The Role of Green Infrastructure—Nature, Economics, and Resilience

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Executive Summary

Water is a precious resource that impacts all aspects of life. Actions taken a generation ago addressed significant public health and pollution challenges to help ensure water security for the U.S. on many fronts. Today, the challenges in the water sector have evolved. Aging infrastructure, increasing impacts from stormwater runoff pollution, accelerated degradation of coastal areas, and a significant and growing funding gap to address infrastructure needs today and into the future are leading issues in the water sector.

The traditional method of addressing these challenges would be to rely on "grey infrastructure", such as treatment plants or concrete bulkheads. A new and emerging approach that relies upon nature-based systems and processes, referred to as "green infrastructure", shows great promise in addressing the challenges of the 21st century within the water sector. Practices such as bioretention, coastal wetlands, and preserving forested headwaters have been shown to not only enhance the value of ecosystems and increase resiliency, but also provide water-management services at a lower cost and with a greater overall economic benefit in many instances.

Many federal agencies recognize the strengths of green infrastructure and have initiated efforts to integrate these practices into federal policy. However, despite these efforts, the promise of green infrastructure is hindered by barriers due to limited funding sources, restricted financing options, institutional inertia, and a fragmented and complex policy landscape at all levels of government.

These impediments are not insurmountable. Many potential solutions exist to encourage the increase in implementation of green infrastructure. This report provides several areas to create these changes, including:

- Adoption of policies to encourage green infrastructure implementation, such as the inclusion of ecosystem services benefits for federal project selection processes in both the Drinking Water and Clean Water regulatory programs and across all federal agencies.

- Expansion of vehicles that provide access to private capital for green infrastructure projects, such as public-private partnerships and the Property-Assessed Clean Energy program that can be adopted for green infrastructure.

- Encourage regional- and watershed-based permitting and integrated planning along with related infrastructure investments through regulatory actions that recognize the value green infrastructure can provide across varying scales and contexts.

- Support market-based approaches for green infrastructure investments, such as water quality trading or cost-based threshold grants for green infrastructure investment.

- Increasing the impact of public capital investments in green infrastructure through strategies such as leveraging State Revolving Fund investments or expansion of the Water Infrastructure Finance and Innovation Act program.

- Support for legislation that enables policies identified and related actions to encourage green infrastructure adoption and investment.

The potential of green infrastructure both to reduce costs, enhance resilience, and provide social and environmental benefits and economic return points to the value of supporting, funding, and encouraging its use to address various issues in the water and coastal protection sectors. This report sets forth the opportunities and policy pathways to enhancing consideration of green infrastructure in federal, state, and local decisions about water-management infrastructure.

Introduction

The solutions and policies to address water pollution have evolved over the last century. Technological advancements in the collection and treatment of wastewater through physical, chemical and biological processes have been hailed as one of the greatest scientific achievements in terms of public health and safety. However, technical progress alone cannot change the landscape for our nation's water infrastructure investment needs. Public policy must help to facilitate the equitable and efficient implementation and reliability of these systems.

Prior to the passage of the Clean Water Act (CWA), states had the freedom to invest in wastewater infrastructure to meet their needs, with some states exceling while others lagged behind. With the passage of the CWA in 1972, a new phase of wastewater infrastructure projects began under the Construction Grants Program (CGP). The CGP supplied half of all public capital spending and one-third of total capital (public and private) investments in wastewater between 1972 and 1995 (U.S. EPA, 2000). Characterized by structural and highly engineered pipes, pumps, and treatment facilities to address wastewater and related discharges, the infrastructure constructed during this time has since become known as "grey infrastructure." With this new technology and improved techniques, raw sewage discharge rates dropped and gains in wastewater treatment levels were achieved.

These investments in wastewater improved water quality. However, the water quality landscape has evolved since the time of the CPG. When the CWA was first enacted, approximately 85% of water quality impairments were from traditional point sources of pollutions (wastewater and industrial effluent), with the remaining 15% composed of runoff from city streets, suburban lawns, and farm fields. While the amount of pollution has clearly been reduced in the intervening years, the distribution today is exactly the converse from 1970: 85% of current water quality impairments are associated with non-point source urban or agricultural stormwater runoff (Ruckelshaus, 2010).

Emerging Challenges

Water shapes our world in many ways providing benefits as well as posing challenges. As the global population expands and our footprint on the landscape grows, we place more stress on water supplies and increase impacts on the quality of waters in both urban and rural areas. Technology and technical approaches to address these challenges have evolved over the last century with impressive results. Consistent access to safe potable water is ubiquitous in the U.S., and catastrophic water pollution problems are identified early and effectively managed. However, challenges have emerged this century that differ from those experienced by previous generations. These challenges include increased water pollution associated with urban and rural stormwater runoff, overwhelmed combined sewer systems, aging water and drainage infrastructure, damage to populated coastal communities caused by extreme weather events, stress on water supplies in arid and semi-arid areas associated with shifting climate regimes, and impacts on surface water supply systems and treatment infrastructure because of increases in sediment and pollutants.

Today's challenges are often less obvious and harder to quantify, making it more difficult for the public and for decision-makers to grasp their magnitude and far-reaching impacts. For example, toxic waste discharged from an industrial facility is a straightforward pollution problem. In contrast, the increase in "dead zones" (areas with low or no dissolved oxygen available to support aquatic life) in coastal waters, resulting from nutrients and sediment delivered via urban and rural stormwater runoff, is a more abstract water pollution problem. Both situations, however, have significant impacts to public health and safety as well as the economic health for those who rely on urban and coastal waters for income-generating activities such as tourism, water-based recreation, and commercial fishing. The impacts and costs of deforestation on the health and stability of a surface water supply system as well as the overuse and depletion of groundwater resources are similarly complex issues to convey.

New Solutions

New challenges require new solutions, which explain the emerging shift in the approach taken to address stormwater runoff-related impacts. Grey infrastructure solutions were appropriate for the challenges that the Construction Grants Program was set up to address; however, there is a recognition that emergence of "green infrastructure" solutions can better address many of today's challenges both cost-effectively and while providing multiple ancillary benefits. Green infrastructure (sometimes referred to as "natural infrastructure" or "nature-based solutions") can take various forms and can work at varying scales, but its central premise is to mimic nature by harnessing processes and features consistent with natural systems.

The benefits of using green infrastructure are wide reaching, diverse, scalable, and supported by science. Attributes range from enhanced resilience of urban areas and coastal communities to improved air and water quality, reduced localized flooding, increased property values, and positive impacts on public health and social well-being. Green infrastructure solutions also integrate regional restoration that achieves rural watershed protection while resulting in sustainable urban drinking water supply. While green infrastructure has many benefits, perhaps its greatest attribute is that it is often more cost-effective than the equivalent grey infrastructure option. A solution that has more benefits at a lower cost is the type of approach this country needs to consider now and in the future.

A Growing Funding Gap

EPA's most recent data on the total need for drinking, waste, and storm water infrastructure over the next 20 years is estimated to be $680B (U.S. EPA, 2010). Clean water sector funding needs over the same time frame are estimated to be $100B to address Combined Sewer Overflow (CSO) Correction and Stormwater Management Programs (referred to as MS4 in reference to the municipal separate storm sewer system permits required under the program) (U.S. EPA, 2010). While this is a significant figure in its own right, the MS4 category saw the largest growth of any category from 2004 to 2008, from $25.4B to $42.3B (67% increase). There are reasons to believe these figures underrepresent the true funding needs, as only seven states make up over 85% of the reported totals, and many states cited the lack of resources and information to document future needs. It should also be noted that awareness and regulatory changes have occurred since 2008 that are driving wet weather and stormwater needs, and this demand is highly likely to continue to grow in the future in a linear, if not exponential fashion.

The American Society of Civil Engineering (ASCE) estimated in a 2011 report that there was approximately $58.3B of investment needs in wastewater/stormwater, of which only $16.1B was funded. Considering current trends, ASCE predicts that this funding gap will grow to $99.5B in unfunded investment needs by 2040 (ASCE, 2011). Considering further that stormwater utilities charge rates for services in less than one-third of all regulated (MS4) communities, it is easy to see that the MS4 sector suffers even more than the wastewater sector from a lack of adequate funding. ASCE also projects the funding gap for the drinking water sector to be over $140B by 2040, highlighting the need for the most reliable and cost-effective means to meet the growing demand for water in the U.S. It is more challenging to determine national figures on funding needs for coastal protection, some of which could be address with green infrastructure; however, it is telling that New York City has identified $2.25B in unmet needs for coastal protection for their area alone (NYC, 2015).

Across the country, our water sector infrastructure needs vary in form and degree. In semi-arid areas, such as Los Angeles, the cost associated with transporting water for water supply is in the millions of dollars per year because only 13% of Los Angeles City's water supply comes from local sources (Chau, 2009). In other areas, such as Des Moines, the added costs to treat excessive nitrates in water supplies attributed to non-point source runoff in order to meet drinking water standards is estimated to be over $180M, which represents over 50% of the 2014 total assets of the existing drinking water system, which is approximately $317M (Des Moines Water Works, 2015). And in the upper Northeast, the Portland (Maine) Water District faces pressure from upstream development and forest conversion, which threaten the quality of its source water drinking supply (Sebago Lake) that may jeopardize its filtration avoidance waiver forcing the District to install a conventional filtration system – a present value cost of $97 to $155 million over 20 years (WRI, 2013). DC Water, the water and wastewater utility in the District of Columbia, is facing a $2.6 billion price tag to reduce combined sewer overflows (CSOs) by 96% over the next 20 years. This project will utilize a series of underground storage tunnels to attenuate stormwater runoff and sanitary flows during peak storm event.

The potential of green infrastructure both to reduce costs, enhance resilience, and provide social and environmental benefits and economic return points to the value of supporting, funding, and encouraging its use to address various issues in the water and coastal protection sectors. This report sets forth the opportunities and policy pathways to enhancing consideration of green infrastructure in federal, state, and local decisions about water-management infrastructure.

1. Green Infrastructure Practices and Value Provided

Nature uses many different processes and features to filter, convey, clean, and store water as well as stabilize shorelines and provide habitat for wildlife. It is not unexpected, then, that green infrastructure would come in many forms, since it relies on these natural processes and features. Similarly, green infrastructure has different meanings in various contexts. The original meaning of "green infrastructure" referred to large-scale natural pathways connecting unfragmented green spaces; however, the application of the term "green infrastructure" has expanded (Firehock, 2010). Thought leaders Edward McMahon and Mark Benedict (2006) provide a good general definition of green infrastructure, which is "a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life for America's communities and people."

This document will focus on the landscape or regional nature of green infrastructure and encompass the following varying contexts in which it is placed: urban green infrastructure, coastal green infrastructure, and watershed-based green infrastructure. While these differing forms of green infrastructure may have unique drivers or functions, bright lines of distinction are not drawn between them, just as bright lines are not drawn in nature itself. Instead, these differing forms of green infrastructure should be considered in a system context with interconnected functions that, when used concurrently, can bolster the resiliency of ecosystems that transcend jurisdictional boundaries and link efforts at urban greening to non-urban, contiguous landscape-scale conservation and restoration (Scarlett, 2010). For instance, a coastal wetland can provide added resilience and protection of coastal infrastructure and natural resources, but it can also provide high levels of water pollution removal for urban stormwater runoff. Similarly, a watershed that has conservation-forested areas can provide important habitat, but also measurably support source water protection to meet drinking water requirements, while also providing enhanced flow control and thermal protection for headwater streams in riparian areas.

Urban Green Infrastructure

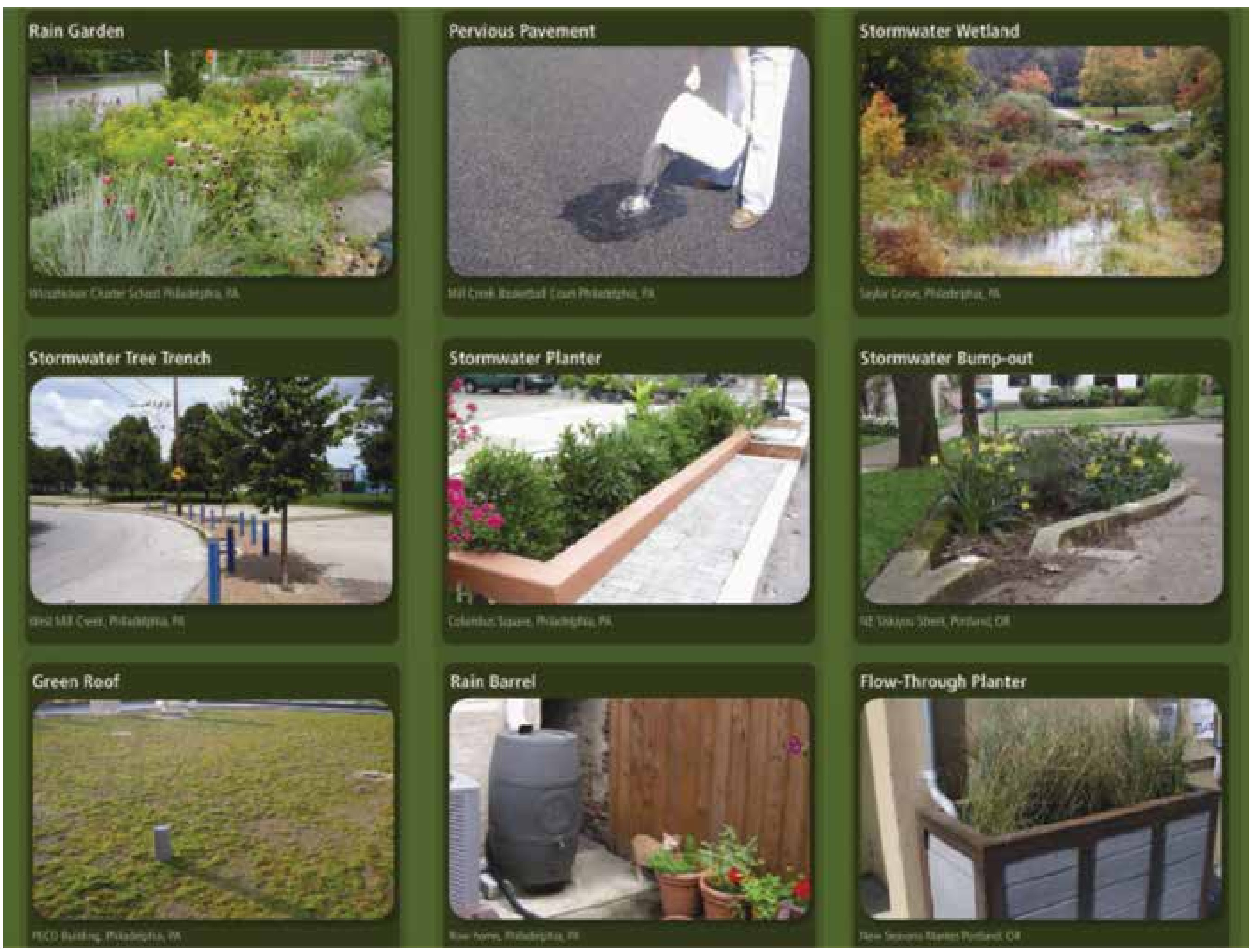
When presenting information on urban green infrastructure, U.S. EPA states that this type of infrastructure "uses vegetation, soils, and natural processes to manage water and create healthier urban environments" (U.S. EPA, 2014a). The universe of green infrastructure practices varies between regulated entities, but some common categories have emerged. Figure 1 illustrates a subset of common green infrastructure practices.

Urban green infrastructure is used to manage stormwater runoff to reduce combined sewer overflows (CSOs) and enhance water quality in separate sewer systems through the use of retention and treatment practices. Additionally, urban green infrastructure aids in the reduction of high-frequency localized urban flooding, provides filtration of airborne particulates, reduces energy costs, lowers ambient air temperatures, and enhances the social and economic value of urban areas (Miller 2007, Wise 2007, Currie and Bass, 2008, Wise et al. 2010). Differing types of green infrastructure practices are more suitable for specific situations and landscapes, reflect varying treatment levels, and provide unique benefits.

For instance, green roofs are well-suited for high-density urban areas, such as on large industrial or office buildings (U.S. EPA, 2014a), and can reduce total annual runoff from a building enclosure by 60 to 70% (Kohler, 2006), while also reducing temperatures on building rooftops by between 40-60 degrees Fahrenheit (Gaffin, et al. 2005). Permeable (or pervious) pavements allow water to soak through paved areas, such as parking lots or basketball courts, which reduce runoff volume. Disconnecting downspouts and other direct drainage connections with the sewer system can mitigate excessive runoff volumes in drainage systems. Urban forest canopy, associated with street trees and other deciduous covers used in green infrastructure practices can have direct impacts as well. Residents of Berkeley, California and Cheyenne, Wyoming showed an energy benefit of $11–$15 per tree (McPherson, et al, 2005) while those in Washington, D.C. realized a reduction of energy consumption costs associated with heating and cooling needs by $2.65 million annually due to tree canopy coverage (Nowak et al., 2006).

FIGURE 1

Urban Green Infrastructure Practices



Philadelphia Water Department, 2011

An extensive study was performed in 2009 by Stratus Consulting to quantify the benefits of urban green infrastructure for the Philadelphia Water Department (PWD), who has taken the bold step of addressing a majority of their CSO mitigation efforts through urban green infrastructure. The scale of this program is unprecedented, as PWD has agreed to "green" (retain the first 1" of runoff) close to 10,000 acres of impervious cover within their combined sewershed, which will cost over $1 billion compared to the nearly $10 billion grey infrastructure alternative. Further details of the economics behind PWD's decision are captured in Box 1.

A similar opportunity exists for the City of Los Angeles, which has interest in reducing dependency on external sources of water supply by using urban green infrastructure to enhance groundwater recharge. A study led by the City estimated that an increased use of green infrastructure would save the City the cost of pumping approximately 152,000 acre-feet of water annually. Translating this volume into costs associated with pumping rates over a 20-year timeframe, the City could save up to 428,000 megawatt-hours, equivalent to the energy use of between 20,000 and 65,000 households. Assuming a rate of 5.4 cents per kilowatt-hour, this would represent a savings of over $23 million dollars for the City (Chau, 2009). As the Philadelphia and LA cases demonstrate, urban green infrastructure presents economic and environmental opportunities for cities with strained budgets and critical water management needs.

BOX 1

Economics of Choosing Green Infrastructure

Philadelphia's internal analysis showed that a **total savings of around $8 billion** would be realized by taking a green infrastructure-led approach to controlling CSOs in place of traditional grey infrastructure.

Co-benefits associated with urban green infrastructure were quantified through a "triple bottom line" (TBL) analysis focusing economic, environmental, and social outcomes. If half of the impervious area within Philadelphia was managed through green infrastructure, the study showed that the following co-benefits would be achieved:

- Over $34 million dollars in energy savings would be realized over the 40-year life of the program
- A total of $134 million would be realized through improved air quality translating to fewer fatalities, heart attacks, and respiratory illnesses
- Enhanced property value benefits would total an estimated $575 million for residential property owners
- The reduction in urban heat island associated with urban green infrastructure would reduce risks of heat-related premature fatalities by $1.1 billion.

The total co-benefit of the approach was shown to result in an estimated **co-benefit of over $2.8 billion** compared with a tunnel option, which provides only $122 million in benefits when using the same metrics. To place in context, the analysis estimated that the green infrastructure option would provide 20 times as much benefit at a much lower cost (Stratus, 2009).

Coastal Green Infrastructure

Practices to protect coastal areas and mitigate flooding potential can take a variety of forms. Traditionally, this type of protection was provided through the use of large, structural measures, such as rip-rap or boulder shorelines, revetments, rock breakwater features, floodgates, and floodwalls. More recently, there has been an interest in using vegetative or natural-based measure to provide these services, which forms the family of coastal green infrastructure practices. A subset of these approaches is illustrated in Figure 2.

This family of practices reduces the energy of wave action, coastal flooding impacts, and storm surge delivered by severe coastal storm events as well as providing ecological benefits. Other impacts addressed through these practices are long-term shoreline erosion and saltwater intrusion (USACE, 2013a). As with urban green infrastructure, coastal green infrastructure can be more cost-effective than grey infrastructure alternatives. For instance, Virginia's Coastal Zone Management Program invested in an oyster restoration program, resulting in a tenfold increase in oyster harvests, coastal risk reduction benefits such as wave energy attenuation, and an increase in dockside value from $575,000 to $8.26 million (Coastal States Organization, 2014a).

Large storm events, such as Hurricanes Katrina and Sandy, have raised the profile of coastal flooding and erosion over the last decade. These two events totaled over $150 billion dollars in damages, were associated with over 1,300 fatalities, impacted hundreds of thousands of properties, left millions without power, and displaced tens of thousands of people in effected regions. Coastal regions also are strong economic drivers in areas related to coastal recreation and tourism. It is estimated that these activities drive between $20 billion and $60 billion across the entire U.S. annually (Restore America's Estuaries, 2008). For example, Florida's coral reef system between Martin County and the Florida Keys generates $6.3 billion in tourism-related sales and income annually and supports over 70,000 jobs (Coastal State Organization, 2014b).

Additionally, coastal areas are home to the commercial fishing industry, ports and marine transportation sector, and a significant portion of private landownership, making real estate values in these areas another important economic

FIGURE 2

Coastal Green Infrastructure Practices

GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM INTENSITY, TRACK, AND FORWARD SPEED; SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY

Dunes and Beaches	Vegetated Features	Oyster and Coral Reefs	Barrier Islands	Maritime Forests/Shrub Communities
Benefits/Processes	Benefits/Processes	Benefits/Processes	Benefits/Processes	Benefits/Processes
Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	Breaking of offshore waves Attenuation of wave energy Slow inland water transfer Increased infiltration	Breaking of offshore waves Attenuation of wave energy Slow inland water transfer	Wave attenuation and/or dissipation Sediment stabilization	Wave attenuation and/or dissipation Shoreline erosion stabilization Soil retention
Performance Factors	Performance Factors	Performance Factors	Performance Factors	Performance Factors
Berm height and width Beach slope Sediment grain size and supply Dune height, crest, and width Presence of vegetation	Marsh, wetland, or SAV elevation and continuity Vegetation type and density	Reef width, elevation, and roughness	Island elevation, length, and width Land cover Breach susceptibility Proximity to mainland shore	Vegetation height and density Forest dimension Sediment composition Platform elevation

USACE, 2013

asset. A 2008 study of the economic and market values of estuarine and coastal areas in the U.S. led by Restore America's Estuaries placed a total value of $31.6 billion for the entire commercial fishing industry with $3.8 billion in "ex-vessel value", which is the price paid directly to fisherman (Lipton and Kasperski, 2008). Regarding real estate impacts, the estimated insured value of coastal properties in 2012 in the Gulf and East Coast regions alone total $10.6 billion, which is up from $7.2 billion in 2004 (Doggett, 2015). The U.S. is among the largest trading nations in the world, making the ports used in coastal U.S. areas critical to the lifeblood of the U.S. economy. Over $800 billion worth of goods are handled in U.S. ports each year, which drives a $30 billion marine transportation sector and over 60,000 jobs associated with this sector (Jin, 2008). An estuary or coastal area that is protected through increased resilience from a green infrastructure investment could reduce the impacts on port areas. For instance, the Ports of Los Angeles and New Orleans handle an average of $354 and $56 million of cargo per day, respectively, so a reduction in the delay of port services attributed to coastal protection can easily be seen to be of economic value.

It is estimated that by 2025, 75% of the U.S. population will live within 50 miles of a coastline (Coastal State Organization, 2014b). This fact makes the human and economic impacts already sustained all the more meaningful and will continue to be drivers for the public and for decision-makers to increase the resilience of coastal areas to protect coastal infrastructure and population centers. Additionally, enhanced ecological benefits provided with coastal green infrastructure, which is tied to tourism, coastal fisheries and related activities, will continue to be drivers in the future.

Watershed-based Green Infrastructure

Watershed-based green infrastructure is the development of a green infrastructure system or network that is composed of core areas, hubs, and corridors (Amundsen et al., 2009). Core areas provide habitat for sensitive species and are located within a hub, which are large, least-fragmented or contiguous areas of forest, wetlands, streams, or other similar native areas, and corridors are green links that provide connectivity between hubs (Amundsen et al., 2009). Figure 3 illustrates this configuration.

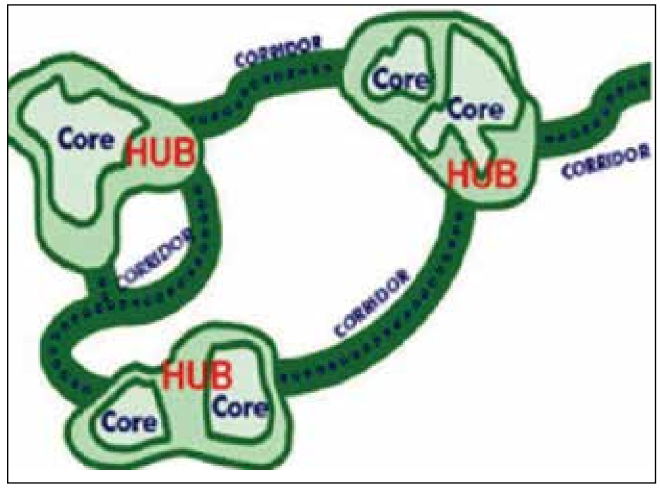
Watershed-based green infrastructure as a systems approach to regional restoration provides the foundation to leverage rural greening strategies, such as forest protection, riparian restoration, and agricultural nutrient management, that positively impact down-stream communities, but also integrate with urban green infrastructure installation to enhance landscape-scale ecosystem services. A subset of watershed-based green infrastructure practices is illustrated in Figure 4.

Watershed-based green infrastructure strategies provide wide-reaching and essential natural ecosystems services that also return direct economic advantages for communities across the country. Example ecosystem benefits include high quality freshwater supply, hydrologic regulation, waste assimilation, non-point source nutrient regulation and pollution control, soil retention and reduced sediment delivery, wildfire mitigation, and enhanced pollination and wildlife habitat (Amundsen e al., 2009; Scarlett, 2010; WRI, 2013; Gartner et al., 2014).

Of the benefits listed above, a leading driver for many communities is *source water protection* for securing high

FIGURE 3

Hub, Core, and Corridor Configuration of Watershed-Based Green Infrastructure



Amundsen et al., 2009

FIGURE 4

Watershed-based Green Infrastructure Practices

	Strategy	Description
	**Forest Protection**	Purchase of easements, land rental, fencing out cattle, and funding for park guards to maintain watershed services
	**Reforestation**	Restoration and planting of native trees, grasses, and shrubs in critical areas to reduce erosion and related sediment transport
	**Agricultural Best Management Practices**	Implementation of cover crops, contour farming to prevent—and wetland and terrace construction to trap—sediment and nutrient runoff
	**Riparian Restoration**	River bank restoration and protection to reduce erosion and improve water quality
	**Forest Fuel Reduction**	Conducting controlled burns and/or mechanical treatment to reduce wildfire severity and related sediment and ash pollution

McDonald and Shemie, 2015

quality, lower cost drinking water supply. Source water protection refers to the protection of water quality, quantity, timing flows, and associated benefits at the water's source—before it reaches the intake of a drinking water system (WRI, 2013). Protecting or restoring forested headwaters can stabilize or improve downstream supply of potable water. Forests cycle water from precipitation through soil and ultimately deliver it as streamflow that is used to supply nearly two-thirds of the clean water supply in the United States (NRC, 2008). The economics are compelling as well.

According to the 2014 American Water Works Association Journal, *Protecting Forested Watershed Is Smart Economics for Water Utilities* (Gartner et al., 2014), "forests and water treatment, transport, and storage are increasingly linked from an economic perspective … by maintaining high source water quality through natural infrastructure investments, treatment plants may avoid capital costs for some of the processes in conventional treatment, such as coagulation, flocculation, sedimentation, and more advanced treatment processes like membrane filtration and activated carbon. Reduced sedimentation in source water also prevents sediment buildup in reservoirs and potential water intake clogging, leading to decreased maintenance costs such as dredging and repairing. Finally, treatment plants with high-quality raw water may also save on variable costs because more chemicals such as coagulants, disinfectants, and pH adjusters are needed when water quality degrades."

This economic incentive was also highlighted by Jim Taft, executive director of the Association of State Drinking Water Administrators, when describing a U.S. EPA study of six communities that concluded, "on average, every $1 spent on source-water protection saved an average of $27 in water treatment costs" (Winiecki, 2012). Another study of 27 water suppliers concluded that each 10% increase in forest cover in a water source area decreased treatment and chemical costs by some 20% (Ernst, 2004).

Cities across the country have invested in watershed-based green infrastructure strategies to achieve cost-effective results. New York City's source water protection initiative has been a hallmark example. NYC took an alternative approach to spending $8–10 billion on a new filtration plant, and instead invested less than $2 billion on land protection and sustainable forestry and agricultural practices achieving EPA's filtration avoidance waiver. Similarly, the City of Auburn, Maine invested $570,000 in land protection and acquisition of 434 acres in the city's drinking water watershed. The purchase saved the city over $30 million in capital and operating costs by maintaining water quality standard and avoiding the need for a filtration plant (WRI, 2013). A 2001 study by natural resource economists Brent Sohngen and Jon Rausch who analyzed dredging costs in Ohio's Toledo Harbor found that annual costs associated with dredging and disposal of dredged materials totaled $6.3 million (1995 dollars), which spurred interest in a sediment delivery reduction study. It was found that a 15% reduction in sediments delivered could be realized if low-cost green infrastructure practices were installed, such as the use of forested filter strips around streams in the Maumee River watershed, which drains to the Toledo Harbor, resulting in reduced dredging and disposal costs by $1.3 million annually. The costs associated with the green infrastructure sediment-reducing actions in the Maumee Watershed are much less than the avoided costs associated with the dredge and disposal services, further illustrating the potential cost-effectiveness of some watershed-based green infrastructure (Sohngen and Rausch, 1998).

2. Policy Context

Though U.S. environmental regulations do not generally reference green infrastructure explicitly, some associated policy guidance documents do reference nature-based solutions, and there are a number of means by which practitioners in the regulated community use green infrastructure practices in order to meet existing requirements. Federal agencies have also undertaken a variety of initiatives to further encourage and implement green infrastructure, and this section highlights a select list of commitments and activities underway. Yet more work is needed to further ingrain green infrastructure as a viable option to address our water resources challenges now and in the future.

The **White House Council on Environmental Quality (CEQ) and the Environmental Protection Agency (EPA)** led the establishment of the Federal Support for Green Infrastructure Collaborative in July 2014, a partnership of seven federal agencies, NGOs, the private sector, and academia (U.S. EPA, 2014b).[1] Leading up to the establishment of the Green Infrastructure Collaborative, CEQ held meetings on green infrastructure in September 2012 and water infrastructure financing in July 2013. CEQ reaffirmed its support for the Green Infrastructure Collaborative and additional green infrastructure assistance through the Administration's *Climate Natural Resources Priority Agenda*, announced at an event in October 2014 (CEQ, 2014).

EPA had previously launched the Green Infrastructure Partnership in 2007 and built upon that effort with the launch of the Green Infrastructure Collaborative. EPA has published a number of Strategic Agendas, most recently in 2013 (U.S. EPA, 2013a), which lay out its efforts broadly on green infrastructure. The Agency has also held two summits to promote green infrastructure across the country, the

[1] The July 2014 agreement was amended in October 2014.

first in 2014 in Syracuse, NY and the second in 2015 in Cleveland, OH.

Since 2007, EPA's Office of Water has issued a series of policy memos encouraging the incorporation of green infrastructure into the CWA's NPDES stormwater program. To support these policies, EPA has developed materials to describe how to integrate green infrastructure into various aspects of the program, including: 1) CSOs long term control plans (LTCPs) and CSO consent decrees, 2) Sanitary Sewer Overflow (SSO) capacity management operations and maintenance (CMOM) plans and SSO consent decrees, 3) Stormwater permits (including permits for construction sites, industrial sites, and MS4s), 4) Total Maximum Daily Load (TMDL) implementation plans, and 5) Antidegradation Reviews or Use Attainability Analyses for maintaining water quality standards.

EPA has emphasized the use of green infrastructure in MS4 permits with a 2014 compendium providing examples of green infrastructure-focused permitting approaches (U.S. EPA, 2014c) and has provided extensive guidance for utilizing green infrastructure in CSO LTCP and CSO enforcement agreements, including a 2014 resource for municipalities and sewer authorities on quantifying green infrastructure contributions in CSO Plans (U.S. EPA, 2014d).

EPA's Office of Enforcement and Compliance Assurance has been a leader in incorporating green infrastructure remedies into CWA consent decrees, administrative orders, agreements, and other settlements. Furthermore, EPA collaborated with a number of agencies to develop technical guidance to assist federal agencies in complying with the Energy Independence and Security Act (EISA) Section 438, which requires federal agencies to reduce stormwater runoff from federal development projects by using green infrastructure and low impact development practices (U.S. EPA, 2009a).

Flexibility of the CWA along with EPA's Water Quality Trading (WQT) policy, last updated in 2003, has allowed for WQT to be used as a means to achieve Total Maximum Daily Load compliance without costly technological improvements to pollutant discharging facilities. WQT programs are a voluntary mechanism allowing sources with high pollution control costs (often a point source such as a wastewater treatment plant or industrial facility) to purchase pollution reduction credits from sources with lower costs (point source or non-point source, such as a farm owner) (WRI, 2013). Green infrastructure principles and practices have been a driver to pollution reductions and WQT credits.

Under the Safe Water Drinking Act (SDWA), drinking water taken from surface water sources must be filtered to meet Maximum Contaminant Levels (MCLs) set by EPA. As previously described, source water protection is an example of another voluntary means to implement green infrastructure techniques, such as forest conservation or reforestation, to protect water in streams, rivers, lakes, and aquifers, thereby helping communities meet MCL standards at a lower cost.

Cutting across the Agency, EPA's Office of Solid Waste and Emergency Response released a guide to assist communities, developers, and other stakeholders in determining if green infrastructure should be used on brownfield redevelopment sites (U.S. EPA, 2013b). Brownfields can be attractive areas to implement stormwater management features. EPA's 2015 National Brownfields Conference also showcased several educational sessions covering green infrastructure integration into redevelopment strategies (U.S. EPA and ICMA, 2015).

EPA's Region 3 (R3) has pioneered a number of significant green infrastructure efforts. It led the establishment of the Green Highways Partnership (GHP) along with DOT and started the Watershed Resources Registry, an outgrowth of the GHP, which they intend to expand upon. Most recently, R3 also undertook a significant research, evaluation, and outreach effort to develop the innovative Community Based Public Private Partnership (CBP3) approach for green stormwater infrastructure (U.S. EPA R3, 2015). CBP3 is a novel application of a traditional P3 model to meet the unique challenges of stormwater management systems, including a focused effort to leverage innovative financing to accelerate community green infrastructure implementation.

Several initiatives are underway to advance a new path forward through innovative partnerships and alternative financing mechanisms. EPA established a new Water Infrastructure and Resiliency Finance Center, announced January 2015, as a resource to assist communities with implementing innovative partnerships and financing tools, such as CBP3, and to explore new ways to leverage successful programs like the State Clean Water and Drinking Water Revolving Loan Funds. The Center supports the *Build America Investment Initiative,* a government-wide effort to increase infrastructure investment and promote economic growth by creating opportunities for state and local governments and the private sector to collaborate, expand public-private partnerships, and increase the use of federal credit programs (OPS, 2014).

Furthermore, the Water Resources Reform and Development Act of 2014 created the Water Infrastructure Finance and Innovation Act (WIFIA), which will result in a new EPA-administered program providing federal credit assistance for water infrastructure projects. WIFIA is expected to advance alternative infrastructure financing solutions as modeled after the Transportation Infrastructure Finance and Innovation Act of 1998 (TIFIA), which has provided over $16 billion in assistance since 1999 to transportation projects costing nearly $60 billion (U.S. EPA, 2014e).

The Clean Water State Revolving Fund (CWSRF), established through the 1987 CWA amendments, is an EPA-state partnership that provides communities with a source of low-cost financing for a wide range of water quality infrastructure projects. Similarly, the Drinking Water State Revolving Fund (DWSRF) was established through the 1996 SDWA amendments. The SRF programs, which initiated the inclusion of a 20% "Green Project Reserve" as part of the American Recovery and Reinvestment Act (ARRA),[2] provide necessary resources for communities to implement "green" projects, including the development of green infrastructure projects. For example, $1 million of ARRA-funded green infrastructure projects support Onondaga County's "Save the Rain" program. This funding was used to help install a rainwater harvesting system in Syracuse's minor league hockey facility to reduce up to 300,000 gallons of water consumption and drove a large-scale rain barrel program in the Harbor Brook Sewershed. Another ARRA-funded GPR project resulted in the retrofitting of ten city blocks in the Seattle area through the construction of features such as bioretention swales, rain gardens and porous concrete, totaling $1.5 million in SRF funding.

In addition to EPA's efforts to advance green infrastructure practices, the following paragraphs describes how various federal agencies, primarily those that are partners in the Green Infrastructure Collaborative, continue to support green infrastructure with policies and programs.

The **Department of Defense (DOD)**, in particular Department of the Navy, has been a leader in the federal government's compliance with EISA Section 438. The Navy issued a Low-Impact Development (LID)[3] policy in December 2007 with a goal of "no net increase in storm water volume and sediment or nutrient loading from major renovation and construction projects" (Navy, 2007). The Navy then released a manual in 2010 to guide the implementation of LID into DOD's Unified Facilities Criteria, in a manner consistent with EPA's technical guidance on EISA compliance (DOD, 2010).

As part of the Green Infrastructure Collaborative, DOD has committed to developing and distributing guidance on how to operate and maintain green infrastructure on military bases and updating the Unified Facilities Criteria on Landscape Architecture to clarify guidance on green infrastructure (U.S. EPA, 2014b).

The U.S. Army Corps of Engineer (USACE) is aiding with the promulgation of green infrastructure primarily through its coastal resiliency efforts (USACE, 2013a). For example, USACE is working on improving methods to quantify the value and performance of coastal green infrastructure practices (USACE, 2015) and has worked with states to encourage coastal green infrastructure through permitting as well as offer technical guidance on its design, construction, and evaluation (Arcadis, 2014).

The **Department of Housing and Urban Development (HUD)** has incorporated green infrastructure as a key strategy for their Office of Economic Resilience and its Sustainable Communities Initiative (SCI) grantees (HUD, 2015).[4] HUD is among the federal agencies signed on to the Green Infrastructure Collaborative and has committed to a host of green infrastructure efforts.

Under its commitments to the Green Infrastructure Collaborative, the **Department of Transportation's (DOT)** Federal Highway Administration (FHWA) is partnering with States, planning organizations, and Federal land management agencies to pilot climate change and extreme weather vulnerability assessments of transportation infrastructure and analyze options for improving resiliency. DOT is working with states to implement ecosystem-based and landscape-scale mitigation and integrated planning that incorporate best stormwater practices. DOT's Transportation Investment Generating Economic Recovery (TIGER) Discretionary Grants, which invest in road, rail, transit, and port projects that achieve national objectives, have included requirements for applicants to describe project benefits in terms of a number of outcomes that include stormwater and resilience considerations.

The U.S. Forest Service is the primary agency within **U.S. Department of Agriculture (USDA)** promoting green infrastructure. Its Urban & Community Forestry program has developed a host of resources related to urban forestry planning and stormwater management. Under the Green Infrastructure Collaborative, the Forest Service has committed to providing guidance to enhance the land-use planning and land conservation components of EPA's current green infrastructure efforts and to encouraging strategically managed networks of natural lands that conserve ecosystem values and functions.

USDA's Rural Development Agency has programs that support water and sewer systems in rural America that often incorporate green infrastructure. USDA's Natural Resource Conservation Service and Farm Service Agency have missions and programs inherently linked with watershed-scale green infrastructure concepts as well.

The **Department of the Interior (DOI)** has worked to facilitate green infrastructure through its Fish and Wildlife

[2] This set aside for projects that address green infrastructure, water, and/or energy conservation and efficiency, or other environmentally innovative activities, is required under the CWSRF and optional under the DWSRF.

[3] LID originated as a design strategy intended to maintain a site's natural hydrology and is often considered a precursor to the broadened concept of "green infrastructure."

[4] SCI is an outgrowth of the HUD-DOT-EPA Partnership for Sustainable Communities formed in 2009, a partnership with a focus on green infrastructure.

Service (FWS), Bureau of Land Management (BLM), National Park Service (NPS), and U.S. Geological Survey (USGS). Another partner in the Green Infrastructure Collaborative, DOI is working to develop metrics and evaluate the performance of their Sandy Supplemental resilience investments, which included $100 million in external grants for green infrastructure and other nature-based solutions. Through FWS's Coastal Program, the agency is implementing restoration projects that incorporate green infrastructure principles and practices to reduce the force of high stormwater events through habitat restoration practices, including culvert repair and replacement, stream and wetland restoration, and enhancing green corridors through tree and grassland plantings.

The **National Oceanic and Atmospheric Administration (NOAA)** has developed a comprehensive suite of tools and resources for supporting coastal green infrastructure including wetlands, floodplains, and other natural buffers. NOAA's Office for Coastal Management, the primary office responsible for administering the Coastal Zone Management Act of 1972, has assisted with pilot studies to assess the economic benefits of green infrastructure in the Great Lakes region (ERG, 2014). NOAA has also partnered with Maryland's Department of Natural Resources (MD DNR) and the Chesapeake and Atlantic Coastal Bays Critical Area Commission to develop a Local Framework for Coastal Resilience Strategies for Critical Area Jurisdictions in 2015, which explores how communities can incorporate green infrastructure into their Critical Area programs for coastal protection.

The **Department of Energy (DOE)** primarily encourages green infrastructure for energy efficiency improvements in transportation, building, and related sectors. A participant in the Green Infrastructure Collaborative, DOE has taken recent actions to implement the stormwater requirements of the EISA Section 438 across the its complex, with site projects at five of its national labs.

3. Accelerating Green Infrastructure Opportunities—Existing Barriers

Considering the many benefits and potential economic advantages associated with green infrastructure, it may seem surprising that green infrastructure is seen as a "new" and "alternative" approach in many areas across the country. There are several reasons for this "implementation gap" for green infrastructure. The water sector has recently focused on this apparent disconnect in an effort to better understand these dynamics. For instance, the Water Environment Federation (WEF) as well as the U.S. Water Alliance (USWA) both conducted surveys of industry experts in 2011 on the barriers to green infrastructure implementation and found comparable results. These two surveys show consistent challenges in the following areas of green infrastructure implementation:

- Financial and funding
- Institutional and public perception
- Regulatory and policy
- Technical and programmatic

This document addresses barriers using these categories and provides contextual background for each. Pathways to solutions through regulatory and legislative tools are proposed in Section 4, page 17 to illustrate how to overcome the hurdles identified below.

Funding and Financing

One area consistently listed as a top-priority challenge in the infrastructure sector is a lack of funding and financing. This obstacle is magnified within the water sector, and stormwater, coastal protection, and watershed-based solutions are often at an even greater disadvantage. While federal programs provide some funding for water, wastewater, watershed, and coastal infrastructure, the role of these federal dollars has become increasingly limited over time. Industry groups state that financial support at the federal level for water and wastewater projects currently represents less than five percent of total wastewater and drinking water investment funding.

Funding input from the federal government for coastal restoration and protection comes through the Coastal Zone Management (CZM) Program, which includes grants that are matched at 1:1 by states and direct funding to support NOAA's Office of Coastal Management, which works to ensure consistency of on-the-ground activities across state programs and coordinate regionally-driven and functionally-aligned programs. These dollars from federal programs can be leveraged at the state and local levels to expand the impact, which is critical at a time when a significant amount of funding needs falls upon municipal and state governments.

Federal Funding

The current lack of adequate funding in the water sector and decreasing water infrastructure investment at the federal level over the last two decades, as discussed in the introduction, present major challenges. Initial large-scale investments through EPA's Construction Grants Program (CGP) gave way to the formation of the Drinking Water and Clean Water State Revolving Funds (DWSRF and CWSRF, respectively). Since the inception of the CWSRF, this program has provided $105.4 billion to communities. These investments have traditionally focused on the wastewater sector, as evidenced by the fact that, as of 2008, less than one percent of CWSRF dollars had been directed towards green infrastructure or stormwater-related activities.

An opportunity to change this trend arose after the establishment of the ARRA GPR requirement. The initial requirement for the GPR was to direct 20% of funding to these projects, which was a good first step towards federal funding of green infrastructure; however, a consistent challenge has been funding green infrastructure within the GPR pool of projects. For instance, in the initial year of implementation of the GPR, only 14% of GPR funds went towards green infrastructure, while a majority of the funds went to energy efficiency and water conservation projects (U.S. EPA, 2012a).

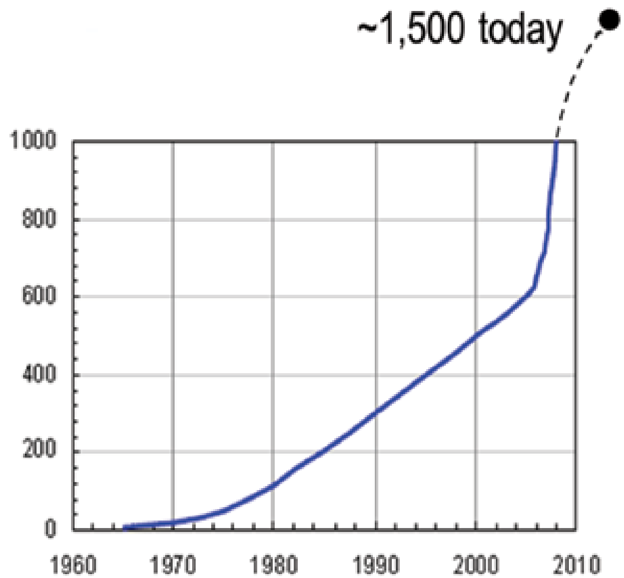
The SRF program is also a challenging avenue for green infrastructure funding. While some states have moved forward with funding green infrastructure through SRF, such as Washington, Ohio and New York, barriers remain with many other states. Innovation is rare in state-run SRF programs. The Government Accountability Office (GAO) led a study on how the SRF program could be improved and found that of the 21 states included in the study, only 3 were found to use innovative investment strategies. Specifically regarding green infrastructure, the University of North Carolina Environmental Finance Center performed a survey of state SRF programs that found when state SRF managers were asked about the possibility of a separate pot of SRF funds for green infrastructure projects, a quarter claimed to already have one set up and close to 40% stated that it either "wouldn't work" or they wouldn't consider it as an option.

Stormwater Utilities

Another challenge in funding/financing is the lack of dedicated funding for some sectors. For instance, there are currently between 1,500 and 2,000 stormwater utilities (entities that administer revenue based primarily upon fees that fund stormwater programs) (WKU, 2014), which represent less than one-third of the 7,500 regulated MS4 communities. This low incidence of dedicated funding for urban green infrastructure is far below dedicated funding levels for other infrastructure sectors. Even considering this, there has been a significant growth in stormwater utility formation due to the large number of newly regulated communities needing to implement stormwater practices and programs. Figure 5 illustrates the growth in the number of stormwater utilities that has occurred from 1960 to 2000. However, there are questions as to whether or not this growth will continue, as political opposition to new fees has arisen since the mid-2000's and legal rulings have occurred questioning the validity of viewing these fees as fees, as opposed to taxes. Examples of stormwater utilities that have been successfully challenged in recent years include Jackson County in Michigan and St. Louis Municipal Sewer District in Missouri. The heightened level of attention paid to the "rain tax" debate in the most recent Maryland gubernatorial race also highlights the political sensitivity associated with stormwater utilities in the current political climate.

FIGURE 5

Number of Stormwater Utilities Created Over Time in the U.S.



U.S. EPA, 2009b

Also, as with other infrastructure sectors that depend upon service fees, establishing a fee structure is only the first step to sustainable dedicated and adequate funding. The average stormwater utility fee is approximately $4.00 per month (WKU, 2014), which has held steady over the last 15 years (Doll and Lindsey, 1999), while increased regulatory pressures have mounted and stormwater programs have become more sophisticated. Many jurisdictions with stormwater utilities have also developed incentive-based programs to credit property owners who voluntary adopt green infrastructure. While these programs are well-intended, the economics for incentives are not often favorable, primarily due to the low fees and credits/rebates associated with these fees (Thurston, 2008).

Institutional and Public Perceptions

Status Quo-ism

Given the evolving and rising challenges in the water sector, simply maintaining the status quo poses great risks.

Green infrastructure used in all contexts (watershed-based, coastal, urban) is still s een as a nascent and novel approach. The default for many engineers, scientists, and other technical professionals who lead municipal departments is to rely on status quo methods to address water resources and coastal protection decisions. There are several good reasons for this default, including:

- Municipalities are risk averse by nature, and budget-limited entities using public funds are likely to select a known methodology or technology that is seen as being more predictable and a "safer" bet;

- Known approaches may provide decision-makers with the comfort that permitting, service procurement, and attainment of design standards will proceed seamlessly, all of which may be viewed as a challenge to navigate for novel technologies or approaches;

- Relying on tested methods may further assure public officials and decision-makers that a planned project has a high likelihood of being constructed and implemented successfully;

- Beyond implementation, existing infrastructure projects come with predictable costs and known methods for inspection, maintenance, and operation activities, and the more ubiquitous the approach across the landscape, the greater the confidence may be gained regarding project performance; and,

When budgeting future activities or projects, those approaches with a long-track record provide budgeting officials and managers with an equally high volume of costing data – this knowledge of project costs may make familiar approaches more attractive, especially when developing long-term infrastructure investment planning.

Assuming Green is More Expensive than Grey

The incorrect assumption is often made that a green alternative is more costly than a traditional approach. Non-standard approaches, such as the use of green infrastructure, can, however, be encumbered by inflated costs under existing policies, standards and codes that favor status quo approaches and often require non-traditional approaches to seek waivers during design review approval, driving up project costs. Additionally, new and innovative approaches suffer from inflated costs due to dis-economies of scale and a lack of easily and inexpensively obtained materials for construction/implementation.

Despite these challenges, communities who implement green infrastructure often find that costs are the same as or less than traditional approaches, while providing the additional co-benefits outlined previously. The classic case for this is Philadelphia's green infrastructure approach to CSO mitigation, as previously presented, among many other examples. For instance, the Boulder Hills and Greenland Meadows residential and commercial development projects in New England each used green infrastructure to manage stormwater runoff to not only meet, but to exceed local regulatory requirements. In both cases, the green infrastructure alternative was less expensive. For Boulder Hills, a residential land development project, the use of green infrastructure produced additional lots to sell, and also reduced the project cost by 6% compared to the traditional stormwater approach. For Greenland Meadows, a commercial "big box" retail site, the total project savings was close to $1 million, approximately 10% of the total project cost (UNH, 2010).

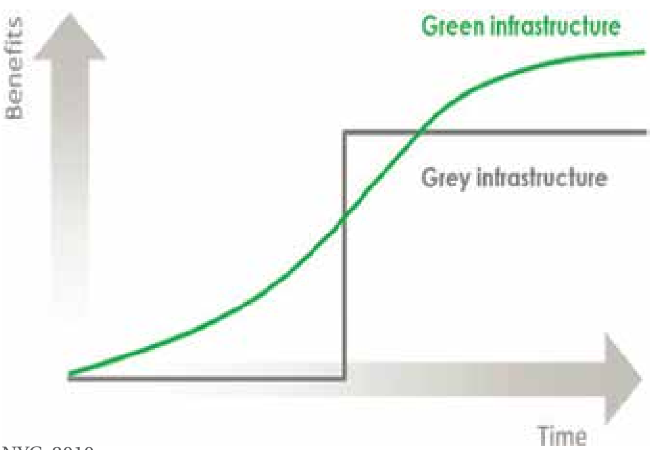
The cost-efficiency of green infrastructure is not limited to urban green infrastructure. As the Coastal States Organization (2014b) points out, "green infrastructure can be more cost effective than grey infrastructure," in the coastal green infrastructure context. The Chesapeake Bay Foundation estimates the cost per foot for living shorelines to be $50 to $100 while costs for structural shoreline stabilization options (bulkheads, riprap, etc.) can range between $500 and $1,200 per foot. Similarly, Shell Global Solutions International has examined structural and non-structural options to protect oil and gas pipelines on or near shorelines, and is promoting the use of green infrastructure practices (oyster reef breakwaters) rather than standard rock breakwaters. Shell has found the cost for green infrastructure practices to be approximately $1M per mile while structural alternative range from $1.5M to $3.0M (TNC, 2013).

Regulatory and Policy

Regulatory Bias towards Grey Infrastructure

A common limitation for green infrastructure implementation is regulatory approval and recognition to meet permit requirements. This is due, in part, to the structure of the current regulatory environment, which is tailored to the implementation of grey infrastructure. For example, utilities with CSO problems are often allowed a 20-year period to alleviate the combined sewer challenges, which is consistent with the time required to plan, finance, and construct an underground storage ("tunnel") project, the traditional approach to CSO mitigation. In comparison, for a green infrastructure-driven plan, implementation of projects can initiate more quickly and progress consistently over time. This dynamic means that the direct CSO mitigation benefit, as well as other co-benefits, can be realized far sooner than a traditional tunnel-type of CSO

FIGURE 6
Phasing of Green and Grey Infrastructure



NYC, 2010

mitigation project. Figure 6 illustrates the dynamics of green and grey infrastructure phasing.

Similarly, the limited track record associated with green infrastructure compared to "traditional" grey infrastructure, as well as the complexity of green infrastructure processes, increases uncertainty in the eyes of the regulators, especially in the enforcement community. As previously discussed, the use of green infrastructure is a relatively new approach that uses complex natural processes and is often less centralized than traditional infrastructure types. To illustrate, the strength of concrete used for a bulkhead coastal revetment project can be tested and quantified. In contrast, the performance of a living shoreline project that will reduce wave energy and enhance the strength of shorelines through soil stability provided by root growth is much more challenging to understand and quantify.

To provide another example, in a clean water context, the ability to measure the influent and effluent water quality of a specific pollutant parameter delivered to and discharged from a wastewater treatment plan can be readily and easily performed in one location, and it is easy to predict the flows that will be delivered to the treatment facility at any given time. On the other hand, the monitoring of water quality treatment of a system of bioretention facilities across a watershed or a catchment area is a more onerous task, requiring multiple monitoring facilities that are intended to capture and test influent based upon an unpredictable and chaotic source (precipitation).

The uncertainties associated with the immediate and long-term performance of green infrastructure systems, along with the complexities of monitoring performance, inject a perceived level of risk when green infrastructure projects are proposed. This additional risk becomes manifest by requiring that green infrastructure alternatives proposed to meet regulatory requirements perform at a higher level than the grey alternative in LTCPs and other infrastructure implementation plans. An additional level of perceived risk for green infrastructure is due to the aspirational nature of green infrastructure plans, especially as compared with a tunnel option. With a traditional tunnel approach to CSO mitigation, there is a contractor hired to plan, design and oversee the project, and if the tunnel does not perform as designed, the contractor can be held responsible. Proposed green infrastructure plans are normally led by the utility or municipality with technical support provided by consulting firms, so there is not a single entity in the private sector responsible for the performance of the green infrastructure plan.

Siloed Clean Water Programs

A common mantra in the water sector is the "One Water" concept, yet our regulatory landscape is anything but unified. Communities are expected to meet requirements in multiple regulatory programs and contexts related to the impacts of stormwater runoff (MS4, CSO, SSO, TMDL). The effort of blindly meeting requirements associated with each of these programs with little regard for areas of efficiency that can be gained through efforts to address these programs concurrently is a lost opportunity to maximize the value of clean water investments.

Considering that wastewater and stormwater discharges have impacts on downstream waters, a new approach to managing NPDES requirements has been proposed by EPA, referred to as "integrated planning." This approach allows communities to consider regulatory obligations for stormwater and wet weather discharges and is further discussed in Section 4, page 17. One potential challenge to green infrastructure becoming a more significant aspect of integrated planning efforts is the tension between the permitting and the enforcement regulatory divisions based upon the previously-discussed perceived uncertainties related to the performance of green infrastructure when compared to traditional grey infrastructure solutions.

Inter-jurisdictional Challenges

Stormwater runoff does not respect jurisdictional or state borders, yet our regulatory programs are inherently tied to such borders. This tension between the physical delineation of a watershed and the local governments who are impacted by stormwater runoff has led to confusion in the regulations and in the courts.

Positive examples of watershed- and regionally-based MS4 permits exist, such as the Menomonee Watershed Permit; however, this approach is still relatively new, and it is not clear how sustainable watershed-based permits will be. Regionally-based permits are not defined by watershed, but rather by varying levels of local government, and are often formed to share resources for a more cost-effective means to meet regulatory requirements. These permits are often held by an entity, such as a county or a soil conservation district that encompasses several other regulated entities. For states with a severely fragmented local government structure, including Pennsylvania and states in New England, regional permits are particularly useful.

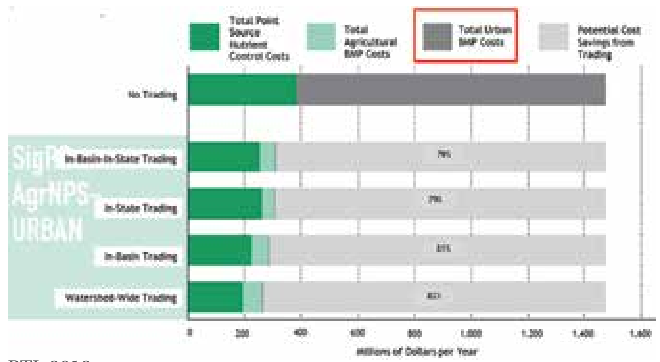
Regulatory Crediting and Lack of Clarity in Market-based Approaches

Any traded commodity requires a commonly-accepted currency of trade. A challenge in the clean water space is defining the currency and the associated credit given towards specific practices or projects. Consider the success of the Clean Air Act Amendments of 1990, which established a trading program for sulfur dioxide to address the acid rain problem in that era. This program provided the basis for credits and assigned limits that emitters were to meet through either upgrades or purchases of credits. The success of this program was due to the fact that a clear requirement was set, a system for crediting actions was established, and large geographic boundaries (airsheds) generated a large enough pool for trades to successfully occur. While the success of this approach has been well documented, it is less clear how successful water quality trading (WQT), the water sector's market-based approach, has been due to sector-specific challenges and a lack of a clear trading policy on the regulatory front.

While air quality trading can occur over large regions, the more localized nature of water quality trading is more conducive to implementation at the watershed or municipality level. For instance, Washington, D.C. has developed a trading market for stormwater retention, the first of its kind in the U.S., if not the world. The Philadelphia Water Department (PWD) is also using an alternative method to meeting a regulatory need, in this case CSO mitigation. PWD is not using a trading platform to attain large-scale green infrastructure investments, but rather, paying the private sector to make these investments at a cost that is at least 30% lower than the public sector. In both Washington, D.C. and Philadelphia's market-based approaches, elaborated in Section 4, page 17, the currency is very clear: stormwater retention. Both cities have expended great efforts to provide clarity on how to generate credits, which may be why these programs have garnered interest from cities such as Chattanooga, TN and the City of Los Angeles, who are developing similar market-based programs to generate more urban green infrastructure.

FIGURE 7

Potential Cost Savings in Chesapeake Bay with MS4 Inclusion in Trading Activities



RTI, 2012

For pollutants such as sediment and nutrients, the challenge of clarity in crediting across a large enough area has limited market-based approaches. This limitation existing despite the well-documented significant cost difference between equivalent treatment levels associated with practices in the agricultural and the urban settings. A 2012 report by RTI International found that this difference could lead to a cost reduction of over 80% if MS4s within the Chesapeake Bay were to trade with agricultural stakeholders to meet Chesapeake Bay TMDL limits for nutrients and sediment (see Figure 7). This reduction illustrates the potential; however, it is unclear how much trading activity will occur in this context. Additionally, few if any MS4s have entered into trading within the Chesapeake Bay region despite this great potential to save money while addressing TMDL requirements. This is likely due to a lack of clear crediting of practices by regulators as well as uncertainties on the duration of credits purchased and high transactional costs. In contrast, the Tualatin Basin Water Trading program illustrates the utility of water quality trading when policies are clear and regulatory programs are harmonized. Rather than spend $60M on a refrigeration system to meet water quality standards related to stormwater and wastewater discharges, a plan to combine five NPDES permits under one umbrella facilitated the payment of $6M to farmers in the watershed to plant trees along 35 miles of stream in the watershed (Scarlett, 2010).

Technical and Programmatic

Standards, Codes and Ordinances

Technical standards and codes in many areas have not kept up with the technologies and technical approaches available in the sector. Often, local design and building codes are legacy approaches used decades in the past. The use of green infrastructure to address stormwater runoff is a relatively new practice, and thus it has not been adopted through the slow process required to update codes and ordinances tied to flood protection and stormwater management. The complex and nuanced nature of green infrastructure further slows the process of updating these standards due to status quo dynamics.

Cross-departmental Challenges

Green infrastructure is designed to be applied at varying scales across many different types of landscapes in a watershed. Additionally, it is often integrated into other infrastructure projects (roadways, land/building development). These aspects of green infrastructure create challenges related to working across departments within a jurisdiction. Drivers to consider the implementation of green infrastructure into projects differ by departments and parties involved. For instance, in a school facility renovation or construction project, the requirement to integrate green infrastructure into the project may be perceived as a burden to the school administration or education board; however, the municipal government may see this as an opportunity to help meet their MS4 permit. A parks department may value the green infrastructure practices in the project in terms of aesthetic, recreational, and ecosystem services provided. The inconsistent valuation of green infrastructure among various departments within jurisdictions can create conflicts. A clearer understanding of benefits through consistent metrics to measure these benefits may provide municipalities with a clearer vision on the relative value of green infrastructure investments.

Lack of Knowledge of Asset Management and Alternative Finance and Project Delivery Options

Traditional grey infrastructure is treated as an asset to be managed; however, green infrastructure is often seen as a resource to valued. While valuing green infrastructure as a resource is a constructive view, a more robust valuation would be based upon asset condition and the management of this asset. This includes a well-funded and robust inspection and O&M program, planning for regular infrastructure rehabilitation and replacement, and risk assessment. Asset management also requires the consideration of sophisticated and complex financing and project delivery options available to communities to fund infrastructure investment, operations and replacement. These alternatives include SRF loans and leveraging, municipal bonds, "green" bonds, public-private partnerships, and private activity bonds (PABs), among other approaches. Currently, green infrastructure is not often treated as an asset the same way that other infrastructure sectors are. This lack of sophistication may limit the potential for it to be adopted and implemented in an efficient and robust manner. Further, this may reduce the valuation of green infrastructure as an asset in the eyes of public officials. Additionally, the current landscape of funding for MS4 programs—primarily rooted in general funds with less than one-third having a dedicated funding source (in the form of a stormwater utility)—limits the sophistication of most MS4 program managers on alternative funding/financing and project delivery.

4. Accelerating Green Infrastructure Opportunities—Pathways to Solutions

The potential of green infrastructure to not only reduce costs and enhance resilience but also to provide social and environmental benefits and economic return illustrates the value of supporting, funding, and encouraging its use to address various issues in the water and coastal protection sectors. This section covers solutions to the existing barriers to green infrastructure implementation, detailed in Section 3, page 12. Solutions will be discussed within the following sub-categories:

- Key partnerships
- Leveraging regional restoration
- Innovative funding/financing tools
- Regulatory pathways to change
- Legislative pathways to change

Key Partnerships

As green infrastructure practices have been implemented and interest in replicating such efforts grows, partnerships between stakeholders across various levels of government and in various sectors have been and will continue to be critical to the advancement of green infrastructure.

Green infrastructure has the potential to impact many infrastructure sectors, stakeholders, and other features within a watershed, from headwater streams and agricultural areas in the upper portion of a watershed down to urban areas tied to major waterways and coastal areas. Considering the flexible nature of green infrastructure as a solution that can be customized across various conditions of a landscape, there is great potential to utilize it as a unifying and collaborative force to bring together stakeholders representing a variety of interests. This collaboration can be synergized if green infrastructure can be seen not simply as an "environmental alternative," but rather, as an economic force that provides lower-cost solutions with a strong economic, social, and environmental return on investment to the community.

Partnerships between municipalities can be critical for the success of regional or watershed-based permits, the subject of increased interest in recent years. Home to nearly 1,000 MS4 permits, Pennsylvania illustrates the fragmented nature of local governments with increased regulatory demands due to MS4 requirements and TMDL goals. Communities there found more cost-effective solutions by working collaboratively within watersheds or regions to share resources and expand programs in order to realize economies of scale.

Community colleges represent local trusted institutions that reach and influence large segments of the population and stand as portals into local communities and their leaders. Partnerships involving community college districts across an eco-region, basin, or large catchment could prove instrumental in increasing recognition of green infrastructure best practices, supporting green infrastructure workforce development needs, demonstrating green infrastructure/low impact development techniques on-campus, and advocating for scalable regional green infrastructure platforms.

An essential cross-discipline and cross-departmental collaboration is the Green Infrastructure Collaborative led by EPA and CEQ, as discussed in Section 2, page 9. This partnership includes NGOs, federal agencies, and private-sector entities. Federal partners have listed official commitments on promoting green infrastructure through specific actions, such as updating manuals to include green infrastructure practices and approaches, requiring green infrastructure elements in the construction of federal facilities, and leading studies on research topics related to green infrastructure. By acting as leaders, these federal agencies set an example that state and local governments can emulate.

Recommendations

- Widely disseminate EPA examples of collaborations between multiple departments within a local government entity, as well as between municipalities within a watershed or a region, who utilize green infrastructure for multiple objectives, including clean water requirements, coastal protection/enhancement, and source water protection.

- Increase EPA encouragement of watershed- and regionally-based permits through technical support and regulatory guidance.

- EPA should continue supporting the Green Infrastructure Collaborative, and consider expanding to other groups as well.

- Convene key affinity groups, investors, and risk managers to further reveal the business case for green infrastructure investment.

- Approach the American Association of Community Colleges and explore regional pilot relationships. For example, currently a nine community college consortium is operating along the length of the Mississippi River consisting of one college located in each of the six U.S. Army Corps of Engineer Districts. Currently this group is advancing a green workforce development effort that is river corridor-based via a significant Department of Labor (TAACCCT) grant. Institutional arrangements and working relationships are already in place and could be leveraged to advance a systematic green infrastructure platform.

Leveraging Regional Restoration

Green infrastructure strategies can open the door to alternative approaches that cut across varying geographical scales to meet a range of environmental challenges. Additionally, the consideration of solutions at a watershed- or region-wide scale can facilitate the identification of opportunities to trade high-cost downstream grey infrastructure investments with lower-cost upstream green infrastructure investments. This approach can also unlock the added co-benefits of green infrastructure that can be realized in communities and areas where the greatest impact can be made for the entire region or watershed.

The landscape-scale nature of environmental challenges underscores that cities and countryside can benefit from ecosystem conservation and restoration efforts that transcend jurisdictional boundaries and link what cities are doing with what the nation and rural communities are doing to restore ecosystems. Many urban efforts are often not integrated into regional strategies that link urban greening to non-urban, contiguous landscape-scale ecosystem restoration, limiting the potential to optimize ecosystem services benefits in terms of both environmental outcomes and revenue streams to support greening goals (Scarlett, 2010).

To achieve a more resilient outcome, states such as Maryland are taking a landscape-scale perspective to green infrastructure strategy and implementation for coastal adaptation. Constructing or implementing piecemeal or site-specific green infrastructure will not enhance the resiliency of a coastal community. Rather, green infrastructure practices must be implemented based on a comprehensive geographic assessment of the coastal community that identifies community needs related to stormwater and nuisance flooding, storm surge, and other coastal impacts (DeWesse, 2015).

Likewise, green infrastructure outcomes could be effected and demonstrated via traditional compliance driven restoration efforts. For example, USACE's Upper Mississippi River Environmental Management Program (UMRS-EMP) has invested hundreds of millions of dollars since the 1986 WRDA authorization that has completed a robust number of Habitat Replacement and Enhancement Projects (HREPs) the length of the upper river that arguably have not made the system any more resilient. These so-called restoration projects are performance measured in acres of habitat reclaimed, have been expensive to design and deploy, and haven't proven to better address regional source protection or control challenges. The Corp's EMP has produced an aggregation of environmental outputs in an effort to balance or offset inland navigation improvements. However, this effort could be recast to more squarely advance a regional green infrastructure platform that could integrate, not simply aggregate outputs, while producing outcomes that measurably improve system resiliency, not simply increase acres of habitat.

One example of a cost-effectiveness watershed approach is the investment in forest management in Denver's source water area. Two devastating forest fires occurred in 1996 and 2002, which led to nearly $150M in damages related to sediment impacts on the drinking water system, fire suppression costs, post-fire restoration and stabilization, and property damage. As a reaction, Denver has invested $16.5M to reduce the fuel load in the source water area to reduce the risk and magnitude of future forest fire events (WRI, 2013).

A related example is the City of Duluth, who analyzed a plan to use green infrastructure throughout the Chester Creek watershed to alleviate flooding impacts. When considering benefits and costs of this plan over a 50-year time horizon, the investment in green infrastructure ($4.17M) to address flooding impacts generated $4.68M in benefits. The benefits included in the analysis were limited to easily monetized benefits (reduced damages, increased recreational value, reduced drainage infrastructure rehab costs), so if other benefits were factored in, such as water quality, increased habitat, green space, and property values, the benefit/cost ratio would be even greater (ERG, 2014).

Recommendations

- Use Clean Water Act watershed permitting guidance to develop a watershed framework for evaluating, planning, and implementing greening strategies that link urban and non-urban actions.
- Identify and document projects that illustrate the cost-effectiveness of green infrastructure applied in a regional context.
- Examine existing Federal environmental output delivery mechanisms, their accomplishments, and their intent, and reveal the opportunity, within existing authority and funding levels, for course correction to more squarely address system resiliency outcomes.

Innovative Funding/Financing Tools

One of the most crucial barriers to overcome in achieving large-scale implementation of green infrastructure is funding and financing, and a number of innovative programs and mechanisms have been established to do so.

Even with modest expansions in grants and other direct payment programs, the federal role in funding and financing is and will continue to be limited. This limitation points to the need to find ways to channel funding from both the private and non-profit sectors. NatureVest and EKO (2014) state in a report titled, *Investing in Conservation: A Landscape Assessment of an Emerging Market*, that funding from the private and non-profit sector does not limit conservation-related impact investment, but rather, those surveyed in a study featured in the report claim that, "the biggest challenge … was the shortage of deals with the appropriate risk/return profiles." The development of creative and innovative financing and alternative project delivery frameworks can help to bridge the gap between available funding and needs in the sector.

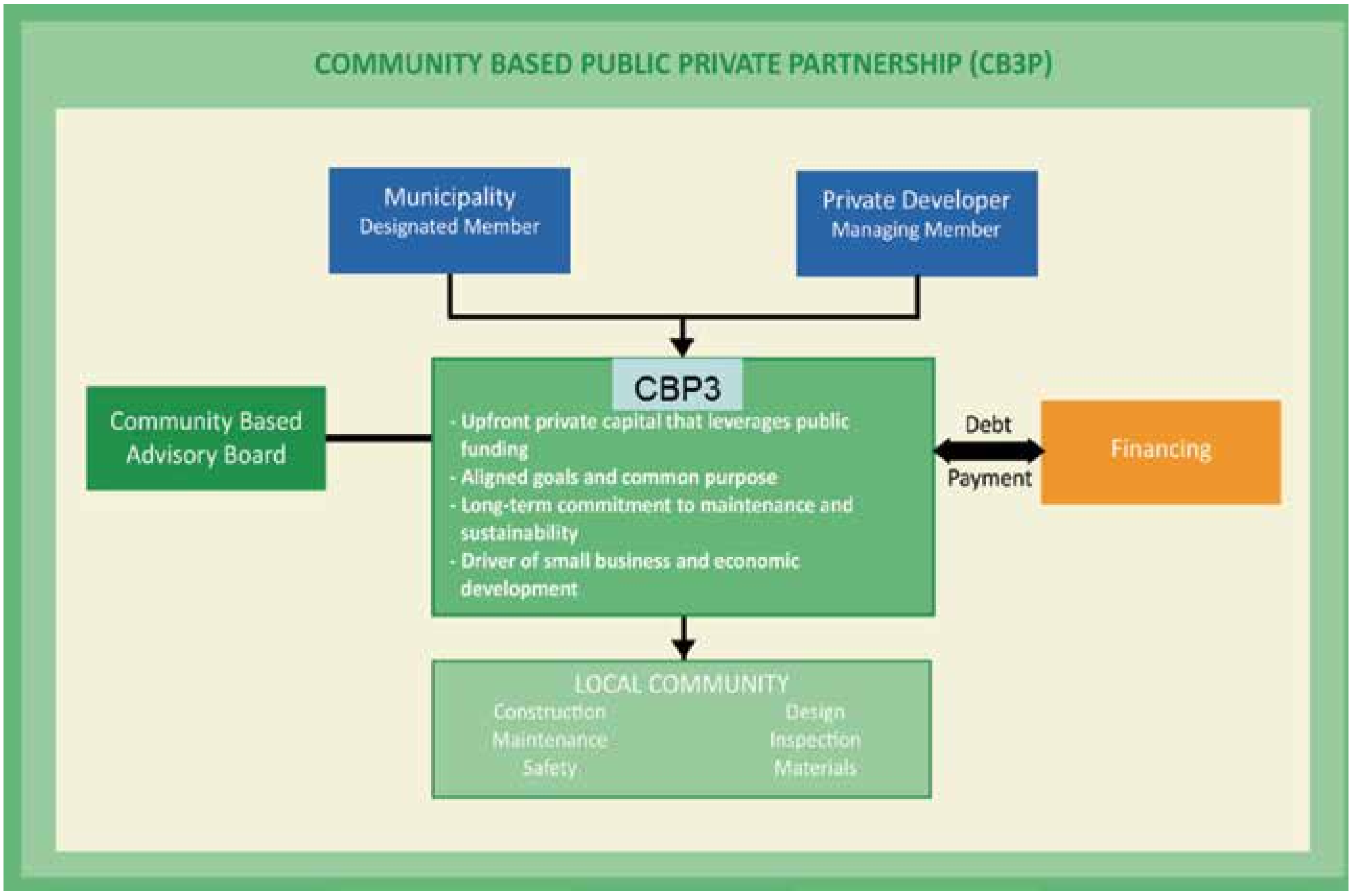
To provide support to communities in their efforts to invest in water infrastructure (drinking, waste, and storm), EPA launched the Water Infrastructure and Resiliency Finance Center (WIRFC) in January, 2015. This Center supports the *Build America Investment Initiative* and seeks to create opportunities for state and local governments to collaborate, expand public-private partnerships, and increase the use of federal credit programs.

WIRFC recently released a new resource on **Community-Based Public Private Partnerships (CBP3s)** for green infrastructure, an innovative approach to engaging the private sector and reducing costs for green infrastructure implementation through alternative project delivery and access to private capital while placing the interests of the community as a top priority. Green infrastructure projects are normally addressed in a piecemeal approach, with each project going through a separate process of planning, design, construction and inspection/maintenance; rarely are these services integrated. This leads to inflated costs due to inefficiencies in project delivery. The CBP3 approach seeks to integrate these services to provide more constructible projects and increase the efficiency of project delivery. Additionally, it seeks to implement green infrastructure at a large-scale, which has not been the norm in the sector up to this point. The vision for large-scale investments drives costs down further by gaining economies of scale.

The value to the community of the CBP3 approach is based upon incentives built into the framework to hire local, small, and minority/disadvantaged businesses and to create a high number of entry-level jobs to construct and maintain the implemented green infrastructure. Additionally, large-scale implementation of green infrastructure positively

FIGURE 8

Community-Based Public-Private Partnership Framework



U.S. EPA R3, 2015

magnifies social and environmental benefits (as opposed to piecemeal, disparate, small-scale implementation) and has proven to be an attractor of economic development and enhanced property values.

Some have expressed concerns with the quality of product associated with P3s; however, the CBP3 model is performance-based by following the "availability payment" model for revenue capture. The premise of this model is that payment is made based upon the amount of effective/functional infrastructure that is completed, and this functionality must be retained over the life of the contract (the CBP3 proposes a minimum of 30 years for a concession period). It should be noted that the CBP3 entity administering the program comprises both the public and the private entity, and that the public entity not only has oversight via a public advisory body, but also has direct input on the development of partnership policies and operations (see Figure 8 for a schematic of this relationship).

In order to finance the project, the CBP3 entity can use all public dollars, all private, or a mix of the two. Ideally, financing would be based upon a dedicated revenue stream (e.g., stormwater fees) that allows the CBP3 entity to obtain reduced-cost private capital by leveraging long-term, dependable revenue source. P3s are governed primarily by state legislation, which often dictates the nature of the contract structure, procurement process, and most significantly, project type allowed. Of the 33 states/territories with P3-enabling legislation, the majority limit P3 projects to transportation. Yet, this trend is changing, and specific language regarding stormwater has been introduced into legislation in the District of Columbia and Pennsylvania. More can be done, however, to encourage and clarify the use of P3s for stormwater projects. EPA Region 3 (Mid-Atlantic) has lead the development of the CBP3 guide and continues to advocate for innovative, market-based solutions to its region's water sector challenges.

Several communities are currently considering the CBP3 approach to address large-scale stormwater infrastructure investments. The first community out of the gate to adopt this approach is in Prince George's County, a county in the Washington, D.C. region facing an estimated $1.2 billion cost to meet regulatory requirements associated with Chesapeake Bay TMDL requirements to reduce nutrient and sediment loading by 2025. To accelerate the schedule to meet this goal as well as reduce the costs, Prince George's County issued a Request for Qualifications (RFQ) to establish a CBP3 program to retrofit up to 15,000 acres of impervious cover. A private partner was selected, Corvias Solutions, who established the Clean Water Partnership in spring of 2015 to lead the program. The first phase of the contract is a $100 million effort to retrofit 2,000 impervious acres using innovative green infrastructure practices. The project requires 35% local workforce engagement in this phase, with this percentage increasing in future years up to 50%. An estimated 5,000 new jobs will be created or added as a result of this project. Similar targets are required for small and woman/minority-owned businesses. Initial findings show that costs reductions of at least 40% are being realized compared to traditional green infrastructure implementation (Lueckenhoff and Brown, 2015). While this example focuses on urban green infrastructure, CBP3 can be applied for a variety of green infrastructure types, including coastal and watershed-based approaches.

Additional **market-based approaches** to green infrastructure investment carry a significant amount of promise, whether these are developed to function within a CBP3 framework or independently. For instance, Washington, D.C.'s stormwater retention trading market, introduced in Section 3, page 12, fully commoditizes stormwater retention. The premise of this market is that the private sector is more likely to be able to develop retention-based practices than the public sector, and that the cost to retain stormwater runoff varies widely across the District of Columbia. For instance, the cost to retain rainwater by using a green roof can be an order of magnitude more expensive than a landscape-based practice, such as bioretention. With higher development rates in areas within the District that would be confined to using green roofs, there should be motivation to pay for "stormwater retention credits" generated more cheaply in another part of the District.

To date, this market has been very inactive, which may be due to a number of factors, including a lack of awareness, a reluctance to enter into the market, and a limited amount of demand potential. In the D.C. context, stormwater retention credits are envisioned to be created and consumed by private developers; however, some think that public demand (from the District Department of the Environment) could help to generate more transactions for the market that could provide more price signals on the cost of a stormwater retention credit and instill confidence from the private sector that this framework is functional and credible.

The Philadelphia Water Department (PWD) is also using a market-based alternative to meeting a regulatory need, in this case CSO mitigation. PWD is not using a trading platform to attain large-scale green infrastructure investments, but rather, is using a cost-threshold grant program whereby private sector entities compete for grant funding based upon identifying projects that can be implemented below a specified cost threshold. This has resulted in private sector green infrastructure investments at a cost that is at least 30% lower than the public sector. To incentivize private property owners to engage in the program, private entities can offer to construct green infrastructure on a site at no cost to the property owner and agree to use a portion of the cost savings realized through a stormwater fee reduction to pay the private entity to maintain the green infrastructure practices over a long period of time (~30 years). This program has already spawned an industry of companies that install and maintain urban green infrastructure. In the context of CBP3, such market-based approaches can be integrated to operationalize the program dynamics at the ground level (U.S. EPA R3, 2015).

SRF leveraging also holds great promise in meeting the needs of green infrastructure investment in the U.S. While investments through the SRF program are likely to remain focused on traditional point sources, there is continued interest in utilizing SRF dollars for green infrastructure projects. As green infrastructure becomes more common, an increase in SRF-backed green infrastructure projects is likely to occur; however, many SRF managers require education on the nature and value of green infrastructure and how these projects can be scored and funded through the SRF program. Further, a report by the EPA Environmental Finance Advisory Board (EFAB) released in January 2014 stated that, "for each dollar of annual SRF cashflows, $3-$14 of triple-A rated funding capacity could be created for (green infrastructure projects)," and that, "based on $2 billion in annual cashflow, this translates to $6 billion to $28 billion in potential untapped funding capacity nationwide." This funding potential is based upon leveraging cashflow dollars, an approach not embraced by all SRF managers.

Other non-traditional financing approaches for green infrastructure include **Green Century Bonds and Property-Assessed Clean Energy (PACE)** options. A $350 million green bond was issued in Washington, D.C. to support the $2.6 billion grey infrastructure "tunnel" project that will greatly reduce CSOs released to the Potomac and Anacostia Rivers. This financing vehicle has been reviewed and accepted as "green" by independent advisors due to the benefits regarding water quality, mitigation of localized flooding, and positive impacts to aquatic ecosystems. More significantly, the term of the financing, 100 years, matches the design-life of the tunnel system, making this the first "green century bond" in the U.S. The case for the unusually long-term duration for this bond issuance is based not only upon the life of the built infrastructure, but also to minimize interest rates, and the financial plan amortizes the costs more affordably over the generations of customers and ratepayers who will benefit from the project. While the D.C.

Green Century bond is financing a grey infrastructure project, this innovative approach illustrates the type of creative financing available in the "green" space. The investment community has stated there was "little trouble selling the $350 million in debt," as "investors are anxious to get exposure to municipal risk, […] there is greater demand than there is issuance for (green projects), [… and] green bonds attract a diverse range of investors including some who would not ordinarily buy municipal bonds" (DC Water, 2014).

The PACE program is a relatively new approach, launched in 2008 in Berkeley, California, that proposes to create zones where property equity can be leveraged to invest in clean energy on a site. This program helps both commercial and residential property owners develop the capital needed to install solar panels and related clean energy and energy efficiency upgrades with the repayment assessed on property tax bills under the assumption that the investment payback would occur within a normal mortgage payment maturity (20 years) considering the lower energy costs realized over time. Similar to the green century bond concept, this program has not targeted green infrastructure; however, some programs across the country (DC, CA) have been expanded to potentially include other infrastructure types, such as green infrastructure. Additionally, the White House recently announced a series of executive actions and private sector commitments to promote the use of clean energy technologies at the household level, which includes the removal of existing barriers to accelerate the use of PACE financing for single family housing. The expansion of PACE created through these actions could help to catalyze the use of green infrastructure at the site or household level as well.

As with P3s, the creation of PACE programs rely on state legislation and local adoption, and at this time, 31 states have developed PACE-enabling legislation (see Figure 9) with most focusing primarily on the clean energy sector. Expansion of statutes governing PACE to allow for piloted green infrastructure projects would illustrate the proof of concept. Pilot restrictions could be removed if the concept proves to be sound to allow for scaled-up applications (PACENation, 2015).

FIGURE 9

States with PACE-Enabling Legislation

PACENation, 2015

Recommendations

- Expand EPA Water Infrastructure and Resiliency Finance Center to:
  - Help educate communities on new and sophisticated funding/financing strategies and alternative project delivery approaches for water infrastructure investment, including green infrastructure;
  - Work directly with states to encourage the integration of green infrastructure into SRF programs; and,
  - Develop tools to help states understand how to leverage SRF funds for green infrastructure projects more effectively.
- Advocate for more states to adopt P3- and PACE-enabling legislation in a format that will encourage the application of these non-traditional approaches for green infrastructure.
- Encourage industry groups to develop tools to more readily adopt non-traditional funding/financing, market-based approaches and alternative project delivery frameworks for green infrastructure based projects.
- Provide forums for public and private entities with a common interest in exploring the potential for innovative funding/finance and alternative project delivery.
- Connect the financing sector with water professionals to facilitate a stronger relationship between these sectors.
- Promote flexibility in procurement processes to integrate P3s more readily into programs.

Regulatory Pathways to Change

Challenges in the regulatory arena often limit the potential for communities to consider new and emerging ways to meet requirements; however, innovative approaches have emerged that may help to overcome some of these challenges. These approaches highlight the significant role of federal and state regulatory agencies can play in creating opportunities to encourage green infrastructure through regulatory pathways.

One example of an innovative way to reduce costs while meeting clean water requirements, as previously discussed, is integrated planning. This approach was developed by EPA and articulated in a 2012 EPA memo. Considering the "disconnect" between the permitting and enforcement branches within EPA, it is significant to note that the memo came from both the Offices of Water and Enforcement Compliance Assurance. Included in this memo was the directive to consider green infrastructure when addressing both MS4 and CSO-related programs, as this approach is effective in both contexts (U.S. EPA, 2012b).

Other examples of potential solutions to overcome regulatory impediments are watershed-based permits and market-based frameworks (water quality trading and other incentive-based approaches). Both approaches can ease financial burdens on communities and help to drive down costs for compliance.

There are other ways that regulatory agencies can aid in the increased implementation of green infrastructure. For instance, a multitude of federal programs provide grants, technical support and recognition for infrastructure projects, including programs within USDA, HUD, DOI (Bureau of Reclamation), DOT, Economic Development Administration, DoD, FEMA, and EPA. The opportunity exists for these programs to increase emphasis on environmental and green infrastructure benefits through their selection criteria. The missions and selection criteria for such programs are, in most cases, dictated by legislative policy that goes through a reauthorization process every two to six years. An analysis could be performed to determine which programs could further emphasize environmental benefits in project funding decisions. When those programs go through the reauthorization process, supporters for changes could advocate before the appropriate congressional committees.

Lastly, increased flexibility in programs such as the NPDES, Coastal Zone Management, and the National Environmental Policy Act that encourage adoption of green infrastructure can provide additional avenues to overcome the regulatory barriers that currently exist.

Recommendations

- Update EPA Water Quality Trading policy to clarify how regulators can accept this approach as a viable option for regulated entities.

- Allow for increased flexibility in the enforcement of permits, which will encourage the use of non-traditional approaches, such as green infrastructure, at various scales.

- Create guidance outlining the development of standard metrics for ecosystem services, public health/safety, job creation, economic growth/revitalization, and other non-traditional factors when performing benefits/cost analysis during project selection process that would be applicable across all federal agencies.

- Expand integrated planning and watershed permits, allowing for smarter investment that would likely catalyze an increase in green infrastructure implementation.

- Continue to promote watershed-based permits through the development of guidance materials as well as officially document feedback on existing watershed-based permit holders.

- Increase emphasis on green infrastructure in federal grant, technical support, and recognition programs through reauthorization processes.

- Build upon existing implementation frameworks (such as the MD DNR and NOAA's Local Framework for Coastal Resilience Strategies for Critical Area Jurisdictions for the Chesapeake and Atlantic Coastal Bays) and expand and tailor to various regions across the country.

Legislative Pathways to Change

Several changes have been made to the CWA since its enactment, including the addition of urban stormwater runoff as a regulated pollution source and the transition from the CGP to the SRF program for funding and financing of water projects. More recently, the Water Resources Reform and Development Act (WRRDA) authorized a new program under the title of the Water Infrastructure Finance and Innovation Act (WIFIA). This program authorizes EPA to provide credit assistance, in the form of loans or guarantees, to corporations, partnerships, joint ventures, trusts, Federal, State, or local government entities, agencies or instrumentalities, tribal governments or consortiums of tribal governments, and State infrastructure financing authorities (State Revolving Fund programs), for the purpose of financing needed water infrastructure improvements of national or regional significance.

Every two years Congress is required to pass authorizing legislation for U.S. Army Corps of Engineers projects and programs. The projects must be justified through an extensive cost-benefit analysis that places high value upon the quantifiable benefits of traditional constructed infrastructure. The Corps either has not been able to quantify the benefits of green infrastructure to justify the cost, or it does not have the statutory authority to incorporate green infrastructure into flood and stormwater management projects. Congress will be undertaking another WRRDA bill in 2016, which could be a vehicle for Corps policy and adjustments to the Corps cost-benefit analysis criteria that support green infrastructure.

This type of legislation is critical in expanding the potential for funding and financing in the water sector. Other legislative actions should be considered to further expand the universe of programmatic, project delivery, and funding/financing options available to communities who wish to invest in green infrastructure.

Other legislation related to green infrastructure has been introduced in recent Congresses. The Intelligent Stormwater Infrastructure Act (ISIA), which called for, among other items, the creation of regional Centers of Excellence; establishing planning and implementation grants to support locally-driven, community-based investments in green infrastructure, and promoting the incorporation of green infrastructure across the EPA's policies and programs. This legislation could help to enhance technical understanding of green infrastructure as well as provide an additional funding vehicle for green infrastructure investment at the local level.

Another piece of legislation related to green infrastructure is the Urban Flooding Awareness Act (UFAA), which calls for a national study of the impacts of localized urban flooding located outside of FEMA-protected floodplain areas. This legislation is based upon a study led by the Center for Neighborhood Technology in 2014 focusing on Cook County, IL. This study, supported in part by State Farm Insurance Company, investigated flooding claims made in the area between 2007 and 2011. An important finding is that only 10% of claim payouts were made by the National Flood Insurance Program, while private insurance companies and the FEMA Disaster Relief program paid 27% and 63%, respectively. The implication is that a significant amount of localized urban flooding occurs outside of FEMA floodplain areas, and as flooding increases in areas such as the Midwest (Saunders, 2012), the impacts on private insurance companies is likely to grow. Unlike large, riverine flooding, localized urban flooding can be readily managed through urban green infrastructure, so a national study could increase the understanding on the costs of localized urban flooding, especially as it relates to the private insurance industry, who are showing a growing interest in preventative and cost-effective approaches to addressing chronic urban flooding.

Recommendations

- Allow for ecosystem and triple-bottom line analysis to be included in decision factors when determining project selection for funding/financing programs.

- Expand WIFIA to free up more financing for green infrastructure investment.

- Promote legislation (ISIA) for green infrastructure Centers of Excellence to help address technical and institutional barriers to green infrastructure implementation.

- Support legislation (UFAA) to study the cost impacts of localized urban flooding across the country, and specifically, the impacts to private insurance companies.

- Support legislation at state and federal level for P3s specifically for water-related projects.

- Expand the funding for the Coastal Zone Management and SRF programs for project types shown to have strong economic payback potential when considering both direct and ecosystem service returns on investment.

Conclusion

The potential for green infrastructure to address many of the current challenges facing the water sector today is clear. From oyster reefs providing enhanced economic return while reducing near-shore wave energy impacts in coastal waters to the protection of forested areas in source water zones to reduce the cost of water treatment, transport, and storage, the value proposition of green infrastructure is strong.

While barriers do exist that limit the potential of green infrastructure implementation, these hurdles can be overcome by considering the many expanded benefits provided by green infrastructure when compared to grey infrastructure alternatives. Additionally, the potential for new and creative financing approaches that can expand public capital impacts as well as catalyze private capital investments is significant.

The current economic climate does not allow for infrastructure investments that have limited impact at a relatively high cost. Now more than ever, we must carefully evaluate the options provided to us when deciding our next steps in the water sector. As the aging infrastructure gets older and replacement/rehabilitation occurs using grey infrastructure, more opportunities to integrate green infrastructure into projects is lost. The time to act is now if we wish to increase community resilience and address our growing water quality problems through cost-effective approaches, such as green infrastructure.

About the Author

The Horinko Group (THG) is an environmental consulting firm operating at the intersection of policy, science, and communications. Founded in 2008 by former U.S. EPA Acting Administrator Marianne L. Horinko, THG has established itself as an innovator and a trusted third party convener. The firm has a proven track record of addressing complex natural resource challenges, while meeting the needs of the broader community. There are unique challenges and opportunities given the fiscal and regulatory uncertainty of these times. THG assists all stakeholders in thinking strategically about these opportunities and capitalizing on the business advantages of sustainability.

THG would like to recognize **Seth Brown** for his significant contributions to this report. Mr. Brown serves as THG's Senior Advisor for Stormwater/Green Infrastructure, Public-Private Partnerships, & Economics; and Principal and Founder of Storm & Stream Solutions, LLC.

For more information on THG, please visit www.thehorinkogroup.org.

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