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Green Infrastructure and Issues in Managing Urban Stormwater

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Summary

For decades, stormwater, or runoff, was considered largely a problem of excess rainwater or snowmelt impacting communities. Prevailing engineering practices were to move stormwater away from cities as rapidly as possible to avoid potential damages from flooding. More recently, these practices have evolved and come to recognize stormwater as a resource that, managed properly within communities, has multiple benefits.

Stormwater problems occur because rainwater that once soaked into the ground now runs off hard surfaces like rooftops, parking lots, and streets in excessive amounts. It flows into storm drains and ultimately into lakes and streams, carrying pollutants that are harmful to aquatic life and public health. Traditional approaches to managing urban stormwater have utilized so-called "gray infrastructure," including pipes, gutters, ditches, and storm sewers. More recently, interest has grown in "green infrastructure" technologies and practices in place of or in combination with gray infrastructure. Green infrastructure systems use or mimic natural processes to infiltrate, evapotranspire, or reuse stormwater runoff on the site where it is generated. These practices keep rainwater out of the sewer system, thus preventing sewer overflows and also reducing the amount of untreated runoff discharged to surface waters.

Cities' adoption of green technologies and practices has increased, motivated by several factors. One motivation is environmental and resource benefits. Advocates, including environmental groups, landscape architects, and urban planners, have drawn attention to these practices. But an equally important motivation is cost-saving opportunities for cities that face enormous costs of stormwater infrastructure projects to meet requirements of the Clean Water Act. Other potential benefits include reduced flood damages, improved air quality, and improved urban aesthetics. However, barriers to implementing green infrastructure include lack of information on performance and cost-effectiveness and uncertainty whether the practices will contribute to achieving water quality improvements.

Another key barrier is lack of funding. At the federal level, there is no single source of dedicated federal funding to design and implement green infrastructure solutions. Without assistance, communities take several approaches to financing wastewater and stormwater projects; the most frequently used tool is issuance of municipal bonds. As a dedicated funding source for projects, the number of local stormwater utilities that charge fees has grown in recent years. Many municipalities try to encourage homeowners and developers to incorporate green infrastructure practices by offering incentives. The most common types of local incentive mechanisms are stormwater fee discounts or credits, development incentives, rebates or financing for installation of specific practices, and award and recognition programs.

The Environmental Protection Agency's (EPA's) support for green infrastructure has grown since the 1990s. The agency has provided technical assistance and information and developed policies to facilitate and encourage green infrastructure solutions and incorporate green infrastructure practices in Clean Water Act permits. EPA also has awarded grants to communities in 23 states for projects to identify green infrastructure opportunities and steps needed to overcome implementation barriers.

Congress has shown some interest in these issues. In the 114th Congress, legislation has been introduced to support research and implementation of green/innovative stormwater infrastructure (H.R. 1775/S. 896 and in provisions in H.R. 2893 and S. 1837). Two other bills, S. 2768 and S. 2848, include provisions calling for EPA to promote green infrastructure. Overall, many in Congress remain concerned about how municipalities will pay for needed investments in water

infrastructure projects generally—not limited to green infrastructure—and what role the federal government can and should play in those efforts.

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Introduction

Managing stormwater is one of the biggest and most expensive problems facing cities across the United States.

Stormwater is in part a water quantity problem, and for decades the focus of local governments and public works officials was on how to engineer solutions to move rainwater rapidly away from urban areas to avoid the economic damages of flooding. Stormwater also is a pollution problem. As it moves across the surface of the land, stormwater picks up toxic contaminants, oil and grease, organic material, and other substances, which may be directly discharged into streams, thus delivering pollutants into nearby waterways. Or, it may enter the public sewer system through storm drains, and then the water quantity and water quality problems are joined in the water infrastructure system.

Cities face dual challenges in managing stormwater—how to prevent or minimize stormwater entering sewers in the first place, thus preventing overflows from the start, and how to remediate overflows that occur. For a variety of reasons, many communities are exploring the use of so-called "green infrastructure" to address both types of challenges. Green infrastructure systems and practices use or mimic natural processes to infiltrate, evapotranspire, and/or harvest stormwater on or near the site where it is generated in order to reduce flows to municipal sewers. There are many success stories in communities around the country, each different, but there also are a number of issues about feasibility, sustainability, and cost-effectiveness.

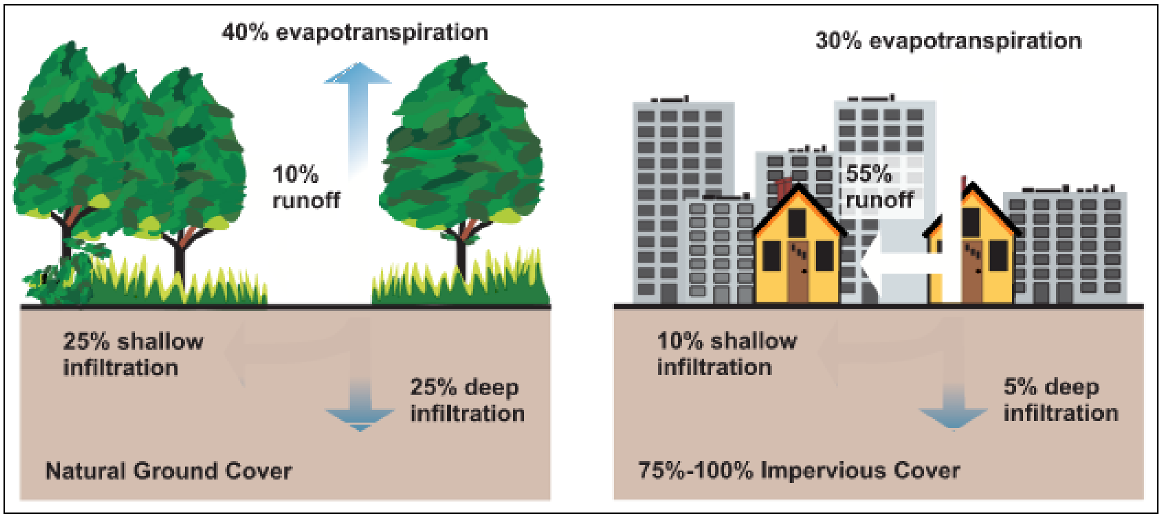
The Urban Stormwater Problem

When rainwater falls, some of the water is absorbed into the ground, and the rest flows along the surface as runoff into rivers and streams. In forested areas, with porous and varied terrain, about half of rainfall infiltrates into the ground, where it recharges groundwater. About 40% returns to the atmosphere through evapotranspiration, and the remaining 10% flows along the surface as runoff.

Unlike forested areas, urbanized areas often have around 45% or more of land surface that is impervious to rainfall, due to hard surfaces such as parking lots, roads, and rooftops. When rain hits impervious cover, it is unable to absorb into the ground and instead flows quickly into sewers and ditches and directly into rivers and streams. The Environmental Protection Agency (EPA) estimates that because of impervious surfaces such as pavement and rooftops, a typical city block generates five times more runoff than a woodland area of the same size, while only about 15% infiltrates into the ground for groundwater recharge. (See **Figure 1**.) Further, the increased amount of runoff also increases pollutant loads that are harmful to aquatic life and public health into streams, rivers, and lakes. Pollutants can include sediment; oil, grease, and toxic chemicals from motor vehicles; road salts; pesticides and nutrients from lawns and gardens; bacteria and pathogens from pet waste and failing septic systems; and heavy metals from roofs, cars, and other sources.[1]

[1] U.S. Environmental Protection Agency, *Protecting Water Quality from Urban Runoff*, EPA 841-F-03-002, 2003, 2 p.

Figure 1. Relationship Between Impervious Cover and Surface Runoff



Source: U.S. Environmental Protection Agency, *Protecting Water Quality from Urban Runoff*, p. 1.

Stormwater runoff that does not directly enter streams and rivers instead enters public sewer systems. Two types of public sewer systems predominate in the United States: combined sewer systems and sanitary sewer systems. Combined sewers convey domestic and industrial wastewaters and stormwater runoff through a single pipe system to a wastewater treatment facility. Nationally, about 750 cities operate combined sewer systems. Most of these are located in the upper Midwest, mid-Atlantic states, and New England. During wet weather events, such as rainfall and snowmelt, the combined volume of wastewater and stormwater runoff entering combined sewers often exceeds conveyance capacity. Most combined systems are designed to discharge when the capacity of the sewer is exceeded. When this occurs, the untreated overflow is discharged directly to nearby surface waters, onto city streets, or as backups in basements prior to the wastewater treatment plant. Overflows pose particularly significant risks to human health when the discharges occur near sources of drinking water. Some combined sewer systems discharge infrequently, while others discharge every time that it rains. Combined sewer overflows (CSOs) are subject to permit requirements under the Clean Water Act (CWA). Permits authorizing discharges from CSO outfalls must include technology-based effluent limits.

Since the beginning of the 20th century, U.S. municipalities have generally constructed sanitary sewer systems, rather than combined sewer systems. Sanitary sewer systems convey domestic and industrial wastewater, but not large amounts of stormwater runoff, to a wastewater treatment works. Separate sanitary sewers are located in all 50 states, but are concentrated in the eastern half of the United States and on the West Coast. Areas served by sanitary sewer systems often have a municipal separate storm sewer system (MS4) to collect and convey runoff from rainfall and snowmelt. Overflows from sanitary sewers and separate storm sewers also can occur, as a result of blockages, line breaks, or sewer defects that allow excess stormwater and groundwater to overload the system. Discharges from MS4s serving more than 100,000 persons and smaller MS4 systems in urbanized areas also are subject to CWA permit requirements. Operators of these systems must implement stormwater best management practices that include public education, eliminating illicit discharges, and control of construction site and post-construction runoff.[2]

[2] For background, see CRS Report 97-290, *Stormwater Permits: Status of EPA's Regulatory Program*, by Claudia Copeland.

Green Infrastructure for Urban Stormwater Management

Traditional, or "gray," infrastructure systems for managing stormwater consist of pipes, storm drains, and concrete storage tanks. These systems are expensive to construct and maintain. EPA estimates that funding needs for stormwater management and projects to correct sewers that overflow total $106 billion over the next 20 years. Thus, the high cost of construction is one challenge with gray infrastructure that has led to considering options that are less costly. As a result, technologies or practices called green infrastructure are receiving increased attention.

Green infrastructure, also known as Low Impact Development (LID), generally refers to the use of the natural landscape, instead of engineered structures, to capture and treat rainwater where it falls. EPA has defined it as using "natural hydrologic features to manage water and provide environmental and community benefits."[3] At its heart, green infrastructure is a demand management technique that eliminates a portion of the stormwater entering municipal sewers or waterways, thereby raising the capacity of the sewer system by lowering pressure on it. Green infrastructure includes, but is not limited to, green roofs, downspout disconnection, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, curb extensions, permeable pavements, reforestation, and protection and enhancement of riparian buffers and floodplains. (For images of some of these practices, see **Appendix A**.) Proponents contend that cities can downsize their gray infrastructure, extend its lifetime, save money, create green jobs, and enhance livability. These technologies do not entirely eliminate the need for gray infrastructure, but they can complement or supplement conventional infrastructure.

Potential Benefits

Green infrastructure can alleviate local urban flooding by minimizing runoff volume and peak discharges. In addition, the infiltration, evapotranspiration, and slow release associated with green infrastructure approaches can control flood flows throughout a watershed. The economic benefits are a combination of the decreased costs of damage resulting from flooding and the reduced cost of constructing stormwater management and drainage infrastructure.

The growing interest in green infrastructure practices is driven to a great extent by arguments that it is a cost-effective way to manage urban stormwater problems, particularly compared with costs of gray infrastructure. Cities with combined sewer systems have documented that the use of green infrastructure practices to reduce runoff volume is cost-competitive with conventional stormwater and CSO controls. In general, recent examples indicate that properly scaled and sited green infrastructure can deliver equivalent hydrological management of runoff as conventional stormwater infrastructure at comparable or lower costs. It has been estimated that green infrastructure is 5%-30% less costly to construct and about 25% less costly over its life cycle than traditional infrastructure.[4] Several examples are described in the following box.

[3] The term green infrastructure can mean different things to different audiences, ranging from site-level stormwater management practices to large-scale conservation of entire landscapes. This report focuses on application of the term to stormwater management. For EPA's definition, see http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm.

[4] See, for example, Christopher Kloss and Crystal Calarusse, *Rooftops to Rivers, Green Strategies for Controlling Stormwater and Combined Sewer Overflows*, Natural Resources Defense Council, June 2006, 54 p., and Noah Garrison and Karen Hobbs, *Rooftops to Rivers II, Green Strategies for Controlling Stormwater and Combined Sewer Overflows*, Natural Resources Defense Council, 2011, 134 p.

Saving Money and Improving Water Quality with Green Infrastructure

A growing number of U.S. cities are citing savings as a result of green infrastructure initiatives, including these.

• **New York City**. In 2012 New York City entered into a modified consent order with state and local officials to invest $187 million over the next three years in green infrastructure to control combined sewer overflows (CSOs), the first installment of an estimated $2.4 billion in public and private funding over the next 18 years to install green infrastructure technologies. The agreement allows the city to set priorities for green investments in areas that will benefit most from the resulting reductions in overflows. The state agreed to defer decisions on the need for significant gray infrastructure projects until completion of the green infrastructure projects—a step that defers approximately $2 billion in capital costs. Overall, by including both gray and green investments, the plan could save $1.5 billion over 20 years.

• **Cincinnati**. Under a 2010 consent decree and CSO control plan, the Metropolitan Sewerage District of Greater Cincinnati was required either to construct a deep tunnel system to alleviate CSOs in many neighborhoods, or conduct further analyses and propose an alternative plan. In June 2013, EPA approved an alternative plan that includes separating sewers to keep rainwater out of the combined sewer system and use of green infrastructure to manage rainwater. The alternate plan is expected to save more than $150 million (in 2006 dollars) from the original deep-tunnel plan that was projected to cost the city $3.3 billion.

• **Louisville**. Under a consent decree requiring elimination of separate sewer system overflows (SSOs) and abatement of CSOs, Louisville, KY, developed a control plan using gray infrastructure that it originally estimated at $850 million. By incorporating a green infrastructure component costing $47 million, the city estimated that the "green capture" cost per gallon is half of the gray counterpart.

• **Campbell County, Kentucky**. Sanitation District No. 1, in Campbell County, KY, signed a consent decree in 2007 to address CSOs and SSOs. The first plan developed to comply relied solely on gray infrastructure. As an alternative, an integrated watershed-based plan was developed that provides savings of up to $800 million. It includes green infrastructure projects that will annually reduce CSO burden on local waterways by 12.2 million gallons.

• **Seattle**. The Natural Drainage Project in Seattle, WA, replaces portions of aging public streets, incorporating drainage features to improve the quality and reduce the quantity of stormwater. Data from Seattle Public Utilities indicates construction cost savings equivalent to $329 per square foot, or $100,000 per block.

• **Chicago**. The city of Chicago has been a leader in promoting urban green roofs. The 20,000 square foot green roof atop City Hall has helped decrease stormwater runoff and improve air quality by reducing the urban heat island effect around the site. Since its completion in 2001, the green roof has yielded an annual building-level energy savings of $3,600. Similarly, the green roof on the Target Center Arena in Minneapolis captures nearly 1 million gallons of stormwater annually and has cut annual energy costs by $300,000.

• **Milwaukee**. To reduce occurrence of CSOs, the Milwaukee Metropolitan Sewerage District (MMSD) created a program to purchase undeveloped, privately owned upstream land for infiltration and riparian services. MMSD estimates that the total acreage holds over 1.3 billion gallons of stormwater at a cost of $0.017 per gallon. In contrast, one of its flood management facilities holds 315 million gallons at a cost of $0.31 per gallon. While the comparison is not apples-to-apples, Milwaukee has found that upstream conservation and use of green infrastructure is cheaper than conventional infrastructure.

• **Lancaster, Pennsylvania.** Lancaster's green infrastructure plan, developed in 2011 to address problems with the city's combined sewer system, will reduce gray infrastructure capital costs by $122 million and reduce wastewater pumping and treatment costs by $661,000 per year, while also providing approximately $2.8 million in energy, air quality, and climate-related benefits annually.

Sources: American Rivers, Water Environment Federation, American Society of Landscape Architects, and ECONorthwest, *Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-Wide*, April 2012, 41 p.; Center for Neighborhood Technology and American Rivers, *The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environment and Social Benefits*, 2010, 80 p.; U.S. Environmental Protection Agency, *The Economic Benefits of Green Infrastructure, A Case Study of Lancaster, PA*, EPA 800-R-14-007, February 2014, 20 p.

In addition to controlling stormwater volume, a number of other benefits are frequently cited by advocates.[5]

[5] See, for example, A Joint Report by American Rivers, the Water Environment Federation, the American Society of Landscape Architects and ECONorthwest, *Banking on Green: A Look at How Green Infrastructure Can Save* (continued...)

- **Reducing Energy Costs.** Green roofs provide insulation and shade for buildings, thus reducing their need for both heating and cooling costs. Water harvesting and reuse reduce the energy consumption of water utilities for conveyance and treatment.
- **Preventing Disease and Protecting Local Economies.** Green infrastructure practices can reduce pollutant loadings to waterways, which can help to minimize illness from recreational contact or consuming contaminated drinking water.
- **Other Non-Water Benefits.** Other non-water benefits include improved air quality (trees and plants filter the air, capturing pollution in their leaves and on their surfaces), reduced atmospheric carbon dioxide (green roof vegetation sequesters carbon), and lowered air temperature (trees and plants cool the air through evapotranspiration). Green roofs and lighter-colored surfaces in urban areas reflect more sunlight and absorb less heat, thus reducing the heat island effect (an urban heat island is a metropolitan area with large amounts of impervious surfaces, which is warmer than nearby suburban and rural areas). Green infrastructure is believed to improve urban aesthetics, increase property values, and provide wildlife habitat and recreational space for urban residents.[6]

Potential Challenges

Despite growing enthusiasm for these practices, a number of obstacles and challenges to integrating green infrastructure into stormwater programs have been identified. Overall, when considering green infrastructure options, decisionmakers confront risk and uncertainty related to skepticism regarding the ability or consistency with which practices deliver the level of benefits expected, and uncertainty that investing in green infrastructure will deliver better returns than more traditional practices.[7] Many observers believe that the biggest barriers are lack of information on performance and cost-effectiveness, and uncertainty whether green infrastructure will contribute to achieving water quality improvements.

Some of the obstacles are technical. For example, green infrastructure is not suitable in areas where soils don't drain, slopes are too steep, or where there just is not enough space. Stormwater is uniquely affected by local climate, soils, groundwater levels, and other site-specific parameters, all of which increase the complexity of design and construction.[8] In many cases, there is insufficient technical knowledge and experience with the practices, and lack of data demonstrating benefits, costs, and performance.

Many private and public engineers are not convinced that green infrastructure is effective in managing stormwater due to lack of performance data in various types of climates. Despite a

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Municipalities Money and Provide Economic Benefits Community-Wide, April 2012, 44 p., http://www.americanrivers.org/assets/pdfs/reports-and-publications/banking-on-green-report.pdf; and Center for Neighborhood Technology and American Rivers, *The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits*, 2010, 80 p., http://www.cnt.org/repository/gi-values-guide.pdf.

[6] Christopher Kloss and Crystal Calarusse, *Rooftops to Rivers, Green Strategies for Controlling Stormwater and Combined Sewer Overflows*, Natural Resources Defense Council, June 2006, p. 10.

[7] Environmental Finance Center, University of Maryland, *Encouraging Efficient Green Infrastructure Investment*, January 15, 2013, p. 15.

[8] Letter from Jeffrey A. Eger, Executive Director, Water Environment Federation, to James A. Hanlon, Director, Office of Wastewater Management, U.S. Environmental Protection Agency, April 1, 2011.

growing literature on these topics (see **Appendix B**), because the technology is relatively new, robust information regarding performance is lacking. Consequently, some municipalities, regulators, and financiers are reluctant to invest in it. Even advocates acknowledge that, from a design standpoint, it is important to realize that systems need to continue to function over time without excessive maintenance or monitoring being required, or the likelihood of abandonment increases.[9] Many believe that a central repository of best management practices, designs, and specifications would be helpful to provide manuals and design standards for local developers, planners, and engineers.[10] Without design standards, it is argued, local design professionals and engineers are less likely to deviate from familiar approaches involving gray infrastructure.

Other barriers can be legal and regulatory. At the local level, barriers include local ordinances; building codes; plumbing and health codes; restrictions involving street width, drainage codes, and parking spaces; and restrictions on the use of reclaimed stormwater. Municipal codes and ordinances often favor gray over green infrastructure. A barrier that is both technical and legal is that green infrastructure is often located on private properties and thus is difficult for public agencies to ensure that proper maintenance is occurring and will continue long-term. At the state level, water and land-use policies and property rights can be complicating factors. For example, downstream water rights may be impacted if upstream water management practices reduce the quantity of water to downstream users. Some point to federal barriers, including lack of guidelines and performance standards, as well as lack of funding for demonstration projects to meet environmental mandates.[11]

A third type of barrier is financial, which has two main aspects—lack of funding to implement projects, and uncertainty over costs and cost-effectiveness. At the local level, it can be difficult to develop, increase, and enforce stormwater fees that can serve as revenue to implement green infrastructure. Although some communities have been able to adopt incentives, such as utility rate reductions, tax incentives, and/or regulatory credits (see "Paying for Green Infrastructure"), many others are constrained or unwilling to do so. Often there is no funding for design, development, and testing of large-scale projects, and without financing, local officials are reluctant to invest in projects with longer paybacks. Further, there is a perception, especially from private lenders and developers, that green infrastructure can be expensive to build and maintain. Funding and cost of implementation are viewed by some as the most significant barriers. In many cases there is not enough understanding about what green infrastructure will cost to design, construct, and maintain in comparison with traditional wastewater and stormwater approaches and insufficient economic analysis of the environmental and social benefits of green infrastructure.[12] Green infrastructure is not in all cases less costly than conventional infrastructure. Due to uncertainties of the cost of long-term maintenance, many communities are not convinced of the long-term cost savings of green infrastructure practices.

A final category is community and institutional barriers, encompassing some of the challenges already described. They include public perception, education of builders and developers, adjusting cultural values to appreciate green infrastructure aesthetics, and need for inter-agency and community cooperation to be successful.[13] According to some officials, green infrastructure

[9] Eric Woolson, "Barriers to Implementing LID," *Stormwater Magazine*, May 2013, p. 36.

[10] Clean Water America Alliance, *Barriers and Gateways to Green Infrastructure*, September 2011, pp. 14-18, http://www.cleanwateramericaalliance.org/pdfs/gireport.pdf. This report is based on results of a survey of municipal employees, government agencies, non-profit organizations, academia, consulting firms, and the private sector.

[11] Ibid., pp. 19-20.

[12] Ibid., pp. 22-24.

[13] Ibid., pp. 26-28.

does not have the public acceptance that traditional infrastructure has. Even proponents acknowledge that the transition to green infrastructure is a multi-decade effort that will require enhanced public outreach, intensive monitoring, and inter-governmental coordination.[14]

Paying for Green Infrastructure

As the previous discussion indicates, funding for and financing of green infrastructure projects is a challenge that many view as a key barrier to implementation. At the federal level, there are more than two dozen funding programs in seven departments and agencies that could potentially be applicable, but there is no single source of dedicated federal funding to design and implement green infrastructure solutions.[15] For example, the Federal Emergency Management Agency (FEMA) administers a flood mitigation assistance program that can provide planning, project, and management grants for communities to implement practices that minimize losses due to flooding. Green infrastructure practices could be eligible, but they are not the focus of the program. Similarly, the Federal Highway Administration administers a congestion mitigation and air quality improvement program, under which congestion mitigation to improve air quality can incorporate green infrastructure components. It has been suggested that the process that communities go through to identify and navigate these programs is daunting.

The largest source of federal financial assistance for municipal water infrastructure projects is authorized in the CWA and Safe Drinking Water Act (SDWA), which authorize federal grants to capitalize State Revolving Fund (SRF) loan programs. At the federal level, the SRF programs are administered by EPA, but project and funding decisions are administered by individual states. SRF assistance to communities can only fund the capital cost of projects, but EPA's definition of capital costs is broad. In addition to traditional gray infrastructure components, capital costs can also include tree plantings, green roofs, and downspout disconnections. Federal SRF capitalization grants are dependent on congressional appropriations, which have been flat or declining in recent years. Moreover, municipalities in many states reportedly have found it difficult to secure SRF loans for projects consisting solely of green infrastructure components.

Recently, dedicated funds for green infrastructure have been provided through the SRF programs. The set-asides originated in the 2009 economic recovery act (American Recovery and Reinvestment Act, ARRA, P.L. 111-5). In regular appropriations since FY2010, Congress has directed that a portion of SRF capitalization grants shall go to projects that address green infrastructure, water or energy efficiency, or other environmentally innovative activities. In ARRA and in EPA appropriations acts for FY2010 and FY2011, Congress directed states to use not less than 20% of the federal capitalization grants for projects with green infrastructure and similar features.[16] Since FY2012, Congress has modified the mandate for a Green Project Reserve to require that 20% of wastewater funds be so allocated by states, to the extent sufficient projects seek assistance, and to give states discretion to use up to 20% of drinking water funds for such projects, but not require them to do so.

[14] Op. cit., footnote 8.

[15] Environmental Finance Center, University of Maryland, *Encouraging Efficient Green Infrastructure Investment*, January 15, 2013, pp. 7, 26-38. Also see U.S. Environmental Protection Agency, "Green Infrastructure Funding Opportunities," http://water.epa.gov/infrastructure/greeninfrastructure/gi_funding.cfm#fundingtools.

[16] EPA reported in 2010 on the use of the Green Project Reserve funds provided in ARRA. After surveying the states, EPA reported that the largest percentage of the funds (41%) went to energy efficiency projects. The smallest percentage (15%) went to green infrastructure projects. See U.S. Environmental Protection Agency, *Clean Water State Revolving Fund Green Project Reserve Funding Status*, March 10, 2010, 9 p.

The U.S. Department of Agriculture's Rural Utilities Service provides grant and loan assistance for wastewater and drinking water projects in rural communities (with populations less than 10,000). Funds may be used for green infrastructure projects, but there is no required set-aside.

Without federal or state assistance, communities take several approaches to financing public capital projects. Local ratepayers fund most wastewater treatment needs, including stormwater projects. Municipal bonds are the most frequently used tool for water infrastructure financing—at least 70% of U.S. water utilities rely on municipal bonds and other debt to some degree to finance capital investments. In 2011, bonds issued for water, sewer, and sanitation projects totaled $29.6 billion, of which $14.2 billion was new-money financing and the remainder was for refunding to refinance prior governmental bonds.[17] Bonds or loans must be repaid, typically from user fees paid by customers.

The number of stormwater utilities that charge fees as a dedicated funding source for projects has grown in recent years.[18] These are fees that are charged to both taxpaying and tax-exempt properties, often based on the property's total area or amount of impervious surface (roofs, driveways, parking lots). The fee can be added to water, sewer, or other utility bills, or charged separately. In many locations, such fees are controversial, and have resulted in legal challenges over whether they are a "reasonable charge" for services provided, or are a tax. Other sources of funding for new stormwater projects can include special assessments (levied on property owners within a defined area that will benefit from the project), development fees (one-time charges or fees on developers), impact fees (another type of one-time fee related to the impact generated by a new development project), and permit and inspection fees (regulatory fees to cover the cost of permitting and inspection programs).[19]

Many municipalities try to encourage homeowners and developers to incorporate green infrastructure practices by offering incentives for both existing and planned developments. On existing property, incentives can be used to encourage landowners to retrofit sites, and incentives also can be used to entice developers to use green infrastructure practices when they are planning, designing, and constructing projects. For developers, key motivators include cost reductions, and streamlined permitting and inspection processes. For homeowners, cash rebates, discounts, tax credits, and grants motivate action. The four most common types of local incentive mechanisms are fee discounts or credits, development incentives, best management practice installation subsidies, and award and recognition programs.[20]

- Many communities that charge stormwater fees also offer a **fee discount or credit** if a property owner decreases the site's impervious cover or adds other

[17] Thomson-Reuters, *The Bond Buyer 2012 Yearbook*, p. 159.

[18] A 2014 survey identified 1,479 stormwater utilities in 40 states and the District of Columbia. Communities with a stormwater utility ranged in size from 88 (Indian Creek Village, FL; Florida is the state with the most stormwater utilities) to more than 3,790,000 (Los Angeles). Western Kentucky University, *Stormwater Utility Survey 2014*, Dec. 21, 2014, https://www.wku.edu/engineering/civil/fpm/swusurvey/wku_swu_survey_2014_incorporating_rd_comments.pdf.

[19] For example, the Sussex Conservation District in Delaware charges a construction inspection fee on all new development based on the size of the project to control to stormwater and erosion control. Noah Garrison and Karen Hobbs, *Rooftops to Rivers II, Green Strategies for Controlling Stormwater and Combined Sewer Overflows*, Natural Resources Defense Council, 2011, p. 26.

[20] U.S. Environmental Protection Agency, "Encouraging Low Impact Development, Incentives Can Encourage Adoption of LID Practices in Your Community," EPA 841-N-12-003G, December 2012, 2 p.; U.S. Environmental Protection Agency, *Managing Wet Weather with Green Infrastructure, Municipal Handbook, Incentive Mechanisms*, EPA-833-F-09-001, June 2009, 33 p.

green infrastructure practices to reduce the amount of stormwater runoff that leaves the property. The concept underlying such arrangements is that private businesses, institutions, and homeowners will experience financial benefits sufficient to support on-site green infrastructure. Examples of cities that offer fee reductions include Portland, Oregon; Seattle; Columbus, Ohio; and Chesapeake, Virginia. An example of this approach in Philadelphia is described in the box below. Anne Arundel County, Maryland, offers property tax credits to landowners.

- Municipalities can offer **incentives to developers** who use green infrastructure practices. Municipalities might offer to waive or reduce permit fees, expedite the permit process, allow higher density development, or provide exemptions from local stormwater permitting requirements. For example, Chicago's Green Permit Program reviews permits faster for projects that meet certain design criteria that include better stormwater management practices. Portland, Oregon's, Floor Area Ratio Bonus increases a building's allowable area in exchange for adding a green roof. Knox County, Tennessee, offers a credit to developers when impervious areas are disconnected from the stormwater control system via filtration/infiltration zones that are designed to receive runoff.
- Some municipalities offer **rebates or financing for installation of specific practices**. The types of financing help may include grants, matching funds, low-interest loans, tax credits, or reimbursements. For example, some communities subsidize the cost of rain barrels, plants, and other materials that can be used to control stormwater. Santa Monica, CA, offers rebates on rain barrels and redirecting rain gutter downspouts to permeable surfaces, such as landscaped areas. Other cities that offer financing or rebates for rain barrels and rain gardens include Palo Alto, CA; Rock Island, IL; Chicago; and Minneapolis.
- Community **award and recognition programs** can help to encourage local participation in green infrastructure projects. For example, some communities highlight successful green infrastructure sites by featuring them in newspaper articles, on websites, and in utility bill mailings. Examples include Chicago; Portland, OR; and King County, WA.

Philadelphia's *Green City, Clean Waters* Plan

Philadelphia has launched an ambitious, 25-year plan called *Green City, Clean Waters* to achieve compliance with the Clean Water Act by establishing binding targets to transform approximately 10,000 acres—about one-third—of the impervious area in combined sewer areas of the city into "greened acres," on which the first inch of rainfall from any given storm is managed on-site. The city plans to reach its goal through a combination of greened public spaces and regulatory changes intended to induce private investment in green infrastructure development. The plan has been formalized in a Consent Order and Agreement entered into by the city and the state of Pennsylvania in 2011 and an Administrative Order for Compliance and Consent between the city and EPA that was signed in October 2012. The city's overall long-term plans to control CSOs are estimated at $1.2 billion. The city has committed to expenditures of approximately $1 billion of green infrastructure to be implemented through the plan.

A key aspect of Philadelphia's plan is that it leverages private investment in green infrastructure to help satisfy CWA obligations. It will take advantage of stormwater improvements that private property owners will install over time, as private-sector redevelopment occurs and is subject to the city's on-site stormwater management rules. Philadelphia estimates that at a roughly 1% projected annual redevelopment rate, the stormwater rule requiring on-site management could generate 2,500 to 5,500 green acres in the city over 25 years. The balance of the greened acres would come from investments by the city in retrofits on publicly owned land, such as city properties, streets, and rights-of-way.

While green infrastructure practices may be more cost-effective in the long run, installation of technologies can require large up-front investment. Recognizing that fact, Philadelphia's stormwater utility fee system offers fee discounts to commercial property owners who reduce impervious area or otherwise manage runoff onsite. The incentive to property owners comes in the form of a credit against future stormwater fees for properties that install stormwater retrofits. Under the credit structure, the property owner receives a reduction in the monthly stormwater fee proportional to the amount of impervious area from which the entire first inch of runoff is managed onsite, up to 100% of the fee for management or retention of the first inch of stormwater over 100% of the impervious area of the site (a monthly minimum charge prevents stormwater fees from being reduced entirely). The plan provides that once a stormwater fee credit is approved by the Philadelphia Water Department, the fee reduction is fixed for a four-year period, at which point the property owner may reapply for the credit, based on a showing that the retrofit has been properly inspected and maintained and remains fully functional.

Source: Alisa Valderrama and Larry Levine, *Financing Stormwater Retrofits in Philadelphia and Beyond*, Natural Resources Defense Council, 2012, 34 p.

EPA Support for Green Infrastructure

EPA's support for green infrastructure was apparent in the 1990s, but was initially slowed by concern about how water quality improvements could be verified. An important concern is that, because compliance with the Clean Water Act is a legal matter, there is little room for an approach that cannot guarantee results.[21] By the mid-2000s, as reports increased of successful performance in U.S. cities, as well as examples of including green infrastructure solutions in MS4 permits and enforcement actions, EPA policies reflected growing endorsement. In 2007, EPA signed a memorandum of understanding with state water quality regulators, a group representing publicly owned wastewater utilities in large cities, and environmental groups to formalize the use of green technology approaches.[22] The agency subsequently issued a series of policy memos and released a Green Infrastructure Strategic Agenda in 2013 (see **Appendix B**). The 2013 Strategic Agenda, which updated earlier policy statements, identifies five major focus areas: federal coordination; CWA regulatory support; research and information exchange; funding and financing; and capacity building. Today, green infrastructure "is a clear priority for the administration."[23]

EPA has awarded funds to a number of communities to implement stormwater management through green infrastructure techniques. Since 2012, the agency has awarded grants ranging from $400,000 to $950,000 to 37 communities in 23 states for projects such as developing tools and guidance to identify green infrastructure opportunities and reviewing local codes and ordinances to identify barriers to green infrastructure.[24] In 2012, EPA announced a $4 million grant to the National Fish and Wildlife Foundation to administer a Green Infrastructure Showcase Project grant program in communities of the Chesapeake Bay region. The agency has been supporting research: in 2014, EPA awarded grants to five universities to evaluate innovative green

[21] Environmental Finance Center, University of Maryland, *Encouraging Efficient Green Infrastructure Investment*, January 15, 2013, p. 16.

[22] "Green Infrastructure Statement of Intent," April 19, 2007, http://water.epa.gov/infrastructure/greeninfrastructure/upload/gi_intentstatement.pdf.

[23] Paul Shukovsky, "EPA Official Says Green Infrastructure Investments Priority for EPA, White House," *Daily Environment Report*, November 16, 2012, p. DEN A-7.

[24] See http://water.epa.gov/infrastructure/greeninfrastructure/gi_support.cfm#CommunityPartnerships. Ten other communities were recognized by EPA in 2011 for their commitment to green infrastructure, but they did not receive grant awards.

infrastructure practices in urban areas, using Philadelphia as the pilot area. EPA also has supported research evaluating green infrastructure BMPs.

The Obama Administration's support for green infrastructure extends beyond EPA. Several other federal agencies administer programs that can assist green infrastructure projects, but none is as focused on green infrastructure and stormwater management as EPA.[25] For example, at the U.S. Department of Housing and Urban Development, the Office of Community Planning and Development administers programs that support a wide range of community initiatives; many communities have identified or used these programs to implement green infrastructure projects. Through its Energy Efficiency and Conservation Block Grant program, the U.S. Department of Energy encourages the use of green infrastructure techniques to improve energy efficiency in transportation, building, and other sectors. At the U.S. Department of Agriculture, the Forest Service focuses activities on urban sustainability including green infrastructure, urban forest sustainability, stormwater management, and smart growth.

The White House has shown interest and support, as well. EPA and the Council on Environmental Quality hosted a 2012 White House Conference on Green Infrastructure "to explore pathways to more broadly implement green infrastructure."[26] In 2013, the White House announced support for green infrastructure, saying that the administration would prioritize smart infrastructure to create jobs and build a strong future for U.S. cities and would align federal agency resources to aid municipalities in building and investing in green infrastructure.[27] Also in 2013, the White House held meetings that discussed financing water infrastructure improvements generally, including green and traditional gray approaches. Administration officials have promoted green infrastructure approaches as a way to help communities become more sustainable and their infrastructure more resilient in the face of changing climatic conditions.

EPA's Stormwater Rulemaking

An additional aspect of urban stormwater management with implications for green infrastructure is a rule that EPA intended to apply to developed and redeveloped sites in communities with municipal separate storm sewer systems (MS4s). As previously described, many communities already are subject to CWA regulation to prevent harmful pollutants from entering MS4 systems. The rule in part was intended to respond to a 2009 report of the National Research Council of the National Academy of Sciences that recommended major changes to EPA's stormwater control program in order to focus the program on the flow volume of stormwater runoff instead of just its pollutant load.[28] The rule also would respond to a 2010 settlement agreement between EPA and environmental litigants, which called for EPA to revise existing rules "to expand the universe of regulated stormwater discharges and to control, at a minimum, stormwater discharges from newly

[25] See Environmental Finance Center, University of Maryland, *Encouraging Efficient Green Infrastructure Investment*, January 15, 2013, 41 p.; and National Association of Regional Councils, "A Roadmap to Green Infrastructure in the Federal Agencies," http://narc.org/issueareas/environment/areas-of-interest/green-infrastructure-and-landcare/roadmap.

[26] See http://water.epa.gov/infrastructure/greeninfrastructure/whconference.cfm.

[27] Nancy Sutley and David Agnew, "Building the Future: Innovative Water Infrastructure," January 18, 2013, https://www.whitehouse.gov/blog/2013/01/18/building-future-innovative-water-infrastructure.

[28] National Research Council of the National Academy of Sciences, Water Science and Technology Board, *Urban Stormwater Management in the United States*, The National Academies Press, Washington, DC, 2009.

developed and redeveloped sites."[29] EPA worked to develop a regulatory proposal for several years but abandoned the effort in 2014.[30]

The proposal, referred to as the "post-construction rule," would set a first-time stormwater retention performance standard and provide regulated entities with several suggested compliance options, including green infrastructure techniques, to limit runoff that would otherwise enter an MS4 system. The rule was expected to be a good opportunity for cities to use green infrastructure techniques such as porous pavements and grassy swales to meet the performance standard alone or in combination with gray infrastructure. Also, incorporating controls during development and redevelopment is more cost-effective than managing stormwater as an after-the-fact problem. Requirements in the rule would be incorporated into MS4 permits as the permits come up for renewal. Support for the rule included environmental advocates and some state and local government representatives, including those who believed that it would provide needed uniformity and consistency in stormwater programs across the nation. Other groups, such as developers, criticized EPA's efforts, and some contended that a national rule would encroach on state and local regulation of land use.

During development of the rule, EPA reportedly considered standards that would require new construction and redevelopment to retain stormwater runoff from a range between the 80th to 95th percentile storm event for up to 24 hours after rainfall.[31] The concept would have sites retain an inch or so of water, although the exact volume required would vary depending on a region's typical rainfall. According to EPA, at least 15 states and the District of Columbia already have similar performance standards that the agency examined as models for the national rule.

Precedent for national performance standards to manage stormwater is reflected in legislation enacted in 2007. Section 438 of the Energy Independence and Security Act (EISA, P.L. 110-140) requires federal agencies to implement strict stormwater runoff requirements for development or redevelopment projects involving a federal facility in order to reduce stormwater runoff and associated pollutant loadings to water resources. It requires agencies to use site planning, construction, and other strategies to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property. To assist agencies in meeting these requirements, EPA was directed to prepare issued technical guidance. The guidance, issued in 2009, provides two options for meeting the performance objective of preserving or restoring the hydrology of a site: retaining the 95th percentile rainfall event (i.e., managing rainfall on-site for storm events whose precipitation total is less than or equal to 95% of all storm events over a given period of record), or site-specific hydrologic analysis (i.e., using site-specific analysis to determine predevelopment runoff conditions).

Under the 2010 settlement with environmentalists, EPA was initially due to propose a national rule by September 2011 and complete the rule in 2014. Subsequently, the deadlines were renegotiated several times. Under the last extension, EPA was to propose regulations by June 17, 2013, but EPA missed that deadline, and on June 18, the environmental plaintiffs notified the agency that it was in breach of the legal settlement. At that point, EPA and the plaintiffs had reached a legal impasse; EPA reportedly continued to work on the rule, while the environmental groups considered further legal action. Among the challenges that EPA faced in developing the

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[29] Fowler v. EPA, D.D.C. No. 1:09-cv-5, May 11, 2010, pp. 18-19.

[30] For additional information, see CRS Report 97-290, *Stormwater Permits: Status of EPA's Regulatory Program*, by Claudia Copeland.

[31] To illustrate, a 95th percentile rainfall event is one whose precipitation total is equal to or greater than 95% of all 24-hour storms on an annual basis.

post-construction rule were what range of percentiles to specify, whether to treat greenfield and redevelopment differently so that redevelopment is not disadvantaged, and whether to expand regulation beyond existing MS4 boundaries to include nearby developing areas or even entire watersheds. Delays in developing the rule reportedly partly involved preparing the rule's cost-benefit analysis, such as measuring the benefits of using green infrastructure techniques, similar to difficulties that many communities have had in evaluating green infrastructure options (see "Potential Challenges").

After nearly four years of work, in mid-March 2014, EPA announced that it would defer action on the rule and instead would provide incentives, technical assistance, and other approaches for cities to address stormwater runoff themselves. In particular, the agency said it would leverage existing requirements to strengthen municipal stormwater permits and continue to promote green infrastructure as an integral part of stormwater management.

Although EPA discontinued development of a national stormwater rule, the agency continues to pursue some of the ideas that the rule was expected to incorporate, such as emphasizing on-site retention of stormwater at construction sites or requiring green infrastructure, when individual MS4 permits come up for renewal. EPA is encouraging use of CWA permits to foster green infrastructure implementation, such as establishing standards for stormwater volume control for sites undergoing development or redevelopment.[32] Similar concepts are reflected, for example, in the MS4 permit for Washington DC, issued by EPA in 2013, and EPA's 2014 proposed MS4 general permit for Massachusetts; both were crafted by EPA, which is the NPDES permitting authority in DC and Massachusetts. In the majority of states, permitting authority has been delegated to states. In those cases, EPA and others (e.g., environmental groups) are encouraging states to strengthen the terms of MS4 permits with green infrastructure measures.

Congressional Interest

Congressional interest in these issues is reflected in legislation and oversight hearings in recent Congresses. In addition, as described previously, EPA appropriations acts since 2009 have directed a portion of funds that states receive for wastewater and drinking water improvements and upgrades to go to projects that address green infrastructure, water or energy efficiency, or other environmentally innovative activities.

Legislation titled the Innovative Stormwater Infrastructure Act of 2015 has been introduced in the 114th Congress to support research and implementation of green/innovative stormwater infrastructure (H.R. 1775/S. 896; and Title II, Subtitle C, of H.R. 2893/S. 1837). The legislation directs EPA to provide assistance to establish centers for excellence to conduct research on green/innovative stormwater infrastructure and authorizes development and implementation grants. It directs the EPA Administrator to ensure the promotion of green infrastructure in EPA offices and programs and would require. In addition, the legislation directs EPA to establish voluntary measurable goals, to be known as the "innovative stormwater control infrastructure portfolio standard," to increase the percentage of water managed using such techniques. Similar legislation was introduced in the 112th and 113th Congresses. Two other bills in the 114th Congress, S. 2768 and S. 2848, include provisions calling for EPA to promote green infrastructure.

[32] U.S. Environmental Protection Agency, *Stormwater*, Green Infrastructure Permitting and Enforcement Series: Factsheet 4, 2012, http://water.epa.gov/infrastructure/greeninfrastructure/upload/EPA-Green-Infrastructure-Factsheet-4-061212-PJ.pdf.

Federal funding for all types of water infrastructure is a long-standing issue in Congress. More generally, recent legislative proposals also have addressed existing CWA funding provisions to assist traditional water infrastructure projects, but not with a particular green infrastructure focus. For example, the 113th Congress enacted certain amendments to the CWA in the Water Resources Reform and Development Act (Title V of WRRDA, P.L. 113-121). The legislation allows use of CWA State Revolving Fund (SRF) monies "for measures to manage, reduce, treat, or reuse municipal stormwater," but it does not expressly mention green infrastructure.

In the 111th Congress, the House Transportation and Infrastructure Subcommittee on Water Resources held an oversight hearing on the growing use of green infrastructure. At the hearing, witnesses expressed some concern that green infrastructure enthusiasm by EPA, some local government officials, and environmental advocates may not be giving adequate attention to questions of cost—especially long-term maintenance costs—feasibility, and demonstrated environmental improvements.

The most specific legislative action on green infrastructure is reflected in recent EPA appropriations acts, which have mandated a set-aside from funds for clean water and drinking water SRF capitalization grants (see "Paying for Green Infrastructure").

Conclusion

Environmental advocates have recommended actions that Congress could take to encourage and support green infrastructure, including enactment of legislation to assist demonstration projects and help improve the knowledge base about performance, cost-effectiveness, and similar topics (see "Congressional Interest"). Some support legislation to require federally funded roads and highways to control runoff pollution to an objective retention standard (similar to provisions in the Energy Independence and Security Act of 2007 applicable to federal facilities). Environmental advocates also have supported legislation to authorize federal assistance for water and wastewater infrastructure investment, and on appropriations legislation to fully fund capitalization grants for State Revolving Funds, since these funds can be a vehicle for green infrastructure investments. States, too, support assistance through the SRF programs to finance green infrastructure projects, as reflected in a resolution adopted by the Environmental Council of States (ECOS), but they do not support prescriptive approaches that would mandate green infrastructure.[33]

The kinds of federal policies and programs favored by stakeholder groups do have associated costs—for example, costs for grant or other types of infrastructure assistance, or for EPA or other federal agencies to research green infrastructure practices, develop guidance and model codes, or provide technical and other types of information to decisionmakers. In the current budgetary context, securing funds for both existing and new programs is a significant challenge. Further, many who are hesitant about investing in green infrastructure approaches, such as some engineers, consultants, and water utility officials, argue that the risk and uncertainty over whether green infrastructure will truly help achieve water quality objectives also involve costs. Nevertheless, advocates argue that without funding for green infrastructure practices, the economic damages and water quality impacts of stormwater will be more costly than if such practices are supported.

[33] Environmental Council of States, "Advancing Green Infrastructure, Energy Efficiency and Clean Energy Production through Wastewater and Drinking Water Facilities," Resolution 09-8, August 27, 2012.

Appendix A. Selected Green Infrastructure Practices

The images below illustrate some green infrastructure practices and techniques being utilized by cities.

Figure A-1. Green Roof in Chicago

Source: National Geographic Magazine, "Up on the Roof," May 2009.

Note: Green roofs use vegetated roof covers, with growing media and plants covering or taking the place of shingles or tiles.

Figure A-2. Rain Garden

Source: Water Environment Research Federation.

Note: Rain gardens are shallow landscape areas that can collect, slow, filter, and absorb large volumes of water, evaporating water through plant transpiration and delaying discharge into the wastewater system.

Figure A-3. Vegetated Swale

Source: Water Environment Research Federation.

Note: Vegetated swales are shallow landscaped areas designed to capture, convey, and potentially filter stormwater as it moves downstream and percolates into groundwater.

Figure A-4. Infiltration Planter

Source: Lawrence Berkeley National Laboratory, Campus Planning and Design Guidelines.

Note: Infiltration planters are narrow landscaped areas framed within hardscape. They are flat-bottomed with vertical walls to allow for more retention capacity in less space. Infiltration planters allow water to infiltrate, while flow-through planters are preferable in areas of high groundwater or where soil is impermeable or contaminated. Flow-through planters have an underdrain system beneath an imported soil bed to provide detention and filtration before discharging offsite.

Figure A-5. Permeable Pavement

Source: Water Environment Research Federation.

Note: Pervious paving allows rainwater to pass through the surface and soak into the ground. It may be arranged with open space so that water can drain and grass can grow.

Figure A-6. Constructed Wetland for Stormwater Management

Source: Lake County Illinois Stormwater Management Commission.

Note: A stormwater wetland drains stormwater, removes pollutants, and provides habitat and aesthetic benefits.

Appendix B. Selected Green Infrastructure Bibliography

The following references are a representative selection of the growing literature on green infrastructure. Many include case studies.

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Noah Garrison and Karen Hobbs, *Rooftops to Rivers II, Green Strategies for Controlling Stormwater and Combined Sewer Overflows*, Natural Resources Defense Council, 2011, 134 p.

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Center for Neighborhood Technology and American Rivers, *The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environment and Social Benefits*, 2010, 80 p.

Charles T. Driscoll, Caitlin G. Eger, David G. Chandler, et al, *Green Infrastructure: Lessons from Science and Practice*, a publication of the Science Policy Exchange, June 2015, 32 p.

Environmental Finance Center Network, *Green Infrastructure Resource Directory*, June 2012, 11 p.

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U.S. Environmental Protection Agency, *Low Impact Development (LID) "Barrier Busters" Fact Sheet Series*, a seven-part series of fact sheets for state and local decisionmakers, http://water.epa.gov/polwaste/green/bbfs.cfm.

U.S. Environmental Protection Agency, *Green Infrastructure Permitting and Enforcement Series*, six factsheets plus four supplemental materials on integrating green infrastructure concepts into permitting, enforcement, and water quality standards actions, at http://www.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm.

U.S. Environmental Protection Agency, *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*, EPA 841-F-07-006, December 2007, 30 p.

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U.S. Environmental Protection Agency, *Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control*, EPA 832-R-14-001, March 2014, 38 p.

Benjamin Grumbles, Assistant Administrator, EPA Office of Water, memorandum, "Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs," March 5, 2007, 2 p.

Linda Boornazian, Director, EPA Water Permits Division, and Mark Pollins, Director, EPA Water Enforcement Division, memorandum, "Use of Green Infrastructure in NPDES Permits and Enforcement," August 16, 2007, 2 p.

Nancy Stoner, Acting Assistant Administrator, EPA Office of Water, and Cynthia Giles, Assistant Administrator, EPA Office of Enforcement and Compliance, memorandum, "Protecting Water Quality with Green Infrastructure in Water Permitting and Enforcement Programs," April 20, 2011, 5 p.

Additional EPA and other resources on green infrastructure can be found at http://water.epa.gov/infrastructure/greeninfrastructure/index.cfm#tabs-6.

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