCORPORATING GREEN AND GRAY INFRASTRUCTURE

In contrast to green infrastructure, gray infrastructure refers to man-made systems that retain, purify, and divert stormwater to mitigate flooding and prevent pollutants from entering waterways.[14] Examples of gray infrastructure include pipes, storm drains, ditches, swales, culverts, retention ponds, dams, seawalls, and water treatment plants. Most localities already use complex gray infrastructure systems to manage stormwater. While the EPA generally recommends transitioning gray infrastructure to green infrastructure, existing gray infrastructure can still complement green stormwater management practices. Gray infrastructure can also address financial concerns, as costs are often more predictable.[15]

Resources for Incorporating Green and Gray Infrastructure:

The World Bank: Putting Nature to Work: Integrating Green and Gray Infrastructure for Water Security and Climate Resilience.

Alberta WaterPortal Society: Introduction to green infrastructure and grey infrastructure.

Conservation International: Global Green-Gray Community of Practice.

14. Duke Nicholas Institute: Stormwater Management – Gray Infrastructure. Accessed here.

15. Water Environment Foundation: Green and Gray Infrastructure Work Together to Enhance Service, Cut Costs. Accessed here.

HOW CAN MUNICIPALITIES MANAGE THEIR IMPACT ON STORMWATER POLLUTION?

Municipalities can implement a blend of small-scale green-gray infrastructure tools to improve water quality and reduce stormwater runoff. However, one of the most effective BMPs in mitigating stormwater runoff at a local level is to implement zoning tools and other community-wide policies. This section will cover a range of municipal strategies.

1. Green Infrastructure Plans & Comprehensive Plans

Municipalities can adopt green infrastructure and/or stormwater specific plans, or incorporate green infrastructure language into existing comprehensive plans. These plans can include specific language that identifies target areas for green infrastructure, monitoring and evaluation policies, key stakeholders, etc. Green infrastructure plans are beneficial for broad vision-setting and policy direction. They can also identify zoning measures that need to be implemented to enforce goals.[16]

Table 2: Comparison of Planning Tools

	Type of Development		Public vs. Private Property		Administrative	Legal
	New	Existing	Public	Private		
Green infrastructure-specific plans	+	+	+	+	~	~
Comprehensive plans	+	~	+	+	~	~

\+ Advantageous: The strategy maximizes benefits and is feasible.
~ Neutral: The strategy may present may present mixed advantages and disadvantages.
\- Disadvantageous: The strategy presents some disadvantages or may be infeasible.

Comparison of Green Infrastructure-specific Plans vs. Comprehensive Plans for Adopting Green Infrastructure Policy
Source: Georgetown Climate Center. Accessed here.

16. Georgetown Climate Center: Planning Tools. Accessed here.

Examples:

The City of Hoboken, New Jersey adopted the Hoboken Green Infrastructure Strategic Plan in 2013 to establish best practices for stormwater management, flooding, and climate change resilience. The plan lays out a framework for adopting new zoning ordinances, pilot projects, and land conservation strategies. Specific strategies include permeable parking, rain gardens, planter beds, etc. The plan also proposes a Stormwater Trust Fund to spur private actors to invest in green infrastructure.

In 2019, Southeast Cook County, Illinois finalized their Land Acquisition Plan. The plan focuses on land conservation as a water quality and stormwater management strategy, and blends conservation efforts with economic development and investment goals. Specifically, the plan encourages collaboration with private real estate developers to incorporate habitat preservation into development plans.

Resources for Green Infrastructure Plans & Comprehensive Plans:

City of Norfolk: A Green Infrastructure Plan for Norfolk: Building Resilient Communities.

Georgetown Climate Center: Green Infrastructure Toolkit - Planning Tools.

Hampton Roads Planning District Commission: A Green Infrastructure Plan for the Hampton Roads Region.

New Jersey Future: New Jersey Green Infrastructure Municipal Toolkit.

United States Environmental Protection Agency. Enhancing Sustainable Communities with Green Infrastructure.

City of Hoboken Green Infrastructure Strategic Plan (2013)
Source: City of Hoboken. Accessed here.

2. Zoning Ordinances

Municipalities can use zoning codes to codify desired land uses that promote water quality, green infrastructure, and stormwater management. For example, an ordinance can enforce overlay districts (i.e. watershed overlay districts) in water-sensitive areas to prohibit high-risk land uses. Zoning ordinances that reduce minimum parking requirements, set water retention requirements, create green design guidelines for roads, set open space requirements, and facilitate mixed-use and transit-oriented development are also effective strategies for addressing water quality.[17] Localities should look at Virginia's enabling legislation to determine what specific zoning practices can be implemented.

Examples:

In 2018, the City of Norfolk, Virginia adopted a new zoning ordinance that featured flood resilience strategies and more dense development requirements. Specifically, the ordinance outlines more stringent construction requirements for new development within the 100-year floodplain, a coastal resilience overlay zone, and a resilience quotient system, which allows developers to earn points for adopting resilience measures that promote stormwater management and water/energy efficiency. Though Norfolk is implementing a coastal strategy, this resource may be helpful in determining Virginia's allowable zoning regulations.

The City of Buffalo, New York updated their Unified Development Ordinance (UDO) in 2016 to include a Green Code, which requires green infrastructure BMPs wherever possible to achieve city-wide stormwater goals. The plan incorporates requirements for bioswales, rain gardens, stormwater reuse, green roofs, land conservation, and more. The UDO's Green Code is fully integrated into Buffalo's Comprehensive Plan, and will guide green infrastructure practices for the next several decades.

17. Georgetown Climate Center: Regulatory Tools. Accessed here.

Resources for Zoning Ordinances:
Code of Virginia: Article 7. Zoning.
Environmental Law Institute: Green Infrastructure for Chesapeake Stormwater Management – Legal Tools for Climate Resilient Siting.
Journal of Infrastructure Systems (Houng Li): Green Infrastructure for Highway Stormwater Management: Field Investigation for Future Design, Maintenance, and Management Needs.
Missouri Department of Natural Resources: Integrating Green Infrastructure into Ordinances.
Pioneer Valley Planning Commission: Understanding Green Infrastructure in Zoning.
Primera: Stormwater and Pavement Design Integration.
Strong Towns: It's Not Just Parking Minimums That Can Shrink.
Sustainable Development Code: Parking Maximums.
United States Environmental Protection Agency: Assessing Street and Parking Design Standards to Reduce Excess Impervious Cover in New Hampshire and Massachusetts.

3. Form-Based Code

Because the Virginia state government sets building code regulations, all localities must enforce the Virginia Uniform Statewide Building Code.[18] However, localities may implement additional regulations to enforce more stringent standards. Localities may choose to utilize form-based code - a green infrastructure technique that emphasizes external design. Form based code is defined as "a land development regulation that fosters predictable built results and a high-quality public realm by using physical form (rather than separation of uses) as the organizing principle for the code.[19] Form-based codes are enforceable, and outline design standards, such as green infrastructure, for geographically-defined communities - typically small areas.

18. Wetlands Watch: Building Code. Accessed here.
19. Form-Based Codes Institute: Form-Based Codes Defined. Accessed here.

GROUND-FLOOR USE	CAFÉ ZONE	PEDESTRIAN ZONE	LANDSCAPE + FURNITURE ZONE	PARKING + PLANTER ZONE	SHARED TRAVEL ZONE
MULTI-FAMILY RESIDENTIAL	*Not Applicable* *See Appendix A.5 Private Frontage Guidelines.*	6' - 8'	6' - 8' Tree wells; Street furniture to be provided per *Section 6;* *See Section 3.5 for Street Landscape Standards.*	8' parallel	*See Section 3.3 for Street Type Standards.*
COMMERCIAL	Where Applicable; 6' - 12' *Additionally, See Appendix A.5 Private Frontage Guidelines.*	7' - 10'		16' - 18' head-in diagonal OR 8' parallel Parking Lane Planters (optional)	

Public Frontage Standards for Commercial Sidewalks in Palm Desert, CA
Source: City of Palm Desert, CA. Accessed here.

Examples:

Albemarle County, Virginia began developing a form-based code for the Rio-29 District in 2019. The draft plan aims to encourage multimodal, interconnected transportation networks, vibrant mixed-use communities, human-scale built environments, and sustainable development. The form-based code outlines design standards related to stormwater management, including the development of 'pocket parks,' stormwater management facilities, optional green infrastructure measures, and conformance requirements.

In 2013, Arlington County, Virginia developed a form-based code aimed at district revitalization for the Columbia Pike neighborhoods. The code specifically outlines standards for permeable paving materials, green landscaping in urban areas, native trees that can be planted to augment the existing tree canopy, and preserved natural areas. Additionally, all proposed developments in the Columbia Pike neighborhoods must conform to green building standards.

Resources for Form-Based Code:
Chicago Metropolitan Agency for Planning: Form-Based Codes – A Step-by-Step Guide for Communities.
Form-Based Codes Institute: Home Page.
Form-Based Codes Institute: Standards of Practice for Form-Based Codes.

4. Stormwater & Water Quality-Specific Zoning Ordinances

Some examples of water quality-specific ordinances include stormwater, aquatic buffers, erosion and sediment control, illicit discharge, construction, etc. Topic-specific ordinances serve as targeted strategies to address local water quality issues. For example, a stormwater ordinance may require stormwater retention BMPs for new development, outline green infrastructure practices, or utilize incentive-based stormwater reduction strategies.[20] Effective stormwater ordinances will specify departments or organizations responsible for stormwater management and enforcement. Successful ordinances may also ease the burden of implementing stormwater BMPs by providing incentives or reimbursement policies.[21]

Examples:
Grand Traverse County, Michigan has a Stormwater and Sediment and Erosion Control Ordinance that clearly outlines stormwater operations and maintenance procedures. The ordinance also includes the process for property owners seeking a stormwater management easement, compliance assurance and performance guarantees, inspection guidelines, and enforcement actions.

Fairfax County, Virginia has a Stormwater Management Ordinance that specifically links stormwater guidelines to the preservation of the Chesapeake Bay. The ordinance demonstrates its compatibility with both the Chesapeake Bay Preservation Act and the Virginia Stormwater Management Act. It provides offsite compliance options, water quality design criteria, rainwater harvesting guidance, and guidelines for long-term maintenance.

20. Georgetown Climate Center: Regulatory Tools. Accessed here.
21. EPA: Urban Runoff – Model Ordinances to Prevent and Control Nonpoint Source Pollution. Accessed here.

Resources for Stormwater & Water Quality-Specific Zoning Ordinances:
Planning for Hazards: Stormwater Ordinance Model and Commentary.
Planning for Hazards: Land Use Tool – Stormwater Ordinance.
United States Environmental Protection Agency: Urban Runoff – Model Ordinances to Prevent and Control Nonpoint Source Pollution.
United States Environmental Protection Agency: Stormwater Operation and Maintenance Model Ordinance.

5. Incentive-Based Programs

Though green infrastructure is often cost-effective over a long period of time, many developers are hesitant to implement infrastructure with high up-front costs. Municipalities can offer incentive-based programs to developers that incorporate green infrastructure and stormwater BMPs. Incentives can be financial, such as direct subsidies, grants, or tax rebates, or development-based, such as expedited permitting processes. Incentive-based programs can support green infrastructure in both new and existing developments that retrofit green infrastructure technology.[22]

Examples:
Washington, D.C.'s Department of Environment and Energy administers the RiverSmart Program, a series of financial incentives that encourage property owners to install green infrastructure technology. Incentives include financial assistance for homeowners, non-profits, and places of worship, technical and educational assistance for schools, a green roof rebate program, green infrastructure audit rebates, discounted stormwater fees, and grant funding.

From 2008 to 2012, Portland, Oregon developed the Ecoroof Incentive Program with the goal of establishing 43 acres of low-maintenance green roofs. The incentive-based program provided a subsidy of $5/square foot. Over the course of the project, over 130 green roofs managing more than 4 million gallons of stormwater per year were funded.[23]

22. Georgetown Climate Center: Incentive-Based Tools. Accessed here.
23. Adaptation Clearinghouse: Case Study – City of Portland, Oregon Ecoroof Incentive. Accessed here.

Resources for Stormwater & Water Quality-Specific Zoning Ordinances:
Greenprint Partners: For Cities + Water Authorities – Green Infrastructure Incentive Programs.
Pioneer Valley Planning Commission: Promoting Green Infrastructure – Strategies, Case Studies, and Resources.
United States Environmental Protection Agency: Managing Wet Weather with Green Infrastructure – Municipal Handbook: Incentive Mechanisms.
United States Environmental Protection Agency: Planning a Green Infrastructure Incentives Program for Target Neighborhoods in the City of Cincinnati.
Water Environment Federation: Five Types of Green Infrastructure Incentive Programs.

6. Smart Growth Approaches

Smart growth is broadly defined as "a range of development and conservation strategies that help protect our health and natural environment and make our communities more attractive, economically stronger, and socially diverse."[24]

Smart growth recognizes the connection between environmental conservation and quality of life. Smart growth is guided by 10 basic principles:[25]

- Mix land uses
- Take advantage of compact building design
- Create a range of housing opportunities and choices
- Create walkable neighborhoods
- Foster distinctive, attractive communities with a strong sense of place
- Preserve open space, farmland, natural beauty, and critical environmental areas
- Strengthen and direct development towards existing communities
- Provide a variety of transportation choices
- Make development predictable, fair, and cost-effective
- Encourage community and stakeholder collaboration in development decisions

24. EPA: Smart Growth. Accessed here.
25. Smart Growth Network: What is smart growth? Accessed here.

Each guiding principle presents an opportunity for municipalities to incorporate stormwater BMPs and green infrastructure into their planning and development. In particular, taking advantage of compact building design and preserving open space reduces the amount of impervious surface and provides more natural surface area for stormwater to be absorbed. Directing development toward existing communities reduces the pressure on existing open space. Incorporating green infrastructure - such as green roofs, planter boxes, and permeable pavement - is an effective way to address these 'Smart Growth' goals.

Downtowns such as Staunton already embody several smart growth principles, such as mixed use, compact building design, and walkability
Source: City of Staunton, VA. Accessed here.

Examples:

Arlington County, Virginia is nationally recognized as a leader in smart growth principles – the county won the EPA's 2002 Smart Growth Achievement Award for its work on the Rosslyn-Ballston Metro Corridor, and a Gold 2017 National Planning Achievement Award for its forward-thinking General Land Use Plan. The plan concentrates high- and mid-density redevelopment along transit stations, encourages mixed-use development, creates high quality pedestrian environments, preserves open space, and preserves and reinvests in existing neighborhoods.[26] By focusing development along transit corridors and emphasizing walkability, Arlington is able to satisfy smart growth goals and facilitate more efficient stormwater management practices.

26. Arlington, Virginia: Arlington County's Smart Growth Journey Implementing the General Land Use Plan. Accessed here.

Resources for Smart Growth Approaches:

Choose Clean Water Coalition: Smart Growth, Clean Water, and Sustainable, Competitive Economic Development.

Sussex County, Delaware: Protecting Water Quality with Smart Growth Strategies and Natural Stormwater Management.

United States Environmental Protection Agency: Smart Growth.

United States Environmental Protection Agency: Smart Growth and Water.

United States Environmental Protection Agency: Using Smart Growth Techniques as Stormwater Best Management Practices.

7. Street Sweeping and Storm Drain Cleaning

Many of the pollutants that flow into our waterways stem directly from waste on streets and in storm drains. While street sweeping and storm drain cleaning are widely-accepted BMPs for stormwater management, they are often not effective because localities do not inspect and maintain this infrastructure frequently enough. Waste accumulates on roadways and is swept into storm drains, which in turn pollutes our natural water systems. Studies show that though the effects of sweeping technologies may be modest compared to other BMPs, they help to improve water quality when performed frequently and effectively.[27] Localities can use mechanical broom sweepers to remove larger debris, or advanced sweeping technologies, such as regenerative air sweepers and vacuum-assisted sweepers, to remove smaller debris from road surfaces. Localities should also periodically inspect and remove debris from stormwater catch basins and/or drain pipes.

27. Chesapeake Bay Program: Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices. Accessed here.

Examples:

In 2020, Corpus Christi, Texas launched a street sweeping program as part of a larger effort to reduce stormwater pollution. Previously, the city had no street sweeping maintenance, due in part to lack of maintenance. City Council awarded a $2.3 million contract to a private sweeping service company to sweep 156 times per year – this contract is partially funded by Corpus Christi's stormwater fund. The program will allow for the street sweeping of the city's arterial, collector, and residential streets as well as core downtown areas, covering 20,200 miles each year. City Manager Peter Zanoni noted the importance of a street sweeping program, stating: "Cleaner streets also mean cleaner waters in our creeks, bays, and estuaries."

In Marietta, Ohio, the Streets Department helps to coordinate the city's robust street cleaning program. The program divides the city into five sections, each with a focused street sweeping and storm drain catch basin cleaning protocol. The city uses a truck with a regenerative air sweeper and catch basin hose attachment to achieve both street and storm drain cleaning efforts with each sweep. These efforts are part of Marietta's "Clean Streets, Clean Streams, Clean Water" campaign, and are recognized as a 'vital' component of pollution reduction efforts.

Marietta, OH Street Sweeping Program
Source: Marietta Times. Accessed here.

Resources for Street Sweeping and Storm Drain Cleaning:

Chesapeake Bay Program: Quick Reference Guide for BMPs – Street Cleaning (Street Sweeping).
Chesapeake Bay Program: Recommendations of the Expert Panel to Define Removal Rates for Street and Storm Drain Cleaning Practices.
Chesapeake Stormwater Network: Urban Street Sweeping.
United States Environmental Protection Agency: Storm Water O&M Fact Sheet – Catch Basin Cleaning.

General Resources for Municipalities:

Center for Watershed Protection: Managing Stormwater in Your Community – A Guide for Building an Effective Post-Construction Program.
Georgetown Climate Center: Green Infrastructure Toolkit – Getting Started: Pilot Projects.
Green Infrastructure Center: A Quick Guide to Community Planning for Green Infrastructure.
Low Impact Development Center: Home Page.
National Nonpoint Education for Municipal Officials (NEMO) Network: Home Page.
Stormwater Manager's Resource Center: Home Page.
United States Environmental Protection Agency: City Green – Innovative Green Infrastructure Solutions for Downtowns and Infill Locations.
United States Environmental Protection Agency: Green Streets, Green Jobs, Green Towns (G3) Grant Program.
United States Environmental Protection Agency: Guidance for Municipal Stormwater Funding.
United States Environmental Protection Agency: National Conference on Urban Storm Water – Enhancing Programs at the Local Level.
United States Environmental Protection Agency: Water Infrastructure and Resiliency Finance Center.

HOW CAN RESIDENTS MANAGE THEIR IMPACT ON STORMWATER POLLUTION?

1. Lawn and Garden Care

While planting native vegetation in your lawn and garden helps to absorb stormwater runoff, lawns that are maintained with harmful chemicals pollute rainwater. The Alliance for the Chesapeake Bay recommends:[28]

- Using organic compost and pesticides
- Allowing grass to grow at least 3 inches high to slow runoff
- Retaining grass clippings and chopped leaves, allowing them to decompose and create a soil layer that facilitates stormwater infiltration
- Avoiding use of fertilizer or pesticides within 15-20 feet of a stream
- Sweeping any granulated chemicals off hard surfaces such as walkways, patios, and roads and onto your lawn to avoid discharge into local storm drains

2. Auto Care & Maintenance

Washing your car on hardscapes such as roadsides or driveways sends harmful chemicals from cleaning agents directly into stormwater systems. Additionally, dumping used automotive fluids into storm drains "has the same result as dumping the materials directly into a waterbody."[29] To reduce the impact of auto care on stormwater pollution:

- Look for commercial car washes that treat and/or recycle wastewater
- Wash your car in the yard to allow water to infiltrate through the ground
- Repair any fluid leaks in a timely manner
- Dispose of automotive fluids and car batteries at designated drop-off facilities, such as recycling centers

28. Alliance for the Chesapeake Bay: Lawn and Garden Care. Accessed here.
29. EPA: Stormwater Pollution Solutions. Accessed here.

3. Septic Systems

Generally, well-maintained septic systems do not pose a threat to stormwater pollution. However, septic systems that are poorly maintained can begin to leak, releasing harmful pathogens that can be picked up by stormwater. To maintain a healthy septic system:[30]

- Inspect your system every 2-3 years
- Pump your tank regularly (the EPA recommends every 3-5 years) [31]
- Avoid clogs by avoiding disposal of cigarettes, cat litter, wipes, etc.
- Avoid pouring harmful chemicals and cleaners down the drain (ammonia, bleach, paint, oil, pesticides, etc.)

Source: San Luis Obispo County. Accessed here.

4. Pet Waste

Pet waste is a common stormwater pollutant, and contains harmful nutrients, bacteria, parasites, and viruses. Remember to pick up and properly dispose of all pet waste. The EPA recommends flushing as the best method for disposing of pet waste, to ensure it flows directly into a water treatment facility.[32]

30. Neponset Stormwater Partnership: Septic System Maintenance. Accessed here.
31. EPA: Stormwater Pollution Solutions. Accessed here.
32. EPA: Stormwater Pollution Solutions. Accessed here.

General Resources for Residents:

Kansas City Water Services: A Resident's Reference Guide to Stormwater Management.

Mid-America Regional Council: A Homeowner's Reference Guide to Stormwater.

Orange County H2OC Stormwater Program: You are the Solution to Runoff Pollution.

United States Environmental Protection Agency: After the Storm – A Citizen's Guide to Understanding Stormwater.

United States Environmental Protection Agency and Virginia Department of Conservation and Recreation: A Virginian's Year-Round Guide to Yard Care.

United States Environmental Protection Agency and Virginia Department of Conservation and Recreation: Tips on keeping your lawn green and the Chesapeake Bay clean.

United States Environmental Protection Agency: Your Septic System – A Reference Guide for Homeowners.

Virginia Department of Environmental Quality: Onsite Wastewater Systems – A Quick Guide for Homeowners.

HOW CAN BUSINESSES MANAGE THEIR IMPACT ON STORMWATER POLLUTION?

1. Prevent Disposal of Chemicals through Storm Drains

Businesses can greatly reduce stormwater pollution by ensuring that no harmful pollutants are dumped in to storm drains. Typically, businesses have indoor sanitary sewer drains that flow directly to treatment plants and are safe for disposal. Storm drains are typically outdoor drains, and flow directly to our natural water sources. If you are unsure which drains are safe for waste disposal, contact your local sewerage agency. Businesses can also take the following measures: [33]

- Label storm drains to prevent improper dumping of pollutants
- Routinely inspect storm drains and surrounding outdoor work spaces, storage areas, waste and recycling areas, etc.
- Do not wash surfaces in proximity to storm drains. Wash equipment indoors when possible
- Pick up trash and keep surrounding areas clean through routine sweeping

2. Safely Store Materials

When possible, materials should be stored indoors to prevent spilling or leaking into storm drains. Businesses can also take several preventative measures to prevent spilling: [34]

- Store any outdoor materials in an enclosed, covered container
- Regularly inspect outdoor materials for leaks or corrosion
- Do not leave outdoor materials in standing water
- Train employees on proper cleaning and containment techniques for outdoor spills. Create a readily accessible 'spill kit' for quick clean-up
- Place materials as far as feasibly possible from storm drains
- Place drip pans under outdoor storage areas

33. Clean Water Program: How Your Business Can Prevent Stormwater Pollution. Accessed here.

34. Stormwater Partners: Preventing Pollution. Accessed here.

3. Proper Waste and Recycling Storage

Businesses should carefully inspect waste and recycling storage facilities to prevent leaking or accidental disposal in to storm drains. Best practices include:

- Inspecting garbage daily for waste outside dumpsters and recycling bins
- Prevent waste overfill and ensure that lids are closed at all times
- Check for leaks frequently
- When washing waste containers, rinse at indoor sanitary sewer drain
- Keep waste and recycling storage in enclosed/covered shelter if possible
- Provide ample recycling bins
- Ensure trash compactors are connected to sanitary sewers and inspect for leaks frequently
- Post signage to share best practices with employees
- Encourage customers to use reusable bags to reduce plastic bags that may end up in storm drains

Signage to prevent disposal of waste into storm drain
Source: USDA Agricultural Research Service. Accessed here.

General Resources for Businesses:

City of Danville, Virginia. Best Management Practices (BMPS) for Businesses.
Clean Water Program: How Your Business Can Prevent Stormwater Pollution.
Fairfax Department of Public Works and Environmental Services: Clean Water is Everyone's Business.
Stormwater Partners of Southwest Washington: Preventing Pollution.

HOW CAN FARMERS MANAGE THEIR IMPACT ON STORMWATER POLLUTION?

Agriculture is the largest contributor of nitrogen and phosphorous, sediment, and pesticide loading to the Chesapeake Bay's waterways.[35] There are several cost-effective strategies farmers can use to reduce pollution from stormwater runoff. The Chesapeake Bay Foundation recommends the following BMPs:

1. Streamside Buffers

Areas along stream banks should be excluded from agricultural use and replaced with natural buffers whenever possible. These buffers can include native trees, shrubs, and grasses. The Chesapeake Bay Foundation recommends that stream buffers be at least 35 feet wide on either side – this allows a sufficient amount of runoff to be absorbed before it reaches streams and provides a more natural habitat for local wildlife.

2. Streamside Fencing

Farmers can install fencing to prevent livestock and associated animal waste from entering streams. Animal waste is a major contributor of harmful pollutants, as well as water-borne diseases.

Streamside Fencing
Source: Chesapeake Bay Foundation. Accessed here.

35. Virginia Department of Conservation and Recreation: Nonpoint Source Pollution Best Management Practices. Accessed here.

3. Nutrient Management Plans

Nutrient Management Plans (NMPs) serve as useful agricultural planning tools - they help farmers determine proper fertilizer usage. Well-design NMPs "minimize fertilizer costs and reduce nutrient runoff"[36] into nearby water systems.

4. Conservation Tillage

Conservation tillage, or 'continuous no-till,' is an alternative to traditional plowing and tilling practices that minimizes soil disturbance, which in turns reduces soil erosion and runoff. Minimizing soil disturbance also promotes healthier soil, as its ability to retain moisture improves over time.

5. Cover Crops

Farmers can plant cover crops on unused/dormant fields to help absorb runoff from fertilizer. Cover crops also help to replenish nutrients to the soil for future agricultural use. Common cover crops include grasses, legumes (i.e. peas), wheat, and barley.

Farmers may find the costs associated with implementing agriculture to be cost-prohibitive. The Virginia Agriculture BMP Cost-Share (VACS) Program supports BMPs related to cropland, pastureland, hay land and forested lands. Funds are provided through a combination of state and federal funding, often reducing landowner expenses to less than 30%. Landowners may receive a maximum of $100,000 per year through the cost-share program. To be eligible, projects must be on farms that cover at least five acres and earn $1,000 in income per year. Additionally, proposed projects must address a specific, existing water quality issue(s). Eligible projects include erosion control, stream fencing, alternative watering systems, stream restoration, planting cover crops, establishing rotational grazing, planting tree seedlings, preserving wetlands, protecting sinkholes, stabilizing eroding stream banks, and nutrient management (including animal waste).

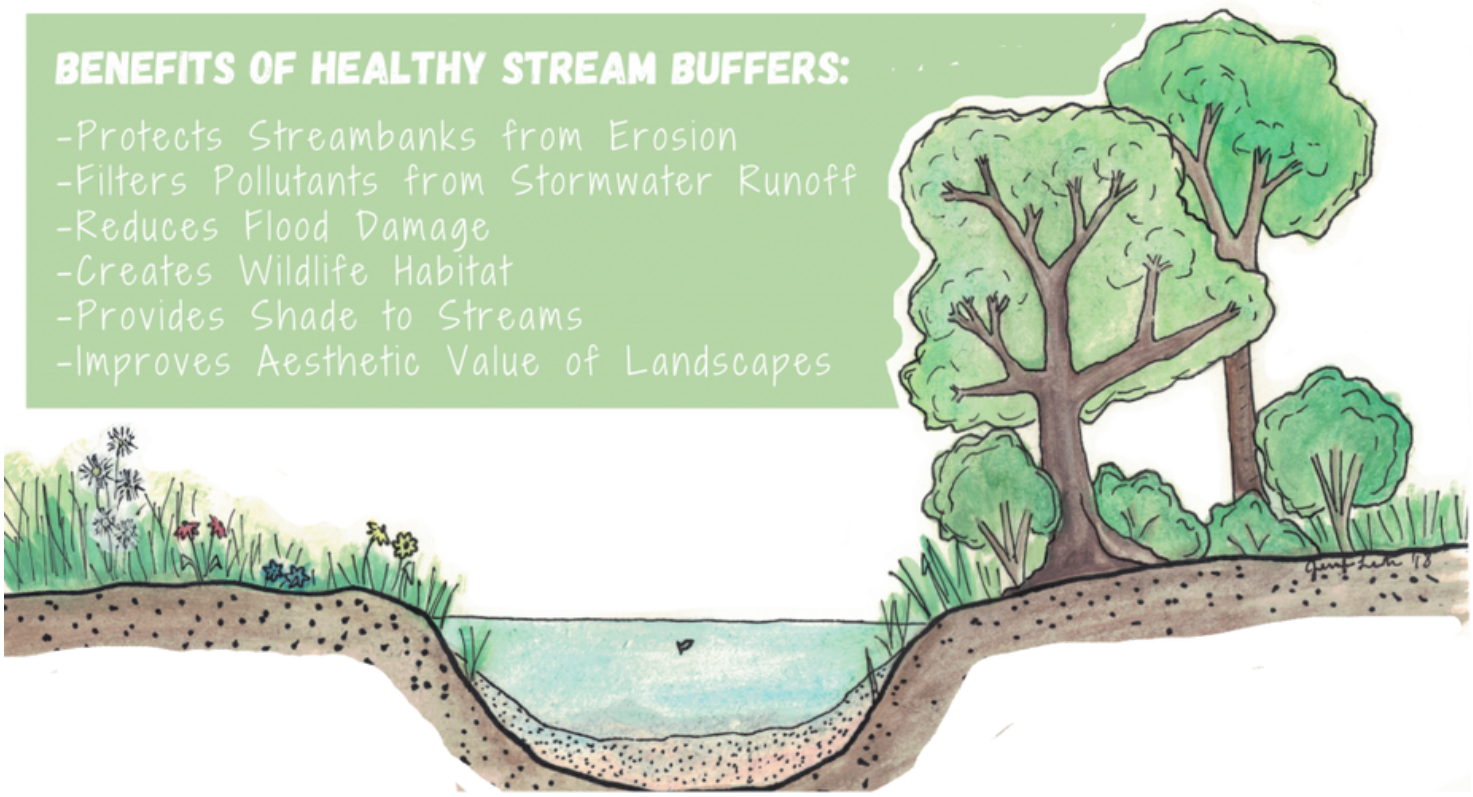
36. Virginia Department of Conservation and Recreation: Nonpoint Source Pollution Best Management Practices. Accessed here.

General Resources for Farmers:

Chesapeake Bay Foundation: Best Management Practices.
Chesapeake Bay Foundation: Regenerative Agriculture.
Chesapeake Bay Foundation: Virginia's Agricultural Cost-Share Program.
Choose Clean Water Coalition: Supporting Virginia Farmers (Youtube).
Earth Observatory (NASA): How Farms Affect the Chesapeake Bay's Water.
North Carolina State University: A Farmer's Guide to Agriculture and Water Quality Issues.
Utah State University Extension: Water Quality Best Management Practices.
Virginia Department of Conservation and Recreation: Nonpoint Source Pollution Best Management Practices.

STORMWATER BMPS FOR PREVENTING STREAM BANK EROSION

As localities continue to develop and the amount of impervious surface increases, more stormwater is flowing directly into our streams and waterways rather than absorbing into the ground. The increased volume of water moves more quickly, which in turn causes stream banks to erode more rapidly. This erosion disrupts our 'riparian buffer' – "the vegetated area along the water's edge."[37]



Source: Bluegrass Green Source. Accessed here.

Riparian buffers provide a wide range of benefits - they improve stream bank stability, slow stormwater flow, provide a habitat for wildlife, moderate water temperatures, and add aesthetic beauty to our waterways. Residents and municipalities can help to mitigate stream bank erosion by refraining from clearing streams and re-building stream banks that have already been cleared.

37. North Carolina Cooperative Extension: Small-scale Solutions to Eroding Streambanks. Accessed here.

The North Carolina Cooperative Extension recommends taking the following measures to improve stream bank conditions:

1. Evaluate your Stream Bank

Observe current conditions. Does your stream flow year-round? Does the water level fluctuate rapidly? Is there a steep vertical bank, or a gradually sloping bank? How deep and wide is the creek? Are there a variety of native plants (trees, shrubs, flowers, ferns, grasses, etc.)?

2. Determine Your Options

What does your stream need?

- You may choose to let the existing vegetation grow uninterrupted for the next year, allowing plants to establish deeper roots.
- If a stream bank is in need of native vegetation, you may plant a variety of trees, shrubs, flowers, etc. Consult with a technical expert to determine which plants should be placed.
- If the stream bank is in poor condition, you may need to grade the stream bank. A 3:1 slope is considered the ideal slope for stream bank conditions. You may need a local permit. After grading, plant native vegetation.

3. Choose the Right Plants

All vegetation should be native to the area. There are a number of additional considerations:

- Consider the ideal view scape from your home.
- Plant in the proper location – plants close to the water's edge will have wet roots nearly 100% of the time. Plants further back can tolerate drier soil.
- Consider planting vegetation that will attract local fauna.
- Prepare ahead – space plants properly to accommodate future growth.
- Consider seasonality, and plant a variety of vegetation throughout the year.

4. Maintain Your Riparian Buffer

Maintenance should be minimal during the first few years, allowing roots to establish along the bank. Proper maintenance measures include:

- Installing fences/gates to prevent wildlife from eating/stepping on younger vegetation.
- Use natural fertilizers when planting to facilitate growth.
- Visit the streambank seasonally, checking for litter and observing plant conditions. Replant if needed. Make visits after large weather events.
- Remove any invasive plants.
- Only prune trees as needed. Facilitate deep root growth.

Riparian Buffer
Source: Chesapeake Bay Program. Accessed here.

Resources for Preventing Stream Bank Erosion:

North Carolina Cooperative Extension: Small-scale Solutions to Eroding Streambanks.
River Network: Restoring Riparian Buffers – A What Works Snapshot.
Township of New Garden, Pennsylvania: Riparian Buffer Information and Resources.
Virginia Department of Conservation and Recreation: Native Plants for Conservation, Restoration, & Landscaping.
Virginia Department of Conservation and Recreation: The Virginia Stream Restoration & Stabilization Best Management Practices Guide.

EQUITY AND ENVIRONMENTAL JUSTICE CONSIDERATIONS

As localities adopt green infrastructure and stormwater management practices, it is important to consider equity and environmental justice throughout the process. Government officials should assess community vulnerability before introducing any green infrastructure best practices that may overburden or 'price out' low-income residents and/or communities of color. Additionally, localities should prioritize funding in communities already facing high risk for flooding and polluted stormwater runoff. Investments in green infrastructure should also be targeted, and aim to correct historically imbalanced patterns of disinvestment where possible. To ensure equity, government officials can first engage in inclusive and thorough public engagement that actively seeks diverse perspectives. This allows communities to guide green infrastructure investment from the bottom up, and provides critical insight to local governments that may lack insight at the neighborhood level.

Examples:

In 2015, the City of Cleveland, Ohio released its Cleveland Tree Plan, a "community-wide collaboration to rebuild the urban forest through partnership." The plan provides an assessment of Cleveland's current tree canopy, and lays out a strategy for rebuilding the urban forest that relies heavily on community input. The plan addresses the impact of urban tree canopy on stormwater management, but focuses primarily on the connections between tree canopy and public health. One of the primary action items of the plan is "plant with a purpose" – the city created a methodology for prioritizing plant sites that incorporates sociodemographic factors, neighborhood revitalization goals, vacant land, and public health indicators. The plan then prioritized each area with an equity ranking to minimized disparities in tree canopy coverage.

Examples:

Baltimore, Maryland launched the Growing Green Initiative (GGI) in 2014, with the goal of repurposing vacant lots and abandoned houses to provide open space, local food sources, green infrastructure, and social gathering spaces. The initiative focused primarily on distressed neighborhoods with high vacancy, and allowed communities and/or non-profits to adopt green spaces for community use. The program also provided grant opportunities to construct stormwater BMPs. GGI hosted a Growing Green Design Competition in 2014, which provided funding for vacant lot project ideas. Funded projects included transforming a parking lot into a pocket park designed to reduce runoff, two public arts and recreation spaces with stormwater BMPs, a Chesapeake Bay Foundation beautification project that resulted in 240,000 fewer gallons of runoff, and a community garden with stormwater filtration technology. GGI provided more accessible community benefits to previously underserved areas.

Pocket Park in Baltimore, MD
Source: Baltimore Office of Sustainability. Accessed here.

Resources for Equity and Environmental Justice:

Georgetown Climate Center: Green Infrastructure Toolkit – Equitable Planning.
Georgetown Climate Center: Green Infrastructure Toolkit – Equitable Investment.
National Association for the Advancement of Colored People: Equity in Building Resilience in Adaptation Planning.
United States Environmental Protection Agency: Green Infrastructure – A Triple Bottom Line Approach to Environmental Justice.
Urban Systems Lab: Environmental Justice of Urban Flood Risk and Green Infrastructure Solutions.

CHILDREN'S/MISCELLANEOUS RESOURCES

Children's Resources:

Enviroscape: Hands-On Products for Environmental Education – Home Page.
Georgetown County Stormwater: Stormwater Walk Activity.
Georgetown County Department of Public Services: DIY Stormwater Experiments.
Tip of the Mitt Watershed Council: Stormwater Matters for Kids.
United States Environmental Protection Agency: Keeping Watersheds and Children Healthy.
United States Environmental Protection Agency: Nonpoint Source Pollution Awareness - Darby Duck, the Aquatic Crusader.
United States Environmental Protection Agency: Nonpoint Source Pollution Awareness – What's Wrong with This Picture?
United States Environmental Protection Agency: Nonpoint Source Pollution Awareness – Word Search Puzzle.
United States Environmental Protection Agency: Take the Stormwater Runoff Challenge.
University of Nebraska-Lincoln: Stormwater Education for Kids.

Performance Measures

The EPA has a webpage dedicated to documenting the performance of specific stormwater management tools. The page includes relevant studies, summary reports, databases and articles. Users can explore this page to determine which stormwater management practices would be best suited for their project.

For Parks

The EPA released a policy guide for implementing green infrastructure in parks, which provides guidance related to collaboration, funding, and community engagement. The guide recommends specific green infrastructure improvements for various park features, including parking lots, visitors' centers, playing fields, trails, and drainage systems. It also includes park infrastructure resources.

For Congregations

The EPA has released specific guidance for implementing green stormwater management practices for congregations – recognizing 'reverence and respect for nature' and environmental stewardship as important facets of these communities. Best management practices include rain gardens, conservation landscaping with native vegetation, bioretention areas, downspout disconnection, rainwater harvesting, green roofs, and permeable pavement. The guide also includes helpful congregation-specific tips and resources for implementing successful stormwater management projects.

Green Infrastructure Handbook for Municipalities

The EPA released a series of documents culminating in a Green Infrastructure Municipal Handbook. The documents cover funding options, retrofit policies, green streets, rainwater harvesting policies, and incentive mechanisms. The EPA also has a webpage dedicated to potential barriers facing municipalities as they implement green infrastructure practices, and provides practical solutions. Handouts for integrating stormwater policies can be found here and here.

Green Infrastructure Modeling

The EPA has a comprehensive toolkit complete with a series of software and digital tools that allow communities to manage water resources and implement green and gray infrastructure practices. The toolkit includes a Storm Water Management Model, a National Stormwater Calculator, a Green Infrastructure Wizard, a Watershed Management Optimization Support Tool, and more.

Stormwater Management Funding

The EPA maintains an exhaustive list of federal, state, and local funding resources for stormwater management projects.

The Georgetown Climate Center also maintains federal and local government funding as well as private financing opportunities.

The EPA and Chesapeake Bay Trust administer the Green Streets, Green Jobs, Green Towns (G3) Grant Program, which supports green infrastructure-based projects including design and implementation projects, green street charrettes, and white papers for green infrastructure ideas.

The Virginia Conservation Assistance Program (VCAP) is an urban cost-share program that offers property owners of residential, commercial, or recreational sites with financial and technical assistance to implement stormwater BMPs. Eligible practices include conservation landscaping, dry wells, constructed wetlands, infiltration projects, impervious surface removal, rainwater harvesting, bioretention and bioswales, green roofs, permeable pavement installation, rain gardens, and living shorelines. Property owners in our region can reach out to the Shenandoah Valley Soil & Water Conservation District to discuss plans, set up a site assessment, and design a plan. Upon plan approval, reimbursement funding is provided for installation.

General Marketing and Outreach Materials:[38]

Georgetown Climate Center – Green Infrastructure Toolkit - Communication Strategies for Green Infrastructure.
Mid-America Regional Council: Pick Up After Your Pet Brochure.
Mid-America Regional Council: Protect Our Streams Brochure.
Mid-America Regional Council: Use Lawn Chemicals Wisely Brochure.
Mid-America Regional Council Regional Water Quality Education Program: If It's On the Ground, It's In Our Water.
Stormwater Outreach for Regional Municipalities (STORM): Only Rain in the Stormdrain Brochure.
Stormwater Outreach for Regional Municipalities (STORM): Public Service Announcements.
United States Environmental Protection Agency: NPS Outreach Toolbox – Logos, Slogans & Mascots.
United States Environmental Protection Agency: NPS Outreach Toolbox – Media Campaigns.
United States Environmental Protection Agency: Soak Up the Rain Outreach Tools.
Virginia Department of Conservation and Recreation: Watershed Connections Brochure.

Construction and Maintenance Resources:

Stormwater Outreach for Regional Municipalities (STORM): Construction Activities Brochure.
Stormwater Outreach for Regional Municipalities (STORM): Construction BMPs.
Stormwater Outreach for Regional Municipalities (STORM): Stormwater Maintenance Guide.
United States Environmental Protection Agency: Stormwater and the Construction Industry.

38. Several of the media/outreach links are for regional campaigns, and are provided to serve as inspiration for local outreach efforts.

Databases:

EPA 'How's My Waterway?' Database
International Stormwater Best Management Practices Database
National Low Impact Development (LID) Atlas
Runoff Reduction Method Technical Memo – Appendix F: BMP Research Summary Tables
Virginia Environmental Data Hub

Primary Sources for Stormwater Toolkit:

Environmental Protection Agency. Green Infrastructure. Accessed here.
Environmental Protection Agency. NPDES Stormwater Program. Accessed here.
Georgetown Climate Center. Green Infrastructure Toolkit. Accessed here.

CSPDC

Central Shenandoah Planning District Commission