Green Infrastructure in Action: Examples, Lessons Learned, and Strategies for the Future

Summary

Municipal wastewater and stormwater utilities are increasingly incorporating green infrastructure (GI) into their wet-weather management plans. GI can be a cost-effective alternative for communities in lieu of traditional gray infrastructure, and also can provide significant community benefits such as redevelopment and green space creation. Regulators support its use, but green concepts are relatively new and questions remain about how GI will be monitored, assessed, and credited and whether, ultimately, it will be effective. On December 16, 2014, the Environmental Law Institute (ELI) hosted a panel that focused on lessons learned with regard to GI implementation, the evaluation and maintenance of green projects following completion, and the growing use of GI following enforcement actions. The panel discussed the pros and cons of GI, whether GI is the best solution for communities, and GI alternatives. Below, we present a transcript of the event, which has been edited for style, clarity, and space considerations.

Jessica DeMonte (moderator) is a Principal Attorney at Squire Patton Boggs.
Carrie Noteboom is a Senior Counsel at the New York City Law Department.
George Hawkins is CEO and General Manager of the District of Columbia Water and Sewer Authority.
Louis McMahon is a Partner at McMahon DeGulis LLP.
Gary Belan is Senior Director at American Rivers and Co-Lead of its Clean Water Supply Program.

ELI's Jessica Werber Sarnowski: Welcome, everyone, to our dialogue on green infrastructure, or GI as it's called. Our moderator, Jessica DeMonte, with Squire Patton Boggs' Chicago office, has a broad environmental practice that includes regulatory and compliance counseling, enforcement events, toxic tort litigation in the defense of citizen suits, and third-party permit challenges under both the Clean Water Act (CWA)[1] and Clean Air Act (CAA).[2] Jessica represents municipal utilities with respect to combined sewer overflow (CSO) and sanitary sewer overflow (SSO) enforcement, integrated planning, GI, and nutrients. She also served for eight years as the executive manager of the Association of Ohio Metropolitan Wastewater Agencies, conducting regulatory and legislative counseling in Ohio on behalf of public wastewater and water utilities and representing them on Ohio matters that impact the interests of the association's members.

Jessica DeMonte: Let me start by introducing Carrie Noteboom. Her practice for the New York City Law Department includes litigation, defense, and regulatory compliance for the city's wastewater treatment system, which consists of 14 plants treating 1.2 billion gallons of wastewater per day. Carrie has been instrumental in the development of the city's GI plan and will give us some of the details related to that.

George Hawkins has been CEO and general manager of the District of Columbia Water and Sewer Authority since 2009, heading an agency responsible for the drinking water and wastewater treatment for more than 2 million people in the D.C. service area extending more than 725 square miles. During his tenure, he's had significant initiatives that have included the $2.6 billion Clean Rivers Project to nearly eliminate overflows of sewage and stormwater to the Anacostia and Potomac Rivers, and Rock Creek; a $950-million nutrient reduction program; and the first-of-its-kind digester program. Prior to joining DC Water, George served as the director of the District's Department of the Environment; director of New Jersey Future, an advocacy group for smart growth initiatives; and as senior assistant regional counsel at the U.S. Environmental Protection Agency (EPA).

Lou McMahon, a private practitioner in Cleveland, Ohio, has worked in the environmental realm for over 15 years, focusing on water law issues, and has provided counsel to municipal utilities on clean water issues including enforcement, CSO negotiations, integrated planning, and GI initiatives.

1. 33 U.S.C. §§1251-1387, ELR Stat. FWPCA §§101-607.
2. 42 U.S.C. §§7401-7671q, ELR Stat. CAA §§101-618.

Gary Belan joined the advocacy group American Rivers in 2003 and works to promote the use of GI to manage water resources. He was also involved in American Rivers' creation of the GI portfolio standard,[3] which encourages cities to set incremental goals for the use of GI to manage stormwater in their facilities, similar to renewable portfolio standards (RPS) that have been set up in the renewable energy context, where you have a certain percentage that has to go toward that on an incremental basis.

GI is an approach to water management that uses natural systems, or engineered systems that mimic natural systems, to manage wastewater and stormwater. It's one of the tools that communities have to manage their water resources, and can include things like rain gardens, green roofs, and green waste. The benefits of GI can include lower cost, reduced flooding, reduced water pollution and enhanced water quality, as well as general community improvement and increased green space and redevelopment in blighted areas.

GI is not a new topic. If you talk to wastewater engineers, they will tell you that the approach has always been around and they've utilized its natural ways of dealing with water runoff. But given its benefits, including cost savings, many communities are now looking at using GI on a much larger scale than in the past.

Additionally, there has been a kind of shift in culture from the regulatory agency perspective in that agencies are much more accepting of GI usage. In late 2014, EPA developed and launched its GI collaborative of federal agencies, nonprofits, and nongovernment organizations (NGOs) that are committed to building a knowledge base for communities, sharing knowledge and expertise to enhance communities' use of GI. EPA has also issued guidance for communities for using enhanced sustainability of GI in stormwater programs.[4]

As communities prepare to use EPA's guidance or implement GI strategies, they face a number of challenges that our panelists will discuss today. For example, how does a community maintain a GI strategy where there is private property involved? What about enforcement of GI strategies? What is the performance matrix? How can communities measure or assess the GI and demonstrate achievement or compliance? Also, in some cases, communities are finding that they have to spend in order to save with GI strategies. There may be times when communities are thinking that maybe gray infrastructure is the better solution.

Carrie Noteboom: That overview of some of the challenges and issues that a lot of communities are facing is certainly true of New York City. Let me provide some background on how the city's GI program came about, to help contextualize what it is that we're doing and what our goals are. I'll explain how our program was incorporated into our CSO consent order[5]; explain the phase one implementation process where we are right now; and then identify some lessons we've learned and emerging issues for the future.

New York City is a very dense urban environment. While this is a very efficient way of living, it has a lot of implications for stormwater and stormwater pollution. The city has been looking at stormwater issues and planning stormwater for quite some time, even before the current iteration of our GI program.

The prior administration under Mayor Michael Bloomberg started what was called the PlaNYC Initiative,[6] a sustainability and resiliency planning initiative that considered how to make the city a more sustainable place to live over the next 30 years, including planning for an additional million residents in that time period. One of the initiatives that came out of PlaNYC was more comprehensive stormwater planning. First, there was the 2007 PlaNYC document, followed up by a 2008 stormwater management plan that looked at the feasibility of doing GI on a wide scale in the city. It also looked at GI's cost-effectiveness as compared to some of the large CSO projects such as storage tunnels and large tanks that we were at that time under consent order obligation to construct.

Prior to these planning efforts, the city looked at natural systems to manage stormwater pollution, both through the extensive Staten Island Bluebelt System (mainly in separately sewered areas of Staten Island, but using constructed wetlands to manage storm flows there), as well as in our upstate drinking water supply, where we are under a filtration avoidance determination and do a lot of watershed protection efforts. So, you can see that the concrete jungle has actually done a lot of watershed planning. The city and its stormwater and drinking water utility agency, the Department of Environmental Protection (DEP), have a lot of experience thinking about natural systems strategies.

Our formal GI plan was issued in September 2010 and built on those earlier planning documents. What we proposed to do is to control the first inch of stormwater runoff over 10% of the impervious surfaces in the combined sewer areas, focusing on ways to more cost effectively achieve our CSO control obligation. We looked primarily at the combined sewer area, though our thinking may be evolving as we're facing other stormwater issues in the city. But the plan is certainly focused on the combined sewer areas, and then incorporates both what we viewed as cost-effective gray infrastructure strategies and this additional GI component to take a portion of the CSO volume reduction.

Two-thirds of New York City is served by combined sewers. (We do have areas that are separately sewered, but the bulk of the area is served by combined sewers.) We have 422 CSO outfalls. Not all of them discharge all of

3. *See* American Rivers, *Green Infrastructure Portfolio Standard*, http://www.americanrivers.org/newsroom/resources/green-infrastructure-portfolio-standard-gips/.
4. *See* U.S. EPA, *Green Infrastructure Collaborative*, http://water.epa.gov/infrastructure/greeninfrastructure/gi_partners.cfm.
5. *See* New York State Department of Environmental Conservation, *New York City CSO*, http://www.dec.ny.gov/chemical/77733.html.
6. For more information on PlaNYC, visit the program's website at http://www.nyc.gov/html/planyc/html/home/home.shtml. Mayor Bill De Blasio has since renamed the plan "OneNYC" and launched a new website: http://www1.nyc.gov/html/onenyc/index.html.

the time; there are varying levels. We currently have in the neighborhood of 25-27 billion gallons of CSO overflow per year. In the city, 72% of the area is covered by impermeable surfaces. While that leads to a lot of polluted stormwater runoff, it also leads to a lot of opportunities for putting in more permeable features and using GI strategies.

The city's GI plan looks at the different types of land use within the combined sewer area and tries to identify opportunities for GI installations. Streets and sidewalks make up over one-quarter of the combined sewer watershed. Those are areas that are controlled and owned by the city and thus represent opportunities to put in green streets and bioswales, enhanced tree pits, and the like in the rights-of-way.

A large chunk of the combined sewer watershed is also in parks. While those may have a certain amount of permeable surfaces already, the parks department is a natural partner for doing GI programs. The plan that we issued in 2010 expected that, of the 10% capture goal, one-third would be accomplished by putting into place a performance standard for new development, which I'll get to in a moment. Another one-third would be accomplished through those rights-of-way projects, and the final one-third would be done on public facilities—parks, schools, and other existing developments.

When the plan was announced, we approached our regulator to talk about incorporating GI goals and plans into our existing CSO consent order, and the consent order was modified in 2012 to incorporate these GI targets. Capturing the first inch of runoff on 10% of the impervious coverage area is incorporated as the target over a 20-year period. The consent order also required implementation of the performance standard for stormwater for new development.

Our CSO long-term control plans incorporate some baseline credit based on the expected penetration of GI in each water body's watershed. We also put in a funding commitment for the first five years of the program, where we were committed to spend at least $187 million on GI implementation. That is the key compliance strategy for the city as part of the consent order, and was also very attractive to our regulator for being a strong commitment to the program upfront.

The target GI penetration rate for the first five years of the program is 1.5%. It ramps up as we get later into the program, and that was by design. We're recognizing that this would be a new program for the city to implement and there would be a lot of things needed to start it up.

The stormwater performance standard regulates flow rates from new development and redevelopment. It basically can be met by detaining water onsite because what we're concerned about in the CSO context is volume rather than treatment. The less water or the slower that the water comes off the site, the happier we are in the CSO context.

There's a contingency plan option in the consent order providing that if we miss one of our targets, we can avoid penalties by submitting a contingency plan for how to make up the difference in volume.

So, the first phase, which we're in right now, has a 1.5% goal. DEP, administering the program, has set up institutional structures to ensure that it takes root and is successful. The Office of Green Infrastructure has staffed up with engineers and planners. DEP, as the stormwater and wastewater utility, works closely with other city agencies. Interagency coordination is key to this program, because it involves projects citywide and implicates issues relating to rights-of-way on properties that are constructed and managed by different agencies. As an example, the Department of Design and Construction handles a lot of these routine roadway construction projects for the city as well as other infrastructure projects.

Another thing that's been very important is the issuance of design standards. DEP worked very hard to put out a set of streamlined and standardized design standards for its GI projects (and these are all available on DEP's website[7]): they include extensive engineering plans for different types of GI installations, a lot of bioswales, but also enhanced tree pits and some other practices. The standardized design package has allowed DEP to facilitate efficient contracting strategies with an areawide contract, because there is a standard design package ready to go. It also helps when we're partnering with other agencies that they can have these designs added on to their existing contracting mechanisms and put out the packages for bid. That's been key for making sure that the program gets off the ground and ramps up.

The program is also very data-driven. We're trying to collect as much data as possible on what works and what doesn't work, in terms of designing the practices, figuring out where to locate them, and then deciding what types of maintenance strategies we need and can use going forward. More than 30 individual projects have close monitoring for pilot testing, and we're testing all the different types of GI installations that we might want to do. We also have three neighborhood-scale projects where we're blanketing a neighborhood with different practices. Those pilot tests included preconstruction monitoring in the sewer pipe of the flows, and then post-construction monitoring as well to try to correlate information on what volume reductions we're actually getting from these practices.

In terms of moving forward under the CSO program, we've identified the initial project priority areas based on high-volume CSO outfalls, contracting efficiencies, and other criteria where we're trying to blanket as many of these practices as possible and really saturate the neighborhood with GI. The standardized designs that DEP developed at the beginning of the program really helped facilitate that process.

Some examples[8] of what we've done: The right-of-way bioswales are placed in publicly owned rights-of-way. We

7. DEP's Green Infrastructure Standards and Specifications are available at http://www.nyc.gov/html/dep/html/stormwater/green_infrastructure_standards.shtml.
8. Additional information on specific GI projects may be found in DEP's annual GI reports, which are available at http://www.nyc.gov/html/dep/html/stormwater/nyc_green_infrastructure_plan.shtml.

bid out about 200-300 bioswale installations at a time. The construction time line is about six months. This is probably the largest and certainly one of the most visible components of the city's GI program because you can see these all over the areas that have been selected for GI construction, and they look really quite lovely.

We're also working with public partners to do on-site retrofits where we can identify sites that are suitable in terms of locating practices and also meet the programmatic goals of the public agency partner. An example might be installing permeable pavement at a public housing complex's playground, and creating rain gardens to help beautify the public housing project. We're also capturing additional stormwater. Finding suitable site conditions has been a bit of a challenge—making sure that the area can support the GI installation, and be an effective and efficient place to put the construction.

There's also a public-private partnership component where we've done outreach with other agencies or other organizations to promote and build GI. An example is partnering with the Trust for Public Land to do schoolyards, playground retrofits. One project is at a public elementary school that manages about 500,000 gallons of stormwater per year. The "after" photo looks quite enhanced beyond just the stormwater part of the project.

In addition, we have a grant program for giving grants to private entities that want to do GI projects. This program was initiated before the consent order, and was updated to include GI. But the consent order also includes an extra funding measure. We're doing great in terms of getting the money out, but some of our project partners are succeeding better than others in terms of being able to find suitable locations to site their projects and completing them. It's been a very popular program. DEP is very proud of it and there's a lot of outreach to promote it, including an online application process to make it easier for people to get involved in doing GI themselves.

So, we're tracking compliance with our first set of five-year obligations. We do an annual report that is submitted to our regulator and made available to the public on DEP's website. DEP is planning to launch a web-based geographic information systems (GIS) project map to track the installations, both public and private. DEP also maintains a GIS database for its own asset management purposes for the publicly owned installations, such as the right-of-way bioswales. All the decentralized infrastructure requires a lot of information to keep track of, for both compliance and maintenance purposes.

As of the end of 2013, we were tracking a total of 28.9 acres managed; as of the end of 2014, we're managing just under 500 acres. At the end of 2012, we managed about 20 acres. So, the ramp-up that we expected in the program is really happening, although you will also note that our 1.5% target, which is due at the end of 2015, requires 1,180 acres managed, and we're definitely not there yet. It will be interesting to see what happens during 2015 as we continue to ramp up the program.

In terms of lessons learned, a lot of the challenges that Jessica mentioned in her introductory remarks are things that we are facing. There are contaminated soil conditions in New York City. All the below-ground infrastructure, other pipes, utilities, and so forth, can make it difficult to find suitable locations to put in installations. And the geology itself, with areas of the city that have high bedrock or high water tables, can make it difficult. For at least one of our pilot projects we had planned for a certain watershed, we had to put in a modification request with our regulator because we were just finding that the bedrock was too high. We couldn't site the practices where we wanted to, and where we thought they would potentially have a good water quality benefit, because the underlying geology just didn't support them. That's been definitely a lesson learned.

The importance of the design standard in doing a lot of the upfront work has been really valuable for DEP and has allowed it to ramp up the program in a way that we think will be very successful. Having that detailed planning effort and design work up-front has been key. We definitely rely on interagency coordination with our sister agencies in the city in finding locations and implementing projects, and that's been quite effective.

GI is popular. Our regulator likes it. Our environmental community likes it. The *New York Times* likes it. There was a great video at the *Times* website in late 2014 featuring the bioswale installations in the East New York neighborhood, in Brooklyn. The residents of these neighborhoods like GI also, so that's been great. I think the challenge going forward is to make sure the program works and meets the goals that we have for it in terms of getting the CSO volume reductions.

One of our emerging issues is calculating how to translate all these decentralized practices into how much stormwater the installations are actually capturing and how much CSO is actually being prevented. Depending on how the program goes in 2015, we may or may not have to take advantage of the contingency plan process. That's something that remains to be seen. We're all happy that contingency planning is available under our consent order. DEP has also recently launched a research and development program to do a more rigorous analysis and documentation of the co-benefits of GI, such as carbon dioxide reduction, quality-of-life improvements, decreased energy demand, and decreased urban-heat island effect. Rigorous data will help make arguments for continuing GI into the future.

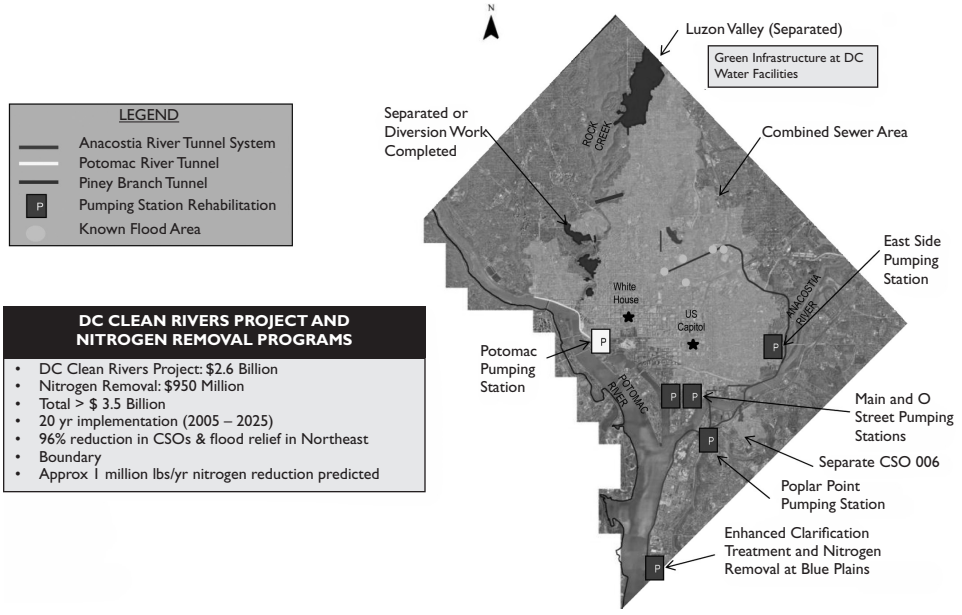
We are in our infancy on the municipal separate storm sewer systems (MS4) side of things in terms of doing separate stormwater controls. Figuring out how we can translate a program, or if we want to translate a program, designed for CSO volume reduction to the MS4 side is something that the city will be undertaking going forward. And, as always, we need to ensure that we have good maintenance strategies so that we can get as much useful life out of these structures as possible.

George Hawkins: I've been asked to tell you a bit about the District of Columbia's experience. One thing we're doing

at DC Water is what we call the Clean Rivers Project. In any city, in contrast to rural areas, there's so much less water that's being infiltrated into the ground and so much more water that has to be handled at the surface. All cities in the United States are handling this challenge, and we are also at DC Water.

We have a combined system: Parts in the middle of the city are combined sewers, while areas around the outskirts or in the newer parts of the city are MS4s. We have CSO outfalls to all three of the rivers in the city: the Potomac River, Rock Creek, and the Anacostia River, where we have fewer outfalls with far more quantity of overflow to the rivers. All three of our rivers are affected by CSO. Interestingly, none of the municipalities or suburbs that surround us in Virginia or Maryland have any CSOs. So, Maryland and Virginia, which contribute to Blue Plains (our big treatment facility that handles 750 square miles across this region) do not contribute significantly to the long-term control plan because there are no CSOs in those areas of the states.

Figure 1: DC Water and DC Clean Rivers: DC Clean Rivers Project and Nitrogen Removal Programs



It's good to be on the panel with a speaker from Cleveland, because Cleveland and D.C. are the only two cities that have the performance standards[9] that we're being asked to reach whether it's green or gray or any other kind of infrastructure: Cleveland because of the discharge to Lake Erie, and Washington, D.C., because of discharge and overflows to the Potomac River and the Chesapeake Bay, the largest freshwater estuary in North America. We have performance standards that are off the charts compared to what most other cities face, and that has made it far more challenging for us to integrate GI.

The other attribute that I think is different for D.C. is that we had a fully negotiated consent decree[10] completed and are now renegotiating with the U.S. Department of Justice, EPA, and the District Attorney General's Office to reopen it and add GI. New York, Philadelphia, and many other cities integrated GI earlier on. I can tell you that it's a much more difficult task to reopen an existing consent decree to put GI in than to negotiate it that way in the first place.

I can tell you about the current Clean Rivers plan for what we will be doing if there is not a consent decree reopening. Figure 1 shows the Anacostia and Potomac Rivers—the dark gray line indicates a gigantic 13-mile tunnel—26 feet as drilled, 23 feet in interior diameter. It's a $1.8-billion project. We have two $30-million drill boring machines on the ground working 24 hours a day, six days a week. Like trains, we hope the two boring machines will meet in the middle happily. We'll have a third machine that will go in at RFK Stadium and drill into the center of the city for the Anacostia tunnel.

Along the Potomac River is what we call the Potomac Tunnel. It's a much wider tunnel, 34 feet in diameter, but much shorter. It's intended to take the overflow from the Potomac. A smaller tunnel near Piney Branch is where the overflow is going to Rock Creek. The total cost of this project is $2.6 billion as estimated in 2002, to be completed by 2025. We're working under a 20-year consent decree, whereas most cities today are getting a 25-year consent decree. So, this is a very stringent consent decree we have in place.

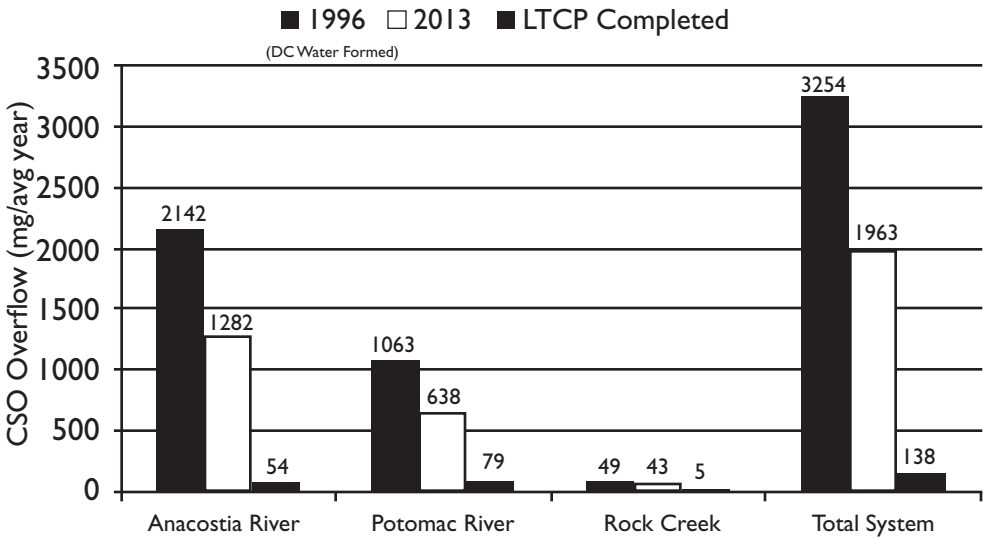
We are full force on budget on time to complete the consent decree as designed. So, if we do not get the consent decree reopened, no one should be concerned whether or not we will deliver on the promises of our current consent decree. The sheer amount of activity that we have going on in the city right now is hard to describe, but all you have to do is visit and take a look. We are deploying all over on this. The Anacostia project is either completed or in full construction with $1.8 billion of activity happening at one stage or another. It's pretty impressive.

9. Both are required to achieve 98% CSO capture. *See, e.g.*, Northeast Ohio Regional Sewer District, NEORSD Green Infrastructure Plan Consent Decree Requirement, *at* http://www.neorsd.org/I_Library.php?a=download_file&LIBRARY_RECORD_ID=5581.
10. Anacostia Watershed Society v. District of Columbia Water & Sewer District, No. 1:CV00183TFH (D.D.C. consent decree filed Mar. 25, 2005), *available at* https://www.dcwater.com/workzones/projects/pdfs/ltcp/ltcp_consent_decree.pdf. On May 20, 2015, DC Water, the District of Columbia, EPA, and the U.S. Department of Justice filed a modification to the 2005 federal consent decree to allow for large-scale GI installations and other modifications to the Clean Rivers Project impacting the Potomac River and Rock Creek. For details, see http://www.dcwater.com/green.

We've already made a lot of improvements to the CSO overflows. To give you a sense of scale, I think the number we used for New York is 27 billion gallons in a calendar year. We have a little over three billion gallons in what we call an average hydrologic year. There's always a question of what data you use. In a heavier rainfall year, you have more CSO discharges, and in a lighter rainfall year, you have less. We're already at the red level at the end of 2014. So, we've reduced from over three billion gallons to less than two billion. We could do all sorts of operational improvements, including floodgates and otherwise. But when we complete this project, whether with green or gray infrastructure, we will be down at those green levels. It is a remarkable reduction: 98% from the Anacostia River, 96% in total. My understanding is that Cleveland's reduction target is 98%. These numbers are much higher than what most other cities are being asked to reach, and that's why our performance is so meaningful.

We've been negotiating our plan of modification for five years. We are not seeking to change the largest part of the project, which is the tunneling system along the Anacostia River that is already largely in construction or at least designed. Instead, we're trying to modify the plan for the two tunnels on the other side of the city: the Potomac Tunnel and the Piney Branch Tunnel. Those two tunnels are pushed back in time in the consent decree and we have the opportunity to put together an alternative plan. We are currently building the Anacostia Tunnel; it would be hard to try to create a modification of a project that is in operation. We are looking at areas where we would want to use GI to capture stormwater on the surface rather than with a tunnel underground. Shown in Figure 2 is what is being captured by the big tunnel for the Anacostia. By the way, we are actually doing a lot of GI, and I'll get to that in a second, but that's not part of the control plan. That's part of other projects we're doing in the city.

Figure 2: DC Water and DC Clean Rivers: Progress to Date Controlling CSOs



The essence of the plan has changed from the original proposal we made several years ago, which was to eliminate the Potomac and Piney Branch Tunnels entirely and replace them with GI. We got a tremendous amount of comment on that plan. The biggest challenge was on the Potomac Tunnel. The quantity of load that we have to capture is 96%. We have to capture the stormwater that otherwise will be going to the Potomac Tunnel, all within the geographic area that's going to drain it or otherwise be captured. That's Georgetown and environs: A very small, densely developed, and expensive part of the city.

We decided that it was technically impractical to get that much GI in that part of the city and succeed. So, the way we modified our proposal was to build a tunnel only half as long as the one that was planned, and to separate two of the CSO outfalls where the tunnel will not be built. Because we have less scale of GI to build, and therefore stormwater to capture, we think that we'll achieve comparable results to the tunnel-only project.

If our modification is approved, we still plan to eliminate the Piney Branch Tunnel entirely. That area is less densely developed and less expensive if we have to acquire land along the way, so we'll have far more opportunity for the Piney Branch than we do for the Potomac.

Now, here is what we worked the hardest on, and I think it's been a principal part of getting as far as we've gotten. Figure 3 shows the numbers for the parameters of our performance and what the long-term control plan was going to achieve for reductions for the Potomac and the Rock Creek and the hybrid GI plan that we have now. The word we're using is comparable. We don't use equivalent. Equivalent is just an impossible word to use with GI. It's comparing the very best trait of a tunnel, which is its exact size and volume so you know precisely how much it will retain, with something that is far less exact, which is how much can be retained in GI. GI changes over time, from one day of the storm to the next day of the storm. There are so many more variables.

We actually think our green hybrid plan will do better than the tunnel by itself on performance per capture, and we're really pleased by that. It took us several years of modeling and assessment in the neighborhoods to come up with performance numbers that were comparable to the ones for the tunnel-only plan.

As for other benefits of GI, all of us are working very hard to quantify them, but we are confident they exist. We've seen them in the jobs category for the GI we've done already. The number of jobs we've been able to create for people to do

Figure 3: Proposed GI Plan: Predicted CSO Performance Is Comparable to LTCP

Parameter	1996 (DC Water Formed)	LTCP	Hybrid GI Plan
Potomac River			
No. Overflows (#/avg yr)	74	4	4
Overflow Volume (mg/avg yr)	1063	79	59
% Reduction from Before LTCP	—	92%	≥92%
Rock Creek (Piney Branch CSO)			
No. Overflows (#/avg yr)	25	1	1
Overflow Volume (mg/avg yr)	49	5	0.6
% Reduction from Before LTCP	—	90%	>90%

Comparable to LTCP

- Additional improvements being undertaken by DC Water exceed the schedule and water quality goals of the LTCP
  - Early completion of the Northeast Boundary Tunnel (2022)
  - Early completion of the First Street Tunnel (2016)
  - McMillan Stormwater Storage project (2014)
  - Irving Street GI project (2014)

GI work is completely different than for the very brave and amazing sandhogs who do tunnels but tend to travel around the country or world to do tunnels, going from one place to the next. Hiring for tunnels is generally not local hiring such as you can do for GI, either for design implementation or maintenance. That local hiring you find with GI is good for the local community.

There is a very interesting change in performance that's not only the end date performance, but also how fast the performance occurs. With a tunnel, you get no performance improvement at all until the tunnel is finished, and then you see a big level of the performance all at once. The performance that we get with GI is gradual performance over time. For a long period of time, we performed better than the tunnel-only solution because you're getting better performance each year as we put in more GI. In our plan, the tunnel performance comes into play before we will have finished the GI, so there will be a period where performance looks better with the tunnel. But then the performance figures catch up with GI thereafter. It's just taking us a longer period of time to attain the final outcome.

We've looked at other cities. I've mentioned Cleveland. It's the city that I think, along with D.C., has performance numbers that are at the highest level. Not that every city doesn't have very substantial performance to reach. But when you're in the 90th percentiles and capturing the performance we have, that's very hard to reach, in my opinion, with GI alone. The hybrid approach is in our judgment the best that we can do.

To date, DC Water has put our money where our mouth is because we've invested $12.5 million in this direction even though we do not yet have a deal. If it turns out that we cannot get the consent decree change that we seek, then this will have been money we've invested for the betterment of the city no matter what. The only part that was required was $3.5 million of GI that is in our existing consent decree. Now remember, our consent decree is a $2.6-billion consent decree. So, we have $3.5 million of GI and about $2.596 billion of gray. So, we've done that. Those projects are completed and we're monitoring them for performance.

We've also been sponsoring the DEP for their River Smart Program. We've done a GI challenge very similar to New York and Philadelphia's.[11] The Irving Street bioretention is in the area of the city that is not in the CSO areas that we're trying to protect, but does have historic flooding problems, and GI has been very helpful in adding to our solutions. So, it's not only a CSO issue. It's very helpful for other approaches. Our success or achievements on GI are very similar to what has been achieved in New York and other cities. These are fun projects. Your staff gets really engaged. Even the public gets engaged with them, which is a very good thing. The Irving Street project has helped us reduce historic flooding in the neighborhood where we had some terrible flooding over several years.

The GI challenge has been fascinating. What we asked is for firms anywhere in the world to compete and tell us: "What are the best projects or innovations that we can do for GI that hadn't been thought of yet?" We have piloted three of those because we want to always be pushing the envelope for what's possible in the city. Those pilots are ongoing now and we've had a great success story on green jobs. The green jobs component, at least at the city level, is an incredible benefit. Every one of the folks we have working on these projects is being taken into a job that really is meaningful in their communities. You should see how fired up they get.

I want to mention some observations of what we've learned very similar to New York. One is the development of infrastructure itself. You've heard of the public spaces. These are top public spaces, the most crowded spaces that restaurants want to expand into. Public space has parking spaces. Georgetown has no parking spaces to save your life. I'm sure that's true in New York. And GI often encroaches in the parking spaces, so you have people liking it and hating it at the same time. I'm impressed with the acreage New York is doing. One of the reasons we're seeking additional time to do GI is that we are discovering there's only so much GI you can do in the city at any one time before you have too many streets blocked off. As a prac-

11. *See* District of Columbia Water and Sewer Authority, *Green Infrastructure Challenge*, *at* http://www.dcwater.com/greenchallenge.

tical matter, Georgetown doesn't work anymore because they've blocked too many streets at the same time while doing construction.

New York's design standards are an excellent step. We've done the same. What's interesting for us is that the most frequent challenge to GI is our own infrastructure. We have water mains and sewer mains under the streets everywhere. One of the things that GI tends to do, more than a cut and cover for a typical road or sidewalk, is go deeper into the ground. That's how it works. But that puts more weight and pressure on any nearby underground pipes. We seek clearance for water mains so that we don't add weight to water mains, which already break with startling frequency as anybody in the city here today knows.

But the other issue is that, as we all know, roots go to water. Washington, D.C., typically has a very hot, dry summer, and those roots will go to our water mains from all that good GI, which will then create a maintenance problem. So, it's frequently our own infrastructure that's a challenge for GI, not because anyone is opposed to it. Getting design standards right in theory is essential, but then seeing how each street lays out, because every street is different, is a fascinating issue we haven't thought about.

Maintenance and upkeep are issues we all watch, but they're also one of my favorites because when I first came to Washington, D.C., I ran the DEP for the city. When I arrived, literally within two weeks of starting the job, I was hauled down to City Hall because the parking lots for the new Nationals Ballpark were being approved and my agency was holding them up for stormwater management. There were 19 parking lots going in on the Anacostia River, and our view was that you need to put in bioswales to catch the stormwater. Folks from the baseball team were coming in weeks, days, and then hours until Opening Day, telling me that I was going to hold up baseball in Washington, D.C., by requiring stormwater management. Fortunately, we came to an agreement and the bioswales were all done. I live in that neighborhood.

Five years later, I saw a little tractor in one of those bioswales digging out the swale, and that's evidence that bioswales work. The sediment will roll off the side of the parking lot and fill up the bioswale. If someone doesn't clean the sediment out, it stops functioning. The water will just keep going right over the swale and back out to the street as if the swale never existed in the first place. And the practical questions of who's buying the tractor, where is it located, who maintains it, who are the people who are going to drive it, who trains them, where do they work, who pays for those—almost all of them are engaging people who need jobs in the city, which is good—but they are very practical questions that we need an answer to now, not one or two years out. To compare it to a tunnel, which we give a minimum useful life of one century, we just did a century bond to match it. We want to have maintenance on these that will last maybe not one century, but decades into the future. That's one of the most interesting challenges in the field.

Lou McMahon: I've been asked to give a private practitioner's overview and talk about some lessons learned. I'm not going into detail on what we do with GI. We represent a number of cities both in Ohio and outside. As one of my partners says, we're a national law firm that's currently exclusively located in Ohio. We have offices in Cleveland, Columbus, and Cincinnati. I pay a mortgage in Cleveland, but I live on I-71 between those three cities because I'm representing cities large and small in Ohio on CWA compliance and infrastructure issues. We also represent cities and authorities outside Ohio, as well as companies for whom these questions come up at the plant level and the corporate level and otherwise.

We represent both public and private clients. Typically, even large cities aren't blessed to have somebody like Carrie Noteboom and the Environmental Department in their Law Department. Most cities cannot staff a position like that. So, they turn to law firms. Our primary task specifically with respect to GI has been to identify and then to counsel clients regarding what are the metrics and what are the targets. In other words, why are they undertaking GI?

We've seen it sometimes as a result of a consent decree, and we ask: What are the client's program goals? Answering that takes a bit of looking into the future. What is future regulation going to be in the area of stormwater? Do you have SSOs in a system? Do you have CSOs? The answer to how GI fits and how you use it out of the toolbox is very different for each of those circumstances.

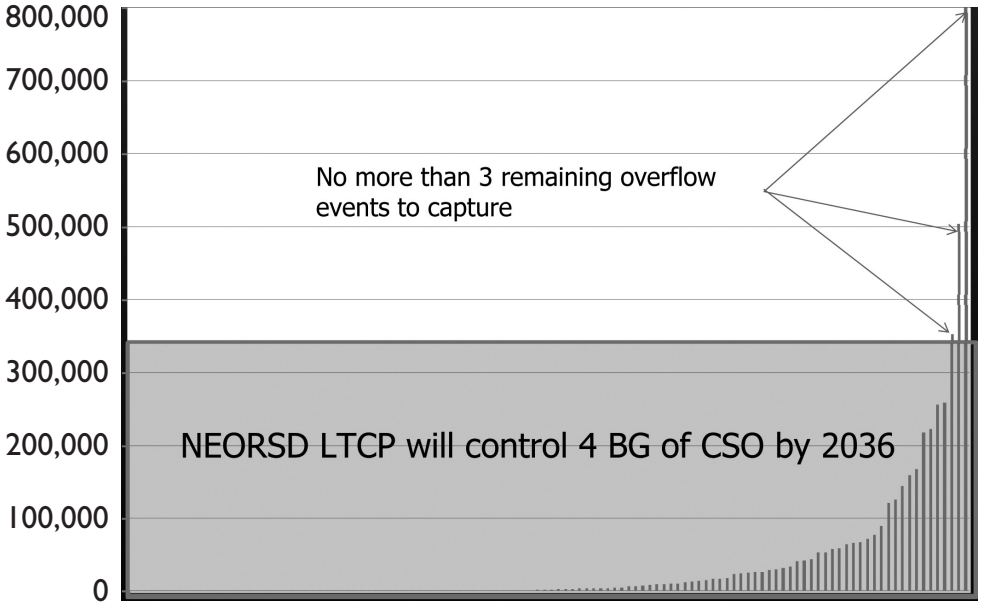
For private development, there are different drivers for GI, and I will have a few words about that at the end. But each company, each institution, has to decide for itself why it's doing what it's doing. Often, it's not just legally driven. There may be some other reason; for example, LEED certification. How does that match up with what you're proposing to do as a project?

After identifying the metric, which is all-important, then you have to come up with a strategy for negotiating either the enforceable document with your regulator (if you're a community) or construction documents, contract documents for performance (if it's a private entity). It works better to have a consent decree that already envisions GI, but who did that 10 years ago? How do you get from here to there today in negotiating and maybe reopening negotiations to get new provisions?

And, of course, there's litigation. That's what lawyers are typically recognized for. The best way to avoid litigation is to prepare very well for it, and that's always going to be part of the negotiating situation in all contexts. But it can't just be litigation-focused. There are emerging questions where the trust and confidence of the regulators or your counterparties is very important. You've got to build in flexibility. Litigation is always there to resolve disputes, but you have to know other ways to get to yes.

Here are a couple of quick examples from some of my clients, starting with Cincinnati MSD. There's the Lick Run Project, probably one of the best examples in the country of where a green sustainable infrastructure project actually

Figure 4: Typical Year Baseline CSO Volume (MG)



reduces CSO overflow and saves money. Exclusive of the co-benefits, this particular project is a culverted creek that by itself is the largest CSO in Cincinnati of over 1 billion gallons per year, but very little of it is now sanitary. It's an industrial neighborhood that has only 2,000 residents and very little industry.

What we were faced with when we got our wet-weather improvement plan in 2009 was that the agencies wanted the deliverable of a tunnel to capture this flow and some CSOs around it and deliver it to the treatment plant. Well, we pushed extremely hard for a study, knowing that we might have a good opportunity for something like this project. We told the agencies: "We'll take that as a default project, but give us a three-year window to come back to you with another approach. If we can convince you that we can get comparable aggregate control and be done in the same amount of time, then let us present that to you." And that's what we were able to do.

This project, instead of building a tunnel to catch the flow downstream before it goes to the Mill Creek, builds upon a valley conveyance system that has an entire surface green feature at the top and green vortex units and other GI aspects up in the watershed. It's a very hilly area where once the stormwater that came out the top of the hills was going into the combined sewer. So, we can measure very closely what is going to be taken out of what would have been combined sewage and put into this new system.

The benefits are at the surface, you can help reinvent an industrial neighborhood. We have the challenges of contaminated property, of utilities. But the public sees the benefits. The public has a 100-year-old neighborhood that has a chance to reinvent itself where there's no market-driven growth going on there. Land became available after 2008 at what I'd call historic prices. We were able to leverage that and make this an affordable way forward. If the co-benefits are all set aside, on a first-dollar cost, it's $200 million less than the tunnel would have been. A tunnel would have been half a billion dollars. This is $200 million less, and it's already in construction. That's one good example.

Here's another example: We started working with the Northeast Ohio Regional Sewer District this year, and there are some lessons learned in their consent decree. The sewer district (as it's called in Cleveland) has the highest level of control requirement of any CSO consent decree: no more than three overflows per year. And most of the CSOs are down to two or one because of the discharge to Lake Erie, which is considered a sensitive water body.

So, what Cleveland and the sewer district have to do is reduce CSO. It had been reduced from 9 billion gallons in the 1970 baseline already down to 4.5 billion, and it has to be reduced by another 4 billion gallons. Figure 4 depicts the outline of a typical year scenario, with a typical year's rainfall. It's those last, largest three storms that are all that are allowed to overflow. The difficulty with GI in that respect is that when you have to get just the last three storms, you're still building a lot of gray infrastructure and anything over and above that is extremely expensive.

How that played out in the consent decree is there was great interest in doing green, and green was viewed at that time as the bridge to get the last increment of control, and to save some money. Good intentions and very vigorous interest. Land was available in many parts of Cleveland, but just because land is vacant doesn't mean it's useful for this purpose. But there was a big interest of using this as an engine to try to improve some of the neighborhoods and realize some of the co-benefits. And that is the spirit of one of the consent decree green programs, the most immediate one for the projects that are underway. It's very much supported by the community, and viewed as a cost-saving mechanism.

How it ended up in the consent decree is a big lesson learned. All three of these metrics (44 million gallons of additional CSO control; a budget of $42 million; and a time line of eight years) all turned out to be aggressive, aggressive in the sense that all of them will be exceeded other than the volume of control, and you'll see why in just a second.

When you have a 98% control, you can only have those last three largest storms overflow. Anything more that you do to inch up in that control is extremely expensive. But green works are across the entire realm of all storms. It operates during every one of those first 120 storms, not

only the last three. GI provides a benefit, but it's extremely expensive. So, instead of a project estimated to achieve 7 million gallons of stormwater reduction and CSO reduction, at the end of the program in 2036, it was only projected to achieve one million gallons of CSO control. That's a very expensive proposition. In order to achieve higher volume of control, to get the largest volume that you can, you have to make basins much deeper than maybe is an amenity to the neighborhood. The project very quickly becomes very expensive, trying to get that kind of volume when you encounter a brownfield, and when you have to go deeper, then you're maybe encountering more items you don't want to see, at least as a sewer authority. So, that's one of the lessons learned.

GI doesn't control CSO, but it provides a great benefit. I believe it provides an increment and resiliency across the full range of storms. GI works all the time, so that means more available capacity in the infrastructure. It does not match up well with a post-gray, post-tunnel system CSO metric. And that's something we'll be discussing with the regulators.

Again, lessons learned: the emerging understanding of what's the proper metric, what's the right way to do GI, how do you account for it. Public property is great because you have control of it if you're a public entity, but in practical terms, it is also the most challenging. GI is highly effective in the stormwater context, and we have a number of communities that are really going heavy into it for stormwater control and even for SSO control in certain contexts, in a critical tool and integrated planning. But for CSO volume reduction, especially when you're at a very high level of control, GI is not often cost effective. Of course, you would argue nothing is cost effective when you're expected to control 98% of volume.

With respect to private entities, our experience is that unless there is some regulation that's driving GI or some stormwater fees—and we may have those fees in Ohio in the future; the state supreme court has not ruled on the Ohio stormwater fees case[12]—absent that, most of our private clients are uncertain or befuddled about GI. We see situations, particularly in smaller communities and smaller systems, where an entity is ready to do a development project such as an expansion, a parking lot, or a roof, and the city authority doesn't know that that's going to happen. There might be an opportunity to leverage some GI in those situations.

The reverse is true too: The city wants to do GI, but they don't know who's doing development. A lot of the challenge is in getting all the component entities to talk to each other. Within smaller cities, it's still a culture change. In larger systems, it's a real challenge where you have a regional sewer authority or county sewer authority and you have multiple jurisdictions that maybe don't know in detail what their stormwater obligations are yet or there's a variety of interest in that. I believe there's a growing opportunity as GI becomes more commonplace and more understood.

Gary Belan: I'm the one representative of a nonprofit in this dialogue, so I'll start by giving some context on American Rivers' point of view for folks who are representing a variety of different cities. American Rivers is a national nonprofit, headquartered in Washington, D.C., but with offices around the country. We work to restore damaged rivers, protect wild rivers, and make sure that there's sufficient clean water for both rivers and communities. A lot of people, when they think about us, they think of those nice pristine rivers out in the West. People often don't think about the damaged urban rivers that most of us interact with and encounter every day.

When I was small, I lived in a very rural area and there was a pristine river, or stream rather, in my backyard, full of life and just a beautiful place. When I was 9, we moved to the D.C. suburbs, and I was very excited to find my backyard river there, but I was befuddled by the fact that it was completely dead, empty. The only time there was any water was when it rained. There was nothing living in it. It perhaps was a stream at one point in time, but it's since become basically a stormwater conveyance in practice. And you see this all around urban areas.

American Rivers is trying to restore these damaged urban streams to a level that is maybe not their condition before development occurred, but getting closer to that. It's something that everybody can benefit from. In the process of making and restoring these rivers, you're also giving benefits to the community and for your stormwater management.

While there are challenges with GI, it's nonetheless a viable solution, particularly when paired with conventional stormwater management. There is plenty of scientific and academic literature out there now proving the variety of ways that GI in all its forms can be a benefit to water management. So, it's no longer a question of whether or not these GI things work. They do. The issue is how they're applied.

Proper construction and maintenance is essential. I'll talk a bit more on whether or not standardization is needed and how maintenance fits in the larger picture. GI is a great tool. It's just that: a tool. It's not a panacea. It should be part of a larger plan. When we're doing development, we should be looking at all the variety of different options. You can't just put in development and expect GI to solve your problems. You need to be looking at how you're planning your development in the first place and using GI as a mitigating factor in the way that you do that. It's important to know that GI can't do everything.

We used to have a joke that, you know, build a rain garden and it'll solve all your problems: love life, male pattern baldness, all these different sort of things. At one point in time, GI was being counted as some sort of panacea just like the rain garden in the joke. A long time ago, we were even discussing whether maybe we're beyond pipes: We

12. Northeast Ohio Regional Sewer District v. Bath Township, No. 2013-1770 (Ohio argued Sept. 9, 2014).

don't need pipes anymore; we'll just use GI. But that's not the case. GI is a great tool, it's something that should be used, but it's not going to solve all the problems. It needs to be done as part of a larger proper plan and have its place in a larger water management strategy.

Technologies have come a long way. In fact, GI initially was only used as a volume control and maybe as a sediment reduction management device. (I'm sorry if I talk a bit technical; my background is in engineering.) But they're now looking at different ways of implementing GI to manage the nutrient control and phosphorus control as well. So, the technology has come a long way. We're not just talking about some families planting rain gardens in their backyard. We're talking about rigorously designed engineering devices. However, they're not magic and they perform according to the fundamental rules of engineering and science. If you're not putting them in the ground correctly and if you're not managing them correctly, they're not going to work correctly. We shouldn't be putting too much burden on GI that it can't handle. We should have reasonable expectations that these are engineering devices and that they need to be managed; they need to be part of a larger plan.

A few words on the role of NGOs. In GI's infancy, NGOs were really playing a large role in advertising the need for it and the utilization of it, and in many cases, the construction of pilot projects. That is still the role that they play to this day, particularly in smaller communities. In many cases, some people started to see NGOs as sort of a solution to the maintenance problem. Depending on the type of NGO you're talking about, whether it's a community garden program or programs by local churches, NGOs can play a role on local maintenance, particularly on private property. I'll have more to say on that in a second. NGOs shouldn't be the only entity involved, but they can have a very strong role in any sort of GI strategy in planning.

In terms of implementation and maintenance, NGOs can play a role in project managing, project design, citizen mobilization and participation, training, public education, and then the actual maintenance. Many people, when they think of environmental NGOs, they think of the World Wildlife Federation or something along those lines. That's not always the case. Nonprofits comprise a wide universe of different groups, including your local watershed group and local churches—in fact, there are nonprofit groups that actually perform a certain amount of technical work and services. There is a wide universe of NGOs that can provide a variety of services.

That leads us to the issue of GI maintenance challenges, several of which you've heard discussed to some degree by my colleagues on the panel here. GI does save money in the long run. You do need to do maintenance because if you don't do maintenance initially, over time you're going to have to rebuild the project and that's going to cost you more money than if you just maintain it from the beginning for the long term. But the challenge is that GI maintenance is a different way of doing things for the folks that would normally be doing maintenance on stormwater systems.

Stormwater managers are accustomed to infiltration basins or stormwater drains. They're not accustomed to the more organic, if you will, applications of GI. A lot of landscape management is now about managing soils in the correct way. It's a different paradigm, and that's the challenge: looking for different innovative ways for changing that paradigm within the management realm. And that leads into the maintenance subject. GI needs to be incorporated into a variety of different appropriate programs. It shouldn't just be coming from the stormwater utility or the department of public works and engineering. It needs to be coming from transportation, park management, landscape management, and it needs to be done in a consistent manner because some of these city agencies are going to have more experience working with this type of landscape management than, say, the department of transportation does.

What we're seeing in Washington, D.C., and Chicago and other areas is collaboration among different city agencies to do both implementation and maintenance, trying to leverage strengths within all these different departments. What that is also going to require in the long term is that the people who are doing the maintenance, whether it be within the public sector or within the private sector, need to have some sort of certification or basic background on how these stormwater control measures work and operate and how they need to be maintained.

There's been a lack of these sorts of certification programs, these training programs, but you're starting to see them come forward. North Carolina State University's extension service is one of the first programs to offer training and certification for best management practices in maintenance and inspection. You're starting to see this in other places as well. It leads to job training and management, which can satisfy a city's interest, as George was mentioning, of keeping jobs local. GI can keep those jobs local. But you need people to have the right training and background to be able to fill those jobs.

The complexity of putting together the right career program can be challenging, particularly given the diversity of GI opportunities. Green roof maintenance is much different from bioretention maintenance, and different from impervious surface maintenance. You have to make sure that the right training programs are in place for people to be able to engage in those fields. And while that's a challenge, it's also a benefit because it means the creation of new types of jobs, new types of training opportunities, and all of those go to local folks.

Looking at the local level, GI and stormwater pollution in general is a result of local decisions and policy; therefore, the local level is where a lot of the decisions are made. But most of the places you see where ingenuity coming around GI is within the cities. It's not necessarily coming from the national level. The cities are really big engines of progress on this particular thing, and the reason is because of the way stormwater works. (That's not to say that there

aren't local challenges that need to be addressed.) GI is most effective when implemented on a large scale. One rain garden and one green roof isn't going to change much of anything. GI takes a vast change in the way we do infrastructure, and it takes a long time, and it has to be done over a broad land area.

That means maintaining momentum over a long period of time, and depending on the size of your municipality, that momentum can burn out. You might have one municipality that is under a consent decree or some other form of regulatory requirement and they are trying to address the GI problem. But because stormwater crosses boundaries, you may have other local municipalities adjacent to that one trying to solve the problem and they are kind of on the hook for other people's problems. So, how you have local municipalities engaging with each other to make sure they're treating this at a watershed level is a challenge.

The engineering community has been coming along with GI, but engineers also tend to be fairly conservative, so the buy-in can be difficult. It's a career that's based on designing something to work, work well, and you have to sign off on it. Engineers are naturally reluctant to engage in something different if they can't be assured that it's working. You see this reluctance both with engineers in city departments and design engineers in private consulting. That has changed quite significantly over the past 10 years, but overcoming that natural hesitation from the engineering field is still something that many municipalities are dealing with.

Local policy changes can take time and effort. There are a lot of codes and ordinance changes that need to take place to ensure GI can be implemented, and that doesn't happen overnight. There have to be initiatives. And this is another area where your local NGOs can be allies, in that they can often effectively put together a campaign to change the codes and ordinances. For example, American Rivers was working in the city of Toledo, Ohio, and we found that local ordinances only allowed rain gardens and permeable pavements to be used for pilot sites. They couldn't be used for larger practices. We managed to successfully work with the city council and the relevant city agencies to change those codes and ordinances to allow broader use of those practices, but it took a couple of years. So, that's another challenge. It's not a complete obstacle, but it takes time to change.

Then, there's the challenge that everybody talks about these days: How do you fund these things? The money has to come from somewhere. A lot of people like to use GI to say that they're going to create jobs. Well, that's great. But who's going to pay those salaries? There are a variety of different ways people are looking at this. I'll touch on that in a second.

In terms of how you sort of address these challenges, planning is key. As I said at the beginning, GI should be a tool within a larger planning agenda. I recognize the D.C. sustainability plan here, which is a great way of getting the different city agencies to work together. The Milwaukee municipal sewage district's regional GI plan is another good example of how you set goals for what you want to achieve, listing how to identify your priorities, set metrics for yourselves for moving forward, and lay out how you're going to work together amongst both the variety of city agencies and entities and also within the private sphere.

Financing solutions are a little complicated. One of the most popular techniques being looked at is creating stormwater utilities, where a fee is charged on different pieces of property for stormwater management. Some areas are having an easier time with this than others. Wisconsin, for example, has a preponderance of stormwater utilities and it seems to be fairly easy to institute there. Michigan actually has a constitutional amendment disallowing utility fees. They're considered a tax, so you have to look at other ways of implementing funding generation there. Ohio is currently struggling with this. The northeast Ohio regional sewage district had a stormwater utility plan put in place, on which they're still waiting to hear from the Ohio Supreme Court. We're all crossing our fingers for a positive development to allow the sewage district to proceed with their utility fee because without that revenue generation, it's very difficult to put the GI into place.

Another way of looking at this is public-private partnerships, working with corporations that might want, for advertising purposes, to fund different GI facilities where they pay for the installation and a certain amount of maintenance and in return are allowed signage around it. Getting into more complexity, you can utilize your stormwater utility fee or other revenue sources as collateral, if you will, for getting investment. So, investors will come in and fund a certain amount of GI up-front, and you can use your utility fee as a way of attracting that investment and repaying it.

Even more interesting, and something that we're looking at, are investments in future personal property taxes. GI can raise the value of property, and we're looking at different ways to bring in investors who will invest in GI in different areas against the expectation of higher property taxes from that particular neighborhood. This has a certain level of complexity in it, because what do you do about the areas where your building tends to be in low-income and disadvantaged communities? If you're talking about raising their property values and property taxes for the investment, that also might price people out of the neighborhood. So, these are different challenges for GI in the future as people are looking into it and considering various ways of funding it.

As I said, stormwater is best worked with at the local level, but there are national and state ways of looking at it. Moving anything at the national level at this point in time is a challenge because of the national political climate, so I'm not expecting to see too much there. State-level policy can be effective, but the variability in their needs is very high. One reason is the way that states operate. Climates and a variety of other factors change from state to state. But you can see movement in GI within state general stormwa-

ter permits, state manuals, and there are other vehicles to incorporate GI there.

That leads me into saying that regulatory controls are needed. The CWA has been incredibly useful in this country in cleaning up our rivers and waterways. These regulatory controls are things we need to have, but they're not going to get us where we need to be. They're great for setting a baseline. But if we are going to take GI or stormwater management to the next level, we need other drivers in place. We need investment. We need this to be seen as a community benefit so that people want it not because it's a regulatory requirement, but because it's a net benefit for their city.

That also leads me to point out that the communities we've talked about today are all combined sewer communities, and that's where we've seen most of the leverage for GI. It's a much bigger challenge to implement this in cities that don't have some sort of regulatory requirement, and that's why we need to take this to the next level. It can't be only CSO communities; it has to be in communities that don't have a long-term control plan. There need to be other drivers.

In summary, the overall picture for GI is that GI works. There's no going back. GI methods are methods that can be utilized, but they need to be used within larger strategies and plans and need to be implemented beyond just these early-adopter cities that we're talking about now. They need to be implemented quite broadly. A focus and a goal are needed: What are you trying to accomplish with GI? It can't just be everything. If you're working with a CSO, obviously you're talking about volume. If you have rivers that are impaired with some sort of pollutant, you're using GI for water quality purposes. You have to have a very good idea of what you want GI to do for you.

The implementation and maintenance paradigm seems to shift. Functional cross-agency partnerships need to be created as part of this. We need to be looking at the different ways of running our stormwater programs. It's not just about one agency anymore; it needs to involve cross-city agencies. Sustainable funding sources need to be found and utilized. These funding systems need to be fair for the more disadvantaged communities because often stormwater and combined sewer overflows are problems in communities that have the least political sway and the least amount of money to spend. And so the way we implement this needs to be done in an equitable and fair manner for those communities, the poorer communities that are probably the most impacted by it.

Jessica DeMonte: That concludes the prepared presentations by our panelists, and many thanks to them for their insights. We have an opportunity to take audience questions now.

Audience Member: I have a couple of questions on best-of-class. Do you have a city in mind that you think has been most successful in terms of implementing GI? And where is the best research occurring today in terms of best management practices (BMPs), both implementation of existing ones and development of new ones?

Gary Belan: I'm sure all my colleagues will say that the cities they work in are probably one of the best, I mean New York City and Washington, D.C. I actually like a lot of what the city of Milwaukee has done, and the city of Portland, Oregon. A lot of the larger cities, particularly ones with combined sewer, a lot of them are doing different cutting-edge things and not necessarily the same in every city. But I'd say what you've seen here is probably a pretty good representation, along with Portland, Seattle, Chicago, and Milwaukee. In terms of the research, I would say North Carolina State University, Villanova University, the University of Maryland, and the University of New Hampshire are four of the best known for their BMP research. Research is being done in other universities as well, but those four are probably the most advanced in their GI research.

George Hawkins: The only thing I would add to that, because there are so many cities doing so well at this, is what the District of Columbia has that most cities don't have—an impervious area charge for CSOs and for MS4s. We have the developed kind of regulations that require 1.2 inches of infiltration, whether it's CSO or MS4. So, I think EPA will tell you that on a regulatory basis of making a level playing field no matter where you build in the city, whether it's in the CSO area or the non-CSO area, stormwater management is an absolute requirement at the city ordinance level. I know Portland is at a level like that, but there are not many cities that have that full scale of stormwater management for MS4, for CSO, at the municipal regulatory level for all new development, regardless of where in the city it occurs.

Jessica DeMonte: Another question from an audience member: "What are the GI incentives and best practices that you've seen incorporated into regulations?"

George Hawkins: I'll say two quick things. In D.C., what it is now is a requirement. Yes, we want incentives; we want to make this. But what I hear from our friends in the real estate world is that once you get to a critical mass, it's being done regardless of requirements because it's a competitive advantage when you're seeking tenants. It is now a situation where if you're redeveloping a building or you have an older building and the new ones that are going up do have all these amenities, you're trying to figure out how to add them to your own portfolio as something to draw on. GI has now become a market maker. In D.C., we have seen the private sector go way beyond what the regulations would require because now the market is pushing it. That's the best place to be. But there is a bottom line. In order to redevelop here, there are standards you must meet.

The impervious area charge that we have—Philadelphia has it, I think Portland may have one—there are incentives where you can get a reduction in the charge. It's very small on our front because our CSO costs don't change even if you do a significant amount of stormwater management (although that may change if we get our modified consent decree). But on the MS4 side, you can have significant reductions to your impervious area charge if you do on your site what the impervious area charge would require and fund in other sites because you're essentially doing what the law would otherwise require. So, there is an economic incentive built in to the charge, particularly for MS4.

Carrie Noteboom: I think that D.C. is well beyond where we are in New York City. Our stage at this point is very regulatory: You have to maintain a certain flow rate off your site. It affects a lot of development sites in the city. But development costs are already so high in the city that I think the incentive picture for us is going to be a little more difficult, although the attractiveness in the market of certain green features is, I hope, an area that developers will notice in New York City.

Jessica DeMonte: Another audience-member question: "What do you consider to be some of the best, basic, low-hanging fruit GI initiatives from an updated perspective for our community?" I think what the question is getting at is, where do you see the most bang for your buck in terms of control and/or treatment, or however you're looking at it?

Gary Belan: There is not a specific shopping list. Ones and twos of different types of things aren't necessarily a low-hanging fruit. The best bang for the buck turns out to be not so much finding a specific project, but having the expectation that it takes time. We talked about how much time this takes. There are parking lots or other things, but it really takes a strategy and then it takes the development partners, the property owners, to find out what your best bang for the buck is. The communities I've seen that are most successful have taken the time to plan.

George Hawkins: I want to agree with that, but I also want to emphasize that, for D.C., the parking lot was probably the bigger thing. Running a municipal agency, we collect revenue (however it's characterized) from those we have a connection with. The irony is that as of five years ago, we were not collecting revenue from parking lots because unless they have a bathroom on site, we wouldn't have a water or sewer connection to the site. Despite the quantity of stormwater being generated at that parking lot, we had to handle that in the system on MS4 or CSO.

When we created an impervious area charge, we automatically gained a whole slew of new customers and in our view it was a fair arrangement because parking lots generate large volumes of stormwater. Even if they do a good stormwater control, we get a lot of bang for your buck engineering-wise because you get so much space all at once. But it's also fair that those parcels that are generating that much stormwater pay into the system, whereas if you're only charging a water sewer bill, you don't get those customers. So, that's where I always recommend to start because you get a new customer base that's fair, and it's a decent amount of space relative to some of the other places you can go.

Jessica DeMonte: George, earlier you alluded to some of the maintenance issues that come with managing the stormwater from those types of new customer bases if they're going to have to install swales and things along those lines. Panelists talked a bit about how the maintenance programs have been set up where you're dealing with the private development piece, but how are you managing that internally for the pieces that are publicly owned or city-owned or city-operated?

Carrie Noteboom: In New York City, as I mentioned, we're doing a lot of right-of-way bioswales, which builds upon an earlier program that the Parks Department had with the Department of Transportation in the city to do "greenstreets," using underutilized traffic islands and such to green the areas. Those types of practices are now being more rigorously designed for the purpose of capturing stormwater. So, DEP has a maintenance agreement with the Parks Department; they have crews. DEP is funding it currently. We have an agreement with the Parks Department, which has natural institutional knowledge for managing these more landscaped areas, and they send folks out to do maintenance. So, that aspect of our program has an advanced maintenance structure. We use a memorandum of understanding (MOU) between the agencies. As for the private side, I'd be interested to hear George's answer.

George Hawkins: My response is relevant particularly for ELI and the legal angle. It's probably the most interesting and tough issue. We're at an advantage in the District of Columbia. Why? Because DC Water is an independent agency, an independent instrumentality, so our revenue stream is independent. Our disadvantage, though, is that we're not part of the District government. So, in order for us to do a program of GI that engages the public space, we are now extending an obligation that would be in a long-term control plan to agencies that are currently not obligated. Any tunnel we build, we maintain it. We do get some surface support here and there, but it's sporadic.

When you turn over an obligation and a consent decree that's as enforceable as a tunnel that you totally control, to something that's either another agency or a private player and you want to extend the obligation decades into the future, my experience with easements for GI (I used to do a lot of easements when I was in the watershed world), is that it's very hard to get the second or third owner out to

have the same commitment to an easement as did the first owner who engaged it because it's personal to them.

Students at Princeton University assessed 20 easements in Hopewell Township in New Jersey, and found that 18 of them weren't being maintained according to their terms because the owners weren't the original owners and they weren't really as aware of what the deal was. We've had a very difficult time figuring out how to obligate parties that were not in the original consent decree when they are essential to the GI.

I think we can figure out on an operational basis how to maintain the work. That's the kind of stuff that cities do all the time. But to be obligated at a certain level of performance in a consent decree format—well, nobody wants to voluntarily obligate themselves for something 20 years from now when they might change their minds. That's the toughest part of a negotiation.

Audience Member: I have a bit of a self-serving question. My background is in environmental law and planning. I'm not a civil engineer, so, Gary, I found it interesting when you said that you think part of these problems are getting engineers who are trained to know how it works before they adapt it. I would be curious if you guys have any advice to take back to those of us with a pile of projects. What can we tell the engineers, the ones who are designing, constructing, and maintaining these projects, to get them on board? Because I have to tell you, it's been challenging. I mean, the door is open, but it's been hard to get them to walk through.

Gary Belan: Get more of them to attend the Environment and Water Resources Institute (EWRI) low-impact development (LID) conference. EWRI is part of the American Society of Civil Engineers. They've done a great job in presenting a lot of the academic research for this. A lot of the people you'll find—well, they might not be your older engineers. They might be folks who are kind of new and accepting of the newer ideas. The specific training they need is going to be incorporated into their continuing education units.

As for getting more engineers to walk through that door, here's an example of a way that happened. The city of Houston held a GI design competition.[13] A lot of engineering firms initially didn't want to do it; they didn't think that GI worked. But when they participated in the design competition, putting their best foot forward and competing with their peers, actually sitting down and doing the work, a lot of them realized: "Oh my God, this is actually working and in certain cases, it is saving me money." When they sat down for themselves and saw where it worked and where it didn't and how could it work for them—I think that's probably where your biggest opening is.

George Hawkins: I have two observations on that score. First, I believe in GI as much as anyone can, but it was oversold at first. And because it was oversold, there was some pushback from engineers with very practical experience who were saying: "No, you're claiming it's going to do too much; that's not right." And that's what started the initial skepticism. The idea that we would be able to capture three billion gallons of consistent stormwater with GI in Washington, D.C.—that's just never going to happen, as an engineering matter. Now that GI has been scaled back to being *part* of a solution, used in combination with other techniques, it's amazing to me. I told our engineers, "Do this like you do any other engineering project," and they are now as forthright and as determined to make this work as they would be to make anything work. That's the great part of the engineering mindset.

My second observation is that the worries that I hear from engineers now are no longer whether we know in the modeling (assuming it's done well) how GI works when we first build it. Instead, the engineers' worry becomes: "How do we ensure performance over time?" Because at DC Water, we know we're going to be on the hook for these performance measures 10 years, 20 years, 30 years, 50 years, 100 years in the future. When you have that kind of longevity as your performance measure, not only in quantity but also in time, that's now the kind of question I hear more often.

I rarely hear that GI doesn't work—as long as it's scaled properly. We're not going to try to make it do everything all the time everywhere. It's a part of a broader plan, just as panelists here have mentioned many times. Now, the big question is: "How do we ensure its use over time?" That's a practical issue, a legitimate issue, and one that I think we can overcome. But I see changes in my organization. Our folks are strongly in favor of GI and really want this to come forward. That was not true five years ago.

Lou McMahon: I would just add that GI works; it does not solve male pattern baldness, but it does indeed work.

Jessica DeMonte: One final question. New York and D.C.'s plans take into account that more storm events are expected from climate change. Looking at it from a long-term perspective, how has GI been developed in those cities to address climate change and climate resiliency issues?

Carrie Noteboom: New York City in general, and DEP in particular, are doing a lot of work on climate predictions and modeling and trying to figure out how to make our infrastructure more resilient. Because our target is to capture the first inch of runoff from any storm, that's what we're designing our practices for and they're performing very well on that metric. Most, if not all, of the practices that we've monitored and measured are really capturing that one-inch storm, so they're performing as designed. I think the questions for us will be: "Is that the right size, or

13. *See* Water Environment Federation, *Hosting a Low Impact Development Design Competition*, Stormwater Report (June 5, 2013), *at* http://stormwater.wef.org/2013/06/lid-design-competition/.

how many of those practices do we really need given the changes in precipitation patterns in New York City?"

George Hawkins: I have two comments on that score. One is from a slightly different angle. One of my biggest worries about GI actually comes from my experience when I ran a watershed association in New Jersey. With the Boy Scouts and Girl Scouts and all sorts of community involvement, we would do GI along suburban streams, and then a very significant flashflood would hit and wipe out everything. Because those things are destroyed, that's why there's the problem in the first place. So, I do worry about GI and the biggest storms, because it's unlike our concrete tunnels. It would take a very significant earthquake to harm one of our tunnels. You know it's going to handle the event—all it will do is fill. When they start a tunnel, they know it will work, almost regardless of how much quantity is in it.

But on the second score, this is why we're doing GI in areas where we still have the full CSO. In effect, it adds a margin. It works all the time and in every storm. The very biggest storms are going to eclipse any storage system we put in. It doesn't matter how much money we spend. Engineers will say you could build those twice as big and you'd still get a bigger storm someday. But the margin that we get in the Bloomingdale neighborhood of D.C. where we will have a tunnel capturing 98% of the flow, we're still very encouraged. We have put in GI. It's faster. It works on every storm. It works more frequently.

If storms get bigger and bigger with climate change, and the question is how big a storm can hit before you have flooding, you want that to be as high as possible. What GI does is it just gives you a slightly bigger margin of safety before the dire consequences will hit, which will probably hit in the biggest storm no matter what you do. All you can do is mitigate as well as possible. I think GI is very good for that.

Gary Belan: What I'll add is that climate prediction is very difficult. And once you've built your tunnel, it's there, it's static. It's very difficult and very expensive to add capacity on that. GI is much more adaptive. Because it does give you that cushion, it's much more cost-effective to add to that cushion or change how those cushions are installed. So, it's probably a much more cost-effective way of dealing with that change, that delta, than having to add more hard infrastructure.

Lou McMahon: In Ohio, we've seen 10-year recurrence of storms actually happening about 20 times in the last 10 years, and the storms are more intense and larger. So, it's a great benefit to have the resiliency. My clients are looking at that margin of safety with respect to compliance, but all the more important is the margin of safety and resiliency for the property owners and for the community.

Jessica DeMonte: That concludes the program. Many thanks to the panelists for their great presentations, and to the audience members for attending today and asking great questions.