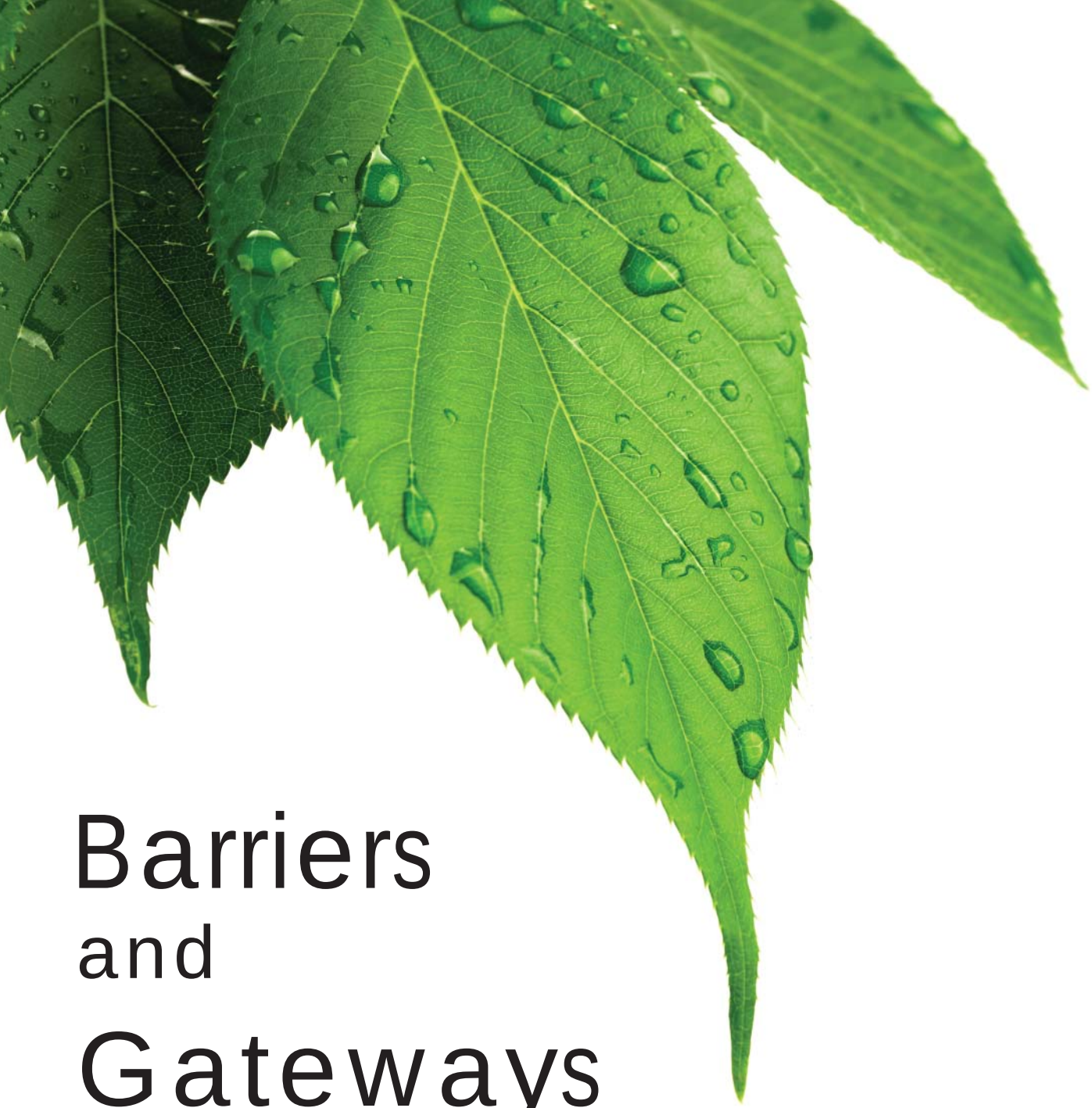


Barriers and Gateways to Green Infrastructure

Clean Water America Alliance

Executive Summary

Communities across the country are facing challenges associated with sewer overflows, stormwater, aging water and wastewater infrastructure, population growth and climate change – in an environment of economic hardship and uncertainty. To meet and address 21st century water challenges, governments are looking at their available options. In the past, communities have relied on gray infrastructure such as pipes, pumps, tunnels, storage basins, and treatment plants to meet stormwater and regulatory needs. Today, new and emerging "green" technologies and practices are becoming a viable option for addressing these emerging challenges.

Green infrastructure systems and practices use or mimic natural processes to infiltrate, evapotranspire, or reuse stormwater and runoff on the site where it is generated. These approaches keep rainwater out of the sewer system which can lead to sewer overflows and also reduce the amount of untreated runoff discharged to surface waters by allowing stormwater to be absorbed and cleansed by soil and vegetation before flowing into groundwater or surface water resources. Green infrastructure has been proven to provide economic, social, and environmental benefits to communities. But it is still new and poorly understood. Despite all these benefits – there is uncertainty and a lack of implementation.

Many studies have described the multiple triple-bottom line benefits of green infrastructure, yet barriers often block the adoption of green infrastructure and practices. With funding and support from the Turner Foundation, the Clean Water America Alliance initiated a study to identify a broad array of green infrastructure barriers from people and institutions on the front lines of green infrastructure – municipal employees, government agencies, non-profit organizations, academia, consulting firms, and those in the private sector from across the nation. Through a large national web-based survey effort, the Clean Water America Alliance collected views on technical/physical, legal/regulatory, financial, and community/instructional barriers people and organizations have encountered. Survey respondents were also given the opportunity to share recommendations on how these barriers might be overcome.

Common themes from the four identified barrier categories are outlined below:

Technical and Physical Barriers

- Lack of understanding and knowledge of what green infrastructure is and the benefits it provides
- Deficiency of data demonstrating benefits, costs, & performance
- Insufficient technical knowledge and experience
- Lack of design standards, best management practices, codes and ordinances that facilitate the design, acceptance, and implementation of green infrastructure

Legal and Regulatory Barriers

- Local rules can be lacking, conflicting, or restrictive
- State water and land-use policies and property rights can be complicating factors
- Federal rules can be conflicting, overly-prescriptive, without needed flexibility, or silent in key aspects

Financial Barriers

- Not enough data about upfront and ongoing maintenance costs and economic benefits
- Perceived high cost over short and long term
- Lack of funding at all levels coupled with poor coordination or integration of programs and funds
- Too much risk - not enough incentives

Community and Institutional Barriers

- Insufficient and inaccessible information about green infrastructure and its benefits for political leaders, administrators, agency staff, developers, builders, landscapers, and others, including the public
- Community and institutional values that under-appreciate green infrastructure aesthetics and characteristics
- Lack of inter-agency and community cooperation

The survey results made it clear - barriers can appear in various shapes and sizes, depending on the watershed, community, and socio-economic context. Some common themes, however, run throughout the survey responses, and the most dominant involve uncertainty and risk. More specifically, uncertainty about outcomes, standards, techniques, and procedures can create an atmosphere where the risks of trying, adopting, or funding green infrastructure projects become unacceptable. A change in status quo is hard when a new approach is undefined, unproven, or under attack by thought leaders and stakeholders. It takes education, coordination, and collaboration to reduce real and perceived risks to shifting paradigms from gray to green.

The recommendations made in this report stem from the responses received by survey participants and the Clean Water America Alliance's experience with green infrastructure policy. The purpose of this report is to inform EPA policy choices on upcoming stormwater regulations and broader green infrastructure strategies involving other key federal agencies. It also provides guidance for green infrastructure pioneers at the local and state levels of government and in the private sector to promote and implement green infrastructure efforts.

Key recommendations include urging EPA to use new stormwater regulations and permits to help drive green infrastructure, fully measure and account for economic and environmental benefits, embrace regional flexibility and results-oriented approaches, and focus increased federal funding for green infrastructure initiatives. Coordination among other federal agencies is critical, especially the USDA, U.S. Department of the Interior, and U.S. Department of Transportation. This can also be true at all levels of government. Only through greater coordination, education, and funding can green infrastructure be advanced meaningfully and sustainably.

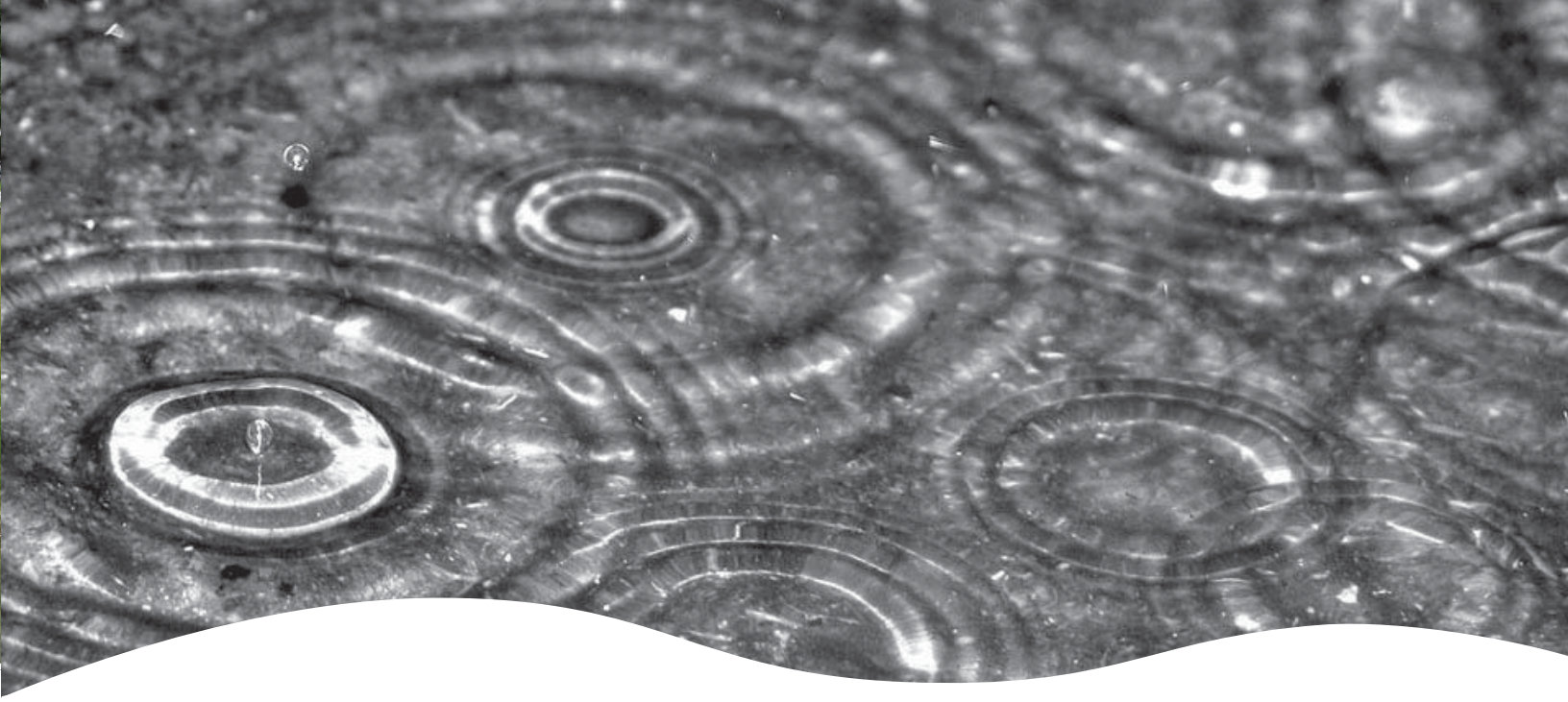
Acknowlegements

First and foremost, thanks to the Turner Foundation for their interest in advancing green infrastructure and sustainable solutions. This research and report were possible through their support.

This report also owes thanks to a variety of people and organizations. The following partners shared their time and expertise in a variety of different ways including reviewing initial concepts and survey drafts, contributing their expertise to the data analysis, reviewing the final report, and presenting the study's findings and recommendation at the WaterWorld VirtualH2O Conference. They include Glen Abrams, Marc Cammarata, and Howard Neukrug of the Philadelphia Water Department; Katherine Baer of American Rivers, Emily Clifton of the Low Impact Development Center, Ken Kirk and Adam Krantz of the National Association of Clean Water Agencies, Erik Meyers of the Conservation Fund, Kevin Shafer of the Milwaukee Metropolitan Sewerage District, and Jon Zeidler of Smart Growth America,

Special recognition is given to Robin Davis of the National Association of Clean Water Agencies for her assistance with formatting this report and EPA for allowing us to use their green infrastructure images.

The report is authored by staff of the Clean Water America Alliance, including Kristyn Abhold, Lorraine Loken, and Ben Grumbles.



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Introduction

Since the Clean Water Act was passed in 1972, the United States has made tremendous progress in protecting and improving the health of our waters and watersheds. Despite nearly four decades of progress, however, the most recent (add date) Environmental Protection Agency (EPA) National Water Quality Inventory Report to Congress indicates that most assessed U.S. water bodies still are not meeting the goals set under the statute. With a growing population of over 311 million people, an aging industrial base, nascent effects of climate change, a resource-intensive farming system, and sprawling metropolitan development patterns, the United States is putting unprecedented strain on its water resources, water systems and watersheds. Water quality in many parts of the country continues to suffer or worsen, due to a variety of pollutants including excessive nutrients and emerging contaminants. Droughts and floods are becoming more frequent and intense. America can no longer afford to look at water issues outside the context of sustainable cities and climate change.

The inability of current state and federal approaches to surmount these increasingly severe challenges indicates that we need to change our approach. America's traditional approach to water resource management is no longer working. A new approach is needed that encourages comprehensive thinking, planning, and management of our surface water resource, groundwater, drinking water, stormwater, and wastewater

Meaningful partnerships and actions must take place more frequently at the local, state, and federal level to resolve serious water management challenges among agencies, utilities, businesses, institutions, civic associations, and environmental groups. The Clean Water America Alliance believes that a consistent and effective national dialogue among all stakeholders, together with efforts that facilitate innovation, is essential to move toward a more sustainable future. The Clean Water America Alliance's goal is to change the water paradigm and break down outdated, compartmentalized silos, which govern our water resources management, so that all stakeholders can collaborate more efficiently to ensure future generations and ecosystems have sufficient clean and safe water.

The Emergence of Green Infrastructure

When the nation's current wastewater and stormwater infrastructure was built in the 19th and 20th centuries, it was designed primarily to move water away from urban environments and surfaces as quickly as possible. Moving water away from structures and streets through pipes and conduits was the preferred approach. The protection of water resources and the environment was an afterthought, and addressed piecemeal with add-on technology. Since water infrastructure funding has been in decline since the 1970s, cities and metropolitan water utilities must be smarter in their economic and environmental infrastructure investments. An in creasing number of states and

municipalities are adopting more holistic approaches to watershed management and stormwater control, including use of non-traditional "green infrastructure" approaches.

Green infrastructure, a term that includes low impact development techniques, is defined by US EPA as a set of techniques, technologies, management approaches and practices that can be used to eliminate or reduce the amount of stormwater and nonpoint source runoff including water and pollutants that run into combined sewer overflow systems. Green infrastructure systems and practices use or mimic natural processes to infiltrate, evapotranspiration, or reuse stormwater and runoff on the site where it is generated. These approaches keep rainwater out of the sewer system which can lead to sewer overflows and also reduce the amount of untreated runoff discharged to surface waters by allowing stormwater to be absorbed and cleansed by soil and vegetation before flowing into groundwater or surface water resources.

"Green Infrastructure should be a tool in the toolbox of water quality management but it should not be considered the only tool available."

Green infrastructure can be combined with traditional "hard" or "gray" infrastructure such as expanding storm systems or building stormwater storage tunnels. Increasingly, green infrastructure techniques and technologies have been identified as 'best practices' at the local, particularly in combination with traditional gray infrastructure, to achieve greater urban sustainability and resilience. In addition, green infrastructure is now being recognized for its value as a means for adapting to the emerging impacts of climate change.

Green infrastructure provides triple-bottom-line results: benefits that accrue to regional economies, the environment, and society as a whole. For example, green infrastructure helps in adapting to the changing climate by moderating the impacts of extreme precipitation and temperature. Other environmental benefits include better management of storm-water runoff, lowered incidents of combined storm and sewer overflows (CSOs), water capture and conservation, flood prevention, storm-surge protection, defense against sea-level rise, accommodation of natural hazards (e.g., relocating out of floodplains), and reduced ambient temperatures and urban heat island effects EPA has also noted air quality improvement, wildlife habitat additions, and increased carbon storage. As to social and economic benefits, US EPA has identified such contributions from green infrastructure as improved human health, lower energy demand and expense, capital cost savings, and recreational space, and even higher land-values of up to 30%.

For green infrastructure to be successful, it must be addressed at all scales, from site-specific and neighborhood to regional and watershed levels. Water utilities, municipal governments, private and non-profit entities are collaborating on a variety of techniques, including, but not limited to: green roofs, trees and urban forestry, rain harvesting, downspout connection, rain gardens, green streets, permeable pavement, vegetated swales, water conservation retrofits, and decentralized systems. It is important not to simply look at green infrastructure techniques in isolation or at the site level but seem focus on their integration with gray infrastructure investments into a unified network that will deliver sustainable, cost-effective benefits at scale and over time.

Current Realities, Future Choices

Cities and communities nationwide need to repair, rehabilitate, or replace their failing pipes and aging wastewater treatment plants. New infrastructure is necessary for compliance with increasingly demanding regulations for public health and environmental protection. The funding gap between what is being spent now and what is needed in our communities is in the hundreds of billions of dollars.

We are at a crossroads. Cities and communities must decide whether to invest limited financial resources in costly 19th and 20th century water pollution control devices, or move in a new, more sustainable direction of adopting and implementing 21st century green infrastructure solutions. Yet the cities and communities are moving in the direction of green infrastructure face a multitude of barriers, including federal and local requirements and regulations that hinder innovative practices. Our study addressed these barriers and the results are reported below.

Fortunately, we see signs of progress. At the national level, EPA is currently working to promote the use of green infrastructure and is in the process of review-

ing proposals from several major U.S. cities looking to take new, sustainable approaches to combined sewer overflow management. In addition, EPA has initiated a national rulemaking to reduce post-construction stormwater discharges from new development and redevelopment and make other regulatory improvements to achieve clean water. A proposed rule is expected from EPA in December of 2011, with final action anticipated no later than November 2012.

While the EPA works to develop this regulation, it will need the input of all concerned stakeholders, including local government officials, utilities, water consultants, conservation organizations, businesses, and others to ensure the final rule promotes the use of green infrastructure to help reduce stormwater impacts. The Clean Water America Alliance undertook an extensive survey project to identify barriers to green infrastructure to provide critical input to EPA and other policy makers to advance green infrastructure policy.

information on current implementation efforts, as well as barriers to the more widespread use of green infrastructure. The Clean Water America Alliance organized the survey by four barrier categories: technical/physical, legal/regulatory, financial, and community/institutional barriers (Appendix 1 – copy of survey).

The goal of the survey was not only to identify barriers to green infrastructure at the local, state and federal levels of government, but to provide concrete and provocative recommendations on how these barriers can be overcome. Survey respondents were prompted to provide quantitative and qualitative information regarding the benefits of green infrastructure, the type of barriers to green infrastructure they have encountered, if/how they have overcome these barriers and recommendations on how these barriers can be overcome. The Clean Water America Alliance designed the survey to collect more qualitative information due to the nature of the study.

From across the United States, a diverse sampling

Figure 1: Survey Respondent's Georgraphic Distribution

About the Barriers to Green Infrastructure Survey

Despite the numerous benefits green infrastructure can provide to communities, many barriers can inhibit its wide-scale implementation. Thus the Clean Water America Alliance conducted a survey to engage utilities, cities, government agencies, nonprofit organizations, and the private sector on the implementation of green infrastructure and related policies. Respondents were asked to complete an online survey to provide

of more than 200 entities participated in the study to identify barriers to green infrastructure. Figure 1 demonstrates the national range of participants from coast to coast. A majority of the respondents represent entities east of the Rockies, where many communities are facing wetter climates, struggling with old infrastructure, and investing more in replacing and retrofitting existing stormwater systems.

The Clean Water America Alliance made a concerted

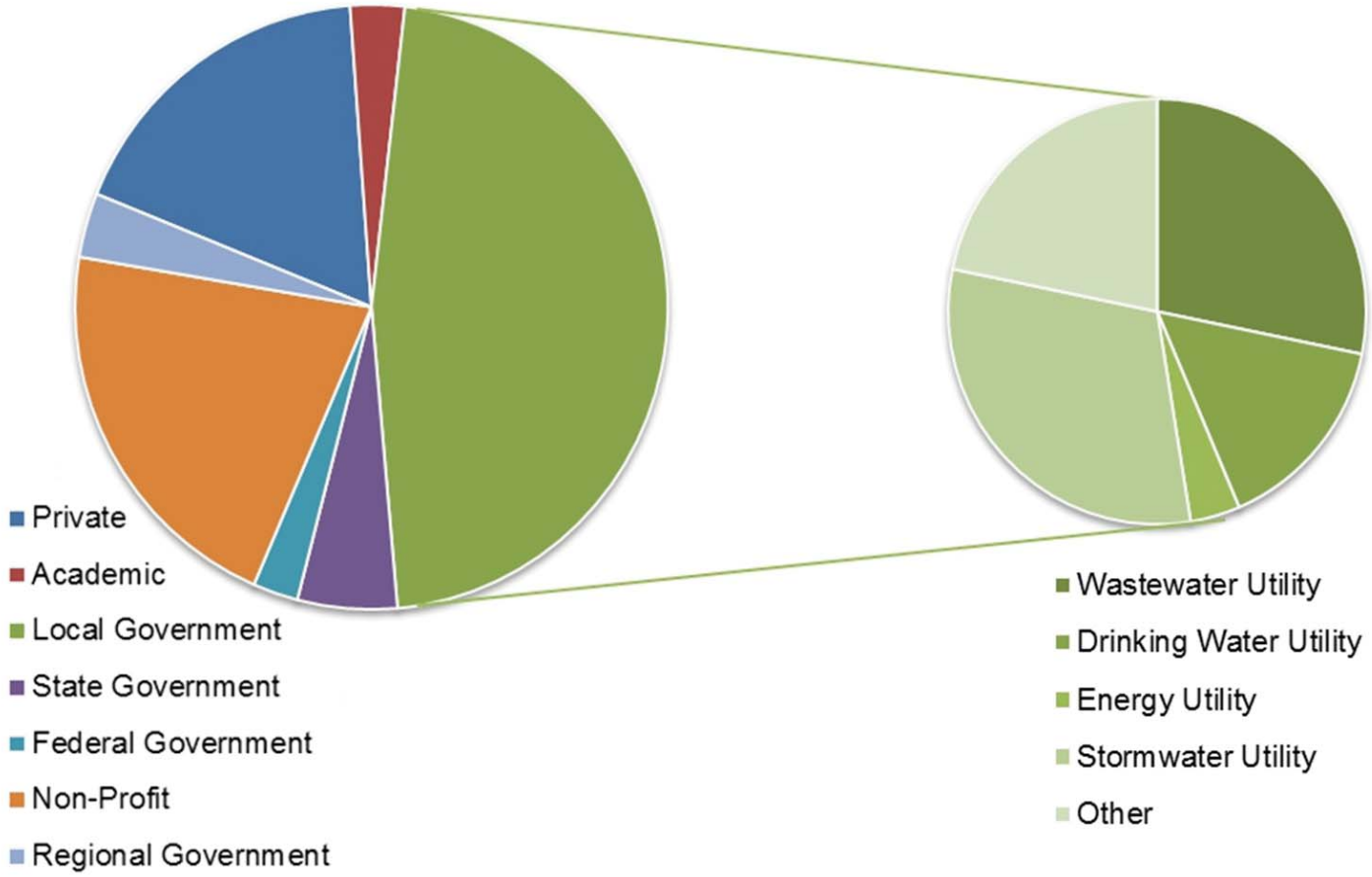


Figure 2: Survey Respondents' Organization Categories

effort to target a diverse range of survey participants. Partnering with national non-profit organizations and trade associations, the Clean Water America Alliance was successful in soliciting wastewater, drinking water, energy, and stormwater utilities; local, regional, state, and federal government agencies and councils; private, non-profit and academic entities to participate in the study (Figure 2). Non-profit organizations included conservation organizations, watershed groups, foundations and associations. Private entities included law firms, engineering design firms, landscape architects, manufacturers, technology companies,, and consulting firms. Local government agencies included municipalities, sustainability offices and transportation agencies.

A majority of survey respondents indicated they have implemented and/or invested in green infrastructure (Figure 3) and provided the reasons why they invested in it, with responses ranging from legal and regulatory obligations, as well as economic, environmental, and social benefits (Figures 4 - 7). The survey results below reinforce the widely published reasons why many communities are investing in green infrastructure. Despite these benefits, many still have difficulty at times articulating the benefits and justifying the costs of green infrastructure to the paying public and regulatory bodies.

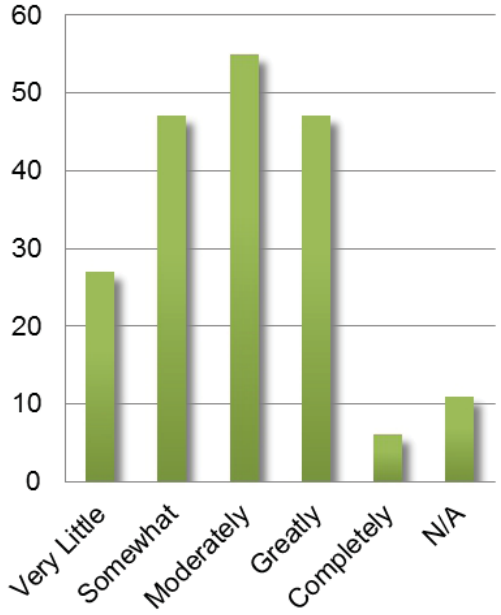


Figure 3: Extent of Green Infrastructure Investment and Impletmentation

Figure 4: Legal and Regulatory Obligations

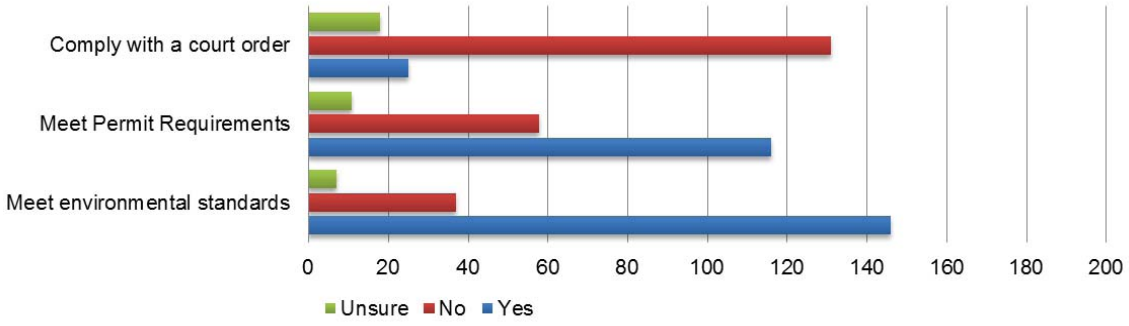


Figure 5: Economic Benefits of Green Infrastructure

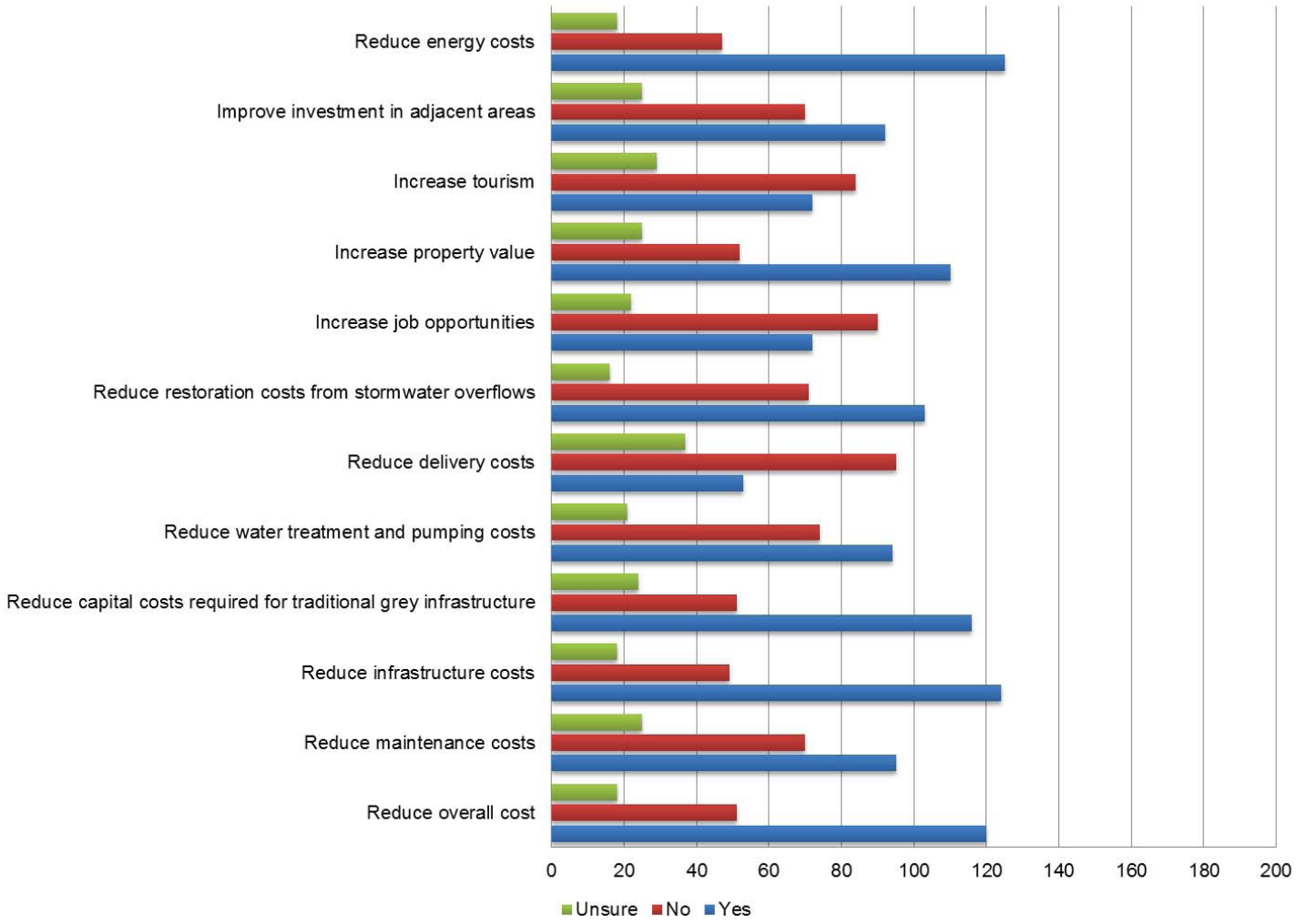


Figure 6: Environmental Benefits of Green Infrastructure

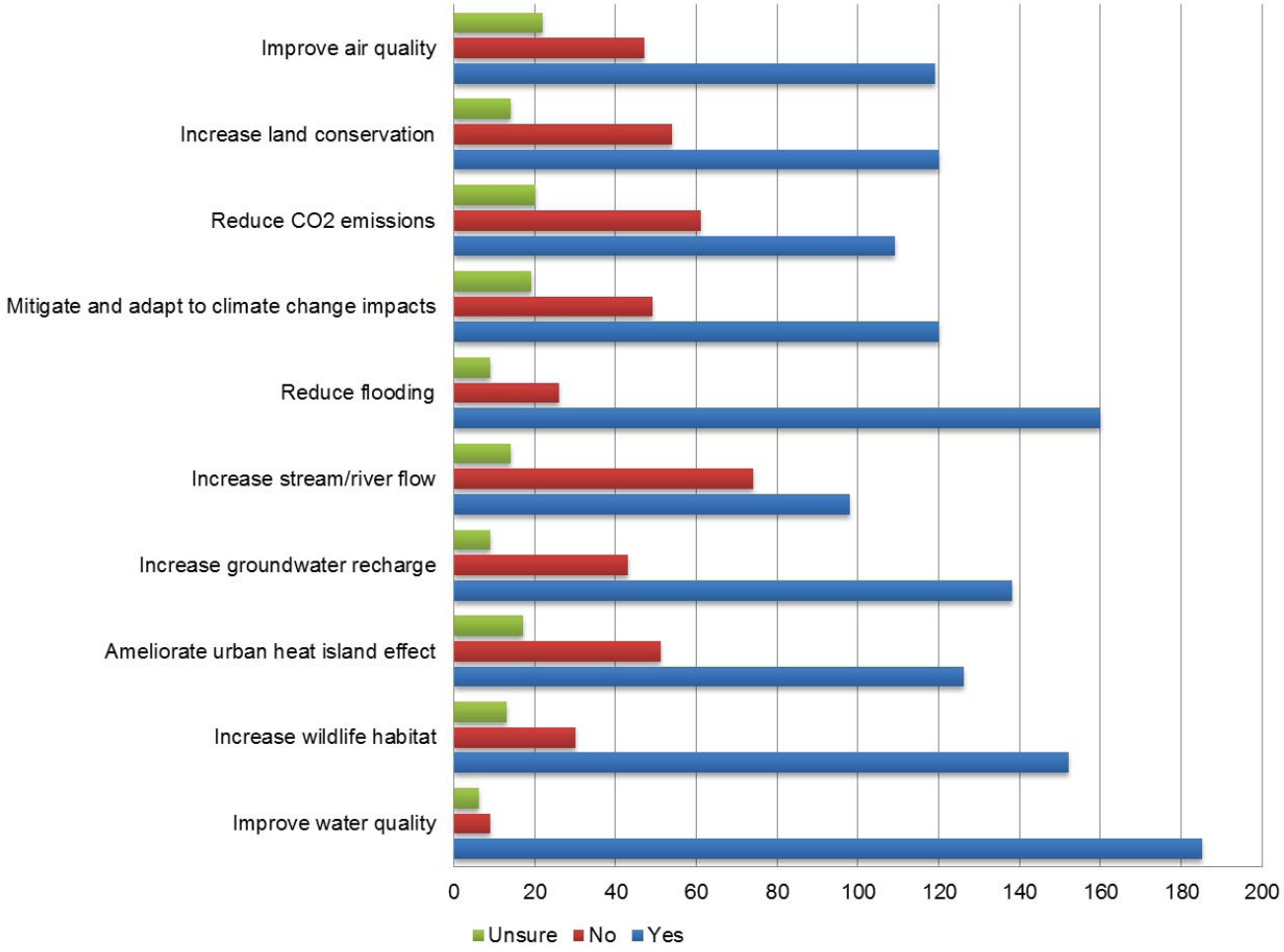
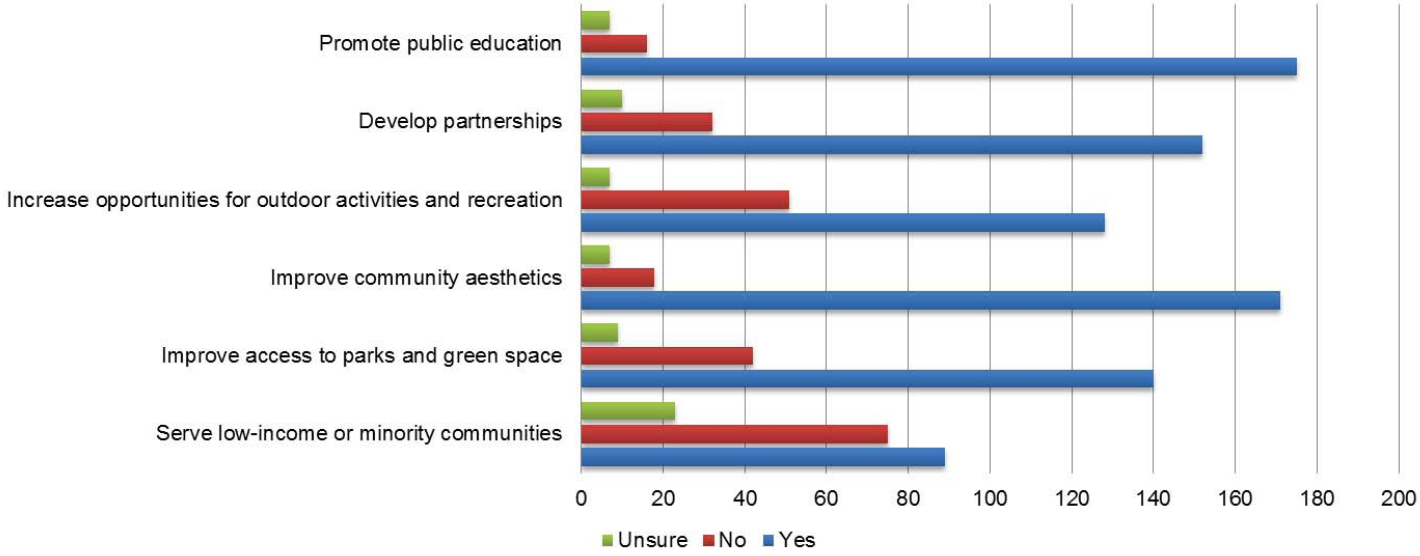


Figure 7: Social Benefits of Green Infrastructure



Barriers to Green Infrastructure

The Clean Water America Alliance identified four major green infrastructure barrier categories to explore: technical/physical, legal/regulatory, financial, and community/institutional barriers. The following sections are a summary of the common barriers the survey respondents have and continue to encounter.

Each section also provides a number of examples and opportunities on how these barriers might be overcome. The Clean Water America Alliance recognizes that many of the barriers identified in the next section overlap and can encompass more than one of the barrier categories developed.

Technical and Physical Barriers

To successfully implement green infrastructure, one must have sufficient knowledge of the desired location/environment, understanding of how the investment will meet the project's objectives, possess the skills necessary to implement the project, have a plan to maintain the infrastructure and track its performance. Each of these criteria represents an area where technical and physical barriers can impede green infrastructure implementation and investment. Technical barriers to green infrastructure refer to such things as design criteria, hydrologic modeling standards, unknown lifecycle costs, inconsistent definitions and lack of long-term performance data. Physical barriers to green infrastructure include geographic constraints, soil suitability, climate, and space availability.

Common Themes

1. Lack of understanding and knowledge of what green infrastructure is and the benefits it provides

2. Deficiency of data demonstrating benefits, costs, and performance

3. Insufficient technical knowledge and experience

4. Lack of design standards, best management practices, codes and ordinances that facilitate the design, acceptance, and implementation of green infrastructure

Specific Examples: Technical Barriers

DEFINING GREEN INFRASTRUCTURE

Some respondents indicated that the narrowness with which many agencies and organizations are defining green infrastructure can itself be a barrier. Defining green infrastructure as only storm-water-focused low impact development can unnecessarily restrict the potential positive impact of this new water management approach. The narrow perspective has also caused confusion around what green infrastructure is, and has created green infrastructure "camps" that have arbitrarily divided efforts and reduced the ability to leverage people and funds. By broadly defining green infrastructure to include the historical green infrastructure - landscape features that provide a variety of ecosystem services – can open doorways.

DESIGN STANDARDS AND CODES

Many respondents indicated that the lack of complete local, state and federal design standards that take into account differences in regional and local soil, climate and topography variances has limited the ability of communities to implement green infrastructure projects. Without design standards, local design professionals and engineers are less likely to deviate from the familiar measures of pipes, basins, and ditches. Furthermore, even when design standards are created locally, some respondents fear unintended con-

sequences. For example, proposed projects that are near the disturbed area threshold that would trigger the use of green infrastructure practices may decide to reduce the project scope enough to avoid having to use green infrastructure.

Municipal codes and ordinances have not evolved with the science of green infrastructure, and historically favor gray over green infrastructure. Many utilities do not regulate land use and are, therefore, relegated to only providing advice to the city and relevant design professionals.

Development Code-required street width in new development is barrier to reducing impervious surface and installation of ROW bioswales. Planning-Zoning has indicated willingness to work cooperatively to allow. Variances will be required until Code is revised.

Native plantings can be in conflict with local weed ordinance (i.e. mowing grass at 8" height). A notification to Code Enforcement is needed to avoid citation of native planting as weeds. Working to modify ordinance to allow native plants while being able to enforce property standards.

Bioretention with curb extensions and the interpretation of traffic safety rules to require large object markers that the residents are highly against on residential streets. This barrier has not been overcome and help at a more national level would be great! MUTCD, "Obstructions within the roadway shall be marked with a Type 1 or Type 3 object marker. In addition to markers on the face of the obstruction, warning of approach to the obstruction shall be given by appropriate pavement markings."

Some state agencies do not seem to be pushing green design, and sometimes unknowingly works against it. For example, an assessment was accepted by EPA, but the state agency required much more sampling. The site development was delayed and owners gave up on a sustainable design because the regulatory agency was requiring even more than the federal.

PERFORMANCE AND DURABILITY DATA

Some local development communities are still unsure about implementing green infrastructure as part of the development process. Many respondents argued that this uncertainty is due to a lack of available data on costs, long term performance, and maintenance requirements of green infrastructure under different flow regimes, soil types and climate. Consequently this has led to many to rely solely on models, which again is difficult to use to convince developers, local land owners, and city governments to buy-in.

For the data that does exist, it is spread over many resources and locations. Many respondents indicated that a central clearing-house of data and demonstrated projects would greatly help improve design and implementation of green infrastructure.

> *Long term performance & maintenance requirements are definitely a barrier to selling the concept of green infrastructure. The long term benefit of "cleaner water" is tough to sell over affordable growth & development in the short run. There is a just not enough information on how well these BMPs [best management practices] will do over time and what it will take to keep them functioning.*

TECHNOLOGY AND MATERIALS

Knowledge of, and access to, free/low cost software to design and choose green infrastructure alternatives, and quantify benefits is limited and in some cases non-existent. Although there are some regional workshops that provide access to this technology, many local government employees are no longer allowed to travel out of state, and seldom to areas far away, due to the current economic climate. Many respondents stated a need for more flexibility by the review agency and more modeling ability in currently available software.

> *Modeling - Demonstrating effectiveness of GSI for achieving a business goal (CSO reduction, creek protection, etc.) relies on models. Models all have inaccuracy, but for GSI the added complexity is that there is little consistency in modeling methodology.*

Knowledge of proper material, supply, and instillation of permeable pavement needs broader dissemination throughout the paving industry. Many respondents struggled with getting consistent quality with permeable concrete. For this reason some communities have limited the use of permeable concrete to sidewalks. Another technical barrier would be the aesthetics of permeable – most property owners are looking for walkways that are more conventional looking.

Engineers do not trust plants and are avoiding the use of plants - and so not learning how to integrate plants, and the maintenance of plants into green infrastructure. There are maintenance costs associated with "gray" infrastructure - and "grey" infrastructure fails, yet engineers will not admit this when they choose to avoid the evolution of the inclusion of plants in green infrastructure.

EDUCATION AND TRAINING

The most common technical barrier respondents identified was an overall lack of education, knowledge, and experience of green infrastructure design, maintenance, and benefits at the local, state, and even federal level. Many also argued that in addition to local utility staff, the development and consulting industries lack sufficient knowledge of green infrastructure – resulting in an industry culture that is either skeptical of green infrastructure (believe it will stop growth) or one that produces poor designs. Many blame this barrier on a lack of training at all levels of government.

OPERATION AND MAINTENANCE

Like traditional infrastructure systems, green infrastructure facilities require periodic maintenance. Maintenance requirements vary depending on the facility, and they may be as simple as weeding a vegetated swale and removing debris from curb cuts. One unique maintenance challenge posed by green infrastructure is that it is often located on private properties and thus difficult for public agencies to ensure that proper maintenance is occurring. Sometimes green infrastructure projects may be filled in or removed during landscaping projects by private owners who are not aware or don't care that the infrastructure is an important part of a stormwater management system. Some communities have attempted to engage private entities to maintain green infrastructure, but have received only minimal interest from the public.

In some cases there is no clearly defined asset to point to and over which to assign ownership and maintenance, there is no public agency willing to operate and maintain a facility for which they have no knowledge, experience, or funding to support. Many utility maintenance divisions are not currently familiar with the types of work necessary to maintain green infrastructure.

> *CONFUSION about implementation - how to make it work within agency requirements. Existing measures are understood. New measures may or may not be against various regulations. People need case studies showing examples of how to change, and specific recommendations for improving their regulations.*

Specific Examples: Physical Barriers

LANDSCAPE

In some cases, green infrastructure may not be suitable due to the physical characteristics of the land. Since green infrastructure techniques rely heavily on infiltration of stormwater (with some exceptions such as green roofs and cisterns), any circumstances in which infiltration is not desirable creates a physical barrier. Examples include the existence of high groundwater tables, steep slopes, landslide hazard areas, flood plains, contaminated soils, and wellhead protection areas. For example, some MS4 permits and BMP guidance manuals require anywhere from 3-10 feet of separation from the groundwater level for infiltration practices. This distance depends on the soil type, pollutants of concern, and groundwater use. In some cases, however, where there may be groundwater or soil contamination, green infrastructure infiltrative practices may be restricted completely. Furthermore infiltration into steep slopes can cause instability, resulting in landslides or erosion.

AVAILABLE SPACE

Whereas traditional systems in urban areas convey stormwater via underground pipes, green infrastructure systems that allow stormwater to infiltrate into the ground on-site may require additional land area, although this is not always the case as green roofs and cisterns allow water to be evapotranspired or reused

without extra space. This can present a challenge when designing a new development or retrofitting existing facilities. It is in developers' financial interest to maximize the amount of buildable land, and they must meet certain density requirements. While stormwater control is a cost for developers, it is rarely the driving factor for redevelopment projects. Setting aside space for green infrastructure can sometimes compete with these other goals. Space limitations can also present a challenge when installing green infrastructure in the right-of-way along public streets. There are multiple demands for space in the right of way, including stormwater treatment, bicycle lanes, sidewalks, utilities, parking and traffic lanes. Green infrastructure projects provide community benefits too but compete with other community-related projects.

CLIMATE

Many private and public engineers are still not convinced that green infrastructure is effective in managing stormwater due to a lack of performance data in cold, hot, and arid climates. In some regions of the country, the ground is frozen most of the year or permafrost exists, thereby reducing the potential for water to infiltrate into the ground. Developers and cities are not convinced these systems will work year round and often install redundant traditional stormwater systems as a backup, increasing the project costs. The need to change the way utilities conduct traditional winter operations (plowing, sanding, salting and snow storage) along with new maintenance requirements presents challenges to local governments, particularly in terms of education and cost.

"An actual working workshop like a design charrette with outside experts, and staff simply doing the work was very helpful."

Tough rainfall and clay soil conditions in the SE lead many to say that green infrastructure cannot be implemented because there is little reduction of stormwater runoff volume. Accessible performance data that engineers can rely on either doesn't exist or they are not aware of it. Therefore, many local engineers have limited knowledge of what methods they could use to estimate the reduction in volume of runoff they had achieved or that could be achieved. That leads them to be highly conservative on what performance standards might be feasible for the SE. We met with them to ask what might be feasible performance standards for EPA to promulgate. They were only willing to commit to a 10% reduction in post-construction runoff volumes compared to traditional grey infrastructure.

SOIL TYPE

One very specific technical challenge is the lack of understanding about soils, soil conservation/restoration, and plant-soil-water relations. Many respondents view clay soils as a substantial impediment to green infrastructure because they do not allow the full effect of green infrastructure infiltration to occur. This problem has been addressed in literature, but remains poorly understood. To compensate, some projects must be designed with an underdrain, thereby reducing the benefits of the systems. Many have overcome this barrier by implementing hybrid green infrastructure projects on a smaller scale. Green infrastructure in clay soils needs further testing, standard development and champions to tout its benefits.

OPPORTUNITIES

Most technical and physical barriers were at the local levels of governance and community. Many felt, however, that a lack of education and acceptance of green infrastructure stems from a lack of guidance from the federal and state level. Better education of young engineers has led to successful model projects that prove the feasibility of green infrastructure. National and local examples/studies proving cost savings are highly influential. Engineering, architecture, landscape architecture schools and continuing education should intensively teach green infrastructure design. Updated cost comparison studies are needed and should be spread widely. State environmental agencies should actively promote/educate about green infrastructure.

There is a strong need for performance and cost data from pilot demonstration projects/practices in different soils and climate regimes. As more pilot projects are implemented, and as green infrastructure becomes more common due to the use of volume-based performance standards for post-construction storm water control, the development and engineering communities should become more comfortable with implementing green infrastructure.

A central repository of best management practices, designs, and specifications would be very helpful. This may be a task for a third party or the federal government.

Federal and state guidance is needed to help local communities develop stormwater/green infrastructure manuals/design standards for local developers, planners, and engineers. It should include design strategies, along with fact sheets that provide guidance for the design of green infrastructure, including designing around site constraints, and advantages and disadvantages of best management practices. Various training and education programs for public works employees and local developers is needed to help drive green infrastructure and complement local manuals.

A paradigmatic change is needed for long-term success of green infrastructure implementation. In many cases stormwater has long been an afterthought of new development and retrofits, there needs to be a strong effort to bring green infrastructure to the forefront of a project. To be considered at the outset of design, green infrastructure should be included in local design manuals. For green infrastructure to be successful, both hydraulic engineers and construction engineers need to be sharing the same information. If stormwater needs are considered at the start of the project, then green infrastructure can be more efficiently incorporated into projects.

Continued education of key stakeholders and interests in addition to policy change that declares green infrastructure as part of a utility's infrastructure might open the door to requiring updates to municipal codes and ordinances.

A potential opportunity to overcome the maintenance barrier is the creation of dedicated staff crews with appropriate expertise to maintain green infrastructure across municipal offices. These crews would become increasingly effective as they gain on the ground experience. Another option would be to elevate this issue to the policy level so a variety of alternative solutions (planning, design, budget) have the level of line support needed. Finally, the last option recommended by respondents includes the use of high levels of citizen involvement to take advantage of interested volunteers to plant and maintain rain gardens, to prune trees, etc.

Attempts at overcoming the limited space barrier include creating innovative designs, creating incentives for private properties to manage stormwater on-site, coordination with affected utilities and working through some of the financial and regulatory challenges associated with where a public utility can undertake projects. Some recommended the development of policies that require the location of utilities in the street and widening of the parkway.

Legal and Regulatory Barriers

Local, State, and Federal rules, regulations, and laws can create significant barriers to greater use of green infrastructure. At the local level, local ordinances, building codes, plumbing and health codes, transportation, and street and parking rules are barriers, while at the state level, state growth policies, western water rights, and restrictions on local districts and utility funding can be barriers. At the Federal level, Federal environmental permitting and enforcement policies and inconsistencies often restrict the growth of green infrastructure, even though public and private supporters and individual agencies may be championing green infrastructure projects in their community or region. At each level, the lack of incentives (such as failure to provide regulatory "credit"), performance standards, accountability and integration can pose problems. Legal and regulatory support is necessary not only for launching green infrastructure strategies but for ensuring projects are sustainable over time and proponents protected against future liabilities.

Common Themes

1. Local rules can be lacking, conflicting, or restrictive

2. State water and land-use policies and property rights can be complicating factors

3. Federal rules can be conflicting, overly-prescriptive, or silent in key aspects

Specific Examples

LOCAL BARRIERS

Locally, some of the most significant barriers include local codes and ordinances, property rights, and a lack of integration among local and regional entities. For some respondents ongoing maintenance constraints for green infrastructure projects on private/residential properties (resembling individual landscaping requirements), local weed ordinances often point to a lack of integration between local water and public works offices. Several cities cite restrictions involving street width, drainage codes, and parking spaces. Lack of data on the multiple benefits of green infrastructure also contributes to barriers and constraints. Other barriers include restrictions on the use of reclaimed stormwater, such as for toilet flushing.

> *Ownership and ongoing maintenance is another issue. Regulating at the individual homeowner level for something that looks like "landscaping" will be fairly difficult.*

> *Lack of institutional understanding of green infrastructure. As a bureau, consistently remind other bureaus in Transportation, Planning, Economic Development, etc., about the complementary goals and benefits achieved with green infrastructure.*

Internal City Permitting capacity and coordination. The development process within the City often bypasses Public Works input until it is too late. Development starts with Planning and/or L&I, and often gets approved and designed before BMPs are considered. One change that could mitigate this would be a GIS based, enterprise wide permitting software that is required to be used by all departments from project inception to approval to post construction.

Some local regulations require that green infrastructure controls that will be installed within municipality right-of-way must be approved by the municipality. These regulations do not provide incentives for implementing green infrastructure, but make it more difficult by requiring additional approvals. Again, the cause of this barrier is due to a lack of hard data on green infrastructure within the region. As more pilot projects are implemented and as green infrastructure becomes a post-construction requirement, more data will be generated to help overcome this obstacle.

Roadway widths in an urban environment and the various demands placed on them, such as turn lanes, bicycle lanes, on-street parking, etc. constrain green infrastructure implementation.

"Surface water and groundwater rules are at odds in some cases, such as soil infiltration"

STATE BARRIERS

Statewide, growth management, private property policies (restricting the maintenance of or access to green infrastructure projects on private lands), western water law, and the lack of integration, funding, and technical guidance manuals can create obstacles. For example, some communities have cited downstream water rights as a constraint on upstream rainwater harvesting. "There is a fine line between water harvesting and water hoarding" in some areas; downstream water rights may be impacted if upstream water management practices reduce the quantity of water to which downstream interests are entitles. One respondent cited a statewide restriction on soils used for infiltration.

Surface Water in our state is over appropriated. Runoff is needed to meet intrastate and international water compacts. Green infrastructure is seen as threatening the volume of runoff necessary to meet those flow requirements. This program is managed by the Office of the State Engineer. A water take is involved if any runoff stream is held for more than 96 hours.

There is a state law requiring that infiltration devices must be used only in soils with 0.52 inches/hour or greater. We do not have a significant percentage of soils meeting this requirement. A change in the state law would help to encourage infiltration in our region. Other, traditional measures would still be needed on most sites to meet water quality goals.

FEDERAL BARRIERS

Federally, barriers include the lack of incentives, guidelines, and performance standards, potential reluctance to include green infrastructure in permits and consent decrees, the resistance of enforcement officials to give "credit" (including for multiple benefits) or "ample" and "appropriate" timeframes for green infrastructure in consent decrees and long term control plans (LTCPs) for CSOs, potentially conflicting policies among Clean Water Act (CWA), Safe Drinking Water Act – Underground Injection Control (SDWA-UIC), and Federal Emergency Management Agency (FEMA) floodplain rules, and the lack of funding for demonstration projects and innovative techniques to meet environmental mandates.

For example, several communities complain about EPA's reluctance to integrate green infrastructure in CWA MS4 (Municipal Separate Storm Sewer) and watershed-based permits, total maximum daily loads (TMDLs), and consent decrees. Some cities are exploring the possibility of changing their LTCP to replace a gray infrastructure tunnel with green infrastructure alternatives which have other added benefits besides stormwater capture such as beautification, heat island impacts, water quality improvements, green jobs and increased property values. Ample timeframes with appropriate allowances for adaption and innovation have also been discussed in the context of consent decrees and long-term control plans.

Several communities cite conflicting directives between EPA CWA and SDWA offices on rain water infiltration and ground water recharge often leading to a UIC permitting requirement that discourages rain water storage and spreading.

Groundwater rules/regulations interfere with infiltration principles in many cases. The Surface water regulators want us to use soil as a filter media, and the groundwater regulators want us to keep dirty water out of the soil. The rules are at odds in some cases. The only way to overcome this barrier is to use alternative methods, or to get groundwater regulators to waive their standards, where drinking water sources are not nearby.

OPPORTUNITIES

Local leadership and knowledge of the regulatory roadmap, as well as the "triple bottomline benefits" of green infrastructure, need to grow. Community forums on green infrastructure and designated green infrastructure "ombudsmen" to steer projects through the process can help, as well as identify the need for changes to current building codes, street/transportation/parking ordinances, conflicting agency policies, and other uniquely local constraints.

State leadership is needed to clarify green infrastructure definitions and water rights implications, integrate and reconcile multiple local and state agency policies that impact green infrastructure and LID practices.

Federal leadership can take many forms, without creating a one-size-fits-all approach that stifles state or local flexibility. Flexible performance standards can help, as would greater promotion of green infrastructure in permits, TMDLs, and consent decrees. Standard-setting, permitting and enforcement offices need to recognize green infrastructure approaches often need more time and different performance milestones than more costly, traditional methods. More robust policies and practices are needed to give appropriate credit for green infrastructure, including benefits under other water and air programs and based on triple bottom line, total project cost analysis.

Financial Barriers

Preserving land, revitalizing brownfields, and investing in green infrastructure all cost money and often require innovative solutions, but most funding programs and resources are geared toward conventional development and infrastructure practices. Green infrastructure can be efficient and cost effective because it often fulfills multi-purpose objectives (for example, rain gardens control stormwater and may re-introduce natural habitat). Moreover, green infrastructure is often less costly than conventional infrastructure and development practices. More resources and incentives are needed for these innovative approaches.

Common Themes

1. Not enough data about upfront and ongoing maintenance costs and economic benefits
2. Perceived high cost over short and long-term
3. Lack of funding at all levels coupled with poor coordination or integration of programs and funds
4. Too much risk - not enough incentives

Specific Examples

FUNDING

Local communities, non-profits, and private interests often lack funding for implementation, such as training or hiring staff to install or maintain, permits, planning, and review.

Local

It can be extremely difficult to develop, increase, and enforce stormwater fees. Many utilities have to use their own funds or revenues to implement green infrastructure. Although some use federal money to implement – they use their own money to maintain as well as fund legal cases with large land owners who don't believe they should pay the stormwater fee. Some states do not enable the creation of a stormwater utility. Many governments must partner with non-profits to secure adequate funding.

There is no funding for the design development and testing of large scale demonstration projects, thus all the funding goes into residential scale rain gardens and rain barrels, which are only a fringe of the bigger problem which is conventional municipal road and storm sewer design and construction standards.

Cost of investment in the upgrades and available financing for a municipality is a huge barrier. For many of the lower hanging fruit projects, there is rate-payer $ that incentivizes the implementation. For many of the larger projects with longer "paybacks" there is little funding available and little understanding of creative funding mechanisms.

State

State Revolving Funds (SRFs) have mandatory percentages of funding dedicated for green infrastructure related projects, but it is very limited and many states choose to use this money for energy efficiency instead. Many respondents expect this percentage to decrease in the future, as well. State grants are few and highly competitive. In some cases federal money is available for planning and design but this is limited and implementation funding is extremely limited because of state and local budget constraints.

"Unwillingness to experiment with public funds on locally 'untested' technologies"

There is a lack of funding to develop state-level technical design and maintenance manuals and watershed plans that are integrated between programs. This impacts cities and counties, as well - who need assistance and review of such manuals and benefit from multijurisdictional watershed plane.

I am very disappointed that our state's Clean Water Revolving Fund is used only for wastewater upgrade projects. The program is housed in the state's wastewater regulations and there is very little education or awareness that these funds could be used for nonpoint source pollution control and green infrastructure projects.

We have had to change our priorities so green infrastructure projects get ranked for funding. Traditional scoring or ranking processes won't capture the benefits of green infrastructure.

Federal

Funding from federal programs, particularly EPA water programs, is very limited. EPA capitalization grants for SRF water programs will likely decrease. Plus, federal grant dollars prohibit the use of funds for National Pollutant Discharge Elimination System/ Municipal Separate Storm Sewer System (NPDES/MS4) permit requirements under the CWA, which prevents many projects that might dovetail with existing permit plans. In addition, federal grant funding cycle can be hard to predict or adequately prepare for at the local level.

Local utilities have also had difficulty obtaining funds to support acquisition and analysis of new data. For EPA grants, base layer data does not lead directly to the kinds of program outcomes that most EPA grants seek to produce.

HIGH COST

There is a perception, especially from private construction lenders and private developers, that green infrastructure can be expensive to build and maintain. In reality, some aspects may be more expensive depending on circumstances. Some techniques like green roofs have higher upfront costs although other techniques are more cost effective. The idea of "cost" is often used as a shorthand for intangibles like uncertainty, risk, and reliability – especially for engineering, design, and development professionals, who are serving clients but also trying to run profitable businesses.

Since the cost of pollution is externalized to the general taxpayer and often difficult to connect to the polluter or consumer generating the pollution, there is a huge disconnect in perceived cost-benefit.

Green roofs are four to ten times more expensive, so unless we mandate them (City Council would never approve this), the market isn't driving developers to make those choices and we do not have the financing to offset the additional cost.

Consequences: Locally & statewide, we have not yet reached a critical mass for the use of green infrastructure, so the cost of materials & engineering remains high.

INCENTIVES

There is a lack of economic incentives at the regional, state, and federal level for projects that help meet regulatory requirements and restore urban watersheds.

At the local level, many cities are struggling between two financial incentives: reducing decrease utilities rates for those that have implemented green infrastructure or provide a tax reduction. Decreasing utility rates directly affects the utility and indirectly affects local city government, while providing a tax reduction or credit will directly affect the city and indirectly affect the utility. Obviously there is difficulty moving in either

direction – making it difficult to adopt financial incentives locally for green infrastructure.

UNCLEAR LIFE CYCLE AND MAINTENANCE COSTS

Construction and maintenance costs are important factors in of green infrastructure implementation. For some projects, green infrastructure is a less expensive method of stormwater management, while in others, green infrastructure is more expensive to implement and maintain than traditional end-of-pipe systems. There is not enough understanding about what green infrastructure will cost to design, construct, and maintain in comparison to traditional/conventional stormwater approaches for each possible combination of soil, climate, and grade throughout the country. These uncertainties can make planners and engineers reluctant to use green infrastructure.

> *Who maintains green infrastructure? There is a lack of technical/financial capability among local governments to do this. In part, this results from the prioritization of potholes over rain gardens/conservation areas and the primacy of public works over parks in the budgeting process. Capital investments are often made independent of budgeting processes for maintenance - an understanding about life cycle costs would be crucial. Further, there is lack of clear data about the actual costs of maintenance.*

PRIVATE INTERESTS

The initial additional costs of green infrastructure to a private development interest are often barriers because many developers are not the final tenants or owners, they will not reap the long term benefits of green infrastructure (see pages 11 - 12). Many respondents argue there is not enough good data about costs and benefits for private developers to invest.

> *Cost-for many owners, especially private developers who will not be owners when the project is complete, the only number that matters is the upfront bottom line. They are not interested in social or other life cycle benefits.*

ECONOMIC BENEFITS

There is insufficient economic analysis of the environmental and social benefits of green infrastructure. When making investment decisions, one needs to know what the economic benefit will be – compared to cost. More data and more tools are needed.

More credit needs to be given for the multiple benefits of green infrastructure (air quality, GHG reduction, stormwater, heat island, etc.) to incentivize green infrastructure over gray infrastructure - like the federal highway funding programs of the 50's.

OPPORTUNITIES

Before the decision is even made to move forward with a green infrastructure project, to seek funding for it – many must decide to consider green infrastructure as an option. Many respondents indicated they have difficulty making this first step because there is a lack of data correlating the costs and benefits of green infrastructure. There is a strong need to quantify the many benefits of green infrastructure. States and localities should conduct cost of service studies and fiscal impact analyses to determine how green infrastructure will affect the fiscal health and viability of the community. Local municipalities should conduct a triple bottom line analysis to identify means for saving and/or funding green infrastructure as opposed to gray infrastructure. Such studies have consistently shown the economic value of green infrastructure projects.

Funding opportunities and mechanisms for green infrastructure are in high demand. Many respondents called for additional and more creative financing options at the federal and state level, including better integration between federal agencies to cost-share federal funds to local green infrastructure projects. Furthermore, respondents indicated there needs to be greater flexibility through existing federal funding sources, beyond simply EPA clean water and drinking

water programs. Some called for a clearinghouse on funding mechanisms for green infrastructure that provides guidance on how the funding process proceeds from predesign to bid to operation.

> *Use transportation funding to install green infrastructure such as vegetated buffers and bioswales alongside new and existing roads. For example, some cities require the establishment of green infrastructure, whenever new road projects are built, in order to protect valued watershed and local water resources.*

Incentives, both financial and non-financial, have long been used to encourage specific behaviors to achieve certain outcomes. A majority of respondents indicated that there is a strong need to incentives at the local and state level to encourage green infrastructure. Green infrastructure incentives can range from instituting tax incentives, utility rate reductions, and/or regulatory credits. Non-monetary incentives that can encourage green infrastructure implementation include development incentives such as streamlined permitting, density credits and transfer of development rights, regulatory credits, and watershed trading for green infrastructure projects.

System management models designed to leverage public infrastructure (stormwater management, water quality, trails, sidewalks, canopy street trees, rain gardens, parks, urban forests -including urban agriculture, and public outreach). These infrastructure systems can be addressed in far more synergistic ways by reducing duplications in public investments. For example: a) Negotiating public access sewer maintenance roads for new subdivisions instead of only requesting construction easements and years later spending many more dollars acquiring similar land for trails. b) Stormwater management approaches that require on-site detention of low level storms and establish detention areas and greenways along streams that also serve as neighborhood parks to handle large storms. A service fee designed to fund the management of these sites would address their long term maintenance. More flexibility in design parameters, understanding of overarching goals, and incentives to go beyond minimum requirements are needed.

Community & Institutional Barriers

Community and institutional characteristics are not physical, fiscal, or technical barriers to green infrastructure, but they can easily hinder opportunities and shut down programs. Because they involve mindsets, they may also be the launch point for shifting the social paradigm for integrating green infrastructure with gray.

Community barriers can involve private properties, public outreach, public perception, the education of builders and developers, equitable distribution, equitable representation, and neighborhood issues. Illustrations of institutional barriers included lack of interagency coordination, resistance to change, diffuse jurisdictional power, shared commitment, and lack of political leadership.

More than half of respondents identified community and institutional factors as moderate to complete barriers while less than 25% didn't view them as significant obstacles to implementation. A few survey participants commented on the positive and motivating support of their political leaders and communities as a result of communication campaigns.

However, for the majority of respondents, community and institutional problems were abundant. Situational descriptions frequently identified three main themes as barriers:

Common Themes

1. Education is needed for political leaders, administrators, agency staff, developers, builders, landscapers, and others, including the public

2. Adjusting cultural values to appreciate green infrastructure aesthetics and characteristics

3. Inter-agency and community cooperation

Notably, these three themes correlate precisely with what respondents rated as the top three social benefits for investing in green infrastructure (see figure 7). Nearly 90% of respondents cited "public education" as the primary benefit (among social factors) driving their investment. A close second was listed as "improving community aesthetics." The third inspiration for investing was "developing partnerships" which equates to the third theme listed above, building community and institutional cooperation.

Specific Examples

EDUCATION

The most common theme in respondents' comments: the quality and scope of education efforts need to improve. From technical training of municipal staff, to lessons in biology that focus on native plants for school children, lessons in green infrastructure must be incorporated into formal and informal education programs in order for institutions and communities to fully adopt green infrastructure.

"Public perception is still forming," observed several participants. "Early buy-in is essential because so much of green infrastructure's potential involves public spaces and private property. A lot of upfront education is needed." Another respondent reinforced the notion: "An initial negative perception is much more difficult to overcome than a citizen prepared with a little education from the start."

Several agency/municipal representatives blamed themselves for the lack of public support. "We've never done a good job of explaining the problem of stormwater pollution and impervious area impacts." Aside from public support for green infrastructure initiatives, the potential for green infrastructure on private property is enormous. However, it hinges on an educated citizenry. One specific example cited was when a storm inlet and bio-retention area is established to prevent a resident's yard from flooding due to stormwater. The homeowner will need to understand the benefits of the landscaping and be able to maintain it in order for it to work over the long run.

"Public education is the key to building trust and collaboration with property owners."
Staff and funds are commonly not available for such an education outreach effort. "It's unfortunate," noted one utility representative while pointing out the benefits of other education efforts like LEED certifications.

> *This is a massive public education project. There is only one staff engineer devoted to stormwater quality issues in this city of 500,000…It's unfortunate, increasing awareness might create a public buy-in of the idea and create added value to LID developments somewhat like what LEED certifications have done."*

Some survey comments identified specific target audiences and issues. Starting with local politicians, one respondent noted, "Getting their attention is an ongoing challenge because there is no regulatory mandate." Another participant was frustrated with developers: "The private development community has been slow to incorporate green infrastructure due to continued misconception of higher costs and greater design engineering needs."

For many developers, green infrastructure represents risk and a threat to the bottom line as the amenity benefits of green infrastructure have not expanded to the whole market. Several comments identified the same needs for developer and home owners: "The only way to overcome the obstacles may be to provide more definitive data on the performance and operations and maintenance requirements of green infrastructure." Remarks confirmed repeatedly the importance of showing a positive bottom line for green infrastructure to be successful. Community incentives are another way to educate developer – if the community places a value on green infrastructure to the community for flood reduction, it can pass this on to developer in the form of tax breaks or other incentives.

Municipal staff education needs are urgent. From University curriculum for engineers, to maintenance and landscaping teams, education should include knowledge about the benefits and design of green infrastructure. In the current void of understanding, efforts are often undermined such as in these examples by two different respondents:

> "Public education is the key to building trust and collaboration with property owners."

> *"…For example, often a raingarden may be installed in public space or the maintenance team may not be informed about the plants and materials used in the installation. It is not uncommon to find that the installations are damaged by well-meaning maintenance crew who may mow or weed out native plants or systems."*

> *Engineers and developers do not think about site requirements for stormwater management. Even now as we see minor on-site stormwater control measures they are often in the wrong location (i.e. bio-retention in highest point of parking lot) or not designed within context of overall combined system.*

Seeking to meet the municipal education challenges, several utilities reported either the need for or development of green infrastructure design and maintenance manuals. Complimentary workshops for utility employees were also being developed.

AESTHETICS

"One person's native plant is another person's weed." This response sums up the cultural aesthetics issue nicely. Collectively, the U.S. preferred cultural aesthetic now and through at least half of the 20th century has been for a manicured and orderly environment, with little room for nature and natural landscaping. There has been some growing awareness with the environmental movement and the advent of xeriscaping. Nonetheless, most cultural values are slow to change and require long-term education efforts.

"One person's native plant is another person's weed."

"Some people think the facilities like rain gardens are ugly," reported a survey contributor while offering a solution. "We have been creating planting plans that are standardized and approved by the community (garden clubs, local leaders, City Council)." Still other respondents noted property owners disdain for any standing water, even during or just after rain events, citing concern over mosquitoes.
"We have good design standards for drainage and have built pilot projects to prove they work, but people still cite this as a concern." There were also several reports of success:

> *The barrier of resistance to change is being overcome as City leaders become educated on the benefits of green infrastructure and, as GI measures are installed, obvious benefits are achieved. Pilot projects have been very successful educational and demonstration tools in dispelling doubts about aesthetics, functionality and costs.*

Equitable distribution of aesthetic benefits was an issue for one urban community. Initially, green infrastructure projects were located according to best sites based on hydraulic analysis. "As the program matures," the municipality explained. "We intend to consider community benefits of green infrastructure in balance with functional benefits to insure equitable distribution of neighborhood improvements."

COOPERATION

An Achilles heel for green infrastructure can be its dependence on inter-agency and community cooperation in order to be successful. On the one hand, partnerships and cooperation leverage efficiencies and economic benefits. On the other hand, they require significant patience and finesse. "So much coordination is required that gray infrastructure becomes easier to implement than green," complained one municipal respondent. Multiple responses verified the sentiment, "The very comprehensiveness of the impacts of green infrastructure serves as a barrier, due to the difficulty of working across division, agency, and political boundaries, with diverse groups with diverse interests. A holistic effort is hard to coordinate, focus and keep moving forward." One solution offered:

> *Many other organizations, such as transportation or building departments view green infrastructure as someone else's issue. We asked our City Council to make it binding City policy to get their attention and commitment to cooperate.*

Maintenance is a major aspect of the cultural and institutional barriers in shifting from gray to green as noted in many responses and interviews:

> *As a regional wastewater and stormwater utility, do we need to trade our vactor trucks for pruning shears? We are not an organization with landscapers. Customers expect solutions that involve well drained turf grass, and not expensive landscaping that they need to maintain. This is a concern that is not fully resolved long term. However, it has been resolved in the short term for the pilot projects with partner involvement.*

"So much coordination is required that gray infrastructure becomes easier to implement than green."

OPPORTUNITIES

Overcoming community and institutional barriers welcomes major opportunities for paradigm shifts leveraging green with gray. Different from gray, green infrastructure is highly visible and dual-purposed to offer recreational space as well as flood protection. This highly visible infrastructure creates opportunity for public conversation and education. It becomes a means for discussing the value of water and infrastructure life cycle costs.

Public support of green infrastructure starts with edu-

cation and the sharing of information. It is important for all age groups in a community to be exposed to information describing what green infrastructure is, green infrastructure benefits, the detrimental effects of stormwater, and linking it to the bigger picture of watershed health. Curricula should be developed for all levels of education. Teaching children is very effective – share with their parents when they go back home. Communications should be in a digestible language. Inform community through various medias on related issues and develop coalitions to support them.

Training of municipal staff – so they understand it, support it, and are able and willing to implement and use it. Get people from different departments together to work out barriers – often barriers are based on having different goals or speaking a different language, but these differences can be working out. Hold outreach efforts to community and other municipal/city agencies – from brown-bag lunches to quarterly meetings intra-agency communication to public hearings, community focus groups

Every city needs at least one demonstration project. However, these first projects cannot be evaluated on cost efficiency because the overhead for initial projects is high. These projects should be visible and very attractive to a wide range of residents. Conduct and promote essential demonstration projects and planning models. Consider a regional case study where projects are built both ways, coupled with specific design tools for developments. Highlight sustainable projects using community groups, schools, etc. to get the community excited and motivated. If the public is behind a movement, there is a much greater success rate. It's important to bring information to the public – they don't often seek out information. Information should be visual, continual, and easy to access. Invite local bloggers, media, community leaders to see demonstration projects – free presentations.

Collaboration among city agencies, local organizations, and the private sector helps facilitate the implementation of green infrastructure. The created of a sustainability coordinator or leader in the government who is responsible for building relationship among city agencies to support green infrastructure would be a good place to start – they can organize outreach efforts to the community and form partnerships.

Involve stakeholder in process – should be open and transparent. Make information available to people – lifecycle costs and benefits. Public should be included in the decisions about how and where green infrastructure is developed with public money – involving the public in the planning and development stages of green infrastructure projects can help to ensure that you have public support as well as equitable distribution of green infrastructure.

Create and advertise incentives – form relationships with key private-side developer – create a leader/partner in the private sector. Promote projects that implement green building through a reference program – companies love to see their names in lights.

Work with the National Association of Counties and International City/County Management Association to inform decision makers. Recognize the professional contributions of landscape architects and collaborate with them on projects, local, state, federal. Seek development pioneers to educate and recruit as early adopters. Support regional scale planning that facilitates integrated water resource management (IWRM), green infrastructure, etc. EPA and the Army Corp of Engineers should work together on ways to support local implementation of IWRM.

Summary

Barriers can appear in various shapes and sizes, depending on the watershed, community, and socio-economic context. Some common themes, however, run throughout the survey responses, and the most dominant involve uncertainty and risk. More specifically, uncertainty about outcomes, standards, techniques, and procedures can create an atmosphere where the risks of trying, adopting, or funding green infrastructure projects become unacceptable. A change in status quo is hard when a new approach is undefined, unproven, or under attack by thought leaders and stakeholders. It takes education, coordination, and collaboration to reduce real and perceived risks to shifting paradigms from gray to green.

Education is key to growing the green infrastructure movement and overcoming technical barriers and understanding physical barriers. It's important for departments within and among utilities and agencies, designers, engineering firms, and others to learn what green infrastructure is, when it's available, and what the benefits, costs, and trade-offs may be in choosing green, natural, and vegetative over more conventional, built, and hardened structures. Training and certification of staff, in both the public and private sectors, build the knowledge base to help overcome obstacles. Consultants and contractors, in particular, are in key positions to sort out the practical from the impractical and show agencies how green infrastructure makes environmental and economic sense.

Legal risk is often a major impediment. Lawyers and engineers are trained to question new approaches that might fail. Utility lawyers research and debate whether liability will arise if the green infrastructure practices don't work as well as intended or as quickly as hoped or required in permits and compliance schedules. Liability and public disclosure of mistakes are also two common reasons engineers cite for reluctance to try green infrastructure practices. Federal and state agencies are in key positions to provide regulatory incentives, even shoulder some of the burden, in stepping forward with nontraditional approaches to managing wet weather flows.

Financial barriers also involve uncertainty and risk. Potential funders refuse to invest in local green infrastructure projects when there's an unacceptable level of risk, whether it's due to regulatory uncertainty, property disputes, or the lack of a proven track record of success returns on investment. Ratepayers also resist paying for new investments unless convinced the projects are good bets, not risky ventures, that will save them money very soon down the road. New or improved stormwater fees can offer important revenue streams for sustainable infrastructure and management systems but are highly controversial in some areas. Federal financial incentives, which are more likely to decline than increase or remain constant in the near future (e.g. Clean Water Act State Revolving Fund dollars), can boost green infrastructure projects but also come at a cost if too many policy and process restrictions are placed on recipients. Increasing federal assistance for state- and locally-led nonpoint

source pollution control, land acquisition and conservation projects makes environmental policy sense and would help advance the green infrastructure movement but runs into complications given the shrinking federal budget pie and the priorities many states and localities put on other projects (such as traditional gray infrastructure investments under the Clean Water Act State Revolving Funds).

Uncertainty and risk also play roles in the creation or perpetuation of cultural and institutional barriers. Education and outreach are key tools for gaining public support and cross-agency collaboration that builds buy-in. Regulators and enforcers of different programs with conflicting missions may be more willing to coordinate and find middle ground to advance green infrastructure if they see support from their leadership in allowing adaptive management provisions in schedules and “soft landings” for demonstrations that don’t meet their intended environmental expectations. Citizens are less resistant to change if community values regarding aesthetics are also changing over time.

Recommendations

Based on survey responses, interviews, meetings, and investigations, Clean Water America Alliance makes the following recommendations for short-term and long-term actions among various sectors and governmental levels:

Private & Non-governmental Organization Sector

Continue the grass roots progress in education, certification, and networking. Annual "Urban Water Sustainability Leadership Conferences" and "Green Infrastructure Summits" help spread useful information and build new partnerships to reduce the barriers. Developers, environmental consultants, urban planners, landscape architects, nursery and forestry experts, parks and recreation officials, and open space and farmland enthusiasts need more forums for convening, comparing, and aligning. Association-sponsored certifications for green infrastructure expertise can also help convince researchers and regulators to keep investing in an approach that has staying power.

Academia

Increase research on techniques, levels of performance, range of multiple benefits, life cycle analysis of costs, and other key areas of green infrastructure implementation. There are also a growing number of graduate institutions offering or considering courses on green infrastructure, which not only help close the knowledge gap but also provide future leaders.

Local and State Government

Greater coordination is needed at the local level where the rubber meets the road and where utilities and water-related departments are often compartmentalized, cash-strapped, and risk-averse. A designated "green infrastructure coordinator" can help connect local agencies and gain the attention of mayors, city managers, and city councils while improving communication among stakeholders and practitioners. Whether through local or regional summits, hearings, or workshops, elected and appointed officials should ask whether local codes, ordinances, energy, transportation, housing, and emergency response plans consider the benefits, costs, and tradeoffs of green infrastructure. In many communities, some of the greatest gains can occur through green streets initiatives, taking into account the significant opportunities roads, bridges, corridors, medians, parking lots and spaces present for improved stormwater management.

States should convene broader, statewide and regional forums to clarify potential uncertainties over legal rights to water and land that may be impacted by green infrastructure projects. The chief executive in a state or tribal nation has unique opportunities to coordinate water, energy, transportation, and housing agencies, through cabinet meetings and executive orders, to develop policies and priorities, including suggested areas for research, testing, regulation, and funding. To help overcome financial barriers, states should explore a range of options involving dedicated

funding, user fees, and other mechanisms, recognizing many may not be viable or appropriate in particular communities or jurisdictions. National associations of state legislatures and of environmental agencies and flood and stormwater districts should continue to look at relevant issues and trends, such as the percentage of state funds used for green infrastructure projects (including state revolving fund dollars and state road and highway dollars dedicated to stormwater management) and the creation of stormwater districts and stormwater impact fees and permit charges.

Federal Government

Over the last eight years, there has been progress at the federal level, particularly in recent years, as agency green infrastructure strategies gain specificity, staff expertise, and broader stakeholder support. EPA's April 2011 strategy offers a good model for improved coordination among headquarters and regional offices and programs and interaction with other federal agencies.

EPA's upcoming Clean Water Act stormwater rule, which the agency intends to finalize by November 2012, should include clear, achievable, and flexible standards and provisions that encourage the adoption and use of green infrastructure practices and help advance a broader green infrastructure strategy, combining regulatory and non-regulatory tools such as financial, technical, and research-related assistance.

Specifically, EPA should:

- Develop regulations featuring the use of green infrastructure as an effective and feasible means of reducing stormwater pollution and sewer overflows;
- Fully measure and account for the economic and environmental benefits realized from the use of green infrastructure;
- Focus increased federal funding for green infrastructure initiatives;
- Prepare and distribute educational documents, technical resources and training materials to assist cities, wastewater treatment plants, and others in developing green infrastructure initiatives in CSO, SSO, and MS4 programs;
- Develop model provisions to incorporate green infrastructure into CSO and MS4 permits; SSO capacity, management, operations, and maintenance plans; and consent decrees and other enforcement vehicles;
- Integrate and coordinate potentially competing and conflicting policies and practices among EPA programs and offices and other federal programs;
- Embrace innovative green infrastructure strategies and practices through the use of compliance assistance and enforcement policies and mechanisms that reduce risks to permittees and practitioners;
- Require all important dischargers of stormwater to reduce pollution, particularly by including green infrastructure practices in areas of new growth and urban reconstruction projects, as appropriate;
- Encourage partnerships among municipalities and private groups to join in identifying and implementing green infrastructure; and,
- Encourage planning for green infrastructure at a large scale that would enhance ancillary green stormwater control benefits, such as habitat, recreation, and temperature control.

Other federal agencies should continue to grow their efforts in reviewing, coordinating, and implementing green infrastructure-related actions. For example, the Department of Interior's U.S. Geologic Survey is well-positioned to support research on topics such as bioinfiltration, soils, and ground water. Over the last decade, the U.S. Department of Agriculture's Forest Service and Natural Resources Conservation Service have been active in green infrastructure, which to them typically means working lands and open spaces, woodlands, wetlands, waterways, wildlife habitats, as well as parks. These agencies can play even greater roles in reaching out further to constituencies in rural and urban communities under Farm Bill and forestry programs involving conservation and water quality.

The U.S. Department of Transportation has significant opportunities to support "green highway" initiatives for conserving wetlands and watersheds and reducing stormwater runoff problems. Mitigation banking for wetlands and habitat can also provide water quality and stormwater management benefits. U.S. DOT and Federal Highways' increased efforts on green infrastructure, whether it's in the selection of materials, the design and location of retention basins and other facilities and features at interchanges, corridors, and medians, can make a significant difference.

Green Ways and Gateways

Green infrastructure is taking root in watersheds across the country. While significant barriers remain, important gateways are opening, as well. Broad, diverse coalitions are discovering the benefits, exploring the possibilities, piloting the projects and probing system-wide changes. The effort takes money, patience, coordination, and courage but it can overcome obstacles and result in fewer technical, legal, financial, and cultural barriers. As understanding grows and risks are reduced, green infrastructure practices and programs are happening in varying degrees and forms, reflecting local watershed conditions and community contexts – good news for cash-strapped communities, businesses and agencies wanting effective, efficient, and equitable solutions.

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