Balancing Green and Gray Solutions to CSO Management

A Report on How to Balance Green and Gray Infrastructure in CSO Long Term Control Plans

Issued by the Jersey Water Works Combined Sewer Overflow Committee

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JERSEY WATER WORKS

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Executive Summary

New Jersey's Combined Sewer Overflow (CSO) permittees are currently developing detailed Long Term Control Plans (LTCPs) to address the requirements of the USEPA National Policy for Combined Sewer Overflows and New Jersey regulations. Significant requirements are contained in their New Jersey Pollutant Discharge Elimination System (NJPDES) permits regarding the development of the plans, with the final LTCP target completion date of July 2020. In the past, nearly all efforts to reduce and/or eliminate CSO discharges were addressed utilizing traditional built infrastructure known as gray infrastructure. Examples of gray infrastructure include sewer separation, holding facilities, additional treatment facilities, and/or storage tanks and tunnels. Most recently, CSO technology has expanded to include green infrastructure (GI) which generally has a lower cost and can provide additional community benefits like decreasing localized flooding, reducing the heat island effect, improved air quality, job creation and providing needed green spaces, although generally not providing the same level of treatment as gray solutions. Examples of GI include rain gardens, swales, impervious pavement, and green roofs. The Jersey Water Works (JWW) CSO Committee recognizes that CSO permittees, communities and stakeholders may struggle with how to balance the gray and green components of their LTCPs. There is a significant amount of information and guidance on implementation of GI, but a clear framework for determining an optimal green/gray balance is missing. This report uses the word "balance" in its title, stemming from the concern that a number of CSO programs that have traditionally addressed their issues with gray infrastructure have struggled to figure out the right level of GI to include in order to find a balance of cost, community acceptance, and performance.

The purpose of this report is to provide guidance to CSO permit holders and their Supplemental CSO Community Teams, to help guide the development of LTCPs for determining an optimal green/gray

balance. Although the target audience is permittees and their communities, other readers should benefit from the summary of current CSO programs. It is recognized that there are varying paths towards inclusion of GI into LTCPs. Developing a methodology to measure and communicate the balance of green and gray infrastructure is an important component of CSO LTCPs. It is also desirable to promote the use of best practices like the USEPA's community alternatives analysis roadmap with all CSO permittees. This report is not, however, intended to provide detailed technical guidance to permittees.

The report begins with background information, including the New Jersey context for CSO LTCPs. The report then describes what is involved in "balancing" green and gray, including costs and other issues such as:

- Performance of various green/gray options on CSO reduction/treatment
- Maintenance considerations
- Implementation schedule
- Sustainability, often expressed as the "triple bottom line," which can be measured using tools like Envision™
- Potential co-benefits for GI
- Regulatory guidance from NJDEP & USEPA
- Physical constraints on GI – soil, geology, terrain imperviousness

Combined sewer overflow controls, both inside and outside New Jersey, are reviewed along with guidance documents from the USEPA and NJDEP.

Recommendations for New Jersey LTCPs

Factors for consideration: There are numerous factors affecting how communities and permittees determine how to balance green and gray solutions in their LTCPs, including:

- New Jersey offers 50 percent principal forgiveness on its New Jersey Environmental Infrastructure Financing Program loans for green infrastructure. This functions as a 50 percent grant, which should be reflected in the LTCP cost/benefit analysis. However, funding is limited, principal forgiveness has stipulations and applications require committing resources.

- Success in incorporating GI into CSO management to date has been driven by grassroots efforts and forward-thinking utilities.
- Private property incentives are not widespread, including for property undergoing redevelopment.
- Stormwater utility authorization does not currently exist; however, the pending stormwater utility bill, S-1073, may be an option in the future. It passed in the Senate in June 2018 and has a companion bill, A-2694, in the Assembly.
- Wastewater treatment plants (WWTPs) that receive combined flows might not be owned by the same communities that generate the combined flow or own the CSO.

New Jersey CSO communities vary widely both physically and demographically, and it should be expected that CSO solutions chosen for their LTCPs may also vary. The guidance that follows is presented to provide flexibility in developing a balancing of green and gray in LTCPs in two broad categories:

- General recommendations based on the reviews discussed in Section 4 are presented as a list of Best Management Practices
- Recommended specific approaches are outlined to provide potential models for LTCPs that can provide a good balance between green and gray solutions

Unlike many other combined sewer systems across the country where one entity owns the treatment facility, the collection system and the CSO, New Jersey has fractured ownership of combined sewer collection systems, CSOs and treatment facilities. This results in significant challenges to developing a unified and integrated approach to implementing green and gray infrastructure in an appropriately balanced manner. However, whereas the New Jersey Department of Environmental Protection (NJDEP) issued 25 CSO NJDPES permits to 25 different entities (municipalities and sewage treatment plants), through a coordinated agreement, all of New Jersey's CSO communities and treatment facilities have agreed to implement regional LTCPs for their WWTP watersheds. These LTCPs are structured such that each treatment plant that receives combined flows (there are nine such plants in the state) and each of the communities that contributes combined flows to that plant, will coordinate and prepare a single LTCP. Therefore, in New Jersey, we will have nine LTCPs, each of which integrates the goals of a receiving treatment facility and the surrounding combined sewer communities that contribute to that treatment facility. Further, the New Jersey NJPDES CSO permits require that each permittee put together a

Supplemental CSO Team, which should be composed of community members and other interested parties, to be a component of the LTCP.

Based on experience in communities across the country, the best fit for green and gray solutions is a site-specific and community-specific endeavor. In New Jersey the best way to be involved in the process is to take advantage of the Supplemental CSO Teams that are already in place. Whether an organization or private citizen chooses to be a member of the team, or simply observe and provide input, these Supplemental CSO Teams are the bridge between the community and the permittees, who are ultimately responsible to meet the USEPA and NJDEP requirements for the LTCP and the national CSO policy.

General Recommendations and Best Management Practices: Based on a review of existing stormwater and CSO programs, several general recommendations or Best Management Practices (BMPs), which can improve any LTCP, are listed below:

1. Significant regulatory guidance is available regarding the planning stage for determining the balance of green and gray.
2. Permittees may want to consider a triple-bottom-line approach such as Envision™, which can be used for the whole plan including gray and green alternatives (see USEPA guidance *Planning for Sustainability: A Handbook for Water and Wastewater Utilities* here.)
3. Computer modeling (hydraulic/hydrologic and water quality) of existing GI and other CSO alternatives provides a quantitative measure of effectiveness. Both costs and benefits of each alternative and combinations of alternatives should be included.
4. Program goals should be identified using input from the community and other government stakeholders. Examples of program goals include:
    a. Meet permit requirements
    b. Create jobs for local residents
    c. Minimize flooding
    d. Enhance the community with additional greening
5. It is useful to identify a measurable goal for green infrastructure, such as gallons of stormwater captured, rainfall in inches managed, or area controlled by GI.

6. Piloting and/or adaptive management (defined as adjusting a plan based on actual performance) can reduce uncertainty about performance of green solutions; for example, maintenance needs of GI can be gauged through pilot programs.
7. Even in a particular catchment area where GI may not be cost-effective, it can help engage the local community to understand more clearly the impacts of CSOs and build acceptance for the more expensive gray solutions.
8. In addition to direct capital investment in GI retrofits on public property, three policy tools can be applied by communities to encourage or require GI on private property:
    - Redevelopment standards. Model municipal stormwater ordinances could be adopted (see the Sustainable Jersey model ordinance here)
    - Private property incentives
    - Pending stormwater utility authorization

Specific Approaches Recommended for New Jersey Communities: It is likely that an all-green solution is impractical because of property constraints or an inability to meet full regulatory compliance. However, all-gray solutions ignore the co-benefits of green infrastructure and its ability to reduce flows to the Waste Water Treatment Plants or CSOs. A review of programs within New Jersey and elsewhere has led to the following recommendations which, individually or in combination, provide sound guidance for New Jersey LTCPs:

1. Implementing while planning: This is the approach that the Camden County Municipal Utility Authorities (CCMUA) and the City of Camden have taken. It is based upon the assumption that the optimal solution will neither be 100 percent green nor 100 percent gray. Building projects (the lowest-hanging fruit for both green and gray) in parallel with implementing a long-range planning approach will reduce the worst flooding/overflow problems more quickly without risking doing "too much" green or "too much" gray. This approach helps incorporate the most effective green and gray elements into the program early, assuring that there is some balance in the LTCP. It also allows communities to learn from the performance of the early installations.

2. Green additions to an all-gray solution: If a utility/municipality is not in an urgent situation and can plan before implementing, the following approach is recommended: Set permit compliance (e.g., no more than four overflows, 85 percent capture, demonstration of water quality standards

compliance, etc.) as the boundary condition for successful implementation, then identify the 100 percent gray solution that would meet those conditions. This will likely be the costliest solution and may offer minimal additional environmental and community benefits beyond the core benefits associated with water quality improvements. Once a 100 percent gray solution is identified, add green in to the project mix to reduce as much gray as possible (when green is cheaper and will add community benefits as well) while maintaining the boundary condition of permit compliance. The best solution will be the one that maximizes green while still meeting the permit requirements.

3. Setting a green target: Perth Amboy used an approach that included upfront modeling of its system to determine the amount of stormwater to target, and then adding additional, feasible GI scenarios to the model run. In its gray/green scenario, it was expected that GI could capture 20-25 percent of stormwater. New York City used this approach, which used modeling, some pilot work and an analysis of publicly owned impervious area, to come up with its GI target of capturing the first one inch on 10 percent of impervious area. It is helpful to identify ranges of GI acre or stormwater management targets that could likely or possibly be managed. As another example, Philadelphia set an aggressive green goal and used it to drive policy to access more land (with varying degrees of success). Both available public land and available private land (via regulations and incentives) should be considered.

Other Recommendations: A review of the various LTCP programs inside and outside New Jersey provides additional recommendations to encourage incorporation of green infrastructure. Those that warrant further consideration include:

- Develop a Green CSO Certificate program that would recognize CSO plans that optimize GI in some measurable fashion.
- Encourage NJDEP to increase grant money for green infrastructure.
- Have JWW establish and publicize benchmarks for consideration.

Background Information

Overview: Traditionally, gray infrastructure such as engineered tanks and pipes has provided the solution to reducing, eliminating and treating CSOs. Most recently, CSO technology has expanded to include GI, a set of natural and nature-based practices that provide retention and detention of stormwater closer to its source, as well as providing other important community benefits. Examples of GI include, but are not limited to, bioretention systems, pervious paving systems, vegetative filter strips, green roofs, cisterns, tree plantings, grass swales, infiltration basins, sand filters, and dry wells.

The NJDEP, like USEPA, has issued guidelines for assessing and implementing GI in New Jersey CSO communities as part of an integrated approach to their permit requirements.[1] This guidance recognizes that every gallon of stormwater that is prevented from entering the collection system can reduce the volume of untreated combined wastewater that overflows into our streams and waterways. It can also help address local flooding, sewer back-ups, and separate stormwater overflows.

The NJDEP recommends that GI be designed to manage what is known as the New Jersey Department of Environmental Protection Water Quality Design Storm (WQDS) which is defined as a rainfall that generates 1.25 inches of rain over a two-hour period. NJDEP reports that approximately 90 percent of rain events (measured on an annual basis) measure 1.25 inches or less. By potentially addressing 90 percent of rainfall events, GI projects that are designed to meet the NJDEP WQDS can have a tremendous positive effect on reducing stormwater and the corresponding CSO discharges.

Another significant advantage of green infrastructure is the fact that it can be designed and built as a series of smaller projects, as funds and staff power become available. In this way, GI projects can be implemented sooner, and results can be realized earlier, than with a conventional grey infrastructure project, which may often take three to five years (or longer) to design, fund and build.

Purpose of this Report: While GI offers considerable promise, the JWW CSO Committee recognizes that CSO communities and stakeholders may struggle with how to balance and integrate optimally the gray and green components of their LTCPs. The purpose of this report is to provide guidance and a proposed framework for determining an optimal green/gray balance.

There are several issues to consider in making such a determination (information about these considerations is reviewed in detail in the next section of the report):

- Performance of various green/gray options on CSO capture/treatment;
- Maintenance considerations, especially the new challenges posed by decentralized and non-traditional aspects of GI maintenance;
- Implementation schedule, including the time required for implementing various options and the implications for costs and financing;
- The sustainability of green/gray options, including documenting these considerations through triple-bottom-line accounting systems;
- Potential co-benefits for GI, including community greening and aesthetics, reduction of the urban heat island effect, improvement of air quality, and increases in groundwater recharge;
- Regulatory guidance from NJDEP and USEPA.

There are also varying possible procedural paths towards inclusion of GI into LTCPs. In developing its recommendations, the committee considered two sets of possibilities:

- Develop a statewide methodology to measure and communicate the balance of green and gray infrastructure in CSO and LTCPs; and
- Promote the use of best practices like the USEPA's community alternatives analysis roadmap with all CSO permittees.

The New Jersey Context for CSO Plans: In 2008, New Jersey's CSO abatement costs were estimated at $9.3 billion.[2] In addition to this significant investment, New Jersey presents unique challenges in controlling CSO discharges, including dense development; older cities and infrastructure; and, critically, the fractured nature of infrastructure ownership and control. Whereas other larger cities (such as Philadelphia and New York City) own and operate their sewer collection systems, pumping stations, and treatment plants, in New Jersey each of these components can have different owners and operators. Sewage generated in one town may flow through several towns (with each collection system owned separately) before finally reaching a publicly owned treatment works (POTW) for treatment and discharge. Combined sewer overflows may occur in the town that generated the sewage, a downstream town, or at the treatment plant.

Further, unlike almost all other CSO communities across the country, which have federal consent decrees in place to implement the national CSO policy through LTCPs, New Jersey is unique in that the LTCP development and implementation is regulated through the NJPDES permits. These CSO permits, specific to development of LTCPs, were issued in 2015 to nine POTWs that receive combined wastewater flows and/or own a CSO, and 16 municipalities that own or operate CSOs. These permits spell out a step-by-step approach to developing and implementing LTCPs that will comply with the requirements of the Clean Water Act, the national CSO policy and the USEPA and NJDEP regulations.

One of the most critical aspects of the permits is that each permittee is required to evaluate green infrastructure for its community, and is required to create a public participation plan and a Supplemental CSO Team made up of community members are other interested parties. This can offer the opportunity to provide comments and input on the LTCP. Communities have used this local approach, integrated with municipal officials and the affected POTW, to evaluate site-specific green and gray solutions.

In January 2018, the NJDEP, Division of Water Quality released a comprehensive guidance document entitled "Evaluating Green Infrastructure: A combined Sewer Overflow Control Alternative for Long Term Control Plans." As the title implies, this document provides detailed guidance for GI in CSO areas. Topics covered in this report include:

- Locating and Assessing the Feasibility of Green Infrastructure
- Green Infrastructure Implementation and Performance Monitoring
- Maintenance Consideration
- CSO Reduction Potential of Green Infrastructure
- Cost Benefit Analysis Methodologies
- Financing Green Infrastructure

Where to locate green infrastructure solutions, what types of green infrastructure to use, and how to evaluate the expected benefits are all dependent on several factors, such as available land (public, private, vacant, rights-of-way); types of soils and their infiltration potential; community support; and costs. In some communities, where and how to implement GI can be obvious – existing parks, schools, and other community areas can be evaluated for rain gardens, swales, impervious pavement and other GI

components. In other areas, where existing green space is minimal and population density makes it difficult to find available open space, GI location can be more challenging.

Many cities, such as the City of Philadelphia, New York City, and Washington, D.C., have invested significant resources into green infrastructure to address CSOs. In doing so, they have identified specific targets and benchmarks that have provided guidance for local siting decisions.

The City of Philadelphia is dedicating close to 70 percent of its proposed $2.4 billion-dollar LTCP budget to green infrastructure.[3] A traditional "all gray" infrastructure model for Philadelphia was estimated to cost close to $8 billion.[4] Instead the city has set a goal of 9,564 "greened" acres – land utilizing a variety of GI tools to capture stormwater.

In New York City, in the early 2000's a $2.9 billion gray infrastructure program was developed to target CSOs. However, in 2012, New York committed $1.5 billion toward a green infrastructure program with a goal, over a 20-year period, of capturing the first inch of rainfall on 10 percent of the impervious CSO areas in the city. New York City's schedule to meet this significant goal as follows:

- December 2015: Achieve 1.5 percent of impervious cover capture
- December 2020: Achieve 4 percent of impervious cover capture
- December 2025: Achieve 7 percent of impervious cover capture
- December 2030: Achieve 10 percent of impervious cover capture

And in Washington, D.C., an initial 2005 consent decree with USEPA required extensive and significant gray infrastructure improvements, including the construction of several large tunnels. In 2015, the city and USEPA agreed to amend the consent decree to allow significant portions of green infrastructure to be implemented, with the potential to eliminate one storage tunnel entirely and reduce significantly the size of another – all of which will provide substantial cost savings to the ratepayers in Washington D.C.

Across the country there are many examples where traditional all-gray infrastructure solutions to CSO discharges are being replaced by a combination of green and gray infrastructure solutions. In New Jersey, we can be ahead of the curve by starting out initially with a combination green/gray solution.

Promoting best practices: As New Jersey communities and permittees that own or operate a combined sewer system move forward in implementing solutions to reduce CSOs, it is helpful to have a roadmap in mind. As mentioned earlier, New Jersey is unique in its municipal boundary and ownership structure with respect to combined sewer systems, but this should not prove to be an obstacle for green infrastructure, as most GI projects are developed and implemented locally. In New Jersey, it is likely that the treatment plant receiving the combined flows, and the owners/operators of major interceptors, CSOs and related gray infrastructure components, will be developing significant gray infrastructure solutions. It is highly unlikely that green infrastructure can ever replace gray infrastructure completely, however the two can complement each other and be integrated in a way that saves time and money and meets the needs of the local community.

Using New York City again as an example, by having a city-wide goal of capturing the first inch of rainfall on 10 percent of the impervious CSO areas in the city, individual GI projects can be implemented in targeted areas, with the knowledge that they will each contribute to a larger, city-wide goal. Green and gray solutions must go together to be successful. As evidenced by Washington, D.C.'s significant modification to its consent decree to allow more GI, the days of considering solely gray solutions are disappearing. However, how a community chooses to balance the gray and green aspects of reducing CSOs is going to be unique to that community, and will depend, in part, on the land available, funds available, and community involvement.

In NJDEP's GI guidance manual referenced earlier, a detailed step-by-step outline for implementation of green infrastructure is provided:

Step 1: Evaluate land use and drainage areas; community drivers; potential locations:

- Locations can include public property, vacant parcels, private property, rights-of-way, and more.
- Prioritize locations taking into consideration the amount of stormwater that can be managed, potential effect to reduce frequency and volume, and other variables.

Step 2: Identify needs and steps for implementation:

- A community vision resulting from outreach and education

- Development of a GI advisory committee
- Planning, design and construction standards
- Maintenance requirements (short- and long-term)
- Skilled workforce
- Pre- and post-installation monitoring program requirements

These steps can be used to assess the level and quality of effort of permitholders in evaluating green infrastructure.

Issues to Consider in Balancing

Performance: NJDEP has provided specific guidance to evaluate the performance of green infrastructure in its document "Evaluating Green Infrastructure: A Combined Sewer Overflow Alternative for Long Term Control Plans".

The first critical component to assess is the development of specific performance criteria. When developing the criteria, many factors must be taken into consideration, such as the following, from NJDEP's guidance manual:

- Impervious area managed
- Storm size managed (i.e., rainfall depth)
- Infiltration rates
- Storage bolume
- Detention release time
- Loading ratio
- Ponding depth
- Depth to groundwater/bedrock
- Material/soil/stone standards
- Vegetation

It should be noted that green infrastructure and gray infrastructure are not entirely interchangeable. The use of GI can reduce CSOs by capturing stormwater, thereby reducing flows into the sewer system. Green infrastructure can also accomplish some treatment of stormwater to reduce pollutants. Traditional gray infrastructure can control CSO release rates and allow treatment to reduce pollutants. This reinforces the need to have both green and gray in a LTCP.

Performance monitoring is another critical aspect of green infrastructure. Not only is it important to be certain the GI solution is performing as designed, meeting performance goals is an integral component of the overall goal of CSO reduction/elimination. If a GI installation fails to meet objectives, the permittee will need to re-evaluate the LTCP and determine if revision needs to be incorporated such that the projected CSO reductions can be met.

Performance monitoring can consist of determining the specific, measurable goals of the projects, the parameters to be measured, the plan for monitoring and measuring, the time frame and any unique characteristics to the site.

Maintenance considerations: Most GI projects will need routine maintenance to maintain their level of performance. The basis for GI projects is often vegetation and intake into the subsoil, or retention. Plant and soil maintenance are key components to ongoing maintenance of these installations.

As described in the NJDEP guidance noted earlier, NJDEP recommends that maintenance responsibilities include an inspection schedule, appropriate training of staff, identification of personnel and equipment needed, and considerations for overall design, location and land use.

Each type of GI installation will also have varying inspections requirements. NJDEP provides detailed maintenance guidelines, including:

- General maintenance: Inspection of all components, removal of accumulated sediment, disposal of debris, inspection of underdrains.

- Vegetated areas: Bi-weekly inspection, mowing, trimming, vegetative cover maintenance, appropriate use of fertilizers, pesticides, mechanical treatment

- Drain time: twice-yearly inspection to ensure permeability meets NJDEP WQDS standards

One of the factors cited in selecting GI for stormwater control is the uncertainty of required maintenance and its effect on long-term performance. This is significant on a long-term basis when considering green alternatives. This uncertainty has declined significantly over the last few years as GI systems have been put in place. Philadelphia, Onondaga County, New York, and other jurisdictions have published maintenance guidance shaped by lessons learned from installed GI systems. The concept of adaptive management, which requires monitoring performance over time and revising plans or installations based on lessons learned, is frequently a requirement of LTCPs, applying to both GI and gray infrastructure. One approach to maintenance concerns for GI-related projects: Use a phased approach to gain experience on effectiveness and cost.

The maintenance requirements and life-cycle costs of gray infrastructure are understood more clearly, having had a longer installation history. Careful selection of planning horizons and life-cycle performance of green vs. gray is recommended for comparisons. Gray infrastructure asset life may be very different from GI. One cautionary note is that selection of the planning horizon affects comparisons of life cycle performance.[5]

For GI, USEPA recommends[6]:

- Designing with maintenance in mind: Make sure the design process includes a review of the maintenance requirements, including access and safety issues.
- Developing a plan for maintenance, to include:
    - Who will provide maintenance: Will it be a public entity, a private one or a mix? A long-term agreement may be necessary, especially if private property is involved. Dedicated funding may be required.
    - What will be required for maintenance (tools, replacement plants, personnel training, etc.)?
    - When and how often does maintenance need to be done?

One significant benefit of incorporating GI is providing green jobs for installation and maintenance, which may not have existed before in a community. One example of this is PowerCorps, applied in Camden.[7]

Implementation schedule: It is recommended that utilities look for low-hanging fruit opportunities first in order to make the most impact in the shortest possible time and get some easy wins early in the implementation process. Examples would include:

- Green infrastructure projects in areas where flooding is prevalent. These projects can usually be done quickly and at a lower cost and have a higher visibility than conventional gray projects.
- Judicious selection of combined sewer separation projects, with high impact-to-cost ratio if possible.
- Cleaning of the combined sewer system to ensure that the existing system has its optimal conveyance capacity available.
- Lining of high-impact sewers to reduce groundwater infiltration and restore optimal conveyance capacity.

In addition to timing considerations, funding is also critical to project implementation. New Jersey is fortunate that its State Revolving Fund, the I-Bank (NJIB) offers low-interest loans, often at less than 1 percent, with a 30-year payback, for all qualifying projects. In addition, it offers 5 0 percent principal forgiveness for green infrastructure projects. The low interest rate and the long payback period associated with the I Bank program ensures that the annual debt service associated with the projects will be as low as possible, therefore reducing impact on rates.

Sustainability/Triple Bottom Line: Comparing alternatives for any public infrastructure need requires a look at sustainability. Envision™, LEED and other rating systems use a triple bottom line approach, which includes criteria for environmental, social and economic performance. USEPA and other regulatory agencies recommend including sustainability criteria, which leads to a balance in both selecting and evaluating alternatives.[8]

An advantage of GI systems is that they provide several co-benefits to a community, such as greening of neighborhoods to improve aesthetics and reduce carbon footprint. These benefits may be ignored or underappreciated in traditional alternatives analyses, which look only at capital cost and annual operation and maintenance costs.

USEPA recommends that:

- Sustainability criteria should be developed with public input. This input is likely to include factors favoring GI. The planning stage is the best time to influence the project. Including sustainability criteria improves the ability to analyze a range of gray and green alternatives.
- Other departments and agencies should be engaged in the planning stage to broaden the opportunities available for alternatives (e.g., land availability, energy use tradeoffs).
- The reference document describes the planning framework as divided into four elements (each element is discussed in further detail in the text:

    1. **Goal-Setting**: Establish sustainability goals that reflect utility and community priorities. Involve the public in developing criteria.
    2. **Objectives and Strategies**: Establish measurable objectives for each sustainability goal and identify strategies for meeting the objectives. Measurable objectives may also be non-numeric; for example, setting an objective that GI alternatives *must* be included in evaluations.
    3. **Alternatives Analysis**: Based on sustainability goals and objectives, set evaluation criteria to analyze a range of infrastructure alternatives both green and gray. Using a scoring system for evaluating potential projects allows better "apples to apples" comparisons.
    4. **Financial Strategy:** Implement a financial strategy. Note that GI may be able to take advantage of green incentives in state and federal funding.

Potential co-benefits of GI: While it is unlikely that long-term CSO control plan compliance can be achieved entirely with green infrastructure, a 100 percent gray infrastructure approach can result in lost opportunities associated with a gray-green combined approach. As discussed above, green infrastructure can usually be implemented more quickly than conventional gray infrastructure projects. It is also usually less costly and almost always more visible to the public as well. In addition, there is the ancillary benefit of providing green amenities to the communities being served; a greener community is viewed as a healthier and cleaner community. Moreover, creation of green spaces offers the resulting opportunity to generate low-barrier green jobs maintaining those green spaces. Such jobs can be given on a preferential basis to residents of the communities being served by combined sewer systems, adding additional benefit.

Regulatory guidance: In recent years, the USEPA and the NJDEP have increasingly supported the inclusion of green infrastructure in LTCPs to mitigate the effects of combined sewer overflows. To guide local governments, utilities, and other stakeholders, these agencies have published several documents that outline the necessary steps for weighing the costs and benefits of green infrastructure with conventional CSO solutions to provide a foundation for incorporating green infrastructure into the planning process. Suggestions and technical assistance include adequate involvement from the public, inclusion of sustainability criteria in the planning process, and strategies for goal-setting and performance evaluation.

There is significant guidance from the USEPA and NJDEP regarding the inclusion of green infrastructure in sewer and stormwater management planning to meet the obligations of the community and regulated entity. The USEPA recognizes that communities can meet their CSO permit obligations through a combination of green and gray solutions that takes advantage of the flexibilities in the Clean Water Act and NPDES permit requirements.[9]

The USEPA also recognizes the ways in which communities can introduce sustainability criteria into the infrastructure planning and decision-making process to accomplish community and utility priorities simultaneously. In *Planning for Sustainability: A Handbook for Water and Wastewater Utilities,* USEPA lays out strategies for applying sustainability criteria in the formulation of a long-term stormwater plan.[10] As green infrastructure embodies many principles of sustainability and characteristics that may be

difficult to quantify, it is recommended that permittees establish goals that reflect what a community intends to achieve through its wastewater and stormwater infrastructure investments, to maximize the benefits attained. Further, because estimating the costs and impacts to CSO volume reduction and other outcomes may include several uncertainties, the document describes ways in which communities and utilities can use self-defined metrics to evaluate alternatives and ultimately make well-informed decisions on the most ideal solution.[11]

In the *Green Infrastructure Permitting and Enforcement Series,* the USEPA provides CSO permittees tools to navigate the regulatory landscape.[12] Specific recommendations include consideration of green infrastructure solutions early in the planning process to identify potential opportunities for substitution of gray infrastructure projects with green infrastructure, as well as maintenance of a green infrastructure performance tracking and reporting system. In addition, the documents suggest that solutions should be analyzed on a sewershed-by-sewershed assessment due to varying characteristics and needs among different permittees.

Likewise, USEPA provides technical assistance to permittees through *Greening CSO Plans: Planning and Modeling Green Infrastructure for Combined Sewer Overflow (CSO) Control.*[13] Unlike other guides, this document specifically discusses tools to help quantify green infrastructure contributions to an overall CSO control plan. The report details how green infrastructure approaches fit into the federal regulatory framework and explains how to develop and evaluate control alternatives that incorporate green infrastructure practices. The document also includes a case study demonstrating how a specific Hydrology & Hydraulics model, USEPA's Storm Water Management Mode SWMM5, can be used to quantify green infrastructure contributions to an overall CSO control program. Although it does not make a recommendation regarding the ideal balance of green and gray infrastructure, this document suggests a method for permittees and others to take a hard look at the potential stormwater management benefits.

Additionally, NJDEP has published an extensive assessment of stormwater and wastewater infrastructure best practices in *Evaluating Green Infrastructure: A Combined Sewer Overflow Control Alternative for Long Term Control Plans.*[14] The report includes case studies of community actions throughout New Jersey as well as a wide variety of recommendations regarding hydraulic system modelling, performance monitoring strategies, finance mechanisms, and feasibility studies.

What Others Are Doing

Communities across New Jersey and the United States have used a wide variety of methods to balance green and gray infrastructure in their plans to reduce combined sewer overflows. Throughout New Jersey and New York, many permittees have created green infrastructure plans that focus on stakeholder engagement, cost-benefit analyses, and stormwater modeling.[15] Others, such as Philadelphia and Camden, have taken a triple-bottom-line approach, evaluating alternatives based on social, economic, and ecological benefits.[16]

While the LTCPs proposed by New Jersey's permittees are still gaining regulatory approval, permittees in other states have already begun LTCP implementation. Recognizing the uneven regulatory landscape and variable funding mechanisms in New Jersey and other states, the following examples are categorized as *New Jersey Permittees* and *Other Permittees.* While these examples are not exhaustive, they demonstrate a diverse range of approaches for improving the effectiveness of wastewater and stormwater infrastructure.

New Jersey Permittees

Camden: The City of Camden and the Camden County Municipal Utilities Authority (CCMUA) have undertaken a strategic mix of green and gray infrastructure upgrades based on timing, cost, and holistic benefits to the city's triple bottom line.[2] First, CCMUA identified and implemented the most obvious green and gray opportunities to mitigate immediate flooding concerns. CCMUA identifies five to 10 green infrastructure projects annually that provide the greatest triple-bottom-line benefit, as determined by scoring positive and negative impacts in various social, ecological, and economic categories. When green infrastructure alternatives are found to result in significant volume reductions at a reasonable cost, CCMUA grants them preference over gray infrastructure projects. Current and past projects include daylighting streams, cleaning brownfields, establishing riverfront parks, and constructing rain gardens.

Camden's development of a Long Term Control Plan also entails the use of modeling to determine an optimal balance of green and gray infrastructure. Model scenarios include: (1) a 100 percent gray approach to determine volume capture and costs; (2) a 10 percent replacement of impervious area with greened areas; and (3) graduated scenarios of greened areas, up to 35 percent green. The goal is to implement the highest possible percentage of green infrastructure to realize the greatest community and

environmental benefits. Working with the community-focused Camden SMART Initiative, CCMUA intends to select a final alternative that meets permit requirements for CSO mitigation and fulfills criteria for costs and community benefits.

Newark: The Long Term Control Plan component for the City of Newark entails a comprehensive evaluation of green infrastructure via modelling and alternative analyses. The plan's green infrastructure element includes the following components:

1. Development of NJDEP-approved hydrologic and hydrodynamic models
2. Evaluation of land uses, drainage areas, and community drivers
3. Evaluation of green infrastructure alternatives (using models or other calculations)
4. Development of a green infrastructure implementation program
5. Determination of life-cycle costs associated with the program
6. Identifying opportunities for funding and/or incentivizing green infrastructure development
7. Identifying locations for the development of green infrastructure
8. Designing and constructing green infrastructure management features
9. Evaluations of performance
10. Adapting the green infrastructure program as needed

So far, the city has modeled performance of two green infrastructure alternatives in a typical rainfall year. The first alternative was based on green infrastructure opportunities identified by a Rutgers University study, which proposed greening 63 sites to replace 11.7 impervious acres. The second alternative was a 10 percent reduction in impervious area (which amounts to 490 acres) modelled after New York City's green infrastructure plan.

Next steps will include investigating potential locations for green infrastructure, implementation of a pilot project, and development of additional modelling scenarios to determine the ideal mix of green and gray solutions.

North Hudson Sewerage Authority: The North Hudson Sewerage Authority (NHSA) serves Hoboken, West New York, Union City, and Weehawken. NHSA's Long Term Control Plan includes discussions of green infrastructure solutions to manage stormwater at its source, thus improving long-term efficacy of gray infrastructure controls. To promote green infrastructure, NHSA has implemented several pilot

projects in West New York, Union City, and Weehawken. In Hoboken, the utility collaborated with the municipality to provide a combined green and gray solution for Southwest Park based on the needs of the immediate area. NHSA also requires a volume of stormwater storage based on the size and coefficient of runoff for each development parcel. Storage on a green roof or other GI reduces the required storage volume. Currently, NHSA is implementing an inspection program that includes maintenance and performance of gray and green stormwater infrastructure.

Other Permittees

Onondaga County, N.Y.: Onondaga County originally proceeded with a gray solution to its CSO consent order but encountered resistance from community members who desired a greener approach. To go beyond merely meeting the obligations of the CSO permit, the county sought to identify opportunities to use green infrastructure to reduce CSO pollution. It also strove to achieve the auxiliary benefits highlighted in the Onondaga Save the Rain campaign.[17] Onondaga received regulatory approval to substitute its last major gray stormwater project with green infrastructure. As a result, the water quality of Onondaga Lake has improved drastically.[18] The county has continued implementation through a program that includes green infrastructure on both public and private property. It also carries out extensive community engagement.

New York City: In 2010, based on recommendations from the city's Department of Environmental Protection, local advocates, and the City Council, New York City developed a 20-year green infrastructure plan. The plan aims to use green infrastructure to manage the first inch of runoff from 10 percent of impervious cover within the CSO sewershed.[19] This effort will capture a projected 1.5 billion gallons of stormwater per year. Combined with various gray infrastructure projects, it will help meet regulatory obligations at a lower cost than the original gray-only approach. To meet the city's green targets, the plan will include green infrastructure in municipal projects, installation of green infrastructure retrofits in priority streets and sidewalks, and incentives for green retrofitting on private land through grants and other tools. After a 2012 revision to its CSO consent decree, New York City eliminated certain gray infrastructure projects from its capital investment pipeline, substituting other more cost-effective gray projects and integrating significant green infrastructure. This change is expected to achieve similar CSO volume reductions, saving $1.4 billion in the process.[20]

Although the city's Department of Environmental Protection set incremental requirements at five-year intervals to meet its 10 percent green goal, New York City failed to meet its first benchmark of managing runoff from 1.5 percent of impervious area by 2015. Likewise, the city is not on schedule to meet the next benchmark in 2020. Over the last several years, the Department of Environmental Protection has submitted and gained state approval for Long Term Control Plans for specific water bodies. In these plans, the only additional investments proposed beyond the green and gray projects in the 2012 consent decree are gray infrastructure projects. The department's website and annual reports provide details on the continuing evolution of the city's green infrastructure program.[21,, 22] The Stomwater Infrastructure Matters (SWIM) Coalition website highlights the program's progress and challenges from the perspective of New York City's environmental organizations.[23]

Philadelphia: The Philadelphia Water Department (PWD) has taken the approach of favoring green infrastructure solutions in its CSO long term control plan. In 2009, PWD commissioned a triple-bottom-line analysis that estimated the cost-effectiveness of 25 percent, 50 percent, 75 percent, and 100 percent green investment scenarios, based on the potential to improve water quality, reduce adverse health effects from urban heat islands, increase property values, and provide other benefits.[24] The study concluded that a predominantly green infrastructure-oriented approach could achieve CSO reduction goals at a much lower cost than an all-gray approach. Another key finding was a projected 45-year positive net return on green infrastructure investment, derived from a cost-benefit analysis of social, economic, and environmental metrics such as property values, public health expenses, recreation, habitat creation, job creation, and water quality.

In accordance with the study's findings, Philadelphia developed its *Green Cities, Green Waters* plan. This plan, which obtained public support and regulatory approval, commits the city to using green infrastructure to manage the first inch of rainfall from one-third of the impervious area in the CSO sewershed — nearly 10,000 acres — over 25 years.[25] In light of the advantages of green infrastructure, such as the benefit of flexible and decentralized capital investment, community quality of life improvements, and comparatively lower costs of implementation, the city committed most of its CSO mitigation funding to green infrastructure projects via capital investment and grant programs. Specifically, the plan projected a $1.67 billion allocation for green infrastructure, $345 million for traditional wet-weather treatment plant upgrades, and an additional $420 million for green or gray projects to be selected on a case-by-case basis between 2011 and 2036. The city met and exceeded its green

infrastructure targets for the first five years of the plan, and reports that it is on track to meet its 10-year target. The city's diversified green infrastructure strategies include retrofits on public property, regulations requiring green infrastructure in new development projects, a stormwater fee that offers credits for using green infrastructure, and grants and other incentives for private property retrofits. The Philadelphia Water Department's website provides information and updates on the various aspects of its program.[26]

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