GREEN INFRASTRUCTURE

status report

University of Pittsburgh
Institute of Politics
Infrastructure Policy Committee

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LETTER FROM THE INFRASTRUCTURE POLICY COMMITTEE COCHAIRS

DEAR COLLEAGUES:

Southwestern Pennsylvania is endowed with an abundance of some of the freshest and cleanest water in the country. However, while this abundance allows our region to reliably fulfill all of our water needs, it also places a greater burden on us to responsibly handle this resource.

Since the passage of the 1972 Clean Water Act, our region and many across the country have made tremendous progress in protecting precious water resources, making them the safest and cleanest possible. However, in light of frequent wet weather events, aging sewer infrastructure, and changes in our region's land use development, Southwestern Pennsylvania still has a long way to go in order to meet full environmental compliance.

As many in the region are aware, in 2008, due to the severity of our region's sewer overflow problem, the United States Environmental Protection Agency, the Pennsylvania Department of Environmental Protection, and the Allegheny County Health Department placed the Allegheny County Sanitary Authority (ALCOSAN) under a consent decree. The decree required ALCOSAN to develop and implement a plan for eliminating sanitary sewer overflow and reducing the frequency of combined sewer overflow in order to comply with the Clean Water Act.

In 2013, ALCOSAN released its Wet Weather Plan, addressing the concerns put forward by the consent decree. The recommendations found within the plan include expansion of its current facility, installation of a retention basin, storage tunnels, and a number of new conveyance lines. Overall, the plan is thought to be the largest and most expensive infrastructure related project that the region has ever seen, estimated to cost upwards of $2 billion.

Meanwhile, green infrastructure initiatives have gained popularity across the nation as regions increasingly face these types of complicated problems related to providing clean, reliable water for drinking and recreational activities. Green infrastructure is seen as a sustainable approach to water management that can mitigate many of the impacts that wet weather events cause. These types of infrastructure initiatives can help to divert excess stormwater from entering streams, rivers, or the sewer system.

Because of its ability to help alleviate some of the issues related to our region's water management issues, green infrastructure has become a high priority for policy makers, elected officials, and other organizations committed to providing safe, clean, and reliable water to residents of Southwestern Pennsylvania.

In the summer of 2014, the Institute of Politics Infrastructure Policy Committee determined it was necessary to do a report on the status of green infrastructure initiatives in the region. The committee was interested in examining the benefits of green infrastructure, especially related to water management, as well as the economic, social, and environmental benefits derived from green infrastructure installation. Additionally, the committee wanted to further understand the challenges and barriers associated with green infrastructure expansion in the region, primarily related to design, maintenance, cost, and requirements of installation.

After months of background research on green infrastructure designs and interviews with a variety of stakeholders working on green infrastructure-related initiatives in the region, the committee reached consensus on a variety of recommendations for the region moving forward. The recommendations revolve around increased research and planning around green infrastructure initiatives, as well as further engaging the public in dialogue and educational activities related to green infrastructure.

We hope you find this document to be educational and beneficial. As always, we welcome your comments and feedback. Our hope is that this report will contribute to further constructive discussions related to policy around green infrastructure initiatives in this region now and into the future.

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1. EXECUTIVE SUMMARY

The passage of the 1972 Clean Water Act transformed American rivers and streams from industrial dumping grounds into waterways suitable for drinking, navigation, and recreation. Despite years of progress, however, the work of protecting and maintaining Southwestern Pennsylvania's most vulnerable waterways is far from complete. Frequent rainfall and outdated sewer infrastructure produce a set of hazardous conditions that degrade waterways and threaten human health. As a result, many communities throughout the region fall short of environmental compliance. As regulators converge on Southwestern Pennsylvania, residents and regional leaders are seeking a sustainable, cost-effective solution to their wet weather crisis.

Traditionally, gray infrastructure—the system of underground pipes and tanks that conveys wastewater to sewage treatment facilities—was considered the only reliable means of preventing polluted stormwater from entering rivers and streams. Recently, however, a reliable and natural alternative has emerged. Green infrastructure, an approach that aims to replicate natural hydrologic processes by managing stormwater where it falls, could offer an alternative to the reliance upon costly, large-scale gray infrastructure expansion. Beyond its water management function, green infrastructure offers a number of community benefits, including its ability to improve neighborhood aesthetics, increase property values, provide cleaner air, moderate temperatures, reduce crime, and generate community engagement.

Local champions of green infrastructure hail from academia, philanthropy, government, and the community—and their numbers are growing. These regional leaders and their vision for Southwestern Pennsylvania have hastened the development of green infrastructure throughout the region, producing a number of innovative projects strategically located in areas of high need. Despite their efforts, however, green infrastructure remains concentrated in small pockets of the region. Realizing the full benefits of green infrastructure requires community buy-in and a strategic watershed-based approach to planning and installation. Before green infrastructure can be considered a feasible and reliable alternative to gray infrastructure, green experts must precisely quantify its costs and benefits and formalize approaches to design and installation that are region specific. When these benefits and technologies are better understood, regional leaders can begin the work of bringing green technologies to every community in the region.

Developing a green infrastructure industry in Southwestern Pennsylvania will take time. Successful implementation requires up-front investments in research, planning, and community engagement. Green technology must be proven and trusted before it can be widely applied. This report recommends that Southwestern Pennsylvania pursue green infrastructure in two distinct phases: first, research and planning, and second, engagement and expansion.

STEPS FORWARD: RESEARCH AND PLAN

1) Convene a regional green infrastructure planning group.
2) Test green infrastructure effectiveness by instituting standardized monitoring and reporting for all new green infrastructure projects.
3) Develop a region-specific protocol for green infrastructure design and installation that culminates in project certification.

STEPS FORWARD: ENGAGE AND EXPAND

1) Generate public support for green infrastructure through a media campaign.
2) Harness growing interest in stormwater fees by enacting a watershed-based utility program that directs resources toward strategic, sustainable, and cost-effective projects.
3) Develop incentives for private installation of green infrastructure through municipal code updates and stormwater credits programs.
4) Provide incentives for municipal source reduction by instituting flow targets.

2. WATER ABUNDANCE IN SOUTHWESTERN PENNSYLVANIA: A RESOURCE AND A BURDEN

"We are fortunate to have wonderful environmental resources: a dependable supply of clean, fresh water and beautiful green spaces. To assure that development is sustainable, it is critical that we understand the resources we have, what should be protected, what can be developed, and what should be changed."

– **Rose Reilly,** Pittsburgh District, U.S. Army Corps of Engineers

The Southwestern Pennsylvania region spans hundreds of streams, rivers, and lakes. The region's position at the headwaters of the Ohio River watershed ensures that it regularly receives some of the freshest, cleanest water in the country. While other regions rely entirely on upstream neighbors to responsibly manage and maintain water supplies, the quality of Southwestern Pennsylvania's water depends, in large part, on the responsible decision making of its local officials and community leaders. To provide residents access to healthy drinking water and clean recreational waterways, Southwestern Pennsylvania has a special responsibility to protect and maintain the region's greatest natural resource: its water.

At a time when much of the American West grapples with severe water shortages, Southwestern Pennsylvania is endowed with reliable water abundance. While this abundance allows Southwestern Pennsylvania to fulfill all of its water use needs, it creates a set of problematic conditions that threaten the health and safety of residents. Frequent wet weather events, changes in land use, and aging sewer infrastructure have produced an array of economic, health, and environmental concerns for the region. In particular, heavy localized rainfall can result in hazardous flooding, erosion, stream impairment, or sewer overflows.

2.1 FLOODING AND EROSION

Heavy rainfall can produce destabilizing erosion and dangerous flooding. Due to its topography and dense clay soils, Southwestern Pennsylvania is naturally flood prone. This vulnerability is exacerbated by recent land development that has replaced much of the natural, pervious ground cover with concrete and asphalt, further increasing flood risk. These hard surfaces prevent precipitation from slowly seeping into the groundwater and act as rainwater accelerators, rapidly moving water into roadways or creek beds. This dangerous combination of increased water volume and velocity erodes hillsides and stream banks, fills waterways beyond capacity, and produces catastrophic flooding.

Climate change is likely to amplify severe weather, producing an increased probability of major storms accompanied by major flooding. These shifting weather patterns, carrying high-intensity and frequent rainfall, could prove costly and dangerous to a region already vulnerable to flooding. Currently, the Pennsylvania Emergency Management Agency estimates that a 10-year storm in Allegheny County would cost $7 million in building loss and displace 24,000 residents, while a 100-year storm would produce nearly $10 million in damage and displace 32,000 residents.[1] (A 100-year storm refers to rainfall totals that have a 1 percent probability of occurring at that location in that year. In other words, there is a 1 in 100 chance that a storm will reach this intensity in any given year.) These costs are disproportionately borne by residents of floodplains and other low-lying areas. For example, in 2004, the communities of Millvale, Carnegie, and Etna suffered particularly destructive flooding during the heavy rainfalls that accompanied Hurricane Ivan. In Allegheny County alone, nearly 5,000 property parcels were deemed flood damaged in the aftermath of the storm.[2] In addition to the direct impacts on affected residents and business owners, these events can increase insurance rates, depress nearby property values, and require greater community investment in government aid and relief programs.

2.2 WATERWAY IMPAIRMENT

Water abundance in Southwestern Pennsylvania also affects water quality by driving polluted runoff into area streams, lakes, and rivers, even during modest rainfalls. When rainfall encounters an impervious surface, rather than infiltrating the groundwater, it collects pollutants and carries them into nearby waterways. This transfer of pollutants from impervious surfaces to streams, lakes, and rivers is known as nonpoint source (NPS) pollution. NPS pollution often is attributed to urban runoff, which carries oil, metals, chemicals, salt, and sediments into nearby waterways, and agricultural runoff, which contributes pesticides, fertilizer, and animal waste. NPS pollution results in significant stream and river impairment, which renders waterways unsuitable for recreation, poses a threat to aquatic life, and places municipalities out of compliance with the Clean Water Act.

Pennsylvania has 6,957 impaired waterways, more than any other state in the country and nearly three times as many as the next worst offender, Michigan.[3] In Southwestern Pennsylvania, approximately 6,500 miles of streams and rivers are deemed impaired by the Pennsylvania Department of Environmental Protection.[4] As a result, many local communities must comply with total maximum daily load (TMDL) requirements, which cap pollutant levels to ensure that waters meet quality standards. Because TMDL goals are set for an entire stream or river, restoring impaired waterways requires cooperation among all communities within a watershed.

2.3 SEWER OVERFLOWS

In addition to pollutant runoff and other forms of nonpoint source pollution, overflows of the sewer system can significantly degrade water quality by allowing wastewater to flow, untreated, into rivers and streams. When sewer pipes are filled to capacity during a rainstorm, they release excess water directly into surrounding waterways. This discharge is composed of rainwater and sanitary sewage material, a hazardous mix that can imperil the health of humans and aquatic life. Water quality impairment caused by direct discharges into a body of water are known as point source pollution.

Overflows can occur in sanitary sewers (systems in which stormwater is separated from sanitary sewage) or in combined sewers (systems in which these flows are merged). Combined sewer overflows (CSOs) are most common because many combined sewers were designed to accept rainwater but not built to accommodate the rapid influx of water that accompanies a storm. Though less common, sanitary sewer overflows (SSOs) occur when rainwater infiltrates sanitary pipes or enters the system through downspout inflows. Inflow and infiltration can quickly overwhelm a sanitary system and produce particularly

hazardous overflows. Following a CSO or SSO, residents are advised to avoid polluted waters and refrain from recreational activities like swimming, fishing, or boating.

Overflows occur frequently in Southwestern Pennsylvania and have a significant impact on regional water quality. The Allegheny County Health Department, which monitors overflows, issues advisories for approximately 70 days of the year as a result of overflows throughout the county.[5] Each year, an estimated 16 billion gallons of storm and wastewater are discharged through CSOs and SSOs in Southwestern Pennsylvania.[6]

3. STORMWATER SOLUTIONS

Effectively managing stormwater is costly. Reducing flooding, erosion, stream impairment, and sewer overflow requires a blend of larger, systemwide investments and smaller, localized projects. Traditionally, the gray infrastructure system was solely responsible for managing stormwater through its underground network of pipes, storage tanks, and conveyance lines. Southwestern Pennsylvania's gray infrastructure network is vast, but the region's stormwater management needs have exceeded the capacity of the existing system. The pipes cannot hold back overflows and often fail to capture and divert floodwaters or polluted runoff. By investing in holding tanks and larger sewer lines, Southwestern Pennsylvania municipalities and sewer authorities can reliably expand the capacity of the entire system, allowing more stormwater to enter sewers before an overflow occurs. Although gray infrastructure offers the potential for large-scale expansion and precise project planning, a gray approach to water management costs billions of dollars and may not address all stormwater management needs.

The ALCOSAN Wet Weather Plan

In 2008, due to the severity of the region's sewer overflow problem, the U.S. Environmental Protection Agency (EPA), Pennsylvania Department of Environmental Protection (DEP), and Allegheny County Health Department (ACHD) placed the Allegheny County Sanitary Authority (ALCOSAN) under a consent decree. This decree required ALCOSAN to develop and implement a plan for eliminating sanitary sewer overflow and reducing the frequency of combined sewer overflow in order to comply with the Clean Water Act. The consent decree followed a set of 2004 DEP consent orders that required the 83 municipalities in the ALCOSAN service area to submit individual wet weather plans detailing their efforts to manage stormwater by inspecting and upgrading segments of sewer pipe that fall under their municipal jurisdiction.

ALCOSAN plant. Photo courtesy ALCOSAN

In 2013, in response to the consent decree, ALCOSAN issued its Wet Weather Plan, which features an exclusively gray approach to water management. ALCOSAN's initial assessment of the costs of EPA compliance determined that a $3.6 billion gray infrastructure overhaul was required to achieve full environmental compliance. However, that initial plan was deemed unaffordable and ALCOSAN had to revise its Wet Weather Plan, scaling back its planned gray infrastructure projects.

To reduce CSOs and SSOs, ALCOSAN plans to expand its current treatment facility and install a large retention basin, several storage tunnels, and a number of new conveyance lines. This updated plan is estimated to cost a total of $2 billion by 2026, $575 million of which will be financed by municipalities. ALCOSAN expects that the $2 billion cost will be funded, in part, by increases to ratepayers. In many communities, this will mean that costs of sewage treatment will draw 2–3 percent of median household income.[7]

The ALCOSAN case demonstrates the scope and cost of expanding a gray infrastructure network for the purpose of CSO and SSO reduction. However, gray infrastructure investments of this kind do not necessarily address all stormwater needs and may neglect stormwater runoff, flooding, and erosion.

Green infrastructure offers an alternative to gray-only methods of stormwater management. While the gray approach is rooted in the belief that quickly removing and transporting stormwater is the best means of reducing risk to a community, green infrastructure aims to slow the movement of water and capture it on site in order to lessen stormwater impacts. Green infrastructure is composed of a set of sustainable engineering practices that can capture precipitation effectively, filter polluted runoff, or recharge the groundwater. Green projects are implemented at a smaller scale than gray but often are less expensive to install and offer multiple environmental, economic, and societal benefits. Green infrastructure alone may not remedy the region's wet weather concerns, but if used alongside gray infrastructure, it has the potential to reduce many of the health, safety, and environmental impacts of heavy rainfall.

4. WHAT IS GREEN INFRASTRUCTURE?

Green infrastructure is a sustainable approach to water management that can mitigate many of the impacts of wet weather by capturing and managing rainfall on site. Effective green infrastructure projects divert excess stormwater and prevent it from entering streams, rivers, or the sewer system.

A Green Infrastructure Toolbox

The technologies detailed below represent a toolbox of effective water management strategies. Although each tool manages water differently, all aim to replicate natural processes by containing water on site or guiding it toward nearby soil or vegetation. While no single tool will address all stormwater impacts, employing a number of these tools strategically and allowing them to complement one another can improve water quality and reduce the quantity entering sewers, streams, and rivers.

1) Permeable Paving

Photo courtesy 3 Rivers Wet Weather

Permeable paving aims to replace impenetrable ground cover, such as concrete and asphalt, with a surface that allows water to infiltrate the soil and the groundwater below. While traditional road surfaces accelerate runoff and contribute pollutants to nearby rivers and streams, permeable surfaces capture stormwater where it falls and allow it to slowly seep into the ground. Permeable paving surfaces are designed with several layers of rock and gravel to purify water and ensure the integrity of the water table. Replacing impermeable surfaces with green paving solutions, where appropriate, can reduce the burden on storm sewers and improve water quality.

2) Bioswales

Photo courtesy 3 Rivers Wet Weather

Bioswales are installed to capture, filter, and purify stormwater runoff. Swales often are located near roadways or parking lots where pollutants tend to accumulate. Bioswales often resemble trenches and are designed with sloping sides to draw rainwater toward filtration features. Bioswales rely on thick vegetation and layers of gravel and soil to slow the movement of stormwater, filter pollutants, and direct precipitation into the ground. Commonly, designers fill swale basins with hardy native plants to reduce the need for extensive maintenance. However, bioswales can be susceptible to damage and erosion, requiring some routine upkeep. Bioswales are a natural approach to reducing the concentration of pollutants in the groundwater and in rivers, lakes, and streams.

Photo courtesy 3 Rivers Wet Weather

3) Rain Gardens

Rain gardens are effective tools for stormwater capture and filtration. They can accept large volumes of polluted runoff and are filled with the soil, sand, and vegetation necessary to remove pollutants and recharge the groundwater. Rain gardens are typically constructed in shallow basins or depressions in the natural landscape where rainwater collects. The presence

of a heavily vegetated rain garden slows the movement of stormwater and draws it toward the roots, sand, and soil below. Rain gardens work well in urbanized settings because they can effectively filter pollutants and can be integrated into existing landscape features. Like swales, however, they require routine maintenance to remove debris buildup and to nurture plants. Rain gardens can improve water quality naturally and capture stormwater before it enters the sewer system.

4) Green Roofs

Photo courtesy Allegheny County

Green roofs are an approach to stormwater management suitable for highly developed urban areas. They are typically constructed on large, flat roofs using sand, gravel, soil, and native plants. Although green roofs capture less stormwater than other green technologies, they are an effective solution in urban centers where traditional methods of groundwater infiltration are costly or impractical. Green roofs allow building owners to capture stormwater and direct it toward the cultivation of small native plants. Due to the use of dense vegetation, green roofs have the potential to improve local air quality and moderate elevated urban temperatures.

5) Retention Ponds

Retention ponds can reduce the volume of rainwater entering sewers, rivers, and streams by collecting and holding water that falls on site. Retention ponds are strategically placed, often near a protected body of water, to capture pollutant-laden stormwater before it reaches the waterway. The banks of retention ponds are lined with vegetation to support the water purification process and to improve the aesthetics of the pond area. Due to their size requirements, retention ponds are more common near farmland or in areas of sparse development. Retention ponds can serve as aquatic habitats while purifying rainwater and offering effective flood management.

6) Tree Groves

Trees can counteract many of the negative environmental impacts of development. They work to purify air, lower temperatures, beautify neighborhoods, and manage stormwater. Mature trees, in particular, are effective at capturing and retaining rainwater. A tree's underground tangle of roots can slow the movement of water and direct flows toward tree growth. Groves are a popular approach to stormwater management because they offer numerous community and environmental benefits; however, trees require an investment of space and the time to reach full maturity.

7) Rainwater Harvesting

Rainwater harvesting refers to methods of capturing and retaining rainwater for future use. Rain barrels or cisterns are commonly used to harvest and retain rainwater, preventing it from entering the sewer system. Rainwater harvesting systems are typically fed by downspouts and, therefore, can only collect water that falls on the roof of a home or building. Water capture also is limited by the storage capacity of a barrel or cistern, and to function most effectively, rain barrels must be drained between rain events. When rainwater-harvesting systems are well maintained, they support stormwater management goals by retaining excess water. They also may reduce a property owner's water usage by providing a source of nonpotable water for activities like watering plants or washing cars.

8) Stream Daylighting

Stream daylighting is the process of returning previously buried streams to their natural state. During periods of urban development, it was common for natural streams to be enclosed and directed through underground channels into the sewer system. Piping natural streams prevents them from performing a stormwater capture function. Replacing natural soil, stone, and vegetation with pipes, tunnels, and culverts accelerates flooding and increases the volume of water in an overburdened sewer system, contributing to overflows. Daylighting is a green infrastructure tool because it can effectively divert and slow the movement of stormwater.

4.1 THE BENEFITS OF GREEN INFRASTRUCTURE

In the coming years, climate change will increase the frequency and severity of wet weather events throughout Southwestern Pennsylvania. Although gray infrastructure updates will be necessary to keep pace with these changes, green infrastructure can offer a number of benefits that can safeguard the health of residents and wildlife. Green infrastructure is considered a sustainable solution because it aims to balance human needs with the restoration of natural processes that protect against environmental degradation. Sustainable projects are designed to exhibit resilience in the face of development and environmental change, and a hallmark of sustainable development is its ability to offer enduring benefits to the environment and to society. In performing its stormwater management function, green infrastructure succeeds in providing communities with additional social, economic, and environmental benefits.

4.1.1 WATER MANAGEMENT BENEFITS

Flooding and erosion, stream impairment, and sewage overflows are serious concerns in Southwestern Pennsylvania. Fortunately, green infrastructure projects are designed to mitigate each of these stormwater impacts. Green infrastructure will likely never supplant gray infrastructure, but it may reduce the need for gray infrastructure expansion and support water management goals not addressed by gray infrastructure alone.

FLOODING AND EROSION MITIGATION

Green infrastructure has been shown to reduce the severity of flooding during a wet weather event. Flooding typically occurs when significant stormwater runoff coalesces in basins or valleys. The presence of green infrastructure interrupts these water flows and draws them into the ground. By reducing the volume and speed of moving water, green projects can lower a flood's high water mark and help to prevent the rapid surge of flash flooding. Green infrastructure also can mitigate basement flooding by drawing stormwater away from buildings and slowing water movement through the ground.

WATER PURIFICATION

Gray infrastructure requires that stormwater be processed through a sewage treatment plant in order to be purified. This process uses energy, at a cost that is passed on to ratepayers. By contrast, green infrastructure removes pollutants naturally; purification occurs when plants absorb stormwater runoff and neutralize pollutants through their biological processes or when stormwater filters through layers of soil, sand, and rock. These materials can break down pollutants and separate them from water molecules, allowing pure water to merge with groundwater below.

SEWER BURDEN REDUCTION

Green infrastructure also improves regional water quality by reducing the volume of stormwater entering an overburdened sewer system. By capturing, retaining, and infiltrating stormwater, green infrastructure can hold back peak flows, curbing the frequency and severity of sewer overflows. Green infrastructure can support both CSO and SSO reduction by impeding the flow of water into combined sewer drains and reducing sanitary sewer inflow through redirected downspout flows.

4.1.2 ECONOMIC, SOCIAL, AND ENVIRONMENTAL BENEFITS

Green infrastructure often is assessed through a water management lens. Although this is reasonable in regions like Southwestern Pennsylvania, where stormwater impacts and environmental compliance are chief concerns, decision makers also must consider green infrastructure's numerous additional benefits. Communities that invest in green infrastructure can secure a number of economic, environmental, and social benefits for their residents. These are referred to as triple bottom line benefits. The triple bottom line, a concept central to the sustainability movement, contends that monetary cost/benefit calculations are no longer sufficient as a measure of a project's viability because they fail to consider a project's impact on the environment and society. Green infrastructure should be evaluated using a triple bottom line framework that accounts for its economic, social, and environmental benefits.

ECONOMIC BENEFITS

Unlike gray infrastructure, green infrastructure projects exist aboveground and are built using natural materials like trees, ponds, stones, and small plants. If well maintained, these green projects can beautify a community, engage and connect residents, and offer spaces for recreation. In urban centers experiencing population decline, replacing abandoned homes and empty lots with green infrastructure can improve community aesthetics and increase property values. This process, known as "rightsizing," has the potential to stabilize real estate markets and improve the appearance of a neighborhood.[8] A study conducted at the University of Wisconsin–Milwaukee's Center for Economic Development examined several commercial and industrial districts in Milwaukee. Holding other factors constant, researchers found that the addition of green infrastructure near the study area raised property values by between 5.8 percent and 20.4 percent.[9]

Similar to the effects of urban green infrastructure on property values, the use of low-impact development strategies has been shown to increase home prices in suburban communities. The U.S. Environmental Protection Agency (EPA) observed this

phenomenon in Sherwood, Ark., where green infrastructure elements were integrated into the construction of a new housing complex. Developers selected several low-impact techniques, including narrowed streets and natural stormwater drainage. These features increased property values by an average of $3,000 and reduced building costs by approximately $4,000 per unit.[10]

SOCIAL BENEFITS

While gray infrastructure exists out of sight and underground, green infrastructure is visible and publicly accessible. It is composed, largely, of natural materials such as plants, trees, or stones, which beautify a community. By improving neighborhood aesthetics and carving out designated green space, green infrastructure can encourage outdoor play and recreation and improve resident safety.

A study conducted in a Chicago housing project observed children at play and levels of adult supervision in a number of outdoor spaces throughout the apartment complex, each with varying vegetation densities. In low-vegetation spaces with hard surfaces, researchers found fewer children playing or adults supervising. When they examined comparable highly vegetated lots, they found twice as many adults and double the number of engaged children.[11] The study suggests that creating green spaces within urban communities may encourage recreation among adults and their children.

Creating outdoor spaces also can improve the safety of a community. When green spaces are populated by residents of all ages, crime tends to fall due to heightened scrutiny and community connectedness. For this reason, the presence of green space has been linked to lower incidence of crime. A study conducted by the University of Illinois at Urbana-Champaign compared crime rates among comparable Chicago apartment buildings with differing amounts of green space. Researchers found that within the same housing project, buildings with access to vegetation had lower rates of property and violent crime, suggesting that the presence of greenery, and its social influences, may deter criminal activity.[12]

ENVIRONMENTAL BENEFITS

In addition to its primary purpose of water quality improvement, green infrastructure offers communities a number of ancillary environmental benefits. The natural materials used in green infrastructure have the potential to improve air quality, moderate summer heat, and provide habitats for wildlife.

Urban environments experience poor air quality due to smog and concentrated particulates. This phenomenon is quite pronounced in Allegheny County, where, according to a 2013 University of Pittsburgh study, cancer risk due to hazardous air pollution is higher than in 98 percent of counties in the nation.[13] Green infrastructure projects that feature vegetation have the potential to improve nearby air quality by absorbing pollutants and releasing oxygen. Moreover, many green infrastructure projects are intentionally located along roadways. In high-traffic areas where vehicle emissions degrade air quality, the presence of vegetated rain gardens or bioswales may mitigate some of these impacts. This view is supported by an EPA study in which researchers found that placing vegetation along roadways can improve air quality and human health.[14]

In addition to poor air quality, densely populated communities experience elevated air temperatures. Additional warm air is generated by human activity and held near to the ground by air pollution and the heat-absorbing properties of roads and buildings. Green infrastructure and its vegetation can help to mitigate elevated air temperature by offering shade, capturing energy from the sun to evaporate moisture, and replacing traditional ground cover with a less heat-absorbent alternative. In fact, a study of Los Angeles' heat island phenomenon found that vegetation is as effective as a white reflective surface at reducing urban air temperatures.[15] As summer temperatures are driven to extremes by climate change, green infrastructure's ability to mitigate urban heat could reduce energy costs and protect human health.

Air pollution and elevated temperatures are just two symptoms of urbanization and rapidly changing land use. These shifts also can threaten native species by altering their natural habitats. Some green infrastructure projects can reestablish these habitats by providing wildlife with access to water, vegetation, and shelter. Wetland restoration projects are most effective at creating an environment where plants and animals can thrive, but green roofs, rain gardens, bioswales, and retention ponds, if well maintained, also can serve as suitable habitats for many small plants and animals.[16]

4.2 THE CHALLENGES OF GREEN INFRASTRUCTURE

Though green infrastructure offers clear benefits, it remains a nascent and developing technology. While gray infrastructure installation is fairly standardized and routine, green infrastructure requires greater design flexibility and retains a potential for error and inefficiency. In many regions, green infrastructure is beset by four major concerns: design challenges, perpetual maintenance, costly experts and materials, and rigorous site requirements.

4.2.1 DESIGN CHALLENGES

Local conditions can present designers and engineers with a unique set of challenges. One such challenge in Southwestern Pennsylvania is the effect of winter weather. The Green Infrastructure Network, a group composed of landscape architects, engineers, and other regional leaders, is seeking solutions to the challenges of designing and installing green infrastructure that can withstand severe winters. While the strain of freezing and thawing may damage green materials, the widespread use of salt on roadways and sidewalks poses an even greater threat to the durability of green infrastructure. For example, following the winter of 2013–14, green infrastructure designers at the Environment and Energy Community Outreach Center in the Pittsburgh neighborhood of Larimer found much of their pervious concrete deteriorating and peeling due to contact with salt. They also noticed that many plants had been damaged by road salt carried into the center by foot traffic. Although winter damage can be repaired, true sustainability requires improvements in techniques and materials that can ensure green infrastructure functions well year-round.

Green infrastructure project designers in Southwestern Pennsylvania also face the region-specific challenge of infiltration. The dominant soil in Southwestern Pennsylvania, clay, is characteristically dense. The presence of this less porous soil throughout the region reduces the speed of stormwater infiltration into the groundwater. Although clay soils do allow infiltration, these highly dense soils limit the volume and rate of stormwater capture. This presents a challenge to green infrastructure designers, who may be required to modify projects to suit local soil conditions. In clay soils, some engineers choose to deepen basins, select vegetation with longer roots, or install holding tanks to increase water capture potential.

In addition to the presence of clay soils, former industrial sites known as brownfields pose a particular challenge to green infrastructure in the region. Brownfield industrial sites typically contain soils that have been deemed to be contaminated. There are dozens of brownfield sites throughout Southwestern Pennsylvania, many located along waterways, and, increasingly, these sites are selected for redevelopment. Although developers may consider green infrastructure a strategy for managing stormwater on a brownfield site, infiltration-based projects are not always appropriate. Infiltrating stormwater can allow hazardous materials to leach into the groundwater or nearby waterways. This concern was present during the development of the South Shore Riverfront Park along the Monongahela River in Pittsburgh. The park and a nearby shopping center occupy a former Jones and Laughlin Steel Company site that was designated a brownfield. Designers aiming to incorporate green infrastructure into park features were careful to avoid any infiltration that would have risked disrupting soil contaminants.

Although the soils and brownfield sites of Southwestern Pennsylvania pose a challenge to green infrastructure design, natural water management still is possible in areas where infiltration is limited or prohibited.

4.2.2 PERPETUAL MAINTENANCE

Green infrastructure, like gray, requires ongoing maintenance to function optimally, and nearly every green infrastructure project demands consistent upkeep. For instance, rain gardens and bioswales located near roadways tend to fill quickly with trash and debris, reducing their ability to capture and filter stormwater. Similarly, projects that rely on vegetation require significant initial maintenance to allow new plants to take root. Even rain barrels and cisterns must be maintained by draining captured stormwater after every rain event. A 2009 study of stormwater management best practices found that sediment buildup, litter and debris, pipe clogging, and invasive vegetation were chiefly responsible for project underperformance.[17]

Although upgrades are necessary for project efficiency, not all green infrastructure projects have a plan for funding ongoing maintenance. A 2013 study by the EPA Office of Water found that of the green infrastructure projects that receive federal funding, only 55 percent have a plan in place for maintaining the project, and just 59 percent have a reliable revenue source to pay for future maintenance.[18] The challenge of routine maintenance is further complicated by the question of who should be responsible for project upkeep. In some cities, the public works department takes full responsibility for all municipal stormwater projects, while in others the responsibility is shared with residents or community organizations. As green infrastructure becomes increasingly common on private property, it will become necessary to clearly define a maintenance plan for the long term. Any efforts to encourage the development of green infrastructure in Southwestern Pennsylvania also must account for the costs and responsibilities of project maintenance.

4.2.3 COSTLY DESIGN AND INSTALLATION

Green infrastructure requires expert design and installation. A single project typically requires the collaboration of engineers, landscape architects, and contractors as well as skilled and trained construction crews. In regions with an emerging green infrastructure industry, demand for project design and installation often outpaces the growth in the number of trained experts. This additional demand can temporarily drive up the price of local experts and labor.

In addition to planning and labor costs, required materials may be more costly for a green infrastructure project than for a traditional infrastructure project. For example, an infiltration

project requires a crew to lay several layers of rock, gravel, and sand before planting vegetation. The use of these additional basin materials can be costly. Another such project, permeable paving, is installed much like a traditional paving surface but must be built on a bed of rock and sand that is double the depth of a typical asphalt road. The additional cost of green infrastructure expertise and material can discourage some from adopting green infrastructure.

4.2.4 RIGOROUS SITE REQUIREMENTS

The effectiveness of green infrastructure varies with the site selected and how well the project is integrated into the natural landscape. Green infrastructure, like any infrastructure investment, should aim to maximize water capture and operate as efficiently as possible. Maximizing the water capture potential of a green infrastructure investment requires careful site selection based on flow modeling that uses topography and permeable surface data to determine where stormwater is likely to collect. In Southwestern Pennsylvania, there are two leaders in this type of modeling: RainWays, developed by 3 Rivers Wet Weather, and Landbase Systems' GIS program. Despite the available tools, however, not all green infrastructure projects are planned and sited using a modeling program. Improperly located projects can create inefficiencies or even exacerbate local stormwater problems. While site selection is not an insurmountable challenge, engaging in a full analysis can increase costs and delay project installation.

Several of the challenges mentioned above are most pronounced in regions with fledgling green infrastructure industries where methods, technology, and training are still under development. As green infrastructure grows and expands, these concerns may abate. However, several of the challenges, including the need for proper project siting and maintenance, are inherent to green infrastructure and will persist.

5. GREEN INFRASTRUCTURE IN SOUTHWESTERN PENNSYLVANIA

5.1 THE HISTORY OF GREEN INFRASTRUCTURE IN THE REGION

Southwestern Pennsylvania has experienced recent growth in its green infrastructure industry. Much of the region's existing green infrastructure was installed within the last decade, with most growth occurring in the last five years. Although Southwestern Pennsylvania has long battled flooding, runoff, and overflows, green infrastructure only recently emerged as a solution. Growing interest in green infrastructure is attributable to EPA's purposeful advancement of green solutions, the public success of green infrastructure in other cities, and the efforts of local environmental leaders and green infrastructure experts.

When green infrastructure first emerged, some experts doubted that it could be effective in Southwestern Pennsylvania due to the region's unique soils and topography. As a result, a number of the earliest projects were constructed as demonstrations, aiming to test various green technologies and quantify their results. In addition to demonstration projects, there have been a number of early adopters in the region, including small projects on private property and grant-funded initiatives at the municipal or neighborhood level. Several of these noteworthy projects are highlighted below.

In 2008, to further support the growth of green infrastructure in Allegheny County, 3 Rivers Wet Weather and the Pennsylvania Environmental Council convened an informal group of local landscape architects, engineers, and activists in environmental policy. The Green Infrastructure Network meets regularly to discuss select project results, brainstorm green solutions, and develop strategies for promoting green infrastructure throughout the region.

5.2 EXISTING GREEN INFRASTRUCTURE

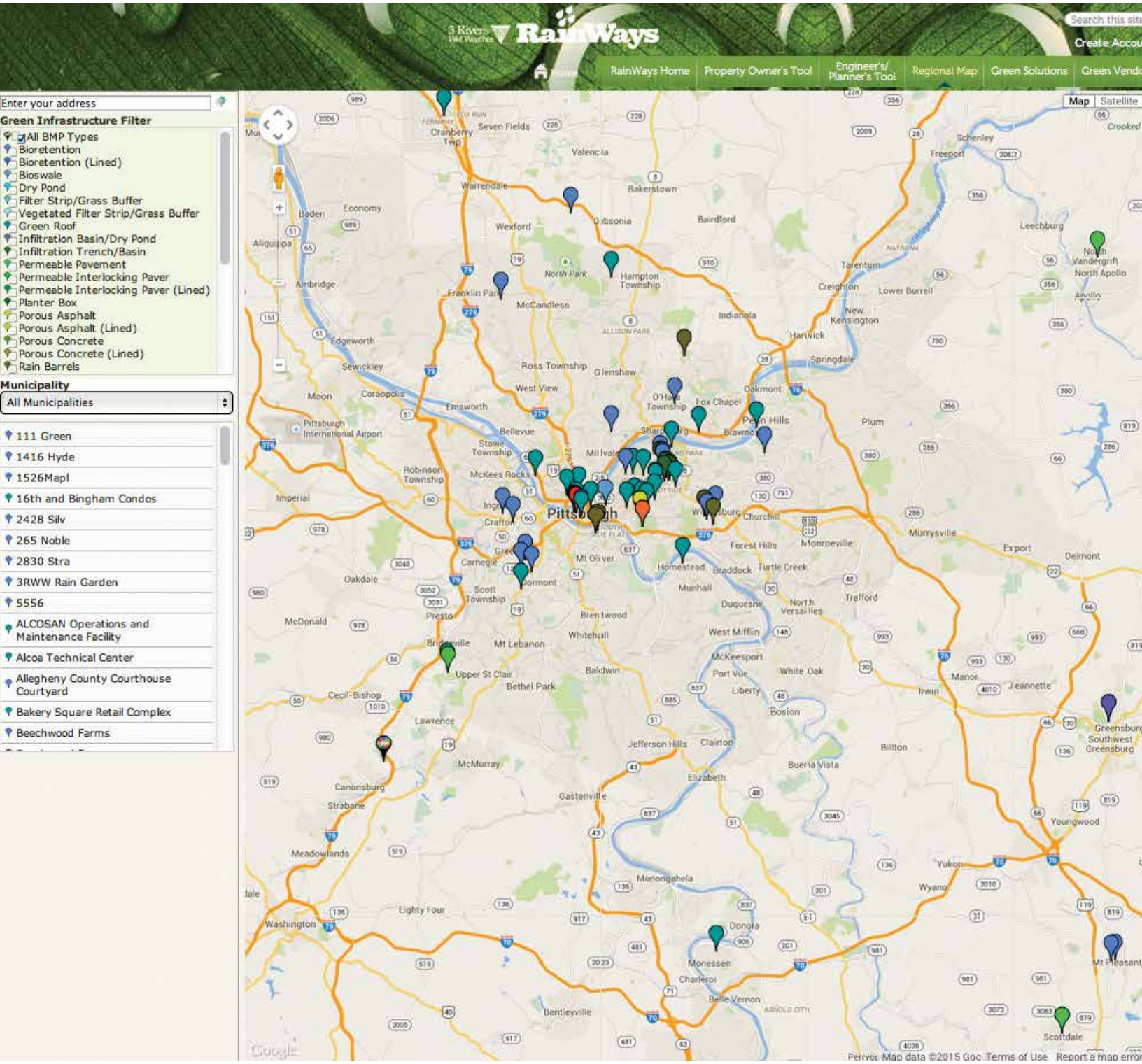
The map on the next page highlights a number of the projects currently in existence in Allegheny County using a database that 3 Rivers Wet Weather maintains of these projects and their locations for use in stormwater planning. As shown on the map, there are pockets of green infrastructure development throughout the region, but its reach and coverage remain fairly limited.

5.3 SOUTHWESTERN PENNSYLVANIA: SPOTLIGHT PROJECTS

The following projects are notable for their approach to green infrastructure. Each illustrates key lessons for regional adoption, including municipal activism, the use of research methods and monitoring, and efforts to engage community members.

MUNICIPAL ACTIVISM: ETNA BOROUGH'S GREEN STREETSCAPE PROGRAM

The Borough of Etna is located in Allegheny County at the confluence of Pine Creek and the Allegheny River. As a lowland borough, Etna is susceptible to creek and river flooding. The borough's central business district has a high proportion of impervious surface, which exacerbates flooding.



This March 2015 screen capture from 3 Rivers Wet Weather's RainWays Web site shows green infrastructure projects in the greater Pittsburgh region. RainWays is an interactive tool that can be used by property owners, engineers, and planners that was created to support the planning and implementation of green solutions to address the region's wet weather problems. The projects resulting from use of these solutions can help to capture stormwater, reduce sewage overflows, improve water quality and human health, enhance groundwater recharge, and increase property values, according to the RainWays Web site.

To moderate flooding and address the community's CSO reduction obligations, Etna has planned a series of green infrastructure projects to be installed along the main street of the central business district. Using GIS technology supplied by Pittsburgh's Landbase Systems, Etna determined where stormwater flows collect and where green infrastructure would be most effective. In preparation for the Green Streetscape program, borough leaders updated municipal ordinances to allow for the use of green infrastructure to manage stormwater. In 2013, Etna was awarded funding through the Pennsylvania Department of Environmental Protection's Growing Greener program. These funds allowed borough leaders to begin the first stage of their project, which includes installing tree pits, decorative grates, underground storage tanks, and permeable paving. The borough also is installing a number of rain gardens and green parking lots to manage stormwater in other areas of the borough.

At the time of publication, this project was under construction, so project results are not yet clear. However, the Etna Green Streetscape program is notable because it demonstrates the scale of green investment that can be achieved when municipalities have an incentive to manage stormwater and choose to actively pursue green infrastructure as a solution.

RESEARCH AND MONITORING: THE ALLEGHENY COUNTY OFFICE BUILDING GREEN ROOF

Photo courtesy Allegheny County

In 2010, Allegheny County constructed a green roof atop its historic office building, located in downtown Pittsburgh. The roof functions as a demonstration project to promote sustainable stormwater solutions and lend credibility to the green infrastructure field. At the time, green technology was fairly new to the region and required testing. The county understood that widespread adoption of green infrastructure depended on the ability of researchers to demonstrate that the benefits of green technology outweigh the costs.

To contribute to this body of research, Allegheny County rigorously monitored the performance of its green roof. To create an experimental control, the county left one side of the roof undeveloped, which allows researchers to precisely determine the green roof's ability to capture water and moderate temperatures as compared to a traditional flat roof. The remaining roof was divided into sections, each with varying soil depths and vegetation. This variation allows researchers to study the impact of each natural material to determine which plants and soils most effectively manage stormwater. In addition to a strategic layout, the green roof was designed to regularly monitor performance. A set of gauges was buried in the soil near each study area to measure moisture capture. These measurements are recorded every 15 minutes then transmitted to the county for analysis. The county makes these findings available to the public through an online portal that allows users to interact with the data and examine trends in performance.

Although there are a number of existing demonstration projects in Southwestern Pennsylvania, the Allegheny County Office Building green roof is unique in its up-to-the-minute monitoring, its inclusion of a control area, and its readily accessible results. This demonstration project has the potential to improve the efficiency and performance of future green roof designs throughout the region.

COMMUNITY ENGAGEMENT: PROJECT 15206

Project 15206 is a green infrastructure initiative in the city of Pittsburgh targeting communities within the 15206 zip code, including Lincoln–Lemington, Larimer, East Liberty, Highland Park, and Morningside. The project is funded by Allegheny County and managed collaboratively by the Penn State Center and Pittsburgh Community Services, Inc., with support from State Senator Jim Ferlo, the City of Pittsburgh, the Pittsburgh Water and Sewer Authority, and the Nine Mile Run Watershed Association. The 15206 area spans hilltops and lowlands and experiences frequent flooding, including the catastrophic 2011 flash flood that claimed four lives along Washington Boulevard. In several 15206 neighborhoods, flooding risks have been exacerbated by dense development and an absence of trees and other vegetation. Project 15206 was developed in response to these flooding events and aims to reduce area runoff and improve water quality.

To target stormwater hot spots in the area, the Penn State Center and Landbase Systems modeled water flows and determined where green infrastructure could be most impactful. They used these data to site a number of new green projects, including rain gardens, pervious paving, and wetland restoration. They also aim to install 100 tree bioswales along area roadways to capture runoff and reduce flows. In addition to their larger-scale initiatives, Project 15206 has launched a resi-

dential rain barrel campaign through StormWorks, an affiliate of the Nine Mile Run Watershed Association. The program provides free or reduced-cost rain barrels to qualified 15206 residents. The barrels are delivered and mounted by Pittsburgh Summer Youth Employment Program participants who have been trained in rain container installation. To promote the initiative, Project 15206 leaders partnered with neighborhood organizations to hold five informational meetings for residents.

Despite their limited potential for water capture, rain barrels can be effective at raising awareness and engaging community members. This engagement is evidenced by the unanticipated demand for rain barrels in the 15206 area, where requests quickly exceeded the original supply of 400 containers. Project 15206 is notable for its use of strategic project siting and for its efforts to engage residents and raise awareness of stormwater issues.

6. BARRIERS TO GREEN INFRASTRUCTURE EXPANSION IN SOUTHWESTERN PENNSYLVANIA

6.1 RESEARCH AND PLANNING BARRIERS

Before Southwestern Pennsylvania embarks on significant green infrastructure expansion, the region must first launch a coordinated research and planning effort. Although some research exists and planning is under way, few of these efforts are coordinated or widely shared. As a result, progress exists in silos, and green infrastructure skepticism flourishes. The following barriers, if left unaddressed, could sap the green infrastructure movement of its legitimacy and lead to investments in inefficient projects.

6.1.1 THE ABSENCE OF A REGIONAL GREEN INFRASTRUCTURE PLAN

Southwestern Pennsylvania's air and water quality crisis has spurred the development of a number of organizations committed to improving the environment. Within the stormwater field, there are many highly active and impactful organizations. Some support key green infrastructure research; some perform an advocacy or education function; and others aim to serve as conduits, connecting stakeholders from across the system. While each organization has a distinct role and serves a necessary purpose, their efforts are not always well coordinated. As a result, many green infrastructure initiatives occur in isolation. This represents a missed opportunity. Without clear regional leadership, green infrastructure suffers from a lack of goal setting, strategic planning, and resource coordination. Developing green infrastructure piecemeal, without a regional vision, could constrain green development and lead to an inefficient allocation of resources.

6.1.2 INSUFFICIENT BODY OF RESEARCH ON GREEN INFRASTRUCTURE IN THE REGION

Although the Southwestern Pennsylvania region is replete with demonstration projects that have confirmed the efficacy of green technology, there remain a number of skeptics who believe that green infrastructure is untenable in the region given its unique soils and topography. This disconnect exists because projects are not universally monitored and results are not always reported or shared. Damon Weiss, civil engineer and principal at Urban Rain Studio, explains the problem: "All the monitoring data that's been collected is sitting in some engineer's drawer. Sometimes it goes up on a Web site or it gets out by word of mouth, but there is no one comparing it." Joel Perkovich, landscape architect and principal at Tsuga Studios, adds, "We're doing a lot of monitoring … It's a matter of trying to piece that data together." Although valuable research is taking place in Southwestern Pennsylvania, it does not always reach an audience. The region is missing a formal reporting mechanism for sharing findings across projects and an organization that serves as a repository for this data.

In addition to research-focused demonstration projects, there are a number of other green infrastructure initiatives across the region that are not collecting data on results at all. These projects are unable to compare future results to a baseline or to measure success. As Katherine Camp, green infrastructure program manager at the Pittsburgh Water and Sewer Authority, explains, "There is not enough monitoring or collecting of baseline data … or much cataloging of the projects out there." Without uniform monitoring standards or a mechanism for reporting results, the green infrastructure movement will suffer from a lack of coordinated research and fail to convince area decision makers that green infrastructure is a worthy and reliable investment.

6.1.3 FEW CLEAR PROTOCOLS FOR DESIGNING AND INSTALLING GREEN INFRASTRUCTURE

Green infrastructure design and installation techniques can differ from region to region. Engineers, landscape architects, and contractors constructing a green infrastructure project in Southwestern Pennsylvania must contend with unique soil and topography challenges. Ruthann Omer, president of the

Gateway Engineers, Inc., explains that green engineering projects are "not as simple to implement as many think." This challenge can be site specific—for instance the challenge of designing an attractive bioswale along the sloped driveway of Baldwin High School—or it can be technology specific, such as selecting the most appropriate and durable pervious paving material for a parking lot. Given the challenge of designing green projects in Southwestern Pennsylvania, there is room for error that could undermine the effectiveness of the entire project. Although many green infrastructure projects receive state, federal, or foundation support, there is no inspection process or project certification program in place to ensure that projects receiving funding are functioning effectively.

6.2 ENGAGEMENT AND EXPANSION BARRIERS

In addition to planning and research barriers, proponents of green infrastructure are impeded by poor environmental literacy as well as a general reluctance across the public and private sectors to fund green technology. In particular, efforts to expand green infrastructure are made more challenging by a widespread underestimation of the hazards of stormwater and a lack of sufficient incentives for developers and local government. Organizations and government agencies interested in green investment often are constrained by competing demands on operating budgets. Overcoming the following barriers is crucial to expanding the reach of green infrastructure throughout the region.

6.2.1 PUBLIC MISCONCEPTIONS ABOUT STORMWATER

Public buy-in is critical to any green infrastructure initiative because the public must be willing to advocate for new projects, support statutory updates, assist in maintaining green spaces, and adopt green practices in their homes and workplaces. Yet, even as green infrastructure spreads across the country, many Americans remain unfamiliar with the hazards of unmanaged stormwater and the benefits of green solutions. The National Environmental Education Foundation highlights this awareness gap in its *National Report Card on Environmental Knowledge, Attitudes, and Behavior*. The report, based on national polling, indicates that just 22 percent of Americans understand that stormwater runoff is the greatest source of pollution in waterways and oceans, while 47 percent incorrectly selected industrial dumping. Likewise, only 16 percent of respondents correctly identified motor oil runoff as the chief source of oil pollution in American waters, while the majority implicated oil spills or refineries.[19] These misconceptions are problematic because they suggest that Americans do not recognize the impacts that their individual choices and behaviors can have on water quality. If most believe that large corporations are responsible for water pollution, they may be more willing to abdicate their responsibility for cleanup and be less likely to support measures, like green infrastructure, that aim to address the impacts of everyday surface runoff.

6.2.2 RESISTANCE TO A REGIONAL STORMWATER UTILITY

Establishing a stormwater utility is a common approach to financing costly stormwater infrastructure upgrades. While water and sewer authorities bill ratepayers for metered water use, stormwater utilities can assess fees based on a property owners' contribution to stormwater runoff as measured by their impervious surface. Stormwater utility programs of this kind are increasingly viable in Southwestern Pennsylvania. The July 2013 passage of Act 68 granted Pennsylvania municipalities the power to collect stormwater fees for use in maintaining and developing green and gray stormwater infrastructure. Although stormwater management fees remain controversial, many local and regional leaders view fee collection as the only sustainable solution to their costly stormwater needs. Armed with the legal assurances of Act 68, a growing number of local leaders are preparing to institute stormwater management fees at the municipal level. However, enacting stormwater programs one jurisdiction at a time could further fragment the region and inhibit strategic, watershed-based infrastructure investments.

Kathy Risko, executive director of the Congress of Neighboring Communities, explains why municipal leaders are resistant to a regional approach, particularly a regional utility: "The idea of a countywide stormwater utility bothers municipalities because they are all in different sewer sheds. Under a single utility, municipalities would be asked to pay for projects in other watersheds—projects that would not offer them any direct benefits." Although a larger countywide stormwater fee program could be met with resistance, municipalities may consider participating in a watershed-based utility. Risko explains that, "if we could do a stormwater utility by watershed, monies collected by the municipalities in that watershed could be used for source reduction and projects within the watershed. Revamping a watershed would benefit all municipalities." As communities across the region move closer to a stormwater utility model, the creation of a patchwork of municipal-level utilities would represent a missed opportunity for regional cooperation and planning.

6.2.3 LACK OF PRIVATE INCENTIVES

In Southwestern Pennsylvania, large-scale green infrastructure resides largely in the public domain. Typically, green projects are developed and managed by nonprofits or community groups

with the support of government leaders. It is far less common for a developer or a private property owner to invest in one of these high-impact projects. This is due, in part, to prohibitive up-front costs but also can be attributed to a lack of private incentives for green development. Some Pennsylvania municipalities have begun to offer a credits program to private landowners for on-site stormwater management, but few of these offer large enough benefits to offset the cost of green infrastructure and ultimately fail to attract many participants. The stormwater management fee cases below illustrate the challenge of successfully inducing private investment in green infrastructure.

Stormwater Management Fees in Pennsylvania: Benefits and Challenges

The following Pennsylvania communities have instituted stormwater management fee programs. Faced with flooding, costly infrastructure updates, and/or regulatory challenges, these communities enacted stormwater programs to generate necessary revenue, create green infrastructure incentives, and ensure that property owners are sharing in the cost of stormwater management.

Lancaster

Lancaster is a state leader in sustainability and green stormwater management. EPA selected Lancaster as a model due to its commitment to integrating green infrastructure citywide through the Save It! Lancaster program. Although many of Lancaster's green infrastructure projects are financed through state and federal grants or loans, the city instituted a stormwater management fee to secure a sustainable source of revenue for new gray and green projects. In the spring of 2014, after soliciting com-munity input and generating support for the program, city leaders began to bill residents according to the size of their impervious surface. Lancaster assesses fees using a tiered system, with an average cost to homeowners of $16–$48 annually and an average cost to commercial property owners of $948. Lancaster's fees are among the lowest in the commonwealth. To encourage private adoption of green infrastructure, Lancaster offers a credits program for projects that manage stormwater on site. However, this program is in the early stages of development, so it is not yet clear whether the program will incentivize private adoption of green technologies effectively.

Meadville

In early 2012, Meadville instituted a stormwater fee in order to generate the funds needed to comply with federal water quality mandates. In advance of the program, Meadville's leaders worked with consultants at the engineering and project management firm AMEC to determine how many stormwater infrastructure updates were needed and how much each project would cost. This total cost was divided among property owners according to their impervious area to determine their fee obligation. Meadville now requires that all single-family homes pay a flat rate of $90 per year, while nonresidential properties are assessed according to the number of equivalent residential units they occupy. Meadville offers property owners a fee credit for managing water on site, either by removing impervious surface or installing green infrastructure. Although property owners are eligible for a 10–40 percent discount, few have taken advantage of the program. In fact, several large property owners who installed green infrastructure prior to the credit program have not applied for the discount because of the time required to apply.

Mt. Lebanon

Mt. Lebanon, a community in Allegheny County, was the first in the Southwestern Pennsylvania region to institute a stormwater management fee. Due to its hilly topography, Mt. Lebanon experiences frequent flooding during wet weather events. Adequately addressing this flooding required investment in costly water infrastructure repairs. Concerned that these investments would divert resources from public safety and other general fund expenses, the Mt. Lebanon Commission established a distinct water infrastructure fund supported by revenues from a municipal stormwater fee. To advise the community on structuring the fee and educating residents, Mt. Lebanon hired a team of consultants from AMEC. In 2011, Mt. Lebanon began billing homeowners at a flat rate of $96 annually and assessing a fee of $96 for each equivalent residential unit of impervious surface on nonresidential properties. To provide incentives for on-site water management, Mt. Lebanon offers fee credits to property owners who install green infrastructure. However, officials acknowledge that few currently take advantage of the credits program because the cost of installing a green project exceeds potential fee savings. Currently, Mt. Lebanon's stormwater fee generates approximately $1 million in revenue for water infrastructure projects throughout the community.

Philadelphia

Philadelphia's stormwater fee program, the oldest in the commonwealth, dates to the 1960s. In 2010, in response to growing stormwater infrastructure costs, the Philadelphia Water Department (PWD) revamped its fee program, moving from a fee based on water usage to a fee determined by impervious surface area. By shifting from a meter- to a parcel-based fee, PWD added 40,000 new customers, many of whom owned parking lots or vacant lands that contributed to stormwater runoff but did not previously require a water bill. Under the new program, PWD assesses fees according to the size of a customer's impervious surface as measured by equivalent residential units. However, all residential property owners pay a flat rate of $156 per year. To provide incentives for private installation of green infrastructure, PWD enacted a stormwater credits program. Through the program, property owners are eligible for up to an 80 percent

reduction in their stormwater fee for constructing green infrastructure on their property. The credit alone, however, did not prompt significant investment in green infrastructure, which PWD believes was due to the high up-front cost of installation. To encourage large on-site water management projects, PWD instituted a grants program, known as Stormwater Management Incentives Program (SMIP), to help customers finance their investment in green infrastructure. Through SMIP, grantees receive free engineering and design services, and to date, PWD has awarded 36 project grants throughout the city.

6.2.4 LACK OF MUNICIPAL INCENTIVES

Due to EPA's outspoken support of green infrastructure, many municipal leaders in Southwestern Pennsylvania are familiar with green infrastructure and its benefits. Most, however, stop short of directing municipal funds toward green infrastructure projects. Most municipalities in the region see little reason for investing in green infrastructure for either flood control or sewage because they are not accountable for their contribution to the sewer system. In the ALCOSAN service area, municipalities have agreed to accept the responsibility of collecting sewer fees on behalf of ALCOSAN in exchange for the ability to convey unrestricted flows to ALCOSAN for treatment, which is known as Z agreement. As John Schombert, the director of 3 Rivers Wet Weather, explains, "Right now there are no incentives for communities to put green infrastructure in place because of their agreement with ALCOSAN. Under the Z agreements, ALCOSAN must take all of their flow." This arrangement exempts municipalities from practicing flow reduction.

This long-standing arrangement may change in the face of mounting regulatory pressure. At its June 2014 municipal update, EPA urged municipal leaders to embrace regionalization and flow reduction goals so that they could achieve Clean Water Act compliance. Municipalities have jurisdiction over roads, parking lots, parks, and government buildings and have the potential to significantly impact stormwater flows in their communities by erecting projects in rights of way and on public lands. Without sufficient incentives, municipalities will likely opt out of green infrastructure, limiting the regional impact of green technology.

7. RECOMMENDATIONS

7.1 RESEARCH AND PLAN

7.1.1 DESIGNATE A REGIONAL GREEN INFRASTRUCTURE PLANNING GROUP

Regional Planning and Reporting Model: Milwaukee's Fresh Coast 740 Program

Milwaukee has been a leader in green infrastructure for more than a decade, constructing numerous green infrastructure projects that are well coordinated and well planned. Through the Fresh Coast 740 Program, the Milwaukee Metropolitan Sewerage District (MMSD) serves as the city's organizing body, tracking the green programs, setting stormwater capture goals, and planning for future green development. MMSD analyzes the costs and benefits of various levels of investment in green infrastructure and maintains a green infrastructure database with precise water capture measurements. Using these data, MMSD is able to quantify water capture volume, in gallons, for each green infrastructure tool to determine which technology is most effective at diverting stormwater.

The green infrastructure movement in Southwestern Pennsylvania suffers from a lack of coordination and clear leadership. To fill the leadership void, Southwestern Pennsylvania decision makers should designate a green infrastructure planning group. This planning group would work at a county level to ensure that all existing and planned green infrastructure projects are strategically placed, well monitored, and properly executed. The regional group would be responsible for setting stormwater capture targets and would serve as a reporting agency for project results. Like MMSD, Southwestern Pennsylvania's stormwater planning group could examine area watersheds using GIS modeling technology and identify sites throughout the region where green infrastructure installation would have the most pronounced effect on stormwater flows. This GIS tool could provide the public with a snapshot of where rain falls and how it is managed by overlaying water quality data, rainfall quantity and flow models, and existing green projects on maps of land use and area flood plains.

In addition to consolidating data and planning for the expansion of green infrastructure, the regional group could work to coordinate the efforts of Southwestern Pennsylvania's multiple environmental organizations to generate more resource sharing and project collaboration. By designating a formal leader of the green infrastructure movement, Southwestern Pennsylvania could enjoy planned and goal-driven green infrastructure growth throughout the region.

7.1.2 TEST GREEN INFRASTRUCTURE EFFECTIVENESS BY INSTITUTING STANDARDIZED MONITORING AND REPORTING FOR ALL NEW GREEN INFRASTRUCTURE PROJECTS

Demonstration projects abound in Southwestern Pennsylvania, but their results can be difficult to locate and interpret. To ensure that all green infrastructure projects are truly sustainable, strategic, and reliable, new projects should collect and report flow data. Currently, only demonstration projects are expected to monitor flows and incorporate gauges into project design, but every project would benefit from an evaluation of the effectiveness of project technology. Standardized reporting would allow engineers to detect when a project is performing poorly or requires maintenance and it would provide crucial data for assembling a regional green infrastructure plan. As in Milwaukee, the data reported by project engineers could be collected and analyzed by the regional green infrastructure planning group. This data would be accessible to the public and could be used for further green infrastructure research. Knowing how well the region's green infrastructure is performing as a whole will lend credibility to the green infrastructure movement and allow regional planners to direct resources toward stormwater hot spots and other underserved locations.

7.1.3 DEVELOP A PROTOCOL FOR GREEN INFRASTRUCTURE DESIGN AND INSTALLATION THAT CULMINATES IN PROJECT CERTIFICATION

Standardized Protocols Model: U.S. Green Building Council's LEED Certification

The U.S. Green Building Council developed the Leadership in Energy and Environmental Design (LEED) program to encourage greener and more energy-efficient development. LEED is a certification program that indicates a building project's level of efficiency. To be considered for LEED certification, a project must meet a set of basic criteria and then earn additional points for particularly energy-efficient features. After an inspection and review process, the Green Building Certification Institute approves all final certification decisions. LEED construction is appealing to developers because buyers are eager to reduce their energy costs by purchasing a more efficient building. The LEED program provides assurance to consumers that a property is well designed and will provide long-term energy savings.

Like energy-efficient LEED buildings, green infrastructure projects can offer long-term benefits and cost savings to communities. The development of a certification process for green infrastructure, similar to LEED, would ensure that all new projects adhere to the highest standards of site selection, pre- and postinstallation monitoring, and ongoing maintenance. While many projects claim to be green, some are incomplete or poorly constructed. The certification would differ for each green infrastructure technology but would involve design specifications, a demonstration of project monitoring results, and an indication that the project was placed in a strategic location for stormwater capture. A certification program would offer funders verification that a project is performing well or ensure that commercial clients are eligible for a stormwater fee credit. A green infrastructure certification program in the spirit of LEED would improve trust in green infrastructure and ensure that projects are designed and installed according to a set of standards.

7.2 ENGAGE AND EXPAND

7.2.1 GENERATE PUBLIC SUPPORT FOR GREEN INFRASTRUCTURE

Media Campaign Model: Philadelphia's Green City, Clean Waters

Philadelphia's Green City, Clean Waters campaign is intended to educate residents about water quality and package numerous Philadelphia green infrastructure projects into one program and slogan. The Green City, Clean Waters Web site is clean and appealing, offering residents access to straightforward information about stormwater management as well as green infrastructure maps and project descriptions. The program has been featured in national publications that have helped to raise its profile, including *TIME*, *National Geographic*, and *The Washington Post*. The Green City, Clean Waters campaign also raises awareness of green infrastructure by holding events like green design competitions, ribbon cutting ceremonies, and art contests.

Stakeholder Input Model: Meadville's Stakeholder Advisory Committee

In 2011, when Meadville was first considering a stormwater management fee, city leaders suspected that the program would be met with resistance from members of the business community, so the city launched an education campaign to inform stakeholders about the city's stormwater runoff problem and convened a stakeholder advisory committee. During one committee meeting, city leaders led stakeholders on a bus tour through Meadville to inspect the stormwater infrastructure. Over the next several months, the committee met to discuss the city's costly water quality obligations and to consider financing options.

The committee understood that a fee was certain, but it offered input on the fee structure and its administration.

To educate the wider public about the stormwater fee program, the City of Meadville relied on local community and environmental advocacy organizations. These groups spoke with community members and provided information about where wastewater goes and why stormwater matters. In advance of the program launch, the *Meadville Tribune* ran an eight-part series about stormwater issues in the city. These outreach efforts offered residents the chance to voice their concerns and helped to ease the transition to a stormwater management program.

The successful expansion of green infrastructure throughout Southwestern Pennsylvania depends on the level of public awareness of stormwater issues and support for green solutions. Before launching any new stormwater program, regional leaders should undertake a media campaign to educate residents about stormwater and water quality. This campaign could be led by local advocacy organizations and could include an attractive and user-friendly Web site, a slogan that generates interest in the region's stormwater programs, informational meetings and community events, and news coverage about green infrastructure in the region.

In addition to a public awareness campaign, regional leaders can build community understanding of a stormwater utility by engaging those who will be hit hardest by a fee program. As part of a stakeholder committee, representatives from universities, hospitals, and businesses could offer input and voice concerns. Like Philadelphia and Meadville, Southwestern Pennsylvania can generate support for green infrastructure and stormwater management programs by informing and engaging the public and key stakeholders.

Photo courtesy Allegheny County

7.2.2 HARNESS GROWING INTEREST IN STORMWATER FEES BY ENACTING A WATERSHED-BASED UTILITY PROGRAM THAT DIRECTS RESOURCES TOWARD STRATEGIC, SUSTAINABLE, AND COST-EFFECTIVE INFRASTRUCTURE PROJECTS

Regional Utility Model: Maryland's Watershed Protection and Restoration Program

Maryland, at the heart of the Chesapeake Bay watershed, is subject to stringent water quality requirements under the Clean Water Act. Several Maryland legislators understood that compliance would be costly and proposed a bill requiring strategic infrastructure upgrades throughout the watershed financed by a stormwater utility fee. In 2011, the Maryland state legislature passed House Bill 987, which aimed to encourage communities to site projects in areas of significant runoff by requiring Baltimore and Maryland's nine most populous counties to each enact its own stormwater utility fee. By targeting the most populous locations in Maryland, state lawmakers could be assured that the most serious contributors to runoff were able to invest in managing their portion of the watershed.

There is growing municipal interest in stormwater utilities in Southwestern Pennsylvania. Mt. Lebanon recently enacted a fee program, and several other communities plan to launch stormwater programs soon. Although stormwater utilities can offer environmental and community benefits at any level of government, they function more efficiently when they are used to support regional infrastructure goals. If Southwestern Pennsylvania were to develop into a patchwork of municipal utility programs, it could produce imbalanced and uncoordinated investments in infrastructure, distracting from the region's stormwater crisis.

Most municipalities in Southwestern Pennsylvania receive stormwater flows from neighboring communities, and many pass their own flows to downstream neighbors. As it stands, municipalities must depend on intermunicipal agreements to address the consequences of these flows. However, the presence of a watershed-based stormwater utility would allow municipalities to formally plan and collaborate with all communities within their watershed. With the collective power of a watershed utility, municipalities could ensure that stormwater fee revenues are used to support the most strategically placed and cost-effective projects. To certify equitable resource allocation, a portion of the revenues could be redistributed to municipalities in accordance with their residents' contributions. These funds could be used for green or gray infrastructure projects that support more localized stormwater management goals.

However unpopular, stormwater utilities seem likely to take hold in Southwestern Pennsylvania. Growing interest in stormwater programs presents municipalities with an opportunity to participate in a watershed-based stormwater utility. If fee programs are organized at the watershed level, Southwestern Pennsylvania residents could be assured that their fee dollars are directed toward high-impact, strategic projects that improve conditions throughout their entire watershed.

7.2.3 DEVELOP INCENTIVES FOR PRIVATE INSTALLATION OF GREEN INFRASTRUCTURE THROUGH MUNICIPAL CODE UPDATES AND STORMWATER CREDITS PROGRAMS

Private Incentives Model: Portland's Clean River Rewards and Floor Area Ratio Bonus

Portland, Oregon, like many cities across the country, relies on a stormwater management fee program to support its investments in gray and green infrastructure. Much like other stormwater programs, Portland's program offers ratepayers a credit for managing their stormwater on site. However, Portland's Clean River Rewards program garners significantly higher levels of participation: 34,000 single-family homes and 2,000 commercial properties. The success of Portland's program is likely attributable to its fee and discount structure. Portland's stormwater fee is among the highest in the country, with a single-family home contributing approximately $270 annually, but property owners who manage stormwater on site are eligible for a 100 percent discount. Portland's stormwater fee model suggests that high costs and high rewards may be necessary to incentivize private investment in sustainable stormwater management.

In addition to its Clean River Rewards program, the City of Portland offers incentives to developers who incorporate green technology into new construction through its floor-to-area ratio bonus policy. Although city zoning conditions limit the size of a new construction project, Portland allows developers to build larger if they meet LEED criteria. Portland credits this program with the construction of 120 new green roofs in the city center.

Stormwater management fee programs typically seek to satisfy two complementary goals: generating revenue for green and gray stormwater infrastructure and incentivizing green infrastructure investment on private property. However, credits programs rarely succeed in encouraging new green infrastructure development because stormwater fees are too low or credit programs offer few benefits. As stormwater management fee programs take hold in the region, local leaders should consider structuring fees and credits to encourage the use and maintenance of green infrastructure on private property. The success of such a program could be measured in revenue generated and in stormwater management projects constructed through the credits program. If the costs of new green infrastructure prove to be prohibitive for property owners, the stormwater utility could consider a grant or loan program, in the model of Philadelphia, to make green projects more affordable for Southwestern Pennsylvania property owners.

In addition to a credits program through the stormwater utility, municipalities could update codes and zoning regulations to support the growth of green infrastructure. Some municipalities have sewer codes that are long out of date and effectively prohibit green infrastructure. Municipalities interested in reaping the benefits of green infrastructure ought to review and update their ordinances to ensure that green projects are permitted. To further spur green growth, municipalities could offer positive incentives to developers who incorporate green technology into their designs, including additional allowable square footage or building height, property tax relief, or expedited permitting. For green infrastructure to have the greatest impact on Southwestern Pennsylvania, private property owners must be involved. Incentives like stormwater fee credits and developer rewards could stimulate private investment in green infrastructure and benefit communities.

7.2.4 PROVIDE INCENTIVES FOR MUNICIPAL SOURCE REDUCTION BY INSTITUTING FLOW TARGETS

Flow Target Model: South Fayette Township

South Fayette Township in Allegheny County is a relatively recent addition to the ALCOSAN service area. In 1983, in response to rapid population growth, South Fayette closed its water treatment facility and entered into an agreement with ALCOSAN. The agreement set a limit on the daily number of gallons that ALCOSAN would accept from the township and required that South Fayette pay a penalty for any flows in excess of that amount. In 1996, ALCOSAN and South Fayette updated the agreement to allow penalties to be returned to South Fayette Township for municipal stormwater projects. These funds are held in escrow, and the township must submit to regular ALCOSAN inspections to ensure that general municipal expenses never comingle with water infrastructure projects. Under the flow targets program, South Fayette has succeeded in reducing its flow to ALCOSAN by reinvesting in township infrastructure.

Currently, few municipalities have an incentive to reduce their contribution to the regional sewer system. This results in hazardous sewer overflows and costly, inefficient infrastructure expansion. The 2013 Sewer Regionalization Evaluation Review Panel led by then Carnegie Mellon University President Jared Cohon, concluded that "If municipalities were to aggressively address precipitation at the source and address inflow and infiltration, remove streams from sewer lines, fix leaking collection pipes, and employ other source reduction and green infrastructure practices where practical, ALCOSAN could likely reduce the amount of proposed gray infrastructure." The Sewer Regionalization Evaluation Review Panel recommended a system of flow targets, similar to South Fayette's, to financially motivate municipalities to practice source reduction. Such a program would support the green infrastructure agenda by encouraging municipalities to seek out cost-effective methods of reducing stormwater inflows. Green infrastructure, while not the only solution, would likely be incorporated into each municipality's source reduction plan. Establishing flow targets could support green infrastructure expansion, while reducing sewer overflows and allowing the region to meet its water quality obligations under the Clean Water Act.

ENDNOTES

1 "Hazus Statewide Multi-Event Flood Study." *County Flood Study GIS Maps*. Pennsylvania Emergency Management Agency, 2007. http://www.pema.pa.gov/responseandrecovery/Disaster-Assistance/Pages/County-Flood-Study-GIS-Maps.aspx#.U8XjII1dX3V.

2 Rittmeyer, Brian C. "Troubles from Hurricane Ivan Flooding Yet to Recede." *Pittsburgh Tribune-Review* 8 June 2008. http://triblive.com/x/pittsburghtrib/news/s_571651.html#axzz36zE9QUFc.

3 "National Summary of Impaired Waters and TMDL Information." *Watershed Assessment, Tracking, and Environmental Results*. Environmental Protection Agency, 2014. http://iaspub.epa.gov/waters10/attains_nation_cy.control?p_report_type=T.

4 "Non-Attaining Waterways Evaluated Use," *PittsburghTODAY*, University of Pittsburgh Center for Healthy Environments and Communities, 2014. http://www.pittsburghtoday.org/view_NonattainingUse.html

5 "About the Wet Weather Issue," 3 Rivers Wet Weather, Retrieved July 2014. http://www.3riverswetweather.org/about-wet-weather-issue.

6 National Research Council of the National Academies. *Regional Cooperation for Water Quality Improvement in Southwestern Pennsylvania*. Washington, DC: National Academies, 2005.

7 "ALCOSAN Draft Wet Weather Plan." *Draft WWP.* Allegheny County Sanitary Authority, 2012. http://www.alcosan.org/WetWeatherIssues/ALCOSANDraftWetWeatherPlan/DraftWWPFullDocument/tabid/176/Default.aspx.

8 Schilling, Joseph, and Jonathan Logan. "Greening the Rust Belt: A Green Infrastructure Model for Right Sizing America's Shrinking Cities." *Journal of the American Planning Association* 74.4 (2008): 451-66.

9 Madison, Catherine, and John Kovari. *Impact of Green Infrastructure on Property Values within the Milwaukee Metropolitan Sewerage District Planning Area: Case Studies*. Rep. N.p.: University of Wisconsin–Milwaukee Center for Economic Development, 2013.

10 United States. Environmental Protection Agency. *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices*. N.p.: n.p., 2007 http://nepis.epa.gov/Exe/ZyPDF.cgi/60000LWT.PDF?Dockey=60000LWT.PDF.

11 Faber Taylor, Andrea, Angela Wiley, Frances E. Kuo, and William C. Sullivan. "Growing Up in the Inner City: Green Spaces and Places to Grow." *Environment and Behavior* 30.1 (1998): 3-27.

12 Kuo, Frances E., and William C. Sullivan. "Environment and Crime in the Inner City: Does Vegetation Reduce Crime?" *Environment and Behavior* 33.3 (2001): 343-67.

13 *Pittsburgh Regional Environmental Threats Analysis (Preta) Report*. Rep. N.p.: University of Pittsburgh Graduate School of Public Health Center for Healthy Environments and Communities, 2013. http://www.chec.pitt.edu/documents/PRETA/CHEC%20PRETA%20HAPs%20Report.pdf.

14 Baldauf, Richard, Thomas Cahill, Chad Bailey, Andrey Khlystov, K. Max Zhang, Richard Cook, Chatten Cowherd, and George Bowker. "Can Roadway Design Be Used to Mitigate Air Quality Impacts from Traffic?" *EM* (August 2009).

15 Kurn, Dan M., Sarah E. Bretz, Benson Huang, and Hashem Akbari. *The Potential for Reducing Urban Air Temperatures and Energy Consumption Through Vegetative Cooling*. Rep. N.p.: U of California, Berkeley, May 1994. https://www.aceee.org/files/proceedings/1994/data/papers/SS94_Panel4_Paper17.pdf.

16 Lundholm, Jeremy T. "Green Roofs an Facades: A Habitat Template Approach." *Urban Habitats* 4.1 (2006).

17 Erickson, Andrew J., John S. Gulliver, Peter T. Weiss, and Bruce C. Wilson. *Survey of Stormwater BMP Maintenance Practices*. Rep. N.p.: n.p., 2009. http://opensiuc.lib.siu.edu/ucowrconfs_2009/1.

18 United States. Environmental Protection Agency. Office of Water. *The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure: A Review of Green Infrastructure O&M Practices in ARRA Clean Water State Revolving Fund Projects*. N.p.: n.p., March 2013. http://water.epa.gov/grants_funding/cwsrf/upload/Green-Infrastructure-OM-Report.pdf.

19 Roper Research Worldwide. *National Report Card on Environmental Knowledge, Attitudes and Behaviors: The Seventh Edition Survey of American Adults*. Rep. N.p.: National Environmental Education Training Foundation, December 2008.

RESOURCES

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ADDITIONAL REFERENCES

"Clean River Rewards: Contain the Rain." *Stormwater Discount Program RSS*. The City of Portland, Oregon, Environmental Services, 2014. https://www.portlandoregon.gov/bes/41976.

"Consent Decree: United States of America, Commonwealth of Pennsylvania, Department of Environmental Protection, and Allegheny County Health Department vs. Allegheny County Sanitary Authority. http://www.alcosan.org/Portals/0/PDFs/Consent%20Decree.pdf.

"Ecoroof Floor Area Ration Bonus Option." *Working Green for Clean Rivers*. City of Portland, Oregon, Environmental Services, 2009. http://www.portlandoregon.gov/bes/article/474490.

"EPA Municipal Update: A Summary of the June 17, 2014 Event." 3 Rivers Wet Weather. June 2014.

"A Flood of Benefits: Using Green Infrastructure to Reduce Flood Risks." *Conservation Gateway*. Nature Conservancy, 2014. https://www.conservationgateway.org/ConservationPractices/Freshwater/HabitatProtectionandRestoration/Pages/floodofbenefits.aspx.

"Fresh Coast 740." Milwaukee Metropolitan Sewerage District. 2014. http://www.freshcoast740.com/.

Garrison, Noah, and Karen Hobbs, "Rooftops to Rivers II: Green strategies for controlling stormwater and combined sewer overflows." Natural Resources Defense Council. http://www.nrdc.org/water/pollution/rooftopsII/files/rooftopstoriversII.pdf

General Assembly of Maryland. *House Bill 987*. April 2012. http://mgaleg.maryland.gov/2012rs/bills/hb/hb0987e.pdf.

"Green City, Clean Waters." *Philadelphia Water Department*. 2014. http://www.phillywatersheds.org/what_were_doing/documents_and_data/cso_long_term_control_plan.

"LEED Certification." *U.S. Green Building Council*. N.p., 2014. http://www.usgbc.org/certification.

O'Gorman, Cindy. "Still Performing, Still Accurate." *Water & Wastes Digest* (February 2009)

Pennsylvania Department of Environmental Protection. *Pennsylvania Stormwater Best Management Practices Manual*. December 2006. http://www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305.

Pennsylvania General Assembly. "Senate Bill 351." 2013. http://www.legis.state.pa.us/cfdocs/billinfo/billinfo.cfm?syear=2013&sind=0&body=S&type=B&BN=0351.

"Sewer Regionalization Evaluation: Review Panel Findings and Recommendations." Allegheny Conference on Community Development. March 2013. http://www.alcosan.org/Portals/0/PDFs/SEWER%20REGIONALIZATION%20EVALUATION%20REPORT_MARCH%202013[1].pdf.

Stratus Consulting, "A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds." State of Michigan. August 2009. http://www.michigan.gov/documents/dnr/TBL.AssessmentGreenVsTraditionalStormwaterMgt_293337_7.pdf/

United States. Environmental Protection Agency. *Costs of Low Impact Development*. N.p.: n.p., March 2012. http://water.epa.gov/polwaste/green/upload/bbfs3cost.pdf.

United States. Environmental Protection Agency. *Green Infrastructure Permitting and Enforcement Series*. N.p.: n.p., n.d. http://water.epa.gov/infrastructure/greeninfrastructure/gi_regulatory.cfm#permittingseries.

United States. Environmental Protection Agency. *Managing Wet Weather with Green Infrastructure: Municipal Handbook, Incentive Mechanisms*. N.p.: n.p., June 2009. http://water.epa.gov/infrastructure/greeninfrastructure/upload/gi_munichandbook_incentives.pdf.

United States. Environmental Protection Agency. "Reducing Urban Heat Islands: Compendium of Strategies." October 2008. http://www.epa.gov/heatisland/resources/compendium.htm.

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