Long Term Control Plan Modification for Green Infrastructure

May 2015

prepared by

District of Columbia
Water and Sewer Authority
Washington, DC

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

LONG TERM CONTROL PLAN MODIFICATION FOR GREEN INFRASTRUCTURE

May 2015

FINAL

Prepared for:

water is life

Prepared by:

dc clean RIVERS PROJECT
RESTORING OUR RIVERS
PROTECTING OUR DISTRICT

Program Consultants Organization
Blue Plains Advanced Wastewater Treatment Plant
5000 Overlook Avenue, SW
Washington, DC 200321

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General Manager's Message

I am pleased to announce the completion of the process to modify DC Water's Long Term Control Plan to enable a significant investment in Green Infrastructure. This plan represents an enormous body of work and painstaking analysis performed by DC Water and its contractors. Exploring Green Infrastructure to reduce combined sewer overflows to the Potomac River and Rock Creek was a personal priority for me when I accepted the position of General Manager at DC Water in 2009. Since then, DC Water has invested $14 million in ratepayer funds to further our understanding of this innovative solution to stormwater control that will bring environmental, social, and economic benefits to the residents of the District of Columbia.

DC Water CEO & General Manager
George S. Hawkins

This document is a product of methodical outreach and collaboration with our regulatory, environmental, and community stakeholders. DC Water solicited feedback on its plans for Green Infrastructure by holding multiple summits, more than 14 public meetings, and notifying District residents through a proactive ad campaign. The updated proposal reflects the nearly 500 comments we received from the public, and I am confident will position DC Water as a leader in the responsible use of Green Infrastructure for combined sewer overflows. We are grateful for the comments we received, and we strongly believe that our proposal is much better for it.

The release of this document marks an important moment in DC Water's history. Some argue about the role of Green Infrastructure in comparison to gray. We have learned over this process that embracing both techniques in a complementary manner builds on their relative strengths and yields an outcome that is better than either alone. I want to thank all who have engaged DC Water on this herculean effort, and I look forward to collaborating with the public and our stakeholders as DC Water begins to make this plan a reality in the District of Columbia.

George S. Hawkins

What is the Purpose of this Initiative?

DC Water is proposing to implement **Green Infrastructure** or **GI** as part of our plan to control Combined Sewer Overflows (CSOs). CSOs are one of the sources of pollution impairing the quality of the District's waterways. The current plan to control overflows in the District's Potomac River and Rock Creek sewersheds relies largely on the construction of large tunnels ("gray" infrastructure) designed to capture CSO during heavy rains and transport it to the Blue Plains Advanced Wastewater Treatment Plant (Blue Plains) for treatment. GI reduces the scope of gray infrastructure needed to control stormwater runoff that contributes to CSOs, and has the potential to provide many environmental, social, and economic benefits to the community. While additional time is needed to effectively implement GI, it will deliver earlier pollutant reductions through phased construction when compared to gray infrastructure. This report explains the basis for this initiative and why a modification to DC Water's plan for controlling CSOs (called the Long Term Control Plan, LTCP or DC Clean Rivers Project) is required to implement it.

Bioretention in the Public Right of Way

What is the Consent Decree?

The Consent Decree is the 2005 agreement among DC Water, the District, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Justice (DOJ) that establishes schedules for construction of the tunnels and related CSO control facilities, including a 2025 deadline to construct and place the tunnels in operation.

What is Green Infrastructure?

GI, also known as Low Impact Development (LID), uses plants, trees and other measures to mimic natural processes to control stormwater, resulting in cleaned, cooled, and slowed stormwater runoff. These systems promote rainwater detention and infiltration into the soil and include techniques such as rain gardens, porous pavements, green roofs and other technologies.

Typical Green Infrastructure Measures
• Rain Gardens (Bioretention)
• Porous Pavements
• Green Roofs
• Rain Barrels and Downspout Disconnections

By integrating natural processes into the urban environment, GI provides not only stormwater management, but also can support additional benefits such as local job creation, improved air quality, a cooler city, greener public and private spaces, added wildlife habitat, increased property values, and greenhouse gas mitigation.

DC Water's recommended plan is to construct a hybrid green-gray solution to control CSOs while improving the quality of life in the District.

What is a Combined Sewer Overflow?

Like many older cities in the United States, the sewer system in the District is comprised of both combined sewers and separate sanitary sewers. While sanitary sewers carry only sewage, combined sewers carry both sewage and runoff from storms.

Modern practice is to build separate sewers for sewage and stormwater. No new combined sewers have been built in the District since the early 1900's. Approximately one-third of the District is served by combined sewers, the majority of which are in the older, developed sections of the District.

CSO Facts

- **"CSO"** stands for **C**ombined **S**ewer **O**verflow
- About 1/3 of the District is served by combined sewers
- Combined sewers have not been built in the District since the early 1900's
- Combined sewers overflow when stormwater runoff exceeds the sewer capacity

In a combined sewer system, sewage from homes and businesses during dry weather conditions is conveyed to DC Water's Advanced Wastewater Treatment Plant at Blue Plains, located in the southwestern part of the District on the east bank of the Potomac River. There, the wastewater is treated to remove pollutants before being discharged to the Potomac River. When the capacity of a combined sewer is exceeded during storms, the excess flow, which is a mixture of sewage and stormwater runoff, is discharged to the Anacostia and Potomac Rivers, Rock Creek and tributary waters. This excess flow is called Combined Sewer Overflow (CSO). There are 47 active CSO outfalls in the District's combined sewer system.

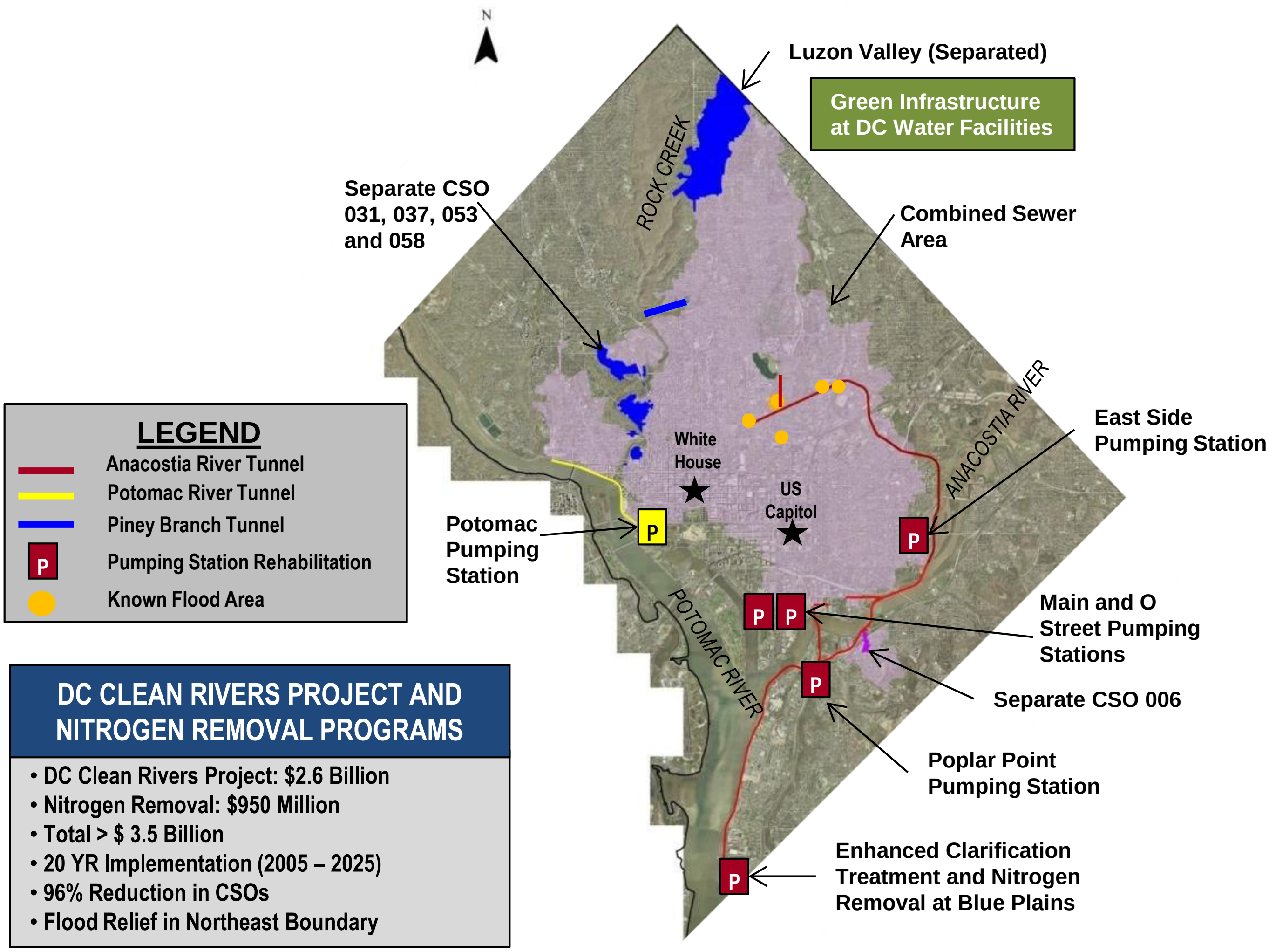
"Lady Bird" Tunnel Boring Machine for the Blue Plains Tunnel

What is the DC Clean Rivers Project?

The DC Clean Rivers Project (DCCR) is DC Water's massive infrastructure program to reduce combined sewer overflows into the District's waterways - the Anacostia and Potomac Rivers and Rock Creek. It includes more than 13 miles of tunnels that are larger than the Metro tunnels and are constructed more than 100 feet below the ground. The tunnels are designed to capture CSO during heavy rains and transport it to Blue Plains for treatment. The tunnels to control CSOs on the Anacostia River are currently under construction.

With the DC Clean Rivers Project, DC Water will improve our waterways by reducing CSOs system-wide by 96% in the average year. The DC Clean Rivers Project will also provide flood relief to neighborhoods in the Northeast Boundary section of the city, such as Bloomingdale, LeDroit Park, Trinidad and Ivy City.

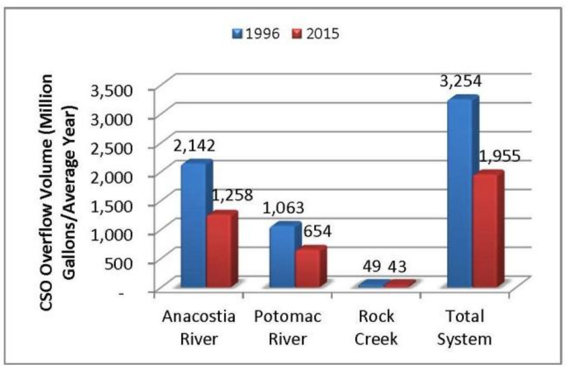
> **DC Water has reduced CSO overflow volume by approximately 40% since 1996 and has issued more than $1.3 billion in engineering and construction contracts.**



Existing Plan

What Progress has already been made in CSO Control?

DC Water has made great strides toward reducing CSOs since the Authority was created in 1996. Since 1996, CSO overflow volume has been reduced by about 40% on a system-wide basis in an average year of rain. DC Water has done this by replacing and upgrading pumping stations and control structures and separating combined sewers in selected sewersheds. The investments have already improved water quality and reduced trash in our waterways.



DC Water has Reduced CSO Overflow Volume by 40% Between 1996 and 2013

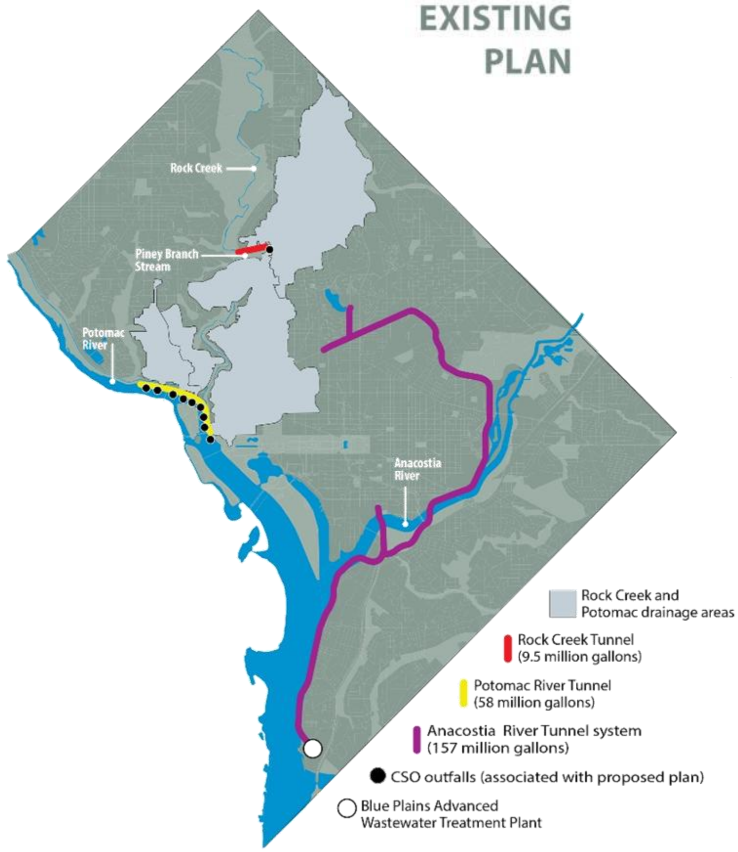
DC Water is currently constructing the tunnel system for the Anacostia River. This will achieve an 81% reduction in CSO volume on the Anacostia by 2018 when the tunnel from Blue Plains to RFK Stadium is placed into operation and a 98% reduction in volume when all Anacostia River controls are placed into service. While the Consent Decree deadline for completion of the Anacostia River Tunnel system is 2025, DC Water is accelerating the work to achieve a completion date of 2022 to provide early flood relief to Bloomingdale and LeDroit Park per the Mayor's Task Force Recommendations.

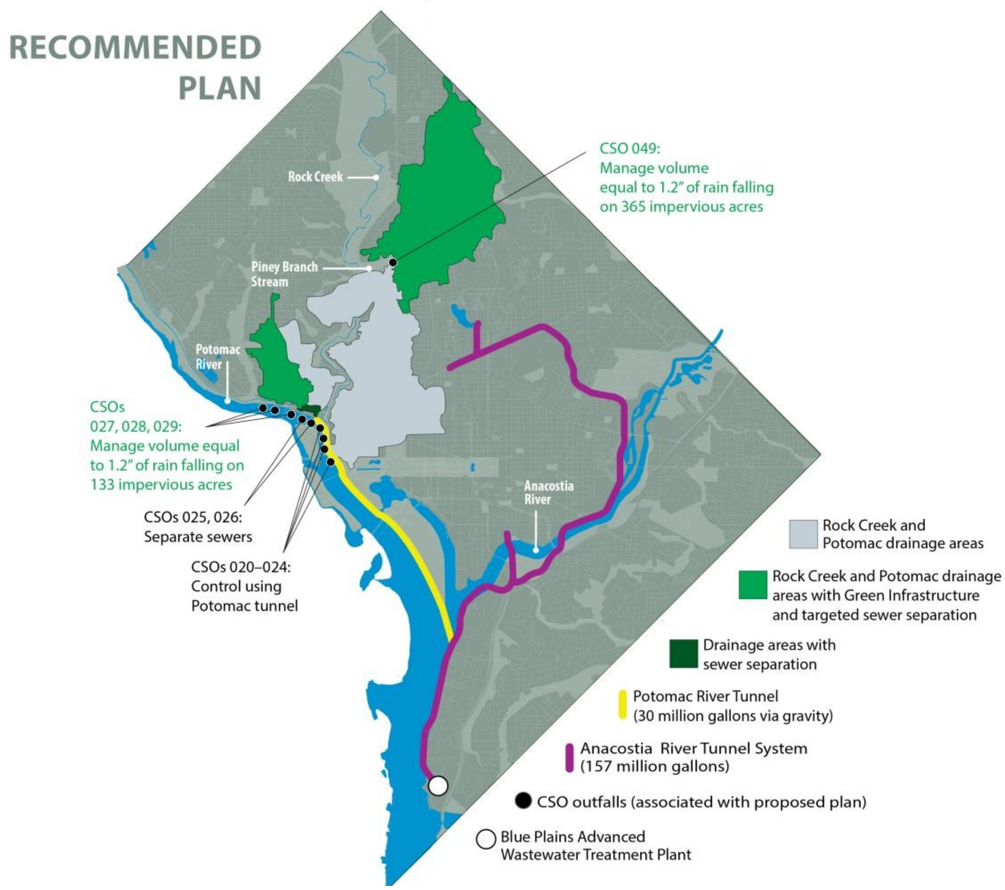
What is DC Water's Recommended Plan?

On the Anacostia River, DC Water will complete construction of the tunnel system and will meet the existing aggressive schedules. For the Potomac River and Rock Creek, DC Water will implement a hybrid plan of green and gray infrastructure, where each technology will be applied in areas selected to maximize their effectiveness.

For Rock Creek, DC Water will construct GI and targeted sewer separation to manage the volume of runoff produced by 1.2" of rain falling on 365 impervious acres instead of the Rock Creek Tunnel to control the Piney Branch CSO Outfall. This approach is feasible in this sewershed because of its low CSO overflow volumes and because of the lower density of

Receiving Water	Existing Plan	Recommended Plan
Rock Creek	• Construct Rock Creek Tunnel by 2025	• Raise the diversion weir at CSO 049 (Piney Branch) by 2020 • Construct GI and targeted sewer separation to manage the volume of runoff produced by 1.2" of rain falling on 365 impervious acres to control CSO 049 (Piney Branch) by 2030
Potomac River	• Construct Potomac Tunnel by 2025	• For CSOs 027, 028 and 029, construct GI and targeted sewer separation to manage the volume of runoff produced by 1.2" of rain falling on 133 impervious acres by 2027 • For CSO 025 and 026, separate these sewersheds by 2023 • For CSOs 020, 021, 022 and 024, construct a 30 million gallon Potomac Tunnel by 2030. Configure the tunnel to drain by gravity to the Blue Plains Tunnel


EXISTING
PLAN
Rock Creek
Piney Branch
Stream
Potomac
River
Anacostia
River
Rock Creek and
Potomac drainage areas
Rock Creek Tunnel
(9.5 million gallons)
Potomac River Tunnel
(58 million gallons)
Anacostia River Tunnel system
(157 million gallons)
CSO outfalls (associated with proposed plan)
Blue Plains Advanced
Wastewater Treatment Plant


RECOMMENDED
PLAN
Rock Creek
CSO 049:
Manage volume
equal to 1.2" of rain falling
on 365 impervious acres
Piney Branch
Stream
Potomac
River
CSOs
027, 028, 029:
Manage volume equal
to 1.2" of rain falling on
133 impervious acres
CSOs 025, 026:
Separate sewers
CSOs 020–024:
Control using
Potomac tunnel
Anacostia
River
Rock Creek and
Potomac drainage areas
Rock Creek and Potomac drainage
areas with Green Infrastructure
and targeted sewer separation
Drainage areas with
sewer separation
Potomac River Tunnel
(30 million gallons via gravity)
Anacostia River Tunnel System
(157 million gallons)
CSO outfalls (associated with proposed plan)
Blue Plains Advanced
Wastewater Treatment Plant

development in the sewershed. GI projects will start in 2017 and will be completed by 2030.

For the Potomac River, DC Water will implement a hybrid green and gray solution. GI and targeted sewer separation will be used to control CSO 027, 028 and 029, while CSO 025 and 026 will be separated because the drainage areas for these outfalls are very small. Implementation will start in 2017 and will be completed by 2027. The largest CSOs are outfalls 020 through 024 and these will be controlled by a modified Potomac Tunnel, with a storage volume of 30 million gallons. The Potomac Tunnel will be drained by gravity to the Blue Plains Tunnel, thereby eliminating the need for a new very large pumping station to empty the tunnel near the National Mall. The Potomac Tunnel will be placed in service by 2030.

For both the Potomac River and Rock Creek, the recommended plan will result in CSO reductions and water quality improvements equivalent to those predicted for the CSO controls in the existing plan.

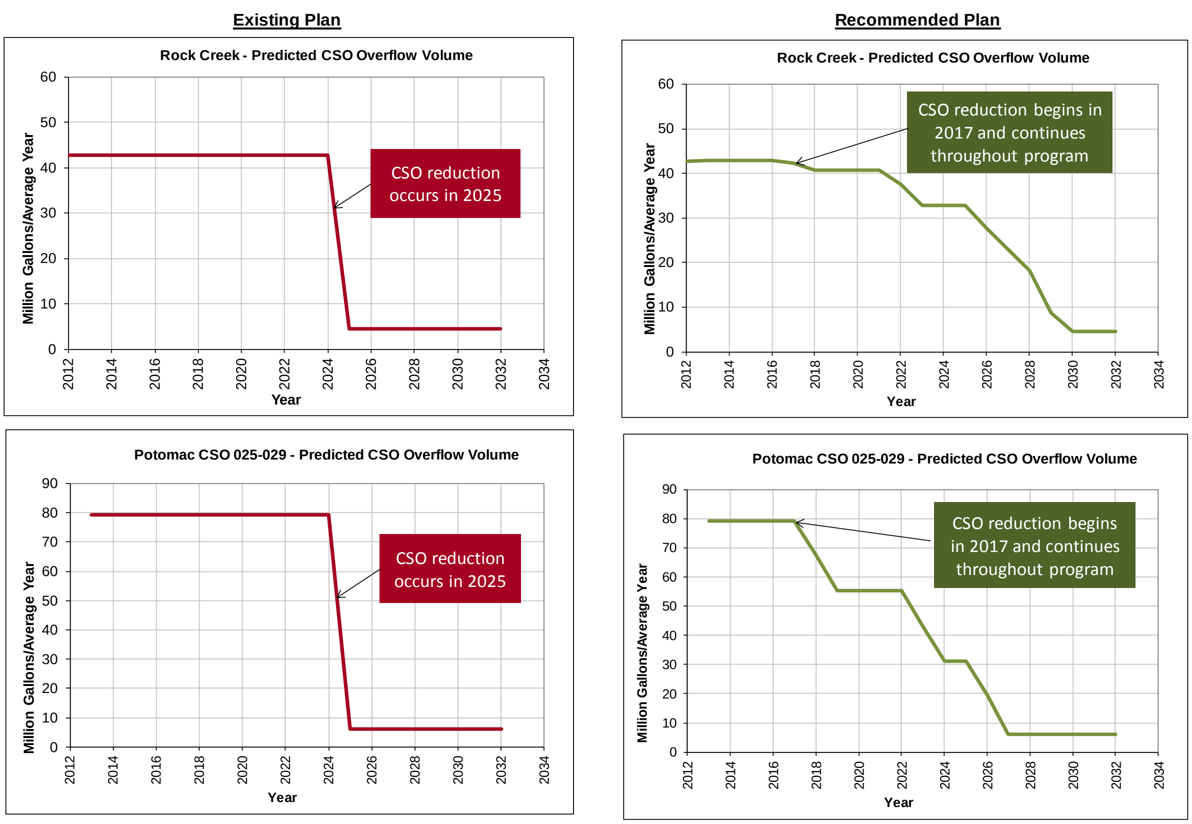
What are the Benefits of the Recommended Plan?

The hybrid GI plan offers many more benefits than the existing tunnel-only solution. These benefits include:

1. ***Timing of CSO Reduction***
   Under the existing plan, the District would need to wait until the tunnels are placed in service in 2025 before any additional CSO reduction is achieved. With the recommended plan, CSO reduction will begin to occur much earlier (in 2017).

   Although the controls for Potomac CSOs 020-024 will be placed in operation in 2030

CSO Reduction versus Time



instead of 2025, installation of these controls would likely have been delayed with the existing plan due to several factors including new federal requirements to perform an Environmental Impact Statement, and new planning and location challenges which did not exist when the original Consent Decree was signed. Establishing a new deadline will also mitigate the financial burden on rate payers for the $2.6 billion project.

2. ***Added Environmental, Social and Economic Benefits***

GI can offer environmental, social and economic benefits that gray infrastructure does not, including, but not limited to, increased property values, neighborhood beautification, reduced heat island effects, habitat creation, green jobs, and enhanced community gathering spaces.

Triple Bottom Line Benefits of Green Infrastructure

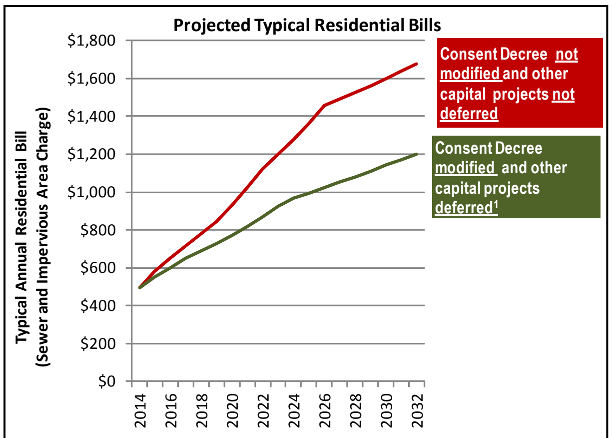
3. ***Reduced Financial Impact on Ratepayers by Spreading Out Construction***

DC Water updated its 2002 affordability analysis as part of evaluating GI plans for CSO control. The analysis showed that the costs associated with the schedule of the existing plan coupled with other necessary sewer and wastewater improvements are projected to be unaffordable for more than 40% of households by 2018. The analysis also showed that extension of both the Consent Decree schedule and optimization of capital spending for other sewer and wastewater projects is necessary to maintain affordable rates.

To complete the CSO control program as early as possible, DC Water evaluated engineering constraints and determined that extending the Potomac River Tunnel schedule by five years and the GI schedule by five years would result in the earliest affordable, practical, and technically achievable schedules for CSO control. With the Consent Decree extended, DC Water determined that more than $2.5 billion dollars of other sewer and wastewater projects must be considered in an optimization of capital spending between 2015 and 2032 to meet the affordability criteria established by the analysis. As shown in the figure below, extending the

Consent Decree schedule and optimizing implementation of other capital projects is projected to reduce typical residential sewer bills from about $1,675 per year to about $1,200 per year.

Given that median sewer age will be approaching nearly 100 years by 2032, optimization of capital spending for other projects inevitably presents risks to customer service, environmental protection, and management of infrastructure. DC Water balanced these risks with our obligations to complete the CSO control program as soon as is practicable when the recommended schedule for CSO control described in this report was developed.



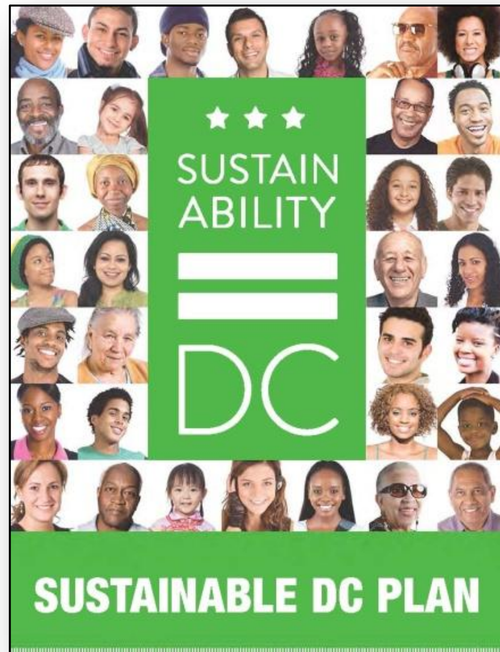
Notes:
1. With Consent Decree Modification and Capital Improvement Progam projects deferred to achieve residential sewer + Impervious Area Charge not more than 2% of household income for incomes at upper limit of second quintile, adjusted for cost of living in Washington DC or $33,926 in 2013. See Section 4 and Appendix E of the *Long Term Control Plan Modification for Green Infrastructure* for a detailed description of the analysis.

4. ***Opportunity for Local, Green Jobs***

GI will increase opportunities for local, green jobs both for construction and for long term maintenance of the facilities. DC Water's economic analysis suggests that GI has the potential to create about 190 more local jobs over three decades than the current plan. See Appendix D of the *Long Term Control Plan Modification for Green Infrastructure* for details.

5. ***Supports Sustainable DC Plan***

DC Water's GI program supports and advances the District's plan to make it the healthiest, greenest, most livable city in the nation over the next 20 years.



Sustainable DC Plan
(http://sustainable.dc.gov/)

Why is Time Needed to Implement the Hybrid GI Approach for the Potomac River and Rock Creek?

DC Water has determined that an extension of the schedule is required in order to implement the GI hybrid approach in the District's Potomac River and Rock Creek watersheds. Specifically, additional time is needed to implement GI for the following reasons:

- **Large-scale GI is new in the District.** Given the scale of such a project, time will be needed to select GI technologies suitable for urbanized areas, address planning issues, develop agreements, and perform outreach to ensure successful GI implementation.

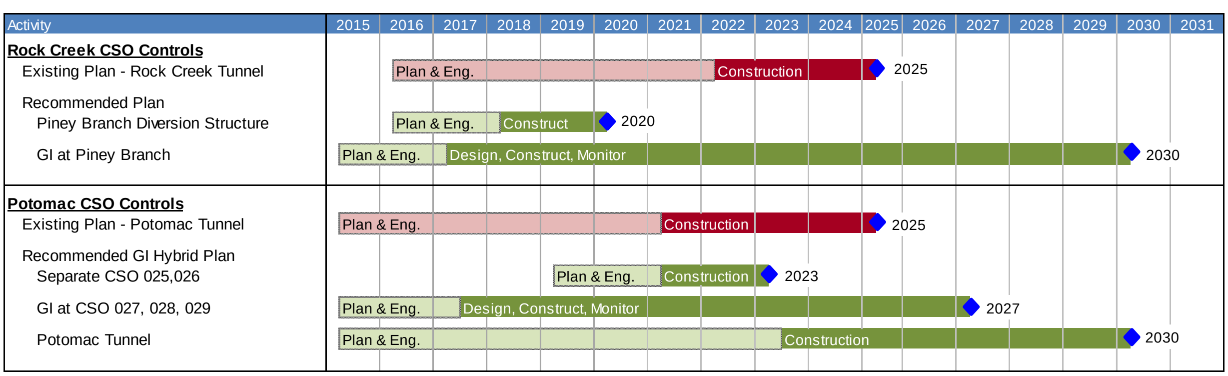
- **Adaptive Management.** DC Water will use an Adaptive Management Approach to implement GI. This means that projects will be constructed in a sequential fashion. In between construction phases, the projects will be monitored and assessed to evaluate their performance. Data collected and lessons learned during the monitoring will be used when planning and designing the next round of GI projects. This will ensure that the GI projects are practical and effective for CSO control and the betterment of the community.

Under both the existing and recommended plans, additional time will be needed to implement the Potomac Tunnel, due to the following:

- **New Federal Requirement to Prepare Environmental Impact Statement.** The development of the LTCP and the Consent Decree included a significant public process to select the CSO controls for each receiving water. Since the existing CSOs are located on National Park Service (NPS) property, and the Potomac Tunnel facilities may have a significant impact on their property, the NPS is requiring that an Environmental Impact Statement be prepared for the Potomac Tunnel. This was not envisioned when the schedule in the Consent Decree was entered in 2005. The NPS indicates that at least three years should be allowed for this process.

Green Roof at Eastside Pumping Station

- **Planning and Location Challenges.** The Potomac riverfront has changed significantly since the existing plan was finalized. The NPS has improved and completed facilities along the riverfront such as the Georgetown Waterfront Park, leaving few undeveloped or vacant sites other than valuable parkland in which to construct facilities. As a result, planning and obtaining approval for the Potomac facilities will take considerably longer than previously anticipated. DC Water's GI proposal will allow shortening the Potomac Tunnel, thereby minimizing impacts to riverfront resources such as the



Schedule Comparison – Existing and Recommended Plans

Georgetown Waterfront Park.

Together, the Environmental Impact Statement and planning and location challenges are expected to extend completion of the Potomac Tunnel beyond the 2025 deadline in the existing plan. DC Water's recommended schedule extension accounts for this anticipated extension.

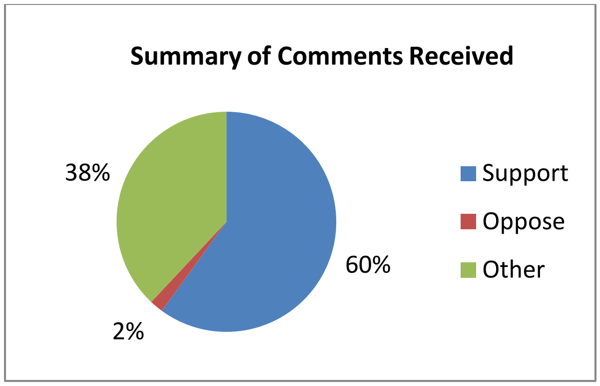
- **Utility Relocation.** Experience gained on the Anacostia River Tunnel System demonstrates that up-front time is needed to identify utilities and arrange for relocation prior to tunnel and shaft construction. This increases the time required to construct the Potomac Tunnel.

Public Comments and Responses

DC Water issued its Proposed Draft LTCP Modification to include GI in January 2014. The public comment period was open from January 12, 2014 through April 14, 2014. An extensive public outreach program was conducted to provide information about the Proposed Draft LTCP Modification and to solicit public comments. In response to the outreach, 366 commenters submitted 471 comments on the draft LTCP Modification for GI. The comments received have been bound in a separate report titled "*Public Comments, Long Term Control Plan Modification for Green Infrastructure*," DC Water, May 2015 and a detailed response to the comments is provided in Appendix K.

Bioretention at DDOE Headquarters, 1200 First Street NE

The figure shows the disposition of the comments, with the majority of comments supporting the Proposed Draft LTCP Modification.



DC Water has made significant revisions to the draft plan in response to the comments. The key comments received and revisions to the plan are summarized below:

Nature of Commitment

DC Water's Proposed Draft LTCP Modification included committing $60 million for GI in Rock Creek and $30 million for GI for the Potomac CSOs 027, 028 and 029. This magnitude of expenditures was based on the estimated costs of the GI. A limit on the financial commitment was proposed given the uncertainties in terms of the cost to construct GI and in order to manage these risks to ratepayers. There was also precedent for a financial commitment in other enforceable documents such as New York City's order with the State of New York to construct GI.

Some commenters indicated that a financial commitment would not ensure that the necessary amount of GI was constructed to provide the degree of CSO control required. These commenters suggested that the commitment to GI should be expressed in terms of acres of GI constructed, gallons stored, or a performance standard other than or in addition to a financial commitment.

In response to these comments, DC Water has removed the limit on its financial commitment to GI and expressed the commitment in terms of constructing sufficient GI and targeted sewer separation to manage the volume of runoff produced by 1.2" of rain falling on the number of impervious acres specified for the applicable sewershed. This is a commitment to manage a specified volume of runoff and will ensure that the necessary amount of GI is in place in order to provide the degree of CSO control required.

Feasibility/Effectiveness of GI

Some commenters indicated that GI may not be feasible to construct at a sufficient application rate to provide the degree of CSO control needed, or may not be as effective as anticipated.

Green Roof During Construction at DC Water's East Side Pumping Station

Given the lack of large scale implementation of GI in the District, DC Water has revised the LTCP Modification to provide for constructing the first GI project in the Potomac and Rock Creek sewersheds and then evaluating GI in terms of constructability, operability, efficacy, public acceptability and cost effectiveness. If, based on that evaluation, it is determined that it is impractical to complete all of the specified GI projects by the specified deadlines, then DC Water would be required to construct the gray controls as specified in the LTCP Modification. Should this occur, DC Water would be required to construct the gray controls within the same timeframe allowed for GI so there is no extension of the time allowed for implementation. If GI is determined to be practicable after the first project, then DC Water will continue to implement the remaining GI projects by the specified deadlines.

Schedule

Some commenters suggested that the seven year extension was too long and advocated for a shorter schedule. In addition, some commenters urged DC Water to accelerate individual components of the controls where feasible.

For GI, the schedule extension allows an adaptive management approach to be implemented to ensure that performance of the GI projects is optimized. Adaptive management means early GI projects will be monitored and assessed so that later projects are as practical and effective as possible. In response to comments, DC Water has evaluated the engineering, fiscal and practicality issues and has revised the modification to complete projects as early as practical. In addition, the separation at CSO 025 and 026 and Piney

Facility	Place in Operation Deadline: Proposed Draft LTCP Modification	Place in Operation Deadline: Recommended Final LTCP Modification	Change
Potomac River			
1. Separate CSO 025, 026	2032	2023	9 years earlier
2. Potomac GI	2028	2027	1 year earlier
3. Potomac Tunnel	2030	2030	No change
Rock Creek			
4. Piney Branch Diversion Str. Improvements	2032	2020	12 years earlier
5. Rock Creek GI	2032	2030	2 years earlier

Branch Diversion Structure improvements have been substantially accelerated. The schedule revisions are summarized in the table above.

For the Potomac Tunnel, extra time in the schedule is needed compared to the original LTCP plan due to a new requirement to complete environmental studies, in view of the increased development in recent years along the Potomac River waterfront, and to mitigate the tremendous financial impacts on ratepayers. It is therefore not feasible to shorten the schedule for the Potomac Tunnel earlier than 2030.

Disruption due to Tunnel in Georgetown, NPS Property and Mall area

Some commenters expressed concern about potential disruption caused by tunneling, particularly in the Georgetown and National Park areas.

The Proposed Draft LTCP Modification included a 21 million gallon, approximately 4,500 foot long Potomac Tunnel to capture CSOs 020-024, a new pumping station to empty the tunnel and the addition of 75 million gallon per day of capacity at the Tunnel Dewatering Pumping Station and Enhanced Clarification Facility at Blue Plains. As part of the response to comments, DC Water has evaluated an approximately 23,000 foot long gravity Potomac Tunnel that would run from the Potomac River CSOs to connect to the Blue Plains Tunnel at Joint Base Anacostia-Bolling (formerly Bolling Air Force Base). This would eliminate the need for a tunnel dewatering pumping station for the Potomac Tunnel. This is advantageous because of the complexity of the station, the difficulty in siting such a facility in the vicinity of the National Mall area, long term operational and power requirements and costs and the need for a permanent building associated with a large deep pumping station. The alternative gravity tunnel provides substantially less disruption both

Bioretention Facility

DC Water Bioretention Facility at Irving St NW

during and after construction.

The gravity Potomac Tunnel also allows interconnecting the storage volumes of the Potomac and Anacostia River Tunnel Systems into one tunnel system, allowing any CSO on either water body access to the entire storage volume of both tunnels. DC Water's analyses have demonstrated that a 30 million gallon gravity Potomac Tunnel for CSO 020-024 connected to the Blue Plains Tunnel provides a degree of CSO control equal to the LTCP without the need to expand the Blue Plains Tunnel Pumping Station and wet weather treatment system. The gravity tunnel offers greater reliability and avoids a new pumping station, making it the recommended plan.

Stewardship for Ratepayer Dollars

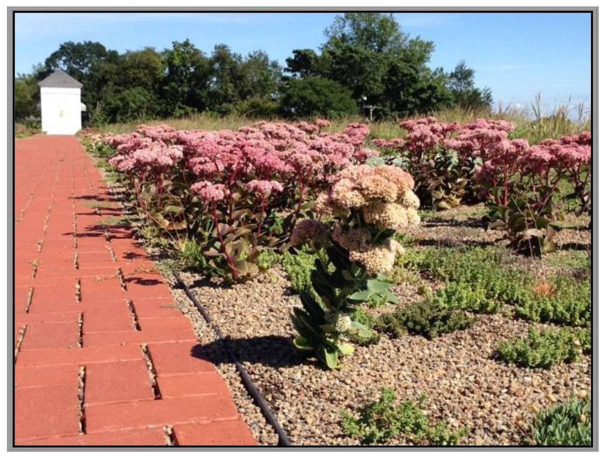
Some commenters expressed concern over affordability for ratepayers.

DC Water is acutely aware of the heavy financial burden born by District ratepayers to implement the DC Clean Rivers Project and has taken steps to both mitigate and spread out water rate increases over time. Unfortunately, this is not voluntary spending by DC Water but is mandated to comply with the Clean Water Act through a Federal Consent Decree signed by the Department of Justice, EPA, the District of Columbia and DC Water. The Final LTCP Modification will mitigate rates by extending the schedule for the Potomac Tunnel, thereby slowing the rate of increase in rates compared to what otherwise would be required.

Maintenance

Some commenters expressed the importance of maintenance in assuring the GI is effective over the long term.

DC Water will perform maintenance or will arrange for others to perform maintenance of all GI implemented to control CSOs. DC Water will be ultimately responsible to ensure that maintenance is performed adequately to maintain the CSO reduction functions of the GI. DC Water also anticipates that this will be a requirement included in its National Pollutant Discharge Elimination System (NPDES) Permit issued by EPA.



Green Roof at Ft. Reno Reservoir

Support for Green Jobs

Some commenters supported the long term economic benefits of GI, specifically the ability to make jobs more accessible to unemployed local residents. This is especially true considering labor required to construct the facilities, as well as that required for long term maintenance.

GI will increase opportunities for local, green jobs both for construction and for long term maintenance of the facilities. DC Water will work to promote green jobs with a living wage for District residents. Activities may include establishing a certification program for GI jobs, partnering with organizations to provide training that ultimately leads to certification, conducting outreach in the District and partnering with local organizations.

Where Can I Obtain More Information?

More information is available on DC Water's website at www.dcwater.com/green or by contacting DC Water's Office of External Affairs at (202) 787-2200.

1 Introduction

1.1 Purpose

The District of Columbia Water and Sewer Authority (DC Water) is implementing a Long Term Control Plan (LTCP or DC Clean Rivers Project, DCCR) to control combined sewer overflows (CSOs) to the District's waterways. The DCCR is comprised of a variety of projects including pumping station rehabilitations, targeted sewer separation, green infrastructure at DC Water facilities and a system of underground storage/conveyance tunnels to control CSOs. The DCCR is being implemented in accordance with a Consent Decree (LTCP Decree) signed by DC Water, the District and the U.S Government that specifies the schedule for implementation. The Consent Decree is provided in Appendix A. Projects on the Anacostia River are first in the schedule and DC Water is implementing those projects in accordance with the Decree.

The purpose of this document is to provide information to the public on a proposed modification to the LTCP to incorporate Green Infrastructure (GI) on a large scale. The tunnel projects for the Potomac River and Rock Creek are later in the schedule and facility planning for those projects is scheduled to start in 2015 and 2016, respectively. Because of this, there is time to revise the LTCP to allow construction of a hybrid green/gray CSO controls instead of the all gray controls currently planned.

Unlike single-purpose gray infrastructure which uses tanks, tunnels and pipes to store and convey CSO, GI uses vegetation and soil to manage stormwater where it falls. GI has the ability to reduce stormwater and CSOs, and provide multiple environmental, social and economic benefits. Examples of these benefits include improved air quality, reduction in heat island effects, improved property values and local job creation. In addition, GI consists of many small projects which can be brought on line as soon as individual projects are completed. In contrast, gray CSO projects can typically only be brought on line when all the elements are completed. Because of this, GI projects can provide earlier CSO reduction than all-gray projects.

Based on an assessment of the sewersheds, DC Water's recommended plan is to implement hybrid CSO controls for the Potomac and Rock Creek as follows:

- In Rock Creek, construct GI instead of the Piney Branch tunnel to control the Piney Branch CSO
- On the Potomac River, construct a hybrid green and gray control system for the Potomac River CSOs

This document provides the bases and rationale for the proposed change to the LTCP to allow implementation of hybrid green/gray controls.

1.2 Background

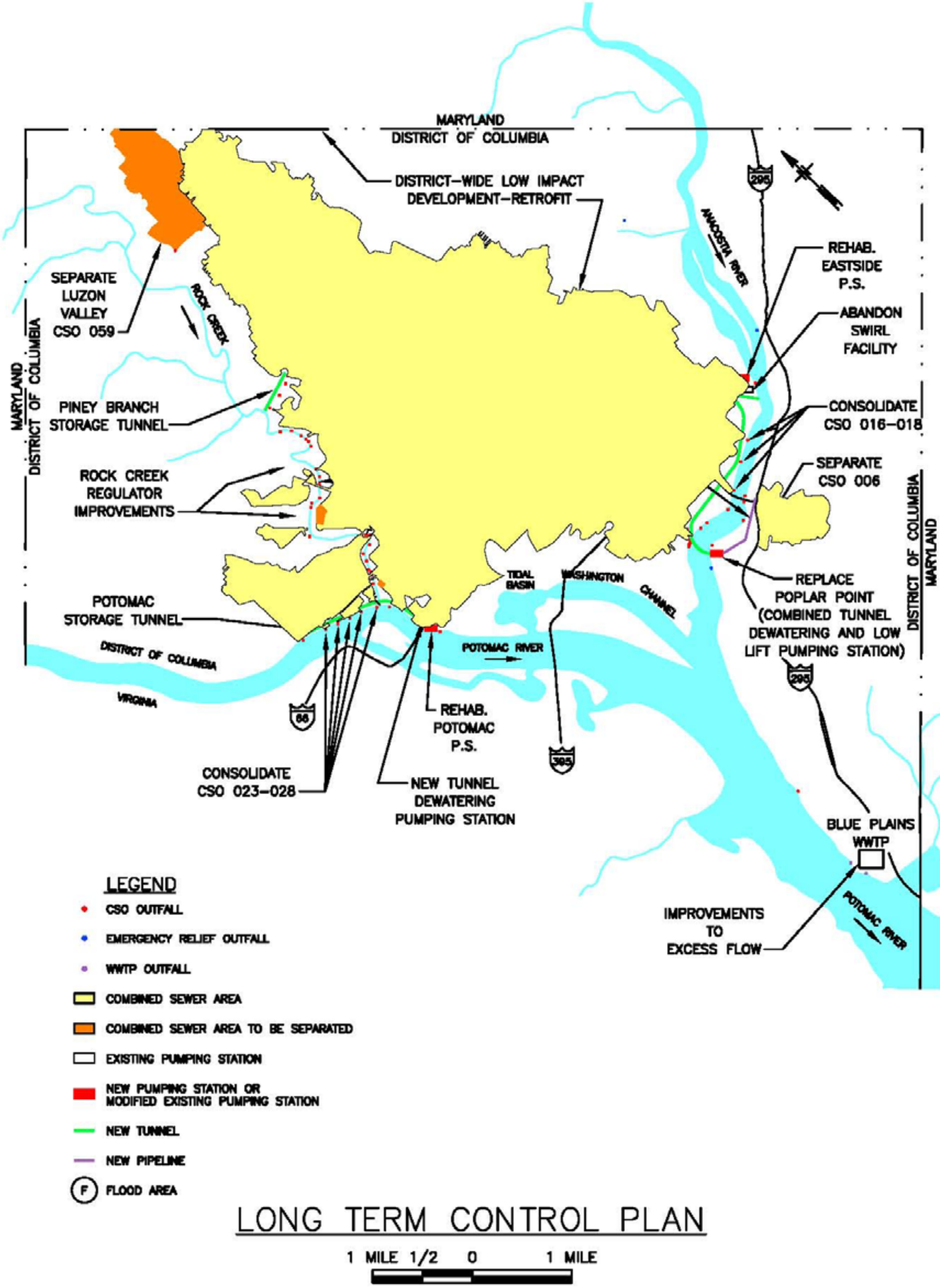
1.2.1 Long Term Control Plan

Like many older cities in the United States, the sewer system in the District is comprised of both combined sewers and separate sanitary sewers. A combined sewer carries both sewage and runoff from storms. Modern practice is to build separate sewers for sewage and stormwater, and no new combined sewers have been built in the District since the early 1900's. Approximately one-third of the District (12,478 acres) is served by combined sewers. The majority of the area served by combined sewers is in the older developed sections of the District.

In the combined sewer system, sewage from homes and businesses during dry weather conditions is conveyed to the District of Columbia's Advanced Wastewater Treatment Plant at Blue Plains (Blue Plains), which is located in the southwestern part of the District on the east bank of the Potomac River. There, the wastewater is treated to remove pollutants before being discharged to the Potomac River. When the capacity of a combined sewer is exceeded during storm events, the excess flow, which is a mixture of sewage and stormwater runoff, is discharged to the Anacostia and Potomac Rivers, in addition to Rock Creek and tributary waters, through outfalls. This excess discharge during storm events is called CSO. A total of 47 active CSO outfalls are listed in DC Water's NPDES Permit issued by the United States Environmental Protection Agency (EPA).

Communities with combined sewer systems are required to prepare long term plans for control of CSOs in accordance with the 1994 CSO Policy at Section 402 (q) of the Clean Water Act. In accordance with the CSO Policy and its NPDES permit requirements, DC Water submitted a Draft LTCP to EPA in 2001. After an extensive public participation program which generated over 2,300 comments on the Draft LTCP, DC Water submitted a Final LTCP to EPA in 2002. The Final LTCP is shown on Figure 1-1. The DC Department of the Environment (formerly Department of Health) and EPA approved the Final LTCP and determined that CSOs remaining after implementation of the plan would not cause or contribute to the exceedance of water quality standards, subject to post construction monitoring. Regulatory agencies also determined that the CSOs remaining after implementation of the plan would comply with total maximum daily loads (TMDLs) established for the receiving waters. An extended executive summary of the LTCP called Control Plan Highlights is provided in Appendix B.

Figure 1-1. Long Term Control Plan



1.2.2 Total Nitrogen Removal/ Wet Weather Plan

On April 5, 2007, EPA issued a modification to DC Water's NPDES permit. The permit modification included a total nitrogen effluent limit for Blue Plains of 4.689 million pounds per year. The total nitrogen limit was developed by EPA to achieve the goals of the Chesapeake Bay Program for nutrient reductions. In addition to meeting the new effluent limit for total nitrogen, DC Water had existing NPDES Permit requirements for treating wet weather flows at Blue Plains. The latter requirement is part of DC Water's LTCP for the combined sewer system.

When the LTCP was finalized in 2002, there was no effluent limit for total nitrogen in DC Water's NPDES permit for Blue Plains and the LTCP. The imposition of the new total nitrogen limit could require a modification to the LTCP and its implementation schedule. DC Water conducted evaluations to assess the impact of adding the new total nitrogen effluent limit on top of the LTCP and existing NPDES permit requirements for treating wet weather flows. On October 12, 2007, DC Water submitted its Final Total Nitrogen Removal/Wet Weather Plan (TN/WW Plan) to EPA. The TN/WW Plan is provided as a companion document to the Consent Decree Modification.

Under the LTCP and the NPDES permit existing at the time, Blue Plains was rated for an annual average flow of 370 mgd. During wet weather events, flows up to 740 mgd receive complete treatment for up to 4 hours. After the first 4 hours, the complete treatment capacity is reduced to 511 mgd to protect the biological process. Additional flows of up to 336 mgd that exceed the complete treatment capacity of the plant receive excess flow treatment, which consists of screening, grit removal, primary treatment and disinfection before being discharged to the Potomac River. This provides a total treatment capacity of 1076 mgd for the first four hours and 847 mgd thereafter.

The TN/WW Plan modified the plant treatment capacities and the handling of flows during wet weather. The major components of the TN/WW Plan are as follows:

- Complete treatment capacity – Blue Plains will provide complete treatment up to 555 mgd for the first four hours and 511 mgd thereafter. In accordance with the existing NPDES permit, combined sewer system flow (CSSF) conditions (i.e., wet weather events) exist and start when plant influent flow is greater than 511 mgd. CSSF conditions stop four hours after plant influent flow drops below 511 mgd or 4 hours has elapsed since the start of CSSF conditions, whichever occurs last.

- Enhanced nitrogen removal (ENR) – ENR facilities will be constructed with capacity to provide complete treatment for the flow rates identified above and to meet the new total nitrogen effluent limit.

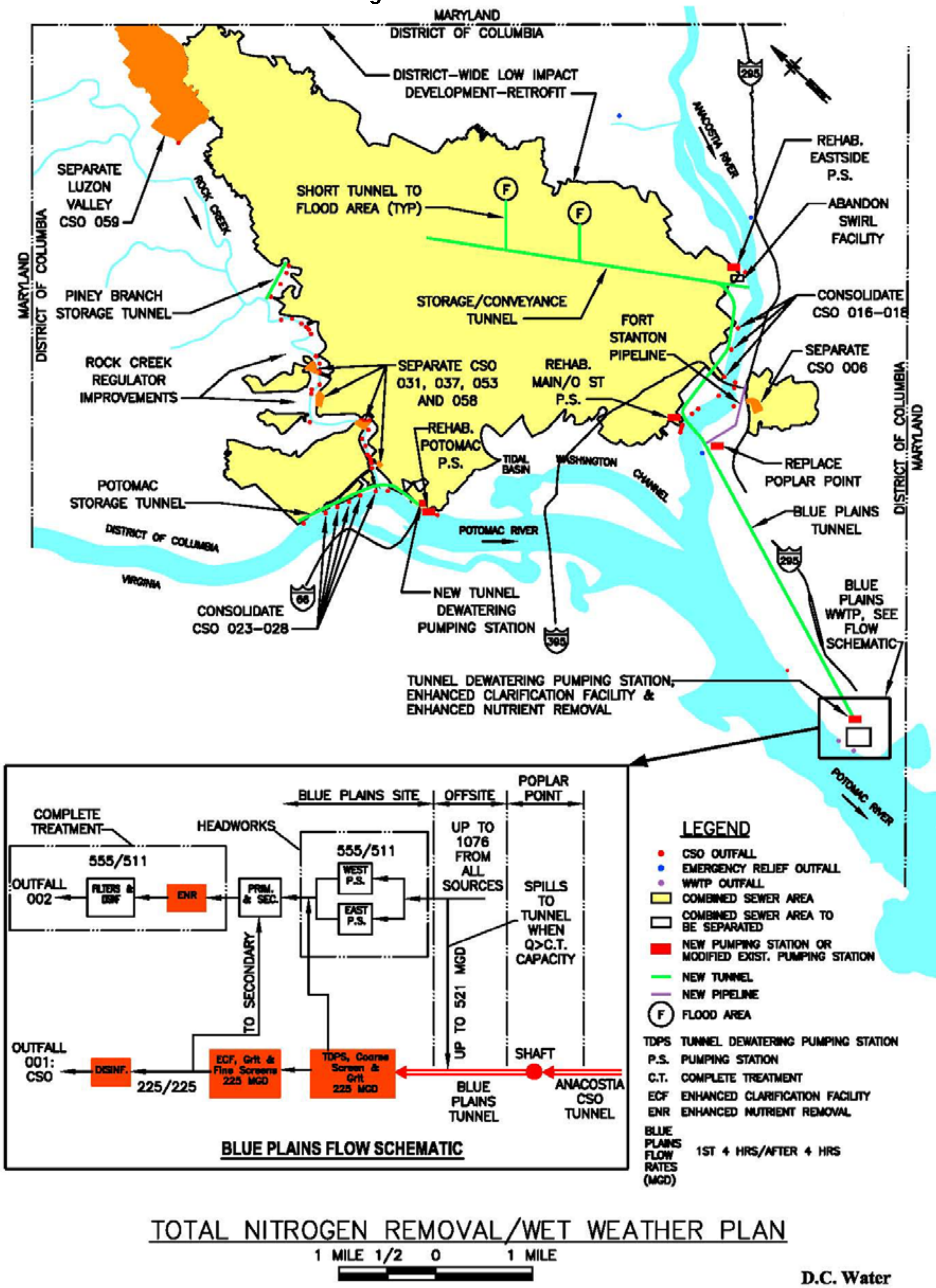
- Enhanced Clarification Facility (ECF) – A 225 mgd ECF facility will be constructed at Blue Plains.

- Tunnel to Blue Plains and System Storage Volume – A new tunnel is being constructed from Poplar Point to Blue Plains. The total tunnels system storage volume will be increased from 126 mg to 157 mg. This new tunnel segment will not only serve as a flow equalization facility but will also allow a reduction in the required capacity of the ECF and the peak flow rates that receive complete treatment at the Plant.

- Outfall Sewer Overflow to Blue Plains Tunnel – Connections between the existing Outfall sewers on the influent side of Blue Plains and the tunnel to Blue Plains will be constructed. These facilities will allow flow from the collection system that exceeds the complete treatment capacity of the plant to overflow into the tunnel.

- Tunnel Dewatering Pumping Station – Under the Final LTCP, a tunnel dewatering pumping station was proposed to be constructed at the tunnel terminus at Poplar Point. As part of the TN/WW plan, the same tunnel dewatering pumping station is relocated to the new terminus of the tunnel at Blue Plains. The pumping station will be sized to have a minimum firm capacity of 225 mgd, equal to the capacity of the ECF. In addition, the facility will have the ability to dewater the tunnel system up to the new ECF and be able to discharge ECF effluent to complete treatment and discharge at Outfall 002 or at Outfall 001. Figure 1-2 shows the TN/WW plan.

Figure 1-2. TN/WW Plan



D.C. Water

1.3 Consent Decrees

DC Water has entered into two consent decrees (CD) related to its CSO program. Each of these decrees is described below:

Three-Party Consent Decree - Civil Action No. 1:00CV00183TFH and No. 02-2511 (TFH)
DC Water and the District of Columbia entered into this CD with the United States Government and certain citizen plaintiffs to resolve allegations regarding the combined sewer system (CSS). The CD was lodged with and entered by the court on June 25, 2003 and October 10, 2003, respectively. The CD provides a schedule for implementation of various operation and maintenance-type items associated with DC Water's Nine Minimum Controls Program. In addition, the CD provides a schedule for replacement of the inflatable dams in the CSS and for rehabilitation of DC Water's pumping stations.

Long Term Control Plan Consent Decree - Civil Action No. 1:CV00183TFH
DC Water and the District of Columbia entered into this CD with the United States Government. The CD was entered by the court on March 23, 2005, and provides a schedule for implementation of the LTCP.

DC Water is proposing to modify the LTCP as described in subsequent sections.

1.4 Partnership Agreement

On December 10, 2012, the EPA, District of Columbia and DC Water signed a Partnership Agreement (PA) to advance Green Infrastructure for urban wet weather pollution control. The PA is included in Appendix C. The PA established a framework and working relationship between the parties to support sustainable stormwater management that can yield multiple benefits for community livability. The PA also demonstrates each party's commitment to GI. The following is a summary of the commitments in the PA:

All Parties (EPA, District, DC Water)

- Implement a Green Design Challenge to engage private sector in demonstrating and advancing GI
- Enlist participation by public and private organizations in a collaborative effort to develop next generation GI designs
- Facilitate participation by local academic institutions in various aspects of the GI Demonstration Project
- Actively involve the environmental community in the GI initiative to facilitate implementation based on an agreed upon course of action
- Review and assess the water quality benefits and impacts of alternative green and gray/green controls compared to the benefits and impacts of the controls now required in the Potomac and Rock Creek watersheds.

<u>DC Water and District</u>

- Consult with each other on a continuing basis to ensure that the GI Demonstration Project, water quality review and assessment, and alternatives analysis conform to EPA's expectations and Clean Water Act requirements.

<u>DC Water</u>

- Once regulatory framework is in place, conduct GI demonstration project
- Prepare EIS required for the Potomac Storage Tunnel

<u>EPA</u>

- Communicate with EPA's Office of Research and Development (ORD) on the progress of the GI Demonstration Project and opportunities for ORD's involvement.
- Assist DC Water in sharing the results of its GI Demonstration Project work so that other communities nation-wide can benefit from DC Water's experiences

The PA also lays out a procedure for modifying the Consent Decree which consists of the following steps:

- DC Water submits draft proposed CD Modification package to EPA
- DC Water public notices proposed CD Modification package within 60 days of receiving EPA comments
- Public Notice the CD Modification package for 60 days
- DC Water responds to comments and submits revised proposed CD Modification Package to EPA in 21 days
- EPA/DOJ determines whether or not to support the proposed CD Modification and makes the corresponding recommendation to the court
- Federal Judge decides whether to accept recommendation from EPA/DOJ
- Consent Decree is modified

Note that in lieu of constructing a demonstration project for GI, DC Water is now proposing to construct hybrid green/gray CSO controls.

1.5 CSO Controls in LTCP Consent Decree

The LTCP Consent Decree specifies the schedule for implementation of the DCCR. The major requirements of the decree are described in the following subsections.

1.5.1 Anacostia River Projects

The Anacostia River Projects components included in the LTCP Consent Decree are summarized in Table 1-1.

Table 1-1. Anacostia River Projects in LTCP Decree

Component	Description
Anacostia River	
Storage Tunnel from Poplar Point to Northeast Boundary Outfall	49 million gallon storage tunnel between Poplar Point and Northeast Boundary. Tunnel will intercept CSOs 009 through 019 on the west side of the Anacostia. Project includes new tunnel dewatering pumping station and low lift pumping station at Poplar Point.
Storage/Conveyance Tunnel Parallel to Northeast Boundary Sewer	77 million gallon storage/conveyance tunnel parallel to the Northeast Boundary Sewer. Also includes side tunnels from main tunnel along West Virginia and Mt. Olivet Avenues NE and Rhode Island and 4th St NE to relieve flooding. Abandon Northeast Boundary Swirl Facility upon completion of main tunnel.
Outfall Consolidation	Consolidate the following CSOs in the Anacostia Marina area: CSO 016, 017 and 018
Separate CSO 006	Separate this CSO in the Fort Stanton Drainage Area
Ft Stanton Interceptor	Pipeline from Fort Stanton to Poplar Point to convey CSO 005, 006 and 007 on the east side of the Anacostia to the storage tunnel.

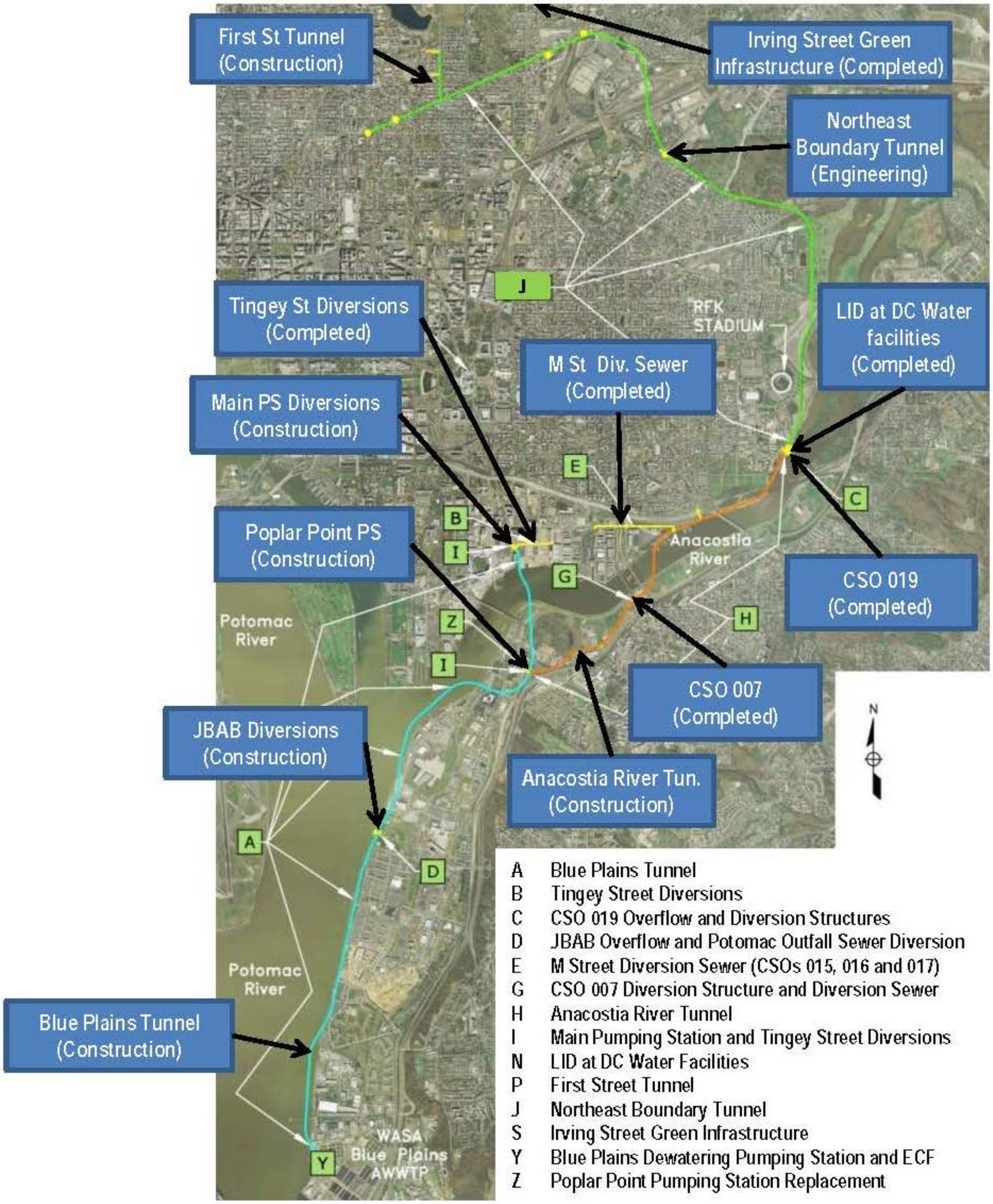
As a result of the TN/WW Plan, DC Water has added 31 mg of storage to the Anacostia Tunnel system for a total of 157 mg of storage. This was accomplished by extending the tunnel from Poplar Point to Blue Plains and constructing the tunnel dewatering pumping station at Blue Plains in lieu of Poplar Point. These and other changes to the LTCP are not reflected in the LTCP Decree. DC Water is proposing to modify the LTCP to conform it to the TN/WW Plan.

Based on the current level of planning, the Anacostia River Projects have been divided into various contract divisions to facilitate implementation. There is one contract division proposed for each of the three major tunnel segments and their associated shafts. The other contract divisions are comprised of near-surface diversion structures, associated diversions, junction sewers and the tunnel overflow structures. The planned contract divisions are listed in Table 1-2. Figure 1-3 shows the contract divisions and the current status of implementation.

Table 1-2. Planned Contract Divisions for Anacostia River Projects

Contract Division	Description
A	Blue Plains Tunnel
B	Tingey Street Diversion Sewer for CSOs 013 and 014
C	CSO 019 Overflow and Diversion Structures
D	Joint Base Anacostia-Bolling Overflow and Diversion Structures
E	M Street Diversion Sewer (CSOs 015, 016, and 017)
G	CSO 007 Diversion Sewer
H	Anacostia River Tunnel
I	Main Pumping Station Diversions
N	Low Impact Development at DC Water Facilities
J	Northeast Boundary Tunnel
P	First Street Tunnel
S	Irving Street Green Infrastructure
Y	Blue Plains Tunnel Dewatering Pumping Station and Enhanced Clarification Facility
Z	Poplar Point Pumping Station Replacement

Figure 1-3. Anacostia River Projects Status (as of May 2015)



1.5.2 Potomac River Projects

The control measures selected for the Potomac River are predicted to limit overflows to four events per average year. The principal control measures include rehabilitation of the Potomac Pumping Station and construction of a storage tunnel from west of the Key Bridge, along the Potomac River waterfront parallel to Georgetown, and terminating at Potomac Pumping Station. The tunnel will intercept the Georgetown CSOs and the large CSOs downstream of Rock Creek. A new pumping station would be constructed to dewater the tunnel. In addition, the LTCP will consolidate and close all CSOs between the Key Bridge and Rock Creek to remove the impact of these CSOs from the Georgetown waterfront area.

The major elements of the Final LTCP for the Potomac River Projects are summarized in Table 1-3 and are shown on Figure 1-4.

Table 1-3. Potomac River Projects

Component	Description	Status (as of May 2015)
Potomac River		
Replace Inflatable Dams (1)	Replace inflatable dams at Potomac River CSOs where these are installed	Completed
Rehabilitate Potomac Pumping Station (1)	Rehabilitate station to firm 460 mgd pumping capacity	Completed
Outfall Consolidation (2)	Consolidate CSOs 023 through 028 in the Georgetown Waterfront Area.	Future work
Potomac Storage Tunnel (2)	58 million gallon storage tunnel from Georgetown to Potomac Pumping Station. Includes tunnel dewatering pumping station	Future work

Notes:
(1). Required by Three Party Consent Decree
(2). Required by LTCP Consent Decree

Figure 1-4. Potomac River Projects

1.5.3 Rock Creek Projects

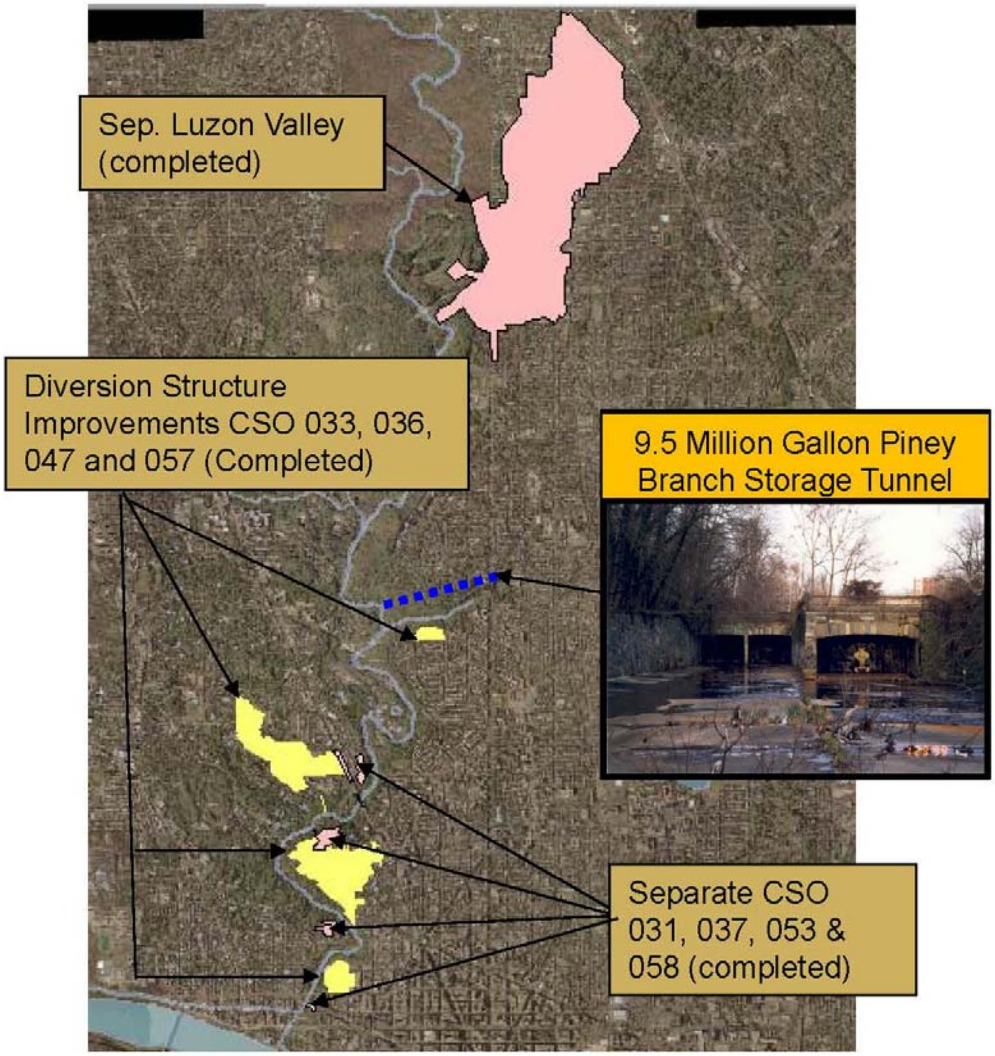
The control measures in the LTCP for Rock Creek are predicted to limit Piney Branch overflows to one per average year. The remaining overflows in Rock Creek will be controlled to 4 events per average year. The principal control measures include separation of four CSOs, construction of a storage tunnel at Piney Branch, and monitoring and regulator improvements to four CSOs south of Piney Branch.

The major elements of the Final LTCP for Rock Creek are summarized in Table 1-4 and are shown on Figure 1-5.

Table 1-4. Rock Creek Projects

Component	Description	Status (as of May 2015)
Rock Creek		
Separate Luzon Valley	Separate CSO 059	Completed
Separation	Separate CSOs 031, 037, 053, and 058.	Completed
Monitoring at CSO 033, 036, 047 and 057	Conduct monitoring to confirm prediction of overflows. If overflows confirmed, then perform the following: • Regulator Improvements: Improve regulators for CSO 033, 036, 047 and 057. • Connection to Potomac Storage Tunnel: Relieve Rock Creek Main Interceptor to proposed Potomac Storage Tunnel when it is constructed	Completed
Storage Tunnel for Piney Branch (CSO 049)	9.5 million gallon storage tunnel	Future work

Figure 1-5. Rock Creek Projects



1.5.4 System-Wide Improvements

The LTCP also includes the following system-wide improvements:

- Low Impact Development Retrofit (LID-R) at DC Water Facilities – the Decree requires DC Water to construct $3 M of LID at DC Water facilities and to evaluate the effectiveness of these measures. The projects are complete.

- Excess Flow Treatment Improvements at Blue Plains – the Decree requires the addition of four new primary clarifiers and improvement to the excess flow treatment control and operations. Because of the TN/WW plan, these improvements have been deleted and are scheduled to be replaced by a new 225 mgd enhanced clarification facility (ECF).

1.5.5 Consent Decree Schedule

There are numerous deadlines and interim milestones in the LTCP Decree. Major deadlines are summarized in Table 1-5.

Table 1-5. Key Deadlines in LTCP Consent Decree

Item	Deadline Type	Deadline
Anacostia River Projects		
CSO 006 Separation	Place in Operation	Completed -2010
Tunnel from Blue Plains to RFK Stadium	Place in Operation	March 23, 2018
Complete System	Place in Operation	March 23, 2025
Potomac River Projects		
Potomac Tunnel	Start Facility Plan Award Design Contract Award Construction Contract Place in Operation	Completed - 2015 March 23, 2018 March 23, 2021 March 23, 2025
Rock Creek Projects		
Separate CSO 059 Luzon Valley		Completed - 2002
Separate CSO 031, 037, 053, 058		Completed - 2011
Rock Creek Regulator Improvements		Completed - 2013
Piney Branch Tunnel	Start Facility Plan Award Design Contract Award Construction Contract Place in Operation	March 23, 2016 March 23, 2019 March 23, 2022 March 23, 2025
System-Wide		
LID-R at DC Water Facilities	Place in Operation	Completed - 2014

1.6 Predicted CSO Reduction

The DC Department of the Environment (formerly Department of Health) and EPA approved the Final LTCP and determined that CSOs remaining after implementation of the plan would not cause or contribute to the exceedance of water quality standards, subject to post construction monitoring. Regulatory agencies also determined that the CSOs remaining after implementation of the plan would comply with total maximum daily loads (TMDLs) established for the receiving waters. Table 1-6 shows the CSOs predicted as a result of implementation of the DCCR.

Table 1-6. Key Deadlines in LTCP Consent Decree

Item	Anacostia River	Potomac River	Rock Creek	Total
CSO Overflow Volume (mg/avg. yr.)				
1996 – DC Water formed	2,142	1,063	49	3,254
2015 – After inflatable Dams and Pumping Station rehabilitations	1,258	654	48	1,960
2025 – LTCP in Place	54	79	5	138
% Reduction	98%	93%	90%	96%
Number of Overflows (#/avg. yr.)				
1996 – DC Water formed	82	74	30	
2015 – After inflatable Dams and Pumping Station rehabilitations	75	74	30	
2025 – LTCP in Place	2	4	1 / 4 (1)	

Notes:

(1) One overflow per average year at Piney Branch, four overflows per average year at other Rock Creek CSOs

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2 Bases for Modification

2.1 New Technology and Recognition by Regulatory Agencies

The LTCP was developed from 1998-2002. At that time, GI was not a well developed and recognized technology for providing CSO control. In addition, there was no formal recognition of the technology by regulatory agencies as a viable method for providing CSO control. Because of this and other factors, GI in the LTCP was limited to a $3 M demonstration project at DC Water facilities.

Since development of the LTCP, GI has been recognized as a potentially viable technology for controlling CSOs. Further, EPA strongly encourages the use of GI approaches to manage wet weather flows. Since 2007, EPA's Office of Water has released the following policy memos and documents supporting the integration of green infrastructure into NPDES permits and CSO programs:

- Memorandum, Achieving Water Quality Through Integrated Municipal Stormwater and Wastewater Plans
  In October 2011, EPA's Office of Water (OW) and Office of Enforcement and Compliance Assurance (OECA) issued a joint memo encouraging EPA Regions to assist their state and local partners in pursuing an integrated planning approach to Clean Water Act waste and stormwater obligations. The memo identifies green infrastructure as one example of a comprehensive solution that can improve water quality while supporting other quality of life attributes that enhance the vitality of communities.

EPA Factsheet 2: CSOs

- Memorandum, Protecting Water Quality with Green Infrastructure in Water Permitting and Enforcement Programs
  In April 2011, EPA OW and OECA jointly issued a memo supporting the use of green infrastructure. The memo reaffirms the commitment of both offices to work with interested communities on incorporating green infrastructure into stormwater permits and into remedies for non-compliance with the Clean Water Act.

- Memorandum, Use of Green Infrastructure in NPDES Permits and Enforcement
  In August, 2007, EPA issued a memo encouraging the incorporation of green infrastructure into National Pollutant Discharge Elimination System (NPDES) stormwater permits and CSO

long term control plans. Additionally, the memo states that green infrastructure can and will be used in future EPA enforcement activities.

- Memorandum, Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs
  In March, 2007, Benjamin Grumbles, EPA's Assistant Administrator for Water, issued this memo to promote green infrastructure as a viable stormwater management solution.

- EPA Permitting and Enforcement Series
  In 2012, EPA issued a Permitting and Enforcement series guide to integrating green infrastructure into NPDES wet weather programs. The series consists of six factsheets and four supplements as follows:

  - Factsheet 1: General Accountability Considerations for Green Infrastructure
  - Factsheet 2: Combined Sewer Overflows
  - Factsheet 3: Sanitary Sewer Overflows
  - Factsheet 4: Stormwater
  - Factsheet 5: Total Maximum Daily Loads
  - Factsheet 6: Water Quality Standards
  - Supplement 1: Consent Decrees that Include Green Infrastructure Provisions
  - Supplement 2: Consent Decree Language Addressing Green for Grey Substitution
  - Supplement 3: Green Infrastructure Models and Calculators
  - Supplement 4: Green Infrastructure in Total Maximum Daily Loads

2.2 Added Benefits

Unlike single-purpose gray stormwater infrastructure, which uses tanks, tunnels and pipes to store and convey stormwater, GI uses vegetation and soil to manage stormwater where it falls. GI has the potential to not only reduce stormwater and combined sewer overflows (CSOs), but to provide multiple environmental, social and economic benefits. Known as Triple Bottom Line, the added benefits fall into three categories:

Environmental

- Water Quality and Quantity - By retaining rainfall from small storms, green infrastructure reduces stormwater discharge volumes. Lower discharge volumes translate into reduced combined sewer overflows. Green infrastructure can also mitigate flood risk by slowing and reducing stormwater discharges.

- Air Quality – Increased vegetation can remove pollutants, such as particulate matter and carbon monoxide, thereby improving air quality.

- Urban Heat Island Reduction - The urban heat island (UHI) effect occurs when urban areas replace natural land cover with dense concentrations of pavement, buildings, and other surfaces that absorb and retain heat. Trees, green roofs, and other green infrastructure features can cool urban areas by shading building surfaces, deflecting radiation from the sun, and releasing moisture into the atmosphere.

US Tax Court Green Roof

- Energy Conservation: GI can reduce local temperatures and shade building surfaces, lessening the cooling demand for buildings, thereby reducing energy needs and decreasing emissions from power plants.

- Carbon Sequestration - Since GI includes plants which use carbon dioxide as part of photosynthesis, GI has the potential to reduce carbon load to the atmosphere and assist with mitigation of greenhouse gases.

- Habitat Improvement - GI can provide habitat for birds, mammals, amphibians, reptiles, and insects. Even small patches of vegetation such as green roofs provide habitat for a variety of insects and birds.

<u>Social</u>

- Health Effects - Increased tree canopy has the potential to reduce ozone and particulate pollution levels enough to benefit mortality, hospital admissions, and work loss days due to illness.

- Enhanced Aesthetics - The aesthetic benefits provided by GI have the potential to increase the quality of life in the District by increasing local jobs, decreasing crime and enhancing the enjoyment of the citizenry

- Reduced Disruption during Construction – Since GI involves primarily construction on a small scale, it can reduce large construction impacts (traffic, noise, dust, closures and relocations) associated with heavy civil construction projects.

<u>Economic</u>

- Poverty reduction/job creation - Specialized labor is required for construction of conventional gray infrastructure (e.g., tunneling). Such skilled laborers might typically be already employed in the construction field. GI creates the opportunity to hire local unskilled – and otherwise unemployed – laborers for landscaping and restoration activities. GI thus can provide an economic boost to the local community and can decrease the costs of social services that would otherwise be required. The economic benefits of GI in the District are described in a report in Appendix D.

- Enhanced Property Values – Improved aesthetics, decreased crime and increased live-ability can improve property values in the areas where GI is installed.

- Enhanced recreation and improved quality of life - The aesthetic benefits provided by GI have the potential to increase the quality of life in the District by increasing local jobs, property values and recreational space. A recent economic study found that when compared to grey infrastructure, a GI program in the District will provide nearly twice as many local jobs.

2.3 DC Water's GI Investigations

DC Water has invested significant resources and funds ($3.5 M) over the past three years to research and analyze GI for CSO control. This work was documented in technical memoranda which are included in the appendices as follows:

- Appendix E: Economic Impact of Alternative CSO Control Strategies
- Appendix F: Technical Memorandum No. 2 - Approach to Hydrologic and Hydraulic Modeling
- Appendix G: Technical Memorandum No. 4 - The District of Columbia's Experience with Green Infrastructure
- Appendix H: Technical Memorandum No. 5 - Green Infrastructure Experience – Foreign and Domestic Case Studies
- Appendix I: Technical Memorandum No. 6 - Green Infrastructure Technologies
- Appendix J: Technical Memorandum No. 7 - Green Infrastructure Screening for the Potomac River and Rock Creek

Technical Memorandum No. 7 (Screening Analysis) assessed the feasibility of implementing GI by itself or in combination with gray infrastructure. The results showed that there are viable green and green/gray hybrid solutions to CSO control. Based in part on this analysis, DC Water has proposed the hybrid green/gray CSO controls summarized in Section 3.

3 Control Plan for Rock Creek and Potomac River

DC Water is recommending a modification of its LTCP to change the CSO control plan for the largest CSO in Rock Creek (Piney Branch, CSO 049) and the Potomac River CSOs. The control plan includes green and green/gray controls. Each control technology will be used where it is the most appropriate. The hybrid green/gray controls are predicted to provide a degree of CSO control equivalent to the gray controls in the LTCP. The hybrid approach will have a higher socio economic benefit to the District, especially in the communities served by GI. Figure 3-1 at the end of this section compares the recommended controls to those in the existing LTCP.

3.1 Green Controls for Rock Creek's Piney Branch Sewershed

3.1.1 Scope

30% GI Implementation in Rock Creek's Piney Branch Sewershed
Total Sewershed area = 2,329 acres
Impervious area = 1,215 acres
30% of impervious acres = 365 acres
Manage volume of runoff produced by 1.2" of rain falling on 365 impervious acres

GI will be constructed in the Piney Branch drainage area in Rock Creek sized to manage the volume of runoff produced by 1.2" of rain falling on 365 impervious acres (30% of the impervious acres) in the sewershed. GI projects may include bioretention practices (bioretention cells, bioswales, vegetated filter strips, and tree box filters), rooftop collection practices (green roofs, blue roofs, downspout disconnection, rain barrels, and cisterns) and permeable pavement. These facilities will be constructed in both public and privately-owned spaces. In addition to GI, targeted sewer separation may be utilized to offload storm water from the combined sewer system.

In addition to GI, the weir height of the existing diversion structure (Structure 70) serving CSO 049 will be raised to increase the capture of combined sewage. The resulting captured sewage will be diverted to the existing East Rock Creek Diversion Sewer for conveyance to Blue Plains for treatment. This control structure modification is not predicted to increase overflow frequency or volume at other downstream CSOs in the Rock Creek sewershed.

3.1.2 Schedule

GI has not been used at a large scale in dense urban areas to provide a high degree of CSO control. Therefore, there is a need to develop basic information regarding permitting, location of facilities, public outreach and involvement, development of design details and maintenance. DC Water will use an adaptive management approach to implement GI. This means that projects will be constructed in a sequential fashion. Lessons learned on early projects will be used to adjust and improve later projects to make GI successful.

DC Water does not own significant property in the District. Construction of GI therefore requires permits and concurrence from the property owner, which is the District or Federal Government in the majority of cases. Siting of GI in public space will require developing and adopting new policies regarding how to organize public space. Examples include establishing standards regarding how bioretention, parking, cross walks and pedestrian access will coexist in the public right of way. In addition, maintenance standards and responsibilities will need to be established and addressed. Further, codes and regulations will need to be reviewed and possibly revised to encourage and allow GI construction in public space. These institutional and planning issues will need to be addressed in order to have successful implementation of GI.

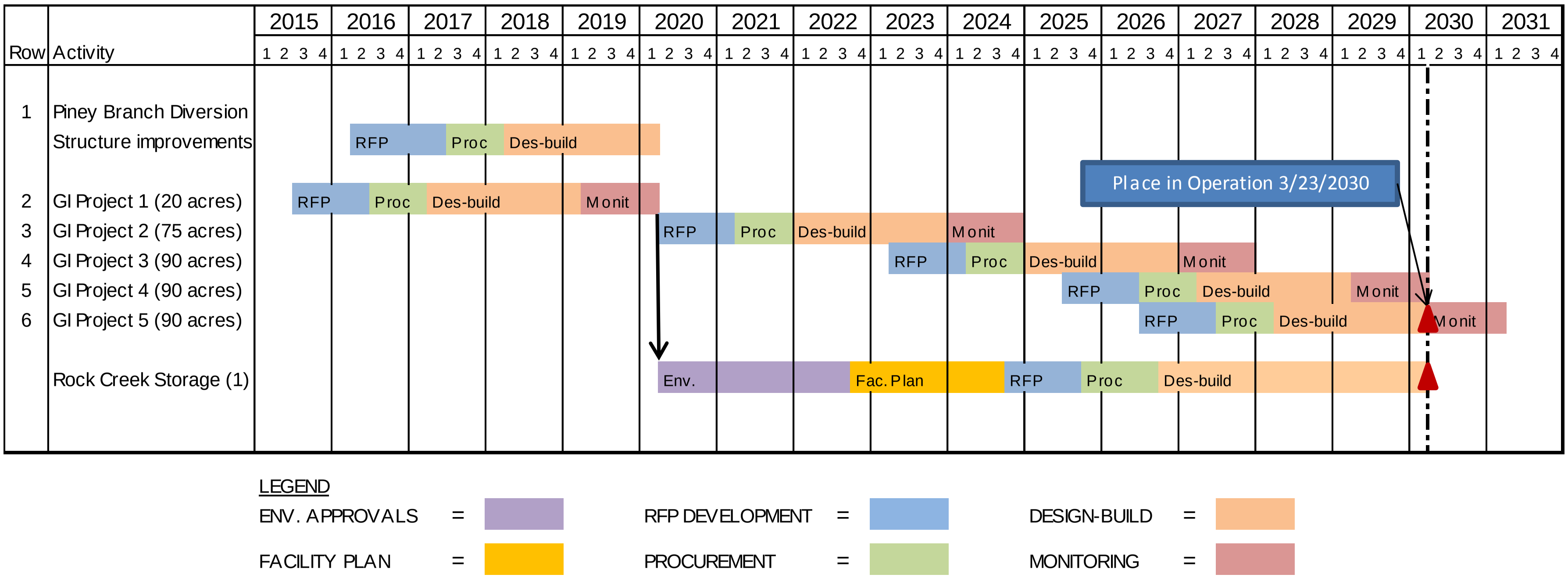
Because of the items identified above, a schedule extension is required in order to implement GI for CSO control. The current consent decree requires completion of the controls for Rock Creek by March 23, 2025. Based on an adaptive management approach and a review of feasible planning, design and construction schedules, DC Water has determined that an extension of the schedule to March 23, 2030 (5 years) is required in order to implement GI. The Piney Branch diversion structure improvements can be implemented early in the schedule.

Given that there is some uncertainty associated with the ability to implement GI in the District at a large scale, DC Water proposes to construct the first GI project in Rock Creek and then evaluate GI in terms of constructability, operability, efficacy, public acceptability and cost effectiveness. If, based on that evaluation, GI is determined to be impracticable, then DC Water will construct the 9.5 million gallons of storage (gray infrastructure) for the Piney Branch CSO. If GI is determined to be practicable after the first project, then DC Water will continue to implement the remaining GI projects.

Figure 3-2 shows the schedule and the basis for the schedule is summarized below:

- Environmental Approvals: This involves prepare National Environmental Policy Act (NEPA) and District Environmental Policy Act documentation necessary to construct the project.
- Facility Plan: The Facility Plan involves preparing preliminary engineering information necessary for detailed design such as siting, geotechnical data, existing utility, property ownership, design criteria and other information.
- Prepare Request for Proposal (RFP) and Neighborhood Outreach: DC Water anticipates using a design-build process that will require coordination with the District and with neighborhood stakeholders and private property owners. Based on past DC projects, the time needed for outreach and RFP preparation is 12 months for GI projects.
- Procurement: The bidding and award process for GI projects will take 9 months which is typical for DC Water construction contracts. The first contract is anticipated to take only 6 months, accounting for a smaller contract scope.
- Design and Construction: GI and sewer separation projects will be performed using design-build project delivery. Based on the area of coverage and prior DC Water design and construction work under the Anacostia River Projects, each contract will take 2 years.
- Post-Construction Monitoring: The schedule includes 12 months of post construction monitoring. The results will be used to determine the effectiveness in a variety of different rainfall and weather conditions, and to inform the implementation approach for subsequent projects.

Control Plan for Rock Creek and Potomac River



Notes:

1. Rock Creek Storage will only be constructed if GI is determined to be impracticable after GI Project 1 in Rock Creek

Figure 3-2. Rock Creek Schedule

3.1.3 Predicted Performance

Hydraulic modeling predictions indicate that GI implementation and modifications to Structure 70 will eliminate the need to construct 9.5 MG of tunnel storage included in the LTCP. The GI program is predicted to provide a degree of CSO control equivalent to the gray controls in the LTCP, as summarized in Table 3-1.

Predicted water quality is summarized in Table 3-2 and the GI controls are predicted to provide a degree of water quality performance in the receiving water equivalent to the gray controls in the LTCP.

Figure 3-3 shows that GI allows earlier reductions in CSO overflow volume than the gray controls because individual GI components provide a benefit as soon as they are placed in operation. This is in contrast to the gray controls which typically require all of the structural components to be completed before the facility provides a CSO reduction benefit.

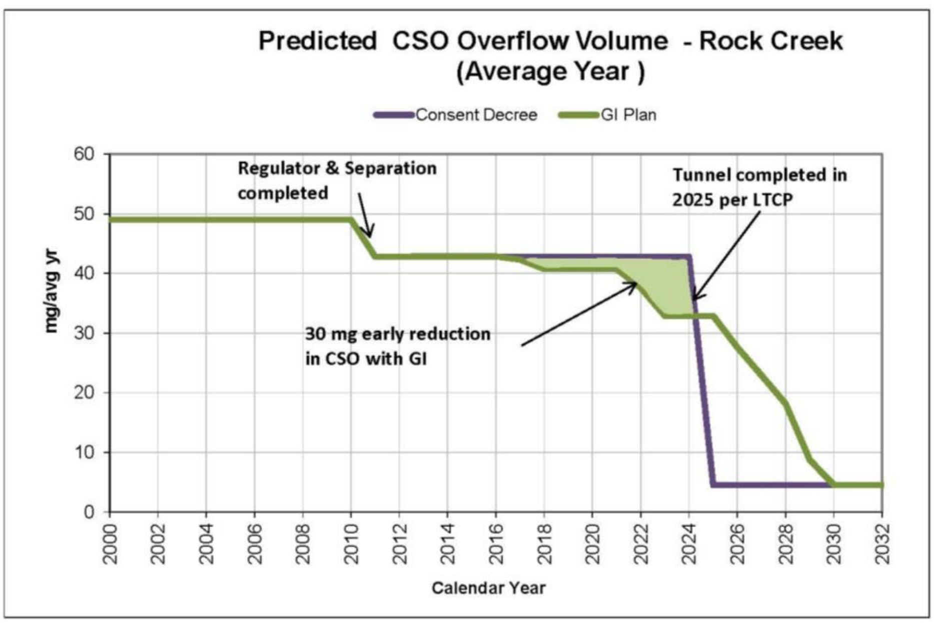


Figure 3-3. Predicted CSO Overflow Volume in Rock Creek

Table 3-1
Piney Branch Predicted CSO Overflows in Average Year

Parameter	Before LTCP[1]	LTCP	Green Controls[2]
No. of Overflows (#/avg yr)	25	1	1
Overflow Volume (mg/avg yr)	39.73	1.41	<1
% reduction from Before LTCP	--	96%	96% or greater

Table 3-2
Predicted Water Quality in
Rock Creek after Piney Branch (Segment 17) in Average Year

Parameter	Before LTCP[1]	LTCP	Green Controls[2]
# Months Fecal Geomean>200 (all loads)	12	12	12
# Months Fecal Geomean>200 (CSO only)	0	0	0
# Days Fecal>200 (all loads)	335	335	335
# Days Fecal>200 (CSO Only)	24	1	1
# Days Fecal>200 (all loads) May - Sept	135	135	135
# Days Fecal>200 (CSO Only) May - Sept	15	1	1
# Months E. Coli Geomean>126 (all loads)	12	12	12
# Months E. Coli Geomean>126 (CSO only)	0	0	0
# Days E. Coli>126 (all loads)	365	365	365
# Days E. Coli>126 (CSO Only)	24	1	1
# Days E. Coli>126 (all loads) May - Sept	153	153	153
# Days E. Coli>126 (CSO Only) May - Sept	15	1	0
# Days D.O.< 5 mg/L (all loads)	0	0	0
# Days D.O.< 5 mg/L (CSO Only)	0	0	0

Notes for Tables 3-1 and 3-2:

1. Results shown for Before LTCP are without Phase1 Controls in place (i.e., without inflatable dams, pumping station rehabilitations and Northeast Boundary Swirl Facility in operation).
2. At the low levels of CSO overflows projected herein, model accuracy is highly dependent on many variables such as the accuracy of rainfall data, information on the drainage area and other factors. Further, additional overflows will occur for rain events which exceed or are not represented in the average year. The model predictions contained herein do not change the level of CSO control determined to be adequate to meet water quality standards which was included by DC Water in its LTCP, and subsequently approved by EPA and the D.C. Department of the Environment.

3.2 Hybrid GI Plan for Potomac River

3.2.1 Scope

DC Water will construct the following controls for the Potomac River CSOs:

- **Potomac Tunnel (CSOs 020 – 024)**
  The Potomac Storage Tunnel will capture CSOs 020 through 024. These outfalls serve the major interceptors draining Rock Creek and the large downtown areas in the Potomac sewershed. Given the large overflow volume produced by these outfalls and the highly urbanized nature of the sewershed, DC Water will construct gray infrastructure to control these CSOs. The tunnel in the LTCP was a 58 million gallon (mg) facility with a tunnel dewatering pumping station at the low end. After rain events, the pumping station would bleed captured flow via the existing system to Blue Plains for treatment. The large size of the tunnel was driven, in part, by the inability to completely dewatering the tunnel during back-to-back rain events.

  As part of this modification, DC Water is proposing to construct a gravity tunnel from CSO 024 to interconnect with the Blue Plains Tunnel on the Anacostia System. The total volume of the Potomac Tunnel will be 30 mg and the tunnel will be emptied by gravity. This configuration will create one interconnected tunnel system. The advantages of this system include:

  - The Potomac and Anacostia Tunnel Systems will be interconnected, with a total system storage volume of 187 mg (30 mg for the Potomac + 157 mg for the Anacostia River Tunnel System). Since rainfall has both geographic and temporal variability, the interconnection of the tunnel system improves the ability of the system to provide CSO control. As an example, intense rain events in one part of the District can utilize the tunnel system volume as needed to control overflows. This, combined with the sewer separation and GI, allows the 30 mg Potomac Tunnel to provide a degree of control equivalent to the gray controls in the LTCP.

  - The gravity tunnel does not require construction of a new pumping station in the National Mall area. This preserves space for other higher value use. In addition, it reduces the need for operation and maintenance associated with a complex mechanical system. Elimination of the pumping station also improves reliability and redundancy since the gravity tunnel does not require electrical power or other mechanical equipment to function.

  - The gravity tunnel improves the reliability and operability of the existing sewer system. The system will be configured such that if the Potomac Pumping Station loses power, then normal sanitary flows in the system will drop into the tunnel by gravity for conveyance to Blue Plains, thereby preventing a dry weather overflow. Further, if the Potomac Pumping Station or the Potomac Force Mains experience equipment failures or need to be worked on for repair or maintenance, the gravity tunnel can be used as a backup to convey flows to Blue Plains for treatment.

- The gravity Potomac Tunnel is more environmentally responsible because it eliminates the need for an energy intensive pumping station.

- **Separation of Combined Sewers (CSOs 025 – 026)**
  The drainage areas for CSO 025 (17 acres) and CSO 026 (3 acres) are very small and, therefore, it is practical to separate the tributary combined sewers. Separation will result in the elimination of combined sewer overflows from these sewersheds.

- **Green Infrastructure (CSOs 027 – 029)**
  GI will be constructed in the CSO 027, 028 and 029 drainage areas sized to provide a retention capacity equivalent to 1.2" of rain falling on 133 impervious acres in the sewersheds. This is equivalent to GI treatment of 30% of impervious areas in the CSO 027 and 028 sewersheds, and 60% of impervious areas in the CSO 029 sewershed. GI projects may include bioretention practices (bioretention cells, bioswales, vegetated filter strips, and tree box filters), rooftop collection practices (green roofs, blue roofs, downspout disconnection, rain barrels, and cisterns), permeable pavement, and large-volume underground storage. In addition to GI, targeted sewer separation may be utilized to offload storm water from the combined sewer system. Diversion structures within the CSO 027, 028, and 029 sewersheds will be modified to increase diversion capacities. The diversion structure improvements coupled with the GI are predicted to provide a degree of CSO control equivalent to the LTCP.

CSO 025 Separation
Sewershed = 17 acres

CSO 026 Separation
Sewershed = 3 acres

CSO 027 30% GI Implementation
Sewershed = 164 acres
Impervious = 104 acres
30% GI = 31 acres

CSO 028 30% GI Implementation
Sewershed = 21 acres
Impervious = 13 acres
30% GI = 4 acres

CSO 029 60% GI Implementation
Sewershed = 330 acres
Impervious = 164 acres
60% GI = 98 acres

3.2.2 Schedule

As with Rock Creek, an adaptive management approach is recommended for the Potomac River to address institutional and planning challenges for GI. The same issues exist on the Potomac River and DC Water will follow the same approach and schedule for the GI for CSOs 027, 028 and 029. The current consent decree requires completion of the controls for the Potomac River controls by March 23, 2025. DC Water has determined that an extension of the schedule to 2027 (3 years) is required in order to implement GI while addressing adaptive management and institutional and planning challenges.

Given that there is some uncertainty associated with the ability to implement GI in the District at a large scale, DC Water proposes to construct the first GI project in the Potomac and then evaluate GI in terms of constructability, operability, efficacy, public acceptability and cost effectiveness. If, based on that evaluation, GI is determined to be impracticable for CSO 027, 028 and 029, then DC Water will construct the Potomac Tunnel with a 40 million gallon capacity instead of a 30 million gallon capacity and will connect CSOs 027, 028 and 029 to the Potomac Tunnel (9.5 million gallons of storage (gray infrastructure) for the Piney Branch CSO). If GI is determined to be practicable after the first project, then DC Water will continue to implement the remaining GI projects.

For the Potomac Tunnel, the current consent decree requires placing the facilities in operation by March 23, 2025. Because of changes that have occurred since the consent decree was negotiated, the Potomac Tunnel schedule should be extended by five years to 2030. This schedule extension is required for the following reasons:

- Requirement to prepare Environmental Impact Statement – The development of the LTCP and LTCP consent decree included a significant public process to select the controls for receiving water. Because the existing CSOs are located on National Park Service property, the Potomac Tunnel facilities may have a significant impact on Park Property. Because of this, the National Park Service has indicated that an Environmental Impact Statement will need to be prepared for the Potomac Tunnel. This was not envisioned or planned for when the schedule in the original consent decree was established. The NPS indicates that at least three years should be allowed for this process.

- Planning and Siting Challenges – The Potomac River front is essentially completely developed. There are few, if any, undeveloped or open sites absent valuable parkland in which to construct facilities. As a result, planning and obtaining approval for the Potomac facilities will take considerably longer than anticipated. Developing the consensus necessary to site facilities, obtaining land rights and obtaining approvals necessary for construction will add significant time to the project.

- Utility relocation – Experience gained on the Anacostia River Projects demonstrates that up-front time is needed to identify utilities and arrange for them to be relocated prior to tunnel and shaft construction. DC Water has therefore planned for early utility relocation contracts.

- Ability to Expand Tunnel to Include CSO 027, 028 and 029 – Time is required to construct and evaluate the first GI project in the sewersheds for CSO 027, 028 and 029. This is required to determine whether a 30 million gallon or 40 million gallon tunnel is required.

The sewer separation projects for CSO 025 and 026 are independent of the GI and the Potomac Tunnel. These projects can therefore proceed earlier in the schedule and can be completed by 2023.

Figure 3-4 shows the schedule and the basic steps in the schedule are similar to that required for the Rock Creek Projects.

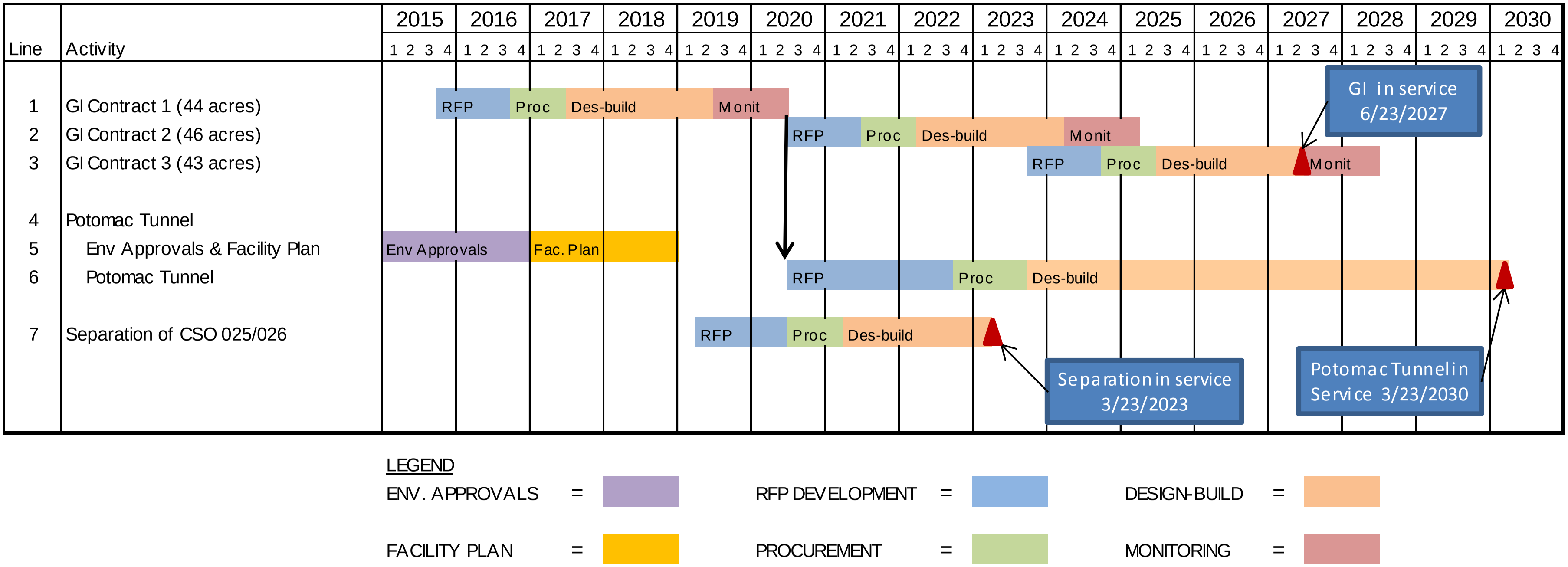


Figure 3-4. Potomac Schedule

3.2.3 Predicted Performance

Once fully implemented, the hybrid green/gray approach will provide the same overall degree of control for the Potomac River as the LTCP, as summarized in Table 3-5 below. Predicted water quality is summarized in Table 3-3, and also meets the improvements predicted for the LTCP. Table 3-4 demonstrates that the pollutant loads to the Potomac River and the water quality in the Potomac River are predicted to be equal to or better than that predicted for the LTCP.

Table 3-3
Potomac River Predicted CSO Overflows
(Average Year)

Parameter	Before LTCP[1]	LTCP	Hybrid GI Plan[2]
No. of Overflows (#/avg yr)	74	4	Equivalent to LTCP
Overflow Volume (mg/avg yr)	953	79	
% reduction from Before LTCP	--	92%	

Notes:
1. Results shown for Before LTCP are without Phase1 Controls in place (i.e. without inflatable dams, pumping station rehabilitations and Northeast Boundary Swirl Facility in operation).

Table 3-4
Potomac River Predicted Water Quality
Memorial Bridge (Segment 6) in Average Year

Parameter	Before LTCP[1]	Original LTCP	Hybrid GI Plan[2]
# Months Fecal Geomean>200 (all loads)	3	1	1
# Months Fecal Geomean>200 (CSO only)	0	0	0
# Days Fecal>200 (all loads)	142	109	109
# Days Fecal>200 (CSO Only)	57	6	3
# Days Fecal>200 (all loads) May - Sept	64	44	44
# Days Fecal>200 (CSO Only) May - Sept	33	4	1
# Months E. Coli Geomean>126 (all loads)	2	0	0
# Months E. Coli Geomean>126 (CSO only)	0	0	0
# Days E. Coli>126 (all loads)	118	77	74
# Days E. Coli>126 (CSO Only)	60	6	3
# Days E. Coli>126 (all loads) May - Sept	57	36	30
# Days E. Coli>126 (CSO Only) May - Sept	35	5	1
# days D.O.< 5 mg/L (all loads)	0	0	0
# days D.O.< 5 mg/L (CSO Only)	0	0	0

Notes:

1. Results shown for Before LTCP are without Phase1 Controls in place (i.e., without inflatable dams, pumping station rehabilitations and Northeast Boundary Swirl Facility in operation).
2. At the low levels of CSO overflows projected herein, model accuracy is highly dependent on many variables such as the accuracy of rainfall data, information on the drainage area and other factors. Further, additional overflows will occur for rain events which exceed or are not represented in the average year. The model predictions contained herein do not change the level of CSO control determined to be adequate to meet water quality standards which was included by DC Water in its LTCP, and subsequently approved by EPA and the D.C. Department of the Environment.

Table 3-5
Blue Plains Facilities, Flows and Loads, and Receiving Water Quality
(Average Year)

Parameter	LTCP	TN/WW Plan[1]	Hybrid GI Plan [1]
Facility Capacities			
Blue Plains complete treatment capacity (mgd)			
1st 4 hrs	740	555	555
After 4 hrs	511	511	511
Excess flow treatment (mgd)	336		
ECF capacity (mgd)	None	225	225
Anacostia tunnel storage volume (mg)	126	157	157
Anacostia tunnel max dewatering rate (mgd)	170	225	225
Min. tunnel dewatering time (hrs)	59	17	17
Outfall 001 Flows and Loads			
Volume (mg/avg yr)	1548	2657	3012
Avg Flow Rate (mgd)	4.2	7.3	8.3
CBOD5 (lb/avg yr)	730,724	703,562	797,861
TSS (lb/avg yr)	1,679,633	586,890	664,884
Ammonia (lb/yr)	112,320	123,461	140,504
TN (lb/avg yr)	219,475	179,396	203,229
TP (lb/avg yr)	30,985	3,989	4,516
Fecal Coliform (MPN x 10^{15}/avg yr)	411	2.0	2.3
E Coli (MPN x 10^{15}/avg yr)	300	1.3	1.4
Outfall 002 Flows and Loads			
Volume (mg/avg yr)	139,596	138,505	138,150
Avg Flow Rate (mgd)	382	379	378
CBOD5 (lb/avg yr)	5,821,153	5,775,659	5,753,948
TSS (lb/avg yr)	8,149,614	8,085,922	8,055,527
Ammonia (lb/yr)	4,424,076	1,617,184	1,611,105
TN (lb/avg yr)	17,579,883	4,509,604	4,485,771
TP (lb/avg yr)	209,562	207,924	207,142
Fecal Coliform (MPN x 10^{15}/avg yr)	106	105	105
E Coli (MPN x 10^{15}/avg yr)	67	66	66
Backcalculated Nitrogen Effluent (mg/L)	15.1	3.9	3.7
Outfall 001 + 002 Flows and Loads			
Volume (mg/avg yr)	141,144	141,162	141,162
Avg Flow Rate (mgd)	387	387	387
CBOD5 (lb/avg yr)	6,551,877	6,479,221	6,551,808
TSS (lb/avg yr)	9,829,247	8,672,812	8,720,410

Parameter	LTCP	TN/WW Plan[1]	Hybrid GI Plan [1]
Ammonia (lb/yr)	4,536,396	1,740,645	1,751,609
TN (lb/avg yr)	17,799,358	4,689,000	4,689,000
TP (lb/avg yr)	240,546	211,912	211,658
Fecal Coliform (MPN x 10^{15}/avg yr)	517	107	107
E Coli (MPN x 10^{15}/avg yr)	367	67	67
Anacostia CSO Overflows (Model Predictions)			
#/Avg Year	2	0	0
Overflow Volume/avg year (mg)	54	0	0
Potomac Water Quality at Segment 129- Blue Plains			
CSO & WWTP Loads Only			
# months FC > 200/100 ml geomean	0	0	0
# days FC > 200/100 ml	9	1	1
# months E Coli >126/100 ml geomean	0	0	0
# days E Coli > 126/100 ml	12	1	1
# days DO <5.0 mg/L	0	0	0
Min Day DO (mg/L)	>5	6.2	6.2
All Loads Present			
# months FC > 200/100 ml geomean	0	0	0
# days FC > 200/100 ml	27	12	12
# months E Coli >126/100 ml geomean	0	0	0
# days E Coli > 126/100 ml	25	7	7
# days DO <5.0 mg/L	27	20	17
Minimum Day DO (mg/L)	4.0	4.6	4.7

Notes:

1. At the low levels of CSO overflows projected herein, model accuracy is highly dependent on many variables such as the accuracy of rainfall data, information on the drainage area and other factors. Further, additional overflows will occur for rain events which exceed or are not represented in the average year. The model predictions contained herein do not change the level of CSO control determined to be adequate to meet water quality standards which was included by DC Water in its LTCP, and subsequently approved by EPA and the D.C. Department of the Environment.
2. FC= fecal coliform
3. DO = dissolved oxygen
4. MPN = Most probable number

Figure 3-5 shows that GI allows earlier reductions in CSO overflow volume for the Georgetown CSOs than the gray controls because individual GI components provide a benefit as soon as they are placed in operation. This is in contrast to the gray controls which typically require all of the structural components to be completed before the facility provides a CSO reduction benefit.

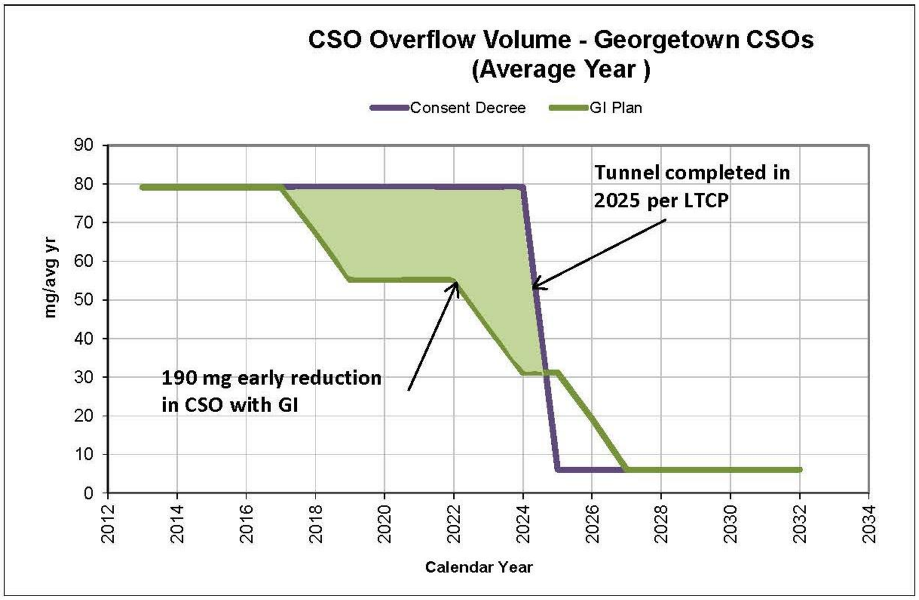


Figure 3-5. Predicted CSO Overflow Volume from Georgetown CSOs

Figure 3-6 shows that for Potomac CSOs 020-024, the recommended plan will result in a delay in CSO control for those outfalls from 2025 until 2030. This additional time is necessary due to new federal requirements to perform an Environmental Impact Statement, new planning and location challenges which did not exist when the original consent decree was signed and to mitigate the financial impact on rate payers.

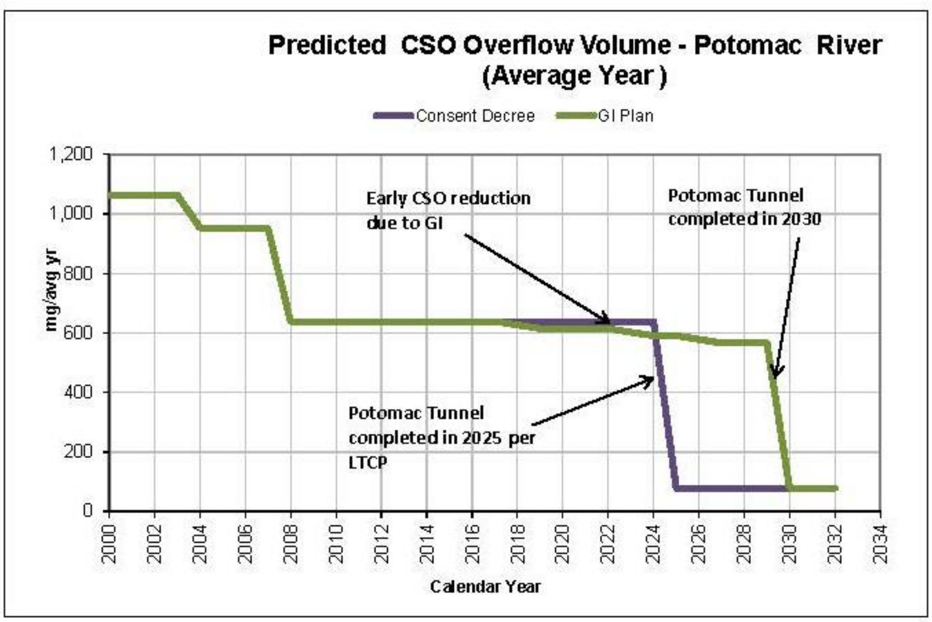


Figure 3-6. Predicted CSO Overflow Volume from all Potomac CSOs

3.3 Change in GI for MS4 Improvements

The District of Columbia recently promulgated stormwater management regulations to address MS4 requirements. The District elected to require that these MS4 regulations apply in the CSO area as well as the MS4 area. In addition to other requirements, the regulations require that land disturbing activities of more than 5000 square feet capture the first 1.2” of runoff volume from the sites. Land disturbing activities in the District public right of way must meet the maximum extent practicable standard. The MS4 regulations require the construction of GI to control storm water volumes.

The new MS4 regulations will therefore require GI to be constructed as a result of redevelopment and other land disturbing activities in the same sewersheds where DC Water will be constructing GI (CSO 027, 028 and 029 on the Potomac and Piney Branch CO 049 on Rock Creek). If this GI is constructed as a result of the MS4 program, it will reduce the GI that DC Water must construct in order to obtain the same degree of CSO control. DC Water will compile the amount of GI actually constructed in the specific targeted sewersheds (CSO 027, 028 and 029 on the Potomac and Piney Branch CSO 049 on Rock Creek) and will reduce the GI required to be constructed based on the retention capacity of the GI constructed pursuant to MS4 requirements.

3.4 Coordination with District

GI can be constructed in public space and private space. DC Water is committed to encouraging GI construction in private space. Possible tactics will be evaluated as part of the GI program but may include review of existing regulations, incentives and partnering with non-profit groups

In public space in the Piney Branch and CSO 027-029 sewersheds, the District of Columbia is the primary public landowner. Coordination and cooperation between the District and DC Water will be important for the success of the GI program for CSO control. The District and DC Water are committed to working together to encourage and make more cost effective the implementation of GI in the District. This coordination is already underway. As an example, the District Department of Transportation is producing engineering design standards and guidelines for construction of GI in the public right of way. DDOE has produced a Stormwater Management Guidebook as part of the MS4 regulations which include design approaches and guides for GI. DC Water has published Utility Protection Guidelines when constructing GI near water and sewer infrastructure. DC Water and the District have provided input and consultation on each other’s guidelines and standards to optimize efficiency and ensure consistency.

The District’s new MS4 regulations have made considerable progress toward implementing GI and will support DC Water’s GI plan. The regulations were issued in July 2013 and require the construction of GI for stormwater control for land disturbing activities that disturb more than 5,000 square feet. This is required in the combined sewer area as well as in the separate MS4 area. These regulations will encourage GI and will make the CSO controls more effective on a City-wide basis.

The District is also implementing the Mayor’s Sustainable DC Plan, which lays out a path to make the District the healthiest, greenest, most livable city in the nation over the next 20 years. Improving the environment and making the District more sustainable are key features of the plan, which is available at http://sustainable.dc.gov/finalplan.

The District and DC Water will continue to work together as GI is implemented to:

- Minimize regulatory and institutional barriers to construction of GI
- Maximize cost effectiveness by looking for opportunities to add GI as part of ongoing DC Government capital projects to minimize costs
- Ensure consistency of design standards as applicable
- Encourage and facilitate GI construction in public and private space.
- Encourage consistency and transfer of ideas and standards between the MS4 program and the CSO program

3.5 Maintenance

DC Water will perform maintenance or will arrange for others to perform it. DC Water will be ultimately responsible to assure that maintenance is performed adequately to maintain the CSO reduction functions of the GI. DC Water also anticipates that this will be a requirement in its National Pollutant Discharge Elimination System (NPDES) Permit issued by EPA.

3.6 Post Construction Monitoring

The NPDES Permit specifies the scope and schedule for post construction monitoring. In accordance with the permit, DC Water will perform post construction monitoring at the completion of the program.

3.7 Compliance with 1994 CSO Policy

The Recommended Final LTCP Modification is in compliance with the CSO Policy. Table 3-6 identifies the key requirements in the CSO Policy and summarizes how the hybrid green/gray approach complies with the Policy.

Table 3-6. Demonstration of Compliance with 1994 CSO Policy

CSO Policy Reference	CSO Policy Requirement	Demonstration of Compliance
II.B.	Implement Nine Minimum Controls	DC Water is implementing a Nine Minimum Controls Plan. Once constructed and in service, the new CSO controls will be operated and maintained in accordance with the nine minimum controls
C.	Long Term Control Plan Development	The CD modifications will modify the LTCP as described in this document
C.1.	Characterization, Monitoring and Modeling	Characterization and monitoring were performed as part of the development of the LTCP. The calibrated models were used to make the performance predictions as part of the GI Screening Analysis.

CSO Policy Reference	CSO Policy Requirement	Demonstration of Compliance
C.2.	Public Participation	Public outreach was conducted as part of the development of the GI Plan and is described in the preceding section.
C.3.	Evaluation of Alternatives	A range of alternatives were considered in the GI Screening Analysis.
C.4.	Cost//Performance Considerations	Cost, performance, efficacy and compliance with water quality standards were evaluated as part of the preparation of the GI Screening Analysis.
C.5.	Operational Plan	The operation and maintenance plan and associated nine minimum controls requirements will be reviewed and adjusted if necessary upon implementation of the controls in the GI Plan.
C.6.	Maximizing Flow at Existing POTW	The LTCP maximizes flow to Blue Plains for treatment. Further, the GI Screening Analysis evaluated maximizing tunnel storage through treatment during wet weather, as described in section 3.2.1 above.
C.7.	Implementation Schedule	An implementation schedule is included.
C.8.	Post Construction Monitoring Program	The NPDES Permit includes detailed provisions requiring post construction monitoring at defined intervals in the implementation of the program.
III.	Coordination with State Water Quality Standards	Subject to post-construction monitoring, the original LTCP was determined to meet water quality standards. The GI Plan is predicted to provide CSO control performance equal to or better than the original LTCP.

Control Plan for Rock Creek and Potomac River

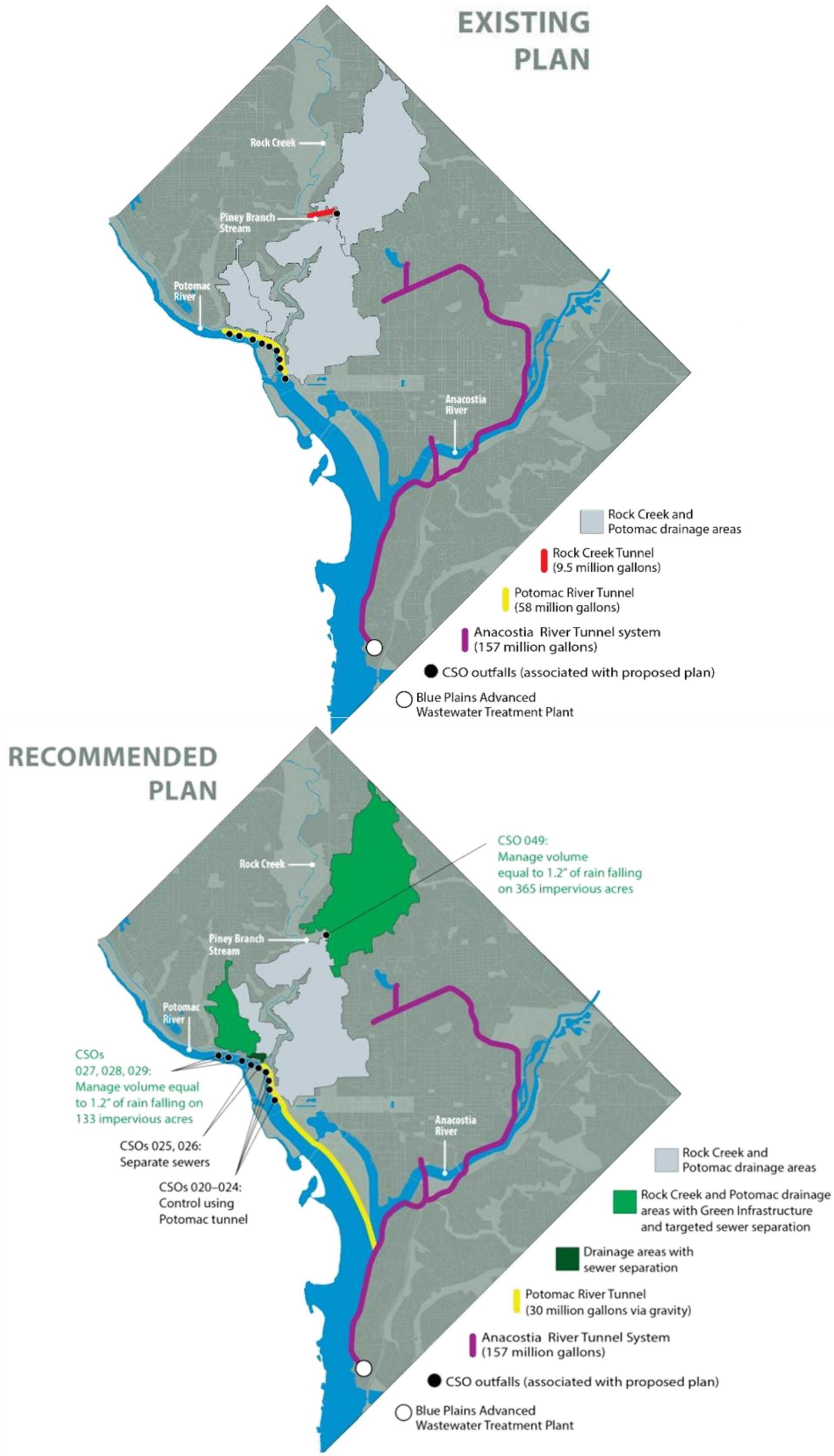


Figure3-1

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4 Financial Affordability Update

4.1 Background

From 1998 to 2001, DC Water developed its Draft LTCP. Following an extensive public comment period where more than 2,300 comments were received, DC Water finalized its LTCP in July 2002. On March 23, the LTCP Consent Decree was entered with the court requiring implementation of the LTCP.

As part of the development of LTCP, DC Water performed a financial affordability analysis based on information available at the time. The purpose of this document is to update the financial affordability analysis. This update is being performed for the following two main reasons:

Significant Changes Have Impacted the Burden on Ratepayers

Since the LTCP Consent Decree was entered in 2005, there have been significant changes that have impacted the burden on District ratepayers. These include, but are not limited to:

- Nitrogen Removal at Blue Plains' effluent to meet the Chesapeake Bay TMDL - this requirement was added to DC Water's NPDES permit in 2007. As a result of this requirement, DC Water implemented the Total Nitrogen Removal/Wet Weather Plan (TN/WW Plan) at a cost of nearly $950 million

- Biosolids Program – In order to achieve a sustainable program for biosolids from Blue Plains Wastewater Treatment Plant, DC Water is implementing a biosolids program. The program includes construction of Cambi digesters which will allow production of Class A biosolids.

- Increased costs for DC Clean Rivers Project – The DC Clean Rivers Project is a $2.6 billion program. This is more than the original estimate in 2002 when the LTCP was finalized.

- Schedule acceleration of Anacostia River Tunnel – In July and September 2102, severe flooding impacted the Bloomingdale and LeDroit park neighborhoods in the Northeast Boundary Sewershed tributary to the Anacostia River. As a result of this, the Anacostia River Projects tunnel facilities have been accelerated in schedule to provide earlier flood mitigation than originally included in the Decree. The First Street tunnel will be placed in operation in 2016 instead of 2025 and the complete Northeast Boundary Tunnel system is scheduled to be placed in operation in 2022 instead of 2025. This has significantly impacted spending on the program

- Infrastructure renewal – The sewer system in the District is extremely old, with some sewers constructed as early as the 1870's. The median age of sewers in the District is over 70 years old. Given this, a significant rehabilitation and renewal program is underway to preserve and improve the sewer system.

Financial Affordability Guidance has Changed

The financial analysis performed as part of the development of the LTCP was based on EPA's CSO guidance document (*Combined Sewer Overflows - Guidance for Financial Capability Assessment and Schedule Development*, Feb 1997, EPA 832-B-97-004). This approach essentially uses 2% of median household income as the threshold for affordability for sewer rates. This approach to measure ratepayer affordability has come under scrutiny with organizations such as the American Water Works Association (AWWA) and the Water Environmental Federation (WEF) recommending alternative approaches.

In response to these issues including the increased financial burdens imposed on water agencies and communities, EPA has also recognized the need to incorporate greater flexibility in meeting Clean Water Act (CWA) requirements. In a January 13, 2013 Memorandum, the Agency clarified its policy going forward on affordability issues as well on using the integrated planning framework process to provide the regulated community with the necessary flexibility to meet CWA requirements while lessening the financial burden, especially to low income populations.

DC Water's complete affordability update is included in Appendix E and this section presents a summary of the results.

4.2 Affordability Measures for the District.

The 1997 Final EPA guidance presented methods for estimating the annual cost per household (for CSO capital expenditures) and for comparing that estimate against Median Household Income (MHI) to derive a "Residential Indicator" (RI). Although the 1997 guidance document did not prescribe a regulatory threshold ratio, it implied that sewer rates resulting in a typical residential bill exceeding 2 percent of MHI could be considered unaffordable.

EPA has acknowledged the increasing cost burden to communities of complying with the CWA, as well as the methodological limitations of using the RI as an indicator of affordability. As a result of these concerns, EPA issued a memorandum on January 13, 2013 that addressed financial affordability issues and clarified the Agency's policy going forward. The Agency's overall message, as articulated in the memorandum, was that EPA has developed, in cooperation with the regulated community, the "Integrated Planning Approach Framework" that "encourages municipalities to balance CWA requirements in a manner that addresses the most pressing health and environmental protections issues first." The memorandum also attempts to clarify that it is not EPA's policy that the RI, based on expenditures as a percentage of MHI, constitutes the sole measure of affordability. The Agency further emphasized that it is a "common misperception that the EPA requires communities to spend to a level of 2% of MHI to meet CWA obligations." Instead, EPA states that the percent MHI calculation should be considered along with a "suite of other financial indicators to assess the overall burden on a community."

DC Water evaluated the following factors to assess affordability:

- Sources of revenue for DC Water
- Current sewer rates and affordability based on MHI
- Household income distribution in the District\
- Poverty rates in the District

- Distribution of income and poverty by Ward
- Degree of public assistance or food stamp use
- Cost of living in DC compared to the national average

The analysis showed that the income distribution in the District is significantly skewed with a large percentage of households in poverty and in affluence, with lower amounts of households with middle incomes. The analysis also showed that the cost of living in the District is significantly higher than in the U.S., primarily due to elevated housing, transportation and food costs.

Given both the skewed distribution of household income and the high cost of living for District of Columbia residents compared to the national average, using 2 percent of unadjusted MHI as the threshold for unaffordability does not effectively capture the real burden of increasing sewer bill costs on low income populations. Considering affordability across a broader household income distribution provides the most accurate indication of how utility bills pose financial burdens to the population of customers.

Therefore, to assess affordability, DC Water used the following alternative criteria for the affordability measurements

- Unadjusted MHI
- Cost of Living Adjusted (COLA) MHI
- Unadjusted Upper Limit of the Second Quintile for Household Income
- COLA Adjusted Upper Limit of the Second Quintile for Household Income

4.3 Scenarios Evaluated

DC Water used its financial model to assess the impact of capital expenditures on rates. The financial model allows the user to enter annual capital outlays to determine the impact on revenue generation for DC Water and on ratepayer household incomes. The financial model was run for the following scenarios:

- Scenario 1 Original Consent Decree – this is the CIP that existed when the 2002 LTCP Decree was negotiated. This was evaluated using the measures of affordability described above

- Scenario 2 Status Quo CIP – this includes the current CIP with the Anacostia River Projects finishing in 2022, and the Potomac and Rock Creek Tunnels finishing in 2025

- Scenario 3 Constrained CIP – for this scenario, the Anacostia River Projects are completed in 2022, the Potomac Tunnel is completed in 2030, and the Potomac and Rock Creek GI projects are completed in 2032. To meet affordability limits, wastewater and sewer CIP projects were deferred.

4.4 Results

Table 4-1 presents the results of the rate model calculation for the various scenarios. Shaded values indicate wastewater costs more than 2% of income for the various scenarios listed.

Table 4-1
Results Summary - Predicted Sewer Bills as Percent of Income

	Scenario 1- Original Decree			Scenario 2 – Status Quo CIP			Scenario 3 – CIP Constrained by Upper Limits 2nd Quintile		Scenario 3 – CIP Constrained by Adjusted Upper Limit 2nd Quintile	
Year	% MHI	% Upper Limit 2nd Quintile	% Adjusted Upper Limit 2nd Quintile	% MHI	% Upper Limit 2nd Quintile	% Adjusted Upper Limit 2nd Quintile	% Upper Limit 2nd Quintile	% Adjusted Upper Limit 2nd Quintile	% Upper Limit 2nd Quintile	% Adjusted Upper Limit 2nd Quintile
FY2014	1.0	1.4	1.9	0.8	1.05	1.51	1.05	1.51	1.51	1.05
FY2015	0.9	1.2	1.7	0.91	1.21	1.73	1.15	1.64	1.64	1.15
FY2016	0.9	1.3	1.8	0.98	1.32	1.89	1.23	1.77	1.74	1.22
FY2017	1.0	1.4	1.9	1.04	1.42	2.03	1.32	1.90	1.85	1.29
FY2018	1.0	1.5	2.1	1.09	1.50	2.16	1.42	2.04	1.92	1.34
FY2019	1.1	1.5	2.2	1.15	1.60	2.29	1.53	2.19	1.99	1.39
FY2020	1.1	1.6	2.3	1.23	1.72	2.47	1.65	2.36	2.06	1.44
FY2021	1.2	1.8	2.5	1.31	1.85	2.65	1.77	2.54	2.14	1.49
FY2022	1.3	1.9	2.7	1.39	1.99	2.86	1.91	2.73	2.22	1.55
FY2023	1.3	2.0	2.8	1.44	2.08	2.98	1.98	2.83	2.31	1.61
FY2024	1.4	2.1	3.0	1.49	2.17	3.11	2.04	2.92	2.37	1.66
FY2025	1.2	1.9	2.7	1.54	2.27	3.25	2.10	3.01	2.39	1.67
FY2026	1.3	2.0	2.8	1.60	2.37	3.40	2.13	3.05	2.41	1.68
FY2027	1.3	2.0	2.8	1.59	2.38	3.41	2.16	3.10	2.42	1.69
FY2028	1.3	2.0	2.9	1.57	2.39	3.42	2.20	3.15	2.44	1.70
FY2029	1.3	2.1	2.9	1.56	2.40	3.43	2.23	3.20	2.46	1.72
FY2030	1.3	2.1	3.0	1.55	2.40	3.45	2.23	3.19	2.48	1.73
FY2031	1.4	2.3	3.2	1.54	2.41	3.46	2.22	3.18	2.49	1.74
FY2032	1.3	2.2	3.1	1.53	2.42	3.47	2.21	3.17	2.50	1.74

4.5 Conclusions

The following are the conclusions of the affordability update:

- Using a sewer bill threshold of 2 percent of MHI is a poor indicator for assessing affordability. In jurisdictions such as Washington, DC, not only are household incomes highly skewed but there has been an increasing divergence between high income households and low income households. From 2006 to 2012, for example, MHI grew more than 28 percent while household incomes at the upper limit of the second quintile grew only 20 percent. Consequently by 2011 the MHI was 25 percent higher than the upper limit of the second quintile.

- Evaluating the financial impacts of DC Water’s CIP on the ratepayer base found that impacts to lower income households become much more apparent when the upper limit of the second quintile is used than when using the 2 percent of MHI threshold. With the COLA factor taken into account, forecasted sewer bills become unaffordable to 40 percent of the households as soon as 2018.

- The impacts on ratepayers for the Status Quo CIP (Scenario 2, CSO Projects completed by 2025) are significantly worse than projected when the LTCP Consent Decree was entered and negotiated.

- The analysis showed that extension of both the Consent Decree schedule and deferment of other sewer and wastewater projects is necessary to maintain affordable rates. To achieve CSO control as early as possible, we evaluated engineering constraints and determined that extending the Potomac River Tunnel schedule by five years and the GI schedule by seven years would result in the earliest practical and technically achievable schedules for CSO control. Given this schedule constraint, DC Water determined that more than $2.5 billion dollars of other sewer and wastewater projects must be deferred between 2014 and 2032 to meet the affordability criteria established by the analysis. Given that average sewer age will be approaching nearly 100 years by 2032, this deferment of other projects inevitably presents risks to customer service, environmental protection, and management of infrastructure. DC Water balanced these risks with our obligations to complete the CSO control program as soon as is practicable when we developed the proposed schedule for CSO control described in this report.

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5 Public Comments and Responses

5.1 Introduction

As part of DC Water's proposal for a Long Term Control Plan Modification for Green Infrastructure (LTCP Modification), a public comment period was instituted from January 12, 2014 through April 14, 2014. A public outreach program was conducted to provide information about the proposed modification and to solicit public comments. This section summarizes the outreach conducted, the comments received and the revisions made to the draft plan in response to comments.

5.2 Public Outreach

Public outreach was facilitated via notifications and advertisements disseminated using distribution channels including press releases, print and social media, DC Water's website, emails and mailings. The following summarizes public outreach conducted:

- Washington Post Legal Notice
  A legal notice was placed in the Washington Post on January 12, 2014. The notice described the purpose of the LTCP modification, indicated where additional information could be obtained and the method and deadline for submitting comments. A second legal notice was placed in the Washington Post on March 9, 2014 extending the public comment period to April 14, 2014.

- Public Information Depositories
  Hard copies of the "*Long Term Control Plan Modification for Green Infrastructure*" Document and its Executive Summary, were made available for review from January 22 through April 14, 2014 at the reference desks of the following libraries in District of Columbia neighborhoods:
    - Capitol View Library - 5001 Central Avenue, SE
    - Mount Pleasant Library - 3160 16th Street, NW
    - Rosedale Library - 1701 Gales Street, NE
    - William O. Lockridge/Bellevue Library - 115 Atlantic Street, SW
    - Martin Luther King, Jr. Library Room 307 - 901 G Street, NW
    - Southeast Library - 403 7th Street, SE
    - Shepherd Park Library - 7420 Georgia Avenue, NW
    - Tenley-Friendship Library - 4450 Wisconsin Avenue, NW
    - Lamond-Riggs Library - 5401 South Dakota Avenue, NE

- Web Site
  The proposed modification, public meeting dates and an on-line survey were placed on the DC Water website on a dedicated web page. A link through the DC Water homepage and its rotating banner were also implemented to facilitate easier access. During the comment period, the webpage overall statistics recorded 3,623 sessions and 2527 new users. Visitors to the

site were also provided links to the following:

- YouTube video of General Manager Hawkins' presentation at the January 22, 2014 GI Summit
- Informational presentation slides presented at DC Water sponsored public meetings
- January 22, 2014 GI Summit slides
- February 18 and 20, 2014 GI Public Meetings
- March 5, 2014 Poplar Point and GI Public Meeting
- February 19, 2014 Kojo Nnamdi Show radio interview of General Manager Hawkins describing the proposed LTCP Modification

- Meetings
  DC Water conducted the meetings summarized below to share information regarding the proposed plan and to solicit public comments:
  - On January 22, 2014, DC Water hosted a Public Summit Meeting held at the Metropolitan Washington Council of Governments. Attendees could review a series of 12 stations manned by DC Clean Rivers technical staff discussing various project components graphically represented on presentation boards. The meeting began with an overview of the proposed amendments and supporting justification presented by General Manager George Hawkins, followed by a question and answer period.

  - On Tuesday, February 18, 2014, DC Water hosted a public meeting in support of its Green Infrastructure proposal at Georgetown Visitation Preparatory School, located at 1524 35th Street, NW. The meeting was held in the 2nd floor New Founders Hall. Attendees could review a series of 12 stations manned by DC Clean Rivers technical staff discussing various project components graphically represented on presentation boards. The meeting began with an overview of the proposed amendments and supporting justification presented by General Manager George Hawkins, followed by a question and answer period.

  - On Thursday, February 20, 2014, DC Water hosted a public meeting in support of its Green Infrastructure proposal at Petworth Public Library, located at 4200 Kansas Avenue, NW. Attendees could review a series of 12 stations manned by DC Clean Rivers technical staff discussing various project components graphically represented on presentation boards. The meeting began with an overview of the proposed amendments and supporting justification, followed by a question and answer period.

  - On Thursday, February 27, 2014, DC Water hosted a public meeting in support of its Northeast Boundary Tunnel Project/Green Infrastructure proposal at McKinley Technology High School, located at 151 T Street, NE.

  - On Tuesday, March 4, 2014, DC Water attended the monthly meeting of ANC 2E to discuss its Green Infrastructure proposal for the Georgetown community. The meeting was held at Georgetown Visitation Preparatory School, located at 1524 35th Street, NW, in the 3rd floor Founder's Hall.

- On Tuesday, March 4, 2014, DC Water attended the monthly meeting of ANC 4A to present its Green Infrastructure proposal. The location of the meeting was held at Fort Stevens Recreation Center, located at 1327 Van Buren Street, NW.

- On Wednesday, March 5, 2014, DC Water hosted a public meeting in support of its Poplar Point Pumping Station Replacement Project/Green Infrastructure proposal at United Planning Organization-Ralph Waldo "Petey" Greene Community Service Center, located at 2907 Martin Luther King, Jr. Avenue, SE.

- On Wednesday, March 12, 2014, DC Water attended the monthly meeting of ANC 4C to present its Green Infrastructure proposal. The meeting was held at Petworth Public Library, located at 4200 Kansas Avenue NW.

- On Wednesday, March 12, 2014, DC Water conducted a briefing on its Green Infrastructure plan to the Construction Management Association of America at the Frank D. Reeves Center, located at 2000-14th Street, NW.

- On Thursday, March 13, 2014, DC Water attended the monthly meeting of ANC 3B to discuss the water quality and cost implications of its Green Infrastructure proposal. The meeting was held at Stoddert Elementary School, located at 4001 Calvert Street, NW.

- On Thursday, March 13, 2014, DC Water attended the monthly meeting of ANC 3E to present its Green Infrastructure proposal. The meeting was held at Woodrow Wilson High School, located at 3950 Chesapeake Street, NW.

- On Thursday, April 3, 2014, DC Water's Clean Rivers Project team attended the 5th Annual Ward 2 Town Hall co-hosted by DC Water General Manager George Hawkins and District Councilmember Jack Evans to provide information and address inquiries pertaining to the proposed Green Infrastructure plan. The meeting was held at Francis-Stevens Education Campus, 2425 N Street NW.

- On Wednesday, April 9, 2014, DC Water's Clean Rivers Project team attended the 5th Annual Ward 8 Town Hall Meeting co-hosted by DC Water General Manager George Hawkins and District Councilmember Marion Barry to provide information and address inquiries pertaining to the proposed Green Infrastructure plan. The meeting was held at United Planning Organization's Ralph Waldo "Petey" Greene Community Service Center, 2907 Martin Luther King Jr. Avenue SE.

- On Thursday, April 10, 2014, DC Water's Clean Rivers Project team attended the 5th Annual Ward 4 Town Hall Meeting co-hosted by DC Water General Manager George Hawkins and District Councilmember Muriel Bowser to provide information and address inquiries pertaining to the proposed Green Infrastructure plan. The meeting was held at Shepherd Elementary School, 7800 14th Street NW.

- Social Media
  DC Water posted the Draft LTCP Modification release, meeting notices and the public comment period extension on both DC Water Twitter and Facebook. In addition, two Facebook ads and two promoted tweets were completed to promote the modification to a wider audience. Also, General Manager Hawkins' videotaped presentation at the Green Infrastructure Summit was posted on YouTube (https://www.youtube.com/-watch?v=JkUJH0Tdh3o) and received 167 visits.

- Public Information Materials
  DC Water created multiple dedicated materials for use in the LTCP Modification public comment period including:

  - 600 informational brochures were printed and distributed at public meetings and events
  - Direct mail or ebill inserts were sent to 120,000 DC Water customers between January and April 2014
  - Comment cards were distributed to approximately 600 attendees at the Public Meetings
  - Reference to the LTCP Modification proposal and its comment period was also provided in the "*DC Water Biannual Report April 2014 Combined Sewer Overflow (CSO) Control Activities Clean Rivers Project News*" newsletter which had ongoing mailings to 120,000+ customers between the end of March and end of April, 2014.

- On-Line Survey
  Seventy-one individuals responded to one or more questions and 51 provided narrative comments.

- Earned Media
  Outreach was conducted to several key DC reporters and bloggers to brief them on the proposed Modification. DC Water General Manager George Hawkins was interviewed live on February 19, 2014 by WAMU's Kojo Nnamdi (http://thekojonnamdishow.org/shows-/2014-02-18/dc-water-proposes-green-infrastructure).

  In addition, the following media printed stories about the LTCP modification proposal:

  - '*Green' Modifications Proposed to D.C. Clean-water Plan; Environmentalists are Skeptical*, Mike DeBonis, Washington Post, January 23, 2014 (http://www.washingtonpost.com/local/dc-politics/green-modifications-proposed-to-dc-clean-water-plan-environmentalists-are-skeptical/2014/01/23/e4c43068-8459-11e3-bbe5-6a2a3141e3a9_story.html).

  - *DC Water Proposal Would Swap Tunnels for Green Infrastructure*, Washington City Paper/Housing Complex Blog, posted by Aaron Wiener on January 22, 2014 at 5:35 pm. (http://www.washingtoncitypaper.com/blogs/housingcomplex/2014/01/22/dc-water-proposal-would-swap-tunnels-for-green-infrastructure/).

- o *DC Water Modifies Long Term Control Plan to Include Green Infrastructure* Civil+Structural Engineer webpost (http://www.cenews.com/post/2696/dc-water-modifies-long-term-control-plan-to-include-green-infrastructure).

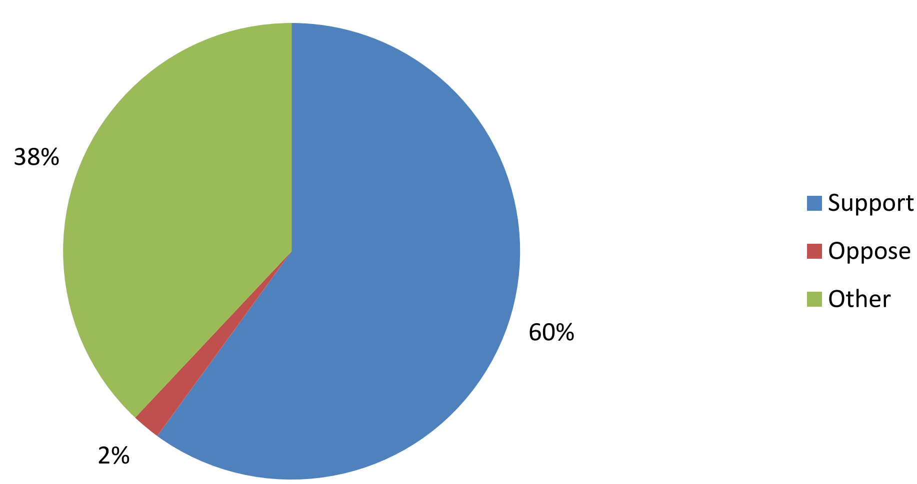
- Key Stakeholder Outreach
  Extensive outreach via phone and email was conducted to stakeholders announcing the LTCP Modification and seeking input including environmental, business and jobs training groups. Briefings were provided to ANCs, Mayor Gray, Congresswoman Norton, DC Councilmember Mary Cheh and key stakeholders. In addition, dedicated email invitations to the January 22, 2014 Green Infrastructure Summit, DC Water February 18 and 20, 2014 Public Meetings and DC Water Town Hall meetings were sent.

5.3 Public Comments

In response to the outreach, 366 commenters submitted 471 comments on the draft LTCP Modification for GI. The comments received have been bound in a separate report titled "*Public Comments, Long Term Control Plan Modification for Green Infrastructure*", DC Water, May 2015.

Figure 5-1 shows the disposition of the comments, with the majority of comments supporting the proposed modification. Comments considered to be "other" in nature covered a variety of topics including comments on other aspects of DC Water's operations, requests for information or suggestions for implementing the program.

Figure 5-1. Summary of Comments



Public Comments and Responses

Since a large number of comments were received and because there are significant degrees of overlap and common themes in the comments, the comments were grouped by type and subject matter and addressed together in a commentary type response. The goal of this approach is to produce a commentary that is both readable and comprehensive. The comments were grouped as being related to the following topics:

- Nature of Commitment
- Degree of Control
- Rates/ Financial
- Implementability
- Schedule
- Maintenance
- Implementation Strategies
- Miscellaneous
- General Opposition
- General Support

Appendix K provides a response to each type of comment received.

5.4 Modifications to Draft GI Plan in Response to Comments

As part of finalizing the LTCP Modification for GI, DC Water has made significant revisions to the draft plan. This section describes the major revisions made.

- **Nature of Commitment**
  DC Water's Proposed Draft LTCP Modification included committing $60 million for GI in Rock Creek and $30 million for GI for the Potomac CSOs 027, 028 and 029. This magnitude of expenditures was based on the estimated costs of the GI. A limit on the financial commitment was proposed given the uncertainties in terms of the cost to construct GI and in order to manage these risks to ratepayers. There was also precedent for a financial commitment in other enforceable documents such as New York City's order with the State of New York to construct GI.

  Some commenters indicated that a financial commitment would not ensure that the necessary amount of GI was constructed to provide the degree of CSO control required. These commenters suggested that the commitment to GI should be expressed in terms of acres of GI constructed, gallons stored, or a performance standard other than or in addition to a financial commitment.

  In response to these comments, DC Water has removed the limit on its financial commitment to GI and expressed the commitment in terms of constructing sufficient GI and targeted sewer separation to manage the volume of water produced by 1.2" of rain falling on the number of impervious acres specified for the applicable sewershed. This is a commitment to manage a specified volume of runoff and will ensure that the necessary amount of GI is in place in order to provide the degree of CSO control required.

- **Feasibility/Effectiveness of GI**
  Some commenters indicated that GI may not be feasible to construct at a sufficient application rate to provide the degree of CSO control needed, or may not be as effective as anticipated.

  Given the lack of large scale implementation of GI in the District, DC Water has revised the LTCP Modification to provide for constructing the first GI project in the Potomac and Rock Creek sewersheds and then evaluating GI in terms of constructability, operability, efficacy, public acceptability and cost effectiveness. If, based on that evaluation, it is determined that it is impractical to complete all of the specified GI projects by the specified deadlines, then DC Water would be required to construct the gray controls as specified in the LTCP Modification. Should this occur, DC Water would be required to construct the gray controls within the same timeframe allowed for GI so there is no extension of the time allowed for implementation. If GI is determined to be practicable after the first project, then DC Water will continue to implement the remaining GI projects by the specified deadlines.

- **Schedule**
  Some commenters suggested that the seven year extension was too long and advocated for a shorter schedule. In addition, some commenters urged DC Water to accelerate individual components of the controls where feasible.

  For GI, the schedule extension allows an adaptive management approach to be implemented to ensure that performance of the GI projects is optimized. Adaptive management means early GI projects will be monitored and assessed so that later projects are as practical and effective as possible. In response to comments, DC Water has evaluated the engineering, fiscal and practicality issues and has revised the modification to complete projects as early as practical. In addition, the separation at CSO 025 and 026 and Piney Branch Structure improvements have been substantially accelerated. The schedule revisions are summarized in Table 5-1.

  For the Potomac Tunnel, extra time in the schedule is needed compared to the original LTCP plan due to a new requirement to complete environmental studies, in view of the increased development in recent years along the Potomac River waterfront, and to mitigate the tremendous financial impacts on rate payers. It is therefore not feasible to shorten the schedule for the Potomac Tunnel earlier than 2030.

Table 5-1
Schedule Comparison

	Place in Operation Deadline		
Facility	**Proposed Draft LTCP Modification**	**Recommended Final LTCP Modification**	**Change**
Potomac River			
1. Separate CSO 025, 026	2032	2023	9 years earlier
2. Potomac GI	2028	2027	1 year earlier
3. Potomac Tunnel	2030	2030	No change
Rock Creek			
4. Piney Branch Diversion Structure Improvements	2032	2020	12 years earlier
5. Rock Creek GI	2032	2030	2 years earlier

- **Disruption due to Tunnel in Georgetown, NPS Property and Mall area**
  Some commenters expressed concern about potential disruption caused by tunneling, particularly in the Georgetown and National Park areas.

  The Proposed Draft LTCP Modification included a 21 million gallon, approximately 4,500 foot long Potomac Tunnel to capture CSOs 020-024, a new pumping station to empty the tunnel and the addition of 75 million gallon per day of capacity at the Tunnel Dewatering Pumping Station (TDPS) and Enhanced Clarification Facility (ECF) at Blue Plains. As part of the response to comments, DC Water has evaluated an approximately 23,000 foot long gravity Potomac Tunnel that would run from the Potomac River CSOs to connect to the Blue Plains Tunnel at Joint Base Anacostia-Bolling (formerly Bolling Air Force Base). This would eliminate the need for a tunnel dewatering pumping station for the Potomac Tunnel. This is advantageous because of the complexity of the station, the difficulty in siting such a facility in the vicinity of the National Mall area, long term operational and power requirements and costs and the need for a permanent building associated with a large deep pumping station. Because of the elimination of the pumping station, the gravity tunnel provides substantially less disruption both during and after construction.

  The gravity Potomac Tunnel also allows interconnecting the storage volumes of the Potomac and Anacostia River Tunnel Systems into one tunnel system, allowing any CSO on either water body access to the entire storage volume of both tunnels. DC Water's analyses have demonstrated that a 30 million gallon gravity Potomac Tunnel for CSO 020-024 connected to the Blue Plains Tunnel provides a degree of CSO control equal to the LTCP without the need to expand the Blue Plains Tunnel Pumping Station and wet weather treatment system. Because the gravity tunnel offers greater reliability and avoids a new pumping station, the gravity tunnel is the recommended plan.

- **Stewardship for Ratepayer Dollars**
  Some commenters expressed concern over affordability for ratepayers.

  DC Water is acutely aware of the heavy financial burden bourn by District ratepayers to implement the DC Clean Rivers Project and has taken steps to both mitigate and spread out water rate increases over time. Unfortunately, this is not discretionary spending by DC Water but is mandated to comply with the Clean Water Act through a Federal Consent Decree signed by the Department of Justice, EPA, the District of Columbia and DC Water. The Final LTCP Modification will mitigate rates to the extent possible by extending the schedule for the Potomac Tunnel, thereby slowing the rate of increase in rates compared to what otherwise would be required.

- **Maintenance**
  Some commenters expressed the importance of maintenance in assuring the GI is effective over the long term.

  DC Water will perform maintenance or will arrange for others to perform maintenance of all GI implemented to control CSOs. DC Water will be ultimately responsible to ensure that maintenance is performed adequately to maintain the CSO reduction functions of the GI. DC Water also anticipates that this will be a requirement included in its National Pollutant Discharge Elimination System (NPDES) Permit issued by EPA.

- **Support for Green Jobs**
  Some commenters supported the long term economic benefits of GI, specifically the ability to make jobs more accessible to unemployed local residents. This is especially true considering labor required to construct the facilities, as well as that required for long term maintenance.

  GI will increase opportunities for local, green jobs both for construction and for long term maintenance of the facilities. DC Water will work to promote green jobs with a living wage for local residents. Activities may include establishing a certification program for GI jobs, partnering with organizations to provide training that ultimately leads to certification, conducting outreach in the District and partnering with local organizations.

6 Proposed LTCP Modifications for Green Infrastructure

6.1 Changes to CSO Controls/Schedule

In order to proceed with the hybrid green/gray controls for the Potomac River and GI for Rock Creek's Piney Branch sewershed, modification of the LTCP is required. Proposed changes to the LTCP are summarized below:

Potomac River CSO Controls

- Require implementation of GI and targeted sewer separation to control CSOs 027, 028, and 029 with the facilities managing volume of water runoff produced by a 1.2" of rain falling on 133 impervious acres. Phased implementation of GI would be required, with all facilities being placed in operation by 2027.
- Indicate that DC Water has awarded a contract for preparation of an Environmental Impact Statement for the Potomac Tunnel.
- Change the deadline for start of the Facility Plan for the Potomac Tunnel from 2015 to 2017
- Require the construction of a 30 million gallon tunnel to control CSOs 020, 021, 022 and 024 with facilities being placed in operation by 2030. Drain the tunnel by gravity to the Blue Plains Tunnel.
- Require the construction and evaluation of the first GI project in the Potomac sewershed to determine its practicability. If, based on that evaluation, GI is determined to be impracticable, require the construction of a 40 million gallon Potomac Tunnel in lieu of the 30 million gallon tunnel and require CSOs 027, 028 and 029 to be controlled by the tunnel. If GI is determined to be practicable after the first project, require the continued implementation of GI.
- Require sewer separation of CSOs 025 and 026 by 2023 to eliminate these outfalls from the combined sewer system.
- Delete the requirement to consolidate CSOs 024 through 028 and replace this requirement with the other CSO controls described above.

Rock Creek CSO Controls

- Delete the requirement to construct the Piney Branch Tunnel.
- Require implementation of GI and targeted sewer separation to control Piney Branch CSO 049 with facilities managing the volume of water runoff produced by a 1.2" of rain falling on 365 impervious acres. Phased implementation of the GI would be required, with all facilities being placed in operation by 2030.
- Require the construction and evaluation of the first GI project in Rock Creek to determine its practicability. If, based on that evaluation, GI is determined to be impracticable, require the construction of 9.5 million gallons of storage for Rock Creek's Piney Branch CSO 049. If GI is determined to be practicable after the first project, require the continued implementation of GI.

Low Impact Development-Retrofit

- Delete the requirement for DC Water to review current LID and LIDR information to determine if the sizes of the Potomac and Piney Branch tunnels can be reduced with the installation of LID and LIDR.

Other

- Require DC Water and the District to cooperate and coordinate efforts to facilitate implementation of GI in the District.

Appendix - A
LTCP Consent Decree

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MAR 25 2005

CLERK, U.S. DISTRICT COURT
DISTRICT OF COLUMBIA

UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

ANACOSTIA WATERSHED SOCIETY, et al. **Plaintiffs** **v.** **DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY, et al.** **and** **THE UNITED STATES** **Plaintiff** **v.** **DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY** **and** **THE DISTRICT OF COLUMBIA,** **Defendants.**	) **Consolidated**) **Civil Action No. 1:CV00183TFH**

CONSENT DECREE

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UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF COLUMBIA

ANACOSTIA WATERSHED SOCIETY, et al., **Plaintiffs**	)
v.	)
DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY, et al., **Defendants.**	)
and	)
THE UNITED STATES, **Plaintiff**	)
v.	)
DISTRICT OF COLUMBIA WATER AND SEWER AUTHORITY	) **Consolidated**) **Civil Action No. 1:00CV00183TFH**
and	)
THE DISTRICT OF COLUMBIA,	)
Defendants.	)

CONSENT DECREE

WHEREAS, on February 2, 2000, the Plaintiffs, Anacostia Watershed Society, Kingman Park Civic Association, American Canoe Association, Friends of the Earth, Sierra Club, and Mary Stuart Bick Ferguson ("Citizen Plaintiffs") filed an action, Civil Action No. 1:00CV00183TFH, against the District of Columbia Water and Sewer Authority (hereinafter "WASA") and its General Manager, Jerry Johnson, pursuant to Sections 309(b) and (d), and 505 of the Federal Water Pollution Control Act, as amended by the Clean Water Act of 1977 and the Water Quality Act of 1987 ("Clean Water Act" or "the Act"), 33 U.S.C. §§ 1319(b) and (d), and

1365;

WHEREAS, on December 20, 2002, Plaintiff, the United States of America, on behalf of the United States Environmental Protection Agency ("EPA"), filed a Complaint against WASA and the District of Columbia, which case has been consolidated with the pending matter against WASA for the alleged violations of the Clean Water Act;

WHEREAS, the Complaints allege that WASA violated the Clean Water Act, 33 U.S.C. §§ 1251 et seq. (the "Act"), by failing to comply with the District of Columbia Water Quality Standards, effluent limitations and other conditions established in the National Pollutant Discharge Elimination System ("NPDES") Permit No. DC0021199 issued to WASA by the Environmental Protection Agency ("EPA") under Section 402 of the Act, 33 U.S.C. § 1342, and by failing to properly manage, operate and maintain all collection, pumping facilities, treatment and/or combined sewer overflow (CSO) control facilities or combined sewer systems ("CSS") owned and/or operated by WASA;

WHEREAS, the United States further asserts inter alia a claim against the District of Columbia pursuant to Section 309(e) of the Act, 33 U.S.C. § 1319(e) and Fed. R. Civ. P. 19(a);

WHEREAS, the United States, the Citizen Plaintiffs, and WASA have resolved the claims for alleged violations of the Nine Minimum Controls and for the performance of certain projects in a partial consent decree, entered by the Court on October 10, 2003;

WHEREAS, in that partial consent decree, WASA agreed to pay a civil penalty and to perform Supplemental Environmental Projects and a Citizen Community Project;

WHEREAS, on April 26, 2004, Plaintiffs and Defendants entered into a stipulation which provided in essence that Defendants would not contest their liability for certain claims; that Plaintiff United States waived its claims for any additional civil penalties and dismissed with prejudice its claims under Count Three of its Complaint; and that Citizen Plaintiffs also waived their claims for civil penalties;

WHEREAS, WASA submitted a draft Long Term Control Plan to EPA in June, 2001. Thereafter, WASA finalized the Long Term Control Plan in July 2002 ("LTCP") and submitted it to EPA in August, 2002;

WHEREAS, WASA has provided for public participation in development of the Long Term Control Plan through public hearings at various locations throughout the District of Columbia, stakeholder meetings, and other means;

WHEREAS, the recommended control plan in Section 13 of the LTCP provides for, inter alia, three or more underground storage tunnels to hold up to 193 million gallons of the combined wastewater and storm water during wet weather and to thereby reduce CSOs significantly;

WHEREAS, the Parties and the Citizen Plaintiffs have stipulated and agreed, and on September 22, 2004, the Court ordered that issues pertaining to the scope of Section 402(q) of the Clean Water Act, including whether the measures proposed in WASA's August, 2002 LTCP conform to the water quality standards of the District of Columbia, would not be addressed in this consolidated action, but rather EPA agreed to address such issues outside the context of this lawsuit, in, inter alia, the modification of WASA's NPDES permit that was pending at that time;

WHEREAS, EPA is the permitting agency and noticed an NPDES Permit containing Phase II conditions for public comment on March 18, 2004. EPA has issued, or is anticipated to issue shortly, the final version of the Permit. The Fact Sheet to the final permit states that "EPA has determined that, based upon current information, including but not limited to documentation in the LTCP and the District of Columbia Department of Health's analysis and interpretation of its water quality standards, WASA has demonstrated, pursuant to Section II.C.4.b of the 1994 CSO Policy, that the CSO control program will not preclude the attainment of water quality standards or the receiving waters' designated uses or contribute to their impairment." The Fact Sheet further provides that this determination is subject to post-construction monitoring adequate to verify compliance with water quality standards, in accordance with Section II.C.4.b and II.C.9 of the CSO Policy;

WHEREAS, since WASA is unable to comply with the water quality based CSO effluent limits in the Phase II conditions of its NPDES Permit until such time as it has completed implementation of the CSO controls in its LTCP, the Parties have agreed to enter into this Consent Decree to establish a judicially enforceable schedule for implementation of the CSO controls in the LTCP;

WHEREAS, WASA contends that, pursuant to Section 202 of its enabling legislation, which provides, with certain exceptions not applicable here, that WASA is subject to all laws applicable to offices, agencies, departments, and instrumentalities of the District government, WASA is subject to the requirements of the Anti-Deficiency Act, 31 U.S.C. §§1341 et seq., to the same extent as other agencies of the District of Columbia;

WHEREAS, the Parties agree, without adjudication of facts or law, that settlement of this matter in accordance with the terms of this Consent Decree is in the public interest and have agreed to entry of this Consent Decree without trial of any issues, and the Parties hereby stipulate that, in order to resolve the claims for alleged violations of water quality standards stated in the Complaint of the United States, and to provide for compliance with the water quality-based effluent CSO limits in WASA's modified NPDES permit, this Consent Decree should be entered;

WHEREAS, the Court, upon consideration of the judicial record before it and review of this Consent Decree, also finds that settlement of this matter and entry of this Consent Decree is fair and in the public interest and will address the underlying causes of the violations. The Court also finds that it should exercise continuing jurisdiction over this matter to resolve disputes and, should the need arise, to modify the obligations in this Consent Decree;

AND WHEREAS, settlement and entry of this Consent Decree does not constitute an admission of liability by WASA or the District of Columbia;

NOW THEREFORE, before taking any testimony, and without any adjudication of any fact or law, it is hereby ORDERED, ADJUDGED, and DECREED as follows:

I. JURISDICTION AND VENUE

1. This Court has jurisdiction over the subject matter of this action, and over the Parties hereto, pursuant to Sections 309 and 505 of the Clean Water Act, 33 U.S.C. §§ 1319, 1365 and 28 U.S.C. §§ 1331, 1345, 1355, and 1367. Venue is proper in the District of Columbia pursuant to Section 309 of the Clean Water Act, 33 U.S.C. § 1319, and 28 U.S.C. §§ 1391 and

1395(a).

II. APPLICATION AND SCOPE

2. The provisions of this Consent Decree shall apply to and be binding upon the Parties to this action, and their agents, employees, successors and assigns, as well as to all persons acting under the direction and/or control of WASA, including firms, corporations, and third parties such as contractors.

3. WASA shall provide a copy of this Consent Decree to any consultant and contractor selected or retained to perform any activity required by this Consent Decree.

4. No later than thirty (30) days prior to transfer of any ownership interest, operation, management, or other control of the CSS, WASA shall give written notice and provide a copy of this Consent Decree to any such transferee or successor in interest. WASA shall require, as a condition of any such sale or transfer, that the purchaser or transferee agree in writing to be bound by this Consent Decree and submit to the jurisdiction of this Court for its enforcement. WASA shall also notify, in writing, EPA Region III, the United States Attorney for the District of Columbia, and the United States Department of Justice, in accordance with Section XXI (Form of Notice) of this Consent Decree, of any such planned transfer at least thirty (30) days prior to the transfer.

III. OBJECTIVES

5. It is the express purpose of the Parties in entering this Consent Decree to further the objectives of the Act, as enunciated at Section 101 of the Act, 33 U.S.C. §§ 1251 et seq. All plans, reports, construction, and other obligations in this Consent Decree or resulting from the

activities required by this Consent Decree shall have the objective of achieving full compliance with the Clean Water Act, all applicable Federal and local regulations, and the terms and conditions of WASA's NPDES Permit, and to meet the objectives of U.S. EPA's April 19, 1994 CSO Policy.

IV. DEFINITIONS

6. Unless otherwise defined herein, the terms used in this Consent Decree shall have the meaning given to those terms in the Clean Water Act, 33 U.S.C. §§ 1251 et seq., the regulations promulgated thereunder, and EPA's 1994 CSO Policy.

7. The following terms used in this Consent Decree shall be defined as follows:

"Blue Plains" means the District of Columbia advanced wastewater treatment plant at Blue Plains.

"Collection System" means both the separate sanitary sewer and combined sewer systems within the District of Columbia.

"Combined Sewer Collection System" or "CSS" means the pipelines, pumping stations, treatment facilities and appurtenances in the District of Columbia which are designed to convey wastewaters and stormwater through a single pipe system to combined sewer overflow outfalls and/or treatment works. It includes the CSS and CSO facilities described in the NMC Report, as well as any future additions or modifications required by this Consent Decree and the Partial Consent Decree.

"Combined Sewer Overflow" or "CSO" means a discharge from the CSS at a CSO outfall designated in the Permit.

"Consolidation" or "Outfall Consolidation" means elimination of a CSO permitted outfall by routing the discharge so that it is joined with one or more other outfalls, or by connecting it with a storage/conveyance tunnel. Consolidation of outfalls does not reduce the volume of the overflow but does allow its location to be changed.

"Contract Award" or "Award Contract" means the date on which a contract is signed by both WASA and the other party to the contract.

"Construction" means the act of building a facility.

"1994 CSO Policy" means EPA's April 19, 1994 CSO Control Policy, published at 59 Fed. Reg. 18,688, and incorporated into the Clean Water Act pursuant to the Wet Weather Water Quality Act, Section 402(q) of the Clean Water Act, 33 U.S.C. § 1342(q).

"Detailed Design" means the final stage of preparing contract documents to be used to receive bids for construction of a facility.

"Excess Flow Treatment Facilities" means those facilities at Blue Plains providing treatment to influent flows in the east primary treatment facilities followed by chlorination and dechlorination with discharge from Outfall 001. Influent flows receive screening and grit removal prior to receiving excess flow treatment.

"Facility Plan" or "Facility Planning" means preparing an engineering study to develop additional definition of the Selected CSO Controls as may be necessary for preliminary design. Examples of Facility Planning activities include, but are not limited to, planning level geotechnical investigations, developing proposed alignments for the tunnels, identifying land acquisition and required approvals, establishing bases for design, establishing system hydraulics, siting shafts, regulators and pumping stations, and other elements needed to define the function and interaction of the Selected CSO Controls in the LTCP.

"Long Term Control Plan" or "LTCP" means the plan for controlling CSOs from WASA's CSS that was prepared by WASA pursuant to the 1994 CSO Policy and submitted to EPA as a final report in August, 2002, and all supplements thereto.

"Low Impact Development" or "LID" means design and techniques that store, infiltrate, evaporate and detain runoff, to mimic predevelopment site hydrology. LID has the potential to reduce both the volume of storm water generated by a site and its peak overflow rate, thereby improving the quality of the storm water. Low Impact Development Retrofit refers to the modification of an existing site to accomplish LID goals. In this Decree, LIDR will refer to both techniques or technologies.

"MGD" means million gallons per day.

"NMC Report" means the report entitled District of Columbia Water and Sewer Authority, EPMC III-Sewer System, "Combined Sewer System Nine Minimum Controls Summary Report", Draft, July 1999 (Engineering Program Management Consultant III, Greeley and Hansen – Program Manager).

"NPDES Permit" means National Pollutant Discharge Elimination System (NPDES) permit number DC0021199 issued to WASA pursuant to Section 402 of the Clean Water Act, 33 U.S.C. § 1342, and any future, extended, modified or reissued permit.

"Partial Consent Decree" means the Consent Decree in this consolidated action entered by this Court on October 10, 2003, resolving, <u>inter alia</u>, Plaintiffs' claim for failure to implement Nine Minimum Controls.

"Parties" means the United States, WASA and the District of Columbia.

"Person" means an individual, corporation, partnership, association, State, municipality, commission, or political subdivision of a State, or any interstate body.

"Place in Operation" means to achieve steady state operation and to operate consistently in such a way as to accomplish the intended function, even though all construction close-out activities (such as completion of a punchlist and resolution of contract disputes or close-outs) may not yet be completed.

"Required Approvals" means approvals and/or permits required from agencies of the District of Columbia government (other than WASA itself), the federal government or any other governmental or private entity or person.

"Selected CSO Controls" or "Selected Controls" means the controls and projects that comprise the recommended control plan in Section 13 of the LTCP and are enumerated in Section VI of this Decree.

"Separation" or "Sewer Separation" means separation of sewers carrying storm water and sanitary wastes, so that storm water and sanitary wastewater each are conveyed through a separate system of pipes. For those CSO outfalls that are separated in this Decree, the permitted CSO outfall may remain as a discharge point but shall discharge only storm water after its separation.

"Settling Defendants" means WASA and the District of Columbia.

"WASA" means the District of Columbia Water and Sewer Authority and any successors thereto.

V. OVERVIEW

8. The LTCP provides for control of CSO discharges to the Anacostia River, the Potomac River, and to Rock Creek and its Piney Branch tributary. The Selected CSO Controls are comprised of a system of underground storage tunnels and pumping stations designed to reduce the discharge of CSO to the receiving waters and to convey stored combined flow to Blue Plains for treatment. Other elements of the LTCP include LIDR, Sewer Separation, Outfall Consolidation, CSO monitoring, public notification, intercepting sewers, regulator improvements and improvements to Excess Flow Treatment Facilities at Blue Plains.

VI. SELECTED CSO CONTROLS AND SCHEDULES

WASA agrees to and is ordered to implement the following Selected CSO Controls, which shall be operated in accordance with the NPDES Permit and shall have the minimum elements and capacities set forth below. Nothing herein shall be deemed to be inconsistent with the NPDES Permit and, in the event of a conflict, the NPDES Permit shall control.

A. Anacostia River Projects

WASA shall plan, design, and Place in Operation the following projects to control CSO discharges to the Anacostia River, at any time up to but no later than the schedules set forth below, and thereafter to operate them.

9. WASA shall start the Facility Plan for the Anacostia River Projects no later than six (6) months from entry of this Consent Decree. No later than three years and six months from

entry, WASA shall submit to EPA pursuant to Section X of this Consent Decree a summary report and detailed implementation schedule for the Anacostia River Projects. That detailed implementation schedule shall set forth anticipated completion dates for stages of work and shall include appropriate deadlines for filing all applications for all permits that WASA knows will be necessary, and dates for notices to proceed with work and construction starts. Except for the milestones in this Section, the deadlines in the detailed implementation schedule shall serve to track and report progress and shall not be enforceable obligations of this Consent Decree.

10. **Rehabilitation of Main, "O" Street, and Eastside Pumping Stations.** These projects are being implemented pursuant to the requirements of the Partial Consent Decree.

11. **Separate Fort Stanton Drainage Area (Outfall 006).** WASA shall separate the combined sewer area tributary to CSO Outfall 006 on the east side of the Anacostia River, eliminating it as a CSO outfall at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: one (1) year from entry

2) Award Contract for Construction: three (3) years from entry

3) Place in Operation: five (5) years from entry

12. **Fort Stanton Interceptor.** WASA shall design and construct an interceptor pipeline to carry flows from CSO Outfalls 005 and 007 on the east side of the Anacostia to the Storage/Conveyance Tunnel at Poplar Point. The interceptor shall have sufficient capacity to provide the degree of control specified in the LTCP. WASA shall design, construct and Place in Operation this interceptor at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: eight (8) years from entry

2) Award Contract for Construction: eleven (11) years from entry

3) Place in Operation: thirteen (13) years from entry

13. **Storage/Conveyance Tunnel From Poplar Point to Northeast Boundary.** WASA shall construct a Storage/Conveyance Tunnel from Poplar Point to Northeast Boundary which shall store combined sewer flow from the Main and O Street Pumping Station site, the CSOs along the Navy Yard and M Street, and the Northeast Boundary CSO, in accordance with WASA's NPDES Permit. This tunnel will be designed and operated to provide CSO storage and conveyance for CSO Outfalls 004, 009, 010, 011, 011a, 012, 013, 014, 015, 016, 017, 018, and 019 on the west side of the Anacostia River. The storage capacity of the tunnel shall be at least forty nine (49) million gallons. The location of the tunnel shall be finalized during Facility Planning and design but its approximate location is depicted in Page ES-9 of Appendix A. After the tunnel is Placed in Operation, in the event of wet weather causing the tunnels to be used for storage, WASA shall dewater the tunnel to the CSS as soon as practicable, but in no event longer than 59 hours, and shall convey the contents of the tunnel to Blue Plains for treatment in accordance with its NPDES permit. WASA shall plan, design, construct, and Place in Operation the tunnel at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: four (4) years from entry

2) Award Contract for Construction: seven (7) years from entry

3) Place in Operation: thirteen (13) years from entry

14. **Poplar Point Pumping Station.** Under the Partial Consent Decree, WASA is required to make certain interim improvements to the existing Poplar Point Pumping Station. In

addition, WASA shall replace the existing Poplar Point Pumping Station with a new facility which shall include a low lift pumping station and a tunnel dewatering pumping station. The firm wastewater pumping capacity of the low lift pumping station shall be not less than 45 MGD and the tunnel dewatering pumping station shall be capable of dewatering the contents of the Storage/ Conveyance Tunnel at Poplar Point when full within 59 hours. WASA shall design, construct and Place in Operation both the new low lift and dewatering portions of the new pumping station at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: seven (7) years from entry

2) Award Contract for Construction: ten (10) years from entry

3) Place in Operation: thirteen (13) years from entry

15. **Storage/Conveyance Tunnel Parallel to Northeast Boundary Sewer.** WASA shall construct a Storage/Conveyance Tunnel generally parallel to Northeast Boundary Sewer to provide additional storage and conveyance for combined sewer flow and to relieve street and basement flooding in the Northeast Boundary area. The tunnel shall capture and store the combined sewer flow, in accordance with WASA's NPDES permit. After the tunnel is Placed in Operation, in the event of wet weather causing the tunnel to be used for storage, WASA shall dewater the tunnel to the CSS as soon as practicable, but in no event longer than 59 hours, and shall convey the contents of the tunnel to Blue Plains for treatment in accordance with WASA's NPDES permit. The storage capacity of the tunnel shall be at least seventy-seven (77) million gallons. The location of the tunnel will be finalized during Facility Planning and design but its approximate location is depicted in Page ES-9 of Appendix A. Once the tunnel and its

appurtenances are Placed in Operation, discharges to the Northeast Boundary Swirl Facility shall be directed to the tunnel and the Swirl Facility shall be abandoned. WASA shall design, construct and Place in Operation the tunnel at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: ten (10) years from entry

2) Award Contract for Construction: thirteen (13) years from entry

3) Place in Operation: twenty (20) years from entry

16. **Northeast Boundary Side Tunnels.** WASA shall construct side tunnels from the Storage/Conveyance Tunnel in the foregoing paragraph, along West Virginia and Mt. Olivet Avenues, NE and along Rhode Island and 4th St., NE to eliminate basement and street flooding. The location of the tunnels will be finalized during Facility Planning and design but their approximate locations are depicted on Page ES-9 of Appendix A. WASA shall design, construct, and Place into Operation the side tunnels at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: fourteen (14) years from entry

2) Award Contract for Construction: seventeen (17) years from entry

3) Place in Operation: twenty (20) years from entry

17. **Anacostia Outfall Consolidation.** WASA shall consolidate and direct all combined sewer flow from Outfalls 016, 017 and 018 in the vicinity of the Anacostia Marina to the Storage/Conveyance Tunnel from Poplar Point to Northeast Boundary, thus eliminating Outfalls 016, 017 and 018. WASA shall consolidate these outfalls at any time up to, but no later

than the following schedule:

1) Award Contract for Detailed Design: eight (8) years from entry

2) Award Contract for Construction: eleven (11) years from entry

3) Place in Operation: thirteen (13) years from entry

B. <u>Potomac River Projects</u>

WASA shall plan, design, construct, and Place in Operation the following projects on the Potomac River to control CSO discharges to that river, at any time up to but no later than the schedules set forth below, and thereafter to operate them.

18. WASA shall start the Facility Plan for the Potomac River Projects no later than ten years after entry of the Consent Decree. No later than thirteen years from entry, WASA shall submit to EPA pursuant to Section X of this Consent Decree a summary report and detailed implementation schedule for the Potomac River Projects. That detailed implementation schedule shall set forth anticipated completion dates for stages of work and shall include appropriate deadlines for filing all applications for all permits that WASA knows will be necessary, and dates for notices to proceed with work and construction starts. Except for the milestones in this Section VI, the deadlines in the detailed implementation schedule shall serve to track and report progress and shall not be enforceable obligations of this Consent Decree.

19. **Rehabilitation of the existing Potomac Pumping Station.** The existing Potomac Pumping Station is being rehabilitated pursuant to the Partial Consent Decree in this consolidated action.

20. **Potomac Tunnel Dewatering Pumping Station.** WASA shall construct a new

tunnel dewatering pump station that will be capable of dewatering the contents of the Potomac Storage/Conveyance Tunnel when full within 59 hours. WASA shall design, construct and Place into Operation the new dewatering pump capability at any time up to, but no later than the following schedule.

1) Award Contract for Detailed Design: fifteen (15) years from entry

2) Award Contract for Construction: eighteen (18) years from entry

3) Place in Operation: twenty (20) years from entry

21. **Potomac Storage Tunnel.** WASA shall construct a Potomac Storage/Conveyance Tunnel which shall store combined sewer flow from the Georgetown CSOs and the large CSOs downstream of Rock Creek [CSO Outfalls 020, 021, 022, 024, 025, 026, 027, 028, and 029] in accordance with WASA's NPDES Permit. The storage capacity of the tunnel will be at least fifty-eight (58) million gallons, unless the tunnel capacity is adjusted to take into account the effects of LIDR as set forth in Section IX. The location of the tunnel will be finalized during facility planning and design but its approximate location is depicted on Page ES-9 of Appendix A. After the tunnel is Placed in Operation, in the event of wet weather causing the tunnel to be used for storage, WASA shall dewater the tunnel to the CSS as soon as practicable, but in no event longer than 59 hours, and will convey the contents of the tunnel to Blue Plains for treatment in accordance with WASA's NPDES permit. WASA will design, construct and Place into Operation the tunnel at any time up to, but no later than the following schedule:

1) Award Contract for Design: thirteen (13) years from entry

2) Award Contract for Construction: sixteen (16) years from entry

3) Place in Operation: twenty (20) years from entry

22. **Outfall Consolidation.** WASA shall consolidate and direct all combined sewer flow from CSO Outfalls 024, 025, 026, 027 and 028 in the Georgetown waterfront area to the Potomac Storage/Conveyance Tunnel, thus eliminating CSO Outfalls 024, 025, 026, 027 and 028, at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: thirteen (13) years from entry

2) Award Contract for Construction: sixteen (16) years from entry

3) Complete Consolidation and Eliminate Outfalls: twenty (20) years from entry

C. **Rock Creek Projects**

WASA shall plan, design, construct, Place in Operation and operate the following projects on Rock Creek to control CSO discharges, at any time up to but no later than the schedules set forth below, and thereafter to operate them.

23. WASA shall start the Facility Plan for the Rock Creek Projects no later than eleven years after entry of the Consent Decree. On or before fourteen years from entry, WASA shall submit to EPA pursuant to Section X of this Consent Decree a summary report and detailed implementation schedule for the Rock Creek Projects. That detailed implementation schedule shall set forth anticipated completion dates for stages of work and shall include appropriate deadlines for filing all applications for all permits that WASA knows will be necessary, and dates for notices to proceed with work and construction starts. Except for the milestones in this Section VI, the deadlines in the detailed implementation schedule shall serve to track and report

progress and shall not be enforceable obligations of this Consent Decree.

24. **CSO Outfall Separation.** WASA has certified pursuant to the Partial Consent Decree that it has separated the Luzon Valley CSS tributary to CSO Outfall 059. WASA shall separate the combined sewer areas tributary to CSO outfalls 031, 037, 053 and 058. The separation shall eliminate them as CSO outfalls, at any time up to, but no later than the following schedule:

1) Award of Contract for Detailed Design: two (2) years from entry

2) Award of Contract for Construction: four (4) years from entry

3) Complete Separation: six (6) years from entry

25. **Monitoring at CSO Outfalls 033, 036, 047 and 057.** WASA represents that it has conducted hydraulic monitoring at CSO Outfalls 033, 036, 047 and 057 to obtain data to further characterize the overflows on Rock Creek, including their frequency and volume. On or before thirty (30) days from entry of this Decree, WASA shall provide the monitoring data to EPA. EPA will review such data and determine whether it is sufficient for the characterization. If EPA concludes the monitoring data is sufficient, it will so advise WASA in writing. If EPA requires additional data or information, it will advise WASA in writing as to what further sampling or information is required. Within sixty (60) days of receipt of such written notification, WASA shall proceed to perform the additional monitoring to provide such additional information to EPA.

26. If the monitoring confirms the predictions of WASA's model for the LTCP – i.e., that overflows occur relatively infrequently in a range of one to six times per year and in

relatively small amounts – regulator improvements shall be implemented to control overflows to Rock Creek and relief of the Rock Creek Main Interceptor shall be obtained by connecting the interceptor to the Potomac Storage Tunnel. If the monitoring shows that the regulator modifications required will cause surcharging in the Rock Creek Interceptor, WASA shall design a relief interceptor parallel to the Rock Creek Interceptor, or other project to provide relief to the interceptor or to provide control of overflows to the degree specified in WASA's NDPES Permit.

27. Within six (6) months of EPA's written notice that the monitoring already performed by WASA is sufficient, or upon completion of any additional monitoring or provision of additional information, WASA shall submit to EPA for approval a report identifying the results of the monitoring and justifying which of the foregoing alternatives it selects, including a schedule for award of contract for design, award of contract for construction and placing the projects into operation that shall be no longer than six years following EPA approval. That schedule shall be incorporated into this Decree by reference and WASA shall commence to implement the plan within 90 days of EPA approval. WASA shall place into operation the alternative that it selected in no more than six (6) years.

28. **Piney Branch Storage Tunnel.** WASA shall construct a Rock Creek Storage/Conveyance Tunnel which shall store the combined sewer flow from the Piney Branch CSO, Outfall 049, in accordance with WASA's NPDES Permit. The storage capacity of the tunnel will be at least nine and one-half (9.5) million gallons, unless the tunnel capacity is adjusted to take into account the effects of LIDR as set forth below. WASA shall design the tunnel to fill and dewater by gravity in 59 hours or less when full. After the tunnel is Placed in

Operation, in the event of wet weather causing the tunnel to be used for storage, WASA shall dewater the tunnel to the CSS as soon as practicable, but in no event longer than 59 hours, and shall convey the contents of the tunnel to Blue Plains for treatment in accordance with WASA's NPDES permit. The location of the tunnel will be finalized during Facility Planning and design but it will be between CSO 049 and Rock Creek and its approximate location is depicted in Page ES-9 of Appendix A. WASA shall plan, design, construct and Place in Operation the tunnel at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: fourteen (14) years from entry

2) Award Contract for Construction: seventeen (17) years from entry

3) Place in Operation: twenty (20) years from entry

D. **Blue Plains Wastewater Treatment Plant Projects**

WASA shall plan, design, construct, Place in Operation and operate the following projects at Blue Plains, at any time up to but no later than the schedules set forth below.

29. **Excess Flow Improvements.** WASA shall make the following improvements to the existing Excess Flow Treatment Facilities at Blue Plains in order to insure availability and improve the reliability of the full 336 MGD excess flow treatment capacity (Outfall 001) at all times: 1) Construct four additional primary clarifiers on the east side of the plant to decrease loadings on the existing clarifiers and to improve reliability by providing redundancy; 2) lengthen the weir on the Excess Flow Chlorine Contact Tank to reduce head loss through the system; 3) replace the influent sluice gates on the Excess Flow Chlorine Contact Tank with motor operated butterfly valves to improve system control; 4) incorporate a control system (and

possibly variable speed drives) into the rehabilitation of Raw Wastewater Pump Station No. 2 to improve control of wet well levels at the plant; and 5) install automated controls to facilitate record keeping, time keeping and communications during excess flow events. WASA shall make and Place in Operation said improvements at any time up to, but no later than the following schedule:

1) Award Contract for Detailed Design: four (4) years from entry

2) Award Contract for Construction: seven (7) years from entry

3) Place in Operation: eleven (11) years from entry

E. **Public Notification:**

30. A visual notification system shall be installed as part of the construction of the tunnel storage projects for the Anacostia River, the Potomac River and for Rock Creek. The system shall be installed at a minimum of three locations on each receiving water at public access locations. The system shall be designed to notify the public of the occurrence of overflows based on flow monitoring at representative CSO outfalls on each receiving water. The system shall comprise a series of colored lights, flags or pendants that shall operate as follows:

a. Color A shall be displayed as long as flow is detected from the representative outfall;

b. Other colors shall be displayed based on the overflow volume from the representative outfall. There shall be two levels of notification: one for an event with a probable impact of less than 24 hours, and another for a longer event;

c. For an event with a probable impact of less than 24 hours, Color B shall be displayed for 24 hours after flow is no longer detected from the representative outfall;

d. For an event with a probable impact of more than 24 hours, Color C shall be displayed for 72 hours after flow if no longer detected from the representative outfall;

e. When operational, the visual notification system shall be described and explained on WASA's web site.

31. WASA shall finalize the details of the public notification system (e.g., selection of representative outfalls, locations, warning devices, and colors) during Facility Planning for each receiving water. WASA shall submit its plan with the final details to EPA for approval pursuant to Section X.

32. The foregoing visual notification Section shall be in addition to the obligations imposed regarding public notification in the Partial Consent Decree.

VII. MODIFICATIONS TO SELECTED CSO CONTROLS AND SCHEDULES

33. Defendants agree that the 20 year implementation schedule and the work set forth in Section VI are feasible and equitable, based on current information, assumptions and financial and other projections. Some of the information currently available to WASA and its current assumptions and projections are set forth in, inter alia, the LTCP appended at Appendix A. WASA's current financial assumptions and projections for the 20 year implementation schedule are set forth in, inter alia, Appendix B.

34. The Parties recognize that the information currently available to WASA as well as WASA's current assumptions and projections may change during implementation of the Selected CSO Controls. The schedule and/or the Selected CSO Controls in Section VI may be modified

based on a significant change in the information currently available to WASA or WASA's current assumptions or projections, whether or not such change is anticipated, that renders the Consent Decree no longer feasible and equitable. Unless the Parties otherwise agree, a request for modification shall not relieve WASA of its obligations pursuant to Section VI and WASA shall continue with implementation of the Selected CSO Controls until the request for modification is either agreed to by the Parties, approved by the Court, or ruled on by the Court under Section XXII of this Decree. Any dispute as to whether or not implementation of the Selected CSO Controls should continue during the pendency of the modification request shall not be subject to judicial review or to dispute resolution.

35. The United States on behalf of EPA has accepted the Selected CSO Controls and the 20 year schedule. Appendices A and B are not stipulations, however, and the United States reserves its right to disagree or to contest particular statements or facts contained therein. In the event that WASA seeks a modification to extend the schedule based upon a significant increase in costs or other changes in financial circumstances, WASA shall provide to EPA an update of the information contained in Appendix B and, at EPA's request, an update of the key financial variables listed at Appendix C.

36. The failure of WASA and/or the District to seek, approve, or enact timely and adequate rate changes or to obtain bond or other financing to implement the work according to the schedule contained herein based on current information, assumptions and projections shall not constitute a significant change in circumstances under this Section nor shall such failure by itself justify any change in or reassessment of the interim milestones or the 20 year schedule in

this Decree.

37. **Grant Funding.** The schedules contained herein assume no federal appropriations, grants, or funding from sources other than WASA, for performance of the work described in Section VI. In the event that WASA receives grant funding from federal or other sources for such work, it shall report to EPA in writing the source, amount, and timing of any such grant funding when it learns that it will be appropriated or otherwise received. WASA has the option but is not required to accelerate the schedule contained in Section VI based on grant funding.

38. Modifications made pursuant to this Section shall follow the procedures set forth in Section XXII (Modification) of this Decree.

39. In the event that WASA, after consultation with the District, requests a modification to the schedule or to the Selected CSO Controls, and the United States does not agree to the proposed modification, WASA and/or the District may invoke the dispute resolution procedures of Section XIV of the Decree.

40. If WASA, after consultation with the District, requests a modification because it has decided that it needs to rebid a contract to construct a project, and if WASA has made best efforts to communicate with the appropriate personnel at EPA Region 3 to obtain a response to a request for modification, and has promptly responded to any requests for information from EPA Region 3 related to the requested modification, but EPA does not act on the request for modification within sixty (60) days after receiving the modification request, WASA may initiate informal dispute resolution and issue a notice of the dispute under the dispute resolution

procedures. For all other requests for modification, if WASA has made best efforts to communicate with the appropriate personnel at EPA Region 3 to obtain a response to a request for modification, and has promptly responded to any requests for information from EPA Region 3 related to the requested modification, but EPA does not act on the request for modification within one hundred twenty (120) days after receiving the modification request, WASA may initiate informal dispute resolution and issue a notice of the dispute under the dispute resolution procedures.

41. Compliance with the terms of this Decree is not conditioned upon the receipt of federal or state grant funds and WASA's failure to comply is not excused by the lack of federal or state grant funds, or by the processing of any applications for the same, subject solely to a force majeure event due to the Anti-Deficiency Act provisions in Section XIII (Force Majeure).

VIII. CONTROL SYSTEM COMPLIANCE AND POST-CONSTRUCTION MONITORING

A. **Individual Construction Project Certification.** Within sixty (60) days of Placing in Operation each project required under Section VI, WASA shall certify under Section XX (Certification) that such project has been designed, constructed and will be operated in accordance with the terms of this Consent Decree and its NPDES permit.

B. **Post-construction monitoring.**

42. When the Selected Controls set forth in Section VI have been Placed in Operation, WASA shall comply with the post-construction monitoring program set forth in its NPDES permit.

IX. LOW IMPACT DEVELOPMENT RETROFIT

43. WASA shall promote LIDR in the District of Columbia by performing projects as set forth in this Section. Such projects shall constitute additional work which WASA agrees to perform in addition to the injunctive relief set forth in Section VI.

44. As set forth in the LTCP, WASA shall incorporate LIDR techniques into new construction or reconstruction on WASA facilities for demonstration projects up to a total expenditure of $3 million and shall maintain the LIDR projects for at least five (5) years after each project is Placed into Operation. WASA shall monitor such projects to obtain data regarding the effectiveness of LIDR in reducing run-off reaching combined sewers and surface waters. These LIDR projects shall be in addition to those constructed as a Supplemental Environmental Project or financed as a Citizen Environmental Project pursuant to the Partial Consent Decree.

45. WASA shall submit a plan to EPA for approval and a schedule for implementing and monitoring LIDR on its own property within two (2) years from entry of this Decree. WASA shall Place in Operation all LIDR projects within six (6) years from approval of that plan by EPA. WASA shall monitor the LIDR projects for twelve (12) months after Placing in Operation all LIDR facilities.

46. WASA shall review the results of demonstration projects on its own property, other current LID and LIDR information and data from other projects in the District and elsewhere as part of its design of the Storage/Conveyance Tunnels for Rock Creek and for the Potomac River set forth in Section VI of this Consent Decree. Its design of those tunnels must

take such data into account and address whether the data permit it to reduce the capacity of those tunnels from that set forth in Section VI. It shall submit its review and analysis of the data concerning LIDR and, upon request by EPA, the proposed design for the Storage/Conveyance Tunnels for Rock Creek and for the Potomac River to EPA for approval pursuant to Section X of this Consent Decree.

X. EPA APPROVAL OF PLANS AND SUBMISSIONS

47. After review of any plan, report, or other item that is required to be submitted pursuant to this Consent Decree (with the exception of requests for modification pursuant to Section VII above), EPA shall in writing: (a) approve the submission; (b) approve the submission upon specified conditions; (c) approve part of the submission and disapprove the remainder; or (d) disapprove the submission.

48. If the submission is approved, WASA shall take all actions required by the plan, report, or other item, as approved. If the submission is conditionally approved or approved only in part, WASA shall, upon written direction of EPA, take all actions required by the approved plan, report, or other item that EPA determines are technically severable from any disapproved portions, subject to WASA's right to dispute only the specified conditions or the disapproved portions, under Section XIV of this Decree (Dispute Resolution).

49. If the submission is disapproved in whole or in part, WASA shall, within 45 days or such other time as the Parties agree in writing, correct all deficiencies and resubmit the plan, report, or other item, or disapproved portion thereof, for approval. Any Stipulated Penalties applicable to the original submission, as provided in Section XII (Stipulated Penalties) of this

Decree, shall accrue during the 45-day period or other specified period, but shall not be payable unless the resubmission is untimely or is disapproved in whole or in part; provided that, if the original submission was so deficient as to constitute a material breach of WASA's obligations under this Decree, the Stipulated Penalties applicable to the original submission shall be due and payable notwithstanding any subsequent resubmission.

50. If a resubmitted plan, report, or other item, or portion thereof, is disapproved in whole or in part, EPA may again require WASA to correct any deficiencies, in accordance with the preceding Paragraphs, subject to WASA's right to invoke Dispute Resolution and the right of EPA to seek Stipulated Penalties, as provided in the preceding Paragraphs.

XI. REPORTING

51. Progress reports are to be provided at quarterly intervals for all milestone events one year or longer in duration. Each progress report shall summarize the status and progress of work required for completion of the next milestone and the impact of any delays on completion of said milestone, and shall be submitted on the 28th day of the month following each calendar quarter.

52. Beginning with the first CSO Quarterly Report due after entry of this Consent Decree, and for every calendar quarter thereafter until this Consent Decree terminates in accordance with Section XXVI, (Termination), below, WASA shall submit written status reports to U.S. EPA, certified pursuant to Section XX, and post them on the WASA website. In each report, WASA shall provide the following:

a. a statement setting forth the deadlines and other terms that WASA is required by this Consent Decree to meet since the date of the last quarterly statement, whether and to what extent WASA has met these requirements, and the reasons for any noncompliance;

b. a statement tracking WASA's progress against the detailed implementation schedules required to be submitted under Section VI upon the completion of Facility Planning for each receiving water, whether there have been any delays, the reasons for the delays, and the actions WASA is taking or intends to take to overcome the delays.

c. a general description of the work completed within the three-month period, and a projection of work to be performed pursuant to this Consent Decree during the next three-month period. Notification to U.S. EPA of any anticipated delay shall not, by itself, excuse the delay.

XII. STIPULATED PENALTIES

53. WASA shall be liable for stipulated penalties for the failure to satisfactorily achieve the deadline for the start of Facility Planning, submission of a detailed implementation schedule and summary report on Facility Planning, Award of Contract for Detailed Design and the Award of Contract for Construction in Section VI, as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1st to 30th Day	$ 500
31st to 59th Day	$ 1,000
60th day until submitted	$ 1,500

54. WASA shall be liable for stipulated penalties for the failure to satisfactorily Place in Operation any of the required projects by the final deadline set forth for that project in the schedules in Section VI, as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1st to 30th Day	$ 1,000
31st to 59th Day	$ 2,000
After 60 Days	$ 5,000

55. WASA shall be liable for stipulated penalties for each failure to properly perform the CSO monitoring required in its NPDES Permit after the Selected Controls are Placed in Operation, as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1st to 30th Day	$ 1,000
31st to 59th Day	$ 2,000
60th day until submitted	$ 2,500

56. WASA shall be liable for stipulated penalties for failure to timely submit any progress or completion report required in Section XI (Reporting) , as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1st to 30th Day	$ 500
31st to 59th Day	$ 1,000
60th day until submitted	$ 2,000

57. Other Violations: If WASA fails to comply with a requirement or provision of this Decree not expressly listed above, it shall be liable for stipulated penalties as follows:

Period of Noncompliance	Penalty Per Day Per Violation
1st to 30th Day	$ 500

31st to 59th Day	$ 1,000
60th day until submitted	$ 2,000

58. General Provisions. Stipulated civil penalties shall automatically begin to accrue on the first day WASA fails to meet any of the schedules required by this Consent Decree or to satisfy any obligation or requirement of this Consent Decree and shall continue to accrue each day until WASA achieves compliance with such schedule, obligation or requirement; provided, however, that if WASA submits an appropriately documented request for modification under Section XXII (Modification) of this Decree 180 days prior to an affected deadline or compliance date, and EPA does not act on such request for modification prior to the deadline or compliance date, stipulated penalties shall not accrue for WASA's failure to satisfy the deadline or compliance date until EPA's approval or disapproval. This provision shall not apply if WASA does not have a reasonable basis to make the request for modification or if the request is made for purposes of delay. In the event EPA approves or disapproves WASA's request for modification after passage of the affected deadline or compliance date, stipulated penalties shall begin to accrue from the time EPA acts on the request for modification.

59. Failure to Meet Award of Construction Contract Deadlines Due to Rebidding. If WASA elects to rebid a construction contract for a project described in Section VI, it may request a modification under Section VII. In the alternative, WASA may rebid and elect to have any stipulated penalties for failure to meet the Award of Construction Contract deadline due and owing but to defer their payment. If WASA meets its deadline for Placing in Operation the specific project for which penalties were deferred, stipulated penalties for failure to meet the

deadline for Award of Construction Contract will be excused. If WASA fails to meet the deadline for Placing in Operation the specific project for which penalties were deferred, stipulated penalties for the failure to meet both the Award of Construction Contract and the Placing in Operation deadlines will be due and payable on demand by the United States. When WASA elects a deferral of stipulated penalties for failure to meet an Award of Construction deadline due to rebidding a project, it shall give written notice to EPA that it intends to rebid the project and to defer stipulated penalties. When it awards the contract for construction of that project, WASA shall so notify EPA and advise it in writing of the amount of stipulated penalties accrued pursuant to Section XII that are due and owing but deferred.

60. Stipulated civil penalties shall be paid within thirty (30) days of the date of a demand for payment of stipulated civil penalties for any non-compliance with any of the schedules of performance or requirements set forth in this Consent Decree.

61. In the event that a stipulated penalty is not paid according to the instructions in a written demand from the United States, the stipulated civil penalty shall be payable with interest from the original due date to the date of payment, at the statutory judgment rate set forth at 28 U.S.C. § 1961(a).

62. Stipulated civil penalties shall be paid electronically or by submitting a certified or cashier's check payable to "Treasurer, the United States of America," and tendered to the United States Attorney for the District of Columbia. Simultaneously, WASA shall send copies of the certified or cashier's check, together with a letter describing the basis for the penalties, to Chief, Environmental Enforcement Section, United States Department of Justice, Post Office

Box 7611, Ben Franklin Station, Washington, D.C. 20044, and to Section Chief, Compliance and Enforcement Branch, Water Protection Division, US EPA Region 3, 1650 Arch Street, Philadelphia, PA 19103. The transmittal letter shall reference the caption, the civil action number, and DOJ Number 90-5-1-1-07137.

63. Payment of stipulated civil penalties as set forth above shall be in addition to any other rights or remedies which may be available to the United States or its agencies by reason of WASA's failure to comply with the requirements of this Consent Decree and all applicable Federal, state or local laws, regulations, wastewater discharge permit(s) and all other applicable permits. Where a violation of this Consent Decree is also a violation of such laws, regulations, or permits, WASA shall be allowed a credit, in the amount of any Stipulated Penalties paid, as a set-off against any statutory penalties imposed for such violation.

64. If WASA invokes dispute resolution and the Court resolves the dispute against WASA, stipulated penalties which have accrued during the pendency of the dispute shall be payable, as set forth herein, upon resolution of the dispute; provided, however, that in the event that the Director of the Water Protection Division requires more than sixty (60) days to issue a final agency decision concerning the dispute, WASA shall be liable only for sixty (60) days of stipulated penalties for the period from submission of the Statements of Position until issuance of the final agency decision, as set forth in Section XIV (Dispute Resolution). Stipulated penalties shall begin to accrue again upon issuance of the final agency decision.

XIII. FORCE MAJEURE

65. "Force Majeure" for the purposes of this Consent Decree is defined as an event

arising from causes beyond the control of WASA or the control of any entity controlled by WASA, including its consultants and contractors, which delays or prevents the performance of any obligation under this Consent Decree. Nothing in this Section is intended to relieve WASA of its duty to use due diligence to complete the requirements of this Consent Decree in a timely manner or of WASA's obligation to meet all discharge limitations and other obligations contained in WASA's NPDES Permit. Unanticipated or increased costs or changed financial circumstances are not Force Majeure events, except as provided in Paragraph 67 (Anti-Deficiency Act) below, although in certain instances they may constitute the basis for a request for modification pursuant to Section VII.

66. **Permitting:** Failure to apply for a required permit or approval, or to provide in a timely manner all information required to obtain a permit or approval necessary to meet the requirements of this Consent Decree, are not Force Majeure events. However, failure of a permitting authority to issue a necessary permit in a timely fashion is an event of Force Majeure where the failure of the permitting authority to act is beyond the control of WASA and WASA demonstrates that it has taken all steps available to it to obtain the necessary permit, including but not limited to:

a. Promptly providing reasonably known permitting authorities with copies of this Consent Decree, when lodged, as well as briefing each such authority, both orally and with written materials if necessary, on the projects and schedules contained therein in order to coordinate permitting submittals and approvals;

b. submitting a complete permit application within two (2) months of the date identified in the detailed implementation schedule to apply for permits that are known to be required, and in a prompt fashion for those permits not known to be required or previously identified in the schedule;

c. responding to requests for additional information by the permitting authority in a timely fashion;

d. making regular inquiry, approximately every 45 days, both verbally and in writing, with the permitting authority after initial or supplemental permit filings, to determine the status of the permit application;

e. seeking relief from higher management officials within the permitting authority where permit processing delays threaten to cause noncompliance with any deadline in this decree;

f. accepting lawful permit terms and conditions; and

g. prosecuting appeals of any unlawful terms and conditions imposed by the permitting authority in an expeditious fashion.

67. **Anti-Deficiency Act Events:** Nothing in this Decree shall be construed to require an expenditure, obligation or contract in violation of the Anti-Deficiency Act, 31 U.S.C. §§ 1341 et seq. Where an expenditure, obligation or contract is subject to the Anti-Deficiency Act, WASA's obligations shall be subject to the availability of appropriated funds as follows:

(a) WASA must initially identify the portion of its budget that is comprised of appropriated funds, identify the other components of its funding, and demonstrate why the unavailability of the appropriated funds will delay specific obligations;

(b) To the extent made necessary by lack of appropriated funds, WASA may obtain deferral of compliance with an obligation of this Consent Decree until its next annual budget cycle if, within sixty (60) days after WASA knew or should have known of the event described in Paragraph 68 below, it provides in writing to EPA Region III a statement which shows the following:

(i) That it included in its annual budget, which accompanies the District of Columbia budget submitted to the President for transmission to the Congress pursuant to Section 466 of the D.C. Self-Government and Governmental Reorganization Act, D.C. Code Sec. 47-304 (1990), sufficient money to carry out such objective;

(ii) That it made diligent efforts to obtain Congressional enactment of that part of the budget act;

(iii) That it expressly identified in the annual fiscal year adopted budget prepared for Congressional use such obligation (not necessarily to include reference to this Decree as such) together with the amount of money tied to performing such obligation; and

(iv) That Congress acted expressly to eliminate such amount of money or to reduce it below the level necessary to perform the obligation, or that Congress made an across the board reduction in WASA's appropriation as shown in WASA's adopted budget without expressly saving such obligation and the across the board reduction, as applied proportionately to the amount of money shown in the adopted budget for such obligation, left an insufficient amount to carry out that obligation.

68. **General Requirements:** When circumstances are occurring or have occurred

which may delay the completion of any requirement of this Consent Decree, whether or not due to a Force Majeure event, WASA shall so notify EPA, in writing, within fifteen (15) days after WASA knew, or should have known, of the delay or anticipated delay. The notice shall describe in detail the bases for WASA's contention that it experienced a Force Majeure delay, the anticipated length of the delay, the precise cause or causes of the delay, the measures taken or to be taken to prevent or minimize the delay, and the timetable by which those measures will be implemented. Failure to so notify the United States shall constitute a waiver of any claim of Force Majeure as to the event in question.

69. If the United States finds that a delay in performance is, or was, caused by a Force Majeure event, it shall extend the time for performance, in writing, for a period to compensate for the delay resulting from such event and stipulated penalties shall not be due for such period. In proceedings on any dispute regarding a delay in performance, the dispute resolution provisions of Section XIV shall apply and WASA shall have the burden of proving that the delay is, or was, caused by a Force Majeure event, and that the amount of additional time requested is necessary to compensate for that event.

70. Compliance with a requirement of this Consent Decree shall not by itself constitute compliance with any other requirement. An extension of one compliance date based on a particular event shall not automatically extend another compliance date or dates. WASA shall make an individual showing of proof regarding the cause of each delayed incremental step or other requirement for which an extension is sought. WASA may petition for the extension of more than one compliance date in a single request.

XIV. DISPUTE RESOLUTION

71. This Court shall retain jurisdiction for the purpose of adjudicating, in the manner provided by this Section, all disputes between WASA and the United States that may arise under the provisions of this Consent Decree. Unless otherwise expressly provided in this Consent Decree, the dispute resolution procedures of this Section shall be the exclusive mechanism to resolve disputes arising under or with respect to this Consent Decree. However, the procedures set forth in this Section shall not apply to actions by the United States to enforce obligations of WASA that have not been disputed in accordance with this Section.

72. Permit actions pursuant to 40 C.F.R. Part 124, including issuance, denials, and modifications, shall not be subject to this Consent Decree, but rather shall continue to be handled through the administrative and judicial procedures set forth in those regulations.

73. Any dispute which arises under or with respect to this Consent Decree shall in the first instance be the subject of informal negotiations between WASA and the United States. Notice of the dispute shall be provided no later than fourteen (14) days from the date of the circumstances giving rise to the dispute. The period for informal negotiations shall not exceed twenty (20) days from the date of the original notice of the dispute, unless WASA and the United States otherwise agree in writing to extend that period.

74. If the informal negotiations are unsuccessful, the position of the United States shall control unless, within twenty (20) days after the conclusion of the informal negotiation period, WASA invokes the formal dispute resolution procedures of this Section by serving on the United States a written Statement of Position on the matter in dispute, which shall set forth the

nature of the dispute with a proposal for its resolution as well as any factual data, analysis or opinion supporting that position and any supporting documentation (including the Long Term Control Plan or portions thereof) relied upon.

75. Within thirty (30) days of the receipt of a Statement of Position, pursuant to this Section, the United States may serve on WASA its own Statement of Position, which may include an alternate proposal for resolution of the dispute as well as any factual data, analysis, or opinion supporting that position and all supporting documentation (including the Long Term Control Plan or portions thereof) relied upon by the United States. Within 15 days after receipt of such Statements, WASA may serve on the United States a Reply.

76. Matters Accorded Record Review: With the exception of modification requests pursuant to Section VII, this Paragraph shall pertain to disputes subject to the procedures of this Section that concerns the adequacy or nature of the work to be performed under Section VI of this Decree, or other matters that are accorded review on the administrative record under applicable principles of administrative law. For matters subject to this Paragraph, WASA shall have the burden of showing that the position of the United States is arbitrary and capricious or otherwise not in accordance with applicable law or this Consent Decree. Plaintiff shall compile an administrative record, which shall consist of the Statements of Position and supporting documentation relied upon (including the LTCP or portions thereof that the parties incorporated into their Statements) and other documents considered and relied upon by EPA in arriving at its final administrative decision. Where appropriate, EPA may allow WASA, the District of Columbia, Citizen Plaintiffs, and/or other members of the public to make supplemental

submissions. The Director of the Water Protection Division shall issue a final administrative decision resolving the dispute based on the administrative record. Stipulated penalties for the period from submission of Statements of Position until issuance of the final administrative decision shall accrue for no more than sixty (60) days, even if EPA issues the final administrative decision after more than 60 days. The final administrative decision shall be effective in ten (10) days, unless WASA may move for judicial review within ten (10) days of its receipt of the final agency decision.

77. Modification Requests: In the case of requests for modification of the Selected CSO Controls and/or schedules pursuant to Section VII, WASA shall bear the burden of demonstrating that the requested modification should be approved in accordance with Section VII of this Consent Decree. EPA's final decision shall be binding on WASA, unless within twenty (20) days of its receipt WASA submits a modification request to the Court. If the Director of the Water Protection Division does not issue a final decision on a request for modification within one hundred twenty (120) days from the date that WASA submits its Reply to the United States' Statement of Position, WASA may elect to move in Court to modify the Consent Decree.

78. Other Matters: In the case of other matters not subject to Paragraphs 76 and 77 above, WASA shall have the burden to demonstrate that its actions or positions were taken in accordance with the terms, conditions, requirements and objectives of this Consent Decree and the Clean Water Act. The Director of the Water Protection Division will issue a final decision resolving the dispute which will be binding on WASA, unless within twenty (20) days of its

receipt WASA serves on the United States a motion for judicial review of the decision setting forth the matter in dispute, the efforts made to resolve it, the relief requested, and the schedule, if any, within which the dispute must be resolved to ensure orderly implementation of this Consent Decree. Stipulated penalties for the period from submission of Statements of Position until issuance of the final administrative decision shall accrue for no more than sixty (60) days, even if EPA issues the final administrative decision after more than 60 days.

79. Where the dispute arises from WASA's request for modification of the Selected CSO Controls and/or schedules pursuant to Section VII, the matter shall not be subject to the principles of record review in Paragraph 76. For other matters, If WASA and the United States disagree as to whether the dispute should proceed under the principles of record review or not, WASA shall follow the procedures determined by EPA to be applicable. Upon appeal, the Court shall determine which procedures are applicable in accordance with the standards set forth in this Section.

80. Submission of any matter to the Court for resolution shall not extend or stay any of the deadlines set forth in this Consent Decree unless the Parties agree to such extension in writing or the Court grants an order extending such deadline(s). Stipulated penalties with respect to the disputed matter shall continue to accrue but payment shall be stayed pending resolution of the dispute as provided in this Section. Notwithstanding the stay of payment, stipulated penalties shall accrue from the first day of noncompliance with any applicable provision of this Consent Decree. In the event that WASA does not prevail on the disputed issue, stipulated penalties shall be assessed and paid as provided in Section XII (Stipulated Penalties).

XV. RIGHT OF ENTRY

81. Commencing upon the date of lodging of this Consent Decree, U.S. EPA and its representatives, contractors, consultants, and attorneys shall have the right of entry into and upon the premises of WASA at all reasonable times, upon proper presentation of credentials, for the purposes of:

(a) Monitoring the progress of activities required by this Consent Decree;

(b) Verifying any data or information required to be submitted pursuant to this Consent Decree;

(c) Obtaining samples and, upon request, splits of any samples taken by WASA or its consultants. Upon request, WASA will be provided with splits of all samples taken by the United States;

(d) Inspecting and evaluating the CSO System;

(e) Inspecting and reviewing any record required to be kept under the provisions of this Consent Decree or any NPDES Permit and the Clean Water Act; and

(f) Otherwise assessing WASA's compliance with this Consent Decree.

82. This Section XV, Right of Entry, in no way limits or affects any right of entry and inspection, or any other right otherwise held by the United States, U.S. EPA and any other governmental entity, pursuant to applicable federal or state laws, regulations.

83. WASA reserves the right to request the laboratory analytical results of samples taken from the CSS by the United States during the term of this Consent Decree, and any non-privileged reports prepared using such results.

XVI. NOT A PERMIT/COMPLIANCE WITH OTHER STATUTES/REGULATIONS

84. This Consent Decree is not and shall not be interpreted to be a permit or modification of any existing permit issued pursuant to Section 402 of the Act, 33 U.S.C. § 1342, nor shall it be interpreted to be such. This Consent Decree does not relieve WASA of any obligation to apply for, obtain and comply with the requirements of any new or existing NPDES permit or to comply with any federal, state or local laws or regulations, including, but not limited to its obligations to obtain a permit for its wastewater treatment and collection system or facilities and to comply with the requirements of any NPDES permit or with any other applicable federal or state law or regulation. Any new permit, or modification of existing permits, must be complied with in accordance with federal and state laws and regulations.

XVII. FAILURE OF COMPLIANCE

85. The United States does not, by its consent to the entry of this Consent Decree, warrant or aver in any manner that WASA's complete compliance with this Consent Decree will result in compliance with the provisions of the Clean Water Act, 33 U.S.C. §§1251 et seq., or with WASA's NPDES permit. Notwithstanding EPA's review or approval of any Scope of Work, report, or plans and specifications, pursuant to this Consent Decree, WASA shall remain solely responsible for any non-compliance with the terms of this Consent Decree, all applicable permits, the Clean Water Act, and regulations promulgated thereunder. The pendency or outcome of any proceeding concerning issuance, reissuance, or modification of any permit shall neither affect nor postpone WASA's duties and obligations as set forth in this Consent Decree.

XVIII. EFFECT OF DECREE AND NON-WAIVER PROVISIONS

86. The Parties agree that this Consent Decree resolves the civil claims for violation of water quality standards and for long-term injunctive relief (Claim One) alleged in the Complaint filed by the United States through the date of lodging of this Decree.

87. The Consent Decree in no way affects or relieves Settling Defendants of any responsibility to comply with any federal, state, or local law or regulation.

88. The Parties agree that WASA is responsible for achieving and maintaining complete compliance with all applicable federal and state laws, regulations, and permits, and that compliance with this Consent Decree shall be no defense to any actions commenced pursuant to said laws, regulations, or permits.

89. The United States reserves the right to file a civil action for statutory penalties or injunctive relief against WASA for any violations of the Clean Water Act by WASA which occur after the date of lodging of this Consent Decree and any such violations occurring prior to that date that are not specifically alleged as Claims for Relief in the Complaints.

90. This Consent Decree does not limit or affect the rights of WASA, the District of Columbia, or the United States as against any third parties which are not parties to this Consent Decree.

91. The Parties reserve any and all legal and equitable remedies available to enforce the provisions of this Consent Decree. This Consent Decree shall not limit any authority of EPA under any applicable statute, including the authority to seek information from WASA or to seek access to the property of WASA, nor shall anything in this Consent Decree be construed to limit the authority of the United States to undertake any action against any person, including WASA,

in response to conditions that may present an imminent and substantial endangerment to the environment or the public health or welfare.

92. Obligations of WASA under the provisions of this Consent Decree to perform duties scheduled to occur after the date of lodging, but prior to the date of entry, shall be legally enforceable from the date of lodging of this Consent Decree. Liability for stipulated penalties, if applicable, shall accrue for violation of such obligations as of the date of violation and payment of such stipulated penalties may be demanded by the United States upon or after entry of this Consent Decree.

93. The United States reserves the right to file a criminal action for statutory penalties or other criminal relief against WASA for any violations by WASA of the Clean Water Act or other applicable federal statutes.

94. It is the intent of the Parties hereto that the clauses hereof are severable, and should any clause(s) be declared by a court of competent jurisdiction to be invalid and unenforceable, the remaining clauses shall remain in full force and effect.

95. The United States reserves all remedies available to it for violations of Federal, State and local law.

XIX. COSTS OF SUIT

96. The Parties shall bear their own costs and attorney's fees with respect to this action and to matters related to this Consent Decree.

XX. CERTIFICATION OF SUBMISSIONS

97. WASA shall maintain copies of any underlying research and data in its

possession, custody or control for any and all documents, scope of work, reports, plans and specifications, or permits submitted to EPA pursuant to this Consent Decree for a period of five (5) years, except that WASA shall not be required to maintain copies of drafts of documents, scope of work, reports, plans and specifications, reports or permits. WASA shall require any independent contractor implementing this Consent Decree to also retain such materials for a period of five (5) years. WASA shall submit such supporting documents to EPA upon request. WASA shall also submit to EPA upon request any other documents that relate to or discuss the operation, maintenance, repair, or construction of the CSO system (or any portion thereof), or that relate to or discuss the number, frequency, volume, quality or environmental impact of CSO discharges. In all notices, documents or reports submitted to EPA pursuant to this Consent Decree, a senior management official of WASA shall sign and certify such notices, documents and reports as follows:

> I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

XXI. FORM OF NOTICE

98. Unless otherwise specified within the terms of this Consent Decree, all reports, notices, or any other written communications required to be submitted under this Consent Decree

shall be sent to the respective parties at the following addresses:

As to the United States:

Department of Justice

Chief, Environmental Enforcement Section
Environment and Natural Resources Division
U.S. Department of Justice
Post Office Box 7611, Ben Franklin Station
Washington, DC 20044
Reference DOJ Case No. 90-5-1-1-07137

United States Attorney
District of Columbia
Judiciary Center
555 Fifth Street NW
Washington, DC 20530

EPA

Director
Water Enforcement Division
Office of Regulatory Enforcement
U.S. Environmental Protection Agency
OECA-ORE-WED
Ariel Rios Building
12th and Pennsylvania Ave, NW
Mail Code 2243A
Washington, DC 20004

Chief
NPDES Branch (3WP31)
Water Protection Division
U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

Yvette Roundtree (3RC20)
Office of Regional Counsel

U.S. Environmental Protection Agency
Region III
1650 Arch Street
Philadelphia, PA 19103

As to WASA:

Jerry N. Johnson or his successor
General Manager
District of Columbia Water and Sewer Authority
5000 Overlook Avenue, SW
Washington, D.C. 20032

Deputy General Manager/Chief Enginner
District of Columbia Water and Sewer Authority
5000 Overlook Avenue, SW
Washington, D.C. 20032

As to the District:

The Attorney General of District of Columbia
One Judiciary Square
441 Fourth Street NW
Suite 600 South
Washington, DC 20001

XXII. MODIFICATION

99. This Consent Decree contains the entire agreement of the Parties and shall not be modified by any prior oral or written agreement, representation or understanding. Prior drafts of this Consent Decree shall not be used in any action involving the interpretation or enforcement of this Consent Decree.

100. The non-material terms of this Consent Decree may be modified by a subsequent written agreement signed by all the Parties. If all the Parties agree to a material modification in writing, they may apply to the Court for approval thereof. If the Parties do not reach agreement

on such material modification, the request for modification shall be subject to the dispute resolution procedures of this Decree. All material modifications shall be in writing and approved by the Court before they will be deemed effective.

101. In the event WASA requests a material modification to the Selected CSO Controls and/or the schedule set forth in Section VI of the Consent Decree, WASA shall arrange for additional public participation prior to submitting the modification request to the United States. WASA shall initially consult with EPA concerning the modification and the scope of public participation to be obtained by WASA prior to submission of a formal request for modification from WASA to EPA.

(a) The proposed modification package shall be submitted to EPA and shall contain the following:

(i) the basis for the modification and the supporting technical and regulatory justification (including if applicable the LTCP or pertinent portions thereof);

(ii) any changes to the Selected CSO Controls and/or to the schedule in Section VI of this Consent Decree, along with any supporting data;

(iii) a demonstration of material compliance with any applicable requirements of the 1994 CSO Policy; and

(iv) a demonstration that public participation has occurred.

(b) If the United States, after consultation with the District of Columbia, agrees to the modification, the proposed changes to the Selected CSO Controls and/or the schedules shall be executed by appropriate officials on behalf of the United States, the District of Columbia, and

WASA and lodged with the Court for a period of public comment prior to entry. If the United States does not agree to the proposed modification, the matter shall be subject to the procedures of Section XIV of this Decree (Dispute Resolution).

XXIII. PUBLIC COMMENT

102. The parties agree and acknowledge that final approval by the United States and entry of this Consent Decree is subject to the requirements of 28 C.F.R. § 50.7, which provides for notice of the lodging of this Consent Decree in the Federal Register, an opportunity for public comment, and consideration by the United States of any comments. This paragraph does not create any rights exercisable by the Settling Defendants, and Settling Defendants shall not withdraw their consent to this Consent Decree between lodging and entry of this Consent Decree and hereby consents to entry of this Decree without further notice.

103. All information and documents submitted by Settling Defendants to U.S. EPA pursuant to this Consent shall be subject to public inspection, unless identified and supported as confidential by WASA in accordance with 40 C.F.R. Part 2.

XXIV. CONTINUING JURISDICTION OF THE COURT

104. The Court shall retain jurisdiction to enforce the terms and conditions of this Consent Decree and to resolve disputes arising hereunder as may be necessary or appropriate for the construction, modification or execution of this Consent Decree.

XXV. APPENDICES

105. Appendix A is the Long Term Control Plan and its Appendices.

106. Appendix B contains WASA's financial assumptions and projections that it sets

forth as its basis for the 20 year implementation schedule in this Consent Decree.

107. Appendix C contains a list of key financial variables to be updated in the event of a request for modification due to changed financial circumstances pursuant to Section VII of this Decree.

XXVI. TERMINATION

108. This Consent Decree shall terminate upon motion of the United States to the Court after each of the following has occurred:

(a) WASA has Placed in Operation all of the construction projects required under Section VI;

(b) WASA has demonstrated that it has achieved and maintained compliance with the water quality based CSO numerical effluent limitations and the performance standards requiring that the Selected CSO Controls be implemented, operated and maintained as described in WASA's NPDES Permit for two years after the Selected CSO Controls are Placed in Operation;

(c) WASA has satisfactorily implemented its LIDR projects and programs as required by Section IX;

(d) WASA has paid all stipulated penalties and any other monetary obligations due hereunder, and no penalties or other monetary obligations due hereunder are outstanding or owed to the United States; and

(e) WASA has certified completion to the United States, and the United States has not contested WASA's completion or compliance.

109. The Consent Decree shall not terminate if, within 90 days of certification by WASA to the United States of compliance pursuant to this Section, the United States asserts in writing that full compliance has not been achieved, or seeks further specific information in order to evaluate WASA's certification. If the United States disputes WASA's full compliance, this Consent Decree shall remain in effect pending resolution of the dispute by the parties or the Court.

110. Notwithstanding Paragraph 109 above, if WASA submits a certification to the United States that it has completed all the requirements in Paragraph 108 above, and the United States does not respond on or before 90 days, WASA may file a motion to the Court seeking termination of this Consent Decree.

XXVII. SIGNATORIES

111. The Assistant Attorney General on behalf of the United States and the undersigned representatives of the Settling Defendants certify that they are fully authorized to enter into the terms and conditions of this Consent Decree and to execute and legally bind such party to this document.

Entered this 23rd day of March, 2005 TFH

Chief Judge, United States District Court

FOR THE UNITED STATES OF AMERICA

Tom Sansonetti

THOMAS L. SANSONETTI
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Environment and Natural Resources Division

John C. Cruden

JOHN C. CRUDEN
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441 Fourth Street, N.W.
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Appendix A

The August, 2002 Long Term Control Plan and its Appendices A through G will be filed in hard copy in lieu of electronic filing, since the Plan exceeds 500 pages and contains numerous graphs, maps, and charts that must be reproduced in color.

APPENDIX B

APPENDIX B

Table 1, attached, presents WASA's financial projections for the impact on sewer rates of the 20-year LTCP implementation schedule as specified in the consent decree. Descriptions of the heading columns in Table 1 are presented below:

Column No.	Heading	Description
1	Year No.	Sequential count of number of years starting in 2004
2	Calendar year	Calendar year starting in 2004
3	Capital 2001 Dollars ($M)	Estimated capital costs for the CSO LTCP expressed in constant year 2001 dollars
4	Capital Actual Dollars ($M)	The estimated capital costs for the CSO LTCP expressed in the year of expenditure dollars using 3% per year to escalate the 2001 value estimate.
5	OM 2001 Dollars ($M)	Estimated operating and maintenance costs for the CSO LTCP expressed in constant year 2001 dollars.
6	OM Actual Dollars ($M)	The estimated operating and maintenance costs for the CSO LTCP expressed in the year of expenditure dollars using 3% per year to escalate the 2001 value estimate.
7	Total 2001 Dollars ($M)	The addition of CSO Costs/OM/2001 Dollars ($M) and CSO Costs/Capital/2001 Dollars ($M).
8	Total Actual Dollars ($M)	The addition of CSO Costs/OM/Actual Dollars ($M) and CSO Costs/Capital/Actual Dollars ($M).
9	Capital Costs Financed ($M)	The amount of actual capital costs that are debt financed.
10	Capital Costs PAYGO ($M)	The amount of actual capital costs that are paid from current year revenues on a pay-as-you-go-basis.
11	Debt Service ($M)	Estimated annual debt service on capital costs that are financed using 30 year term and borrowing costs of 7%.
12	O&M ($M)	Same as Column 6, OM Actual Dollars ($M)
13	Total Rate Requirements	The addition of PAYGO, Debt Service, O&M costs.
14	Other WASA Wastewater Costs Paid by DC Ratepayers	Operating and capital costs for wastewater services that are funded by retail ratepayers before the addition of CSO LTCP costs.
15	Typical Residential Bill Without CSO LTCP	Estimated annual residential wastewater bill before addition of the CSO LTCP costs.
16	Bill Increase Without CSO LTCP	Estimated annual change in residential wastewater bill before addition of CSO LTCP costs.
17	Typical Residential Bill Without CSO LTCP	Estimated annual residential wastewater bill after addition of the CSO LTCP costs.
18	Bill Increase Without CSO LTCP	Estimated annual change in residential wastewater bill after addition of CSO LTCP costs.
19	MHI	Estimated median household income (MHI) using 3% annual growth rate
20	% of MHI	Estimated residential bill as a percent of MHI.
21	Lower 20%	Household income of the most affluent household of the lower 20th percentile of households in the District.
22	% of Lower 20%	Estimated residential bill as a percent of the household income for the most affluent household of the lower 20th percentile of households in the District.

The financial projections are based on certain assumptions, which include, but are not limited to the following:

1. Billed water use is projected to decrease at 1% per year. Residential bill estimates are based on average consumption of 100 ccf per year.

2. Customers are assessed a charge for water and wastewater services based on water consumption. With the exception of certain federal government customers located outside of the District, all customers pay the same rate, regardless of account class, meter size, or size of service connection. The analysis assumes this practice will continue.

3. The analysis assumes a revenue collection rate of 97.7% of billed amounts.

4. Median Household Income in the District of Columbia is projected to increase at 3% per year. The most affluent of the lower 20[th] percentile of households in the District have a household income in 2004 dollars of $19,669 and this is projected to increase at the rate of inflation, which is assumed to be 3% per year.

5. Projections take into account discounts to low-income customers under the Authority's customer assistance program. The Authority's program covers 6,000 low-income customers and provides discounts of approximately $500,000 each year. Each eligible participant receives an exemption for water service charges in the amount of 4 ccf per month.

6. The financial analysis assumes an all-in borrowing cost assumption of 7 percent including cost of issuance (including bond insurance premiums, premiums for debt service reserve facility and fees and expenses related to bond issuance; approximately 2% on the Authority's 2003 revenue bond issue). The analysis assumes a debt coverage ratio of 1.40 x Term of Debt. The financial analysis utilizes fixed rate financing with a term of 30 years.

7. CSO operating and maintenance and capital costs are escalated at a rate of 3% per year from 2001 cost estimates to the year of expenditure. Non CSO-related wastewater operating and capital costs are projected to increase at approximately 5 percent per year reflecting impacts of inflation and reinvestment in capital facilities.

Table 1
20-Year LTCP Financial Projections

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
		CSO Costs						CSO LTCP Financing					Other WASA Wastewater Costs			Effect on Users					
		Capital		O&M		Total															
Year No.	Calendar Year	2001 Dollars ($M)	Actual Dollars ($M)	2001 Dollars ($M)	Actual Dollars ($M)	2001 Dollars ($M)	Actual Dollars ($M)	Capital Costs Financed ($M)	Capital Costs PAYGO ($M)	Debt Service ($M)	O & M ($M)	Total Annual Rate Requirements ($M)	Other WASA WW Costs Paid by DC Ratepayers ($M)	Typical Residential Bill w/o CSO LTCP	Bill Increase without CSO LTCP	Typical Residential Bill with CSO LTCP	Bill Increase with CSO LTCP	MHI	% of MHI	Lower 20%	% of Lower 20%
1	2004	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 120.47	$ 297		$ 297		$ 40,610	0.7%	$ 19,669	1.5%
2	2005	$ 4.07	$ 4.58	$ 0.04	$ 0.04	$ 4.11	$ 4.62	$ 3.86	$ 0.15	$ 0.31	$ 0.04	$ 0.50	$ 126.53	$ 310	5%	$ 311	5%	$ 41,634	0.7%	$ 20,259	1.5%
3	2006	$ 4.46	$ 5.17	$ 0.08	$ 0.09	$ 4.54	$ 5.26	$ 1.86	$ 0.29	$ 0.46	$ 0.09	$ 0.84	$ 132.60	$ 323	4%	$ 325	4%	$ 43,089	0.8%	$ 20,867	1.6%
4	2007	$ 12.61	$ 15.06	$ 0.19	$ 0.22	$ 12.80	$ 15.28	$ 7.63	$ 0.67	$ 1.09	$ 0.22	$ 1.99	$ 139.87	$ 344	6%	$ 348	7%	$ 44,382	0.8%	$ 21,493	1.6%
5	2008	$ 13.45	$ 16.54	$ 0.31	$ 0.37	$ 13.76	$ 16.92	$ 5.36	$ 0.97	$ 1.53	$ 0.37	$ 2.87	$ 149.23	$ 369	8%	$ 376	8%	$ 45,713	0.8%	$ 22,138	1.7%
6	2009	$ 15.23	$ 19.29	$ 0.45	$ 0.56	$ 15.68	$ 19.86	$ 14.74	$ 1.23	$ 2.71	$ 0.56	$ 4.50	$ 158.08	$ 397	8%	$ 408	8%	$ 47,085	0.9%	$ 22,802	1.8%
7	2010	$ 12.67	$ 16.52	$ 0.57	$ 0.72	$ 13.23	$ 17.24	$ 14.91	$ 1.62	$ 3.92	$ 0.72	$ 6.26	$ 166.47	$ 424	7%	$ 439	8%	$ 48,497	0.9%	$ 23,486	1.9%
8	2011	$ 55.90	$ 76.12	$ 1.07	$ 1.40	$ 56.97	$ 78.52	$ 71.13	$ 3.99	$ 8.65	$ 1.40	$ 15.04	$ 173.07	$ 440	4%	$ 477	8%	$ 49,952	1.0%	$ 24,190	2.0%
9	2012	$ 60.19	$ 83.32	$ 1.62	$ 2.18	$ 61.81	$ 85.49	$ 76.77	$ 6.54	$ 16.83	$ 2.18	$ 24.56	$ 179.02	$ 459	4%	$ 520	9%	$ 51,451	1.0%	$ 24,916	2.1%
10	2013	$ 60.96	$ 86.91	$ 2.17	$ 3.01	$ 63.13	$ 89.92	$ 77.76	$ 9.14	$ 22.10	$ 3.01	$ 34.24	$ 177.46	$ 460	0%	$ 545	5%	$ 52,994	1.0%	$ 25,664	2.1%
11	2014	$ 53.55	$ 78.64	$ 2.66	$ 3.79	$ 56.21	$ 82.43	$ 67.26	$ 11.36	$ 27.52	$ 3.79	$ 42.89	$ 184.34	$ 482	5%	$ 590	8%	$ 54,584	1.1%	$ 26,434	2.2%
12	2015	$ 57.05	$ 86.29	$ 3.17	$ 4.66	$ 60.22	$ 90.96	$ 72.60	$ 13.79	$ 33.37	$ 4.66	$ 51.82	$ 191.51	$ 505	5%	$ 637	8%	$ 56,221	1.1%	$ 27,227	2.3%
13	2016	$ 61.13	$ 95.24	$ 3.73	$ 5.64	$ 64.86	$ 100.88	$ 76.82	$ 16.42	$ 39.72	$ 5.64	$ 61.77	$ 198.96	$ 530	5%	$ 688	8%	$ 57,908	1.2%	$ 28,043	2.5%
14	2017	$ 63.43	$ 101.79	$ 4.30	$ 6.71	$ 67.73	$ 108.49	$ 82.82	$ 19.17	$ 46.98	$ 6.71	$ 72.25	$ 206.69	$ 556	5%	$ 743	8%	$ 59,645	1.2%	$ 28,885	2.6%
15	2018	$ 69.02	$ 114.07	$ 4.93	$ 7.91	$ 73.95	$ 121.98	$ 91.84	$ 22.23	$ 53.78	$ 7.91	$ 83.92	$ 214.73	$ 582	5%	$ 802	8%	$ 61,435	1.3%	$ 29,751	2.7%
16	2019	$ 66.99	$ 114.04	$ 5.54	$ 9.15	$ 72.52	$ 123.19	$ 88.85	$ 25.19	$ 60.94	$ 9.15	$ 95.28	$ 223.06	$ 611	5%	$ 863	8%	$ 63,278	1.4%	$ 30,644	2.8%
17	2020	$ 70.36	$ 123.37	$ 6.18	$ 10.61	$ 76.53	$ 133.98	$ 95.02	$ 28.36	$ 68.59	$ 10.61	$ 107.46	$ 231.78	$ 640	5%	$ 928	8%	$ 65,176	1.4%	$ 31,563	2.9%
18	2021	$ 116.31	$ 210.07	$ 7.23	$ 12.68	$ 123.54	$ 222.75	$ 176.86	$ 34.21	$ 82.77	$ 12.68	$ 129.65	$ 240.78	$ 671	5%	$ 1,021	10%	$ 67,131	1.5%	$ 32,510	3.1%
19	2022	$ 125.00	$ 232.54	$ 8.36	$ 15.11	$ 133.37	$ 247.66	$ 191.94	$ 40.60	$ 98.23	$ 15.11	$ 153.94	$ 250.14	$ 704	5%	$ 1,124	10%	$ 69,145	1.6%	$ 33,485	3.4%
20	2023	$ 107.76	$ 206.48	$ 9.34	$ 17.38	$ 117.10	$ 223.85	$ 160.63	$ 45.95	$ 111.17	$ 17.38	$ 174.50	$ 259.86	$ 738	5%	$ 1,219	8%	$ 71,220	1.7%	$ 34,490	3.5%
21	2024	$ 108.12	$ 213.39	$ 10.32	$ 19.78	$ 118.44	$ 233.17	$ 162.04	$ 51.35	$ 124.23	$ 19.78	$ 195.35	$ 269.99	$ 774	5%	$ 1,318	8%	$ 73,356	1.8%	$ 35,525	3.7%
22	2025	$ -	$ -	$ 10.32	$ 20.37	$ 10.32	$ 20.37	$ -	$ -	$ 124.23	$ 20.37	$ 144.60	$ 280.50	$ 812	5%	$ 1,218	-8%	$ 75,557	1.6%	$ 36,590	3.3%
23	2026	$ -	$ -	$ 10.32	$ 20.98	$ 10.32	$ 20.98	$ -	$ -	$ 124.23	$ 20.98	$ 145.21	$ 291.42	$ 851	5%	$ 1,264	4%	$ 77,824	1.6%	$ 37,688	3.4%
24	2027	$ -	$ -	$ 10.32	$ 21.61	$ 10.32	$ 21.61	$ -	$ -	$ 124.23	$ 21.61	$ 145.84	$ 302.77	$ 893	5%	$ 1,311	4%	$ 80,159	1.6%	$ 38,819	3.4%
25	2028	$ -	$ -	$ 10.32	$ 22.26	$ 10.32	$ 22.26	$ -	$ -	$ 124.23	$ 22.26	$ 146.49	$ 314.56	$ 936	5%	$ 1,361	4%	$ 82,563	1.6%	$ 39,983	3.4%
26	2029	$ -	$ -	$ 10.32	$ 22.93	$ 10.32	$ 22.93	$ -	$ -	$ 124.23	$ 22.93	$ 147.16	$ 326.81	$ 982	5%	$ 1,413	4%	$ 85,040	1.7%	$ 41,183	3.4%
27	2030	$ -	$ -	$ 10.32	$ 23.61	$ 10.32	$ 23.61	$ -	$ -	$ 124.23	$ 23.61	$ 147.84	$ 339.53	$ 1,030	5%	$ 1,467	4%	$ 87,591	1.7%	$ 42,418	3.5%
28	2031	$ -	$ -	$ 10.32	$ 24.32	$ 10.32	$ 24.32	$ -	$ -	$ 124.23	$ 24.32	$ 148.55	$ 352.78	$ 1,080	5%	$ 1,524	4%	$ 90,219	1.7%	$ 43,691	3.5%
29	2032	$ -	$ -	$ 10.32	$ 25.05	$ 10.32	$ 25.05	$ -	$ -	$ 124.23	$ 25.05	$ 149.28	$ 366.50	$ 1,133	5%	$ 1,583	4%	$ 92,925	1.7%	$ 45,001	3.5%
30	2033	$ -	$ -	$ 10.32	$ 25.80	$ 10.32	$ 25.80	$ -	$ -	$ 124.23	$ 25.80	$ 150.03	$ 380.78	$ 1,188	5%	$ 1,645	4%	$ 95,713	1.7%	$ 46,351	3.5%
31	2034	$ -	$ -	$ 10.32	$ 26.58	$ 10.32	$ 26.58	$ -	$ -	$ 124.23	$ 26.58	$ 150.81	$ 395.62	$ 1,246	5%	$ 1,710	4%	$ 98,585	1.7%	$ 47,742	3.6%
32	2035	$ -	$ -	$ 10.32	$ 27.37	$ 10.32	$ 27.37	$ -	$ -	$ 123.92	$ 27.37	$ 151.29	$ 411.04	$ 1,307	5%	$ 1,777	4%	$ 101,542	1.8%	$ 49,174	3.6%
33	2036	$ -	$ -	$ 10.32	$ 28.20	$ 10.32	$ 28.20	$ -	$ -	$ 123.77	$ 28.20	$ 151.96	$ 427.06	$ 1,371	5%	$ 1,848	4%	$ 104,588	1.8%	$ 50,650	3.6%
34	2037	$ -	$ -	$ 10.32	$ 29.04	$ 10.32	$ 29.04	$ -	$ -	$ 123.13	$ 29.04	$ 152.18	$ 443.70	$ 1,438	5%	$ 1,921	4%	$ 107,726	1.8%	$ 52,169	3.7%
35	2038	$ -	$ -	$ 10.32	$ 29.91	$ 10.32	$ 29.91	$ -	$ -	$ 122.70	$ 29.91	$ 152.62	$ 461.00	$ 1,509	5%	$ 1,997	4%	$ 110,958	1.8%	$ 53,734	3.7%
	Total	$ 1,138.24	$ 1,898.43	$ 216.78	$ 469.93	$ 1,356.60	$ 2,368.36	$ 1,641.56	$ 333.22	$ 2,540.09	$ 469.93	$ 3,343.24	[redacted]								

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APPENDIX C

APPENDIX C
Certain Financial Information to Perform Financial Analysis
Pursuant to Section VII

In the event that WASA seeks a modification of the Schedule pursuant to Section VII of the Consent Decree due to cost overruns or changed financial circumstances, WASA shall update its financial information. Information that may be relevant includes the following list or categories of information, and WASA agrees to provide such information in the event the United States requests it. Nothing in this Appendix in any way limits or narrows the United States' right to obtain or request other information in order to review and respond to WASA's request for a modification.

1. DC population, current and projected

2. Number of households, current and projected
   - Single-family residence
   - Multi-family buildings

3. Median household income

4. Wastewater billings and volume billed for past three years, broken out for all user classes

5. Wastewater revenues and expenditures for past three years.

6. WASA financial statements for past three years.

7. Prospectuses issued within the past three years.

8. Rate studies prepared within the past three years related to wastewater or stormwater programs.

9. Per household wastewater metering fee and ROW fee

10. Average per household volume billed for
    - Single-family residence
    - Multi-family residence

11. Current baseline revenues and expenditures.

12. LTCP costs
    - Capital costs incurred to date
    - Capital costs projected by year
    - Additional operations and maintenance costs projected by year
    - Costs to date financed with grants (amount and interest rate by year)
    - Costs to date financed with low interest, non-market loans (amount and interest rate by

year)

13. Projected costs other than those required by this consent decree that should be considered in addition to baseline costs. Identify and project by year.
    - Costs necessary to comply with regulations or other legal requirements.
    - Projected sewer system assessment and rehabilitation costs
    - Other increases that would cause total annual expenditures to rise at a rate greater than inflation

14. Debt coverage ratio

15. Bond interest rate and term

16. Rate of inflation

17. PAYGO assumption

18. Current wastewater rate per ccf for single-family residential customers.

19. History of rate adjustments or rate recovery approach during the past five years. Identify the current basis for recovery of LTCP costs and any expected changes in the basis for the recovery of these costs. If rates are recovered through other than the wastewater rate, identify the mechanism, and the amount of costs born by each user class.

20. Projection over twenty years estimating per household impact of LTCP.

21. Current programs to provide relief to low-income residents.

22. Other documentation or analysis that EPA and/or WASA deems relevant for the particular circumstances.

Appendix - B
Control Plan Highlights
(Summary of LTCP)

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

Serving the Public • Protecting the Environment

WASA's Recommended Combined Sewer System Long Term Control Plan

Control Plan Highlights

July 2002

1. WHAT IS THIS REPORT?

The District of Columbia Water and Sewer Authority (WASA or Authority) has prepared this report to describe the development and selection of the plan for controlling combined sewer overflows (CSOs) in the District of Columbia. The plan for controlling CSOs is called a Long Term Control Plan or LTCP. In June 2001, WASA submitted a Draft LTCP to regulatory agencies and the public for review and comment. An extensive public outreach and comment period followed in the summer and autumn of 2001. This report presents the proposed Final LTCP. It has been developed taking into consideration regulatory agency comments, public comments, and additional regulatory requirements.

2. WHAT IS A COMBINED SEWER OVERFLOW?

Like many older cities in the United States, the sewer system in the District is comprised of both combined sewers and separate sanitary sewers. A combined sewer carries both sewage and runoff from storms. Modern practice is to build separate sewers for sewage and storm water, and no new combined sewers have been built in the District since the early 1900's. Approximately one-third of the District is served by combined sewers. The majority of the area served by combined sewers is in the older developed sections of the District. The combined sewer area is shown on Figure 1.

CSO Facts

- **"CSO" stands for Combined Sewer Overflow**
- **About 1/3 of the District is served by combined sewers**
- **Combined sewers have not been built in the District since the early 1900's**
- **Combined sewers overflow when rainfall exceeds their capacity**

In the combined sewer system, sewage from homes and businesses during dry weather conditions is conveyed to the District of Columbia's Wastewater Treatment Plant at Blue Plains, which is located in the southwestern part of the District on the east bank of the Potomac River. There, the wastewater is treated to remove pollutants before being discharged to the Potomac River. When the capacity of a combined sewer is exceeded during storms, the excess flow, which is a mixture of sewage and storm water runoff, is discharged to the Anacostia and Potomac Rivers, Rock Creek and tributary waters. The excess flow is called Combined Sewer Overflow (CSO). There are a total of 60 CSO outfalls in the combined sewer system. Figure 2 shows the difference between combined and separate sewer systems.

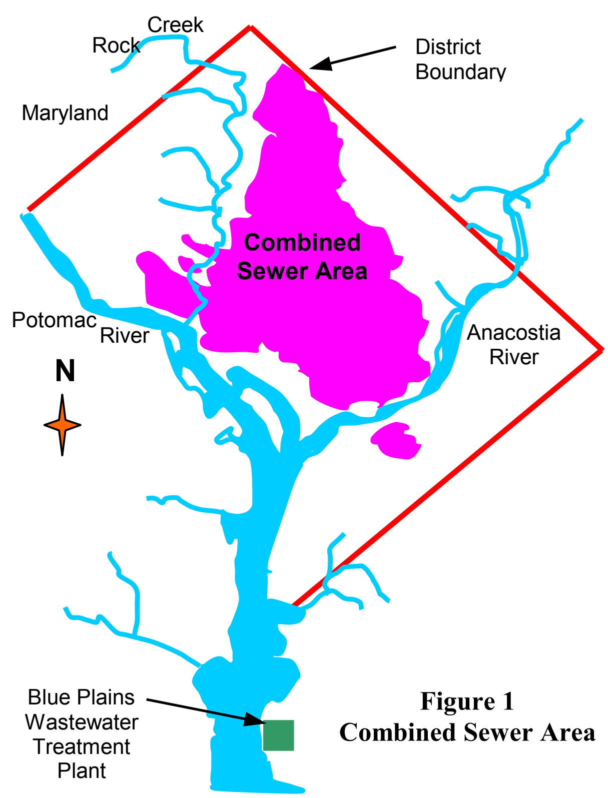
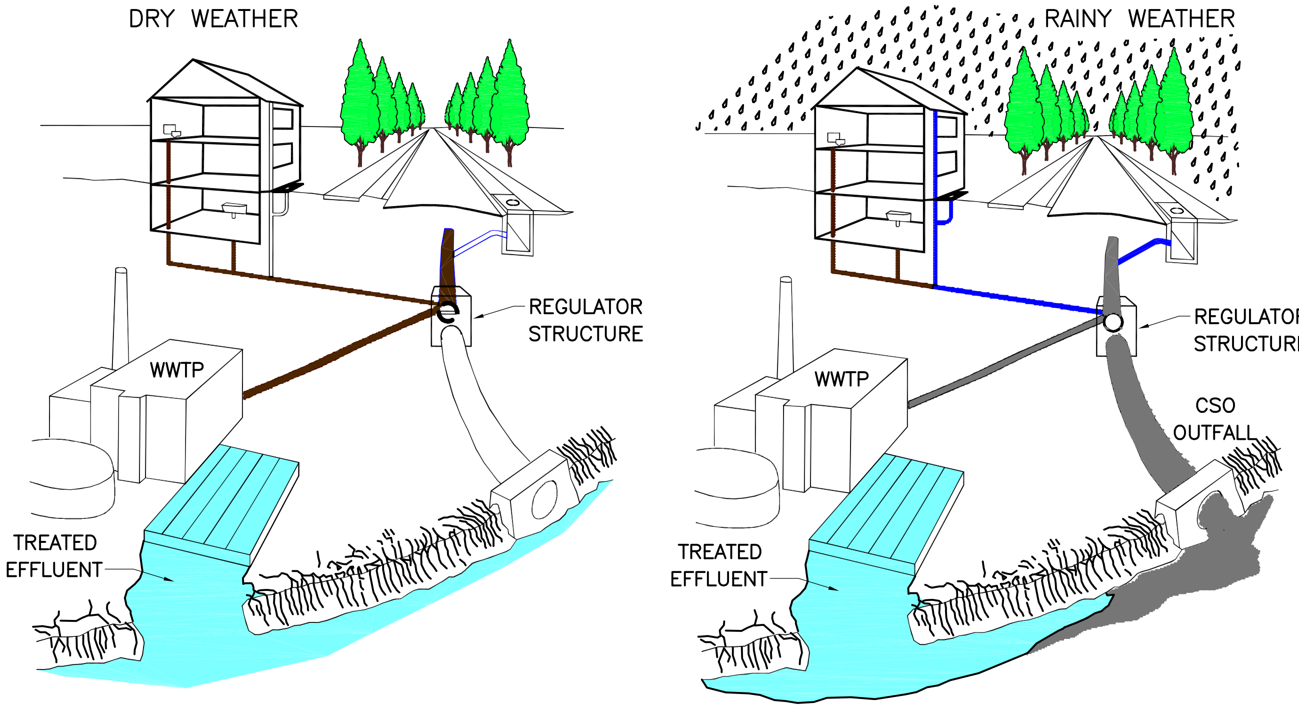
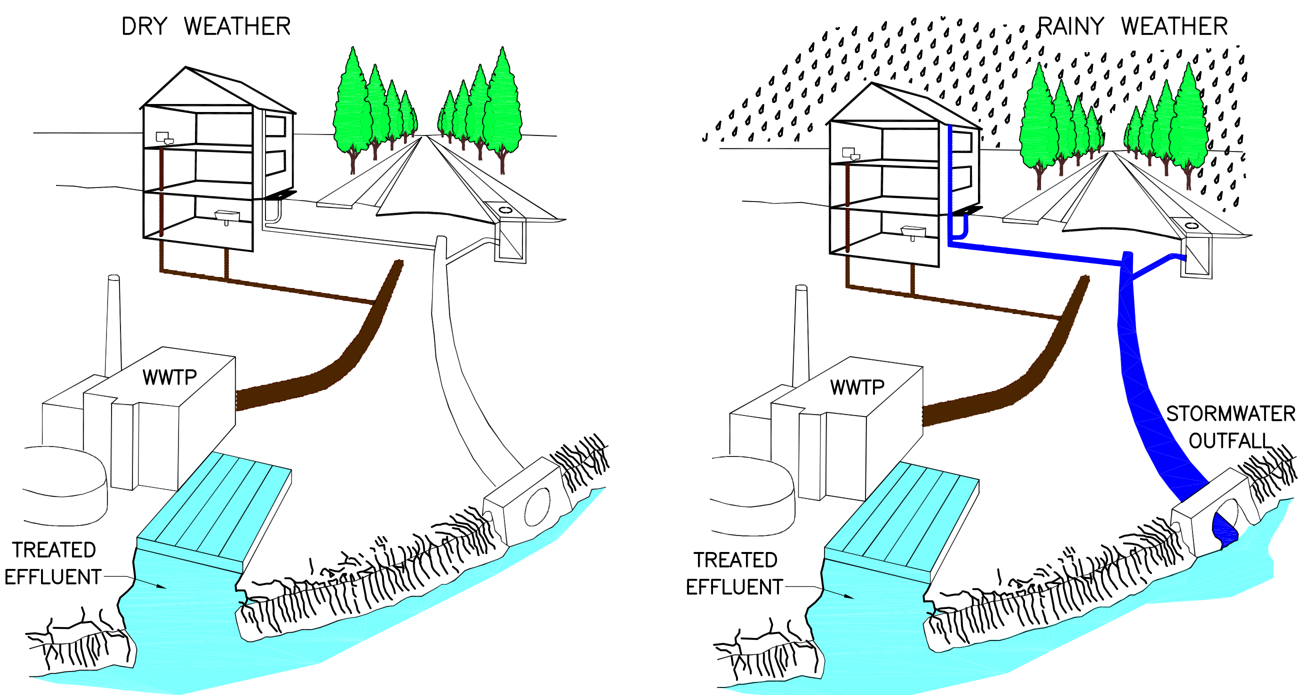


Figure 1
Combined Sewer Area

FIGURE 2



COMBINED SEWER SYSTEM



SEPARATE SEWER SYSTEM

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CSS LONG TERM CONTROL PLAN

3. WHY ARE CSOs A CONCERN?

Discharges of CSOs can adversely impact the quality of the receiving waters. The primary purpose of the LTCP is to control CSOs such that water quality standards are met. In the District of Columbia water quality standards, the designated use of the Anacostia River, Potomac River and Rock Creek is Class A or suitable for primary contact recreation. Because the water quality in the receiving waters currently does not meet these standards much of the time, the actual use of the water body is Class B or suitable for secondary contact recreation and aquatic enjoyment. In recognition of this condition, District law prohibits swimming in each of the receiving waters.

4. WHY IS A WATERSHED APPROACH NECESSARY?

There are three principal waterbodies within the District. These are the Potomac River, Anacostia River and Rock Creek.

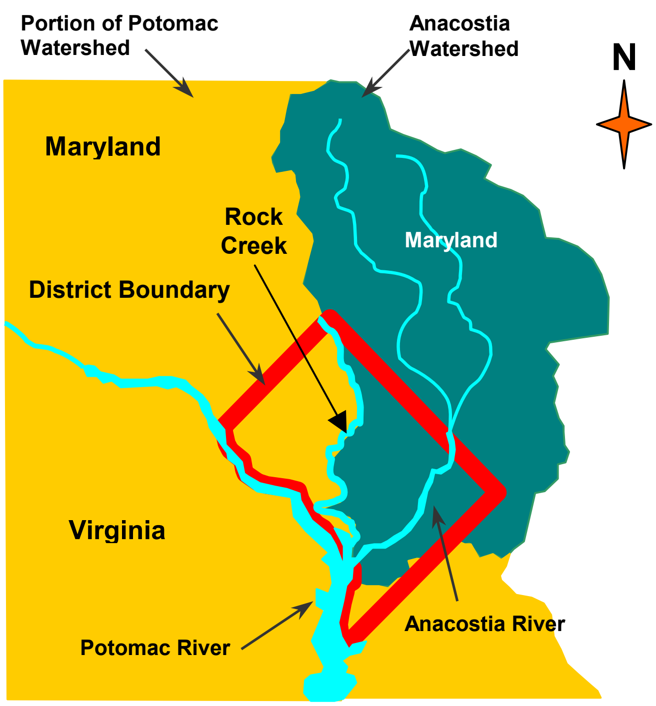


Figure 3
Watersheds

Figure 3 shows the watersheds of these waterbodies with drainage areas extending across multiple states and/or jurisdictions. Both the Anacostia River and Rock Creek watersheds include land area in Maryland and the District. The Potomac watershed includes land area in Virginia, West Virginia, Maryland, Pennsylvania and the District.

The District encompasses only a small portion of each watershed. The percentage of the land area in the District for each watershed is shown in Table 1.

Table 1
Percent of Drainage Area in District of Columbia

	Anacostia River	Potomac River	Rock Creek
% of Drainage Area in District	17%	0.5%	20%

This LTCP demonstrates that water quality is affected by many sources other than CSOs, including storm water, upstream sources outside of the District, and in the Anacostia River by the sediments in the bottom of the river. While the LTCP is only required to address CSOs, WASA is considering these other sources to identify the impact of CSOs as compared to other sources of pollution. This will assist in developing a watershed-based approach to improving water quality.

5. WHAT ARE THE EXISTING CONDITIONS?

In order to assess the impact of CSO control on receiving water quality, computer models of the combined sewer system, separate storm water system and of Rock Creek were developed. In addition, existing computer models of the Anacostia River and the Potomac River were adapted for use in the study. The computer models were calibrated based on historical data and on 9 to 12 months of monitoring data collected in the receiving waters, the combined sewer system, CSOs and in the separate storm water system.

In accordance with EPA guidelines, CSO planning was based on "average year" conditions. The rainfall in the period 1988-1990 was selected as representative of average conditions based on review of 50 years of rainfall data at Ronald Reagan National Airport. The representative three-year period contains a relatively wet year, a dry year and an average year. Average year conditions are defined as the arithmetic average of the predictions for years 1988, 1989 and 1990. Using the combined sewer system model, CSO overflow volumes and frequencies were predicted for existing conditions in the average year. The predicted CSO overflow volumes for the average year conditions are shown on Table 2.

Table 2
Annual CSO Overflow Predictions for Average Year

Item	Anacostia River	Potomac River	Rock Creek	Total System
CSO Overflow Volume (million gallons/yr)				
No Phase I Controls	2,142	1,063	49	3,254
Phase I Controls	1,485	953	52	2,490
Number of Overflows/yr				
No Phase I Controls	82	74	30	-
Phase I Controls	75	74	30	-

The Phase I CSO controls consist of in-system storage devices called inflatable dams and a CSO treatment system called the Northeast Boundary Swirl Facility. These controls were completed in 1991. As of the writing of this report, certain inflatable dams are not functional and are in the process of being replaced.

Using the predicted pollutant loads from the combined sewer system, separate storm water system and the upstream boundary, the water quality in each receiving water was predicted for average year conditions.

6. HOW IS EACH RECEIVING WATER DIFFERENT?

Each receiving water in the District has unique characteristics which are summarized below:

Anacostia River - The Anacostia River is a relatively stagnant water body significantly affected by the tide. Both dissolved oxygen and bacteria concentrations are problems. Low dissolved oxygen levels typically occur in the summer months of June to August and typically follow a significant local or upstream wet weather event. The low dissolved oxygen is driven by the naturally low saturation level of oxygen in the water due to the high water temperature and the influx of pollutant loads from wet weather events. The sluggish nature of the river does not allow effective re-aeration, contributing to the low dissolved oxygen. In addition to direct loads of oxygen-consuming pollutants from CSO, storm water, and the upstream boundary, the sediments in the Anacostia River are known to exert a substantial oxygen demand. Dissolved oxygen levels below 2 mg/L can occur several times per summer month, with each episode lasting 1 to 2 days. Fish kills have been observed in the past under these conditions. Bacteria concentrations (fecal coliform) are relatively high and are predicted to exceed the Class A monthly standard for the majority of the average year. In addition to CSO, bacterial pollution from storm water and the upstream boundary are significant.

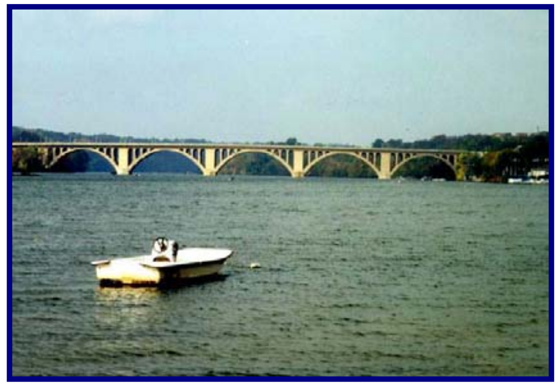
Anacostia River

Rock Creek - Rock Creek is a free-flowing stream that is unaffected by the tide for most of its length. The stream is naturally aerated by turbulence as it flows over the irregular bottom of the creek bed. There is no evidence of low dissolved oxygen problems in Rock Creek and bacteriological concentrations are the primary concern. Bacteria (fecal coliform) concentrations in Rock Creek are predicted to be above the Class A monthly standard every month in the average year under existing conditions. The majority of the load comes from storm water and upstream sources. The volume of water in Rock Creek in any particular section is relatively small. As a result, it is not able to absorb significant pollutant loads without causing relatively high bacteria concentrations in the creek. The free-flowing nature of the creek causes relatively short residence time of wet weather pollution.

Rock Creek

Potomac River - The water quality of the Potomac River is much better than that in the Anacostia River or Rock Creek. This is due both to the low pollutant loads and the size and assimilative capacity of the river.

In the upstream reaches of the river from the Memorial Bridge to Georgetown, the Class A bacteria standard is only predicted to be exceeded one month out of the year by a relatively small amount. Downstream of the Memorial Bridge, no exceedances are predicted on a monthly basis. Low oxygen is not a significant problem in the Potomac River.



Potomac River

7. WHAT ALTERNATIVES WERE CONSIDERED?

A wide range of technologies was considered to control CSOs. The technologies are grouped into the following general categories:

Source Controls– such as public education, a higher level of street sweeping, additional construction site controls, more frequent catch basin cleaning, and garbage disposal bans

Inflow Controls – such as Low Impact Development-Retrofit, rooftop greening, storm water treatment, street storage of storm water, rain leader disconnections, extending storm sewers to receiving waters

Sewer System Optimization - such as real time control, storing combined sewage in existing sewers, revision to facility operations

Sewer Separation – partial and complete separation

Storage Technologies – such as retention basins and tunnels

Treatment Technologies - such as screening, sedimentation, high rate physical chemical treatment, swirl concentrators and disinfection

Receiving Water Improvement – such as aeration and flow augmentation

Each technology was evaluated for its ability to reduce CSO volume and the pollutants in CSO. After the initial screening, groups of technologies were assembled into control plans for each receiving water. The alternatives were evaluated against the following criteria:

- Regulatory Compliance – Ability to meet the EPA CSO Policy which is now part of the Clean Water Act, D.C. Water Quality Standards, the total maximum daily loads (TMDLs) developed by the District of Columbia Department of Health for dissolved oxygen and water clarity for the Anacostia River, and WASA's existing National Pollutant Discharge Elimination System (NPDES) Permit.
- Cost effectiveness – Ability to achieve the greatest benefit at the lowest reasonable cost.
- Northeast Boundary Flooding – Ability to relieve street flooding and basement sewer back-ups from the combined sewer system in the Northeast Boundary area.
- Non-monetary factors – Implementability, operational complexity, ability to upgrade and other non-monetary factors.
- Public Acceptance – Responsiveness to public comments.

In accordance with EPA guidelines, each alternative was configured and evaluated to reduce CSO overflows to between zero and 12 events per average year. Note that control plans which achieve zero overflows for all storms in the 1988-1990 analysis period would not eliminate overflows under all conditions. For that reason, complete sewer separation that would achieve zero CSO overflows under all conditions was also evaluated. Costs, CSO overflow volume reductions, and benefits to receiving waters were evaluated for each level of CSO control.

8. HOW HAS THE PUBLIC BEEN INVOLVED?

WASA conducted an extensive public participation program designed to educate the affected public and to obtain their input and consultation in selecting the long term CSO controls. The public participation process included public meetings, establishment of a Stakeholder Advisory Panel, and an elaborate public information process. Four public meetings have been held to educate the public and to obtain feedback about CSO issues. At the request of the public during the first public meeting, a Stakeholder Advisory Panel was formed. The panel consisted of representatives from government agencies, regulatory agencies, citizens' groups, and environmental advocacy groups that are concerned about water quality issues within the District. Twelve Panel meetings were held during development of the LTCP.

In addition, the public outreach program included educational mailers in water and sewer bills, establishment of a CSO website, creation of a CSO mailing list, informational CSO newsletters, and establishment of public information depositories.

After release of the Draft LTCP, nine neighborhood meeting were held throughout the District to explain the program and obtain public comments. The D.C. Council and WASA held public hearings on the plan. Informational mailers, WASA's website and presentations to interested groups were also used to obtain input on plan. The Draft LTCP was well publicized and members of the public provided thoughtful comments. Over 2,300 comments were received on the Draft LTCP.

9. WHAT IS THE RECOMMENDED PLAN?

WASA is committed to improving the quality of the Anacostia River, Rock Creek, and the Potomac River. The recommended LTCP has been selected to provide a significant improvement in the quality of each receiving water while balancing the affordability to ratepayers. The recommended LTCP consists of many elements and program components. Table 3 lists the components by receiving water. Figure 4 shows the location of the principal elements.

The principle components of the control program are described below.

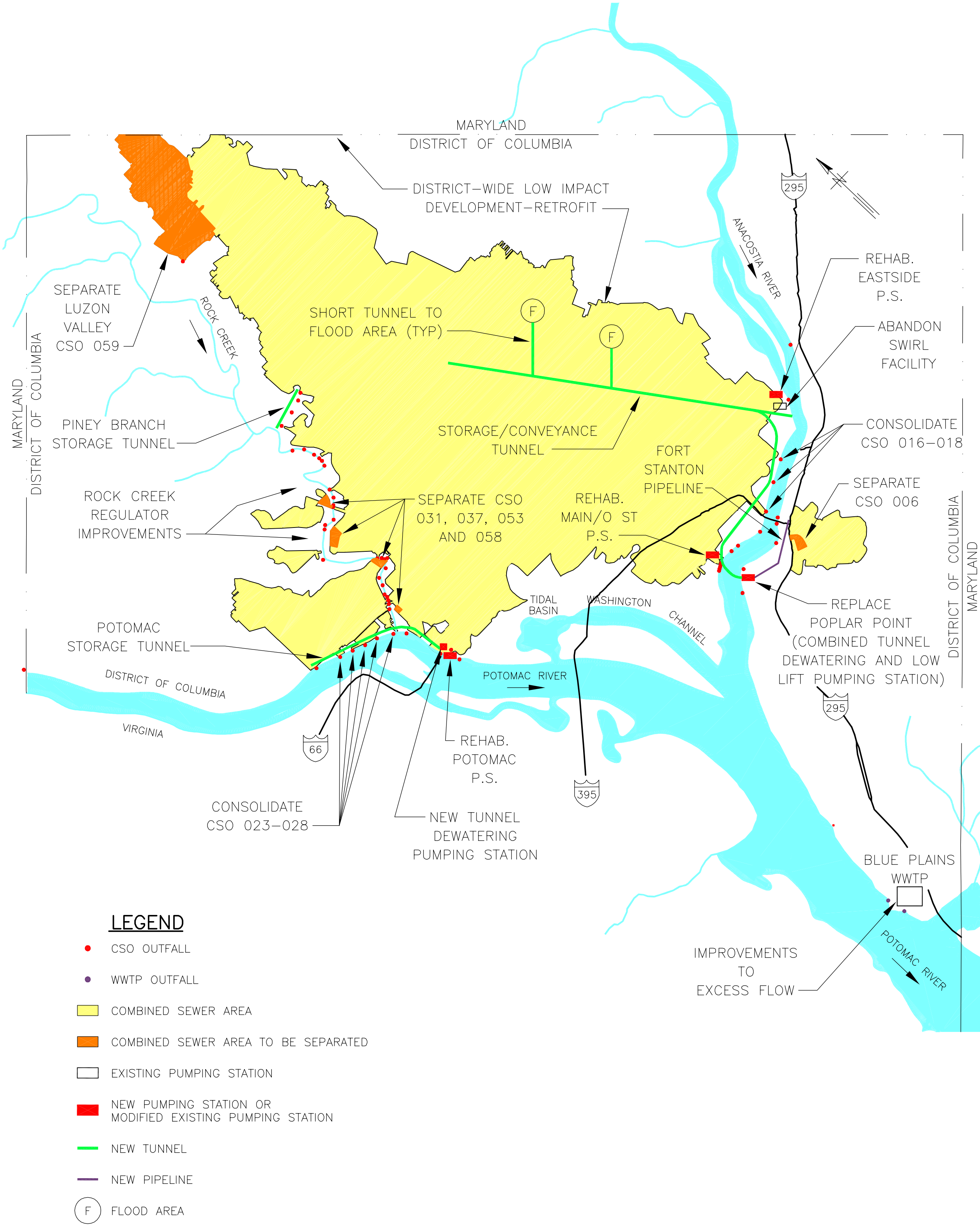
System Wide Controls - WASA recommends the implementation of Low Impact Development Retrofit (LID-R) in the District. In addition to reducing CSOs, LID-R also has ancillary benefits such as reducing storm water volume and pollutant concentrations, reducing cooling costs and increasing aesthetic value. Reduction of storm water pollution is a part of the District's storm water management efforts as part of its Municipal Separate Storm Sewer (MS4) Permit. Since WASA does not control development or redevelopment in the District, WASA cannot mandate application of LID-R. WASA will, however, incorporate LID-R techniques into new construction or reconstruction on WASA facilities where applicable, and will act as an advocate for LID-R in the District.

In addition to these, WASA looks forward to participating in a partnership with others to investigate the feasibility of apply LID-R in an urban setting. Possible goals of the partnership would be to demonstrate and evaluate LID-R effectiveness on a sewershed basis, establish design, construction and performance standards, assess costs, and determine practicality. Given the Federal Government's role in the District and its interest is identifying techniques that could be applied elsewhere, a significant Federal participation in such a partnership would be appropriate.

WASA would also be willing to participate in a watershed forum or planning group, with a Federal presence, to address pollution in the watershed. The LTCP has identified that storm water is one of the major pollution sources for all of the urban watersheds. Storm water pollution is a common concern of the District, Virginia and Maryland. This could serve as a catalyst to create the forum and to strive for solutions.

Anacostia River Components - The control measures selected for the Anacostia River are predicted to limit overflows to two events per average year. During the three year analysis period (1988-1990), the frequency of overflow ranged from one per year to three per year for dry and wet years, respectively. The controls were selected to make maximum use of existing facilities and to provide supplemental storage via a tunnel to control overflows. Major elements of the controls include the rehabilitation of Main, 'O' Street, and Eastside pumping stations, separation of a CSO on the east side of the Anacostia River, construction of a storage/conveyance tunnel from Poplar Point to Northeast Boundary and construction of a pipeline from Fort Stanton to Poplar Point to address the remaining CSOs on the east side of the Anacostia. An additional leg of the tunnel will be constructed parallel to the Northeast Boundary Sewer and to several low lying areas to provide additional storage for CSO and to relieve street and basement flooding in the Northeast Boundary area. The existing Poplar Point Pumping Station will be replaced by a new facility located at the end of the tunnel that both dewaters the tunnel and replaces the function of the existing pumping station. In addition, three CSOs on the west side of the River near the marinas will be consolidated to eliminate their impacts to this area of the River. One CSO on the east side of the river will be eliminated by separation. Once the tunnel is operational,

FIGURE 4



RECOMMENDED CONTROL PROGRAM

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EPMC-III
GREELEY AND HANSEN LLC

D.C. WATER AND SEWER AUTHORITY
CSS LONG TERM CONTROL PLAN

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Table 3
Recommended Control Program Elements and Estimated Costs

Component	Capital Cost Opinion (Millions, ENR=6383)	Annual Operation and Maintenance (Millions, ENR=6383)
System Wide		
Low Impact Development – Retrofit (LID-R)– Advocate implementation of LID-R throughout entire District. Provide technical and regulatory assistance to District Government. Implement LID-R projects on WASA facilities where feasible.	$3	$0.11
Anacostia River		
Rehabilitate Pumping Stations – Rehabilitate existing pumping stations as follows: • Interim improvements at Main and 'O' Street Pumping Stations necessary for reliable operation until rehabilitation of stations is performed. • Rehabilitate Main Pumping Station to 240 mgd firm sanitary capacity. Screening facilities for firm sanitary pumping capacity only. • Rehabilitate Eastside and 'O' Street Pumping stations to 45 mgd firm sanitary capacity • Interim improvements at existing Poplar Point Pumping Station necessary for reliable operation until replacement pumping station is constructed as part of storage tunnel	$115	$0[1]
Storage Tunnel from Poplar Point to Northeast Boundary Outfall – 49 million gallon storage tunnel between Poplar Point and Northeast Boundary. Tunnel will intercept CSOs 009 through 019 on the west side of the Anacostia. Project includes new tunnel dewatering pump station and low lift pumping station at Poplar Point.	$332	$7.98
Storage/Conveyance Tunnel Parallel to Northeast Boundary Sewer – 77 million gallon storage/conveyance tunnel parallel to the Northeast Boundary Sewer. Also includes side tunnels from main tunnel along West Virginia and Mt. Olivet Avenues, NE and Rhode Island and 4th St NE to relieve flooding. Abandon Northeast Boundary Swirl Facility upon completion of main tunnel.	$452	
Outfall Consolidation – Consolidate the following CSOs in the Anacostia Marina area: CSO 016, 017 and 018	$27	$0[1]
Separate CSO 006 – Separate this CSO in the Fort Stanton Drainage Area	$3	$0.01
Ft Stanton Interceptor – Pipeline from Fort Stanton to Poplar Point to convey CSO 005, 006 and 007 on the east side of the Anacostia to the storage tunnel.	$11	$0.04
Anacostia Subtotal	**$940**	**$8.03**
Rock Creek		
Separate Luzon Valley – Completed in 2002.	Completed	$0
Separation – Separate CSOs 031, 037, 053, and 058.	$5	$0.02
Monitoring at CSO 033, 036, 047 and 057 – Conduct monitoring to confirm prediction of overflows. If overflows confirmed, then perform the following: • Regulator Improvements: Improve regulators for CSO 033, 036, 047 and 057 • Connection to Potomac Storage Tunnel: Relieve Rock Creek Main Interceptor to proposed Potomac Storage Tunnel when it is constructed	$3	$0.01
Storage Tunnel for Piney Branch (CSO 049) – 9.5 million gallon storage tunnel	$42	$0.60
Rock Creek Subtotal	**$50**	**$0.63**
Potomac River		
Rehabilitate Potomac Pumping Station – Rehabilitate station to firm 460 mgd pumping capacity	$12	$0[1]
Outfall Consolidation – Consolidate CSOs 023 through 028 in the Georgetown Waterfront Area.	$20	$0[1]
Potomac Storage Tunnel – 58 million gallon storage tunnel from Georgetown to Potomac Pumping Station. Includes tunnel dewatering pumping station.	$218	$2.78
Potomac River Subtotal	**$250**	**$2.78**

Component	Capital Cost Opinion (Millions, ENR=6383)	Annual Operation and Maintenance (Millions, ENR=6383)
Blue Plains Wastewater Treatment Plant		
Excess Flow Treatment Improvements – Four new primary clarifiers, improvements to excess flow treatment control and operations	$22	$1.81
Grand Total	**$1,265**	**$13.36**

Notes: 1. No significant change from existing.

the Northeast Boundary Swirl Facility will be abandoned.

Rock Creek Components - The control measures selected for Rock Creek are predicted to limit Piney Branch overflows to one per average year. At Piney Branch, the frequency of overflow ranged from zero per year to two per year for dry and wet years, respectively, during the three-year analysis period. The remaining overflows in Rock Creek will be controlled to 4 events per average year. For these overflows, the frequency of overflow ranged from one per year to six per year for dry and wet years, respectively, during the three year analysis period. The principle control measures include separation of four CSOs, construction of a storage tunnel at Piney Branch, and monitoring and regulator improvements to four CSOs south of Piney Branch.

Potomac River Components - The control measures selected for the Potomac River are predicted to limit overflows to four events per average year. During the three year analysis period, the frequency of overflow ranged from zero per year to five per year for dry and wet years, respectively. The principle control measures include rehabilitation of the Potomac Pumping Station and construction of a storage tunnel from west of the Key Bridge, along the Potomac River waterfront parallel to Georgetown, and terminating at Potomac Pumping Station. The tunnel will intercept the Georgetown CSOs and the large CSOs downstream of Rock Creek. A new pumping station would be constructed at Potomac Pump Station to dewater the tunnel. In addition, the LTCP will consolidate and close all CSOs between the Key Bridge and Rock Creek to remove the impact of these CSOs from the Georgetown waterfront area.

Blue Plains Advanced Wastewater Treatment Plant

Blue Plains Wastewater Treatment Plant (BPWWTP) Components – BPWWTP has an existing excess flow treatment system designed to provide screening, grit removal, primary treatment, and disinfection to storm flows up to 336 mgd. Improvements to the excess flow treatment train are recommended to improve performance and reliability. These improvements consist of the addition of four new clarifiers and appurtenant weir and control system improvements. In addition, the BPWWTP conducts voluntary denitrification in accordance with the Chesapeake Bay Agreement. The plant uses the existing nitrification reactors to conduct both nitrification and denitrification. Nitrification capacity was reduced to the first four stages of the reactor, to accommodate denitrification in the last stage. This approach to denitrification utilizes one facility for two processes. There are difficulties in conducting denitrification under all conditions of flow, load and temperature. This was shown to be the case when implementation of nitrogen removal was negotiated with regulatory agencies. Experience with the full scale facility has shown that the denitrification process produces poorly settling solids which contribute to solids washouts and blinding of the effluent filters at high flow rates. This is due to attempting to treat high flows during storm events simultaneously with nitrification-denitrification using the same tankage, particularly during cold weather. Based on this experience, it appears that BPWWTP will not be able to reliably denitrify under high flow conditions. Because the Chesapeake Bay Program is considering revised nitrogen limits for the Bay, future NPDES permits may require nitrogen removal at Blue Plains to an effluent concentration as low as 3 mg/L. Chesapeake Bay Program Goals may thus dictate nitrogen removal requirements at the plant, and further measures should be based on the final outcome of the Bay Program. No costs for additional nitrogen removal are included in the LTCP.

10. WHAT ARE THE BENEFITS OF THE RECOMMENDED PLAN?

The selected CSO control program is expected to provide the following benefits:

- Reduction of CSO overflow volume
- Outfall elimination
- Improved water quality
- Reduction in floating trash on receiving waters

Each of these is described in greater detail below:

Reduction of CSO Overflow Volume – The frequency and volume of CSO overflows will be greatly reduced as a result of the recommended LTCP. Table 4 illustrates the reduction in overflows:

Table 4
CSO Overflow Reduction of Recommended Plan (Average Year)

Item	Anacostia River	Potomac River	Rock Creek	Total System
CSO Overflow Volume (million gallons/yr)				
No Phase I Controls	2,142	1,063	49	3,254
Recommended Plan	*54*	*79*	*5*	*138*
% Reduction	97.5%	92.5%	89.8%	95.8%
Number of Overflows/yr				
No Phase I Controls	82	74	30	-
Recommended Plan	*2*	*4*	*1 / 4[1]*	-

Notes: 1. One at Piney Branch, four at the other Rock Creek CSOs.

The recommended CSO plan is predicted to reduce CSO overflows to 138 million gallons or by about 96% on a system-wide basis compared to 1991 conditions (No Phase I Controls). In the Anacostia the number of overflows are predicted to decrease from the current 82 per average year to 2 per average year. Similarly, the number of overflows in the Potomac River and Rock Creek are predicted to decrease from 74 and 30 to 4 and 1 per average year respectively. In addition to demonstrating reductions in overflows from current levels, EPA's CSO Policy calls for calculating the percentage of combined sewage that is captured for treatment in the combined sewer system. The percentage of capture without the Phase I CSO controls is already very high at 76%, primarily due to the ability of BPWWTP to treat high flows during wet weather events. With implementation of the recommended LTCP, the CSO capture rate is predicted to be 99% on a system wide, annual average basis. This is extremely high when compared to EPA's guideline of 85% capture.

Outfall Elimination – The recommended plan will eliminate 14 CSO outfalls by separation and consolidation. The outfalls were selected based on proximity to public use areas and include those along the Georgetown waterfront and along the Anacostia Marinas. The outfalls to be eliminated are listed in Table 5. The outfalls to be eliminated along the Anacostia and the Potomac River are also shown on the following page using aerial photographs.

Table 5
Outfalls to be Eliminated

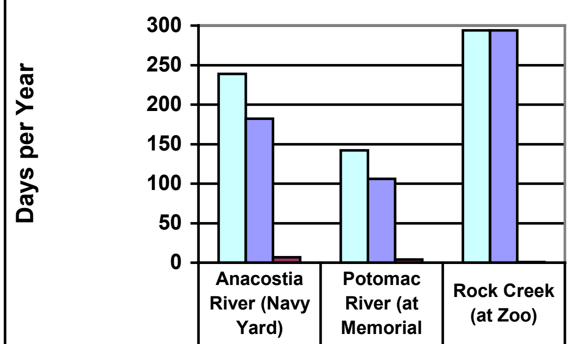
Receiving Water	Outfall Eliminated	Location	Method of Elimination
Anacostia	CSO 006	Fort Stanton	Separation
Anacostia	CSO 016	Anacostia Marinas	Consolidation
Anacostia	CSO 017	Anacostia Marinas	Consolidation
Anacostia	CSO 018	Anacostia Marinas	Consolidation
Potomac	CSO 023/024	Georgetown	Consolidation
Potomac	CSO 025	Georgetown	Consolidation
Potomac	CSO 026	Georgetown	Consolidation
Potomac	CSO 027	Georgetown	Consolidation
Potomac	CSO 028	Georgetown	Consolidation
Rock Crk.	CSO 031	Penn Ave.	Separation
Rock Crk.	CSO 037	Kalorama Circle	Separation
Rock Crk.	CSO 053	Q St.	Separation
Rock Crk.	CSO 058	Connecticut Avenue	Separation
Rock Crk.	CSO 059	Luzon Valley	Separation Complete
Total Number	**14**		

Improvements to Water Quality –Bacteria and dissolved oxygen are the two common performance measures used to assess water quality and the benefits provided by CSO control.

Bacteria

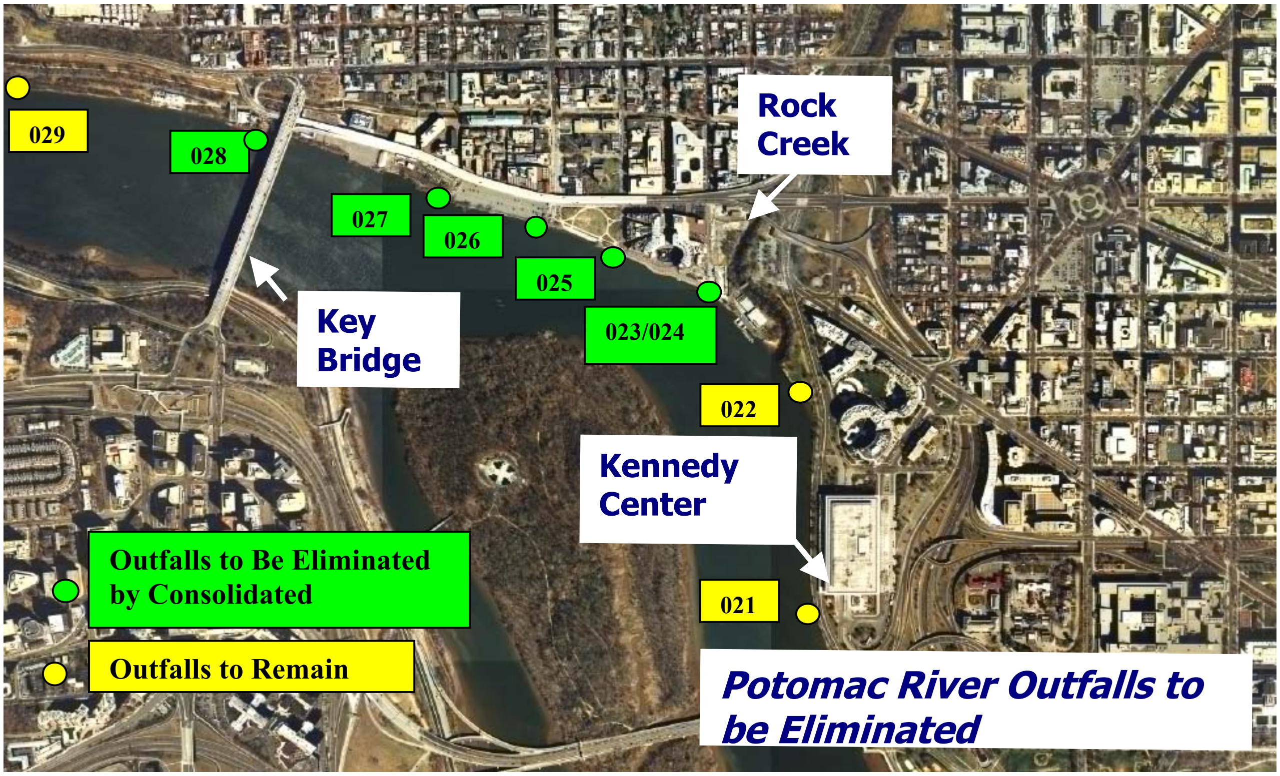
By themselves, CSOs will meet the fecal coliform bacteria water quality standard in all the receiving waters. However, the analyses conducted as part of the LTCP demonstrated that other sources of bacteria will prevent meeting the Class A water quality standard for fecal coliform in the Anacostia River and Rock Creek, much of the time. Figure 5 shows the number of days where the predicted fecal coliform concentration is greater that 200/100 ml.

Figure 5
Number of Days Fecal Coliforms Exceeding 200/100 ml



	Anacostia River (Navy Yard)	Potomac River (at Memorial	Rock Creek (at Zoo)
No Phase I Controls	239	142	294
Recommended Plan - All Loads	182	106	294
Recommended Plan-CSO's Only	7	4	1

In the Anacostia River, implementation of the recommended LTCP will reduce the number of days where the predicted concentration is above 200/100 ml from approximately 239 days to 182 days. Figure 5 also shows the predicted days the concentration in the receiving waters would exceed 200 due to CSOs if there were no other sources of bacteria in the river. Of the 182 days predicted to exceed 200/100ml, 7 days in the year would be caused by CSOs. Of those 7 days, 5 are in the period May through September, the period of most likely primary contact recreation. A similar pattern is observed for the Potomac River and Rock Creek. Additional CSO controls provide incrementally smaller benefits at greatly increased costs.


029
028
027
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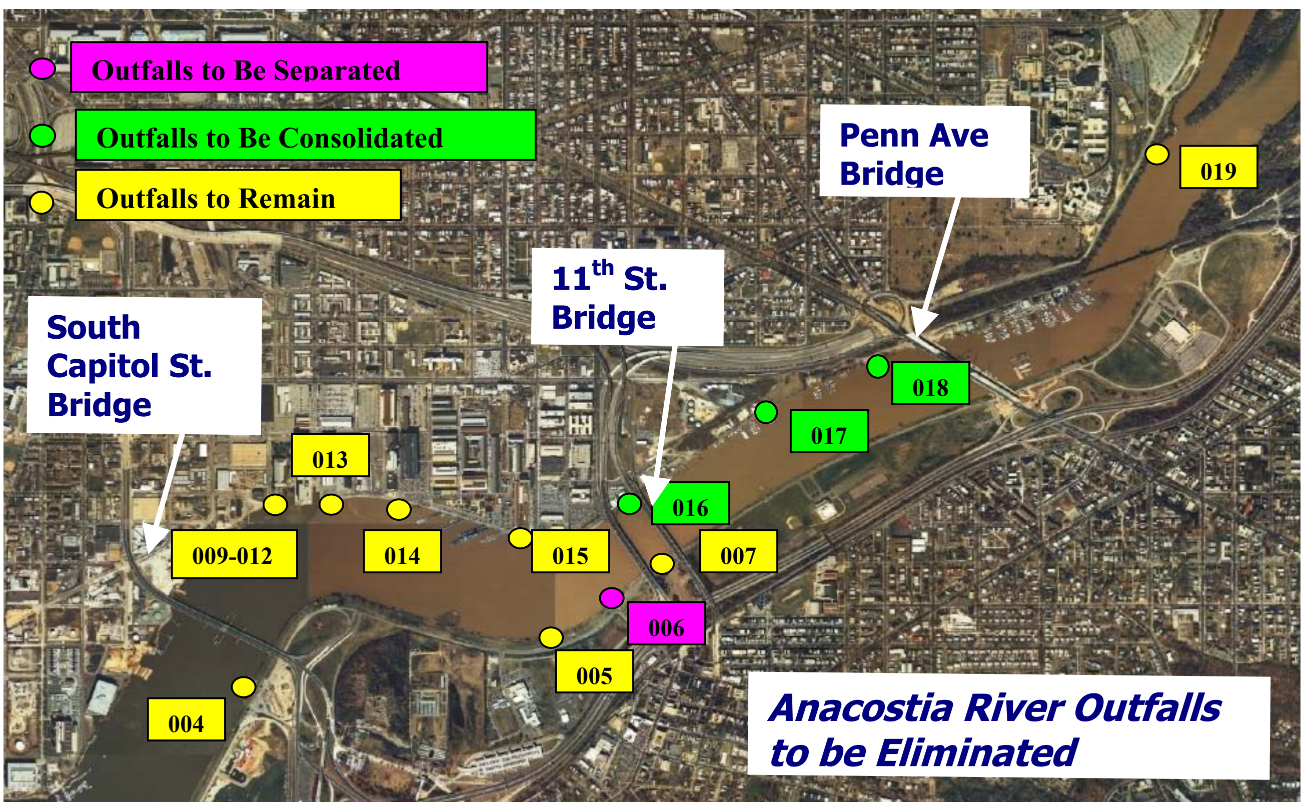
021
Rock Creek
Key Bridge
Kennedy Center
Outfalls to Be Eliminated by Consolidated
Outfalls to Remain
Potomac River Outfalls to be Eliminated


Outfalls to Be Separated
Outfalls to Be Consolidated
Outfalls to Remain
Penn Ave Bridge
019
11th St. Bridge
South Capitol St. Bridge
018
017
013
016
009-012
014
015
007
006
005
004
Anacostia River Outfalls to be Eliminated

In the Anacostia River, implementation of the recommend LTCP will significantly reduce the concentrations of bacteria in the receiving waters. As an example, the fecal coliform concentrations in May in the Anacostia at the Navy Yard are predicted to decrease from about 3,300 organisms/100ml (no Phase I Controls) to about 800 organisms/100ml (4 overflows per year).

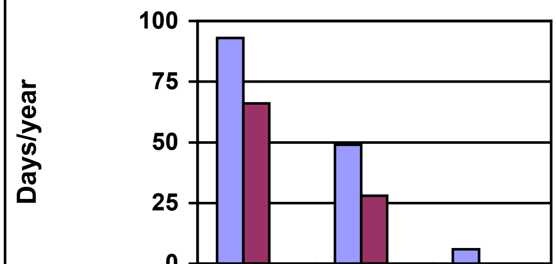
<u>Dissolved Oxygen</u>

Dissolved oxygen is not a significant concern in Rock Creek or the Potomac River because existing water quality standards are met the majority of the time. The reduction of CSO overflows to these receiving waters will reduce the quantity of pollutants which contribute to oxygen deficiencies.

In the Anacostia River, dissolved oxygen is a significant concern. Low dissolved oxygen levels typically occur in the summer months of June to August and typically follow a significant local or upstream wet weather event. The low dissolved oxygen is driven by the naturally low saturation level of oxygen in the water due to the high water temperature, the influx of pollutant loads from wet weather events, and the demand exerted by polluted sediments in the river bottom. Dissolved oxygen levels below 2 mg/L can occur several times per summer month, with each episode lasting 1 to 2 days. Fish kills have been observed in the past. Figure 6 shows the projected benefits provided by the recommended CSO plan at South Capitol Street.

In addition to the number of days less than 5 mg/L, the figure also shows the number of days less than 4 mg/L and 2 mg/L. Below 4 mg/L, certain fish begin to experience stress, while dissolved oxygen levels below 2 mg/L cause a risk of fish kill.
It is predicted that the recommend LTCP will reduce the number of days less than 5 mg/L from approximately 93 to 66. A similar reduction is observed for the 4 mg/L threshold. At South Capitol Street, the selected plan is predicted to eliminate the number of days less than 2 mg/L, the fish kill threshold. It is important to note that dissolved oxygen levels below 2 mg/L are still predicted to occur at other locations in the river such as at the Navy Yard and RFK Stadium.

Figure 6
Number of Days Per Year Dissolved Oxygen is Less Than Indicated Value at South Capitol Street in Anacostia River



	Days < 5 mg/L	Days <4 mg/L	Days <2 mg/L
No Phase I Controls	93	49	6
Recommended LTCP-All Loads	66	28	0
Recommended LTCP-CSO's Only	0	0	0

The assessments conducted as part of the LTCP have demonstrated that it is not possible to meet the water quality standard or to prevent dissolved oxygen from dropping below 2 mg/L anywhere along the Anacostia through CSO control alone. Control of other sources in conjunction with CSO control is required.

Reduction of Floating Trash on Receiving Waters - Solids and floatables on the receiving waters come from the following sources:

- Combined sewer overflows
- Storm water outfalls
- Littering and dumping directly into or along the receiving waters
- Upstream sources

Implementation of the recommended control plan will virtually eliminate solids and floatables from combined sewer system discharges because the majority of CSOs will be captured and treated. For storms that are beyond the capacity of the proposed controls, the first flush of CSO which contains the vast majority of solids and floatables will be captured and treated. Overflows from the proposed control system will typically occur near the end of extreme storm events after most of the solids and floatables have been washed from the streets and captured by the control facilities. In addition, the following control measures will be implemented:

- WASA will incorporate floatables control for overflows which exceed the capacity of the recommended control plan into the design of new CSO diversion structures/facilities which will be constructed as part of the recommended plan, where practical.

- WASA continues to operate the Anacostia River Floatable Debris Removal Program, which consists of skimmer boats that remove solids and floatables from the Anacostia and Potomac Rivers. Note that this program removes materials from the rivers from all sources, not just from CSOs.

WASA Skimmer Boat

- WASA continues to operate the Floating End of pipe netting system at CSO 018 on the Anacostia River

- The storm water pumps at the Main and O Street Pumping Stations incorporate trash racks on the influent side of the pumps that remove floatables before discharge to the Anacostia River.

Floating End-Of–Pipe Netting System at CSO 018 – Anacostia River

After implementation of the recommended plan, a large amount of trash may still be present due to sources other than CSO. Control of these other sources in a watershed-based approach is recommended.

11. WHAT ARE THE MAJOR FINDINGS OF THE LTCP?

The following are findings regarding the impact of the recommended LTCP on water quality:

- Bacteria conditions are a problem in all three receiving waters. CSO control will significantly reduce the concentrations of bacteria, but will not result in conditions in the river that meet water quality standards all the time because of pollution from storm water and upstream sources. Control of other sources coupled with CSO control is required to meet current water quality standards

- Elimination (by separation) of combined sewer discharges to the receiving waters is not economically feasible for the District and has numerous drawbacks, including the disruption associated with constructing essentially a new sewer system for one-third of the District. The recommended plan is predicted to provide better water quality than separation. This is due to the large amount of storm water that is collected in the combined sewer system and treated prior to discharge.

- Significant sources of bacteria are found in storm water runoff and in water entering the District from upstream sources. Cost-effective and reliable technical programs to reduce these pollution sources to the degree required to meet current water quality standards may not be available for the foreseeable future.

- The recommended plan for CSO control will meet the geometric mean bacteria standard in all receiving waters. Initial discussions with the D.C. Department of Health indicate it will also meet the fecal coliform TMDL which is expected to be promulgated for all receiving waters.

- CSO control will improve the dissolved oxygen levels in the Anacostia River. However, CSO control alone will not allow the dissolved oxygen standard to be met and will not prevent the dissolved oxygen from dropping below the level where fish kills are possible. Control of storm water and upstream sources are required to achieve this standard.

- The recommended control plan will virtually eliminate solids and floatables from the combined sewer system because the majority of CSOs will be captured and treated. For storms which are beyond the capacity of the proposed control system, the first flush of CSO which contains the vast majority of solids and floatables will be captured and treated. After implementation of the recommended plan, a large amount of trash may still be present due to sources other than CSO. Control of these other sources in a watershed-based approach is recommended.

12. COMPARISON OF FINAL LTCP TO DRAFT LTCP

The Final LTCP described in this report represents a major increase in CSO control over the Draft LTCP that was released in June 2001. In developing the Final LTCP, consideration was given to public and regulatory agency comments, the CSO Policy, the need to meet D.C. water quality standards, and existing and prospective TMDLs for the receiving waters. Particular attention was paid to separation, outfall elimination, low impact development and increasing the level of CSO control. Major advances in each of these categories have been made. The Final LTCP is compared to the Draft in Table 6.

Table 6
Comparison of Final and Draft LTCPs

Item	Draft LTCP	Final LTCP
No. CSO Overflows/Avg. Year		
Anacostia	4	2
Potomac	12	4
Rock Creek at Piney Branch	4	1
Rock Creek – other outfalls	4	4
CSO Overflow Volume (mg/avg yr)		
Anacostia	93	54
Potomac	153	79
Rock Creek	13	5
Total	259	138
% Reduction From Existing	92%	96%
% Reduction on Anacostia	96%	98%
System Characteristics		
CSO Storage Volume (mg)	147	193
No of CSO Outfalls	60	46
Water Quality Criteria		
Meets Oxygen and Bacteria Water Quality Standard for Design Condition?	Yes	Yes
Meets Anacostia BOD and TSS TMDLs?	BOD - Yes TSS - Yes	Yes
Cost		
Capital Cost (Billions, Year 2001)	$1.05	$1.265
Cost Increase over Draft LTCP	-	20%

13. FINANCIAL IMPACTS

Financing CSO programs in an equitable manner without placing an unreasonable burden on ratepayers is one of the most challenging aspects facing CSO communities. WASA has used the following two methods to document the burden on the District of the proposed LTCP:

- Long-term rate impact analyses using the Authority's financial planning and rates model, and
- Affordability analysis using procedures developed by EPA.

A key indicator of the affordability of the proposed LTCP is the impact on the annual household budgets for District ratepayers as measured by the timing and extent of the required annual rate increases. To document the actual impact on household budgets and to supplement the EPA approach, WASA conducted an analysis of the impacts of the CSO program on wastewater rates.

To finance its current $1.6 billion capital program, annual increases in retail rates of approximately 6.5% to 7.0% through FY 2008 followed by 6% annual increases from FY 2009 through FY 2012 will be required. Over the long-term, WASA is projecting that future necessary infrastructure re-investment will continue to require steady rate increases of about 5% per year. This longer-term outlook is consistent with national infrastructure studies that document the need for doubling of rates over 20 years for infrastructure investment. Under this "baseline" scenario, the annual cost for water and wastewater for a typical residential customer with metered consumption of 100 CCF per year will increase 113% (from $290 to $617) in fifteen years.

Implementation of the LTCP will result in additional rate increases and higher costs to the Authority's customers over and above the increases needed to fund the baseline capital program. Through analysis of a range of LTCP implementation schedules WASA has determined that the only rates impacts that are feasible are those associated with the longest implementation schedules. Table 7 displays the impacts for a 100 CCF customer over 15 years for the baseline and for several LTCP implementation schedules.

Table 7
Rate Impacts of the CSO LTCP on 100 CCF Residential Customer

	FY 2003 Annual Bill	Annual Bill in 15 Years	Annual Rate Increases Over 15 Years
Baseline – No LTCP	$290	$617	6.0%
Baseline + 40-yr LTCP	$290	$722	7.2%
Baseline + 30-yr LTCP	$290	$795	8.0%
Baseline + 20-yr LTCP	$290	$942	9.4%
Baseline + 15-yr LTCP	$290	$1,002	9.9%

If WASA implemented the proposed LTCP over a 40-year period, a typical residential customer with annual metered water consumption of 100 CCF will see their annual wastewater costs rise from $290 to $722 in 15-years; a 150% increase.

Shorter LTCP implementation schedules create too high a burden on the Authority's rate payers in terms of rapid escalation of the cost of wastewater services. The 15 and 20-year LTCP implementation schedules would require a large number of consecutive "double-digit" rate increases when the costs of those programs are added to the demands imposed by the baseline investment in water and wastewater infrastructure. As shown in Figure 7, the 15-year program is projected to require 8 consecutive increases over 10% per year. Such rate increases would outpace expected growth in household incomes by two to three times, thereby eroding household resources for other items. As shown in Figure 8, longer implementation schedules require lower peak rate increases and reduce the number of increases over 10% from 8 consecutive increases to fund the 15-year schedule to a single increase exceeding 10% in the case of the 40-year schedule.

Figure 7
Annual Rate Increases required for 15 and 20-Year LTCP Plans

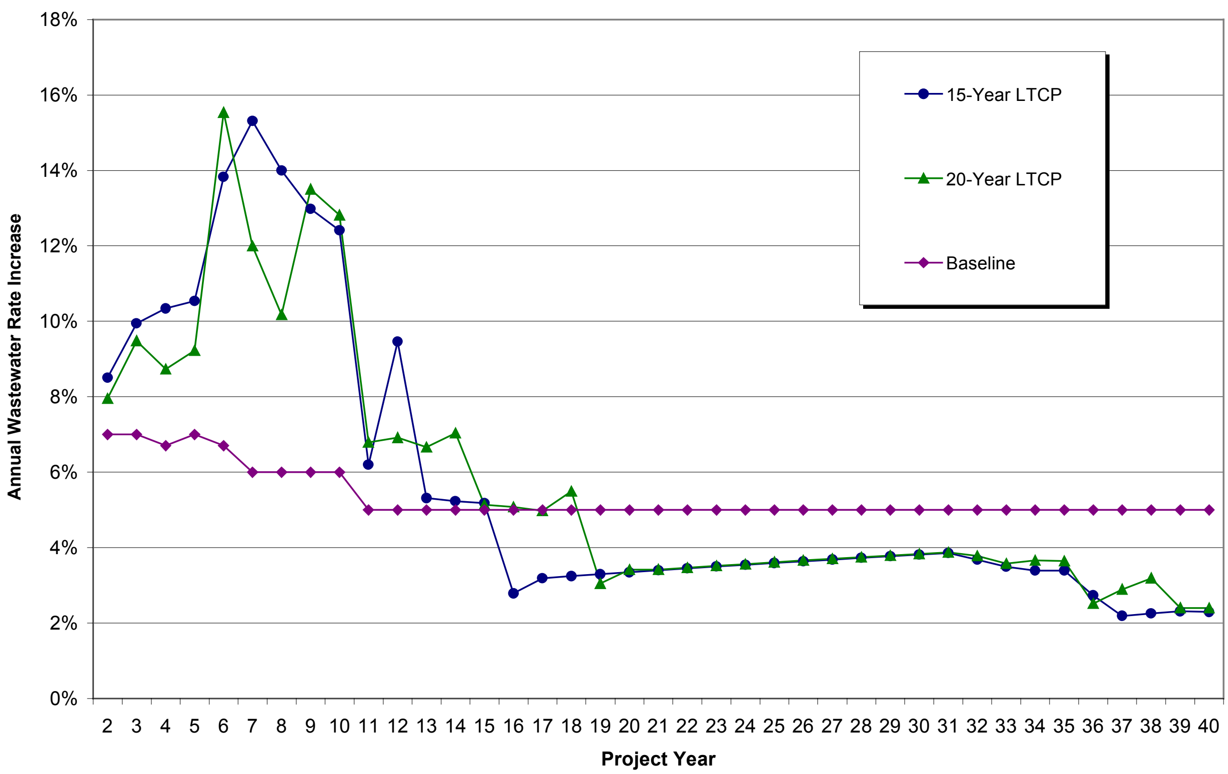
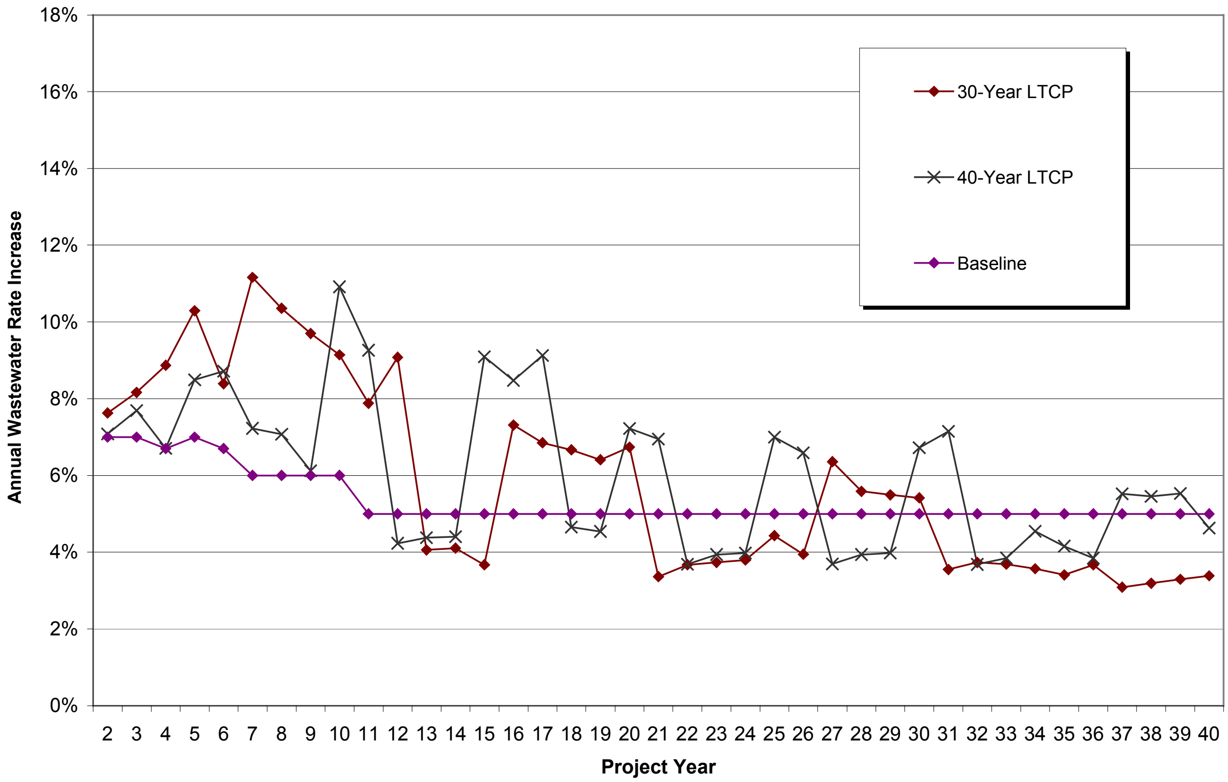


Figure 8
Annual Rate Increases required for 30 and 40-Year LTCP Plans



There are two ways to reduce the rate impacts of a shorter LTCP implementation schedule, external funding assistance and deferral of other water and wastewater capital expenditures. External assistance targeted at limiting peak rate increases can reduce the severe impacts of high annual rate increases associated with the shorter programs. External assistance of approximately 62% of the capital cost of the program can keep rate increases to 8% per year as shown in the following chart. Total external capital assistance under this scenario would be $960 million. It is important for any external assistance to reflect year-of-expenditure values or the actual "cost to complete" the project. If external assistance is determined on current dollars or on an amount per year, the cost to complete and inflation risks are shifted to ratepayers.

The EPA's approach involves calculating the cost per household (CPH) for residential customers for current and proposed wastewater treatment and CSO control costs. The CPH is used in conjunction with the median household income (MHI), estimated at $39,760 per year in 2001, to estimate residential impacts. Residential impacts are considered by EPA to be 'low' if the CPH is less than 1% of the MHI, 'medium' if the CPH is between 1% and 2% of the MHI, and 'high' if the CPH is greater than 2% of the MHI. The CPH is combined with other factors such as unemployment rate, property tax collection rates and other factors to develop an overall assessment of financial burden.

In the District, there is a distinct clustering of household incomes at the lower and upper extremes of the income spectrum. Because of the disproportionate number of low-income households in the District, the impact of wastewater treatment and CSO control costs on the lowest 20% of income distribution in the District was calculated. The analysis was performed for the maximum income in this category, which is $18,000 per year.

Table 8 summarizes the results of the analysis. For median incomes, wastewater treatment costs including the proposed CSO controls are projected to impose a medium burden according to EPA guidelines. Current wastewater treatment costs alone impose a medium burden on lower income households. Addition of CSO controls to low income households increases the burden level to EPA's highest level, reaching nearly 3.5% of household income alone for wastewater costs. Various levels of Federal assistance are also listed showing the degree to which they reduce the CPH as a percent of median income.

Table 8
Cost Impacts on Residential Customers (Year 2001 Dollars)

Scenario	Cost Per Household for Wastewater Treatment ($/yr)	Cost Per Household as % of Income	
		Median Incomes	Upper end of Lower 24% of Incomes ($18,000/yr Income)
Current Residential Bill (April 2001)	$271	0.8%	1.5 %
After Completion of Current Capital Improvement Program, but no additional CSO controls[1]	$329	0.83%	1.83%
Current Capital Improvement Program Plus Additional Recommended CSO Controls:			
0% Assistance	$602	1.51%	3.35%
25% Assistance	$539	1.36%	3.00%
75% Assistance	$413	1.04%	2.30%

Notes: 1. Includes cost of rehabilitation of Main, 'O' Street, Eastside and Poplar Point Pumping Stations.

14. WHAT IS THE PROPOSED IMPLEMENTATION SCHEDULE?

In accordance with public comments, the schedule for implementing the recommended control plan was developed by giving priority to projects that benefit the Anacostia River. The projects in the LTCP can be divided into two categories: those in the existing Capital Improvement Program (CIP) and those not currently in the CIP. Projects in the CIP have been budgeted and scheduled and these projects will move forward without approval of the LTCP. For projects not currently in the CIP, an implementation schedule has been developed based on years after approval of the LTCP. Based on the financial capability assessment and in order to mitigate the annual rate increases that would be required to fund the full LTCP, a 40-year implementation time is proposed for the entire recommended plan if no outside financial assistance is received. If significant outside financial assistance is obtained, it is technically feasible to accelerate the schedule to a 15-year implementation time frame. Significant outside assistance on the order of 62% would be required to achieve this schedule.

15. WATER QUALITY STANDARDS REVIEW

The current water quality standards for the District of Columbia do not address the transient nature of wet weather events. The standards also include a narrative component, which, among other items, require that discharges be free of untreated sewage. Given the current standards, no alternative short of complete separation can completely eliminate overflows (and thereby comply with current standards) during all conditions. The analyses conducted as part of the LTCP have shown that complete separation is not economically feasible, has numerous technical drawbacks, and is less beneficial in terms of water quality than the recommended control program. As a result, WASA has selected a LTCP that offers an effective combination of costs, benefits and environmental protection. However, although greatly reduced, CSO discharges will continue to occur under the LTCP and water quality provisions will need to be adopted that address wet weather discharges from the combined sewer system.

Studies conducted as part of the LTCP have demonstrated that pollution sources other than CSOs (storm water, upstream sources, non point sources) cause substantial impairment to the receiving waters. These sources will have to be significantly reduced to reach the equivalent degree of protection that can be achieved by the LTCP. Cost-effective and reliable technical programs to effectively reduce the impact of the other pollution sources may not be available for the foreseeable future. Besides the technical uncertainties of reduction of the other pollution sources, a significant component of these sources originate in political jurisdictions outside the District. Given the history and experience of dealing with diverse pollution sources and other political jurisdictions, the results of future efforts to control these sources cannot be predicted with any degree of certainty.

The CSO studies have shown that the benefits of the LTCP are reliable and implementable. As WASA and the District develop provisions to implement the LTCP, consideration should be given to formation of a watershed based forum to reduce the other pollution sources.

In view of the complex and technically difficult situation regarding control of diverse and undocumented pollution sources, consistent "fishable and swimmable" water quality conditions for District waters receiving CSO discharges may not be achievable, particularly during wet weather. In any case, the recommended LTCP would provide the foundation to work towards "fishable-swimmable" conditions. To such an end, the recommended LTCP would accomplish the following:

- A situation whereby the remaining CSO discharges would not negatively affect achieving the "fishable" component of the "fishable-swimmable" use designation. In this regard, fishing could be practiced whether or not a CSO discharge was occurring.
- A situation wherein the remaining CSO discharges would preclude achieving full body contact a small percentage of the time. However, there would be few occurrences throughout the warm weather recreational period when the public might occasionally be precluded from full body contact by CSO discharges.

Given the magnitude of the investment proposed for CSO control, WASA has a responsibility to protect the investment in the LTCP and to seek wet weather discharge provisions in the water quality standards prior to implementation. Implementing the LTCP without such provisions would expose rate payers to significant economic risk since the control plan would not technically meet water quality standards and would be subject to challenge. A framework for such provisions in the standards could be as follows:

- Provide for the limited discharges as included in the LTCP to continue. The designated use would be restricted during times of discharge and for a limited time thereafter.
- Develop compliance requirements based on the physical elements of the control plan (e.g. capacity to store a set volume or to convey CSO at a set rate).
- Exclude those wet weather events over and above the capacity of those facilities included in the plan.
- Provide for public notification when discharges are occurring and for established times after discharges cease.
- Provide for a post construction-monitoring program to measure instream conditions.

16. WHAT IS COMPLIANCE MONITORING?

A program will be required to monitor performance of the final LTCP. This program would commence as usable components of the final LTCP are placed in operation. The monitoring program would comprise elements as follows:

- Flow monitoring and sampling at representative CSO outfalls on each receiving water system.
- Flow monitoring on representative facilities that transfer flow from CSO outfalls to storage and a system to measure the degree to which storage facilities are filled.
- A visual notification system placed at three or four locations on each receiving water at public access locations. This system would serve to notify the public of the occurrence of overflows based on the flow monitoring at the representative CSO outfalls. The system would comprise a series of colored lights, flags or pendents.
- An instream monitoring program would be developed to periodically obtain information on water quality. This program could be structured similar to that employed to obtain information for the LTCP.

17. WHAT ARE THE NEXT STEPS?

The recommended LTCP has been sent to regulatory agencies and has been made available to the public for review. If regulatory agencies approve the plan, WASA will develop an implementation plan and schedule for the LTCP. In order to make the LTCP a reality in a short time frame, a significant amount of Federal funding will be required.

18. HOW CAN I GET MORE INFORMATION?

There are many opportunities to get more information on the LTCP. The complete text of the LTCP can be viewed at the following locations:

- WASA's web site at www.dcwasa.com, click on "Environment & Education", "Combined Sewer System"
- At the following public libraries:

Martin Luther King Jr.	**901 G St, NW in Washingtoniana Room**
Capitol View	**5001 Central Avenue, SE**
Mount Pleasant	**3160 16th Street NW**
Northeast	**330 7th Street NE**
Woodridge	**18th & Rhode Island Avenue NE**
Southeast	**403 7th Street SE**

Shepard Park	**7420 Georgia Avenue NW**
Tenley-Friendship	**4450 Wisconsin Avenue NW**
Washington Highlands	**115 Atlantic Street SW**

- Write, call or e-mail WASA at:

  Dr. Mohsin Siddique
  CSO Control Program Manager
  D.C. Water and Sewer Authority
  5000 Overlook Avenue, SW
  Washington D.C. 20032
  Tel.: 202-787-2634
  E-mail: Mohsin_Siddique@dcwasa.com

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
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Appendix - C
Partnership Agreement

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December 10. 2012

Clean Rivers, Green District

Green Infrastructure Partnership Agreement

District of Columbia Water and Sewer Authority, U.S. Environmental Protection Agency, and the Government of the District of Columbia

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Introduction

The U.S. Environmental Protection Agency (EPA), the District of Columbia Water and Sewer Authority (DC Water), and the Government of the District of Columbia (District) are joining in a partnership to advance Green Infrastructure for urban wet weather pollution control. This Agreement demonstrates the parties' strong support for sustainable stormwater management yielding multiple benefits for community livability and other urban environment improvements. This Agreement also demonstrates DC Water's and the District's commitment to Green Infrastructure (GI).

DC Water is moving forward with the design and construction of a system of tunnels and related facilities in the Anacostia watershed to capture, store and convey combined sewer flows to the Blue Plains Advanced Wastewater Treatment Plant in accordance with the 2005 federal Consent Decree (Consent Decree) with EPA. DC Water now proposes to expand its commitment to GI and has invested significant resources and engaged a broad group of stakeholders to prepare a draft Green Infrastructure Project Plan (GI Project Plan). This plan has been submitted to EPA for review.

The GI Project Plan advances DC Water's proposal to conduct a large-scale, multi-million dollar GI demonstration project (GI Demonstration Project or GI Project) in the Potomac and Rock Creek watersheds for the purpose of evaluating the practicality and efficacy of implementing GI for the control of combined sewer overflows (CSOs) in these watersheds. The GI Project Plan proposes a comprehensive approach to the GI Demonstration Project, including GI site selection, identification and resolution of institutional issues and obstacles, public outreach, design and construction, monitoring and evaluation, and the preparation of a series of technical memoranda that detail every aspect of the GI Demonstration Project.

Following completion of the GI Demonstration Project, as informed by a preliminary screening analysis, DC Water proposes to use the project's findings to conduct an analysis of alternative green and green/gray infrastructure controls (Alternatives Analysis) with the goal of identifying alternative solutions for each of the two watersheds that, compared to present plans laid out in the Consent Decree, would be consistent with the CSO Control Policy, potentially more sustainable, and capable of yielding a range of additional benefits to the community. If such feasible alternatives are identified, the Alternatives Analysis would provide the foundation for proposing changes to DC Water's Long Term Control Plan (LTCP).

EPA and the District strongly support GI approaches to meeting wet weather challenges. This partnership agreement memorializes EPA's and the District's commitment to encourage and support DC Water's efforts to explore how GI could meet or help to meet its CSO Control Policy obligations under the Clean Water Act and to work with DC Water to overcome obstacles to moving this initiative forward expeditiously.

This Partnership Agreement fosters principles articulated in EPA's "Integrated Municipal Stormwater and Wastewater Planning Approach Framework", dated June 5, 2012. Specifically, it integrates the storm water management obligations of the District with combined sewer overflow control obligations of DC Water.

GI Projects Already Completed or Underway in the District

This Agreement builds upon a number of GI projects by both the District and DC Water that have either been completed or are now underway. Some of these projects are supported with financial and technical assistance from EPA and other federal agencies.

The most significant District of Columbia's projects include:

- **Green Streets Initiative** – A project to revitalize major urban corridors in the District by improving transportation, encouraging private investment, and providing environmental benefits through incorporating GI practices into the streetscape.
- **Green Infrastructure Demonstration Projects** – A variety of transportation projects across the District that incorporate GI to better understand how GI can be blended into the streetscape to realize the many benefits of green.
- **Street Trees, Park Trees, and Planting Spaces** –District agencies are working together to incorporate GI into District projects (Impervious Surface Reduction Project, Green Median Renovation Project, and Tree Canopy Renovation Project) to reduce storm water runoff and increase the urban tree canopy within the District's combined sewer system.

- **RiverSmart Washington Project** – A project designed to determine the extent to which uncontrolled storm water is reduced by a suite of GI retrofits in three District sewersheds. The project consists of RiverSmart Homes, RiverSmart Communities, RiverSmart Rooftops, Municipal Green Roofs, and RiverSmart Schools.

In addition to providing funding support for a variety of GI projects undertaken by the District of Columbia and others in the District, DC Water has undertaken or is committed to several GI projects of its own, including:

- **Conducting a rain barrel demonstration project** to reduce runoff to the combined sewer system.
- **Constructing a rain garden and bio-retention area at Irving and North Capitol Streets** as part of a Supplemental Environmental Project to reduce runoff to the combined sewer system.
- **Constructing an infiltrating tree pit, permeable pavers and native landscaping at the Bryant Street Pumping Station** as part of the rehabilitation of this pumping station.
- **Constructing permeable pavers and a grass swale at the Eastside Pumping Station** as part of the rehabilitation of this pumping station.
- **Constructing green roofs and bio-retention** at three of its facilities.

Partnership Actions and Agreements

Green Infrastructure Screening Analysis and GI Project Plan Refinements

In order to provide additional information on the feasibility of using GI alone or in combination with gray controls for CSO control, DC Water has conducted a preliminary screening analysis of the feasibility of alternative scenarios for incorporating GI into the CSO controls for the Potomac and Rock Creek. With input from EPA, DC Water will use the information generated by the screening analysis to refine the GI Project Plan to focus on sewersheds where GI has the best possibility of providing, or being part of, an integrated solution for controlling CSOs. This analysis was submitted to EPA on July 11, 2012.

The GI Demonstration Project and the Roles and Responsibilities of DC Water, the District of Columbia, and EPA

As described in more detail below (Coordination on Consent Decree Amendments), the parties have agreed to work together to put in place the framework needed to accommodate and facilitate the GI Demonstration Project. Once this framework is in place, DC Water will proceed with the GI Project in accordance with the final GI Project Plan, including site selection, identification and resolution of institutional issues and obstacles, public outreach, design and construction, monitoring and evaluation, and preparation of a series of technical memoranda to be submitted to EPA and the District for review. DC Water has also agreed to proceed with preparation of the Environmental Impact Statement (EIS) required for the Potomac Storage Tunnel while the GI Demonstration Project and Alternatives Analysis are underway.

While DC Water will be responsible for conducting the GI Project, EPA and the District will assume responsibilities in support of DC Water's efforts that will be of critical importance to the success of the GI Project, including, but not limited to:

- Participating in developing and implementing a Green Design Challenge, which will engage the private sector and other interested parties in projects to demonstrate the practicality and efficacy of decentralized, large-scale and small-scale GI for the control of stormwater;
- Enlisting participation by public and private organizations in a collaborative effort to develop and demonstrate next generation GI designs and techniques;
- Facilitate participation by local academic institutions in various aspects of the GI Demonstration Project;
- Actively involving the environmental community in design and development of the GI Project to facilitate implementation; and
- Reviewing and providing input on DC Water's technical memoranda and reports.

DC Water has agreed to provide funding, as needed, to assist the District with its cost of participating in the GI initiative.

Throughout this initiative, DC Water, EPA, and the District will work closely together to review and assess the water quality benefits and impacts of alternative green and gray/green controls compared to the benefits and impacts of the controls now required in the Potomac and Rock Creek watersheds to ensure that the GI Project, water quality review and assessment, and Alternatives Analysis conform to EPA's expectations and Clean Water Act requirements.

Keeping in mind that the GI Project is also designed to facilitate implémentation of GI in those parts of the District served by the separate storm sewer system and to integrate the stormwater management obligations of the District with the combined sewer overflow control obligations of DC Water, the District and DC Water will also consult with each other on a continuing basis to ensure that (1) the GI Demonstration Project designs, data, and results can be used by the District to promote and advance the widespread use of GI in those parts of the District served by separate storm sewers; and (2) the data and information developed in connection with the District's RiverSmart Washington GI project and other GI project work experience is applied to DC Water's GI Project.

To ensure that the results of the GI Project serve to advance GI implementation nation-wide, EPA will (1) communicate with EPA's Office of Research and Development (ORD) on the progress of the GI Demonstration Project and opportunities for ORD's involvement, and (2) assist DC Water in sharing the results of the GI Demonstration Project work so that other communities nation-wide can benefit from DC Water's experiences.

DC Water's proposal to extend the deadlines for undertaking design and construction of the Potomac and Piney Branch (Rock Creek watershed) tunnels and related facilities includes "decision points" where DC Water would be required to end the GI Project and revert back to the Consent Decree schedule for designing and constructing the Potomac and Piney Branch tunnels, and related facilities, if specified criteria are not achieved. The decision points would be designed to ensure that the deadline extension will continue only if the GI Project is on track to produce the level of protection consistent with the CSO Policy and reflected in the preliminary screening analysis.

DC Water envisions proposing the use of decision points at key phases in the process, such as at the completion of the construction of the GI Project itself and after post–construction monitoring has been completed. In addition, an early decision point focusing on the identification and resolution of institutional issues and obstacles to GI implementation will be scheduled. This institutional decision point may consider (1) the extent to which reviews, permits and approvals required for the installation of individual GI demonstration projects have been completed for lands controlled by District departments and agencies; (2) the extent to which review and revision of District regulations, ordinances, and codes related to streets, sidewalks, and public and private property to identify necessary changes to mandate GI retrofit requirements required to implement the GI Project Plan have been completed; (3) the extent to which institutional impediments to large scale GI have been resolved; (4) an evaluation of impervious area fee incentive programs to incentivize GI implementation has been completed; and (5) the extent to which District departments will commit to revising capital expenditure plans to prioritize GI retrofits in priority areas. The District will play a critical role in achieving the institutional modifications required for the GI Project to proceed beyond the early planning phases.

Coordination on Consent Decree Amendments

DC Water and the District believe that the deadlines in the Consent Decree for the Potomac and Piney Branch tunnels and related facilities will need to be extended to accommodate a demonstration project of this scale. DC Water and the District recognize that the data from the GI Demonstration Project must be collected and evaluated before it can be determined whether to proceed with full-scale GI implementation. Accordingly, DC Water will file a request to modify the affected deadlines pursuant to Section VII of the Consent Decree (Modifications to Selected CSO Controls and Schedules) to allow the GI Demonstration Project to proceed. Therefore, in order to expedite the consideration of the GI Demonstration Project, the parties have agreed to the following process for amending the Consent Decree.

- DC Water will notice the proposed Consent Decree modification package for public comment within 60 days of receiving EPA's comments on the draft Consent Decree modification package. DC Water will perform the following public outreach at a minimum:
  - Make the modification package available on DC Water's web site;
  - Advertise legal notices in at least two local papers and customer invoices;
  - Allow a minimum of 60 days public comment;
  - Hold at least one public meeting to explain the proposed modification and take comments; and
  - Receive public comments via mail, e-mail and fax.
- DC Water will prepare responses to comments received from EPA and the public and will revise the Consent Decree modification package as appropriate and submit the final package to EPA no later than 21 days after close of the public comment period.
- EPA will expeditiously review the modification package (including the public comments and DC Water's response to the comments) to determine if the GI Demonstration Project can reasonably be expected to lead to implementation of green or green/gray controls that will provide for compliance with the applicable requirements of the CSO Control Policy. Thereafter, EPA will make a recommendation to the U.S. Department of Justice concerning whether it supports or does not support the proposed Consent Decree amendments.

As is standard procedure, the United States will review the proposed Consent Decree amendments and determine whether or not to support the proposed amendments. In the event the United States makes a determination to support the proposed Consent Decree amendments, the United States will move to amend the Consent Decree pursuant to its usual procedures and Paragraph 101 of the Consent Decree. In the event the Court approves the amendments, DC Water shall begin implementing the GI Demonstration Project pursuant to the court-approved schedule. The United States will make a substantive determination as to whether or not to recommend modification of the existing CSO controls in the Consent Decree through a subsequent modification upon review of the outcome and data from the GI Demonstration Project and such modification, if any, will be the subject of a later amendment to the Consent Decree. If the United States notifies DC Water that it does not support the proposed Consent Decree amendments or if the Court refuses to approve the proposed Consent Decree amendments, this Agreement will be terminated and DC Water will discontinue the GI Demonstration Project and proceed with implementation of the CSO controls for the Potomac and Piney Branch storage tunnels now required by the Consent Decree.

Ongoing Communication and Coordination

Representatives of EPA, DC Water and the District will meet periodically to assess the goals and commitments of this Partnership Agreement to evaluate and assure progress. The parties will each identify key individuals who will be responsible for advancing this Agreement. Other partners critical to the success of this effort, such as non-governmental organizations, will be engaged to assist and help assess progress.

It is the intent of the parties to work diligently to implement this Agreement. The commitment to ensure that Green Infrastructure, as part of the Clean Rivers, Green District initiative, meets the requirements of the Clean Water Act and is legally authorized and protected is acknowledged by the parties. Should either EPA, DC Water, or the District determine that it is unable to continue participation in this Agreement, it may terminate this Agreement by notifying the other parties in writing. The parties have voluntarily entered into this Agreement and therefore agree that it does not modify their respective legal rights or obligations.

Shawn M. Garvin Regional Administrator U.S. EPA	**Vincent C. Gray** Mayor District of Columbia	**George S. Hawkins** General Manager DC Water

Appendix - D
Economic Impacts and Benefits of Alternative CSO Control Strategies

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Economic Impacts of Alternative Combined Sewer Overflow Control Strategies: Evaluation of Green and Grey Infrastructure Approaches for the DC Clean Rivers Project

Update to August 2012
Economic Impact Report

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This report describes the economic impact analysis (EIA) conducted by Stratus Consulting to evaluate the relative impact of alternative combined sewer overflow (CSO) control strategies on the Washington, DC (the District) economy. This report serves as an update to the 2012 report *Economic Impacts and Benefits of Alternative CSO Control Strategies: Evaluation of Green and Grey Infrastructure Approaches for the DC Clean Rivers Project*, based on revisions to the proposed CSO control alternatives recently made by DC Water.

Specifically, the EIA compares the economic impact of a "baseline" CSO control alternative that consists only of grey infrastructure solutions, to the impacts of a "hybrid" alternative that includes both grey and green infrastructure (GI) components. The following sections provide a background on EIA within the context of the current project, describe the methods used to conduct the analysis, and present the results.

1. Background

When policymakers make decisions about public investments, they must always weigh competing priorities and different levels of return on investment for different uses of public funds. According to a recent report by Green For All (2011), investments in water and other infrastructure are one of the most efficient methods of job creation in the current economy. The report states that infrastructure investments create 16% more jobs, dollar-for-dollar, than a payroll tax holiday; nearly 40% more jobs than an across-the-board tax cut; and more than five times as many jobs as a temporary business tax cut (Green For All, 2011, based on Moody's Analytics).

There are two reasons for infrastructure's high job-creation potential. First, infrastructure investments are targeted toward areas in the economy with high excess capacity (i.e., market demand is below what the industry could potentially supply), such as the construction and landscaping industries and the associated suppliers. Second, tax cuts – especially those for high-income individuals – are more likely to be saved (especially in times of economic downturn), whereas worker-directed income (such as that resulting from infrastructure investment) is more likely to be put back into the economy (Green For All, 2011).

Evidence suggests that compared to grey infrastructure, the wide-scale implementation of GI has the potential to create more positive local economic impacts. Grey civil engineering projects require specialized skills, and firms performing these activities typically have these skill sets with their existing staff. Acquiring additional staff for a new project happens largely by hiring labor from competitors or other markets that are low on work. For the most part, these skilled laborers are also represented by trade unions, and are therefore already in the labor force. When a city water department implements a traditional infrastructure project in this manner, the net effect is that these already employed workers are simply bid away from other construction projects, resulting in a transfer of employment. In addition, many of the large engineering/construction firms hired for this work may be located outside of the District area.

In contrast, GI construction and operations and maintenance (O&M) require fewer highly trained and skilled employees. If the GI jobs can be targeted to District residents who are not employed or are underemployed, the GI program can result in a net gain in employment in the local economy, providing significant economic and social benefits.

The relative economic impact of a grey vs. GI program can be evaluated using EIA, which traces the flows of spending associated with a given activity in a region (e.g., a green or grey infrastructure program) to examine the effect of that activity on the local economy. Economic impacts are typically measured in terms of changes in economic growth (output or value added) and associated changes in jobs (employment) and income (wages). An EIA measures or estimates the level of economic activity occurring at a given time as a project or policy is occurring, and calculates the difference between that and what would be expected if the project or policy did not occur. In the context of this analysis, grey infrastructure serves as the baseline case, or what would occur in the absence of a GI program. Sections 2 through 6 provide a more in-depth discussion of EIA and the methodology used for this analysis.

2. Economic Impact vs. Benefit-cost Analysis

This analysis uses an EIA approach rather than a benefit-cost analysis (BCA) to evaluate the job creation and other local economic benefits associated with spending on green and grey infrastructure. EIA focuses on the effects of a project or policy on the amount and type of economic activity in a region, as well as the distribution of that activity. In contrast, BCA and triple bottom line (TBL) analyses are used to determine an action’s social welfare effects (compared to costs). Benefit-cost and TBL analyses include market and non-market values (consumer surplus) to reflect overall societal well-being, while EIA is restricted to actual cash flows of money (costs and revenues) accrued through market transactions.

Although the current analysis focuses on economic impacts, both approaches can be used by DC Water to evaluate and compare different CSO control strategies. For example, the EIA conducted as part of this analysis provides information on local jobs created and the economic sectors impacted under the green and grey infrastructure alternatives. This allows us to compare the local return on investment associated with similar levels of spending.

On the other hand, BCA can help inform DC Water on the social benefits associated with the different types of jobs under each alternative. As noted above, many jobs associated with GI implementation and maintenance are suitable for low and unskilled laborers and require no experience. There are significant social benefits that result from creating these specific types of jobs in an urban setting as part of a greening campaign. Such jobs can serve as a crucial steppingstone out of poverty for otherwise unemployed or underemployed people who reside in the same neighborhoods to which the greening is targeted. If GI jobs can be targeted to District residents who are unemployed or underemployed, the costs for social safety net programs in the District can be reduced. The value of these savings represents quantifiable benefits of a GI program.

3. EIA and the IMPLAN Model

Stratus Consulting used the IMPLAN model for the District area to evaluate the economic impacts associated with spending on the baseline grey infrastructure alternative and the hybrid green and grey infrastructure alternative (described below). Used by more than 2,000 public and private institutions, IMPLAN is the most widely employed and accepted regional economic analysis software for predicting economic impacts.

IMPLAN is an economic impact model that uses actual dollar amounts of all business transactions occurring in a regional economy (as reported each year by businesses and government agencies) to develop local-level multipliers. A multiplier summarizes the total impact that can be expected from spending in a given economic sector. For example, money spent on landscaping services can spur ripple effects or spin-off activities, such as increased output by local nurseries. Multipliers measure the economic impacts of these activities, including the ripple effects and spin-off activities. Multipliers categorize the impacts resulting from spending in a given economic sector into three components, as follows:

1. ***Direct effects*** are production changes associated with the immediate effects of changes in expenditures. For example, an increase in GI spending would directly yield increased sales in the landscaping sector. The additional landscaping sales and associated changes in jobs, and in payments for wages, salaries, taxes, supplies, and services, are the direct effects of this spending.

2. ***Indirect effects*** are production changes resulting from various rounds of re-spending by affected industries. In the previous example, indirect effects result from the re-spending of the landscaping industry’s receipts in backward-linked industries (i.e., industries supplying products and services to the landscaping industry). Changes in sales, jobs, and income in the turf grass industry, for example, represent indirect effects of changes in landscaping services sales. Businesses supplying products and services to the turf grass industry represent another round of indirect effects. Indirect spending will eventually affect, to varying degrees, many other economic sectors in the region.

3. ***Induced effects*** are the changes in economic activity resulting from household spending of income earned directly or indirectly as a result of additional spending. For example, landscaping employees supported by the District's infrastructure investment spend their income in the local region for housing, food, transportation, and the usual array of household product and service needs. The sales, income, and jobs that result from household spending of added wage, salary, or proprietor's income are known as induced effects. Indirect and induced effects are sometimes collectively called *secondary effects*.

The total economic impact is the sum of direct, indirect, and induced effects within a region. In the example above, changes in infrastructure spending, by means of indirect and induced effects, can impact virtually every sector of the economy in some way. However, the magnitude of secondary effects depends on the propensity of businesses and households in the region to purchase goods and services from local suppliers. This is taken into account in the development of local multipliers.

4. CSO Control Alternatives

This section briefly describes the CSO control alternatives developed for this analysis, including the baseline Long-term Control Plan (LTCP) grey infrastructure (baseline) alternative and the hybrid green and grey infrastructure (hybrid) alternative, which consists of both green and grey components. These alternatives will be implemented in the Potomac and Piney Branch watersheds.

Baseline alternative

The baseline alternatives for the Potomac and Piney Branch watersheds are based on a level of capital spending amounting to approximately $736 million ($616 and $120 million in the Potomac and Piney Branch watersheds, respectively, 2012 USD). The baseline alternative consists primarily of constructing large underground storage tunnels and pumping stormwater to wastewater treatment plants for treatment and discharge.

Analysis of the baseline alternative assumes that design, engineering, and construction activities/management will be initiated in 2021 and completed in 2025. Annual O&M activities are assumed to begin following project completion.

Table 1 shows the yearly cost for design and construction/implementation of the baseline infrastructure alternative. The spending shown in Table 1 reflects 2012 USD values and has not been escalated to adjust for inflation. Based on data provided by Greeley and Hansen for the Anacostia River grey infrastructure projects, we estimate that annual O&M costs will amount to about $2.0 million per year (in 2012 USD).

Table 1. Annual costs for design and construction/implementation of baseline infrastructure alternative, Potomac and Piney Branch watersheds ($M, 2012 USD)

Year	Potomac	Piney Branch	Total
2021	71.4	–	71.4
2022	145.6	21.5	167.2
2023	182.1	38.5	220.5
2024	145.6	38.5	184.1
2025	71.4	21.5	92.9
Total	**616.0**	**120.0**	**736.0**

Totals may not sum due to rounding.

Hybrid alternative

The hybrid alternative for the Potomac and Piney Branch watersheds represents about $706 million (2012 USD) in capital spending over a 19-year design and construction/ implementation period. This includes $641 million on grey infrastructure and about $65 million on GI (equivalent to $90 million over time deflated back to 2012 values). Under this alternative, GI replaces some of the grey infrastructure improvements planned under the baseline alternative.

GI techniques that will be implemented as part of the hybrid alternative include:

- Bioretention
- Vegetative filter strips
- Tree box filters
- Permeable pavement
- Large-volume underground storage
- Green roofs/blue roofs
- Rain barrels
- Downspout disconnects
- Cisterns.

The mix of GI projects included in the hybrid alternative is largely based on the mix of GI projects incorporated into GI demonstration projects that have been planned and/or implemented by the District, with some adjustments to reflect realistic conditions on the ground (e.g., taking into account the number of projects that can feasibly be implemented on private lands vs. within the public right-of-way). Specific details on the mix of GI demonstration projects, including unit costs and square footage/units of GI project types, can be found in the DC Clean Rivers Project *Technical Memorandum No. 3: Green Infrastructure Project Plan – Draft* (DCCR, 2012).

Table 2 shows the amount of spending (in 2012 USD) for grey and green infrastructure installations for each year of implementation of the hybrid alternative. For this alternative, O&M activities associated with grey infrastructure are assumed to begin immediately following construction, and will amount to about $1.77 million per year (2012 USD). O&M activities associated with GI will be initiated upon completion of the first GI project and will incrementally increase until all GI projects are fully implemented. In addition to the capital costs reflected in Table 2, at full implementation, GI O&M activities will cost an estimated $915,000 per year (2012 USD).[1] For the EIA, Stratus Consulting analyzed spending associated with 10 years of O&M activities.

Table 2. Annual costs for design and construction/implementation of hybrid alternative, Potomac and Piney Branch watersheds ($M, 2012 USD)

	Potomac		**Piney Branch**		
Year	**Grey**	**Green**	**Grey**	**Green**	**Total**
2014				0.94	0.94
2015				2.75	2.75
2016				0.89	0.89
2017		1.73		1.73	3.45
2018		5.02		5.02	10.05
2019		1.63		1.63	3.25
2020					
2021		1.53			1.53
2022		4.46		5.21	9.67
2023		1.44		5.78	7.22
2024					
2025	67.9			1.73	69.66
2026	134.6	3.31	10.9	5.29	154.02
2027	166.9	3.21	20.7	3.21	194.00
2028	134.6		20.7		155.23
2029	67.9		10.9		78.79
2030	1.3			4.11	5.29
2031	3.9			4.56	7.98
2032	1.3				1.11
Total	**578.4**	**22.3**	**63.0**	**42.2**	**706.6**

Totals may not sum due to rounding.

1. O&M cost estimates are based on data and assumptions from Stratus Consulting's work in Philadelphia (Stratus Consulting, 2009).

5. EIA Methodology

The EIA compares the relative economic impacts associated with the baseline and hybrid infrastructure alternatives for the Potomac and Piney Branch watersheds. As detailed above, each alternative represents more than $700 million (2012 USD) in capital spending on green and/or grey infrastructure over the design and construction/implementation periods: 2021–2025 for the baseline alternative and 2014–2032 for the hybrid alternative, including all GI components. In addition, for this analysis we included 10 years of spending for O&M activities, which are assumed to begin the first year following the final year of construction/implementation (under the hybrid alternative this applies to the completion of individual GI projects, so that some O&M activities begin as soon as the first GI project is complete).

To estimate economic impacts in IMPLAN, it was necessary to first determine how the direct project spending associated with each alternative would be spent (i.e., in which economic sectors). To accomplish this task, Stratus Consulting conducted a detailed analysis of cost information for both green and grey infrastructure techniques. Based on this information, we mapped spending over time under each alternative, to the relevant economic sectors included in IMPLAN (440 economic sectors are modeled in IMPLAN based on North American Industry Classification System codes).

For the GI installations under the hybrid alternative, this information was developed based on data from existing studies, data provided by utilities that have implemented (or planned) GI programs, and conversations with experts in the field. We separately analyzed costs for green streets (i.e., permeable pavement), bioretention, green/blue roofs, and other treatments (e.g., cisterns, downspout disconnects, and rain barrels), and applied this information to the relative mix of GI projects and the timeline planned for the Potomac and Piney Branch watersheds.

To model grey infrastructure, we relied on detailed cost information for the tunneling project currently being planned for the Anacostia River Watershed. We scaled this information and applied it to the timeline and total costs associated with the grey infrastructure planned under each alternative.

A second key part of the IMPLAN analysis included estimating the number of direct jobs that would be created due to spending on GI. Because grey infrastructure represents a traditional economic sector within construction, jobs associated with this alternative were developed within the IMPLAN model, based on established patterns of spending and job creation within the District area. For GI, which is not representative of a typical industry, Stratus Consulting developed direct job estimates for GI construction and O&M based primarily on data and assumptions used by the Philadelphia Water Department to estimate the job benefits of the city's Green City, Clean Waters Plan. Other direct jobs generated by GI spending (e.g., design/

engineering jobs, jobs created by spending in specific retail or wholesale sectors) were developed within the IMPLAN model.

A third component of the IMPLAN analysis was estimating the percentage of money that would be spent locally under each alternative. For this analysis, we relied primarily on Regional Purchase Coefficients (RPCs) developed by IMPLAN and specific to the District. The RPCs represent the proportion of local demand purchased from local producers. For example, an RPC of 0.25 for a given commodity means that for each $1 of local need, 25% will be purchased from local producers. This method is based on the characteristics of the region and describes the actual trade flows for the region mathematically. IMPLAN software generates RPCs automatically with a set of econometrically based set of equations. In some cases, we adjusted the RPCs to better reflect the reality of the alternatives. For example, we assumed that with GI, a higher percentage of construction laborers would be local residents, compared to the District average. We therefore adjusted the RPC accordingly.

Finally, in order to compare similar levels of spending for the green and grey alternatives, it was necessary to account for the difference in costs for the alternatives. This was accomplished by including the difference in total costs as an increase in household income under the hybrid alternative. As shown in Tables 1 and 2, DC Water would spend about $30 million (2012 USD) more for capital expenditures under the baseline alternative. At the same time, O&M costs for the hybrid alternative will be greater than under the baseline. On net, the baseline alternative will cost about $15 million (2012 USD) more than the hybrid when 10 years of O&M activities are taken into account. Thus, under the hybrid alternative, DC Water would not need to increase wastewater rates as much as they would under the baseline alternative. This essentially represents a savings (or an increase in available income) for District households. The analysis assumes that these savings occur equally across households of all income levels.

The estimated amount of spending under each alternative (by economic sector) was then input into IMPLAN for each year of the analysis period. The spending data include capital and O&M costs, as well as the household savings expected with the hybrid alternative. Because we are interested in the relative, proportional impact of the two alternatives, we entered all spending into the model in 2012 USD (i.e., we did not apply inflation rates or a discount rate to future year values, however, results are presented in 2013 USD based on the increase in gross domestic product from 2012 to 2013). For the hybrid alternative, we also input into IMPLAN the estimated number of direct construction and O&M jobs associated with GI spending.

6. Results

This section presents the results of the EIA for the baseline and hybrid CSO control alternatives. When reviewing results, it is important to keep in mind that the difference in impacts between the two alternatives is primarily due to the $65 million spent on GI under the hybrid alternative (2012 USD, including 10 years of O&M),[2] which accounts for only about 8.5% of total spending under either alternative.

Local vs. non-local spending

The hybrid alternative would result in more money being spent locally on CSO control strategies, compared to the baseline alternative. As noted in the methodology discussion (Section 5), Stratus Consulting relied primarily on the RPCs developed within the IMPLAN model to estimate the amount of money under each alternative that would be spent locally (i.e., within the District) and non-locally. The IMPLAN analysis confirms that not only will more jobs be created locally, but more money will likely be spent locally under the hybrid alternative. Results indicate that under the baseline alternative, DC Water will be able to obtain about 54% of supplies and labor locally. That number increases to about 56% under the hybrid alternative, including both the green and grey components. For the green component only, DC Water would be able to obtain 70% of supplies and labor locally. These estimates reflect the percentage of materials and labor purchased locally for all aspects of the project, including engineering, financial, construction, and landscaping services, and other related industries. Under the baseline alternative, the percentage of materials and labor purchased locally for construction, which makes up a large percentage of total spending, is only about 27%.

Employment

This section describes the employment impacts generated by each alternative. In IMPLAN, a job is defined as the annual average of monthly jobs in an industry (this is the same definition used nationally by the Quarterly Census of Employment and Wages, Bureau of Labor Statistics, and Bureau of Economic Analysis). Thus, one job lasting 12 months is equal to two jobs lasting six months each, and three jobs lasting four months each.

Table 3 shows the local direct, indirect, and induced employment generated by infrastructure spending under each alternative. These estimates represent the number of jobs that would likely be filled by local District residents. As shown, there is a higher level of direct employment associated with the hybrid alternative compared to the baseline alternative. This is due in part to

2. The difference in induced impacts is also attributable to the $15 million in household savings that occurs under the hybrid alternative due to its lower capital costs.

Table 3. Employment impacts of CSO control alternatives

Impact type	Baseline alternative	Hybrid alternative
Direct effects	1,951	2,083
Indirect effects	568	564
Induced effects	422	486
Total effects	**2,942**	**3,133**

Totals may not sum due to rounding.

the higher O&M requirements associated with GI throughout the project period, as well as the higher percentage of total jobs that would be created locally. Again this difference in jobs is due primarily to the relatively small proportion of money spent on GI under the hybrid alternative.

Direct employment represents employment generated by the initial spending under each alternative. An example of a direct job would be a landscaper hired by DC Water to install a bioswale. The direct employment shown in Table 3 for the GI alternatives includes direct employment associated with all aspects of the project, not only construction and O&M jobs.

Indirect employment represents jobs created due to the re-spending of money by directly affected industries. An example of an indirect job would be one created due to increased spending by the landscaping industry in an industry that supplies products and services to the landscaping industry. Induced employment represents employment generated as a result of increased spending by households that receive direct or indirect income as a result of a project or policy (e.g., now that the landscaper has a job, he/she spends a portion of the income from that job in the District's economy).

Labor income

Table 4 shows the total labor income generated under each alternative. Total labor income includes all forms of employment income, including employee compensation (wages and benefits) and proprietor income. Similar to Table 3, there is a higher level of labor income generated under the hybrid alternative. The direct income-to-direct employment ratio is slightly lower under the hybrid alternative, indicating that individuals employed under this alternative will earn less income than those employed under the baseline alternative (i.e., due to the GI component).

Table 4. Labor income impacts of CSO control alternatives ($M, 2013 USD)

Impact type	Baseline alternative	Hybrid alternative
Direct effects	212.9	213.6
Indirect effects	51.6	51.0
Induced effects	27.2	31.3
Total effects	**291.8**	**296.0**

Totals may not sum due to rounding.

Total economic output

Table 5 presents the local (i.e., within the District) direct, indirect, and induced effects on economic output under the baseline and hybrid infrastructure alternatives. Economic output represents the value of industry production.[3] As shown, spending under the hybrid alternative would result in close to $15 million more in economic output within the District compared to the baseline alternative.

Table 5. Economic output impacts of CSO control alternatives ($M, 2013 USD)

Impact type	Baseline alternative	Hybrid alternative
Direct effects	425.9	430.0
Indirect effects	108.7	108.6
Induced effects	71.1	81.9
Total effects	**605.7**	**620.6**

Totals may not sum due to rounding.

Total value added

Total value added is defined as the difference between the total output of an industry or establishment and the cost of its intermediate inputs. It equals gross output (i.e., sales or receipts and other operating income, plus inventory change) minus intermediate inputs (i.e., consumption of goods and services purchased from other industries or imported). Value added consists of compensation of employees, taxes on production and imports minus subsidies (i.e., formerly

3. For manufacturers, this represents sales plus or minus the change in inventory. For service sectors, production is equal to sales. For retail and wholesale trade, output is equal to gross margin, not gross sales.

indirect business taxes and nontax payments), and gross operating surplus. Table 6 presents the total value added generated under the baseline and hybrid alternatives over their respective analysis periods. As shown, the hybrid alternative will result in about $9 million more in value added than the baseline infrastructure alternative.

Table 6. Total value added impacts of CSO control alternatives ($M, 2013 USD)

Impact type	Baseline alternative	Hybrid alternative
Direct effects	256.5	258.3
Indirect effects	72.4	72.3
Induced effects	48.2	55.5
Total effects	**377.1**	**386.1**

Totals may not sum due to rounding.

Impacted economic sectors

As noted above, green and grey infrastructure result in different types of jobs and draw upon different services and inputs for implementation. Tables 7 and 8 show the top economic sectors impacted under the baseline and hybrid alternatives, respectively, by employment impact. Results for each sector include total employment, labor income, value added, and economic output generated locally.

Many of the sectors shown in Tables 7 and 8 are the same due to the large amount of spending on grey infrastructure under both alternatives. However, the analysis of economic sectors impacted under the different alternatives further demonstrates that a greater percentage of jobs needed for GI implementation can be filled by District residents who are currently unemployed and/or underemployed. For example, most of the jobs within the economic sector "services to buildings and dwellings," which will receive a large number of jobs under the hybrid alternative due to GI implementation, generally require limited or no experience. IMPLAN estimates that close to 99% of jobs within this sector could be filled with local residents. By comparison, construction jobs, which represent one of the largest industry sectors generated under the baseline alternative, require a higher percentage of skilled laborers. IMPLAN estimates that only about 27% of these jobs could be filled by local residents. Although the IMPLAN estimates for services to buildings and dwellings seems high, even if a smaller percentage of jobs are filled by local residents (e.g., 80%), this is still much higher than the local percentage estimated for the construction industry.

Table 7. Top economic sectors impacted, by employment generated – baseline alternative

Economic sector	Total employment (jobs)	Labor income ($M, 2013 USD)	Value added ($M, 2013 USD)	Economic output ($M, 2013 USD)
Architectural, engineering, and related services	1,186.0	157.0	159.6	235.2
Construction of other new nonresidential structures	456.2	33.7	43.7	87.4
Funds, trusts, and other financial vehicles	151.3	16.4	31.9	61.7
Commercial and industrial machinery and equipment rental and leasing	136.6	7.1	16.3	32.1
Food services and drinking places	104.8	3.7	5.3	8.7
Securities, commodity contracts, investments, and related activities	99.3	8.6	9.0	14.8
Employment services	61.2	3.8	4.1	5.0
Water, sewage and other treatment and delivery systems	57.4	4.0	9.6	11.6
Services to buildings and dwellings	45.3	1.2	1.5	3.0
Private hospitals	38.3	3.4	3.7	6.2

Table 8. Top economic sectors impacted, by employment generated – hybrid alternative

Economic sector	Total employment (jobs)	Labor income ($M, 2013 USD)	Value added ($M, 2013 USD)	Economic output ($M, 2013 USD)
Architectural, engineering, and related services	1,094	144.8	147.2	216.9
Construction of other new nonresidential structures	469	31.9	41.4	82.7
Services to buildings and dwellings	205	10.7	14.2	27.2
Commercial and industrial machinery and equipment rental and leasing	143	7.4	17.0	33.6
Funds, trusts, and other financial vehicles	133	14.4	27.9	54.1
Food services and drinking places	111	3.9	5.6	9.2
Securities, commodity contracts, investments, and related activities	91	7.9	8.3	13.6
Employment services	64	4.0	4.3	5.2
Water, sewage and other treatment and delivery services	52	3.7	8.6	10.5
Retail stores – building material and garden supply	45	2.3	3.4	4.2

In addition, although not in the top 10 sectors shown, services such as environmental and other technical consulting services, and management scientific, and technical consulting services show up relatively high on the list of impacted sectors under the hybrid alternative. This is consistent with interviews conducted by Stratus Consulting which indicate that GI is spurring the development of several smaller design and technical businesses within several cities (Stratus Consulting, 2012).

7. Summary

Overall, given the same level of spending (or household savings), the hybrid alternative results in a greater economic impact compared to the baseline alternative. This is primarily due to the increased utilization of local resources associated with GI (which accounts for only a small percentage of total spending). The hybrid alternative would result in an estimated 3,133 jobs over the 29-year implementation period (which includes 10 years of full O&M activities), including direct, indirect, and induced employment. This compares to an estimated 2,942 jobs over a 15-year period (including 10 years of O&M activities) under the baseline alternative. A higher percentage of the jobs under the hybrid alternative will be filled by unemployed/underemployed local residents, resulting in a larger net gain in employment rather than a transfer of employment. The hybrid alternative would also result in approximately $620.6 million in local economic output – about $15 million more than the baseline alternative.

Table 9 summarizes the total direct, indirect, and induced effects for employment, labor income, total value added, and economic output under the baseline and hybrid alternatives. Results represent the same general level of spending, including household savings under the hybrid alternative.

Table 9. Summary of economic impacts over design, construction/implementation, and 10-year O&M period

Impact type	Baseline	Hybrid
Employment (jobs)	2,942	3,133
Labor income ($M, 2013 USD)	291.8	296.0
Total value added ($M, 2013 USD)	377.1	386.1
Economic output ($M, 2013 USD)	605.7	620.6

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Appendix - E
Financial Affordability Update

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DC WATER
FINANCIAL AFFORDABIITY UPDATE

October 2013

Prepared By Louis Berger Water Services, Inc.

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1. Purpose and Introduction

From 1998 to 2001, DC Water developed its Draft LTCP. Following an extensive public comment period where more than 2,300 comments were received, DC Water finalized its LTCP in July 2002. On March 23, the LTCP Consent Decree was entered with the court requiring implementation of the LTCP.

As part of the development of LTCP, DC Water performed a financial affordability analysis based on information available at the time. The purpose of this document is to update the financial affordability analysis. This update is being performed for the following two main reasons:

Significant Changes Have Impacted the Burden on Ratepayers

Since the LTCP Consent Decree was entered in 2005, there have been significant changes that have impacted the burden on District ratepayers. These include, but are not limited to:

- Nitrogen Removal at Blue Plains effluent to meet the Chesapeake Bay TMDL - this requirement was added to DC Water's NPDES permit in 2007. As a result of this requirement, DC Water implemented the Total Nitrogen Removal/Wet Weather Plan (TN/WW Plan) at a cost of nearly $950 million.
- Biosolids Program – in order to achieve a sustainable program for biosolids from Blue Plains Wastewater Treatment Plant, DC Water is implementing a biosolids program at cost of nearly $44 million. The program includes construction of Cambi digesters which will allow production of Class A biosolids
- Increased costs for DC Clean Rivers Project – the Clean Rivers project are a $2.6 billion program. This is significantly more than the original estimate in 2002 when the LTCP was finalized.
- Schedule acceleration of Anacostia River Tunnel – In July and September 2102, severe flooding impacted the Bloomingdale and LeDroit park neighborhoods in the Northeast Boundary Sewershed tributary to the Anacostia River. As a result of this, the Anacostia Rivers project tunnel facilities have been accelerated in schedule to provide earlier flood mitigation than originally included in the Decree. The First Street tunnel will be placed in operation in 2016 instead of 2025 and the Complete Northeast Boundary Tunnel system is scheduled to be placed in operation in 2022 instead of 2025. This has significantly impacted spending on the program
- Infrastructure renewal – the sewer system in the District is extremely old, with some sewers constructed as early as the 1870's. The median age of sewers in the District is over 70 years old. Given this, a significant rehabilitation and renewal program is underway to preserve and improve the sewer system, at a cost of more than $700 million.

Financial Affordability Guidance has Changed

The financial analysis performed as part of the development of the LTCP was based on EPA's CSO guidance document (*Combined Sewer Overflows - Guidance for Financial Capability Assessment and Schedule Development*, Feb 1997, EPA 832-B-97-004). This approach essentially uses 2% of median household income as the threshold for affordability for sewer rates. This approach to measure ratepayer affordability has come under scrutiny with organizations such as the American Water Works Association (AWWA) and the Water Environmental Federation (WEF) recommending alternative approaches.

In response to these issues including the increased financial burdens imposed on water agencies and communities, EPA has also recognized the need to incorporate greater flexibility in meeting Clean Water Act (CWA) requirements. In a January 13, 2013 Memorandum, the Agency clarified its policy going forward on affordability issues as well on using the integrated planning framework process to provide the regulated community with the necessary flexibility to meet CWA requirements while lessening the financial burden, especially to low income populations.

The current study was conducted to assess and compare the financial affordability of DC Water's CIP under alternative scenarios and criteria for establishing thresholds of affordability. The study makes use of a financial model developed for DC Water by Raftelis Financial Consultants for evaluating the impacts for sewer rate structures on the utility's financial capacity and on ratepayer affordability. The financial model generates key indicators including service-debt ratio, capital outlays, and household income impact.

The study also revisits the original financial analysis performed in 2001-2002 and recalculates the projected income impacts using updated criteria for establishing thresholds of affordability. To accurately compare the household cost impacts of the original CIP with the proposed CIP the same criteria need to be applied so that the analysis is internally consistent. The updated affordability analysis will also describe how conditions over the past decade have varied from the original forecast in terms of regulatory financial burdens and income growth among the poorest households in the ratepayer base.

Finally, the study presents the process used to rank and prioritize CIP projects under a constrained approach. In particular, the prioritization procedure is designed to configure the CIP in way that maximizes benefits while deferring cost and affordability impacts to the extent feasible.

The remaining sections of the report are organized as follows:

Section 2: EPA's Guidance on Assessing Ratepayer Affordability
Section 3: 2002 LTCP Financial Capability Assessment
Section 4: Affordability Measures for District of Columbia
Section 5: Financial Affordability Assessment of DC Water's CIP
Section 6: Conclusions

2. EPA's Guidance on Assessing Ratepayer Affordability

The EPA has issued two sets of guidance regarding the issue of ratepayer affordability. The 1995 Interim Guidance for Water Quality Standards provided an analytical framework to municipalities for evaluating the economic impact of complying with water quality standards. The second set of guidance issued in 1997, the "Combined Sewer Overflows—Guidance for Financial Assessment and Schedule Development" document, addressed both the financial capacity of water agencies to accommodate their portfolio of capital investments and the ability of ratepayers to afford the costs to pay for those investments.

The 1997 Final EPA guidance presented methods for estimating the annual cost per household (for CSO capital expenditures) and for comparing that estimate against Median Household Income (MHI) to derive a "Residential Indicator" (RI). Although the 1997 guidance document did not prescribe a regulatory threshold ratio, it implied that sewer rates resulting in a typical residential bill exceeding 2 percent of MHI could be considered unaffordable. Specifically, the guidance noted that an RI greater than 2 percent would signal a "large economic impact" on residents.

Since the 1997 EPA guidance was issued, the 2 percent of MHI threshold has been used to assess the affordability of sewer rates. However, because sewer bills are almost always combined with water use charges, and sewer charges are tied to water consumption, water agencies have typically assessed affordability issues based on the total utility bill. EPA's stated view is that water fees are affordable if total charges account for less than 2.5 percent of a small community's MHI. Accordingly, a total water and sewer bill in excess of 4.5 percent would, based on these thresholds, be considered to pose issues of affordability to the ratepayer population. It should be noted, however, that the current study focuses exclusively on household financial burdens from the sewer bill because it is the financial impact of the sewer system CIP alone that is being assessed.

With rapidly increasing capital expenditures being borne by communities and water agencies to meet CWA regulatory requirements and/or meet Consent Decree obligations for controlling CSOs, the issue of ratepayer affordability, especially for low income households, has become a growing concern in many jurisdictions. The prolonged impact of the recession of 2008, including persistent high unemployment rates and the continued stagnation of household incomes at the middle and lower strata of the economy, has further underscored the issue of ratepayer affordability.

EPA has acknowledged the increasing cost burden to communities of complying with the CWA, as well as the methodological limitations of using the RI as an indicator of affordability. As a result of these concerns, EPA issued a memorandum on January 13, 2013 that addressed financial affordability issues and clarified the Agency's policy going forward.[1] The Agency's overall message as articulated in the memorandum was that EPA has developed, in cooperation with the regulated community, the "Integrated Planning Approach Framework" that "encourages municipalities to balance CWA requirements in a manner that addresses the most pressing health and environmental protections issues first." The memorandum also attempts to clarify that it is not EPA's policy that the RI, based on expenditures as a percentage of MHI, constitutes the sole measure of affordability. The Agency further emphasized that it is a "common misperception that the EPA requires communities to spend to a level of 2% of MHI to meet CWA obligations." Instead, EPA states that the percent MHI calculation should be considered along with a "suite of other financial indicators to assess the overall burden on a community." Although not specifically identified in the memorandum, factors cited elsewhere include:

- Burdens placed on low income households,
- Unemployment rates,
- Percent of the population on public assistance, and
- Percentage of household income spent on non-discretionary necessities.

The EPA memorandum provides communities and water agencies an opportunity to revisit the current methods for calculating affordability threshold and to use alternative measures of affordability based on criteria that are tailored to the economic conditions of the local ratepayer population.

3. 2002 LTCP Financial Capability Assessment

A financial capability and affordability assessment was performed in 2002 to evaluate the impacts of the CSO LTCP on the District's residential users and on the overall fiscal health of the community. The assessment evaluated the impacts of forecasted sewer rate increases on household incomes as well as the overall capacity of the ratepayer base to support those rate increases based on such factors as bond rating, debt burden, unemployment rate, and property tax collection rates.

The financial analysis projected future residential bills based on scenarios with and without a 20-year LTCP to control CSOs. Financial impacts to residential ratepayers were estimated using Year 2000 U.S. Census data and projecting these data forward. The forecast assumed a 3 percent annual income increase for all households for the 20 year forecast period. Projected median household incomes were compared against estimated annual residential sewer bills to ascertain affordability using the 2 percent threshold discussed in the previous section. Recognizing the skewed income distribution for the District of Columbia, the analysis also assessed financial impacts to the bottom 20 percent of the households.

Ratepayer bills were estimated based on projections of the cost per household for the LTCP that in turn was generated using assumptions on total capital requirements to meet the CSO Consent Decree; percentage of capital requirements financed; cost of financing; debt service requirements; and household water demand.

[1] Nancy Stoner. January 13, 2013. Memorandum: "Assessing Financial Capability for Municipal Clean Water Act Requirements United States Environmental Protection Agency, Washington DC.

The analysis incorporating the LTCP forecasted that residential sewer bills would increase from $297 per year in 2004 to $689 in 2014 and to $1,318 in 2024. Without the LTCP, rates for the same years were forecasted to increase from $297 to $482, to $774. In terms of impact on households at the MHI level and at the lowest 20 percent level, the differences were quite dramatic. The forecast indicated that for ratepayer households at the median income, sewer bills s would account for 1.8 percent of household income in 2024. For the bottom 20 percent, however, the 2 percent threshold was projected to be reached by 2011 and by 2024, sewer bills were forecasted to consume 3.7 percent of household income by 2024.

In terms of the actual financial impacts, the 2002 forecasts underestimated income growth for the higher income households and significantly overestimated income growth rates for the lowest income households. In particular the initial analysis projected that in 2011, the upper limit of the bottom quintile household incomes would reach $24,190 while the MHI for the District hit $49,952. The actual household incomes for 2011 were $20,941 for the bottom quintile households, while the MHI reached $62, 214. The disparity between forecasted and actual incomes is attributable to large divergence in income growth rates between the different income groups. Regarding the accuracy of the forecast of the typical residential sewer bill, the 2002 analysis projected a 2014 annual sewer bill of $689 compared to the current estimate for 2014 of $609. The 2013 forecast was for a bill of $535 compared to the actual of $506 (using rates effective October 2013). So for the current year and next year, the 2002 forecast for residential bills were somewhat higher that what actually materialized. A revised analysis of the original LTCP using actual household incomes and revised threshold criteria is presented in Section 5.

4. Affordability Measures for District of Columbia

This section discusses the alternative approaches to measuring affordability, describes the current financial burden on residential ratepayers, and details the limitations of using MHI given the skewed household income distribution in the District and the high cost of living relative to the national average.

4.1 Current Sources of Revenue for DC Water Operations

DC Water has a stable and diverse rate base from which it derives its revenues. As of September 30, 2012, DC Water had 125,751 active metered water and wastewater accounts and 9,232 separate accounts for billing impervious surfaces.[2] As seen in Table 1, wholesale customer payments comprise about 17 percent of the annual operating cash receipts for FY 2013 and are paid in advance of usage.

[2] DC Water Operating Budgets, Section IV: Rates and Revenues. Revised FY 2013 and Approved FY 2014. DC Water and Sewer Authority.

Table 1 DC Water FY 13 Operating Cash Receipts

Retail Customers	FY 2013	Percent of Total Receipts
Residential	73,331	16%
Commercial	104,461	23%
Multi-Family	58,455	13%
Federal Government	52,838	12%
District Government	12,037	3%
DC Housing Authority	6,270	1%
Rate Stabilization Fund	6,500	1%
Metering Fee	10,776	2%
Total Retail	324,668	73%
Wholesale Customers		
IMA Wastewater Charges	67,469	15%
Potomac Interceptor Wastewater Charges	7,726	2%
Total Wholesale	75,195	17%
Other Revenues	46,616	10%
Total Operating Cash Receipts	446,479	

Source: DC Water Operating Budgets, Section IV: Rates and Revenues

The Federal government accounts for another 12 percent of operating revenues and because of the budget cycle, water and sewer charges are paid two-years in advance. The retail customer base is dominated by residential and multi-family customers, which together accounts for 29 percent of operating revenues, and includes a small number of non-residential customers.[3] Commercial customers contributed 23 percent to operating revenues, and single non-governmental retail customer accounted for more than 1 percent of the retail generated revenues.

Based on these figures, it is clear that future water rates changes would be borne primarily by DC's residential population. The largest single customer, the Federal government, would likely be unaffected by rates changes whether they be large or small given that these expenditures are appropriated by Congress and are a minuscule contribution to the cost of operating the Federal government in Washington, DC.

4.2 Current Sewer Rates and Affordability based on MHI

In terms of FY 2013 user rates, DC Water customers have been paying $3.42 per CCF for water and $4.18 per CCF for sewerage. As shown in Table 2, DC rates fall in the middle of the range for the 11 selected cities; about double the lowest rates but some 40 percent lower than the highest rates incurred by the residents of San Francisco and Portland.

[3] District of Columbia Water and Sewer Authority. Report on the Operating Reserves of the Authority. Amawalk Consulting Group, March 29, 2013

Table 2 Water and Sewer Rates (FY 13) for Selected Cities in the United States[4,5]

City	Water Rate (Per CCF)	Sewer Rate (Per CCF)	Combined Rate
Milwaukee	$1.68	n/a	$1.68
Memphis	$1.47	$1.70	$3.17
Chicago	$2.16	$1.99	$4.15
Columbus	$2.60	$3.72	$6.32
San Diego	$3.61	$3.60	$7.21
Washington	$3.42	$4.18	$7.60
Baltimore	$3.68	$4.94	$8.62
New York City	$3.39	$5.39	$8.78
Boston	$4.45	$5.76	$10.21
Portland	$3.32	$8.14	$11.46
San Francisco	$4.20	$7.90	$12.10

Evaluation of the affordability of DC water and sewer rates based solely on the 2 percent of MHI measure (as was done in the 2002 financial affordability analysis) would indicate that current billing rates do not pose an undue burden on its residential customer base. As recently as in 2011, water and sewer rates accounted for more than 2 percent of household income for just about 30 percent of DC households. For about 15 percent of the households, water and sewer costs accounted for more than 4.6 percent of household income. As annual sewer rates increased beyond annual income growth rates for lower income households, these percentages have likely increased over the past two years and will likely continue to do so with forecasted increases. However, as will be shown in the following section, MHI is a poor indicator of affordability given the income distribution of households in the District of Columbia. Furthermore, it must be recognized that beyond the water and sewer rate charges, residential customers are also billed for the Clean Rivers Impervious Area Surface Charge (CRIAC). The charges for residences fall into six tiers, depending on the size of the impervious area. CRIAC rates have increased significantly in recent years; rising from $3.45 per Equivalent Residential Unit (ERU) per month in FY 2011 to a rate of $11.85 for FY 2014. One ERU applies to a residential impervious area of 700 to 2000 square feet, which would translate to an additional $153 per year for sewer charges.

4.3 Limitations to using MHI as a Measure of Affordability for DC Residential Ratepayers

DC Water's current CIP will necessarily result in substantial rate increases to its entire customer base. Under the status quo CIP, DC Water estimates that the typical sewer bill will increase by more than 70 percent from 2014 to 2020. These rate increases would follow the 43 percent increase in sewer charges over the period 2010 to 2014.

The cost burden however will fall disproportionately on poorer households, especially but not exclusively, to the bottom 20 percent. As will be detailed in the succeeding sections, persistent high annual rate increases would over time begin to pose financial burdens, not just for the bottom 20 percent, but the bottom 40 percent of District of Columbia households. As shown below, the financial impact to these lower income and financially vulnerable populations is not accurately captured using sewer cost as a percentage of median household income.

4 Figures are based on data from 2011 America Community Survey (ACS) 5-year estimates, and are shown in 2011 inflation-adjusted dollars

5 For DC Water, the cited sewer rates do not include the Clean Rivers Impervious Area Charge(CRIAC)

Although EPA's January 2013 memorandum emphasized the "guidance" aspect of using percentage of a community's MHI as a measurement of affordability, this in fact has been the prevailing measurement used by water agencies since the 1997 guidance document was published. There is, however, substantial literature documenting the flaws of using community MHI as indicator of affordability. A recent study prepared jointly by the United States Conference of Mayors, the American Water Works Association, and the Water Environment Federation, captures the key limitations of MHI: [6]

- "MHI is a poor indicator of economic distress and bears little relationship to poverty or other measures of economic need";
- Income inequality is increasing in many communities rendering MHI a poor measure of poverty;
- "MHI does not capture trends and or social conditions";
- "MHI does not capture impacts to landlords or public housing agencies"; and
- RI does not capture household burdens for all nondiscretionary spending.

The inadequacy of MHI as an indicator of affordability is worsened in jurisdictions where income distribution is skewed, which is often the case in large urban areas, such as Washington, DC, which tend to have disproportionate populations of low income and very high income households. Based on a statistical analysis performed as part of the above mentioned study, poverty rates ranged from 14.1 percent to 23.3 percent for 21 of the 100 largest cities in the US with an MHI within $3,000 of the national average MHI. These data show that relatively small variations in MHI (at the city level) are associated with large disparities in poverty rates; hence there is a poor correlation between MHI and poverty levels as well as household affordability.

Another critical deficiency in using expenditures as a percentage of MHI is that it does not take into account the financial burden for other non-discretionary spending by households. These expenditures vary significantly across different geographical areas of the United States. Nondiscretionary expenditures include not just household expenditures for water and sewerage, but also for housing; other utilities including electricity and gas; groceries, and transportation. For example, the 2010 Census Composite Cost of Living Index for Selected Cities showed that these household expenditures ranged from a low of 82 percent of the national average (Harlingen TX) to more than 216 percent of the national average (Manhattan, NY).[7] For the Washington, DC Metropolitan Area that includes the jurisdictions of Arlington and Alexandria, the 2010 Census cost of living index was 140.1, or more than 40 percent above the national average. This large variation in cost of living means that while a 2 percent of household income expenditure for sewer services in one jurisdiction might not cause an unreasonable burden, in another locality the financial burden becomes onerous given the costs for other non-discretionary purchases. Hence, in evaluating affordability issues for Washington, DC, it is important to consider both the income distribution of the residential ratepayer population and the burdens of non-discretionary expenditures for lower income households. These two factors are discussed in detail in the following two sections.

4.4 Household Income Distribution in the District of Columbia

The median household income in Washington, DC was $62,214 in 2011, compared to $51,484 for U.S. households.[8] Although this implies that Washington DC is significantly more affluent than the average locality, the statistic does not

[6] Affordability Assessment Tool for Federal Water Mandates, United States Conference of Mayors, American Water Works Association, and Water Environment Federation. 2013.

[7] United States Census. The 2012 Statistical Abstract. Prices: Consumer Price Indexes, Cost of Living Index. http://www.census.gov/compendia/statab/cats/prices/consumer_price_indexes_cost_of_living_index.html Accessed on July 3, 2013.

[8] U.S Census Bureau, American Community Survey 2001 Median Household Income

take into account the disparity between the highest and lowest income levels; which in DC is quite dramatic. The following statistics demonstrate the degree to which incomes in Washington DC are skewed:

- The top 5 percent of DC households have an average income of $500,031, while those in the bottom 20 percent received an average income of under $9,630 (Table 3).
- The mean household income of $96,128 or 50 percent higher than the $62,214 MHI or double the income of households at the upper limit of the 2nd quintile.

These disparities show that Washington DC, while boasting relatively high number very affluent residents is also home to many residents with very low household incomes. Exacerbating the problem is that according to a report from the Center of Budget and Policy Priorities, income inequality in the nation's capital has actually worsened in recent years.[9] An analysis of income data at the Ward and neighborhood level shows the persistent gap between the rich and poor in DC.

As shown in Table 4, household income is also unevenly distributed across the different neighborhoods within the District. Eighty percent of households in Ward 3 in Northwest DC have an income greater than $44,000 and 20 percent have an income greater than $211,876. By comparison, in Ward 8 the top 20 percent households earned more than $63,894, while the bottom 10 percent earned less than $10,070. Similarly in Wards 5 and 7, the bottom 20 percent of households earned less than $15,943 and $12,423, respectively. Consequently, the income of the poorest households in Wards 5, 7, and 8 is well below the federal poverty threshold of $23,021.[10]

Table 3 U.S. and DC Household Income - Mean and Upper Limit by Quintile (in 2011 dollars)

	U.S. (Mean)	DC (Mean)	U.S. (Upper Limit)	DC (Upper Limit)
Lowest Quintile	12,041	9,631	21,865	20,943
Second Quintile	31,505	34,029	41,515	47,004
Third Quintile	53,132	62,662	65,961	80,830
Fourth Quintile	83,303	106,207	104,624	139,962
Highest Quintile	182,792	268,388		
Lower Limit of Top 5 Percent			191,469	250,000+
Top 5 Percent	323,395	500,031		
Median Household Income	51,484	62,214		
Mean Household Income	70,909	96,128		

Source: U.S. Census Bureau, 2007-2011 American Community Survey

[9] McNichol, Elizabeth. "Pulling Apart: A State-by-State Analysis of Income Trends." November 2012. Center on Budget and Policy Priorities. http://www.cbpp.org/cms/index.cfm?fa=view&id=3860. Accessed July 12, 2013
[10] U.S. Census Bureau poverty threshold for a family unit of four people for 2011.

Table 4 Annual DC Household Income by Ward – Quintile Upper Limits (in 2011 dollars)

	Ward 1	Ward 2	Ward 3	Ward 4	Ward 5	Ward 6	Ward 7	Ward 8
Lowest Quintile	25,755	31,123	44,025	25,203	15,942	28,192	12,422	10,069
Second Quintile	53,587	65,031	77,101	44,768	37,605	65,157	28,805	22,971
Third Quintile	86,046	105,805	125,905	78,981	62,350	103,888	48,551	39,345
Fourth Quintile	135,568	178,919	211,876	144,943	105,708	163,787	78,530	63,894
Lower Limit of Top 5 Percent	249,044	250,000+	250,000+	250,000+	179,500	250,000+	138,733	117,035

Source: U.S. Census Bureau, 2007-2011 American Community Survey

4.5 Washington DC Household Poverty Rates

Based on the 2011 ACS data,[11] 15.3 percent of Americans were living below the poverty level. Within the District, 18.2 percent of the population, or about 102,000 residents were living in poverty. Across the different age groups and family type, poverty rates were higher in the District and in poorer neighborhoods than the national average (Table 5). In particular, 16.6 percent of the DC population under 18 years of age was living in deep poverty, which is defined as having a household income below half of the poverty line, compared to 8.8 percent nationally. The child poverty rate is even higher in the poorer neighborhoods in DC, such as in Wards 5 and 7, where 28.2 percent and 26.5 percent of children under 18 were living in deep poverty (Table 5).

Table 5 Poverty Rates in the U.S. and Washington, DC

	U.S.		Washington, DC	
	Less than 50 percent of the poverty level	Below the Poverty Level	Less than 50 percent of the poverty level	Below the Poverty Level
Age				
Under 18 years	8.8%	20.0%	16.6%	28.3%
18 to 64 years	6.0%	13.1%	9.3%	16.2%
65 years and over	2.4%	9.4%	4.3%	14.0%
Family Type				
Single Female Headed Household	15.6%	32.1%	17.8%	31.1%

Source: U.S. Census Bureau, 2007-2011 American Community Survey

In the U.S., single parent households, in particular female-headed households, often have lower-incomes and higher living expenses. Nationwide and within the District, 15.6 percent and 17.8 percent, respectively, of households with a female-headed households were living in deep poverty (Table 5). The financial challenges and cost burden faced by female-headed households are further amplified in the poorer DC neighborhoods, where statistics show that about 23 percent and 25 percent of households in Wards 7 and 8, respectively, were living in deep poverty (Table 6).

[11] Unless otherwise noted, analysis throughout the paper is based on the 2011 ACS 5-year estimates data.

Table 6 Poverty Rates in Wards 5, 7 and 8

	Ward 5, DC		Ward 7, DC		Ward 8, DC	
	Less than 50 percent of the poverty level	Below the Poverty Level	Less than 50 percent of the poverty level	Below the Poverty Level	Less than 50 percent of the poverty level	Below the Poverty Level
Age						
Under 18 years	14.4%	25.9%	28.2%	40.7%	26.5%	49.0%
18 to 64 years	9.8%	18.3%	12.0%	21.3%	16.5%	32.1%
65 years and over	5.9%	21.1%	4.0%	16.6%	6.6%	21.3%
Family Type						
Single Female Headed Household	12.8%	22.5%	23.2%	36.9%	25.0%	45.9%

Source: U.S. Census Bureau, 2007-2011 American Community Survey

4.6 Cash Public Assistance or Food Stamps

Another indicator of community economic stress is the percentage of population receiving public assistance. Across the District, 12.6 percent of households received cash for public assistance or Food Stamps to supplement their income, compared to the national average of 11 percent that received the same benefits (Table 7). As would be expected, in the poorer neighborhoods in DC such as Wards 5, 7 and 8, a much higher percentage of households are recipients of public assistance compared to the more affluent Wards.

Table 7 Households Receiving Public Assistance Income or Food Stamps in the U.S. and DC (selected Wards)

	U.S.	Washington, DC	Ward 5, DC	Ward 7, DC	Ward 8, DC
With cash public assistance or Food Stamps/SNAP	10.99%	12.56%	17.74%	25.71%	35.51%
No cash public assistance or Food Stamps/SNAP	89.01%	87.44%	82.26%	74.29%	64.49%

Source: U.S. Census Bureau, 2007-2011 American Community Survey

In the U.S., 11.1 percent of households and 6 percent of households with female-headed household received Food Stamps (Table 8). By comparison, in the District, 18.1 percent of total households and 13.9 percent of households with female-headed households are in the program (Table 8). In Ward 8, one of the poorest areas in the District, 34.4 percent of households with female-headed households received Food Stamps—more than 5 times the national average.[12]

Table 8 Households that received Food Stamps in the U.S. and DC (and selected Wards)

	U.S.	Washington, DC	Ward 5, DC	Ward 7, DC	Ward 8, DC
Household received Food Stamps/SNAP in the past 12 months:	11.08%	18.07%	22.41%	32.15%	42.10%
Single Female Headed household	5.93%	13.88%	15.43%	26.54%	34.43%

Source: U.S. Census Bureau, 2007-2011 American Community Survey

[12] It should be noted that these rates are likely lower than current rates, since the number of food stamp beneficiaries has increased significantly in the last 3 years.

4.7 DC Water's Consumer Assistance Program

The Washington DC Water Utility provides assistance to low income households through its Customer Assistance Program (CAP). The program dates back to the year 2000 by providing a discount of 4 CCF per month of water service for single family residential home owners that meet income eligibility requirements. The program has been twice expanded to include, in FY 2004, tenants whose residence is separately metered and, in 2009, to provide a discount of 4 CCF per month of sewer services to eligible customers. The 2014 approved eligibility requirements are shown in Table 9.

Table 9 Customer Assistance Program FY 2014 Income Eligibility Guidelines

Household Size	Maximum Annual Income
1	$27,425
2	$35,864
3	$44,302
4	$52,741
5	$61,181
6	$69,618

The total cost of the program peaked at approximately $1.4 million in FY 2009 when the program had about 6,400 participants. It should be noted that this participation is quite low relative to the more than 101,000 residents in DC that live below the poverty line.

DC Water also sponsors a second and much smaller assistance program—referred to as S.P.L.A.S.H—that is administered by the Greater Washington Urban league, with the purpose of providing temporary assistance to families in need so as to "maintain critical water and sewer services" until the families "get back on their feet." The modest program has, on average, served around 300 households annually with a budget of approximately $100,000.

Together, these programs help to provide some financial relief for vulnerable populations and can serve as cushions against sewer rate increases. However, they are narrowly targeted and can only assist a small percentage of the households that are burdened with high utility and housing costs in the District of Columbia. Providing financial relief to a much larger proportion of the population without initiating a large cross subsidization program could significantly alter the financial health of the utility.

4.8 Cost of Living in the District of Columbia

4.8.1 Washington DC Cost of Living Compared to the National Average

One of the reasons the household income measures, whether the MHI method or the quintile method, is inadequate in measuring utility bill affordability is that it fails to consider the local cost of living. This is especially relevant to municipalities such as Washington, DC, which has been consistently ranked as one of the highest cost places to live in the country.

The Council for Community and Economic Research (C2ER) measures the cost of living index (COLI) for municipalities and communities throughout the United States and publishes this index on a quarterly basis. In their year-end review for 2012, Washington DC ranked as the eighth most expensive city in the U.S. (Table 10). Although C2ER uses a different methodology than the Census, its COLI comports quite closely with the Census index discussed earlier.

Table 10 Ten Most Expensive Urban Areas, 2012

Rank	Urban Area	Cost of Living Index
1	New York (Manhattan) NY	225.4
2	New York (Brooklyn) NY	178.6
3	Honolulu, HI	167.0
4	San Francisco, CA	163.4
5	San Jose, CA	153.4
6	New York (Queens), NY	148.3
7	Stamford, CT	146.1
8	Washington, DC	144.7
9	Orange County, CA	140.6
10	Boston, MA	139.9

Source: C2ER, 2013.

4.8.2 Key Contributors to Washington DC's High Cost of Living

The high cost of living for residents of Washington, DC, derives from multiple factors including high housing costs, food, and transportation. As noted earlier, utility costs are similar to the national average for the full basket of utility services, including power, water, and sewerage. Food and transport costs, according to the 2012 Statistical Abstract are about 8 and 10 percent above national averages, respectively. Housing costs, however, are more than double the national average and this cost adversely impacts the poor populations of the District. Most government agencies consider housing costs of between 30 percent and 50 percent of household income to be a moderate burden on affordability, and housing costs above 50 percent of household income are considered a severe burden.[13]

This can be seen in the expenditures for housing borne by residents in Wards 5, 7, and 8. For both rental and owner-occupied housing, DC poor households pay a much higher percent of total household income than the national average. As shown in Table 11, more than 53 percent of the Ward 8 house owners and 56 percent of renters devote more than 30 percent of their household income on mortgage and rent, respectively. In Ward 8, almost 50 percent of the renters pay more than 35 percent of their income for monthly rent.

[13] USCM, AWWA & WEF, "Affordability Assessment Tool for Federal Water Mandates", 2013.

Table 11 Selected Monthly Owner Costs in U.S. and DC as a Percentage of Household Income

Percent of Income Expenditures for Housing	U.S.		Washington, DC		Ward 5		Ward 7		Ward 8	
	Mortgage	Rental	Mortgage	Rental	Mortgage	Rental	Mortgage	Rental	Mortgage	Rental
30.0 to 34.9	8.9%	9.1%	8.5%	8.5%	8.5%	9.1%	10.4%	6.7%	9.7%	9.6%
35.0 or more	28.6%	42.4%	28.7%	40.7%	34.2%	47.1%	35.3%	45.8%	43.8%	49.2%

Source: U.S. Census Bureau, 2007-2011 American Community Survey

As shown in the Table 11, 28.6 percent (with a mortgage) and 42.4 percent (rental) of U.S. households spent 35 percent or more of their income on housing cost. The figures were comparable with the District, where 28.7 percent (with a mortgage) and 40.7 percent (rental) of households spent 35 percent or more of their income on housing. There was, however, a wider variation in the figures across the different wards in DC. Table 11 shows that 34.2 percent, 35.3 percent and 43.8 percent of households pay a mortgage in Wards 5, 7, and 8, respectively; and had housing costs greater than 35 percent of their income. For rental units, 47.1 percent, 45.8 percent, and 49.2 percent of households in Wards 5, 7, and 8, respectively were spending 35 percent or more of their income on housing.

It should be noted that in estimating expenditure burdens for utilities, not all rentals incur these costs. As shown in Table 12 below, approximately 39 percent of rental tenants in DC do not pay for any utilities. However, this percentage drops considerably in Wards 7 and 8, where 72 percent and 78 percent pay extra for at least one utility service. Unfortunately, the ACS does not disaggregate which utilities are being paid, so it was not determined from the ACS data if water and sewer charges are being incurred or whether those costs are for power. Nonetheless, the data indicate that even in the poorer wards of the District, a large percentage of renting households must pay for utilities and for these households, the burden of utility costs must be taken into account in assessing affordability rates for the urban poor.

Table 12 Inclusion of Utilities in Rent (Rental-occupied Housing Units)

	U.S.	DC	Ward 1	Ward 2	Ward 3	Ward 4	Ward 5	Ward 6	Ward 7	Ward 8
Pay extra for one or more utilities	88.76%	60.76%	52.62%	49.46%	37.68%	70.97%	70.01%	63.86%	72.41%	78.17%
No extra payment for any utilities	11.24%	39.24%	47.38%	50.54%	62.32%	29.03%	29.99%	36.14%	27.59%	21.83%

Source: U.S. Census Bureau, 2007-2011 American Community Survey

4.8.3 Cost of Living Adjustment for Washington DC

C2ER also publishes a modified median household income for every county in the country. The latest data (2010) shows an adjusted median household income for DC, when factoring in the cost of living would be $42,379 (Table 13). The adjustment factor yields an income with a purchasing power that is the same regardless of location. Accordingly, because of the high cost of living in Washington DC, a household income of $60,729 is equivalent to a household income of just $42,379 in a location where the cost of living is at the national average.

Table 13 Adjusted Median Household Income for the District of Columbia, 2010

Median HH Income for District of Columbia (2010)	Cost of Living Index	Adjusted Median HH Income for District of Columbia
(1)	(2)	(3) = (1)/((2)/100)
$60,729*	143.3	$42,379

*Median household income is based on 2010 county level income from the Census Bureau's Small Area income and Poverty estimates. Source: C2ER, 2013b.

The same approach can be used to adjust income levels for all quintiles to indicate how the high cost of living affects DC households at all income levels. Table 14 shows the adjusted upper limit income for each quintile for DC in 2011.[14] The impact of the adjustment becomes even more graphic when applied to the mean income of each quintile. As seen in Table 14 and Table 15, for the lowest quintile, the upper limit of income falls from $21,233 to $14,817 but the mean household income drops from $9,483 to just $6,618.

Using either the upper limit or the mean of the lowest quintile indicates that when taking into account the high cost of living in DC, the poorest households would have minimal capacity to bear the large increases in sewer rates planned for the District. In addition, households below the highest quintiles (the second quintile, for example) would also be financially vulnerable to steadily increasing utility rates.

Table 14 Adjusted Upper Limit Income Levels for Washington DC, 2011

Quintile	Upper Limit Income Levels	Number of Households	Adjusted Income
Lowest Quintile	$20,943	50,310	$14,615
Second Quintile	$47,004	50,570	$32,801
Third Quintile	$80,830	51,611	$56,406
Fourth Quintile	$139,962	52,573	$97,671
Lower Limit of Top 5 Percent	$250,000+	19,042	$174,459

Source: U.S. Census Bureau, 2007-2011 American Community Survey

Table 15 Adjusted Mean Income Levels for Washington DC, 2011

Quintile	Mean Income	Adjusted Mean Income
Lowest Quintile	$9,631	$6,721
Second Quintile	$34,029	$23,747
Third Quintile	$62,662	$43,728
Fourth Quintile	$106,207	$74,115
highest Quintile	$268,388	$187,291
Top 5 Percent	$500,031	$348,940

Source: U.S. Census Bureau, 2007-2011 American Community Survey

[14] Income levels in Tables 11 and12 were adjusted using the COLI for DC for 2011 of 143.3 (C2ER, 2011).

5. Financial Affordability Assessment of DC Water's CIP

5.1 Alternative Affordability Criteria

Given both the skewed distribution of household income and the high cost of living for District of Columbia residents compared to the national average, using 2 percent of unadjusted MHI as the threshold for unaffordability does not effectively capture the real burden of increasing sewer bill costs on low income populations. As noted earlier the AWWA, WEF and the USCOM recently prepared the "Affordability Assessment Tool for Federal Water Mandates. For alternative measurements of water system financial capability, the Assessment Tool considers unemployment rates, property tax collection rates, and local tax revenues as a percent of gross taxable resources. Others have suggested using rate of termination of services or defaults. Clearly, if sewer and/or rates increase beyond the ability of consumers to pay their bills, default rates are likely to increase, which not only indicates decreasing affordability but also declining revenue bases that would harm the water system's financial viability.

The Assessment Tool also considers income distribution as a method for assessing affordability. We believe considering affordability across a broader household income distribution provides the most accurate indication of how utility bills pose financial burdens to the population of customers. By stratifying populations into distinct income levels, one can obtain a much clearer picture as to the percent of household income that is being spent on utility bills for low income households. This is particularly relevant for Washington, DC, which as the previous section showed is characterized by skewed household income distributions. Nonetheless, even disaggregating household incomes by quintiles is not fully adequate for capturing localized burdens for non-discretionary expenditures. Hence the exceptionally high COLI for Washington DC bolsters the argument for using an adjustment factor. Therefore, to assess the affordability DC's Water' CIP, the current study used the following alternative criteria for the affordability measurements

a. Unadjusted MHI
b. COLI Adjusted MHI
c. Unadjusted Upper Limit of the Second Quintile for Household Income
d. COLI Adjusted Upper Limit of the Second Quintile for Household Income

The analysis retained the MHI measure for a basis of comparison with the alternative approaches. The 2 percent threshold was used for all alternatives as the basis for determining unaffordable expenditures for annual sewer costs.

5.1.1 Financial Model Overview and Study Assumptions

5.1.1.1 Model Overview

As noted earlier, the impacts of the CIP were assessed using a financial model developed by the financial consulting firm Raftelis and used by DC Water over the last decade for projecting revenues and determine the need for rate increases.

The financial model allows the user to enter annual capital outlays to determine the impact on revenue generation for DC Water and on ratepayer household incomes. Conversely, the model can be used to generate annualized capital outlays based on rate increases and service debt requirement restraints. For the purposes of the study, the financial model was run for the following scenarios:

Scenario 1	Original Consent Decree
Scenario 2	Status Quo CIP
Scenario 3	Constrained CIP

The impacts of Scenario 1 were estimated in the evaluation performed for Consent Decree; however; under the original analysis ratepayer impacts were projected using the 2 percent of forecasted MHI as the threshold for unaffordability. The current analysis uses the upper limit of the 2nd Income quintile using historical household income data and projections through 2020.

Scenario 2 Impacts were projected based on the current CIP, which differs from the original 2002 CIP in that it incorporates Green Infrastructure and projects required under CWA requirements that have been imposed since the Consent Decree was signed. Affordability is estimated for the upper limit of the 2nd quintile using unadjusted and COLI adjusted incomes. Finally, Scenario 3 is a generated scenario and it is based on the maximum outlays that would be permitted given the constraint on the DC Water's allowable service debt ratio and the objective of deferring the point of unaffordability as far into the future as possible. We should note that even under the constrained CIP, ratepayer costs for those in the upper limit of the 2nd quintile (i.e., 40 percent of the ratepayer population) would eventually exceed 2 percent of household income. This is demonstrated in the results section.

5.1.1.2 Financial Model Assumptions

To project CIP impacts on ratepayer household incomes over the life of the CIP, numerous assumptions were needed to be made regarding household income growth, household water consumption rates and demand trend, sources of revenues to pay for capital outlays, minimum service debt ratio, Cost of Living Adjustments, and operating expense escalation. These key assumptions are detailed as follows:

Household Income Growth: Household income growth has stagnated over the past decade with even slower growth gains achieved by the households in lower income brackets. The model conservatively uses an annual income growth of 3 percent for households with median household income and above and 2 percent for households in the 2nd quintile and below.

Household Water Consumption: Water demand at the household level has decreased at a rate of 1 percent annually over the past decade. The model assumes an annual consumption of 80ccf starting in 2013 and a continued 1 percent decline throughout the 20-year forecast period

Sources of Revenues to Fund CIP: The vast majority of funds used to pay for capital improvements are generated by issuing debt, with only a small portion generated from the sewer bills. The financial model assumes that 95% of the capital funding is generated by bond issuance and 5 percent from recurring charges to the customer base.

Interest Rates on Debt: The model assumes interest rates of 5.5% for FY2014; 5.8 % for 2015; and 6.5% for FY2016-FY2038. It also assumes a 1.5 percent underwriting cost and 0.5 percent for insurance.

Minimum Service Debt Ratio: The service debt ratio is the ratio of the annual generated revenue divided by the total annual costs to pay down a scheduled debt (e.g., interest payments on bonds). To maintain its AA rating, DC Water is required to maintain a service debt ratio of 1.2. Hence, the model requires revenues to be maintained at a level to keep the debt service ratio above 1.2.

Cost of Living Adjustment for Washington DC: As discussed earlier, Washington DC has a very high cost of living. It has been consistently high and will likely remain so although it is challenging to predict whether that cost disparity will grow or shrink during the forecast period. For purposes of the study, it is assumed that the COLI remains at 144.7.

Operating Expense Escalation: The financial model assumes operating costs will increase at an average annual rate of 3 percent.

5.2 Financial Model Results

5.2.1 Scenario 1 - Original Consent Decree

As discussed earlier in Section 3, a financial capability and affordability assessment was performed in 2002 to evaluate the impacts of the CSO LTCP on the District's residential use. The analysis estimated impacts on the residential ratepayers with median household incomes and ratepayers at the upper limit of the bottom quintile. That analysis indicated that for households at the MHI level, sewer bills would not exceed the 2 percent threshold at any time during the 20 year forecast period.

However, the projected impacts would have been different if the original analysis had assessed the financial costs to households at the upper limit of the second quintile and had taken into account the high cost of living. For the purposes of the current study, a retrospective analysis was performed that entailed the following:

- Retained original forecast for typical residential bills
- Updated the household income data for the period 2004-2011 using actual data from the ACS
- Used Census Cost of Living Index for the period to adjust District of Columbia Household Incomes

As shown in Table 16, financial impacts were estimated for MHI, adjusted MHI, upper second quintile, and the adjusted upper second quintile. Using the updated criteria, the affordability threshold would have been reached in 2023 for the upper second quintile residents using an adjusted household income. Using adjusted income, the threshold is surpassed in 2018 and reaches 3 percent by 2024. The 3 percent threshold is sustained after 2030. At the MHI income level the 2 percent threshold is reached twice during the forecasted period but is not exceeded. It should be noted that the forecast period assumes a continued divergence in income growth between the households in the lower income quintiles and those households at the MHI or higher levels.

Table 16 LTCP Impacts on Household Income

	Percent of MHI	Percent of COLI Adjusted MHI	Percent of Upper Limit Second Quintile	Percent of COLI Adjusted Upper Limit Second Quintile
2006	0.6%	0.90%	0.80%	1.10%
2007	0.7%	0.90%	0.90%	1.20%
2008	0.7%	0.90%	0.90%	1.20%
2009	0.7%	1.00%	0.90%	1.30%
2010	0.7%	1.00%	0.90%	1.30%
2011	0.8%	1.10%	1.00%	1.40%
2012	0.8%	1.10%	1.10%	1.50%
2013	0.8%	1.10%	1.10%	1.50%
2014	1.0%	1.40%	1.40%	1.90%
2015	0.9%	1.20%	1.20%	1.70%
2016	0.9%	1.30%	1.30%	1.80%
2017	1.0%	1.40%	1.40%	1.90%
2018	1.0%	1.40%	1.50%	2.10%
2019	1.1%	1.50%	1.50%	2.20%
2020	1.1%	1.50%	1.60%	2.30%
2021	1.2%	1.70%	1.80%	2.50%
2022	1.3%	1.80%	1.90%	2.70%
2023	1.3%	1.90%	2.00%	2.80%
2024	1.4%	2.00%	2.10%	3.00%
2025	1.2%	1.80%	1.90%	2.70%
2026	1.3%	1.80%	2.00%	2.80%
2027	1.3%	1.80%	2.00%	2.80%
2028	1.3%	1.80%	2.00%	2.90%
2029	1.3%	1.80%	2.10%	2.90%
2030	1.3%	1.80%	2.10%	3.00%
2031	1.4%	2.00%	2.30%	3.20%
2032	1.3%	1.90%	2.20%	3.10%

5.2.2 Scenario 2 - Status Quo CIP

Financial affordability was assessed for the current CIP using MHI, upper limit of the second quintile, and COLI adjusted upper limit of the second quintile. The Status Quo CIP expenditures assume a 2025 completion date as required by the Consent Decree. As shown in Table 17, the projected impact on the residential ratepayer base differs dramatically. Using the conventional unadjusted MHI, sewer bill impacts remain below 2 percent through the year 2032, and never exceed 1.6 percent. Thus using this approach the issue of affordability does not raise serious concerns. When projected ratepayer bills are measured against household incomes at the upper limit of the second quintile or at the upper limit of 40 percent of DC households, the 2 percent threshold is crossed in year 2023. In subsequent years it rises to 2.4 percent. It is also noteworthy that forecasted impacts are worse under the Status Quo CIP then what was forecasted under the original analysis and presented in Table 16. As described above, under the original analysis for the LTCP, unaffordability is reached in 2026 compared to 2023 under the Status Quo CIP Impacts are to household incomes are generally about 10 percent greater under the Status Quo CIP.

The changes are more dramatic when cost of living is taken into account. As shown in the table, the affordability issue starts in 2017, with over 2.0% of the adjusted upper limit of the 2nd quintile income bracket; by the end of the forecast period (FY2032), over 3.47% of the adjusted upper limit of the 2nd quintile income bracket. It should be emphasized that the threshold is at the upper income limit for 40 percent of the population; at the mean or lower limit of the 2nd quintile the financial impacts would be higher. For example for some years in the past decade the mean of the bottom 40 percent is only half of the upper limit.

Table 17 Status Quo CIP – Evaluation Against MHI

	Sewer Increase	CRIAC Increase	Capital Outlay	Debt Service Coverage[1]	Evaluation Against MHI	Evaluation Against Upper Limit of Second Quintile	Evaluation Against Adjusted Upper Limit of Second Quintile
FY 2014	na	na	$ 322,525,021	1.44	0.80%	1.05%	1.51%
FY 2015	15.0%	25.0%	$ 410,472,757	1.42	0.91%	1.21%	1.73%
FY 2016	10.0%	15.0%	$ 342,389,555	1.35	0.98%	1.32%	1.89%
FY 2017	10.0%	10.0%	$ 262,810,047	1.38	1.04%	1.42%	2.03%
FY 2018	8.0%	10.0%	$ 370,809,067	1.40	1.09%	1.50%	2.16%
FY 2019	8.0%	10.0%	$ 359,799,784	1.32	1.15%	1.60%	2.29%
FY 2020	10.0%	10.0%	$ 283,881,143	1.30	1.23%	1.72%	2.47%
FY 2021	10.0%	10.0%	$ 319,123,724	1.35	1.31%	1.85%	2.65%
FY 2022	10.0%	10.0%	$ 398,495,357	1.39	1.39%	1.99%	2.86%
FY 2023	5.0%	10.0%	$ 469,116,343	1.36	1.44%	2.08%	2.98%
FY 2024	5.0%	10.0%	$ 392,795,815	1.31	1.49%	2.17%	3.11%
FY 2025	5.0%	10.0%	$ 311,209,766	1.30	1.54%	2.27%	3.25%
FY 2026	5.0%	10.0%	$ 234,420,220	1.35	1.60%	2.37%	3.40%
FY 2027	2.0%	3.0%	$ 245,444,120	1.38	1.59%	2.38%	3.41%
FY 2028	2.0%	3.0%	$ 229,722,712	1.39	1.57%	2.39%	3.42%
FY 2029	2.0%	3.0%	$ 219,531,387	1.37	1.56%	2.40%	3.43%
FY 2030	2.0%	3.0%	$ 224,415,459	1.33	1.55%	2.40%	3.45%
FY 2031	2.0%	3.0%	$ 194,160,017	1.27	1.54%	2.41%	3.46%
FY 2032	2.0%	3.0%	$ 199,057,478	1.21	1.53%	2.42%	3.47%

1.Debt service coverage needs to be above 1.2 to satisfiy minimum requirement

5.2.3 Scenario 3 - Constrained CIP

Based on its technical and institutional analysis, DC Water has determined that a 5 year extension of consent decree deadline is required for the gray Potomac CSO controls and that a 7 year extension is required for the green Potomac and Rock Creek controls. Under Scenario 3, these schedules were fixed. In order to get those to affordability limits, other sewer, wastewater and stormwater projects must be deferred.

Under Scenario 3, the financial model was run under a constrained approach in which projects were prioritized to achieve maximum benefits, with sewer rate increases deferred as long as practicable to avoid the 2% threshold.

As shown in Tables 18 and 19, the constraints were applied to the upper limit of the 2nd quintile and the upper limit of the 2nd quintile adjusted for cost of living. It is worth noting that in order for DC Water to meet its regulatory obligations typical resident bills will eventually exceed the 2 percent threshold; it is just a matter of when the threshold is reached. When the constraint is applied to the unadjusted income, the 2 percent threshold is not exceeded until 2024. Using the same constraint, but measuring costs against adjusted income, the unaffordability threshold is exceeded as early on 2018. When the constraint is applied to the adjusted income, unaffordability issues arise in the year 2020.

The economic impacts become direr when the evaluation focuses on poorer wards and minority populations. For example, the 2 percent threshold for African American households at the upper limit of the second quintile (unadjusted) is exceeded by the year 2017. By the year 2025, sewer bills would account for more than 3.3 percent of this demographic group. In Ward 8, sewer bills would account for 4.4 percent of household incomes at the upper limit of the second quintile. By the year 2032, sewer bills would exceed the affordability threshold in 4 out of the 8 wards for the upper limit of the second quintile. The outlook is made further grim when COLI is used to take into account DC resident purchasing power. By 2025, sewer bills would account for 5 percent of Ward 8 household incomes at the upper limit of the second quintile and 3.8 percent of African American house hold incomes at the upper limit of the second quintile city-wide. The affordability impacts on the different demographic groups and across the different Wards are shown in the figures 1 and 2 below.

Figure 1 Impacts to Household Income (Unadjusted) by Demographic Group

Figure 2 Impacts to Household Income (COLI adjusted) by Demographic Group

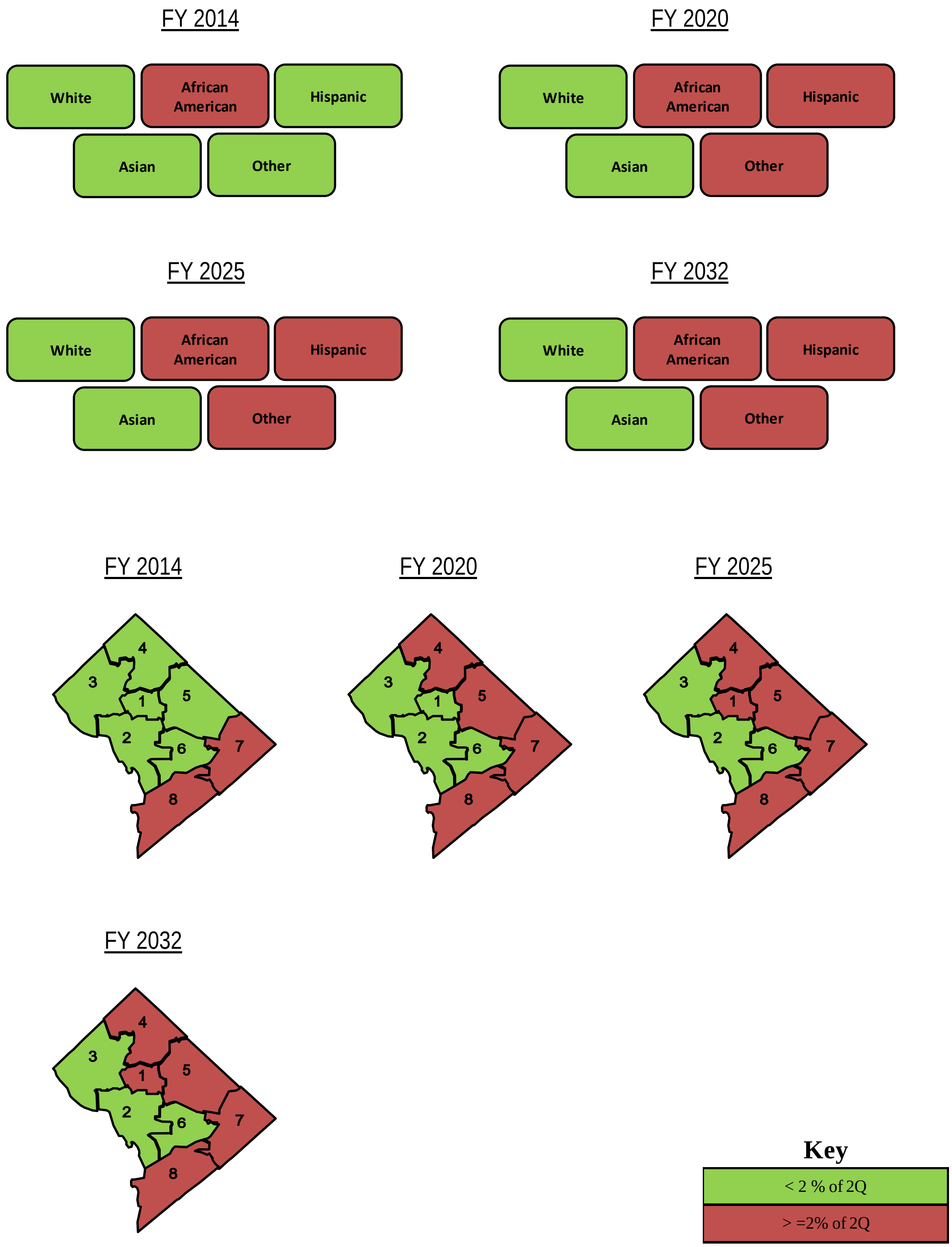


Table 18 Projects Scheduled and Constrained by Upper Limit of Second Quintile

	Sewer Increase	CRIAC Increase	Capital Outlay	Debt Service Coverage[1]	Evaluation Against Upper Limit of the Second Quintile	Evaluation Against Adjusted Upper Limit of the Second Quintile
FY 2014	na	na	$ 301,000,000	1.46	1.05%	1.51%
FY 2015	10.0%	15.0%	$ 340,000,000	1.37	1.15%	1.64%
FY 2016	10.0%	10.0%	$ 300,000,000	1.30	1.23%	1.77%
FY 2017	10.0%	10.0%	$ 300,000,000	1.27	1.32%	1.90%
FY 2018	10.0%	10.0%	$ 300,000,000	1.25	1.42%	2.04%
FY 2019	10.0%	10.0%	$ 300,000,000	1.23	1.53%	2.19%
FY 2020	10.0%	10.0%	$ 300,000,000	1.24	1.65%	2.36%
FY 2021	10.0%	10.0%	$ 300,000,000	1.28	1.77%	2.54%
FY 2022	10.0%	10.0%	$ 300,000,000	1.37	1.91%	2.73%
FY 2023	4.0%	10.0%	$ 300,000,000	1.43	1.98%	2.83%
FY 2024	4.0%	8.0%	$ 250,000,000	1.48	2.04%	2.92%
FY 2025	4.0%	8.0%	$ 250,000,000	1.54	2.10%	3.01%
FY 2026	3.0%	5.0%	$ 250,000,000	1.57	2.13%	3.05%
FY 2027	3.0%	5.0%	$ 250,000,000	1.57	2.16%	3.10%
FY 2028	3.0%	5.0%	$ 250,000,000	1.55	2.20%	3.15%
FY 2029	3.0%	5.0%	$ 250,000,000	1.52	2.23%	3.20%
FY 2030	1.0%	3.0%	$ 250,000,000	1.45	2.23%	3.19%
FY 2031	1.0%	3.0%	$ 250,000,000	1.34	2.22%	3.18%
FY 2032	1.0%	3.0%	$ 250,000,000	1.20	2.21%	3.17%

1.Debt service coverage needs to be above 1.2 to satisfiy minimum requirement

Table 19 Projects Scheduled and Constrained by Adjusted Upper Limit of Second Quintile

	Sewer Increase	CRIAC Increase	Capital Outlay	Debt Service Coverage[1]	Evaluation Against Adjusted Upper Limit of Second Quintile	Evaluation Against Upper Limit of Second
FY 2014	na	na	$ 300,000,000	1.47	1.51%	1.05%
FY 2015	10.0%	15.0%	$ 340,000,000	1.38	1.64%	1.15%
FY 2016	8.0%	10.0%	$ 300,000,000	1.27	1.74%	1.22%
FY 2017	8.0%	10.0%	$ 250,000,000	1.23	1.85%	1.29%
FY 2018	4.0%	10.0%	$ 180,000,000	1.21	1.92%	1.34%
FY 2019	4.0%	10.0%	$ 180,000,000	1.23	1.99%	1.39%
FY 2020	4.0%	10.0%	$ 180,000,000	1.22	2.06%	1.44%
FY 2021	4.0%	10.0%	$ 180,000,000	1.22	2.14%	1.49%
FY 2022	4.0%	10.0%	$ 180,000,000	1.23	2.22%	1.55%
FY 2023	4.0%	10.0%	$ 180,000,000	1.26	2.31%	1.61%
FY 2024	3.0%	8.0%	$ 150,000,000	1.29	2.37%	1.66%
FY 2025	2.0%	4.0%	$ 150,000,000	1.30	2.39%	1.67%
FY 2026	2.0%	4.0%	$ 100,000,000	1.30	2.41%	1.68%
FY 2027	2.0%	4.0%	$ 100,000,000	1.31	2.42%	1.69%
FY 2028	2.0%	4.0%	$ 100,000,000	1.31	2.44%	1.70%
FY 2029	2.0%	4.0%	$ 100,000,000	1.30	2.46%	1.72%
FY 2030	2.0%	4.0%	$ 100,000,000	1.27	2.48%	1.73%
FY 2031	2.0%	3.0%	$ 90,000,000	1.24	2.49%	1.74%
FY 2032	2.0%	3.0%	$ 90,000,000	1.20	2.50%	1.74%

1.Debt service coverage needs to be above 1.2 to satisfiy minimum requirement

5.3 DC Water Project Ranking Approach

Not all projects can be completed while meeting affordability criteria. Therefore, a project ranking system was needed to determine which projects would be deferred.

As the financial analysis above has shown, the CIP is an expensive undertaking which will impact the ratepayer community in a significant way. Even under the constrained approach ratepayer costs will increase and impose a financial burden on segments of Washington DC's population. Nonetheless, configuring the CIP to bring to the forefront as many benefits as possible, while deferring costs to the extent possible, can alleviate that burden somewhat while still meeting regulatory obligations.

To achieve that objective, DC Water developed a Project Ranking System to rank all CIP projects in a 20 year planning horizon, in an effort to maximize environmental, social and financial benefits. The system was developed as a joint effort of the DC Water's senior managers and the Louis Berger Water Services Team. The overall ranking process included project data collection, criteria development, project scoring, importance weighting factors development and affordability analysis.

5.3.1 Project Data Collection

The first activity completed by the team was to compile a list of CIP projects for DC Water. The initial list included those projects already identified by DC Water in its existing 20 Year CIP. To this base list of CIP projects, the team also added needed projects that had previously not been considered because of funding constraints. These were the projects that were important for utility efficiency or productivity purposes or had to be delayed because compliance schedules required other projects to be completed first. DC Water provided a 20 year horizon plan, which was used to develop the 20 year list of CIP projects.

The general guidelines used by the team in compiling the project list included:

- The CIP list provided by the DC Water.
- Projects previously not considered for funding constraints.
- All phases of the project lifecycle, including project planning, feasibility studies, design and construction were included.
- Long-term projects, which extend past the current CIP end schedule date, are defined as recurring programs. For financial modeling purposes, the end dates for these recurrent programs are the same year the financial model ends.
- Schedules were based on earliest start date and latest finish date.

The original project list provided by DC Water included discreet projects and multiple recurring projects. To reduce the number of projects to a manageable size, those projects were "bundled" so that the separate projects or the recurring projects were included as one Project. The bundling process reduced the project list to 207 projects. It is expected that over time additional needs will be identified and refined information available will result in revisions to the project list with projects being modified, added or removed as necessary.

The following is a list of guidelines used by the team to bundle the projects:

1. Projects with components that could be implemented independently of each other were broken into separate projects, and were bundled at the most logical level for decision making.

2. Similar projects spanning various divisions were bundled (e.g. Asset Management Project).

3. Within the same project, separate geographic service areas limits with similar schedules were bundled (e.g. Large Sewer Rehabilitation projects).

4. A recurring program was added for recurring projects that have the same scope of work or similar description. Extra cost escalated from previous years was added to end the recurring programs at the same time with financial model. For example: per the 2014 CIP, sewer rehabilitation projects do not extend beyond FY30; therefore, two additional sewer rehabilitation projects were added to capture the fact that this is recurring program with an anticipated annual expenditure.

5.3.2 Criteria Development

The team used a modified Triple Bottom Line ("TBL") benefit analysis, referred to in this document as a Quadruple Bottom Line ("QBL") analysis, to evaluate the benefits associated with each of the bundled projects. The QBL added "Project Implementation" as the fourth category to the TBL environmental, social and economic categories.

The current evaluation list includes the 20 criteria shown in Table 20 below. LBWS and DC Water senior managers conducted a meeting on June 25, 2013 to vote and select those criteria deemed most important. The evaluation criteria encompass eight environmental, five social, four economic, and three project implementation criteria.

Each project was scored with respect to each criterion. Wherever possible, the scores were based on benefit calculations in quantifiable terms. Scores were either data-based scores or scale-based scores. The data input for each of the criteria required either a score from 0 to 10 or an input of actual numeric data.

Table 20 DC Water Projects Ranking Approach Criteria

Environmental	Social	Economic	Project Implementation
Regulatory Driven	Health and Safety	Annual O&M Costs	Service Life and Consequences of Failure
Reduce Sewage Overflows	Quality of Life	I/I Reduction	Impact of Project Delay
Pollutant Loading to Receiving Waters – Nitrogen	Environmental Justice	Capital Costs	Ease of Implementation
Pollutant Loading to Receiving Waters – Bacteria	Customer Satisfaction	Job Stimulus	
Stormwater Management – At Surface Only	Mayor's Sustainable DC Plan		
Flood Control			
Improve Air Quality			
Reduce Greenhouse Gas Emissions and Urban Heat Factor Mitigation			

5.3.3 Project Scoring

To score the projects for evaluation, a protocol was developed to promote consistency and accuracy of information collected from various sources. The scoring process is described below.

1. Met with DC Water staff to obtain a comprehensive list of projects as discussed above.
2. Obtained project baseline information for the projects
3. Obtained all scale-based raw scores and available information for data-based score calculations.
4. Performed calculations to obtain data-based raw scores
5. Converted data-based raw scores to 0 to 10 scale scores

Two distinct types of scoring were collected:

• Scale-based scores representing a scale from 0 to 10, with 0 being the least favorable and 10 being the most favorable.

• Data-based scores comprising actual data from each project.

Actual numeric data represented a specific number with an associated unit (e.g. jobs created, cost in dollars, etc.) for the criteria. All the numbers in a given criteria would then be converted to a 0 to 10 score using a scaled statistical analysis run against the largest number in that criteria, and associate a unique value to each data point for statistical evaluation. Job stimulus and capital cost criteria required an additional calculative process to be performed in order to yield the data point for that criteria. They were as follows:

The number of jobs created for every project was calculated using multipliers from a regional economic impact model combined with project expenditures to estimate the number of direct, indirect and induced jobs that would be generated by each project type. The Capital Cost Criterion will use the total project cost directly as the raw data.

The project team held a series of interviews, meetings and workshops with DC Water. Each project scoring meeting entailed:

- meeting with each group individually;
- meeting with the individuals responsible for project management of the projects in that group;
- reviewing and discussing of each project for each criteria individually; and
- recording the data either on paper or in digital format.

Throughout the entire process, the data inventory spreadsheet was updated with the raw data, scores and notes to explain certain scores.

5.3.4 Project Type Score Balancing

As a result of the varying characteristics of wastewater treatment, Clean River projects, stormwater and sanitary sewer projects, not all project types score against the same criteria. Therefore, based on the selected evaluation criteria and the disparity between those projects, some projects would be at a disadvantage if the score totals were to be used to set priority rankings.

The project team chose to perform mathematical score balancing via appropriate balancing score multipliers. Mathematical balancing resulted in the use of the desired criteria with equivalent scoring opportunities for each project type. To balance the maximum possible scores for each project type, a multiplier was applied so that maximum possible scores for each project type were adjusted upward. This ensured that all project types had the same maximum possible score. Table 21 shows the possible points that can be gained by criteria of group; Table 22 shows the group balancing multipliers.

Table 21 Possible Points Gained by Criteria of Group

	WWTP	Clean Rivers	CSO	Sanitary Sewer	Stormwater	Maximum Possible Scores
Environmental	80	80	80	50	60	80
Social	50	50	50	50	50	50
Economic	30	40	40	40	40	40
Project Implementation	30	30	30	30	30	30
Total	190	200	200	170	180	200

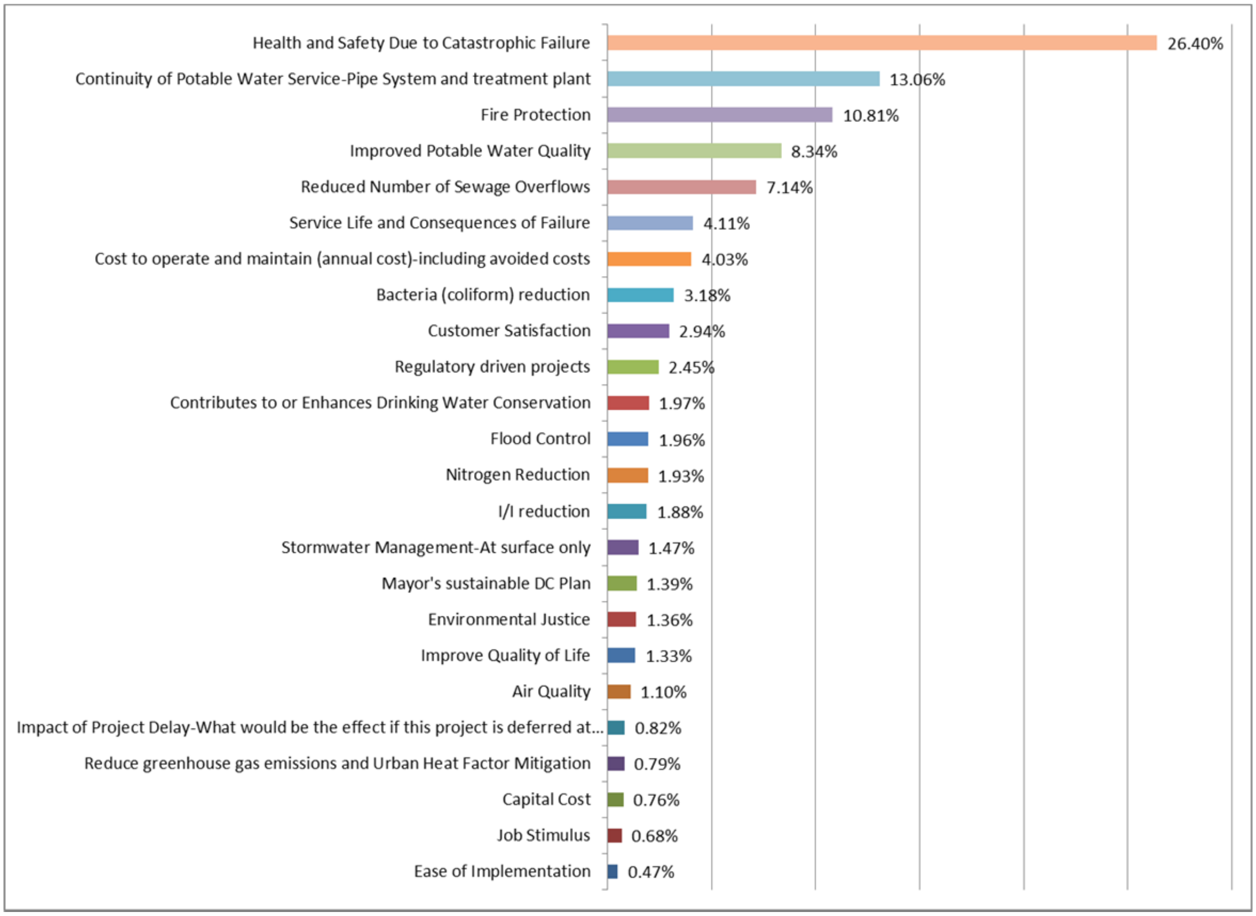
Table 22 Group Balancing Multipliers

	WWTP	Clean River	CSO	Sanitary Sewer	Stormwater
Environmental	1.00	1.00	1.00	1.60	1.33
Social	1.00	1.00	1.00	1.00	1.00
Economic	1.33	1.00	1.00	1.00	1.00
Project Implementation	1.00	1.00	1.00	1.00	1.00

5.3.5 Importance Weighting

After assigning and balancing project scores, LBWS and DC Water senior managers conducted a meeting on August 1st, 2013 to determine weighting factors for the criteria. Decision-making software, Expert Choice, was used to conduct pair-wise comparisons evaluating the relative importance of one criterion against another, and repeat the process until all criteria could be presented on the same scale. These pair-wise comparison weightings were then used as the basis for developing a team consensus across the DC Water team members. Importance weighting factors are a critical part of a prioritization process because each change to a weight has the potential to result in a different prioritized project list. The weighting factors are shown in Figures 3 below.

Figure 3 DC Water Project Ranking System Weighting Factors



5.3.6 Ranked Project List

Weighted scores of 20 criteria were added up to get the total weighted score for each project. All projects were ranked from the highest to the lowest of total weighted score. Figure 4 summarizes the steps required to generate a ranked project list.

Figure 4 Steps Required for Ranked Project List

Raw Score

Service Area	Project Name	Regulatory	Health and Safety	Ease of Impementation
Sanitary Sewer	Sewer Rehab Near Creek Beds	3.0	10.0	10.0

Balancing Multplier 1.6

Balanced Score

Service Area	Project Name	Regulatory	Health and Safety	Ease of Impementation
Sanitary Sewer	Sewer Rehab Near Creek Beds	4.8	10.0	10.0

X

Importance Weighting Factors

0.0301	0.4412	0.0082

=

Weighted Score

Service Area	Project Name	Regulatory	Health and Safety	Ease of Impementation
Sanitary Sewer	Sewer Rehab Near Creek Beds	0.144	4.412	0.082

5.4 DC Water Projects Ranking Approach Results

Based on the DC Water Ranking Approach and the affordability scenarios previously described, charts have been developed to show the resulting annual capital outlays for the 20 year planning horizon. With the exception of the original Consent Decree chart (Figure 5), the charts show the outlays by DC Water service area, including the Consent Decree. A summary of each chart result is provided below:

Figure 5 represents the original 2002 Consent Decree: this shows the original capital outlay projections used as part of the 2002 Consent Decree. As can be seen, the overall capital spending shows a steady increase over time, culminating in expenditures exceeding $500M in FY23 and FY25. A significant spike was projected from FY22 to FY25 to accommodate the construction of Consent Decree projects.

Figure 5 Scenario 1: DC Water 2002 Consent Decree

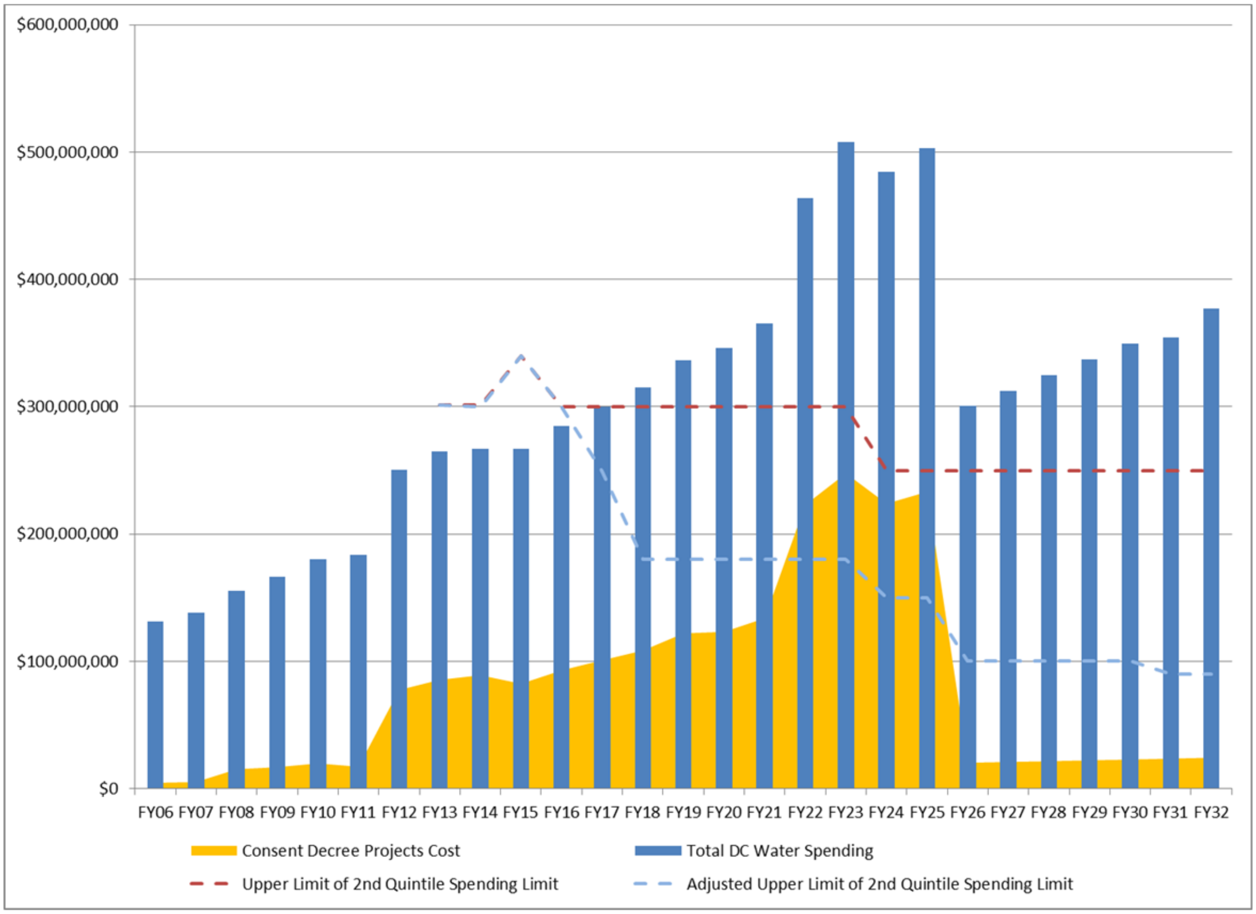


Figure 6 represents the current capital project portfolio with the original Consent Decree schedule requirements. Results show significantly increased annual capital outlays in most years compared to Figure 5, mostly due to a better defined CIP, with a spike still existing in FY 22 to FY 25 to accommodate the construction of Consent Decree projects.

Figure 6 Scenario 2: DC Water 20 Year CIP without CD modification (Status Quo)

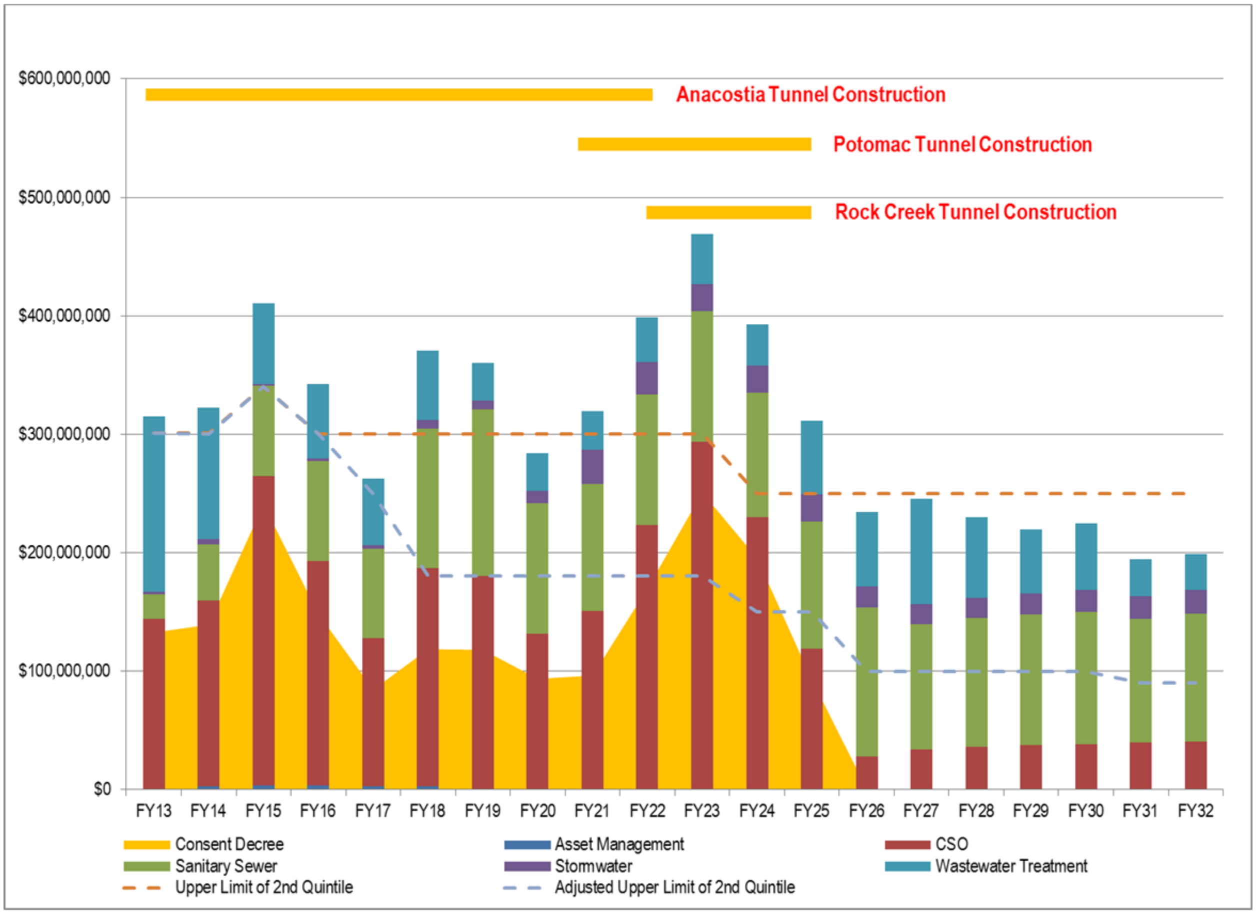


Figure 7 shows the capital project portfolio allowable using the DC Water Ranking Approach, with the proposed Consent Decree modification schedule, and constrained by an affordability measure of the upper limit of the 2nd quintile (as previously defined).

It shows that, compared to the model in which CD projects are not fixed, 35 projects are delayed. Out of the 35 projects delayed, 14 projects have higher benefit scores than the Potomac Tunnel Projects.

Results indicate that the proposed Consent Decree modification schedule can be met within this affordability scenario, however, non-Consent Decree projects ranking higher than the Consent Decree projects end up being delayed to accommodate the Consent Decree projects.

Figure 7 DC Water 20 Year CIP with CD modification, CD Projects Fixed – Other Projects Delayed and Constrained by Upper Limit of 2nd Quintile

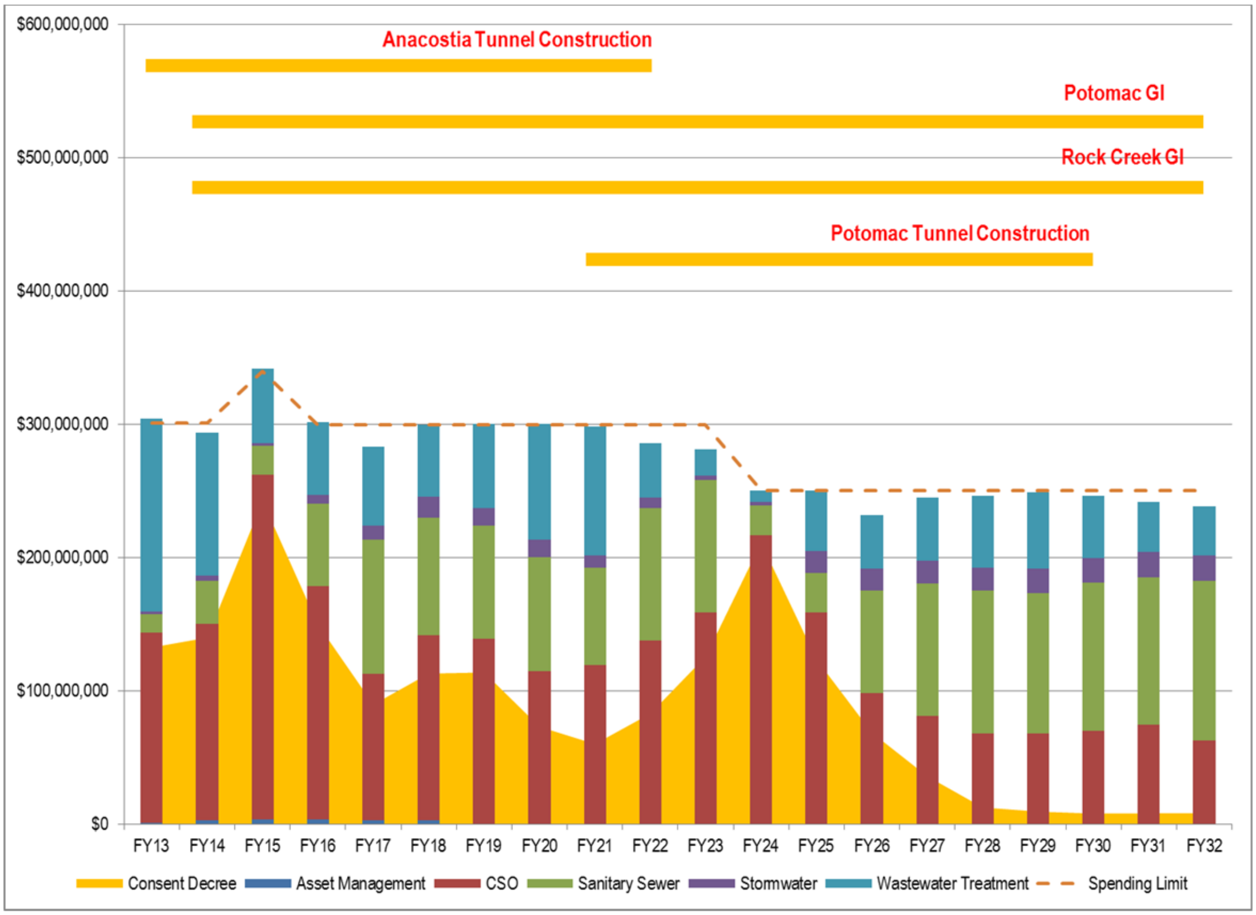
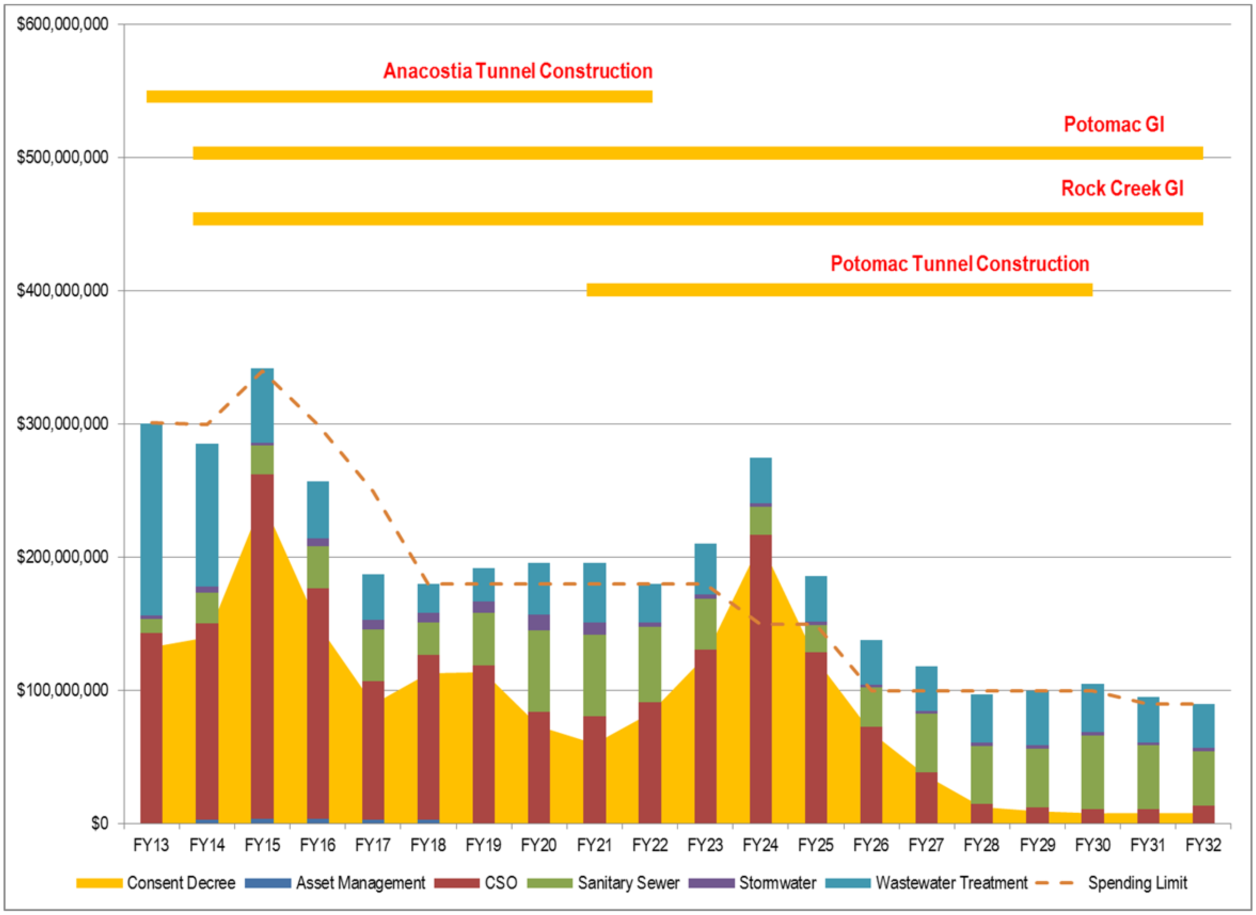


Figure 8 shows the capital project portfolio allowable using the DC Water Ranking Approach, with the proposed Consent Decree modification schedule, and constrained by an affordability measure of the COLI adjusted upper limit of the 2nd quintile (as previously defined).

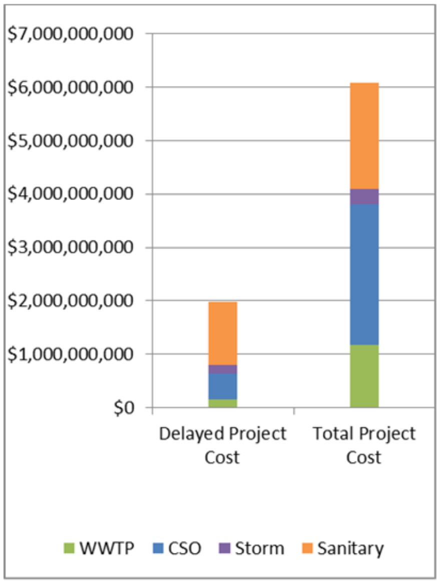
Results indicate that the Consent Decree modification schedule would exceed the affordability in multiple future years, while also resulting in a severe impact (delays or deferral beyond the 20 year horizon) for other critical projects ranked higher than the Consent Decree projects.

Figure 8 DC Water 20 Year CIP with CD modification, CD Projects Fixed – Other Projects Delayed and Constrained by Adjusted Upper Limit of 2nd Quintile



Figures 9 and 10 correspond to Figure 7 and 8 and show projects delayed and/or unfunded constrained by upper limit of 2nd quintile and adjusted upper limit of 2nd quintile. Delayed/unfunded projects list can be found in Appendices A through C.

Figure 9 Projects delayed- Constrained by Upper Limit of 2nd Quintile



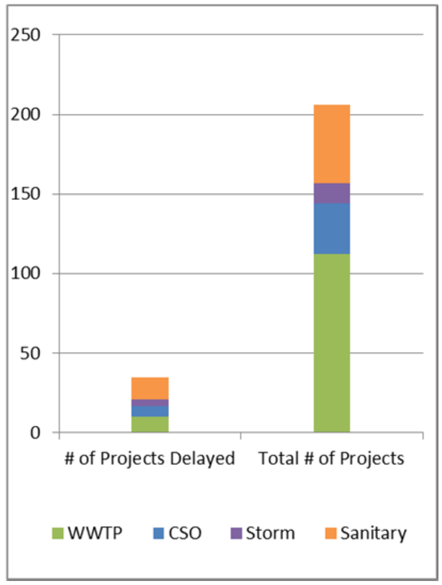
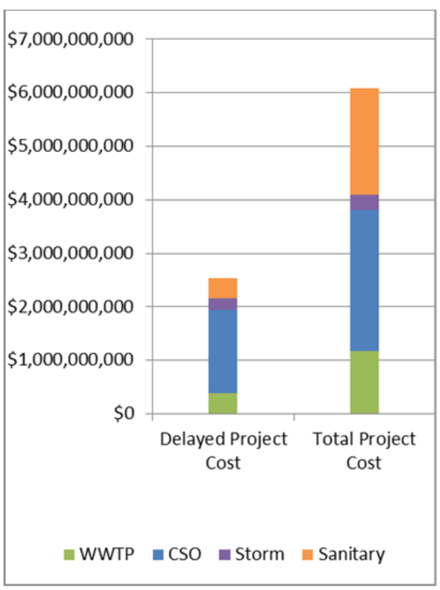
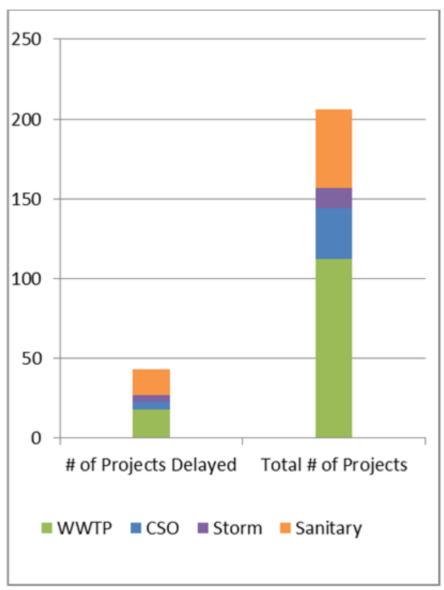


Figure 10 Projects delayed/unfunded- Constrained by Adjusted Upper Limit of 2nd Quintile





6. Conclusions

In general accordance with EPA's 2013 guidance on affordability, DC Water has evaluated affordability within the District using factors other than the standard MHI. These include financial impacts to the ratepayer base at the 2nd quintile income level (upper limit of 40% of the household income), and cost of living index. The findings indicate that a significant portion of District residents are facing severe affordability issues.

Our analysis shows that the using a sewer bill threshold of 2 percent of MHI is a very poor indicator for assessing affordability. In jurisdictions such as Washington DC not only our household incomes highly skewed but there has been an increasing divergence between high income households and low income households. From 2006 to 2012, for example MHI grew more than 28 percent while household incomes at the upper limit of the second quintile grew only 20 percent. Consequently by 2011 the MHI was 25 percent higher than the upper limit of the second quintile. Low income ratepayers also face high prices for other non-discretionary expenditures in Washington DC, where the cost of living is more than 40 percent higher than the national average. Hence rising utility bills will have a higher and disproportionate impact on lower income households.

Evaluating the financial impacts of DC Water's CIP on the ratepayer base found that impacts to lower income households become much more apparent when the upper limit of the second quintile is used than when using the 2 percent of MHI threshold. With the COLI factor taken into account, forecasted sewer bills become unaffordable to 40 percent of the households as soon as 2018.

This evaluation has included a revised ranking approach for all capital projects within DC Water's 20 planning horizon, based on the goal of maximizing environmental, social, financial and project efficacy benefits. Using this approach and the revised affordability factors to determine annual capital spending limits, DC Water will reprioritize the schedules for capital projects base on their project ranks, and base on the 5/7 year extension for the Consent Decree projects.

Results indicate that extending the CSO Controls Consent Decree Program by 5/7 years ameliorates affordability, as compared to the original Consent Decree schedule. However, even with the 5/7 year extension, multiple other essential projects, ranked higher than the CSO Controls Consent Decree program, get further delayed to out years.

Appendix A: Delayed projects List - Constrained by Upper Limit of 2nd Quintile

Service Area	Project Name	Previous Start	Previous Complete	Revised Start	Revised Complete	Weighted Score	FY13 DC Share	FY14 DC Share	FY15 DC Share	FY16 DC Share	FY17 DC Share	FY18 DC Share	FY19 DC Share	FY20 DC Share	FY21 DC Share	FY22 DC Share	FY23 DC Share	FY24 DC Share	FY25 DC Share	FY26 DC Share	FY27 DC Share	FY28 DC Share	FY29 DC Share	FY30 DC Share	FY31 DC Share	FY32 DC Share	Total DC Share
Wastewater Treatment	Primary Treatment Facilities Ph II	10/01/2015	01/16/2022	10/01/2017	01/16/2024	0.06331	$0.00	$0.00	$0.00	$0.00	$0.00	$36,376.09	$241,130.75	$280,036.41	$842,285.67	$3,178,037.59	$436,894.99	$1,145.87	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$5,015,907.37
Wastewater Treatment	DWT Research / Pilot Projects	10/01/2007	05/30/2016	10/01/2017	05/30/2020	0.06505	$0.00	$0.00	$0.00	$0.00	$209,980.57	$19,025.04	$19,025.04	$12,667.27	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$260,697.92
Wastewater Treatment	Additional Chemical Systems PH III	10/01/2015	06/28/2025	10/01/2018	06/28/2028	0.16381	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$68,588.11	$91,202.15	$88,377.71	$10,941.44	$70,863.25	$23,630.98	$334,675.09	$610,400.78	$217,191.97	$9,067.14	$0.00	$0.00	$0.00	$0.00	$1,524,938.62
Wastewater Treatment	Construction of Flood Seawall	10/01/2014	07/01/2021	10/01/2015	07/01/2022	0.28332	$0.00	$0.00	$0.00	$32,416.46	$284,139.95	$346,221.69	$2,321,251.77	$1,129,311.59	$94,345.36	$1,742.42	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,209,429.24
Wastewater Treatment	Security	10/01/2015	10/01/2029	10/01/2024	10/01/2038	0.19986		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$357,844.29	$357,844.29	$357,844.29	$358,824.68	$357,844.29	$357,844.29	$357,844.29	$358,824.68	$2,864,715.10
Wastewater Treatment	Gravity Thickerner Odor Scrubbers	05/01/2014	04/20/2027	05/01/2016	04/20/2029	0.27606	$0.00	$0.00	$0.00	$12,567.15	$0.00	$0.00	$15,651.20	$38,190.56	$39,066.87	$31,886.60	$17,210.21	$94,915.97	$118,382.59	$471,115.42	$1,256,942.93	$311,529.55	$9,822.76	$0.00	$0.00	$0.00	$2,417,281.81
Wastewater Treatment	Thermal Hydrolysis and Digester Expansion	01/01/2021	04/19/2027	01/01/2030	04/19/2036	0.04877		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,318,640.17	$4,888,118.92	$5,015,952.68	$12,222,711.77
Wastewater Treatment	High Strength Waste Receiving Facility (Includes FOG)	01/01/2016	02/24/2019	01/01/2018	02/24/2021	0.05890	$0.00	$0.00	$0.00	$0.00	$0.00	$130,603.16	$379,694.43	$2,571,855.79	$363,097.91	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3,445,251.30
Wastewater Treatment	Centrate Treatment Facilities	03/18/2022	04/27/2028	03/18/2025	04/27/2031	0.04847	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3,400,922.10	$3,370,555.12	$10,618,035.91	$14,789,102.40	$8,156,909.17	$2,881,223.13	$747,162.44	$0.00	$43,963,910.27
Wastewater Treatment	Secondary Treatment Upgrades for TN	02/04/2016	07/27/2028	02/04/2020	07/27/2032	0.04135	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$68,105.72	$259,665.90	$482,810.83	$0.00	$0.00	$87,346.15	$697,313.21	$1,391,102.07	$4,760,833.47	$15,847,779.72	$8,151,013.37	$1,032,247.58	$89,572.69	$32,867,790.71
CSO	Main & O St. PS Intermediate Upgrade	04/01/2014	10/27/2018	04/01/2016	10/27/2020	0.63308	$0.00	$0.00	$0.00	$350,043.96	$228,595.20	$1,350,928.25	$6,519,978.51	$2,200,185.92	$29,770.36	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$10,679,502.21
CSO	Combined Sewer Rehabilitation	12/01/2017	10/29/2027	12/01/2025	10/29/2035	0.54260		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$13,629,656.33	$2,147,989.57	$11,534,308.46	$19,620,966.81	$21,234,221.73	$23,583,516.11	$26,918,329.08	$14,264,325.82	$132,933,313.91
CSO	Tiber Creek Trunk Sewer Rehabilitation	08/01/2013	01/05/2020	08/01/2016	01/05/2021	0.72743	$0.00	$0.00	$0.00	$12,460.43	$280,247.55	$478,501.95	$3,264,724.05	$2,278,025.25	$59,181.23	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$6,373,140.45
CSO	Slash Run Sewer Rehabilitation	10/01/2013	10/30/2016	10/01/2015	10/30/2018	0.79560	$0.00	$0.00	$0.00	$122,568.69	$183,764.83	$2,775,822.01	$239,613.36	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3,321,768.88
CSO	Northwest Major Sewer Rehabilitation	10/01/2013	04/30/2017	10/01/2015	04/30/2019	0.81947	$0.00	$0.00	$0.00	$45,512.72	$129,720.50	$2,087,290.45	$525,144.74	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,787,668.41
CSO	Combined Sewer SLRP - Recurring Program	10/02/2020	09/29/2032	10/02/2025	09/29/2032	0.36566	$0.00									$0.00	$0.00	$0.00	$0.00	$19,907,179.49	$18,723,158.99	$20,773,913.69	$21,674,527.16	$19,787,363.62	$21,404,030.95	$30,368,102.10	$152,638,276.01
CSO	Combined Sewer PS Refurb - Recurring Program	10/02/2015	09/29/2032	10/02/2024	09/29/2032	0.65729	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,502,035.24	$4,637,096.30	$4,776,209.19	$4,919,495.46	$5,067,080.33	$5,219,092.74	$5,375,665.52	$5,536,935.48	$40,033,610.25
Stormwater	Storm Sewer Rehab @ Various Location	10/01/2012	06/18/2018	10/01/2016	06/18/2020	0.59992	$0.00	$0.00	$0.00	$1,700.95	$36,668.73	$200,651.68	$368,137.71	$59,845.53	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$667,004.59
Stormwater	Storm Sewer Rehabilitation	03/01/2014	08/04/2027	03/01/2017	08/04/2030	0.61847	$0.00	$0.00	$0.00	$0.00	$4,049.77	$20,026.62	$214,995.31	$252,785.33	$264,823.11	$13,712.09	$121,910.79	$10,282.48	$147,727.08	$13,873.73	$38,007.26	$92,377.09	$46,319.63	$4,006.67	$0.00	$0.00	$1,244,896.96
Stormwater	DDOT STORMWATER PROJECTS	08/10/2004	09/30/2020	08/10/2014	09/30/2021	0.60998	$0.00	$344.02	$3,526.21	$18,420.01	$17,620.73	$18,112.04	$19,141.52	$16,101.99	$11,639.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$104,905.50
Stormwater	Storm Sewer SLRP	10/02/2018	09/29/2030	10/02/2024	09/29/2036	0.56476	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$13,778,281.35	$14,191,629.79	$14,617,378.69	$15,055,900.05	$15,507,577.05	$15,972,804.36	$16,451,988.49	$16,945,548.15	$122,521,107.94
Sanitary Sewer	Small Local Sewer Rehab - Recurring Program	10/01/2019	05/27/2038	10/01/2030	05/27/2049	0.47623	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,038,598.21	$9,129,697.63	$24,573,221.63	$34,741,517.47
Sanitary Sewer	Sewer Facilities Security Upgrades	10/01/2009	01/30/2015	10/01/2016	01/30/2018	0.15482	$0.00	$0.00	$0.00	$140,808.80	$393,461.49	$99,598.79	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$633,869.08
Sanitary Sewer	Sewer Instrumentation & Control	10/01/2011	10/01/2015	10/01/2016	10/01/2018	0.56809	$0.00	$0.00	$0.00	$113,200.68	$122,029.58	$40,121.38	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$275,351.63
Sanitary Sewer	3rd Street & Constitution Ave NW - Pumping Station	10/01/2013	05/04/2017	10/01/2015	05/04/2019	0.72442	$0.00	$0.00	$0.00	$87,570.93	$207,691.33	$1,864,313.20	$614,155.01	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,773,730.48
Sanitary Sewer	Sewer Inspection Program - Recurring Program	10/01/2016	01/01/2026	10/01/2025	01/01/2035	0.56226	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,206,667.58	$3,758,385.54	$3,728,570.03	$2,806,764.29	$2,130,143.80	$2,053,095.68	$1,285,294.92	$1,884,433.87	$21,853,355.70
Sanitary Sewer	UAMI Relief Sewer	10/01/2009	09/25/2019	10/01/2017	09/25/2020	0.78551	$0.00	$0.00	$0.00	$0.00	$140,997.40	$1,776,578.11	$13,003,639.67	$5,429,153.73	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$20,350,368.91
Sanitary Sewer	Sewer Structure Rehabilitation (1)	10/01/2015	04/10/2019	10/01/2016	04/10/2020	0.73111	$0.00	$0.00	$0.00	$72,465.10	$233,322.20	$1,017,211.95	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,322,999.25
Sanitary Sewer	Rehabilitation of Influent Sewers	06/01/2014	07/31/2025	06/01/2021	07/31/2032	0.63341	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$42,258.30	$2,100,013.70	$0.00	$537,091.39	$1,745,578.76	$3,085,204.92	$8,158,938.11	$28,380,100.04	$33,764,474.84	$30,816,107.68	$11,346,530.41	$119,976,298.16
Sanitary Sewer	Creekbed Sewer Rehabilitation - Recurring Program	10/01/2010	09/30/2033	10/01/2019	09/30/2033	0.76182	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$60,094.61	$832,303.27	$9,972,483.70	$1,468,527.61	$8,846,099.48	$326,822.65	$3,532,305.86	$7,169,713.66	$10,916,826.16	$11,244,648.84	$11,582,405.53	$11,930,096.25	$12,287,720.98	$12,655,942.00	$102,825,990.62
Sanitary Sewer	Upper East Side Trunk Sewer Rehabilitation	06/27/2014	08/31/2022	06/27/2015	08/31/2023	0.73908	$0.00	$0.00	$0.00	$30,049.99	$3,809,672.49	$1,323,729.49	$455,896.63	$1,767,841.06	$5,031,204.68	$3,918,344.19	$2,092,094.14	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$18,428,832.66
Sanitary Sewer	South Major Sewer Rehabilitation	06/01/2013	07/31/2018	06/01/2015	07/31/2020	0.90002	$0.00	$0.00	$0.00	$50,780.40	$51,885.24	$286,034.57	$1,081,679.08	$3,715,467.69	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$5,185,846.98
Sanitary Sewer	Hydraulic Protection Project	10/01/2013	07/30/2017	10/01/2015	07/30/2019	0.76256	$0.00	$0.00	$0.00	$36,024.79	$136,264.66	$470,205.49	$23,789.66	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$666,284.61
Sanitary Sewer	Sanitary Sewer Rehabilitation 4	10/01/2013	09/30/2017	10/01/2015	09/30/2019	0.90987	$0.00	$0.00	$0.00	$327,981.25	$309,723.94	$2,359,882.33	$1,447,914.58	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,445,502.10
Sanitary Sewer	Large Sewer Rehab - Recurring Program	11/03/2017	09/30/2032	11/03/2024	09/30/2032	0.57796	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$630,867.01	$5,041,446.33	$13,859,511.64	$19,368,715.07	$18,546,768.50	$34,120,713.53	$39,531,859.48	$31,707,829.89	$162,807,711.46

Appendix B: Delayed Projects List - Constrained by Adjusted Upper Limit of 2nd Quintile

Service Area	Project Name	Previous Start	Previous Complete	Revised Start	Revised Complete	Weighted Score	Status	FY13 DC Share	FY14 DC Share	FY15 DC Share	FY16 DC Share	FY17 DC Share	FY18 DC Share	FY19 DC Share	FY20 DC Share	FY21 DC Share	FY22 DC Share	FY23 DC Share	FY24 DC Share	FY25 DC Share	FY26 DC Share	FY27 DC Share	FY28 DC Share	FY29 DC Share	FY30 DC Share	FY31 DC Share	FY32 DC Share	Total DC Share
Wastewater Treatment	Grit Chamber Facilities Phase II	10/01/2026	10/12/2031	10/01/2027	10/12/2032	0.04061	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$37,428.74	$207,516.67	$982,638.80	$1,074,920.08	$14,406.84	$2,316,911.14
Wastewater Treatment	Primary Treatment Facilities Ph II	10/01/2020	01/16/2027	10/01/2031	01/16/2038	0.04133	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$55,022.09	$55,022.09
Wastewater Treatment	DWT Research / Pilot Projects	10/01/2016	05/30/2019	10/01/2019	05/30/2022	0.06120	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$222,768.39	$20,183.66	$20,183.66	$13,438.71	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$276,574.42
Wastewater Treatment	Replace/Upgrade Influent Screens	06/01/2023	10/09/2031	06/01/2029	10/09/2037	0.07455	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$142,589.79	$172,717.58	$532,605.42	$706,112.86	$1,554,025.65
Wastewater Treatment	Secondary Treatment mech equip	06/30/2022	06/30/2026	06/30/2027	06/30/2031	0.05763	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$428,598.03	$1,682,132.03	$1,682,132.03	$1,686,740.62	$1,253,534.01	$0.00	$6,733,136.72
Wastewater Treatment	ENR sed basins mechanical	06/30/2026	06/30/2030	06/30/2032	06/30/2036	0.05436	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$531,812.45	$531,812.45
Wastewater Treatment	Dual Purpose sed basins equipment	06/30/2018	06/30/2021	06/30/2019	06/30/2022	0.08525	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$122,086.11	$479,155.18	$480,467.93	$357,069.06	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,438,778.28
Wastewater Treatment	Disinfection	09/15/2015	09/15/2020	09/15/2032	09/15/2037	0.04261	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$20,865.33	$20,865.33
Wastewater Treatment	Additional Chemical Systems PH III	10/01/2015	06/28/2025	10/01/2026	06/28/2036	0.12839	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$86,885.37	$115,532.15	$111,954.24	$13,860.28	$89,767.44	$29,935.02	$447,934.50
Wastewater Treatment	Perimeter Security at Blue Plains	05/01/2016	09/30/2021	05/01/2019	09/30/2024	0.22087	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$98,510.52	$302,128.84	$188,724.70	$285,425.93	$284,646.31	$284,646.31	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,444,082.61
Wastewater Treatment	Plantwide Painting of Steel Pipes	12/01/2021	09/18/2026	12/01/2030	09/18/2035	0.03832	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$12,966.57	$0.00	$33,612.80	$46,579.38
Wastewater Treatment	COF Renovations and Additions	09/01/2020	09/09/2024	09/01/2032	09/09/2036	0.03620	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$50,085.04	$50,085.04
Wastewater Treatment	Construction of Flood Seawall	10/01/2015	07/01/2022	10/01/2017	07/01/2024	0.26658	0	$0.00	$0.00	$0.00	$0.00	$0.00	$34,390.63	$301,444.07	$367,306.59	$2,462,616.00	$1,198,086.67	$100,090.99	$1,848.53	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,465,783.48
Wastewater Treatment	Process Service Water Upgrade	06/30/2018	06/30/2023	06/30/2019	06/30/2024	0.08532	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$94,990.53	$372,812.31	$373,833.71	$372,812.31	$372,812.31	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,587,261.18
Wastewater Treatment	Gravity Thickerner Odor Scrubbers	05/01/2014	04/20/2027	05/01/2018	04/20/2031	0.25974	0	$0.00	$0.00	$0.00	$0.00	$0.00	$13,332.49	$0.00	$0.00	$16,604.36	$40,516.37	$41,446.04	$33,828.50	$18,258.31	$100,696.36	$125,592.09	$499,806.35	$1,333,490.75	$330,501.70	$10,420.96	$0.00	$2,564,494.27
Wastewater Treatment	Co-Digestion - Fats Oils and Grease Addition	02/01/2022	11/27/2025	02/01/2031	11/27/2034	0.03732	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$42,938.49	$117,685.69	$160,624.18
Wastewater Treatment	Combined Heat & Power as Backup Power	06/01/2019	09/30/2023	06/01/2031	09/30/2035	0.03305	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$79,375.20	$79,375.20
Wastewater Treatment	Site runoff pumping station for stormwater management purposes	01/01/2016	01/01/2018	01/01/2019	01/01/2021	0.22578	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$188,101.91	$564,305.72	$188,101.91	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$940,509.53
CSO	Potomac Pumping Station-PH IV Rehab	01/27/2015	05/22/2018	01/27/2019	05/22/2022	0.38884	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$64,710.39	$267,823.02	$1,625,975.40	$379,921.75	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,338,430.58
CSO	Rehab Northeast Boundary Sewer-PH 1	06/01/2024	10/01/2031	06/01/2030	10/01/2037	0.43698	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$20,788.69	$2,649,498.23	$2,670,286.92
CSO	Slash Run Sewer Rehabilitation	10/01/2013	10/30/2016	10/01/2018	10/30/2021	0.72743	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$134,175.53	$201,166.73	$3,038,682.83	$262,303.92	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3,636,329.00
CSO	Northwest Major Sewer Rehabilitation	10/01/2013	04/30/2017	10/01/2018	04/30/2022	0.74993	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$49,867.50	$142,132.50	$2,287,008.00	$575,392.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3,054,400.00
CSO	Sewer Structure Rehabilitation	10/01/2014	12/31/2017	10/01/2018	12/31/2021	0.68444	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$190,855.70	$920,816.46	$4,029,408.96	$526,893.84	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$5,667,974.95
Stormwater	Storm Sewer Rehab @ Various Location	10/01/2012	06/18/2018	10/01/2019	06/18/2023	0.54753	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,858.67	$40,068.91	$219,257.50	$402,274.01	$65,394.83	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$728,853.93
Stormwater	Storm Sewer Rehabilitation	03/01/2014	08/04/2027	03/01/2017	08/04/2030	0.61847	0	$0.00	$0.00	$0.00	$0.00	$4,049.77	$20,026.62	$214,995.31	$252,785.33	$264,823.11	$13,712.09	$121,910.79	$10,282.48	$147,727.08	$13,873.73	$38,007.26	$92,377.09	$46,319.63	$4,006.67	$0.00	$0.00	$1,244,896.96
Stormwater	Stormwater Pump Stations Rehabilatation	10/01/2013	05/28/2017	10/01/2019	05/28/2021	0.60159	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$152,981.78	$841,186.16	$918,104.31	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,912,272.25
Stormwater	DDOT STORMWATER PROJECTS	08/10/2004	09/30/2020	08/10/2014	09/30/2021	0.60998	0	$0.00	$344.02	$3,526.21	$18,420.01	$17,620.73	$18,112.04	$19,141.52	$16,101.99	$11,639.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$104,905.50
Sanitary Sewer	Sewer Upgrade - City Wide	07/02/2017	05/06/2020	07/02/2019	05/06/2022	0.66608	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$342,927.04	$556,190.75	$5,976,699.81	$1,816,080.71	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$8,691,898.32
Sanitary Sewer	Sewer Facilities Security Upgrades	10/01/2016	01/30/2018	10/01/2019	01/30/2021	0.14130	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$153,865.58	$429,945.99	$108,834.28	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$692,645.86
Sanitary Sewer	3rd Street & Constitution Ave NW - Pumping Station	10/01/2013	05/04/2017	10/01/2018	05/04/2022	0.66116	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$95,691.12	$226,949.93	$2,037,185.38	$671,103.76	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$3,030,930.18
Sanitary Sewer	Additional Sewer SCADA System Sites	10/01/2015	04/02/2021	10/01/2028	04/02/2034	0.24576	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$436,230.88	$277,006.61	$377,339.71	$0.00	$1,090,577.19
Sanitary Sewer	Sewer Inspection Program - Recurring Program	10/01/2026	01/01/2036	10/01/2027	01/01/2037	0.52903	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,462,853.63	$3,987,271.22	$3,955,639.94	$2,977,696.23	$2,259,869.55	$2,178,129.20	$19,821,459.78
Sanitary Sewer	Low Area Trunk Sewer Rehabilitation	04/16/2015	04/29/2018	04/16/2018	04/29/2021	0.68951	0	$0.00	$0.00	$0.00	$0.00	$0.00	$23,183.16	$625,310.21	$7,578,233.19	$3,625,220.45	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$11,851,947.01
Sanitary Sewer	Sewer Rehab Near Creek Beds	10/01/2019	05/06/2026	10/01/2031	05/06/2038	0.46911	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$478,234.73	$766,924.81	$1,245,159.54
Sanitary Sewer	New Field Operations & Maintenance Facility	09/01/2015	07/22/2017	09/01/2018	07/22/2020	0.02177	0	$0.00	$0.00	$0.00	$0.00	$0.00	$25,167.20	$802,406.41	$5,947,606.97	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$6,775,180.58
Sanitary Sewer	New Fleet Management Facility	09/01/2015	07/22/2017	09/01/2028	07/22/2030	0.01606	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$39,618.33	$1,102,469.61	$8,193,081.47	$0.00	$0.00	$9,335,169.41
Sanitary Sewer	B St/New Jersey Ave Trunk Sewer Rehab	10/01/2016	09/29/2021	10/01/2030	09/29/2035	0.49320	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,357,162.70	$543,691.21	$428,017.88	$2,328,871.79
Sanitary Sewer	Oxon Run Sewer Rehabilitation	10/01/2009	03/01/2018	10/01/2017	03/01/2021	0.76349	0	$0.00	$0.00	$0.00	$0.00	$44,761.35	$38,087.50	$739,287.89	$1,196,778.87	$223,455.28	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,242,370.89
Sanitary Sewer	Little Falls Rehabilitation Project	10/01/2014	08/15/2018	10/01/2018	08/15/2022	0.82364	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$195,182.50	$712,033.96	$1,544,024.36	$321,380.91	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$2,772,621.73
Sanitary Sewer	Hydraulic Protection Project	10/01/2013	07/30/2017	10/01/2014	07/30/2018	0.78614	0	$0.00	$0.00	$34,975.52	$132,295.79	$456,510.19	$23,096.76	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$646,878.26
Sanitary Sewer	Sanitary Sewer Rehabilitation 4	10/01/2013	09/30/2017	10/01/2018	09/30/2022	0.83266	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$359,363.38	$339,359.16	$2,585,682.20	$1,586,454.93	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$4,870,859.67
Sanitary Sewer	Investigation and rehabilitation of PI Phase 3	09/30/2020	09/30/2024	09/30/2027	09/30/2031	0.76946	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$9,888,000.00	$9,888,000.00	$9,888,000.00	$9,888,000.00	$9,888,000.00	$0.00	$49,440,000.00
Sanitary Sewer	Easby Point modifications (FEMA)	09/30/2016	09/30/2020	09/30/2019	09/30/2023	0.74163	0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,648,000.00	$1,648,000.00	$1,648,000.00	$1,648,000.00	$1,648,000.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$8,240,000.00

Appendix C: Projects List of not funded - Constrained by Adjusted Upper Limit of 2nd Quintile

Service Area	Project Name
Wastewater Treatment	Primary Sedimentation Tank Odor Scrubblers
Wastewater Treatment	Spent Washwater Treatment
Wastewater Treatment	Effluent Filter Upgrade
Wastewater Treatment	Deammonification Project
Wastewater Treatment	RWWP1
Wastewater Treatment	Grit Removal
Wastewater Treatment	Secondary Blowers and Diffusers
Wastewater Treatment	Secondary upgrade
Wastewater Treatment	Faciltiies Upgrades
Wastewater Treatment	Gravity Thickener Upgrades Ph II
Wastewater Treatment	Thermal Hydrolysis and Digester Expansion
Wastewater Treatment	Ammonia recovery
Wastewater Treatment	Centrate Treatment Facilities
Wastewater Treatment	Secondary Treatment Upgrades for TN
Wastewater Treatment	Secondary Treatment Upgrades for TN
CSO	Long Term Rehab-Main & O Pump Sta
CSO	Combined Sewer Rehabilitation
CSO	Potomac LTCP Projects
CSO	Rock Creek CSS LTCP Project
CSO	Long Term Rehab-Main & O Pump Sta
CSO	Combined Sewer Rehabilitation
CSO	Combined Sewer SLRP - Recurring Program
CSO	Combined Sewer PS Refurb - Recurring Program
Stormwater	Storm Sewer SLRP:P1 Recurring Program
Stormwater	Stormwater Pumping Station
Sanitary Sewer	Rehabilitation of Influent Sewers
Sanitary Sewer	Rehabilitation of Anacostia Force Main
Sanitary Sewer	Sanitary Sewer Rehabilitation
Sanitary Sewer	Potomac Interceptor Projects - Rehab Phase 2

Appendix - F
Technical Memorandum No. 2 – Approach to Hydrologic and Hydraulic Modeling

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

TECHNICAL MEMORANDUM NO.2: APPROACH TO HYDROLOGIC AND HYDRAULIC MODELING

July 19, 2013

Prepared for:

dc water is life

Prepared by:

dc clean RIVERS PROJECT
RESTORING OUR RIVERS
PROTECTING OUR DISTRICT

Program Consultants Organization
Blue Plains Advanced Wastewater Treatment Plant
5000 Overlook Avenue, SW
Washington, DC 20032

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Reviewed By:	Ray Hyland DC Clean Rivers

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Executive Summary

Purpose

The purpose of this report is to document the approach to hydrologic and hydraulic modeling that will be applied to support the assessment of green infrastructure practices as a viable approach to the management of combined sewage discharges. This report gives an overview of DC Water's combined sewer modeling background, compares and analyzes several models for their ability to model green infrastructure practices and large collection systems, and suggests models and a modeling approach to be used for future work.

Background

DC Water has used the MIKE URBAN Model and its predecessor (the MOUSE Model) for all of its hydrologic and hydraulic analysis dating back to 1998. The MOUSE Model incorporating both hydrologic and hydraulic modeling capabilities was selected by DC Water in 1998 to support development of the LTCP (DC Water, 2001). MOUSE was chosen at the time because it had the capability to directly simulate Real Time Control (RTC) operations, a feature that was not then available in the widely-used Storm Water Management Model (SWMM).

Model Selection and Modeling Approach

Based on screening and evaluation detailed in the report, SWMM5 is recommended for selection as the hydrologic model to support DC Water's assessment of green infrastructure practices. SWMM5 was selected because it explicitly models the performance of several green infrastructure practices, referred to as LID Controls in SWMM5, in addition to its wide acceptance as a reliable, robust hydrologic model. MIKE URBAN is recommended for selection as the hydraulic model. DC Water has made significant investment and has had successful application of MIKE URBAN in a variety of projects, and there is no real need to move to a different model for the simulation of flow through the pipe system. MIKE URBAN can accept time series output files from SWMM5 to interface between the two models.

The report contains specific methodology for simulating green infrastructure practices using SWMM5 and the other models that were considered. SWMM5 will be applied to simulate runoff across all of the District to include the CSS and the MS4 areas. The runoff generated in SWMM5 with and without green infrastructure will be used as input to the MIKE URBAN hydraulic model.

To transition to using SWMM5 for hydrology simulations, model parameters will be transferred from MIKE URBAN when available, or developed based on site-specific data. Following this process, the SWMM5 outputs will be compared to MIKE URBAN outputs for equivalent baseline simulations to confirm the SWMM5 baseline model is equivalent to the current MIKE URBAN model. To accurately model green infrastructure practices, data for the DC RiverSmart study, metered sewer flow data, and rainfall data will be used.

1 Introduction

1.1 General

The District of Columbia Water and Sewer Authority (DC Water) provides wastewater collection and treatment for the District of Columbia and wastewater treatment for nearby suburban sections of Maryland and Virginia at its Blue Plains Advanced Wastewater Treatment Plant (Blue Plains). Part of the wastewater collection system is a combined sewer system (CSS) that conveys domestic, commercial and industrial wastewater and storm water runoff through a single pipe to Blue Plains. As part of the DC Clean Rivers Project, DC Water intends to implement green infrastructure projects and to assess the use of green infrastructure as a means of reducing stormwater runoff delivered to the CSS in the District of Columbia (District). The current long-term control plan (LTCP) for the CSS is comprised of pumping station rehabilitations, targeted sewer separation and a system of underground storage/conveyance tunnels to capture and store combined sewage and convey it to Blue Plains for treatment. The Anacostia Tunnel system is under construction, while facility planning of the Potomac and Rock Creek tunnels is scheduled to begin in 2015 and 2016, respectively. Using the green infrastructure projects, DC Water expects to reduce runoff from impervious surfaces (rooftops, alleys, parking lots, etc.) in the CSS. Reductions in runoff volume may lessen the need for tunnels and reduce storage and treatment requirements.

1.2 Purpose

The purpose of this report is to document the approach to hydrologic and hydraulic modeling that will be applied to support the assessment of green infrastructure practices as a viable approach to the management of combined sewage discharges.

1.3 Technical Approach

The technical approach will include the following activities:

- Determination of modeling needs
- Identification of available models
- Screening of available models
- Evaluation of a preferred subset of the available models
- Model selection
- Summarization of the approach to modeling

This evaluation will be carried out independently for hydrologic models and hydraulic models.

1.4 System Description

The Potomac and Rock Creek portions of the CSS are shown in Figure 1-1. The key characteristics of the individual permitted combined sewer overflows (CSOs) are presented in Table 1-1.

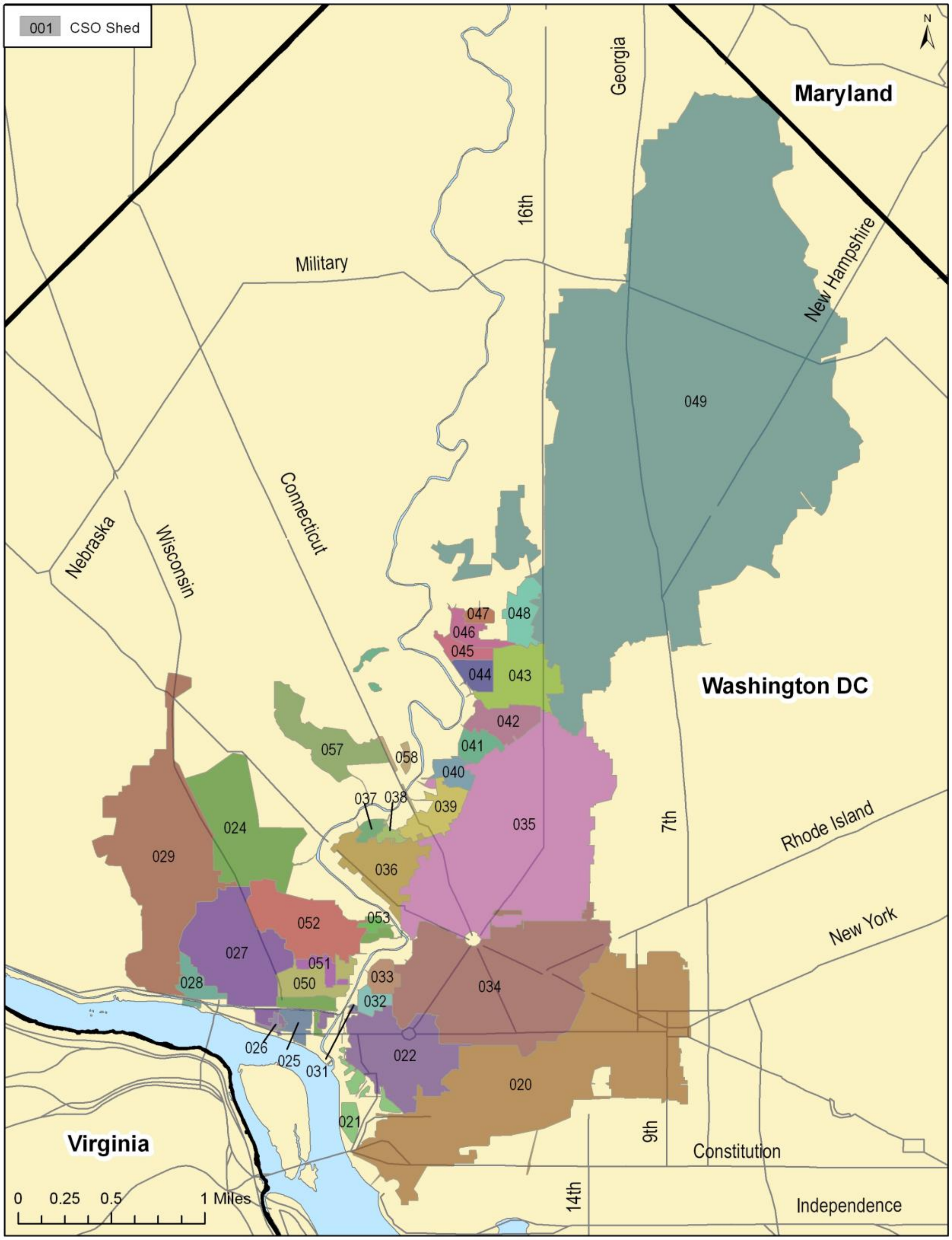

Figure 1-1. Potomac and Rock Creek Portions of CSS

Table 1-1. Key Characteristics of Permitted Potomac and Rock Creek CSOs

CSO#	Sewershed Name	Area (acres)	Impervious Area (acres)
Potomac River			
020	Easby Point	600.02	448.75
021	Slash Run	23.93	19.47
022	I St. – 22nd St., NW	200.39	162.78
023+024	West Rock Creek Diversion Sewer	174.43	61.47
025	31st & K St., NW	14.51	14.51
026	Water St. District (WRC)	2.99	2.70
027	Georgetown	163.44	104.07
028	37th St. – Georgetown	21.02	12.70
029	College Pond	329.65	165.93
Rock Creek			
031	Penn Ave. – Mid. E. Rock Creek	0.82	0.67
032	26th – M St. – Mid. E. Rock Creek	12.51	9.54
033	N St. – 25th St. – Mid. E. Rock Creek	16.44	12.30
034	Slash Run Trunk Sewer	392.62	342.51
035	Northwest Boundary	551.52	399.70
036	Mass Ave & 24th – E. Rock Creek	71.73	43.17
037	Kalorama Circle W. – E. Rock Creek	7.99	3.84
038	Kalorama Circle E. – E. Rock Creek	6.15	3.15
039	Belmont Rd. – E. Rock Creek	38.93	25.85
040	Biltmore St. – E. Rock Creek	18.31	13.33
041	Ontario Rd. – Up. E. Rock Creek	24.67	15.01
042	Quarry Rd. – Up. E. Rock Creek	37.53	23.75
043	Irving St. – Up. E. Rock Creek	73.23	48.79

Table 1-1. Key Characteristics of Permitted Potomac and Rock Creek CSOs

CSO#	Sewershed Name	Area (acres)	Impervious Area (acres)
044	Kenyon St. – Up. E. Rock Creek	19.21	11.30
045	Lamont St. – Up. E. Rock Creek	15.91	9.47
046	Park Rd. – Up. E. Rock Creek	20.12	11.02
047	Ingleside Terr. – Up. E. Rock Creek	8.09	4.54
048	Oak St. – Mt. Pleasant – Up. E. Rock Creek	32.75	16.64
049	Piney Branch	2,328.64	1,220.45
050	M St. – 27th St. – W. Rock Creek	37.61	26.42
051	Olive – 29th St. – W. Rock Creek	11.99	7.84
052	O St. – 31st St., NW	104.46	57.60
053	Q St. – W. Rock Creek	5.43	3.53
057	Cleveland – 28th St. & Conn. Ave.	85.85	47.11
058	Connecticut Ave.	7.26	4.98

2 Background on Hydrologic and Hydraulic Modeling

2.1 General

Hydrologic and hydraulic models are computer simulation tools used by planners and engineers to evaluate rainfall and runoff relationships in urban areas. The hydrologic model simulates the major components of the hydrologic cycle; that is, the physical processes of rainfall, evapotranspiration, storage, and runoff. The response of urban neighborhoods to rainfall is determined by the relative degree of imperviousness (e.g., rooftops, parking lots, roads, etc.) and the infiltration capabilities of the soils.

The hydraulic model simulates the movement of runoff and sewer flows through the below-ground network of pipes and other infrastructure that make up the sewer system. Flow through the sewer system is determined by the capacity of pipes, pumps, and other hydraulic control structures, and backwater conditions.

2.2 Model Application

Hydrology and hydraulic models are calibrated based on observed rainfall and flow data. The model parameters (e.g., infiltration rate, slope, roughness coefficient, etc.) are adjusted in calibration to an optimal point where the ability of the model to simulate the volume and timing of runoff events is maximized. Independent validation of models is done by gauging the ability of the model to simulate a separate group of rainfall/runoff events without adjustment of the model parameters. Model calibration and validation provide confidence in the ability of the models to “predict” the response of the system under a variety of conditions. This is particularly true when the calibration and validation data sets include a wide variety of rainfall and flow conditions.

Following calibration, hydrologic and hydraulic models are applied in a planning mode to evaluate the ability of various management scenarios to reduce runoff and contain as much flow in the sewer system as possible. This includes the evaluation of green infrastructure (e.g., green roofs, downspout redirection, rain gardens, etc.) in the hydrologic model and gray infrastructure (e.g., pumps, tunnels, etc.) in the hydraulic model. Management “scenarios” that define a certain set of control conditions ranging from no control to full control are the central focus of planning and analysis. The model output metrics used to evaluate differences among the scenarios modeled include runoff reduction, storage volume, pumped volume, CSO frequency and volume, and total flow delivered to wastewater treatment facilities.

2.3 Recent Use of Hydrologic and Hydraulic Models in the District

2.3.1 General

DC Water has used the MIKE URBAN Model and its predecessor (the MOUSE Model) for all of its hydrologic and hydraulic analysis dating back to 1998. Both models are products of DHI, formerly the Danish Hydraulic Institute (www.dhigroup.com).The models were applied to support a wide range of projects and studies including:

- Original LTCP for the CSS
- Emergency Operations Planning
- Inter Municipal Agreement (IMA) Negotiations
- Multi-Jurisdictional Use Facilities Planning & Cost Allocation
- Anacostia Facilities Plan
- Updated LTCP/Total Nitrogen-Wet Weather Plan
- Federal Triangle and other Flood Studies
- Quarterly NPDES Reporting of CSO Estimates

The MOUSE Model incorporating both hydrologic and hydraulic modeling capabilities was selected by DC Water in 1998 to support development of the LTCP (DC Water, 2001). MOUSE was chosen at the time because it had the capability to directly simulate Real Time Control (RTC) operations, a feature that was not then available in the widely-used Storm Water Management Model (SWMM).

The major sources of data used in development of the initial MOUSE application included:

- District of Columbia land use and zoning maps
- Counter maps of the sewer system
- As-built drawings
- Structure book
- Other drawings and reports
- Pump station logs
- Blue Plains long-term flow record
- SCADA data for District of Columbia boundary flows
- District of Columbia Soil Survey
- Topographic maps
- NOAA Tide data and information

During model development, sewersheds for both the CSS and the municipal separate storm sewer system (MS4) in the District were delineated based on sewer maps and topography. Hydrology parameters in the hydrologic model (e.g., pervious vs. impervious, infiltration, etc.) were based on available soil, land use, and zoning maps. Hydraulic controls (e.g., regulators, pump stations, outfalls, inflatable dams, etc.) were based on drawings, pump curves, operations documents, and other studies.

Model calibration and validation was based on rainfall and flow records in the CSS collected during 1999-2000. This included 24 rainfall events for model calibration and another 20 rainfall events for model validation. Several rain gages in the District and observed rainfall at DC National Airport were used to drive the hydrologic model. The hydrologic model was calibrated ahead of the hydraulic model. Overall, the emphasis of calibration and validation was placed on developing a mass balance of flow at Blue Plains, and a reasonable representation of the frequency and volume of CSO discharges. The calibration and validation results from this model are presented in Tables 2-1 and 2-2.

Table 2-1. Observed and Simulated Flow Volumes at Different Locations for the Calibration Events

Location	Monitored Flow Volume (MG)	Modeled Flow Volume (MG)	Difference (%)
Pump Stations			
Potomac Pump Station	3,709.34	3,654.58	-1.50
Main Pump Station (Sanitary)	1,829.16	1,832.95	0.20
Raw WW Pump Stations 1 & 2	9,194.90	9,156.87	-0.41
Overflows			
Main & "O" Area (Storm Pumps and Tiber Creek)	178.39	203.20	13.90
Northeast Boundary Area (Swirl and Swirl By-pass)	398.32	446.73	12.20
Slash Run (Outfall 021)	150.41	167.07	11.10
Easby Point (Outfall 020)	22.58	26.72	18.30
Piney Branch (CSO 049)	7.72	5.39	-30.1
Ft Stanton (Outfall 007)	11.57	16.07	38.9

Table 2-2. Observed and Simulated Flow Volumes at Different Locations for the Validation Events

Location	Monitored Flow Volume (MG)	Modeled Flow Volume (MG)	Difference (%)
Pump Stations			
Potomac Pump Station	3,195.29	3,288.58	2.9
Main Pump Station (Sanitary)	1,764.85	1,802.30	2.1
Raw WW Pump Stations 1 & 2	8,247.94	8,312.04	0.78
Overflows			
Main & "O" Area (Storm Pumps and Tiber Creek)	145.66	154.99	6.4
Northeast Boundary Area (Swirl and Swirl By-pass)	374.24	418.19	11.7

Table 2-2. Observed and Simulated Flow Volumes at Different Locations for the Validation Events

Location	Monitored Flow Volume (MG)	Modeled Flow Volume (MG)	Difference (%)
Slash Run (Outfall 021)	80.01	85.78	7.2
Easby Point (Outfall 020)	18.60	14.20	-23.6
Piney Branch (CSO 049)	4.83	3.60	-25.5
Ft Stanton (Outfall 007)	8.48	10.38	22.4

2.3.2 Improvements During 2003-2004

DC Water began using the MIKE URBAN Model in 2003. The switch to MIKE URBAN was based on several factors that were thought to improve the model applications. MIKE URBAN is essentially an upgrade to MOUSE. It was able to be applied in a continuous simulation mode, a very important consideration where long multiple year simulations are required. MIKE URBAN also included GIS-based software. This made it easier to use GIS coverages for impervious surfaces (e.g., roads, sidewalks, parking lots, etc.) and soils more spatially and directly. In addition, DC Water had its sewer maps (i.e., the counter maps) digitized and developed as a geodatabase that could be directly linked to MIKE URBAN. An example of the DC sewer counter map and the sewer database developed from the counter map is presented in Figure 2-1.

The result of this update was a much improved representation of surface conditions across the CSS in the hydrologic model. In addition, the pipe network in the hydraulic model was based on better information on pipe slopes, diameters, roughness, and other relevant characteristics.

2.3.3 MIKE URBAN Recalibration 2005-2006

MIKE URBAN was recalibrated during the period 2005-2006 based on metered flow data for the collection system and Blue Plains. This flow data was supplemented with point rainfall data at National Airport and other District of Columbia stations, with radar rainfall estimates on a square kilometer basis available for some key rainfall events. The results of this recalibration for several metered flow sites in the Northeast Boundary section of the CSS are presented in Table 2-3. The calibration results compare metered flow volume with modeled flow volume for many rainfall events.

Figure 2-1. Example of Sewer Counter Map and Sewer Database with DC GIS

Table 2-3. Recalibration: Northeast Boundary (NEB) Sewershed & Overflow Volumes

Meter Name	No. of Events	Total Metered Volume (MG)	Total Modeled Volume (MG)	Difference (%)
NEB2	44	272.12	279.24	2.62%
NEB3T	44	265.63	266.62	0.37%
NEBT1	44	324.31	346.25	6.76%
CSO-019 meters	44	752.98	804.10	6.79%

2.3.4 Green Build-out Model 2007-2009

MIKE URBAN served as the modeling framework for the Green Build-out Model (GBOM) developed and applied during the period 2007 to 2009 (LimnoTech, 2009). The GBOM was the product of collaboration between LimnoTech and Casey Trees. The principal application of the GBOM was to assess the ability of green infrastructure practices to reduce runoff volume. The main modeling need associated with this application was for the model to be able to simulate the relevant hydrologic processes associated with green infrastructure. In addition, the hydrologic model needed to be able to replicate the implementation of green infrastructure practices on a neighborhood or block-to block scale. For the purposes of this project, MIKE URBAN met these requirements.

The use of MIKE URBAN for this project was sanctioned by DC Water. Funding was provided by EPA under a grant to Casey Trees and a direct contract with LimnoTech.

2.3.5 Federal Triangle Flood Study 2009-2010

The District experienced a severe storm over the period June 24 – 26, 2006, which caused extensive flooding within the Federal Triangle area and resulted in millions of dollars in damage. Rainfall data indicated that this June 2006 storm had a return frequency in excess of 200 years. The MIKE URBAN Model was applied in conjunction with MIKE FLOOD, another DHI product, in order to investigate the capacity and performance of the existing CSS under these unusual circumstances. MIKE FLOOD was employed in this project because it is able to simulate ponding and 2-dimensional surface flow on streets. Following model calibration to the observed level of street ponding and estimates of the volume of water in building basements, the models were used to evaluate the utility of control alternatives to lessen or eliminate flooding. The findings of this project are documented in a report to FEMA and the National Capital Planning Commission (DC Water, 2010).

3 Hydrologic Models

3.1 Hydrologic Modeling Needs

The principal application of the hydrologic model will be to assess the ability of green infrastructure practices to reduce runoff volume. The main modeling need associated with this application is for the model to be able to simulate the relevant hydrologic processes associated with green infrastructure. That is, the parameterization of the model must be sufficient for adequate definition of the infiltration, storage, and evapotranspiration processes that define the use of green infrastructure. The hydrologic model also needs to be able to replicate the implementation of green infrastructure practices on a neighborhood or block-to block scale. In addition, the hydrologic model must produce runoff time series output on a time step that is compatible with the hydraulic model of the sewer system. Finally, the hydrologic model needs to be defensible based on prior use and recognition, calibration and validation, peer review, or a combination of these supporting factors.

3.2 Available Hydrologic Models

A survey and review of available models identified eight candidate software programs for further evaluation. These are:

MIKE URBAN is a program for the simulation of urban hydrology and hydraulics supported by DHI Software of Denmark (DHI, 2011). MIKE URBAN uses the ArcGIS user interface to display and manipulate the model geodatabase. MIKE URBAN's MOUSE hydrologic model engine is similar to SWMM runoff.

EPA SWMM5 is the most recent version of the EPA supported Storm Water Management Model (SWMM) program (EPA, 2011a). Its primary use is the simulation of runoff quality and quantity in urban areas.

HSPF is an EPA supported program for simulation of watershed hydrology and water quality, with HSPF standing for Hydrologic Simulation Program Fortran (EPA, 2011b).

WWHM3/4 is a program developed by Clear Creek Solutions, Inc. that is a blend of HSPF hydrology with SWMM hydraulics (Clear Creek Solutions, 2011). It models specific stormwater BMPs and green infrastructure practices and uses a proprietary graphical user interface (GUI).

HEC-HMS is a US Army Corps of Engineers supported hydrologic modeling system designed to simulate rainfall-runoff processes for storm events in watersheds including urban watersheds (US Army Corps of Engineers, 2010).

GSSHA is a US Army Corps of Engineers supported grid-based surface and subsurface hydrologic analysis model used for the evaluation of urban and non-urban watersheds.

WinSLAMM (the Source Loading and Management Model for Windows) is a modeling package developed by PV & Associates for the evaluation of hydrology and pollutant loadings in urban areas (PV & Associates, 2011). It was developed to evaluate nonpoint source pollutant loadings in urban areas using small storm hydrology and simulates treatment through a variety of stormwater control practices.

SUSTAIN (System for Urban Stormwater Treatment and Analysis INtegration Model) is an EPA supported framework for optimizing the placement and sizing of best management practices in urban watersheds to protect water quality.

3.3 Screening of Available Hydrologic Models

The available hydrologic models were screened to identify a subset of the most promising models for the evaluation of green infrastructure practices. The key factors considered in the screening process included:

- General Model Characteristics
- Compatibility with Hydraulic Models
- Ability to Simulate Green Infrastructure

Each of these key factors consisted of a number of sub-factors or criteria. Information for the criteria was organized in an array that contains the specific qualities and characteristics of each hydrologic model. This information was largely based on experience, review of software documentation, and references. Table 3-1 summarizes the array of information on each hydrologic model, and shows that the differences among the hydrologic models can be quite substantial.

Using information in the array, the hydrologic models were further evaluated with a short list of important considerations. Specifically,

- Is the model a recognized planning tool?
- Has the model been successfully applied in a similar project to evaluate green infrastructure?
- Can the model be used in a continuous simulation mode and produce time series output for multiple year periods?

Table 3-1. Model Comparison Matrix

Metric	Mike Urban/MOUSE	SWMM5	SUSTAIN	WinSLAMM	WWHM3/4	HSPF	HEC-HMS	GSSHA
General Model Characteristics								
Parameterization	Instantaneous and storage-based impervious, 3 categories of pervious runoff, Horton Infiltration for currently-used 'Model B' (kinematic wave). Options for other runoff modeling approaches include Time-Area, Linear Reservoir, and Unit Hydrograph. Lumped-parameter, continuous simulation model. Also option to use SWMM5 hydrology internally.	Non-linear reservoir model using kinematic wave runoff. Impervious and pervious runoff surfaces independent of land uses. Separate LID controls can be applied to each runoff surface and routed to another surface or the collection system. Lumped-parameter, continuous simulation model.	Hydrology generally based on SWMM5 runoff algorithms.	Runoff using basic runoff coefficient based on land use characteristics. Lumped for each land use type and contributing area.	HSPF hydrology, detailed land use and soils specifications.	Flexible, lumped-parameter, continuous simulation model. Uses soil moisture accounting for multiple groundwater layers and kinetic wave runoff.	Lumped or semi-distributed parameter model. In addition to unit hydrograph, hydrologic and reservoir routing options, continuous simulation with either a one-layer or more complex five-layer soil moisture method	Physically based, distributed-parameter, two-dimensional structured grid, hydrologic model.
GUI	Integrated w/ArcGIS 10 (many ArcGIS features disabled within Mike Urban, but full Arc Editor license included).	Basic standalone GUI available to interface with text input files. More feature-rich, third-party GUIs are available for purchase.	Integrated in ArcGIS 9.3. Requires spatial analyst license.	Form-based GUI.	Custom GUI and GIS (Not ESRI-based).	WinHSPF included as a possible GUI. Typically interact through text input files.	Custom GUI. GIS integration possible with Geospatial Hydrologic Modeling Extension (HEC-GeoHMS)	Watershed Modeling System (WMS), proprietary interface
Pre- and post- processing	Limited pre- and post-processing available.	Limited pre- and post-processing available.	No. Post-processing if used for specific defined purpose.	Limited pre- and post-processing available. Results viewer.	Limited pre-processing, built-in post-processing (duration, frequency, hydrographs, WQ).	Not well developed. Some availability in WinHSPF.	Limited pre- and post-processing	WMS serves as proprietary pre- and post-processing tool
Intended use	Large or small-scale collection system modeling, feeds into MOUSE hydraulics. No explicit green infrastructure components or parameters.	Intended for use over a wide range of urban hydrology situations, including green infrastructure. Flexible model that includes runoff, water quality, and fully dynamic hydraulic simulations. Models continuous or event simulation periods.	Designed to be used in optimizing stormwater control placement, sizing, and number within a roughly represented watershed. Intended to be used with internal routing developed from SWMM5 kinematic wave functions, but runoff could be manually exported to link to other models.	Stochastic model used to predict stormwater flows and pollutant characteristics using a variety of control practices based on stormwater control field data and runoff variability.	Watershed-based BMP planning, siting, testing.	Designed for large-scale watershed runoff applications, especially for modeling water quality. Very flexible, but highly data-intensive input parameters needed.	Large or small scale hydrologic modeling, and flood determinations.	Large or small scale hydrologic modeling, groundwater-surface water interactions, sediment transport. Ability to simulate small scale green infrastructure limited by grid-cell sizing (typically 10-250 m) and computational effort.

Table 3-1. Model Comparison Matrix

Metric	Mike Urban/MOUSE	SWMM5	SUSTAIN	WinSLAMM	WWHM3/4	HSPF	HEC-HMS	GSSHA
Intended scale	Large watershed to small catch-basin level.	Large watershed to small catch-basin level.	Small watershed, several BMPs. Could be used with more BMPs, but data management support not developed for it.	Used primarily for small sites to specifically calculate runoff and runoff quality.	Watershed-based, multiple BMP options (including 9 LID-specific BMPs).	Intended for use in watershed-scale systems, but very flexible.	Large watershed to small catch-basin level.	Large watershed to small catch-basin level.
Data requirements	Medium. Catchment parameters include opportunity to specify 3 different pervious land types. ET input as timeseries or constant rate.	Medium-High. Stormwater controls and structures must be physically sized and specified. Parameters are entered as separate LID controls. Subcatchment parameters included impervious percentage and other physically based parameters (roughness, depression storage, etc.)	Medium-High. Stormwater controls and structures must be physically sized and specified. Runoff coefficients are identical to SWMM5.	Low. Uses easy to answer questions and basic watershed data to produce curve numbers, runoff coefficients, and stormwater control parameters	High. Specify individual BMP parameters, soil types, land uses.	High. Surface runoff characteristics are highly parameterized with seasonal and land-use depended coefficients. Soil moisture accounting requires high parameterization.	Medium. Multiple choices for type of model used for runoff and infiltration with varying degrees of data requirements.	High. Global and/or distributed parameters, including land use, soils, and vegetation.
Ease of use and support availability	Larger community in Europe, growing but still small community in North America. DHI Support (w/current licenses) usually responsive.	Large community in US has support through EPA and discussion boards.	Very small established user community. Some support through EPA contractor developer, but no developed user support group.	Established community with support and training available. Intended to be a user friendly alternative to more complex models.	Technical support available from supplier.	Lack of well-developed GUI, complex text-based input files, and lack of detailed error messages make this model challenging to use by somebody without experience. Large body of research and user community available.	Well established user community. Good documentation.	Limited user community, primarily USACE. Model documentation updated on Wiki page.
Code availability	Proprietary.	Available and free.	Under development. Code available.	Proprietary.	Model engines' (HSPF, SWMM for hydraulics) code available, GUI/GIS code is proprietary.	Available and free.	Available and free.	Code available. GUI is proprietary.
Maturity	Mature code, maturing user base, some bugs but fewer with every release.	Mature code actively being developed.	Mainly used by EPA. Beginning to be used by public. Frequent bugs.	Mature model in development since mid-1970's. Continuing to be developed.	HSPF very mature. WWHM3/4 framework relatively new (<10 years?). Published use in Philadelphia and Seattle.	HSPF is a well-developed mature model that has long-term widespread use in many watershed modeling applications.	Mature code and user base.	Relatively new model, used primarily by USACE.

Table 3-1. Model Comparison Matrix

Metric	Mike Urban/MOUSE	SWMM5	SUSTAIN	WinSLAMM	WWHM3/4	HSPF	HEC-HMS	GSSHA
Cost	~$12K for single license (hydrology & hydraulics), plus ~$3K per year in SMA costs	Free. More feature-rich proprietary versions are available (including incorporation in MIKE URBAN)	Free.	$300 for new licenses. $150 for renewal licenses.	$2,500 for 3 seats.	Free.	Free.	Model free, WMS is $5,600.
Regulatory acceptance	Accepted by EPA.	Distributed and accepted by EPA.	Distributed and accepted by EPA.	Unknown	Claims to meet "NPDES MS4 requirements," uses established model engines.	Accepted by EPA.	Accepted by EPA	Unknown
Compatibility with Hydraulic Models								
Ability to interact with other models	Limited. With post-processing, can export timeseries. Can display results in GIS.	Able to export complete time series data to other models and accept time series input from other models, with (usually) minor format adjustment.	Output text files created for any model node for several parameters.	Natively reports results on event basis, so not inherently compatible with collection system models. Connection to SWMM is in development.	Limited (other than built-in HSPF hydrology, SWMM hydraulics).	Many options for model output through text files or .wdm files.	Yes, tabular output files	Limited. Significant post-processing required.
Ability to model collection system hydraulics	Dynamic wave collection system model. BMPs not explicitly modeled or specified.	SWMM is designed for use as a dynamic wave collection system model in addition to modeling runoff.	Contains kinematic wave routing and version of SWMM runoff algorithms.	Collection system modeling is not included in WinSLAMM.	Collection system modeling based on SWMM, including dynamic wave routing	Pipes/collection systems specified using volume/flow relationship. Not suitable for urban collection system models where surcharging, backwater, or branching occur.	Kinematic wave methodology only. Not suitable for collection system.	Kinematic wave methodology only. Not suitable for collection system.
Ability to Simulate Green Infrastructure								
Losses within controls	Not explicitly modeled, must area-weight controls and assign to appropriate pervious/impervious category for link to storage, infiltration parameters.	Storage, infiltration, ET, underdrains (within LID controls)	Deep infiltration, underdrain treatment, ET losses.	Varying outlet, infiltration, and ET options available for control devices.	Storage, infiltration, ET, underdrains, basin-to-basin controls.	Controls are either modeled as river segments, in which case only ET losses are possible, or as special pervious or impervious surfaces with all parameters specified as any other runoff catchment.	Not explicitly modeled. Storage, infiltration, ET possible through surface processes.	Storage, infiltration, ET

Table 3-1. Model Comparison Matrix

Metric	Mike Urban/MOUSE	SWMM5	SUSTAIN	WinSLAMM	WWHM3/4	HSPF	HEC-HMS	GSSHA
Water quality(WQ)	Has WQ modeling capability. Could require additional licensing costs.	Can model water quality with transformation equations for treatment and first order decay.	Yes. First-order decay, percent reduction, or K-C method.	Yes. Pollutant reductions calculated based on statistical distribution of empirical data.	No (modeling of flow through water quality facilities, but no apparent explicit WQ modeling) – HSPF WQ modeling capabilities not mentioned in available documentation.	Yes. Detailed water quality modeling for many constituents including nitrogen cycle and nutrient modeling, bacteria die-off, etc.	No.	Yes.
Routing flexibility	Can only route from surface runoff to an outlet, not to another surface	Yes. Can route surface runoff to another surface, and LID control, or to an outlet	Yes. Routing between surfaces, land uses, and stormwater practices.	Routes from runoff surface to green infrastructure control	Can route roof runoff to lawns, basin flow, emptying controls.	Yes. Can route surface runoff to another surface or to an outlet.	Can only route from surface runoff to an outlet, not to another surface	Yes, cell to cell routing.
Routing to/from pervious surfaces within single catchment	Can quantify routing from pervious, but not explicit. Cannot route to pervious surfaces explicitly.	Yes, in LID controls	Yes. Also to/from land uses	No.	Yes.	Yes. Very flexible routing.	No.	Yes, cell to cell routing.
Flexibility to incorporate controls into runoff methodology	Limited (area-weighting only)	Yes	Yes	Limited	Yes	Limited to specific depth/release curve for storage, or complete soil moisture accounting.	Yes	Limited, grid sizing required to simulate small scale controls is computationally intense

Based upon screening summarized in Table 3-1, two models were identified as being promising for additional evaluation. These are MIKE URBAN and SWMM5. In brief,

MIKE URBAN has several advantages. It is the current planning tool used by DC Water and, along with the MIKE URBAN Hydraulic Model, it is applied to support other LTCP analyses and NPDES reporting. In addition, the Green Build-out Model is a MIKE URBAN application that has already been applied to assess the potential for green infrastructure to reduce runoff on a city-wide basis.

SWMM5 is the current version of the most widely applied urban stormwater model across the world. Recent extensions of SWMM5 include specific green infrastructure applications. EPA's long-term support to the development and application of SWMM5 and earlier SWMM models underscores its acceptance in applications to support regulatory programs.

The other hydrologic models were viewed as unfit or not necessarily adequate or appropriate for the analysis of green infrastructure. In brief,

SUSTAIN is a decision support system specifically designed to facilitate selection and placement of green infrastructure practices. It has attractive optimization features and facility sizing features that are not available in other models. SUSTAIN is also supported by EPA, but it is a relatively new model compared to SWMM5, and the record of successful applications is not as strong. Furthermore, some recent experience revealed problems with regard to frequent bugs, weak pre- and post-processing, and other shortcomings.

HSPF is widely applied to evaluate runoff, stream flow, and water quality at the watershed scale. However, the overall complexity of HSPF, particularly the soil moisture accounting algorithms, is neither advantageous nor required for urban stormwater applications where impervious cover is generally more important than pervious cover. In addition, the model input requirements are not well suited for the assessment of green infrastructure in dense urban neighborhoods.

WWHM3/4 is applied to model runoff and the performance of urban best management practices in urban storm water systems. It blends HSPF hydrologic modeling with SWMM hydraulic modeling within the context of a database management system. Like HSPF, it has some unneeded complexity for modeling urban soils. Another drawback is that the GUI is not ESRI-based.

HEC-HMS is a hydrologic model that is widely used in urban settings to address flooding and water quantity issues. While it has very adequate parameterization, it is not often applied to model green infrastructure. Other shortcomings include narrow pre- and post-processing capabilities and some limitations on running multiple year scenarios in a continuous simulation model.

GSSHA is a grid-based hydrologic model that places emphasis on simulation of the interaction between surface water and ground water. GSSHA is used primarily for watershed assessment modeling by the US Army Corps of Engineers. Application of GSSHA to assess green infrastructure in urban areas is not well documented and appears to be limited by grid cell sizing requirements.

WinSLAMM was developed to evaluate nonpoint source pollutant loadings in urban areas using small storm hydrology. It is a stochastic model built upon a great body of field data for stormwater systems. Because it is empirically based and an event rather than a continuous simulation model, it is not appropriate for modeling rainfall response over multiple year periods.

3.4 Evaluation of Promising Models

Additional evaluation of the two hydrologic models identified as "promising" was undertaken to determine which model would be recommended for future applications. This evaluation was for the most part centered on the ability of these hydrologic models to simulate the specific green infrastructure applications intended for the DC Clean Rivers Project. The evaluation is summarized in a side-by-side comparison of MIKE URBAN with SWMM5.

MIKE URBAN and SWMM5 both have powerful hydrologic modeling capabilities and are both well suited for use over a wide range of urban hydrology situations. As shown in Table 3-1, both models have many similarities. A critical point of comparison for each model is the specific runoff methodology and flexibility (or lack thereof) to simulate green infrastructure practices. A brief description of the runoff parameters and computations specific to each model are presented below. A side-by-side comparison of the approaches to simulating green infrastructure practices within each model are presented in Table 3-2.

MIKE URBAN
Surface runoff is computed in MIKE URBAN using the kinematic wave equation, a commonly used method for simulation of urban hydrology. The model engine distinguishes between five different surface types: two categories of impervious area (immediate-response "steep" and depression-storage-enabled "flat") and three categories of pervious area. The Horton's infiltration method is used for the pervious areas. Runoff parameters include:

- Wetting
- Depression storage
- Manning's roughness
- Maximum infiltration rate
- Minimum infiltration rate
- Infiltration rate decay
- Infiltration rate recovery

Catchment-specific physical parameters include: area, slope, overland flow length, and percentages of each land cover type. See Figure 3-1 for examples of the MIKE URBAN hydrology input parameters.

The runoff volume is controlled by the amount of precipitation, the size and characteristics of the sewershed, and various hydrological loss mechanisms or processes (namely evapotranspiration, infiltration, and storage). Calculation of runoff is represented by the following equation:

Runoff = Precipitation – Evapotranspiration – Infiltration – Storage

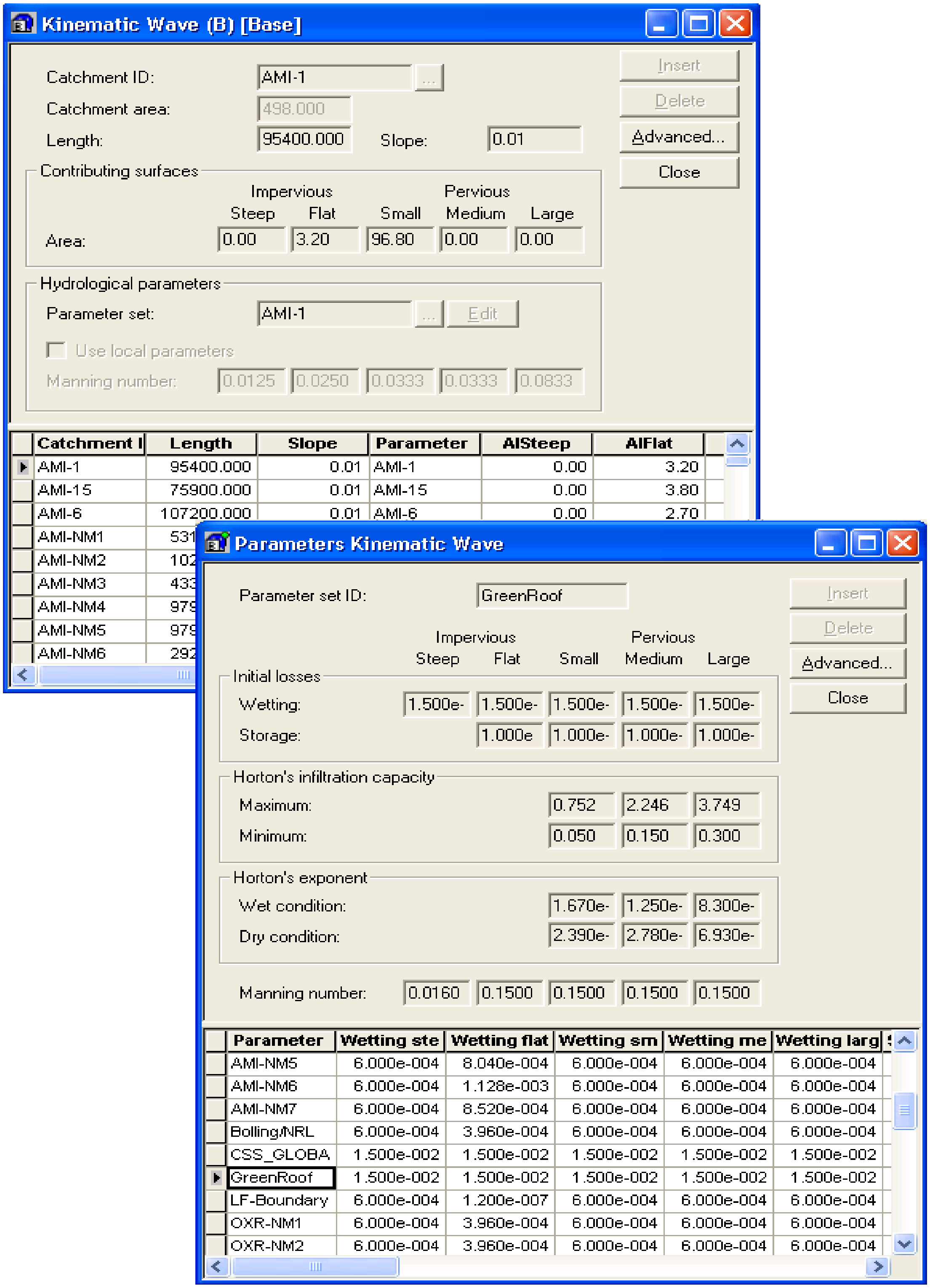

Figure 3-1. Example of MIKE URBAN Hydrology Input Parameters

The modeling of green infrastructure practices in MIKE URBAN is not explicit, and thus imprecise. Within MIKE URBAN, the three primary input parameters that influence the modeled hydrologic response of green infrastructure are infiltration, evapotranspiration, and storage. The user must manipulate these three parameters to integrate green infrastructure practices into the model. This approach is further constrained by the fact that the runoff formulation in MIKE URBAN does not allow runoff to be routed from catchment-to-catchment, or from one land cover type to another (e.g., from impervious area to pervious area). This lack of flexibility forces the user to manipulate the parameterization of land surface types and key hydrological processes in an indirect fashion. See the approach for each major practice type in Table 3-2 below.

SWMM5

In SWMM5, each subcatchment surface is treated as a nonlinear reservoir. Inflow comes from precipitation and the runoff from any designated upstream subcatchments, and the total area is partitioned into pervious and impervious surfaces. Outflows consist of infiltration (on pervious surfaces), evaporation, and surface runoff. The capacity of this reservoir is the maximum depression storage, which is the maximum surface storage provided by ponding, surface wetting, and interception. Surface runoff occurs only when the depth of water in the reservoir exceeds the maximum depression storage, in which case the outflow is given by Manning's equation, adapted to simulate sheet flow.

Infiltration is modeled using either Horton’s method, the Green and Ampt method, or an adaptation of the SCS Curve Number method. Runoff parameters include:

- Subcatchment area
- Subcatchment width
- Slope
- Percent impervious
- Roughness
- Depression storage
- Percent of impervious area not subject to depression storage
- Infiltration parameters (dependent on model selected)
- Pervious/Impervious routing
- LID controls
- Water quality parameters

SWMM5 has incorporated green infrastructure controls, referred to as LID controls in SWMM5, as a method for representing common green infrastructure and LID practices. LID controls are represented by a combination of vertical layers whose properties are defined on a per-unit-area basis. This allows controls of the same design but differing areal coverage to easily be placed within different subcatchments in a study area. During a simulation SWMM5 performs a moisture balance that keeps track of how much water moves between and is stored within each LID layer. As an example, the layers used to model a bioretention cell and the flow pathways between them are shown in Figure 3-2. Examples of the SWMM5 LID control input parameters are shown in Figure 3-3.

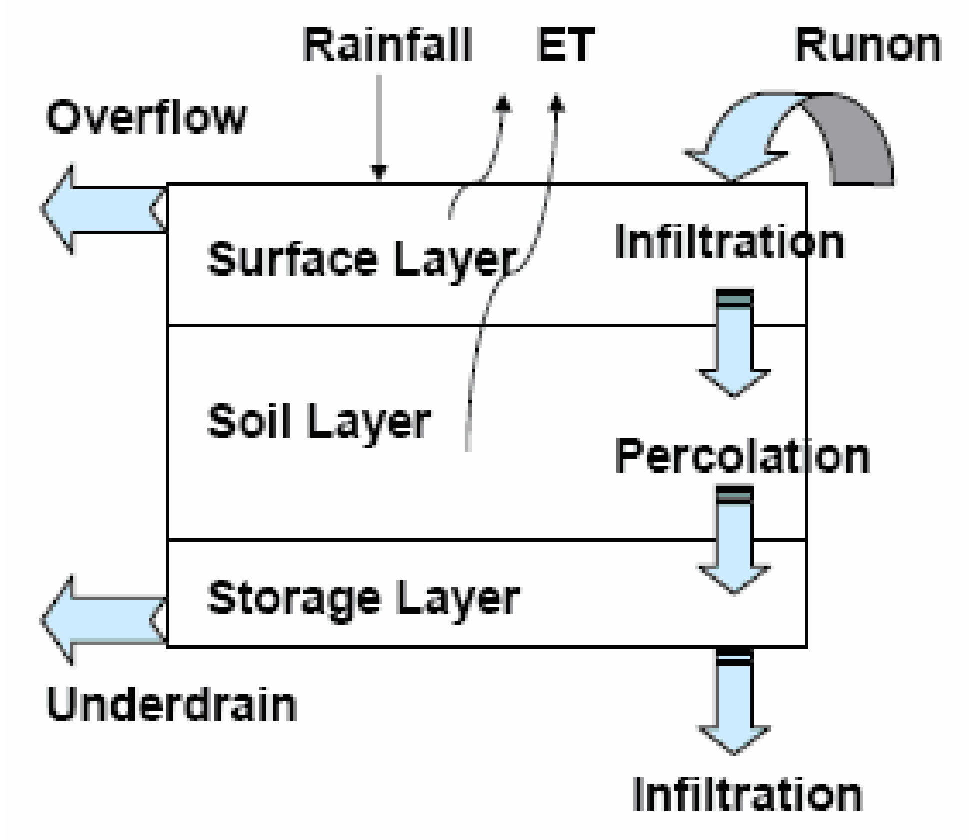

Figure 3-2. Conceptual Model of LID Bioretention Cell in SWMM5

In SWMM5, runoff can be routed from a subcatchment to another subcatchment with or without an LID control, or routed to a collection system node. This allows considerable flexibility in constructing a representation of LID controls (Rossman, 2010).

SWMM5 is supported by EPA and is the most widely applied urban stormwater model in the U.S. SWMM5 is the first iteration of the model to have integrated green infrastructure modeling capabilities. A number of municipalities and utilities are using SWMM5 to support their own green infrastructure evaluations, including: Philadelphia, Cincinnati, Kansas City, and Portland, among others.

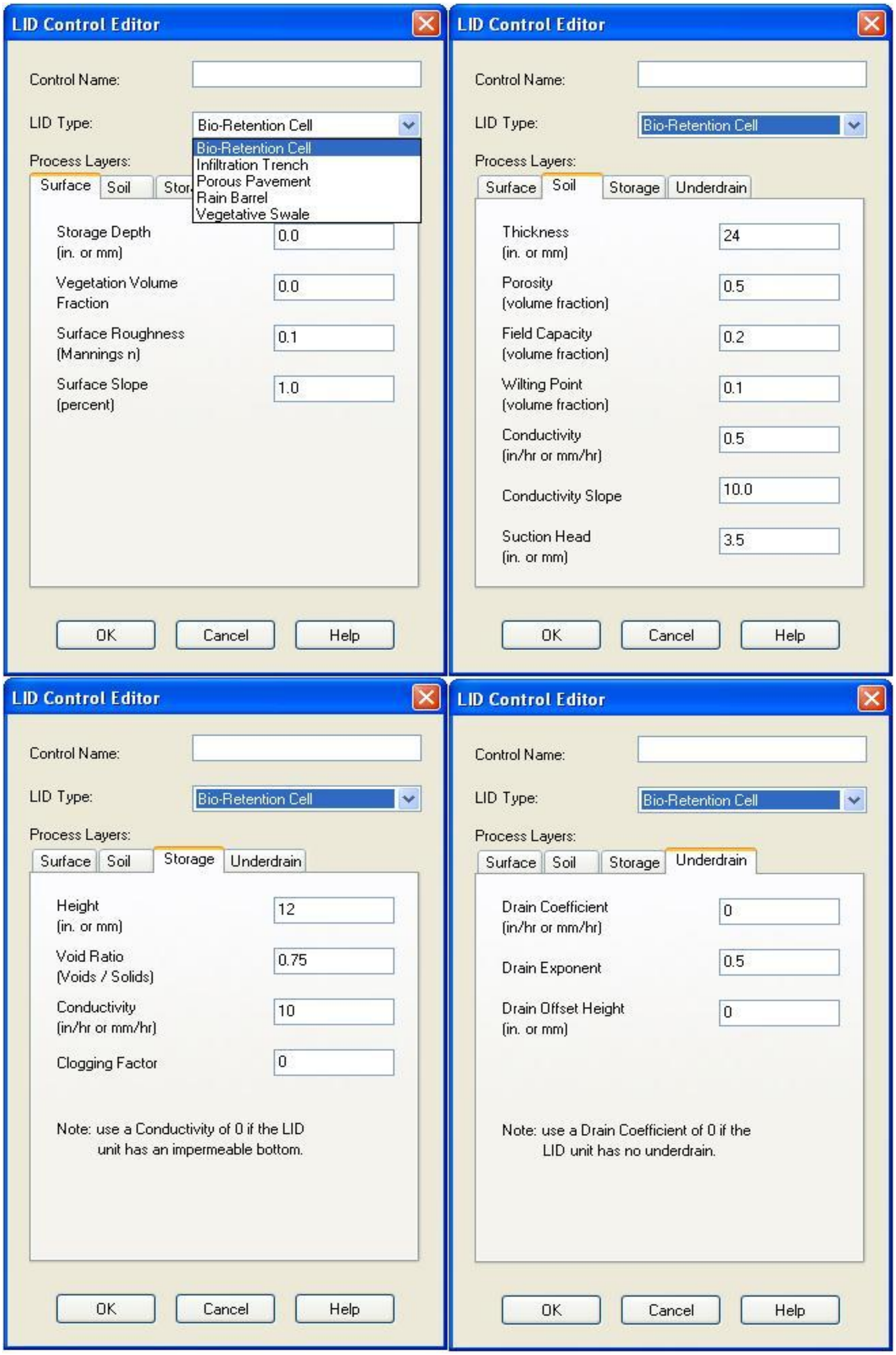

Figure 3-3. Example of SWMM5 LID Control Inputs

Table 3-2. Comparison of Approaches to Simulating Green Infrastructure Practices

Green Infrastructure Applications	Installation Types/ Locations	Hydrologic Processes	Simulation Approach in MIKE URBAN	Simulation Approach in SWMM5
Green Roofs	Intensive roofs, Extensive roofs	Detention storage, Evapo-transpiration	Add impervious depression storage proportional to the green roof(s) depth and footprint. Use evapotranspiration rate to replenish storage.	Add bioretention cell LID control on a separate subcatchment to represent the green roof(s), including soil, storage, and drainage properties. Route the outlet flow to another subcatchment or subcatchments representing the area to which the roof(s) runoff is routed (lawn, driveway, etc.)
Bioretention	Streetside planters, Curb bump-outs, Parking lot islands, Medians, Roof disconnection	Detention storage, Retention storage, Evapo-transpiration, Infiltration	Change drainage area and footprint of the practice(s) from impervious to pervious. Add pervious depression storage. Modify infiltration rate to account for practice design performance.	Add bioretention cell LID control to the subcatchment representing the area to be controlled by the practice(s). Include parameters to represent the control including soil, storage, and drainage properties.
Permeable Pavement	Sidewalks, Parking lots, Alleys, Road parking lanes, Residential impervious	Detention storage, Retention storage, Evapo-transpiration, Infiltration	Add impervious depression storage proportional to the depth and footprint of the practice(s) (or drainage area for handling run-on from adjacent area.) Use evapo-transpiration rate to replenish storage.	Add porous pavement LID control to the subcatchment representing the area to be controlled by the practice(s) (or its own subcatchment if it is only controlling direct runoff). Include parameters to represent the control including soil, storage, and drainage properties.
Storage/ Harvesting	Surface cisterns, Subsurface cisterns, Rain barrels	Storage, reuse	Add impervious depression storage equivalent to the volume of the practice(s) spread over the drainage area. Use evapotranspiration rate to replenish storage.	Add rain barrel LID control to the subcatchment representing the area to be controlled by the practice(s). Include sizing parameters for the storage unit. Number and surface area of the units is set in the subcatchment dialog box.

3.5 Model Selection

Based on screening and further evaluation presented above, SWMM5 is recommended for selection as the hydrologic model to support DC Water's assessment of green infrastructure practices. The key advantage of SWMM5 over MIKE URBAN is that it explicitly models the performance of several green infrastructure practices, referred to as LID Controls in SWMM (see Figure 3-3), and that it has the ability to route runoff from catchment-to-catchment. As shown in Section 3.4, these LID controls can be used to replicate all of the green infrastructure practices that will be used in the DC Clean Rivers Project.

The selection of SWMM5 is supported by an evolving trend in modeling wherein individual models are being redesigned to be compatible with other models. One example of this is that the use of SWMM5 is already possible in broader applications in the MIKE URBAN environment. A second example is that SWMM5 is linked with SUSTAIN in a manner that bodes well for future applications. SWMM5 is provided as open source code allowing for more customization of the model compared to MIKE URBAN's proprietary code. The SWMM5 engine is available at no cost from EPA.

The selection of SWMM5 over MIKE URBAN for hydrologic modeling represents an important upgrade in DC Water's ability to simulate green infrastructure practices. The earlier work with MIKE URBAN relied on the adjustment of input parameters to imitate green infrastructure in a manner that was beyond the original intent of the model formulation. The runoff algorithms used in SWMM5 are similar to the algorithms used in MIKE URBAN with kinetic wave routing, Horton infiltration, and evapotranspiration modeled similarly. Both models are established as robust runoff models, but MIKE URBAN has not developed the ability to explicitly model green infrastructure practices at this time. With SWMM5, on the other hand, the green infrastructure practices can be represented and modeled in a framework specifically designed for this purpose. Characteristics and parameters of these practices can be input directly into the model, rather than being averaged across entire subcatchments where their benefits may not be fully represented.

4 Hydraulic Models

4.1 Hydraulic Modeling Needs

The principal application of the hydraulic model in the DC Clean Rivers Project is to convey runoff and sanitary sewage through the sewer system. This includes the routing of flow through pipes, diversion structures, siphons, pump stations, force mains, and other hydraulic controls. The accounting of flows that arrive at individual CSO outfalls, tunnels, and Blue Plains will serve as the basis for the assessment of the ability of green infrastructure to reduce runoff and the need for storage capacity in tunnels. Features that are important to selection of the hydraulic model include:

- Continuous simulation over several years
- Compatibility with SWMM5, the selected hydrologic model
- Ability to simulate the real time control of hydraulic features (e.g., inflatable dams)
- Recognition as a sewer system planning tool

4.2 Available Hydraulic Models

There are three hydraulic models that are widely used in the US for sewer system planning that stems from LTCP development and implementation for large, complex sewer systems. They are MIKE URBAN, SWMM, and InfoWorks.

4.3 Model Selection

As described earlier in Section 2.3.1, DC Water has made a substantial investment in the MIKE URBAN modeling package over the past ten years. This includes the MIKE URBAN hydraulic model. The MIKE URBAN hydraulic model is currently established to include:

- CSO area (1/3 of the District)
- Separate sanitary area (2/3 of District) with inflow/infiltration
- Sixty (60) CSO outfalls
- Nine (9) pump stations
- Various force mains and siphons
- Nine (9) major points of suburban flow
- Approximately 1,100 nodes with additional detail in Northeast Boundary Area due to flooding
- Potomac Interceptor Sewer extending from the District to Dulles Airport

The sewer network in the District included in MIKE URBAN is presented in Figure 4-1.

Given this investment, and the successful application of MIKE URBAN in a variety of projects, there is no real need to move to a different model for the simulation of flow through the pipe system. The MIKE URBAN hydraulic model has the features that are needed to complete the DC Clean Rivers Project in a manner that will be consistent with previous projects. Additional justification for remaining with the MIKE URBAN hydraulic model includes the following:

- The MIKE URBAN hydraulic model is established, calibrated, and fully functional.
- The MIKE URBAN hydraulic model can accept time series output files from SWMM5 that represent surface runoff and the presence or absence of green infrastructure.
- No additional investment in hydraulic modeling is needed.

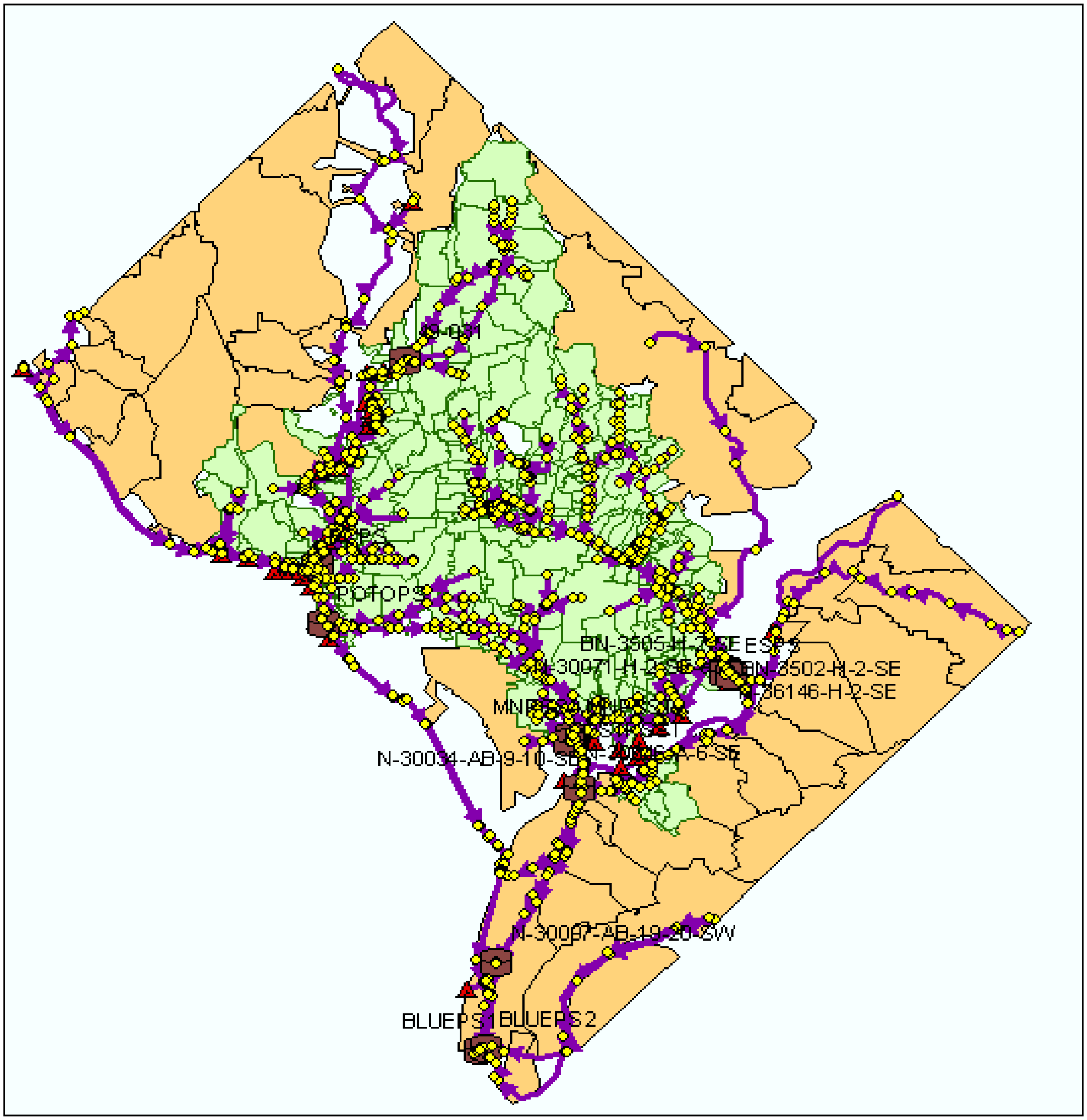

Figure 4-1. MIKE URBAN Hydraulic Model

5 Summary of Approach for Hydrologic and Hydraulic Modeling of Green Infrastructure

5.1 General Approach

The general approach to modeling for the DC Clean Rivers Project is to use SWMM5 for hydrologic modeling and to remain with MIKE URBAN for hydraulic modeling. As previously described, the switch to SWMM5 for hydrologic modeling is based on the fact that LID and green infrastructure practices can be explicitly modeled in SWMM5. This explicit modeling is facilitated by the native LID controls in SWMM5 and the ability to route runoff from catchment-to-catchment.

SWMM5 will be applied to simulate runoff across all of the District to include the CSS and the MS4 areas. The runoff generated in SWMM5 with and without green infrastructure will be used as input to the MIKE URBAN hydraulic model. Observed and estimated sewer flow from the suburbs will also be input to the MIKE URBAN hydraulic model at the District boundary. The results of MIKE URBAN hydraulic model simulations, particularly the multi-year accounting of flows at CSOs and Blue Plains, will be used to assess the effectiveness of green infrastructure to reduce the frequency, volume, and duration of CSOs.

5.2 Model Transition and Calibration

One of the first steps towards utilizing SWMM5 as the hydrologic model for green infrastructure evaluation will be to transition the existing MIKE URBAN hydrologic model data to the SWMM5 platform. This process will entail some combination of automated transfer and manual manipulation of model parameters and inputs. Following this process, the SWMM5 outputs will be compared to MIKE URBAN outputs for equivalent baseline simulations. This effort will help confirm that the SWMM5 baseline model produces identical results as the baseline MIKE URBAN model currently being used by DC Water.

To simulate green infrastructure scenarios, the green infrastructure applications in the SWMM5 hydrologic model will be calibrated and validated in several ways. The first component will be to use the rainfall and metered sewer flow records for the DC RiverSmart demonstration studies (LimnoTech, 2011). Rainfall and sewer flow records are available for three sewersheds:

- McFarland Site (13.9 acres)
- Lafayette Site (13 acres)
- New Hampshire Avenue Control Site (10.4 acres)

Post-construction monitoring data for these sites is expected to be available in 2013.

The second component will be calibration and validation using rainfall and metered sewer flow data collected as part of the green infrastructure projects implemented as part of this project. This work would probably not begin until 2016 or 2017, when the first facilities would come on-line.

The third component will be to use metered flow records collected at specific current or future green infrastructure practice installations in the District to support the calibration of individual practices at the site level. This work would commence when these records become available.

It is expected that the data available from these demonstration sites will be sufficient for calibration of SWMM5. Additional recalibration and validation of the MIKE URBAN hydraulic model will be based on the SWMM5 hydrologic model results supplemented with metered sewer flow data at key places within the sewer collection system. It is expected that data collected for other special studies will be central to this effort (e.g., post construction compliance monitoring).

5.3 Data Needs

The data needs for implementing hydrologic and hydraulic modeling for the evaluation of green infrastructure are substantial. Data needs are outlined in this sub-section by type of data.

5.3.1 Metered Flow Data

The metered sewer flow data that is needed to support model calibration and validation for green infrastructure evaluations are summarized as follows:

- Green Infrastructure Sites: Inline flow meters should be placed at key locations to quantify sewer flow and runoff at the downstream outlet of the demonstration sewershed, at upstream locations where flow enters the sewershed (where applicable), and at key locations in the sewershed where additional metering is advantageous (e.g., major sub-sewersheds, above bottlenecks, etc.).
- Green Infrastructure Practice Types: Outflow flow meters should be placed to monitor runoff from individual practices (e.g., green roofs, permeable pavement, etc.). This data will support the definition of model parameters that described individual practices, and calibration of practices at the site level.

Metered flow data in five-minute intervals will be satisfactory, with the understanding that briefer time intervals (e.g. one minute) may be needed in some instances.

5.3.2 Rainfall Data

The rainfall data that is needed to support model calibration and validation for green infrastructure evaluations are summarized as follows:

- Green Infrastructure Sites: At least one recording rain gauge should be installed at each demonstration site.
- Radar-Rainfall Data: Radar-rainfall estimates should be obtained for key storms to support city-wide applications of the hydrologic model and as a cross reference for the other recording rain gauges.

Rainfall data in five-minute intervals will be satisfactory. Rain gauges at the green infrastructure installation sites should be in place at the same time that flow meters are in place.

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Appendix - G
Technical Memorandum No. 4 – The District of Columbia's Experience with Green Infrastructure

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

TECHNICAL MEMORANDUM NO. 4: THE DISTRICT OF COLUMBIA'S EXPERIENCE WITH GREEN INFRASTRUCTURE

December 2, 2013

Prepared for:

Prepared by:

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1 Defined Terms and Acronyms

ASLA	American Society of Landscape Architects
BLUE PLAINS	Blue Plains Advanced Waste Water Treatment Plant
CBF	Chesapeake Bay Foundation
CBOD5	Carbonaceous biochemical oxygen demand
CSO	Combined Sewer Overflow. Discharge event of combined sewage into a receiving water body that occurs when the combined sewage flow exceeds the carrying capacity of the Combined Sewer System. CSO is the portion of the combined sewage flow that, during certain wet weather events, is not conveyed to the Blue Plains Advanced Wastewater Treatment Plant (Blue Plains) for treatment
CSS	Combined Sewer System. A network of Combined Sewers and other ancillary physical facilities that collect, convey, channel, hold, inhibit or divert flow that originates from both sanitary wastewater (dry weather flow) and storm runoff (wet weather flow) sources
DC Water	District of Columbia Water and Sewer Authority
DDOE	District Department of the Environment
DDOT	District of Columbia Department of Transportation
DRES	Department of Real Estate Services
EPA	United States Environmental Protection Agency
Green Infrastructure	Natural and engineered systems that mimic natural systems to treat polluted runoff and manage stormwater for combined sewer overflow (CSO) control. Green infrastructure practices promote stormwater filtration, infiltration and evapotranspiration, ultimately reducing the stress on traditional drainage infrastructure. Examples include: permeable pavements, rain gardens, green roofs and constructed wetlands. Also referred to as low impact development (LID)
LID	Low Impact Development. See green infrastructure
LID Center	The Low Impact Development Center
LTCP	Long Term Control Plan
MS4	Municipal Separate Storm Sewer System
NIF	Neighborhood Investment Fund
TMDL	Total Maximum Daily Load

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2 Introduction

2.1 Purpose

The District of Columbia Water and Sewer Authority (DC Water) is implementing a Long Term Control Plan (LTCP or DC Clean Rivers Project, DCCR) to control combined sewer overflows (CSOs) to the District's waterways. The DCCR comprises a variety of projects including pumping station rehabilitations, targeted sewer separation, low impact development at DC Water facilities and a system of underground storage/conveyance tunnels to controls CSOs. The DCCR is being implemented in accordance with a Consent Decree signed by DC Water, the District and the U.S Government that specifies the schedule for implementation. Projects on the Anacostia River are first in the schedule and DC Water is implementing those projects in accordance with the Decree.

The tunnel projects for the Potomac River and Rock Creek are later in the schedule and facility planning for those projects is scheduled to start in 2015 and 2016, respectively. For the tunnel projects in the Potomac and Rock Creek, there is an opportunity to implement Green Infrastructure for CSO control. GI projects may allow downsizing or elimination of the tunnels, or may be coupled with a different type of grey infrastructure to provide control of CSOs. In addition, GI may offer other societal and economic benefits to the District.

Whereas conventional stormwater systems strive to move stormwater away from a property as quickly as possible, green infrastructure systems strive to keep stormwater out of the sewer system and handling it where it falls. Green infrastructure mimics natural hydrological systems to absorb or capture stormwater that would otherwise become runoff and either allow it to infiltrate into the ground, be evapotranspirated back into the air, or be contained for reuse in either a grey water system or as landscape irrigation. When combined with conventional stormwater management approaches, the use of green infrastructure can cut down on the costs of CSO controls (Gunderson et al, 2011).

There is precedence for considering whether green infrastructure's use could play a more significant role within the city's combined sewer overflow program. Within the two-thirds of the District that is serviced by a (relatively) newer, separate sewer system, the federal government recently issued a new permit that, for the first time, requires the use of green infrastructure techniques to treat stormwater pollution (EPA, 2011d). The purpose of this technical memo is to examine existing policies, planning documents, programs, and studies to evaluate the District's experience with green infrastructure. In addition, this technical memo serves to identify any existing opportunities or gaps there may be for planning, implementing, and monitoring large-scale green infrastructure implementation within the portion of the city served by a combined sewer system. While most of this technical memo focuses on the District as a whole, the review of existing neighborhood plans is limited to CSO subsheds within the Potomac and Rock Creek sewersheds where DC Water is considering green infrastructure implementation.

2.2 Background

DC Water has taken great strides over the years to improve water quality and make the District's waterfronts and waterways a place to enjoy. Since 1996, DC Water has reduced its combined sewer overflows by an estimated 40%. This has been accomplished by improving its pumping stations, placing 12 inflatable Combined Sewer Overflow (CSO) storage dams into 8 existing sewers, installing tide gates, separating portions of the combined sewer system, and installing a monitoring and control system for key system components at a cost of $140 million (DC Water, 2009 & 2010a). Traditional approaches to reduce CSOs further include an existing $2.6 billion CSO Long-Term Control Plan (LTCP) for the construction of additional, large underground structures.

While DC Water's improvements have primarily been restricted to traditional stormwater controls, some green infrastructure controls have also been incorporated. In 2003, DC Water provided the Chesapeake Bay Foundation with roughly $300,000 to administer a green roof grant program which resulted in more than 121,000 square feet of green roofs that provide estimated annual stormwater retention of 1.8 million gallons (Chesapeake Bay Foundation, 2008). In 2006, DC Water retrofit its Bryant Street and Eastside Pumping Stations with porous pavers, tree filters (at Bryant Street), vegetative swales (at Eastside), and additional pavement elimination (at Eastside) to divert stormwater from the combined sewer system and promote groundwater infiltration. Green infrastructure projects at other DC Water facilities are currently under design. (DC Water, 2010b).

DC Water has also worked cooperatively with other District departments to increase tree coverage and install green infrastructure pilots within the city. For example, DC Water has provided $1.3 million to the District Department of Transportation (DDOT) to plant trees in the combined sewer area and has embarked upon a $2.41 million joint project with DDOT, the District's Department of the Environment (DDOE), Friends of Rock Creek's Environment, and LimnoTech to construct green infrastructure pilots at Roosevelt High School in the District's Piney Branch Watershed (DC Water, 2010b). DC Water is currently exploring the inclusion of green infrastructure techniques—such as rain gardens, green streets, and green roofs—within its Long Term Control Plan as an alternative to reduce the size of future tunnels necessary to limit CSO discharge frequencies in the District's Potomac and Rock Creek drainage areas.

In comparison to traditional approaches, which include the construction of additional large and costly underground structures, green infrastructure is often less costly and provides additional environmental, social, and economic benefits to the District's residents, such as reduced urban heat island effect, reduced energy usage, increased property values, and an improved quality of life. These benefits are often immediate, as opposed to the 15-20 years it might take to build additional underground structures (NYC Environmental Protection and Plan NYC, 2010).

The use of green infrastructure techniques within the District of Columbia is not new. DDOE and DDOT and their various partners, in addition to DC Water, have successfully implemented numerous green infrastructure projects across the District. This technical memorandum serves to identify, document and, where possible, analyze the performance of green infrastructure projects and pilots or research efforts within the District of Columbia. It also serves to examine how the implementation of additional green infrastructure projects can help the District meet various regulatory and policy goals. Improvements to the District's waterways do not just represent the hard work of DC Water, but the work of the District's Department of the Environment, the Department of Transportation, and the Office of Planning, as well as Federally-led projects to reduce stormwater runoff at various locations within the District.

2.3 Combined and Separate Sewer Systems

DC Water was established in 1996 and operates about 1,800 miles of sanitary and combined sewers. About two thirds of the District is serviced by "separate" sanitary and storm sewers, while the other third is serviced by a "combined" sewer system which dates back to the late-19th century. In the separate system, there are two independent pipes – one which carries sewage from homes and businesses to the Blue Plains Advanced Wastewater Treatment Plant (Blue Plains), where it is treated before being discharged to the Potomac River, and another which conveys stormwater directly to surface waters.

Within a combined sewer system, stormwater and sanitary sewage are conveyed through the same pipe. During normal dry conditions, this waste is diverted to Blue Plains for treatment. During moderate to heavy rain events or after a heavy snow melt, however, the system will become overwhelmed by the volume of combined sewage, and excess flow is discharged to the nearest surface water via a CSO outfall (DC Water, no date, b). Such CSOs adversely affect the quality of the District's rivers and tributaries by contributing to elevated levels of bacteria (as evaluated based on the amount of fecal coliform present) and low levels of dissolved oxygen (as evaluated by measuring the Carbonaceous biochemical oxygen demand) that harm fish and other aquatic life. Presently, there are 53 CSO outfalls listed in the National Pollutant Discharge Elimination System (NPDES) Permit issued by the US Environmental Protection Agency (EPA) to DC Water.

As part of the NPDES permit issues by EPA, DC Water was required to develop and implement a CSO LTCP, now known as the Clean Rivers Project, for controlling CSO discharges to area waterways. After several years of planning and public input, a final LTCP was submitted to EPA and the District Department of Health (DDOH) in August 2002 and was approved in December 2004 (DC Water, 2002) (DC Water, no date, a). The resulting Consent Decree was issued in March 2005 (DC Water, 2005). Since that time, DC Water has implemented its initial part of the plan, resulting in an estimated 40% reduction in CSOs—from 3.254 billion gallons down to 2.490 billion gallons of combined sewer overflow being released into the Anacostia, Potomac, and Rock Creek Rivers each year. Now in the second phase of its plan, DC Water will build a series of underground tunnels to capture large amounts of stormwater during wet weather events and direct it to Blue Plains, where it can be treated before being released. Starting in the Anacostia, the tunnel project is expected to take 13 more years to complete, with benefits being realized in the Anacostia drainage area by 2018. Upon completion, the Clean Rivers Project is expected to reduce CSOs by 96% (DC Water, 2002). DC Water is currently exploring the potential for the use of green infrastructure practices in the Potomac and Rock Creek drainage areas to either eliminate or reduce the size of the tunnel in these watersheds.

2.4 Receiving Waters

The CSO receiving waters include the Anacostia, Potomac, and Rock Creek Rivers and their tributaries. The unique characteristics of the receiving waters are summarized below.

2.4.1 Anacostia

The Anacostia River is a shallow, slow-moving waterbody that is influenced by the tide. During low flow, the residence time of water can be as long as 110 days. The average tidal range, or the vertical distance between high tide and low tide, is 3 feet. The Anacostia watershed comprises about 176 square miles, with 17% of the drainage within the District, and the remainder within Prince George's (49%) and Montgomery (34%) Counties, MD (DC Water, 2002). Low levels of dissolved oxygen, high levels of bacteria pollution from the CSO, sediment, nutrients, trash, and debris are all problems associated with the Anacostia, as are oil, grease and toxins (DC Appleseed, 2011). Low dissolved oxygen levels are a result of the naturally low saturation due to a high water temperature, the influx of oxygen-consuming pollutants from CSO discharges during/after storm events, the sluggishness of the water, upstream sources, and sedimentation. When organic matter is consumed by biological activity, dissolved oxygen levels are depleted. During the summer months, it is not uncommon for dissolved oxygen levels to fall below 2 mg/L, which can lead to fish kills. In total, CSOs account for approximately 14% of the Anacostia River's biochemical oxygen demand (CBOD5) load, and stormwater from the District's separate storm sewer system accounts for another 24%. Sources not attributable to the District include sources from upstream (61%) and other sources (1%), such as stormwater from parklands that run directly into the river (DC Water, 2002).

High levels of fecal coliform and other bacteria are also a problem within the Anacostia and are the primary reason that the Anacostia is considered unsafe for swimming. For the majority of an average year, bacteria concentrations are predicted to exceed Class A monthly standards. The sources of bacterial contaminants are CSO discharges (61%), discharges from the District's separate stormwater system (13%), upstream influences (25%), and other sources (1%) (DC Water, 2002).

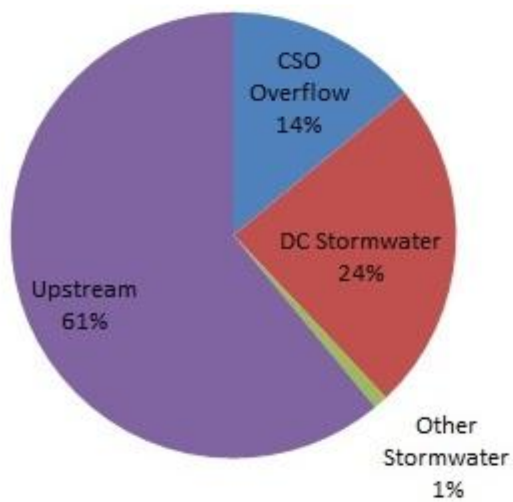

Figure 2-1. Sources of CBOD5 to the Anacostia River
Source: DC Water Combined Sewer System and Long Term Control Plan: Final Report (2002).

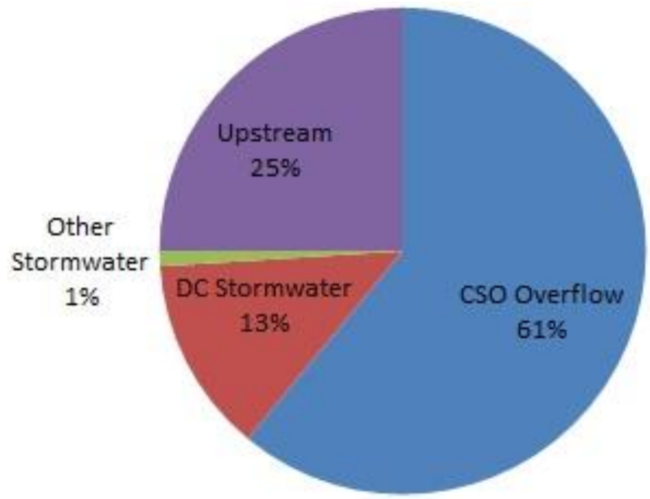

Figure 2-2. Sources of Fecal Coliform to the Anacostia River
Source: DC Water Combined Sewer System and Long Term Control Plan: Final Report (2002).

2.4.2 Rock Creek

Rock Creek is a free-flowing river that is naturally aerated as it flows over the irregular bottom of the creek bed, and as such, does not suffer from the low dissolved oxygen problems that afflict the Anacostia. The Rock Creek watershed is 76.5 square miles in size, with 20% of the drainage in the District, and the remaining 80% in Montgomery County, MD. Like most urban rivers, Rock Creek is affected by high levels of bacteria (fecal coliform) concentrations. The volume of water within Rock Creek is relatively small, making it difficult for the river to absorb significant levels of pollutants, and bacteria levels are predicted to exceed Class A monthly standards throughout the year. Sources of bacterial loads include CSO deposits (42%), stormwater from the District's separate sewer system (33%), upstream sources (22%), and other sources, such as stormwater that runs directly into the river from parklands on either side of Rock Creek (3%) (DC Water, 2002).

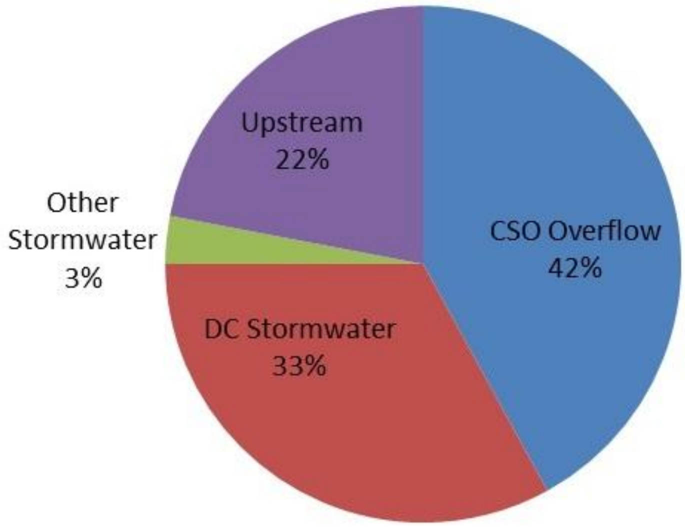

Figure 2-3. Sources of Fecal Coliform to Rock Creek
Source: DC Water Combined Sewer System and Long Term Control Plan: Final Report (2002).

2.4.3 Potomac

The Potomac River is the largest of the three rivers and has substantial flow rate. As it passes through the District, the Potomac is tidal, with an average vertical tidal range of about three feet. The Potomac River is a little over 383 miles in length, and its watershed is 14,670 square miles in size. Only 1.1% of the drainage area falls within the District, with the remainder of the drainage area in Virginia, West Virginia, Maryland, and Pennsylvania. The Potomac River's average flow in the District is about 7 billion gallons per day. Water quality within the Potomac fares better than either the Anacostia or Rock Creek—partly due to lower pollutant loads, and partly due to the river's large size, which helps to dilute the flow of pollutants. While the Potomac does suffer from low dissolved oxygen levels, it has not been deemed a significant problem. The source of low dissolved oxygen (87%) is largely upstream, with a small portion (10%) emanating from surrounding wastewater treatment plants (which includes loads from Arlington, Alexandria, and Blue Plains Wastewater Treatment Plants) and stormwater from Alexandria and Arlington and Virginia streams such as Four Mile Run and Spout Run (2%). Only 1% of the load comes from the District's separate sewer system, and 0% of the load is attributed to the CSOs. Class A bacteria in the upper reaches of the river from the Memorial Bridge to Georgetown is only predicted to be exceeded one month out of the year, and no Class A bacteria exceedances are predicted for portions of the Potomac that are downstream of the Memorial Bridge. Sources of fecal coliform to the Potomac include CSO deposits (35%), stormwater from the District's separate sewer system (4%), stormwater from Alexandria and Arlington and Virginia streams (9%), loads from surrounding wastewater treatment plants (11%), and upstream sources (41%).

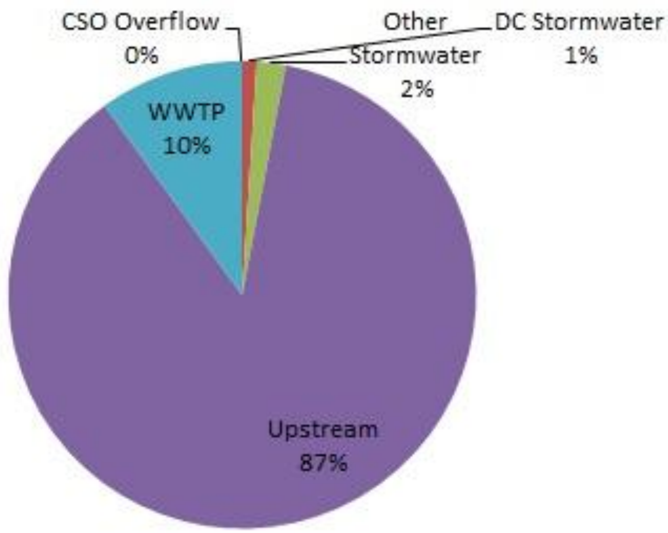

Figure 2-4. Sources of CBOD5 to the Potomac River

Source: DC Water Combined Sewer System and Long Term Control Plan: Final Report (2002).

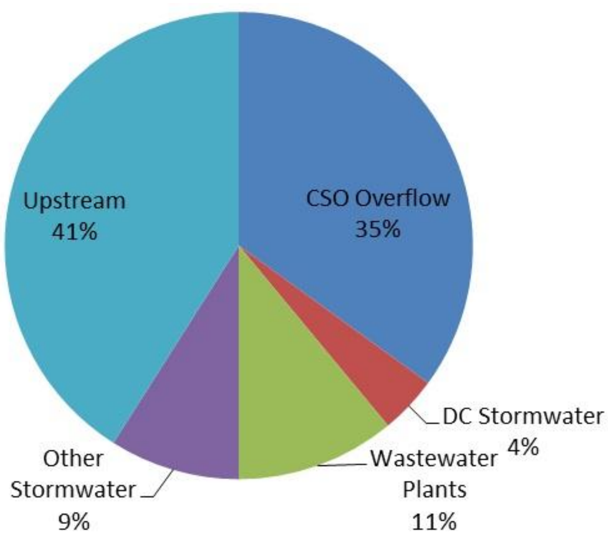

Figure 2-5. Sources of Fecal Coliform to the Potomac River

Source: DC Water Combined Sewer System and Long Term Control Plan: Final Report (2002).

2.5 Rainfall Conditions

To determine the effectiveness of various CSO control solutions, DC Water's Clean Rivers Project evaluated average rainfall conditions for the years 1988, 1989, and 1990. These years were selected as representative of average conditions based on rainfall data at Ronald Reagan National Airport, and include a relatively wet year (1989), a dry year (1988), and an average year (1990). CSO overflow volumes and frequencies were then predicted and the benefits to receiving waters evaluated using a combined sewer systems model. Control plans using rainfall conditions for 1-year, 2-year, and 5-year design storms were also prepared and evaluated. Each alternative was configured and evaluated to reduce CSO overflows to between zero and 12 events per average year. Complete sewer separation that would achieve zero CSO overflows for any year, regardless of rainfall conditions, was also evaluated.

Average rainfall conditions in the District between 1988 and 1990, as provided in the final report of the CSO LTCP are shown in Table 2-1.

Table 2-1. Average Annual Rainfall Conditions.

Statistic	1988	1989	1990	Average of 1988-1990	Long Term Average
Annual rainfall (inches)	31.74	50.32	40.84	40.97	38.95
No. events > 0.05 inches	61	79	74	71	74
Avg. storm duration (hours)	9.6	11.2	9.6	10.1	9.9
Avg. maximum intensity (in/hr)	0.15	0.18	0.15	0.16	0.15
Maximum intensity (in/hr)	1.32	1.31	1.25	1.29	1.30
Percentile (based on total annual rainfall)	14th	90th	68th	68th	

Source: DC Water Combined Sewer System and Long Term Control Plan: Final Report (2002).

2.6 Current State of Implementation

The limitations of the District's combined sewer system to treat large volumes of stormwater and wastewater became apparent as early as the 1950s in the rapid population expansion during and after World War II. Between the 1950s and 1990s, numerous studies of the city's combined sewer system were conducted, and several attempts were made to increase the system's conveyance capacity and/or provide relief to the existing system. Prior to DC Water's 2002 Combined Sewer System and Long Term Control Plan that was approved in 2004, the most successful of these efforts was a two phase program initiated in the 1980s that focused primarily on overflows to the Anacostia. Under this plan, Phase I consisted of installing 12 "inflatable dams" at 8 CSO locations in the existing CSS to store excess volume and reduce overflows, as well as the installation of a 400 million gallon per day CSO treatment facility known as the Northeast Boundary Swirl Facility that functions only during wet weather periods in order to provide preliminary treatment of CSOs prior to discharge. Phase I was completed in 1991. Phase II, which consisted of two additional swirl facilities, a sewer separation project, and a screening facility for Piney Branch, was not implemented due to funding constraints (DC Water, 2002).

In addition, DC Water received EPA approval to institute a set of nine minimum controls (NMC) in 1996, which were updated in July 1999 in a report titled, "Combined Sewer System Nine Minimum Controls Summary Report." A February 2000 report titled, "NMC Action Plan Report" provided a detailed schedule for implementing recommended enhancements. Activities undertaken as part of the NMC include:

- Installation and operation of the Northeast Boundary Swirl facility
- Use of inflatable dams to maximize storage

- Regular inspections of outfalls, regulators, pump stations and tide gates, and inspection, maintenance, and improvements of regulators and outfalls to prevent or correct dry weather overflows
- Implementation of a pretreatment program for industrial users
- Operation of skimmer boats (Anacostia) and pump station screens (select locations) to control floatables, as well as one demonstration End-of-Pipe Netting system for floatable control
- Development of a notification system and signs at outfalls
- Development of a CSO web page
- Other major maintenance projects

Between 1988 and 2002, DC Water performed extensive monitoring, modeling, alternatives evaluation, and public outreach to develop its Long-Term Control Plan, now known as the Clean Rivers Project.

The major components of the plan include the completion of the nine minimum controls (completed in 2008), making improvements to Blue Plains to better handle wet weather flows, and the investment of $3 million in green infrastructure projects throughout the city and at select DC Water facilities to reduce runoff. For the Anacostia, Rock Creek, and Potomac, the plan includes measures to limit overflows for the average year by incorporating the following measures.

For the Anacostia to limit overflows to 2 events per average year:

- Rehabilitate the Main, ‘O’ Street, and Eastside pumping stations
- Separate, eliminate, and/or consolidate select CSOs to reduce impacts on the River
- Construct a 157 million gallon storage/conveyance tunnel to intercept and store combined sewage until it can be treated and discharged
- Replace the existing Poplar Point Pumping Station with a new facility located at the end of the tunnel that dewaters the tunnel and replaces the function of the existing pumping station
- Abandon the Northeast Boundary Swirl Facility once the tunnel is operational

For the Rock Creek, limit overflows to 4 events per average year:

- Separate four CSOs
- Construct a 9.5 million gallon storage tunnel at Piney Branch
- Conduct monitoring and regulator improvements to four CSOs south of Piney Branch.

For the Potomac, limit overflows to 4 events per average year:

- Construct a 58 million gallon storage tunnel that terminates at the Potomac Pumping Station to intercept the Georgetown CSOs and the large CSOs downstream of Rock Creek.
- Rehabilitate the Potomac Pumping Station
- Construct a new pumping station at Potomac Pump Station to dewater the tunnel
- Consolidate and close all CSOs between the Key Bridge and Rock Creek to reduce the impact on the Georgetown waterfront area

A total of $140 million in "early action projects" were identified to be implemented first. These include the upgrade and replacement of the 12 original inflatable dams; the separation of select sewers in the Anacostia and Rock Creek areas to eliminate several CSO outfalls; the replacement of tide gates that keep river water from entering the system; and the rehabilitation and reconstruction of pumping stations to increase flow capacity, which were substantially completed in 2009 (DC Water, 2004) (DC Water, 2009a). To predict reductions in CSO overflow volumes for the average year, a combined sewer systems model was utilized. Table 2-2 shows the results of this analysis at three points in time: prior to 1991; after the implementation of early action projects in 2009; and at the project's conclusion in 2025.

Table 2-2. Average Annual CSO Overflows Predictions for an Average Year for the Baseline Year (1991) and with Phase I and II Controls Installed

Drainage Area	CSO Events per Year			Avg. CSO Overflow Volume (million gallons/yr)		
Year[1]	1991	2008	2025	1996	2009	2025
Anacostia	82	75	2	2,142	1,485	54
Potomac	74	74	4	1,063	850	79
Rock Creek	30	30	4	49	52	5

Source: Adapted from the DC Water Combined Sewer System and Long Term Control Plan: Final Report (2002).

[1] The 1991 baseline refers to the configuration of the CSS prior to implementation of Phase I CSO controls, which include the addition of 12 inflatable dams and the Northeast Boundary Swirl Facility. In some documents, 1996 is referred to as the base year, as that is the year that DC Water was formed.

While designs for a tunnel to relieve CSO volumes in the Anacostia are well underway, with tunnel mining starting in 2013 and end in 2022, DC Water is exploring the potential for the implementation of green infrastructure practices within the District's Potomac and Rock Creek drainage areas (DC Water, 2009b). If their effectiveness is deemed probable and substantial, DC Water will remodel and reevaluate the need for tunnels in the Rock Creek and Potomac drainage areas, subject to regulatory approval (DC Water, 2010b).

2.7 Challenges / Implications

With a $140 million investment, the early action projects put in place as part of the Clean Rivers Project have resulted in an estimated 40% reduction in CSO volumes to the District's rivers. The main part of the plan – a series of 3 tunnels intended to capture and store combined sewer until it can be treated and discharged at Blue Plains is currently underway. By 2025, the Clean Rivers Project is projected to reduce CSOs by 96% overall at an estimated cost of $2.6 billion. To help recover program expenditures, DC Water's board created an Impervious Area Charge in FY2009, replacing their previous rate structure. The chart below estimates the expected impact on monthly rates through FY2018 per equivalent residential unit (ERU).

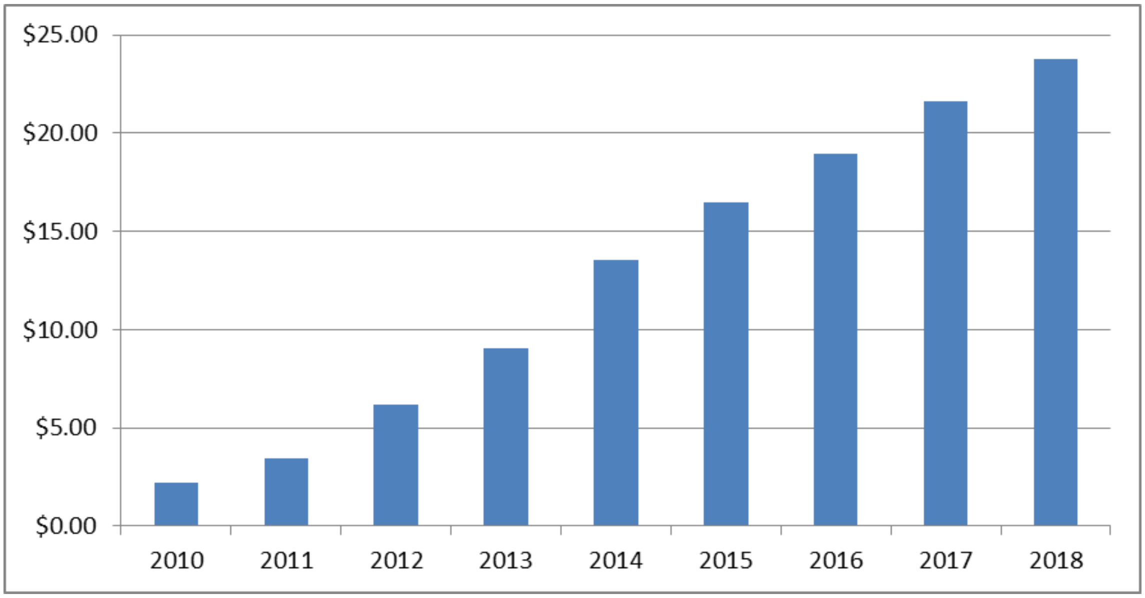

Figure 2-6. Expected Monthly Impervious Area Charge per Equivalent Residential Unit per Fiscal Year
Source: Testimony of George S. Hawkins, Esq., April 30, 2010

Because of the massive volume of combined sewer overflow deposited to the Anacostia River each year, the DC Water Clean Rivers Project has identified the Anacostia as its first priority for its deep tunnel project. DC Water will construct pipelines to capture and divert flow from the 15 CSOs along the Anacostia River into a future Anacostia River Tunnel, and the facilities to divert flow from three of the outfalls (CSO 15, 16 and 17) is ready to start construction (DC Water, 2011a). Scheduled for completion by 2018 at a cost of $1.7 billion, the Anacostia River Tunnel will reduce combined sewer overflows by 98% in the Anacostia River as compared to 1996 levels.

Underground storage tunnels are a vital means to controlling the peak flow and velocity of stormwater runoff while also allowing the treatment of combined sewer before it is discharged back into the river. The importance of such projects—particularly in the Anacostia, which receives an estimated 1.5 billion gallons of CSO per average year—should not be understated. However, more and more cities such as Philadelphia, Kansas City, and Seattle have successfully incorporated green infrastructure programs in their CSO Long-Term Control Plans as a cost-effective means of capturing and treating stormwater on-site. Green infrastructure in these communities has been embraced not only as a means to reduce the volume of stormwater runoff going into the combined system, but as a means to control peak flow, erosion, and localized flooding events, as well as the filtering of pollutants, and provide other quality of life benefits. In portions of the District serviced by separate sewer systems, new performance standards are expected to be issued this year requiring the first 1.2 inches of stormwater to be retained on-site for all new large development, re-development, and retrofit projects—including portions of the Anacostia, Potomac, and Rock Creek drainage areas.

The incorporation of better on-site requirements throughout the District for treating stormwater also address an additional concern of the existing Clean Rivers Project: that water quality is affected by many sources other than CSOs—which include stormwater from portions of DC not in the combined sewer system, stormwater from nearby parks and surrounding communities, other upstream influences, and, in the Anacostia River, by sediments in the river's bottom. While, as part of DC

Water's Clean Rivers Project, it is only required to address CSOs, DC Water has recognized for some time the need for a more watershed-based approach to improving water quality. The following chapters serve to identify and document existing green infrastructure projects, pilots, and policies in the District to provide baseline information to DC Water as it moves forward in its effort to evaluate the value and cost-effectiveness of a larger-scale green infrastructure implementation to meeting the goals of its long term CSO program.

3 Existing Modeling and Monitoring Studies and Demonstration Projects

Water and sewer districts such as DC Water are required to ensure that CSO reduction or elimination techniques provide a clear level of control to meet overarching health and environmental objectives (EPA, 1994). One of the greatest challenges to the integration of green infrastructure practices has been a lack of widespread performance data to bolster understanding of green infrastructure's effectiveness in controlling combined sewer overflows (The Civic Federation, 2007).

On a national scale, several readily available sources exist that provide a growing amount of information on volume and pollutant removal performance for green infrastructure practices. These include the International Stormwater BMP Database and the Center for Water Protection's National Pollutant Removal Performance Database for Stormwater Treatment Practices. On the local scale, several studies exist that have helped drive the implementation of green infrastructure. The following chapter synthesizes the results of modeling, planning, implementation, and monitoring studies or demonstration projects within the District. These include a rain barrel demonstration project prepared for DC Water; a green infrastructure build-out model and urban ecosystems analyses that modeled the effects of planting additional trees and increasing the installation of green roofs; planning and modeling exercises for specific areas within the District; and existing monitoring reports and data.

3.1 Rain Barrel Demonstration Project

From 2000 to 2001, the Metropolitan Washington Council of Governments (MWCOG) carried out a CSO rooftop type analysis and rain barrel demonstration project for DC Water as part of its ongoing efforts to evaluate alternative approaches to address the District's CSO problems. This study evaluated the use of rain barrels as a means of reducing stormwater from entering the combined sewer system and to research potential CSO flow reduction techniques. The project included several objectives:

- Calculate both the individual and collective surface area and composition of all rooftops (residential, industrial, commercial, and federal) in the District's CSO area.
- Estimate the rooftop capture efficiency of rain barrels for rainfalls totaling 1 inch or less.
- Evaluate the seasonal performance of rain barrels to positively affect water quality and quantity, as well as overall maintenance experience from pilot participants.
- Calculate the runoff capture efficiency for rain barrels based on a 0.19 inch storm event, which is the equivalent amount expected to be stored by two rain barrels from the roof of a 25' x 50' row house.
- Evaluate various scenarios to evaluate cost effectiveness of rain barrel use under various runoff control levels (MWCOG, 2001).

Utilizing 1996 0.2-meter resolution aerial orthophotos, MWCOG determined that the total combined rooftop area within the District's CSS service area was approximately 2,898 acres. Just over half of these, or 1,490 acres, drain to the Anacostia River, while 1,060 acres (36%) drain to Rock Creek, and another 348 acres (12%) drain to the Potomac River. Utilizing GIS information to digitize and categorize rooftop surfaces, MWCOG determined the total acreage by rooftop, and evaluated the impact on the ability to capture rainfall from different sized storm events (0.19", 0.25", 0.50", and 1.0") on the system as a whole and by drainage area. The estimated CSO area-wide rooftop runoff volume capacity associated with 0.19 to 1.0-inch rainfall events ranged from 14.8 to 78.2 million gallons. Table 3-1 provides a breakdown of the results by rooftop type.

Table 3-1. Total Acreage and Collection Capacity of Rain Barrels per Rooftop Type for Four Different Rainfall Levels (0.19" – 0.25")

Rooftop Type	Total Area		Collection Capacity for 0.19 – 1.0" Rainfall Events (million gallons)			
	Acres	Percent	0.19" Rainfall	0.25" Rainfall	0.50" Rainfall	1.0" Rainfall
Detached House	193	6.7%	1.0	1.3	2.6	5.2
Semi-Detached	83	2.9%	0.4	0.6	1.1	2.2
Row House	1,038	35.8%	5.3	7	14.1	28.1
Apartment	297	10.2%	1.5	2	4	8.1
Commercial/Industrial	1,060	36.6%	5.4	7.1	14.2	28.4
Federal	227	7.8%	1.2	1.5	3.1	6.2
Total	**2,898**	**100.0%**	**14.8**	**19.5**	**39.1**	**78.2**

Source: Modified from MWCOG, 2001.

In modeling and evaluating the impact of collection capacity of rain barrels associated with different rooftop types in the drainage areas, the study determined that row houses provided the greatest potential to detain runoff in the Anacostia and Rock Creek CSS drainage areas due to: 1) the predominance of row houses in these drainage areas, and 2) the suitability of rain barrels to row houses as opposed to apartment, commercial/industrial, or institutional uses. For the Potomac CSS drainage area, the study determined that commercial/industrial rooftops provided the greatest potential to detain runoff. Table 3-2 summarizes the distribution of rooftop types in each drainage area.

Table 3-2. Summary of CSO Area Rooftop Distribution by Type

Watershed	Area by Rooftop Type (acres)						
	Detached House	Semi-Detached	Row House	Apartment	Commercial/ Institutional	Federal	Total Acres
Anacostia	31	26	629	95	550	158	**1489**
Rock Creek	154	54	343	173	312	24	**1060**
Potomac	8	3	66	29	198	45	**349**
Total	**193**	**83**	**1,038**	**297**	**1060**	**227**	**2898**

Source: Modified from MWCOG, 2001.

To evaluate the utility of rain barrels to detain runoff and consequently reduce stormwater flows, MWCOG staff recruited 10 study participants from privately owned detached, semi-detached, and row houses in the District's NW, NE, and SE quadrants to install between 1 to 4 rain barrels each. The number of rain barrels installed was based both on the number of 75-gallon barrels necessary to collect water from a 0.19" rainfall event and the available space to hold such rain barrels. One additional rain barrel was installed as a control. In total, 15 rain barrels were installed in order to control runoff for a 0.19" rain event from 0.21 acres, or 82% of the total combined rooftop area of the ten sites. MWCOG then monitored their use over a course of 9 months. Key finding from both the modeling and the pilot are summarized below.

3.1.1 Summary of Major Findings

- The total acreage of rooftops within the CSS service area in 1996 was 2,898 acres. Of this, 51% was in the Anacostia, 36% in Rock Creek, and 12% in the Potomac.
- Rain barrels were identified as a good tool for raising awareness of the CSO problem and promoting an environmentally friendly lifestyle.
- Rain barrels require minimal information to be installed properly. However, they require regular dewatering and occasional maintenance. Drainage frequency by 10 pilot participants averaged 2.7 times per month, which was well below the recommended level for effective operation. Water level measurements taken by MWCOG staff indicated that, on average, rain barrels remained 60% full, greatly reducing their overall effectiveness. Also, to capture the runoff capacity of one roof often requires more than one rain barrel.
- Four out of 10 pilot participants declined to assume ownership of the rain barrels at the end of the pilot. Reasons for dissatisfaction included "excessive maintenance demands, insufficient yard area for drainage, and a lack of need for water stored in rain barrels." (MWCOG 2001).
- While the study did not provide estimates on the average number of rain barrels required for a typical roof type to capture 100% of the runoff volume for various levels of rain events, it does state that "the cost effectiveness of rain barrels as an integral part of the Long Term Control Plan… is somewhat questionable…because of the large number of 75-gallon barrels required to control a significant percentage of roof area." (MWCOG, 2001).
- Utilizing rain barrels for row houses was estimated to be more cost-effective than for detached houses on a unit cost/acre of roof basis ($8,095/acre vs. $16,079/acre). To achieve a 1 million gallon reduction in stormwater volume, rain barrels would need to be installed at approximately 20% of all row homes at an estimated cost of $1.7 million.

The conclusion of this study, which was conducted at the time that the draft CSO LTCP was being prepared, was that the use and effectiveness of rain barrels as a long term CSO control was questionable (MWCOG, 2001). However, these results should be compared with the more recent efforts by DDOE to install rain barrels within the city.

3.2 Decentralized 006 SWMM Study

In 2003, the DC Office of Planning, the Low Impact Development Center (LID Center) and the Anacostia Watershed Society (AWS) received funding through the National Fish and Wildlife Foundation to develop a process for selecting green infrastructure practices most suitable for meeting watershed planning goals at specific sites, particularly in the context of extensive redevelopment and public works projects. The study area encompassed the Anacostia Waterfront Initiative area, which was selected due to the numerous redevelopment projects within the area, streetscape improvement projects scheduled by DDOT, and DC Water's planned combined sewer separation project targeted to separate Anacostia Combined Sewer Overflow Outfall #006 (Sewershed #006), allowing the group to coordinate efforts to improve stormwater discharge water quality controls using green infrastructure retrofit designs.

In urban environments, planning and implementing green infrastructure practices into redevelopment and urban retrofits can be complex. Multiple community and economic goals, regulations, and land uses must be considered. Physical constraints, such as heavily compacted soils and limited pervious areas, provide an additional challenge. The study modeled 5 redevelopment nodes and 2 blocks in

Sewershed #006 to demonstrate their potential to integrate green infrastructure into existing or proposed land uses in urbanized areas. Using a five-step process (see Figure 3-1), the Office of Planning, LID Center, and AWS engaged the community through a series of meetings and tours to determine the watershed planning goals and select appropriate green infrastructure practices.

Figure 3-1. Planning Process
Source: LID Center, 2004

Two of the 7 sites were modeled in depth to determine water quality and quantity benefits for the proposed practices. The first was a 4.4-acre redevelopment site in Historic Anacostia, identified as the Government Center at the Gateway Center Node, which was designed with the following features:

- One green roof encompassing 64% of the total roof area, with a bioretention cell designed to capture 29% of the remaining roof area, while 7% was left untreated
- One bioretention cell to treat driveway runoff
- 0.8 acres of reforestation with amended soil

Figure 3-2. Site Plan for the Government Center – Summary
Source: LID Center, 2004

The Government Center was selected for its ability to demonstrate the benefits of incorporating green infrastructure into a redevelopment project. The primary goals were to reduce the annual runoff volume, peak discharge rate, and loadings for 5 common urban non-point source pollutants, while providing a green visual amenity for the surrounding neighborhood and building occupants was identified as an ancillary benefit.

In total, 1.6 acres (54%) of the 4.4 acre site was treated by best management practices (BMPs)—with 34% covered by green roofs, and 20% draining to rain gardens which occupied 2.7% of the total site area. A full 73% of all impervious area was treated by BMPs. Additional BMPs such as permeable pavement and cisterns were not included in the design, but could be added to provide additional runoff volume reductions. Using the Prince George's County BMP Evaluation Module, the identified practices were calculated to provide annual reductions of 33% of the total runoff volume, 70% of the sediment load, and 64% of the 5-day biological oxygen demand (BOD5). Results are included in Table 3-3.

Table 3-3. Effectiveness of the Selected LID Practices at Government Center

Indicator	Units	No LID	LID Improvements	% Reduction
Outflow	million gallons/yr	3.24	2.18	33%
Sediment	tons/yr	35.1	10.4	70%
BOD5	pounds/yr	136.5	48.6	64%
Total N	pounds/yr	36.3	16.2	55%
Total P	pounds/yr	3.3	1.6	53%
Total Zinc	pounds/yr	2.0	0.7	67%

Source: LID Center, 2004

In addition, individual storms were examined to determine the reduction in peak runoff rate. Reductions were found to range from 26 – 42%, with lower-intensity storms having higher peak rate reductions than storms with more inches of rain per hour.

The second node selected for more intense modeling was the U Street SE block, which is 3.2 acres of individual properties that are 65% covered by impervious surfaces. Of the impervious area, 43% is road or sidewalks associated with both commercial and residential use, 29% is commercial rooftops, and 28% is residential rooftops. This block was selected to study the potential that an aggregation of individual site retrofit plans within a single city block could provide. Like the Government Center, the primary goals were to reduce the annual runoff volume, peak discharge rate, and loadings for 5 common urban non-point source pollutants, while providing a green visual amenity identified as an ancillary benefit. Once the sewer separation was completed, it was noted that implementing a suite of practices on these individual sites would reduce the amount of non-point surface pollutants potentially flowing to the Anacostia through the new, separated storm sewer. Table 3-4 summarizes the annual reductions in volume and select pollutants of the selected retrofits, as determined by using the Prince George's County BMP Evaluation Module. For individual storm events, the reduction in peak runoff rate ranged from 23–34%, with lower-intensity storms having higher peak rate reductions.

Table 3-4. Effectiveness of the Selected LID Practices at U Street SE Block

Indicator	Units	No LID	LID Improvements	% Reduction
Outflow	million gallons/yr	2.11	1.8	15%
Sediment	tons/yr	12.6	6.4	50%
BOD5	pounds/yr	138.4	114.2	18%
Total N	pounds/yr	25.7	17.5	32%
Total P	pounds/yr	3.1	2.2	29%
Total Zinc	pounds/yr	2.3	1.4	41%

Source: LID Center, 2004

3.2.1 Summary of Major Findings

- Planning and implementation of green infrastructure stormwater controls in redevelopment areas and urban retrofits is complex and requires a more iterative process than do the planning and implementation of standard end-of-pipe controls. Water quantity and quality benefits must be evaluated and calculated based on existing goals and opportunities.
- In the planning process, comprehensive outreach is necessary to engage community members and developers, as the overall acceptance of identified projects is dependent upon the roles of various public and private stakeholders. Community participation at such events can be unpredictable and may result in limited participation.
- The flexibility of green infrastructure practices makes them particularly useful in urban environments. Numerous combinations of acceptable solutions can be utilized to meet various watershed goals, and can help meet volume reduction and water quality goals.

3.3 Arthur Capper Hope VI SWMM Study

In 2002, the DC Office of Planning Anacostia Waterfront Initiative, the Low Impact Development Center (the LID Center), and the Metropolitan Washington Council of Governments (MWCOG) received a grant from the National Fish and Wildlife Foundation to develop Low Impact Development /green infrastructure design guidelines for the Arthur Capper Hope VI project in the District near the Navy Yard. The Hope VI program is a United States Housing and Urban Development (HUD) redevelopment initiative focused on revitalizing large urban areas with mixed use development. The project's goal was: 1) to demonstrate the performance and feasibility of sustainable development techniques such as green infrastructure, and 2) to provide the Office of Planning with strategies and techniques that can be incorporated into the zoning and site design approval process.

The project involved developing a set of design templates for each land use to demonstrate how green infrastructure could be incorporated into streetscape, site, and building designs (see Figure 3-3 for a sample template for a streetscape and parking lot). The area was also modeled using EPA's Stormwater Management Model (SWMM) to determine the potential effectiveness of incorporating green infrastructure practices to meet water quality objectives.

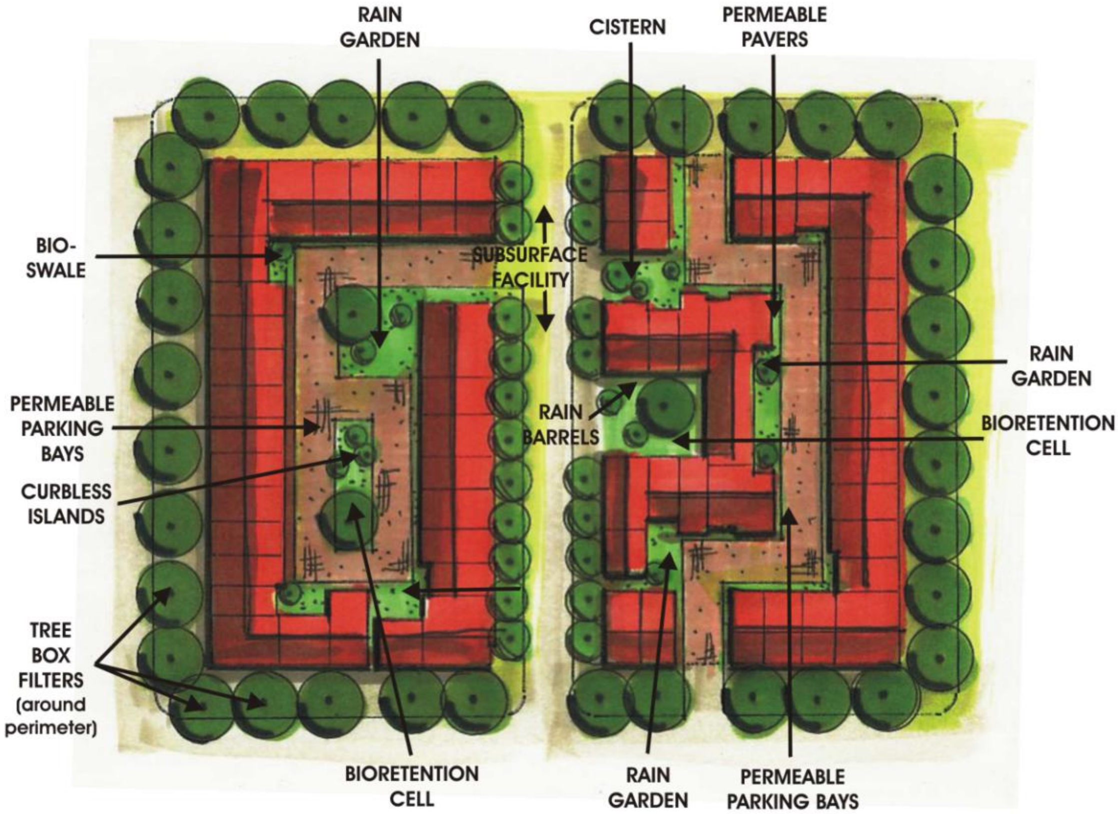

Figure 3-3. Design Template: Streetscape and Parking Lot

Source: Low Impact Development Center, Inc.

The study included two separate project reports—the first of which included design guidelines, and the second of which is a water quality model of the potential effectiveness of these strategies and techniques at managing stormwater and reducing pollutant loads to the Anacostia River.

3.3.1 Summary of Major Findings

- Green infrastructure design techniques are compatible with community development and can be incorporated into the design of each of the proposed land uses.
- There is a significant opportunity when the streets are being reconstructed to disconnect the stormwater flows from the combined sewer system. This could potentially help reduce the number of overflow events in the system because of the large drainage area that is associated with the disconnected drainage area.
- Modeling results show that green infrastructure features can have a significant effect on improving water quality of runoff from the western portion of the development. The model shows that even if the features provide a small and conservative amount of storage and filtering, approximately 20” of rainfall can be fully treated by a retention area (minimal or no discharge) while the remaining rainfall could receive partial treatment. Data on the removal efficiencies from green infrastructure studies indicates that this level of treatment could remove a significant volume of pollutant loads. A more detailed

modeling effort would be required to accurately characterize the potential load reductions.

- If placed strategically in front of inlets or incorporated into the design, even a small number of green infrastructure practices could have a significantly positive effect on water quality. If designed to completely retain the first ¼ inch of rainfall, it would result in 15 – 20 fewer discharges of pollutants to the Anacostia per year.

3.4 Urban Ecosystem Analysis for DC Metropolitan

In 2001, Urban Forests conducted an urban ecosystem analysis of the Washington DC metropolitan area to develop a "green infrastructure" data layer identifying areas covered by trees, shrubs, and grass utilizing remote sensing satellite data from the summer of 2001. In addition, the analysis identified those areas covered by impervious surfaces such as buildings, roads, and parking lots. Within the District, tree canopy accounted for 26% of the total land cover, and impervious surfaces accounted for 46%. A breakdown of the land cover by Ward is provided in Table 3-5. The ecological value of the existing tree canopy in terms of stormwater retention and air quality benefits is provided in Table 3-6.

Table 3-5. Tree Cover and Impervious Surface Percentages by Ward.

	% Tree Cover	% Impervious	% Other
Ward 1	8%	75%	17%
Ward 2	11%	76%	13%
Ward 3	46%	35%	19%
Ward 4	29%	50%	21%
Ward 5	20%	56%	24%
Ward 6	12%	69%	19%
Ward 7	33%	42%	25%
Ward 8	32%	45%	23%

Source: Adapted from American Forests, 2002

Table 3-6. Ecological Value of Tree Canopy Benefits by Ward

	Lbs. Air Pollution Removed	Annual Air Pollution Value	Volume of Stormwater Retained (gallons)	Stormwater Retention Value (per 30 years)
Ward 1	14,204	$35,054	2,208,950	$4,417,900
Ward 2	33,605	$82,934	4,703,286	$9,406,572
Ward 3	276,425	$682,183	14,052,955	$28,105,910
Ward 4	140,851	$347,603	7,793,427	$15,586,854
Ward 5	117,133	$289,069	8,383,417	$16,766,834
Ward 6	33,520	$82,723	3,571,973	$7,143,946
Ward 7	149,953	$370,065	7,669,123	$15,338,246
Ward 8	113,997	$281,330	5,584,479	$11,168,958
Total	**879,688**	**$2,170,961**	**53,967,610**	**$107,935,220**

Source: Adapted from American Forests, 2002

3.4.1 Summary of Major Findings

- In 2001, American Forests determined that the DC metropolitan area included 46% (187,767 acres) of urban forest, 27% (110,300 acres) of impervious surfaces, and 17% open space (70,747 acres). The remainder was designated as 7% bare soil, and 3% water. The total stormwater retention capacity of the urban forest was calculated to provide 949 million cubic feet in avoided costs of constructing grey stormwater infrastructure controls, valued at $4.7 billion per 30 year construction cycle. Annual air pollution reduction benefits were calculated to be $49 million. Both were calculated using American Forests' CITYgreen software.
- Within the District of Columbia, 26% was identified as urban forest/tree canopy, and 46% was identified as impervious. The District's urban canopy was estimated to provide $2.17 million in air quality benefits annually and $108 million in stormwater retention benefits per 30 year cycle.
- Evaluating data at the neighborhood scale can help set more specific tree canopy goals. For example, the study determined that only 3% canopy cover exists in Ward 1's commercial area. Increasing this to 15% provides an estimated $300,000 in benefits.

3.5 Green Roof Demonstration Project

In 2003, DC Water provided $300,000 through a lawsuit settlement to the Chesapeake Bay Foundation (CBF) to administer a green roof grant program—the purpose of which was to install a series of green roof demonstration projects within the city. Between 2004 and 2008, 121,200 square feet of green roofs were constructed under this grant program, providing estimated annual stormwater retention of 1.8 million gallons (Chesapeake Bay Foundation, 2008). The stormwater retention benefits were calculated using the information provided in Table 3-7. These numbers were determined using monitoring data from CBF as well as research from Penn State, the City of Portland Bureau of Environmental Services, and the US Department of Energy.

Table 3-7. Determining the Stormwater Retention Capacity of Extensive Green Roofs in the District

	Gallons per square foot of green roof	Gallons per acre of green roof
Maximum stormwater retention capacity for a single rain event	0.6	25,000
Stormwater retention capacity for an average year	15.0	63,000

Source: Chesapeake Bay Foundation, 2008

One project that was funded in part from the settlement program was a 3,000 sq ft green roof installed in 2006 at the headquarters of the American Society of Landscape Architects (ASLA). Subsequent monitoring over a ten month period showed that the green roof was able to retain 75% of total rainfall (Glass and Johnson, 2008). Although pollutant concentrations have gone up, total pollutant loads have gone down because the volume of stormwater leaving the site has been greatly reduced.

3.5.1 Summary of Major Findings

- Green roofs are effective in reducing stormwater volumes. Based on monitoring results from the ASLA green roof, storm events of 1 inch or less per 24-hour period can effectively be retained. In general, storms must be greater than 1 inch per 24-hour period and must come in quick succession for runoff to be produced. For the 10 month period that data was collected for the ASLA green roof, it was able to retain 75% of the total rainfall volume (Glass, 2007).
- Green roofs also have the potential for reducing harmful pollutants; however, more extensive monitoring studies are needed.
- The cost per square foot of green roof decreased as the size of the green roof increased. The estimated per square foot cost of a small re-roofing project under 5,000 square feet in size was $25-30. For a medium sized new roof up to 10,000 square feet in size, the cost was $20-25 per square foot, and for a large new roof (15,000–70,000 square feet), the cost was estimated between $10–15 per square foot.
- A grant program, where 20% of the total costs of installing a green roof were provided, appeared to provide a sufficient enough monetary incentive to encourage commercial building owners and developers to install green roofs. While no attempt was made to calculate the other monetary benefits a green roof can provide, it was speculated that part of the return or incentive for owners and developers to invest in a green roof include the ability to substitute a green roof for other required pretreatment systems (such as sand filters), energy cost savings, and tenant esthetic preferences.

3.6 Enhanced Green Build-Out Model

In 2007, Casey Trees and LimnoTech completed an analysis of the benefits of increasing tree and green roof coverage within the District of Columbia. Known as the Green Build out model, this study determined that increasing the existing tree cover from 35 to 57% by adding trees and green roofs wherever physically possible, would prevent more than 1.2 billion gallons of stormwater from entering the sewer systems. This would reduce discharges to the District's rivers by more than 1 billion gallons and reduce cumulative CSO frequencies by 6.7% (74 individual CSO discharges) in an average year. Also under this scenario, reductions in stormwater runoff volume of up to 10% could be expected across the city, with up to 27% reductions in individual sewersheds.

Increasing the tree and green roof coverage from 35 to 40% was estimated to prevent more than 311 million gallons of stormwater from entering the sewer systems in an average year. This would reduce discharges to the river by 282 million gallons and reduce cumulative CSO frequencies by 1.5% (16 individual CSO discharges). In total, DC Water could expect to save between $1.4 and $5.1 million per year in annual operations due to reduced pumping and treatment costs (Casey Trees and LimnoTech, 2007). Table 3-8 provides proposed greening scenario assumptions for the two greening scenarios. Assumptions were derived through the expert opinion of this Advisory Group and through discussions with other District agency representatives. Benefits were calculated by utilizing the Mike Urban model (for a description of the model, see *Technical Memorandum No.2: Approach to Hydrologic and Hydraulic Modeling).*

Table 3-8. Existing and Modeled Tree Cover Scenarios for the District

Land Cover Type	Existing (2005) Tree Cover[1]	Moderate Tree Cover Scenario	Intensive Tree Cover Scenario
Impervious			
Streetscape (roads, sidewalks, intersections)[2]	22%	25%	35%
Parking lots	7%	30%	50%
Paved drives	23%	50%	80%
Alleys	26%	35%	50%
Median islands, traffic islands, other	23%	30%	40%
Pervious			
Includes parks, open space, recreational areas, golf courses, soccer fields, cemeteries, residential and school yards, etc.	53%	57%	80%
Total Tree Cover	**35%**	**40%**	**57%**

Source: Casey Trees and LimnoTech, 2007

[1] Existing tree cover was determined using July 2006 IKONOS satellite imagery classified for land cover (1m).

[2] Street tree space was determined using a 2002 Street Tree Inventory for DC.

Parking lots appeared to provide a very strong opportunity for additional tree plantings as compared to the baseline scenario. Casey Trees and LimnoTech utilized the precedence set by several US city parking lot ordinances that require up to 50% tree coverage as the basis for their justification of the available opportunity. Paved drives also received a significant boost in the percentage tree cover in the two different scenarios. Both 50% and 80% were agreed to be reasonable amounts based on samplings of images of paved drives throughout the District that showed that many paved driveways already achieve approximately 80% of tree cover. Assumptions and justifications for all of the scenario inputs are provided in their 2007 report titled *The Green Build-out Model: Quantifying the Stormwater Management Benefits of Trees and Green Roofs in Washington, DC*.

Building sizes were also analyzed to determine the opportunity for green roofs within the District. Assuming that 75% of an individual roof could be covered, with the remainder being utilized for HVAC, maintenance, and access, and assuming no structural or historic preservation issues, it was determined that the greatest amount of green roof coverage possible was 195 million square feet. Buildings were further characterized by square footage (<1,000 sq ft, 1,000-2,000 sq ft, 2,000-5,000 sq ft > 5,000 sq ft) and were also evaluated based on their location either within the CSS or MS4 service area. Green roofs were assumed to include three to four inches of growth media. In the moderate green roof scenario, stormwater benefits were estimated if 10.5% of the total building area, or 20,531,989 square feet was covered with green roofing material. In the intensive green roof scenario, stormwater benefits were estimated assuming a green roof coverage 40% of the District's total roof area, or 102,659,943 square feet.

The expansion of existing tree boxes was also considered as a means of increasing stormwater retention. The size of an average tree box in downtown DC is 4 x 9 feet, while sidewalks average 20 feet in width. For the tree box scenario, the stormwater management benefits were analyzed for increasing existing downtown tree boxes to 6 x 20 feet.

3.6.1 Summary of Major Findings

- Increasing the city's green canopy and green roofs from 2005 levels could provide 6% reductions in untreated discharges in the CSS area for the moderate greening scenario and 22% for the intensive greening scenario.
- An intensive greening scenario was calculated to prevent more than 1.2 billion gallons of stormwater from entering the sewer systems, reducing discharges to the District's rivers by more than 1 billion gallons and reducing cumulative CSO frequencies by 6.7% (74 individual CSO discharges) in an average year. Also under this scenario, reductions in stormwater runoff volume of up to 10% could be expected across the city, with up to 27% reductions in individual sewersheds.
- A moderate greening scenario was calculated to prevent more than 311 million gallons of stormwater from entering the sewers, reducing direct untreated discharges by 282 million gallons and reducing cumulative CSO frequencies by 1.5%, or 16 individual CSO discharges, per average year.
- In the downtown area, enlarging existing tree boxes could reduce stormwater runoff by 23 million gallons per year.
- In total, DC Water could realize $1.4 - $5.1 million in operational savings per year in the CSS area.

3.7 Washington Navy Yard: Monitoring of Bioretention Strip

As part of an overall initiative to help restore the water quality of the Chesapeake Bay and the Anacostia and Potomac Rivers, bioretention areas were installed at the Washington Navy Yard in 2001 along parking lot perimeters and between the parking stalls in various lots. The bioretention areas were designed to intercept preferential stormwater pathways and to treat, at a minimum, the first one-half inch of rain from half acre segments of impervious parking surface. To evaluate pollution control effectiveness, samples from 15 storm events were collected from March 21, 2003 to June 20, 2003. The bioretention area's pollutant removal efficiencies are listed in Table 3-9.

Figure 3-4. Navy Yard Bioretention Strip
Source: Low Impact Development Center, Inc.

Table 3-9. Pollutant Removal Efficiencies for Navy Yard Bioretention Strip

	TSS	Zn	Cu	Pb	Cd	NH3-N	Fe	Cr	NO-2-N	Al	PO3-4-P
Percent Removed	~98%	~80%	~75%	~71%	~70%	~65%	~51%	~42%	~27%	~17%	~3%

Source: Glass and Bissouma, 2003

Since 2001, additional green infrastructure practices have been employed throughout the Navy Yard to take advantage of existing parking lots, roads, rooftops, and landscaped areas by incorporating LID features. These include a rain barrel to collect runoff from Building 292, permeable pavers in the center of a parking lot, permeable pavers adjacent to Building 70, a rain garden to capture roof runoff from Building 76, a tree-box filter at the 9th Street gate (Buranen, 2010) (NRDC, 1999).

3.7.1 Summary of Major Findings

- Bioretention strips employed at the Navy Yard have proven to be very effective for filtering out and reducing key stormwater pollutants.
- While not readily available as part of this report, the Washington Navy Yard may also be monitoring the project to evaluate stormwater volume reductions and stormwater discharge frequency

3.8 Conclusions

While a limited number of performance and maintenance studies have been conducted within the District, results are largely positive. As part of the large-scale green infrastructure implementation that DC Water is considering, an effort should be made to collect additional monitoring, performance, and cost data from existing projects in order to generalize results for a larger number or green infrastructure practices. For example, several green infrastructure practices have been employed at the Washington Navy Yard; however, monitoring results are currently only readily accessible for a bioretention area installed along a parking lot perimeter. Monitoring results from an ASLA green roof during its first year of installation provided valuable information on rainfall retention rates. Efforts should be made to obtain additional data now that the green roof's vegetation has been matured.

In all but one of the studies examined for this report, the evaluation of green infrastructure practices—the rain barrel demonstration project—was overwhelmingly positive. While identified as a good educational and public relations tool, the rain barrel demonstration project prepared for DC Water during the preparation of the CSO LTCP highlighted several difficulties with relying on rain barrels on private properties for use as a long term control. These included the need to install more than one rain barrel to capture 100% of the runoff volume for various levels of rain events, and the lack of desire to maintain the rain barrel over time by several of the participants. In addition, the installed rain barrels remained 60% full on average, greatly reducing their overall effectiveness.

In recent years, DDOE has distributed or installed numerous rain barrels through its RiverSmart Homes program, discussed in Chapter 5. DC Water should consider working with DDOE to undergo a joint effort to evaluate the effectiveness of rain barrels that have been voluntarily installed through this program. Of particular concern is the dewatering of rain barrels between wet weather events, which is necessary for the rain barrel to serve its stormwater control function. Determining the rate of dewatering could allow existing programs to be tweaked to further emphasize the necessity of manual draining or coupling such a program with the continual, slow release using a soaker hose to a garden or infiltration area.

Where monitoring data is limited, computer modeling has been used to supplement the lack of data. The enhanced Green Build-Out Model conducted by Casey Trees and LimnoTech is an excellent example of where modeling scenarios have provided useful information to evaluate the use of widespread green roof installations and tree plantings. The findings show that such practices can provide substantial stormwater runoff reductions District-wide.

These studies have also helped provide additional data about costs for certain practices. The Green Build-Out Model, for example, estimates that DC Water could realize $1.4 - $5.1 million in operational savings per year in the CSS area. Results from the CBF grant program show that the cost of green roof installation decreases as the size of the roof increases, making the practice particularly suitable for large commercial/industrial and multi-family residential buildings. Buildings less than 1,000 square feet in size, however, dominate the landscape in downtown Washington, highlighting the need to identify specific programs tailored to encourage green roofs on smaller buildings. DC Water might want to consider, for example, developing a do-it-yourself guide in cooperation with DDOE to encourage the installation of green roofs on sheds that could serve as an outreach tool to homeowners within the District and further encourage their use on residential buildings. CBF's final report also suggests that a grant program to defray 20% of the costs was enough of an incentive to encourage program participation. More research would need to be done, however, to determine whether this was a valid finding.

The needs for additional performance and cost data are not unique to DC Water but common to several agencies. Additional efforts should be made to identify research needs across agencies and share information. For projects implemented as part of DC Water's large scale green infrastructure implementation, if DC Water decides to pursue this option, the agency should consider developing an annual monitoring report that provides data results on green infrastructure practices.

4 Policies, Planning Documents, and Context Related to Green Infrastructure Implementation

Urban and regional planning help guide the framework by which land use decisions are made and establish the goals and policies that support the community's larger social, environmental, and economic objectives. As such, the District's planning documents and policy statements influence the degree to which sustainable development practices such as green infrastructure can be integrated into a community.

In the past five years in particular, the District has set forth a number of measurable goals, policies, and plans that influence the incorporation of sustainable development practices such as green stormwater infrastructure. District-wide goals and policies include the District's green jobs initiative, the Green DC Agenda, DDOT's LID and sustainability plans, and DDOE's Wildlife Action Plan. An overview of each is included in this chapter.

Land use planning is also strongly influenced by the small area plans, studies and reports produced by the Office of Planning. Due to the large number of such documents, a review of existing planning documents was limited to CSO subsheds 020-007, 026-001, 027-003, 029-003, 049-018, and 049-019. The nine CSO subsheds fall into Wards 2, 3, and 4. Planning documents from these Wards were reviewed to identify opportunities where green stormwater infrastructure goals were compatible with existing plans.

4.1 District-Wide Goals and Policies

4.1.1 Green Jobs Initiative

In 2007, the Center for American Progress put out a report identifying stormwater management, green building practices, river restoration, and comprehensive energy policies aimed at reducing carbon emissions as the largest forthcoming opportunities to develop and employ a green jobs industry in the District of Columbia (Hendricks and Goldstein, 2007). That same year, the District launched a green jobs initiative to build a "green" workforce and encourage opportunities in areas such as green buildings, transit jobs, climate and renewable energy solutions, and the installation of stormwater management practices. The District's efforts appear to be paying off. In 2008, investments by DC Water through their CSO LTCP were estimated to generate a labor demand for 1,500 workers in the construction industry over a ten-year time period (The Louis Berger Group, Inc., 2008). Similarly, DDOE has estimated that about 235 jobs have or will be created through a $14 million investment in American Recovery and Reinvestment Act grants through the EPA's Clean Water State Revolving Fund (Weber, 2011). By focusing on green infrastructure practices, DC Water has the potential to create new local jobs for in the landscaping and restoration fields. As an example, see the analysis prepared by Stratus Group for the city of Philadelphia, where it was projected that green infrastructure projects would provide more than 15,000 jobs for low-skilled local workers over a 40-year period, resulting in a present value benefit of nearly $125 million (Stratus Consulting Inc., 2009).

4.1.2 Green DC Agenda

In 2009, former DC Mayor Adrian M. Fenty announced a Green DC Agenda as the city's new blueprint for a healthier, more sustainable city, with specific action items identified for various District government agencies. The Green DC Agenda is divided into seven major categories:

- Homes
- Schools
- Neighborhoods and Community
- Parks and Natural Areas
- Transit and Mobility
- Business, Jobs, and Economic Development
- City and Government Operations

In addition, special emphasis was placed on developing a climate protection initiative and the restoration of the Anacostia River (DDOE, 2009a). Information below highlights the District's new Urban Tree Canopy Goal and Climate Protection Initiative which were introduced as part of the Green DC Agenda – both of which have linkages to the identification of future green stormwater infrastructure demonstration projects. In addition, Table 4-1 highlights other actions identified by the plan which may serve useful as DC Water continues to refine its implementation areas and/or serve as areas for collaboration with other District agencies in the collection, monitoring, and disseminating of information.

4.1.2.1 Urban Tree Canopy Goal

In April 2009, the District adopted a goal of increasing the city's urban tree canopy (UTC) from 34.8% to 40% by 2036. This goal was unveiled as part of the Green DC Agenda. According to Casey Trees, this goal will require the addition of 2,041 new acres of UTC within the District. Accounting for a 6% mortality rate and 100 trees to an acre, this equates to planting a total of 216,300 trees, or 8,600 trees a year. As of August 1, 2011, Casey Trees reports that the total number of trees planted by Casey Trees, DDOE, DDOT, the US General Services Administration, the US National Park Service, and Trees for Capitol Hill since the 2009 UTC goal was announced is 21,076 (Casey Trees, 2011).

4.1.2.2 DDOT Low Impact Development Action Plan

In December 2010, DDOT released a Low Impact Development Action Plan in response to the Comprehensive Stormwater Management Enhancement Amendment Act of 2008, recommending policies and measures to reduce impervious surfaces and promote green infrastructure projects in public spaces. The action plan includes six strategy statements, as well as a set of near- and longer-term steps to lead to the further achievement of each strategy. While more are included in the plan, the near-term steps to be completed within the next one to two years which are most relevant to DC Water are highlighted below (DDOT, 2010d).

Strategy 1: Reduce impervious surface and employ other LID measures in right-of-way (ROW) construction projects and retrofit projects. Near-term actions include:

- Continue to implement LID and look for impervious surface reduction opportunities in planning, design, and construction projects.
- Evaluate completed LID projects for effectiveness and durability of design, construction, and maintenance.
- Evaluate/develop all options for reducing impervious surface in and managing stormwater from the ROW.
- Start a DDOT green streets program.
- Establish design guidelines and standards for LID in the ROW.
- Develop a city-wide master plan to identify all LID retrofit and impervious surface reduction opportunities in the public ROW.

Strategy 2: Require and provide incentives for private developers to reduce impervious surface and employ LID measures when their projects extend into the public ROW.

- Explore incentives/means to obtain higher developer participation in DDOT's voluntary Preliminary Design Review Meeting process to ensure that LID and reduced impervious surfaces are considered.
- Perform reviews of all projects that disturb the streetscape for LID and reduced impervious options.

Strategy 3: Use public space to manage stormwater runoff from private property.

- Establish an annual fee for use of public space for management of stormwater runoff from private property.

Strategy 4: Prepare a revised DDOT public space permitting process and the development of a mechanism to minimize stormwater runoff from the public right-of-way.

Strategy 5: Address ongoing maintenance of LID or stormwater best management practices installed in public right-of-way areas adjacent to private property.

Strategy 6: Remove impediments to LID projects on residential properties relating to public space.

- Encourage homeowners that want to install LID practices to participate in the RiverSmart Homes program.
- Change the permitting process to allow all homeowners to obtain a Public Space permit for LID implementations as described in the RiverSmart Homes program without going before the Public Space Committee.

4.1.2.3 Climate Protection Initiative

In September 2010, the District released a draft climate action plan—*Climate of Opportunity*—that lays out a detailed action list to reduce the government's "carbon footprint" below 2006 levels of 720,000 metric tons of carbon dioxide equivalence (CO_2e) by 20% in 2012; 30% in 2020; and 80% in 2050. The plan further divides actions and policies into 5 categories: buildings, transportation, street lighting, water and wastewater, and solid waste, providing benchmark goals for each. Of the 2006 CO_2e levels from government operations, the second highest levels of emissions were from wastewater facilities (163,000 metric tons CO_2e, or 23%), with buildings and other facilities (59%) being the highest. Actions highlighted to reduce emissions from wastewater treatment included decreasing flow volumes, increased process innovation, and re-using process by-products. Upgrades to water distribution and wastewater treatments alone are projected to result in savings of 36,700 metric tons of CO_2e in 2012; 73,800 in 2020; and 129,500 in 2050.

The actions listed to reduce energy use from wastewater treatment highlight several major initiatives being undertaken by DC Water, including the installation of bubble diffusers for use in aerated water treatment and the implementation of an anaerobic digester at Blue Plains. These and other DC Water initiatives will cut wastewater facility emissions by almost 50% by 2020. Other parts of the draft climate action plan highlight additional proposed measures to reduce community emissions that could cut energy use for wastewater treatment even further. In addition to the energy benefits, the proposed measures highlighted below help to reduce stormwater runoff volumes and provide on-site water quality benefits:

- The use of green roofs, along with cool roofs, to reduce the amount of energy necessary to cool buildings and combat the urban heat island effect that causes the inner city to be hotter than surrounding suburban and rural areas.
- The promotion of green development and green building methods, in addition to green roofs, in new construction and rehabilitation projects, and public realm designs in the District that favor tree boxes, planting areas on public sidewalks, and reductions in impervious surfaces. Such practices help absorb and reduce the flow of stormwater into the system.
- The implementation of smart growth policies that favor walkable communities and increase vegetation such as green spaces and urban trees. Such vegetation provides cooling benefits that reduce energy use and mitigate the urban heat island effect.
- The update of the District's zoning code to encourage sustainability. From the stormwater perspective, major topics include water conservation and greywater, as well as slopes, streams, stormwater, and hydrology
- The increase of tree canopy to 40% by 2036.

4.1.3 Other Green DC Agenda Action Items

Table 4-1 highlights those actions identified by the Green DC Agenda which may prove useful as DC Water continues to refine its pilot project selection areas and/or serve as areas for collaboration with other District agencies in the collection, monitoring, and disseminating of information.

Table 4-1. Green DC Agenda Action Items Applicable to Data Collection, Monitoring, and Implementation of District Green Infrastructure Projects

Name of Action Item	Theme	Status	Lead Agency	Category	Description
Develop Urban Tree Canopy Goal	Homes; Neighborhoods and Community; Parks and Natural Space; Business, Jobs, and Economic Development: Anacostia; Climate Change	Upcoming	DDOE	Water	DDOE and DDOT have officially adopted a city-wide tree canopy goal of 40 percent canopy coverage. The District will develop an implementation plan that identifies specific funding sources for tree planting and maintenance projects by August 2009. Lead Agency: DDOE. Other Agencies: DDOT.
Plant Street Trees	Neighborhoods and Community; Parks and Natural Space; Anacostia; Climate Change	In progress	DDOT	Water	DDOT and DDOE will improve tree planting standards for trees on public lands to provide larger tree boxes and improve maintenance and plant a minimum of 4,150 trees annually (13,500 additional trees over the next 3 years). Lead Agency: DDOT. Other Agencies: DDOE.
Conduct Casey Trees Silva Cell Demonstration Project	Parks and Natural Space; Climate Change	Upcoming	DDOT	Green Space	DDOT will install Silva cells and street side infiltration planters to manage runoff from roadway. Silva cells can hold soil, allow water percolation, and support traffic loads beneath paving and hardscapes. This project will analyze their effectiveness to support urban tree life. Lead Agency: DDOT
Assess District Buildings for Green Roofs	Government and City Operations; Anacostia	In progress	DRES	Water	DDOE will complete a structural assessment of all District properties maintained by OPM to determine feasibility for green roof installations. Based on this list DDOE will develop an implementation schedule for retrofitting District properties. Lead Agency: DRES.
Expand Green Roof Incentive Program	Homes; Schools; Neighborhoods and Community; Business, Jobs, and Economic Development; Anacostia; Climate Change	In progress	DDOE	Water	DDOE to make $500,000 available for new and retrofit green roof installations on federal, residential, commercial, and District-controlled properties. DDOE will assess the effectiveness of the green roof incentive program and increase funding as appropriate up to $1,000,000 annually. Lead Agency: DDOE

Table 4-1. Green DC Agenda Action Items (Continued)

Name of Action Item	Theme	Status	Lead Agency	Category	Description
Fund Green Roofs on District Properties	Government and City Operations; Anacostia	In progress	DRES	Water	$1.3 million in green roof projects to manage stormwater runoff from District properties in support of the District's municipal separate storm sewer system (MS4) National Pollutant Discharge Elimination System (NPDES) Permit (MS4 Permit). Lead Agency: DRES. Other Agencies: DDOE.
Install Green Roofs on Fire Stations	Government and City Operations	In progress	FEMS	Water	DDOE and FEMS identified 22,000 square feet of roof area at two District fire stations scheduled for roof rehabilitation and could add green roof components to reduce, detain, and treat stormwater runoff. Twelve additional fire stations have been identified as potential sites. Lead Agency: FEMS. Other Agencies: DDOE.
Install additional Green Roofs	Government and City Operations; Anacostia	In progress	DRES	Water	Over 200,000 sq ft of green roofs are planned for installation on District buildings in the next 3 years. Lead Agency: DRES. Other Agencies: DDOE.
Install Rain Barrels on Public Housing Developments	Government and City Operations; Anacostia	In progress	DRES	Water	Over 200,000 sq ft of green roofs are planned for installation on District buildings in the next 3 years. Lead Agency: DRES. Other Agencies: DDOE.
Expand RiverSmart Homes Stormwater Reduction Program	Homes; Business, Jobs, and Economic Development; Anacostia	In progress	DDOE	Water	DDOE and WASA provide incentives to encourage homeowners to install stormwater control devices at their homes. By October 2009, DDOE will install 50 rain gardens and 125 rain barrels and perform 200 downspout disconnections. Lead Agency: DDOE. Other Agencies: WASA.
Demonstrate Low Impact Development in Public Space	Neighborhoods and Community; Anacostia	In progress	DDOE	Water	Install demo projects to reduce stormwater runoff in public space. Projects should include bioretention in parking spaces where traffic calming measures have been requested by community; curbside bioretention in tree boxes; "green alleys"; and roadway triangles and small parks to treat roadway stormwater runoff. Lead Agency: DDOE. Other Agencies: DDOT, DPR, DPW, WASA, DCPS.

Table 4-1. Green DC Agenda Action Items (Continued)

Name of Action Item	Theme	Status	Lead Agency	Category	Description
Support Low Impact Development in the Right-of-Way by private developers	Neighborhoods and Community; Transportation and Mobility; Anacostia; Climate Change		DDOT	Water	DDOT will encourage and support private developers to implement LID in right-of-way where feasible. Lead Agency: DDOT.
Retrofit Catchbasins for Street Trash Reduction	Neighborhoods and Community; Anacostia	Upcoming	DDOE	Water	DDOE will retrofit 50 stormwater catch basins in 2009 to investigate the cost and effectiveness of different technologies designed to reduce the flow of trash into our waterways. Lead Agency: DDOE.
Coordinate Great Streets Initiative	Transportation and Mobility; Anacostia; Climate Change	In progress	DDOT	Transit	DDOT is performing major street upgrades on designated corridors in support of economic development and mobility. The work will result in improved walkability, tree canopy, and transit services (in some cases). Example - Nannie Helen Burroughs. Lead Agency: DDOT. Other Agencies: DMPED
LaFayette Spray Park Water Reuse	Parks and Natural Space; Anacostia	In progress	DPR	Water	DPR and DDOE will implement a "gray water" system to reuse water from a children's spray park feature to irrigate plantings and reduce use of potable water. Lead Agency: DPR. Other Agencies: None.
Create Anacostia Fringe Wetlands	Parks and Natural Space; Anacostia		DDOE	Water	DDOE and the National Park Service will create fringe wetland sites at stream outfalls near Ft. DuPont, the National Arboretum, Poplar Point, and other locations. Fringe wetlands reduce erosion, filter pollutants that would flow downstream, and provide vital wildlife habitat. Lead Agency: DDOE. Other Agencies: USACE, NPS.
Create Kingman Lake Wetlands	Parks and Natural Space; Anacostia; Climate Change		DDOE	Water	DDOE, the National Park Service, and US Army Corps of Engineers will create additional wetlands in Kingman Lake (adjacent to Kingman and Heritage Islands) to expand tidal wetlands and improve water quality and wildlife habitat in the Anacostia watershed. Lead Agency: DDOE. Other Agencies: USACE, NPS.

Table 4-1. Green DC Agenda Action Items (Continued)

Name of Action Item	Theme	Status	Lead Agency	Category	Description
Develop a Neighborhood Sustainability Indicators Pilot Project (NSIPP, Ward 3)	Neighborhoods and Community; Climate Change	Upcoming	OP	Development	The NSIPP will provide a framework for the public and private sector to move the study area and Ward 3 towards a more sustainable existence. Results will inform city-wide green policy decisions and sustainability strategies. It is anticipated that the study will serve as a model for developing similar neighborhood sustainability indicators across the city. Lead Agency: OP. Other Agencies: DDOE.
Capital Space Initiative Program	Neighborhoods and Community; Parks and Natural Space; Anacostia	Upcoming	NCPC	Green Space	A partnership among the National Capital Planning Commission, the Office of Planning, the Department of Parks and Recreation and other District agencies was established to create a set of environmental objectives for park planning and operations. The group will develop new objectives and standards for park development and maintenance in order to achieve the full potential of our parks system. Lead Agency: NCPC. Other Agencies: OP, DPR, DDOT, DDOE, NPS.
Maryland Stormwater Retrofits	Parks and Natural Space; Government and City Operations; Anacostia	In progress	DDOE	Water	DDOE is working with Maryland to encourage stormwater retrofits and stream restoration in Prince George's and Montgomery Counties and develop and coordinate cross-border watershed projects. In the long term, DDOE will work with Maryland to ensure that stormwater retrofits (rain gardens, permeable pavement, etc.) and stream restoration projects are installed to reduce the flow of polluted stormwater downstream into the District. Lead Agency: DDOE. Other Agencies: AWRP.
Participate in Maryland Partnership in Watershed Management Planning	Government and City Operations; Anacostia	In progress	USACE	Water	Work with Maryland to develop a comprehensive watershed management plan for the Anacostia River. Working with Maryland to protect the Anacostia upstream benefits the portion of the river that's housed in the District. Lead Agency: USACE. Other Agencies: DDOE, AWRP.

Table 4-1. Green DC Agenda Action Items (Continued)

Name of Action Item	Theme	Status	Lead Agency	Category	Description
Develop Anacostia Watershed Restoration Plan	Government and City Operations; Anacostia	Upcoming	USACE	Water	The Plan is a two-year study developed by the US Army Corps of Engineers in partnership with Prince George's and Montgomery Counties and the District to identify restoration projects and opportunities. The plan will lead to a 10-year environmental and ecological restoration plan for the entire watershed. Lead Agency: USACE. Other Agencies: DDOE, Prince George’s County, Montgomery County.
Develop Green DC Map	Neighborhoods and Community	Upcoming	DDOE	Education	DDOE will release printed and web-based maps to identify green facilities, practices, and businesses across the city. Residents, business owners, and tourists will be able to identify environmentally-friendly sites by neighborhood or type. Lead Agency: DDOE. Other Agencies: OCTO.
Develop Low Impact Development Tracking Database	Government and City Operations; Anacostia	Upcoming	DDOT	Water	DDOT will develop a database to track existing LID structures installed throughout the District by all Agencies. Lead Agency: DDOT.
Implement the Green Collar Jobs Initiative	Business, Jobs, and Economic Development; Government and City Operations	In progress	DOES	Development	The Green Collar Jobs Initiative is a cooperative effort among the District Government, for-profit entities, non-profit organizations, and academic institutions to help prepare District residents and businesses to take advantage of the growing green sector of the economy. The Office of Planning will issue a report for the Mayor and launch a pilot training program in 2009. Lead Agency: DOES. Other Agencies: OP, DDOE

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4.1.3.1 DDOT Sustainability Plan

The District Department of Transportation (DDOT) transportation right-of-way represents 22% of all of the land within the District, making it one of the District's largest landowners. DDOT's responsibilities include the design, building, and maintenance of 1,100 miles of streets; 241 bridges; 1,600 miles of sidewalks; and 453 miles of alleys. Through its Urban Forestry Administration, DDOT also provides for the care and maintenance of 144,000 city street trees.

One of DDOT's greatest challenges is to provide a sustainable transportation system that enhances the economy and promotes livability while protecting the environment. DDOT's Sustainability Plan identifies 8 priority areas, each with measurable goals, to ensure that the department works to meet current needs in a manner that is not compromising the needs of future generations. The following is a list of recommended actions, measures, and targets from these priority areas which are relevant to DC Water's green infrastructure planning efforts (DDOT, 2010b).

Table 4-2. DDOT Goals, Actions, Measures, and Targets Related to Green Stormwater Infrastructure

Goal	Action	Measure	Target
Build great streetscapes to promote economic vitality	Implement the Great Streets program and incorporate the Great Streets principles into all streetscape projects	Number of miles of streetscape improved	Increase 2 miles per year
		Increase in usable open/green space	0.3% annually
Incorporate environmental features in transportation projects	Increase environmentally focused projects & address environmental considerations in project planning and development process	Number of environmenttally focused projects	5 projects per year
		Number of environmental components	At least 1 component per project annually
Reduce air pollution	Promote and implement transportation projects that reduce air emissions	Reduction (in lbs) of pollution due to DDOT projects	Reduce 5% annually
Minimize the environmental impacts of transportation infrastructure	Implement Congestion Mitigation and Air Quality Improvement Program	Number of vehicles taken off the road through CMAQ Program	700 vehicles per year
	Use low impact development approach to manage stormwater runoff	Treat and reduce runoff volume from impervious surface in the right-of-way using LID	Reduce 5% annually
Reduce greenhouse gas emissions	Promote and implement transportation projects that reduce greenhouse gas emissions	Reduction of annual greenhouse gas emissions from DDOT projects	Reduce 5% annually
Partner with local stakeholders to help protect and preserve assets	Launch a tree steward program to encourage community involvement in protecting street trees	Number of Canopy Keepers	Increase by 150 per year

Source: DDOT, 2010b

4.1.3.2 DDOE Wildlife Action Plan

In 2006, the District Department of the Environment's Fisheries and Wildlife Division produced a Wildlife Action Plan (WAP) in order to identify species of greatest conservation need, their habitats and locations, and action needed to protect, conserve, and enhance the species and their habitats. The District houses a diverse array of flora and fauna. Its river system and urban landscape provide habitat to 149 species of greatest conservation need. Through the preparation of the WAP, DDOE determined that more than 500 species of birds, fish, mammals, reptiles, and amphibians exist within the District's boundaries, with the number of invertebrates estimated to be in the thousands (DDOE, 2006a; DDOT, 2010b).

Providing suitable environments in fragmented, urbanized areas is one of the District's greatest challenges. Table 4-3 and Table 4-4 show the greatest identified threats to terrestrial and aquatic habitats with a priority ranking greater or equal to 1.

Table 4-5 identifies conservation actions related to green infrastructure planning for both terrestrial and aquatic habitats.

Table 4-3. Top Threats to Terrestrial Habitats

Threat	Priority Rank
Invasive/alien species	2.5
Recreation	1.6
Fragmentation	1.6
Dumping	1.5
Contaminants	1.5
Noise pollution	1.5
Habitat loss	1.4
Parasites/pathogens	1.3
Overbrowsing	1.2
Stormwater erosion	1
Air Pollution	1

Source: DDOE, 2006a

Table 4-4. Top Threats to Aquatic Habitats

Threat	Priority Rank
Invasive/alien species	2.1
Sedimentation	2.1
Changes to hydrologic regimes	2
Stormwater erosion	1.9
Pollution	1.9
Erosion	1.2
Habitat loss	1

Source: DDOE, 2006a

Table 4-5. Overarching Conservation Actions Related to Green Infrastructure Planning[1]

Threat	Conservation Plan	Action
Sedimentation	Reduce Sedimentation	Promote best management practices for all DC projects
		Create/enhance buffers of vegetation along rivers for bank stabilization
Changes to Hydrologic Regimes	Reduce or eliminate activities that cause changes to hydrologic regimes	Preserve groundwater recharge areas and avoid creating impervious surfaces, and where possible, remove impervious surfaces
		Maximize the effects of stormwater management projects on maintaining the hydrologic regime
		Promote 'best management practices' for all DC projects to increase the quality of runoff
Stormwater Erosion	Reduce or eliminate stormwater runoff	Implement the District's stormwater control plan District-wide
		Promote 'best management practices' for all new DC development projects
		Work with contractors and designers during the planning process to mitigate stormwater runoff
Erosion	Reduce or eliminate erosion	Promote 'best management practices' for all new DC development projects; perform stream bank restoration

Source: DDOE, 2006a

[1] While additional action plan exist for the various habitats identified, only those related to green stormwater infrastructure were included in this table.

4.2 Small Area Plans and Studies, Comprehensive Plan Area Elements, and Retail Action Strategies – Office of Planning

Office of Planning documents such as the comprehensive plan, the District's 20 small area plans, and various retail action strategies help to guide development throughout the city. Many such plans, which are prepared with community input, include language supportive of green stormwater infrastructure, and as such, can provide guidance to DC Water in identifying and selecting project areas and green infrastructure practices that are desired by the community. The identified sample subsheds fall into three of the District's eight wards: Wards 2, 3, and 4. In order to determine whether the incorporation of green infrastructure stormwater practices was supported by planning documents, a thorough review of the planning documents for each of the four wards was performed. The following information includes a brief description of each ward, as well as information pulled from existing planning documents that either support or highlight opportunities for green infrastructure practices to be incorporated.

4.2.1 Ward 2

Ward 2 encompasses most of Downtown DC and includes the National Mall, the White House, and many monuments and museums, as well as Federal Triangle and Southwest Federal Center. The ward contains some of the most diverse housing stock, varying from single-family homes to high-rise apartments. While the area has experienced a lot of growth and redevelopment over the past ten years, some of the oldest residential neighborhoods are situated in Ward 2, including Georgetown (027-003), which predates the

District of Columbia and is known for its shopping and village-like setting. Foggy Bottom and the West End, also located in Ward 2, comprise a mix of historic townhouses, apartment and office buildings, while Sheridan-Kalorama and DuPont Circle include larger Victorian townhomes and mansions. Logan Circle (020-007), Mount Vernon Square, and Shaw neighborhoods include a mix of renovated houses and new multi-family and commercial development, primarily along 14th Street corridor. Ward 2 also includes the area along the Whitehurst Freeway (026-001) (DC OP, no date b).

4.2.1.1 Office of Planning Documents Affecting Identified CSO Subsheds in Ward 2

Affected Subsheds: 020-007, 027-003, 026-001

Small Area Plans and Studies Affecting Identified Subsheds

- Logan Circle Neighborhood Investment Fund (DC OP, 2008d):
  - **Investment Goal #3:** Provide a walkable safer, cleaner and more active environment, including clean sidewalks, maintained tree boxes and other aesthetic amenities to encourage more people to frequent the commercial corridors.
  - **Strategy 1:** Support public space maintenance programs along the five main corridors of 14th Street, U Street, **11th Street, Rhode Island Avenue,** and 9th Street to improve cleanliness, safety, and appearance. This strategy proposes using NIF funding for activities that are geared towards street cleaning, **street greening activities,** or other safety improvements (includes **020-007**, though largely residential).

Comprehensive Plan Area Elements Affecting Identified Subsheds

- Near Northwest Area Element (DC OP, 2006b):
  - Largely corresponds to Ward 2's inner core and affects all subsheds and CSOs in Ward 2 (020-007, 027-003, and 026-001).
  - Parts of the area still struggling to find balance between development and preservation.
  - Near Northwest has higher percentages of commercial and institutional land. However, street rights-of-way occupy more land than any other use in the Planning Area, representing about 1/3 of the total acreage, due to the prominent street grid and broad avenues.
  - Residential uses occupy 26% of total land area. Of this, about 30% is mid- to high-rise apartments, 55% row houses, and 15% single family detached or semi-detached homes. The percentage of housing units in large apartment buildings is double the citywide average. Recreational and open space make up 16% of the area; slightly below the citywide average.
  - Maintaining its tree-lined streets, urbane and historic architecture, and the proportions of its buildings and public spaces is a top priority for the community.
  - Need to retain and enhance existing parks, make better use of street rights-of-way as open space, provide better connections to the area’s large parks, and set aside ample open space within new development. Landscaping, tree planting, and rooftop gardens should all be strongly encouraged.
  - **Policy NNW-1.1.12: Pedestrian Connections**. Improve pedestrian connections through Near Northwest, especially between the DuPont/Logan Circle area (**020-007**) and Downtown, and along the waterfronts in the Georgetown area (**026-001**). Create a continuous tree canopy along the area’s streets to create more comfortable conditions for pedestrians and bicyclists.
  - **Policy NNW-1.2.10: Sustainable Development.** Encourage the use of **green building practices** within Near Northwest, with **emphasis on green roofs.** Rooftop gardens

should be encouraged in new construction and major rehabilitation projects to create additional green space, reduce stormwater runoff, and provide an amenity for residents.
  - **Policy NNW-2.4.1: Georgetown Waterfront.** Provide a continuous linear park connection along the Potomac River waterfront in Georgetown and Foggy Bottom, including paths for pedestrians and bicyclists, fountains, seating areas, landscaping and open space, lighting, public access to the water, new non-motorized boating facilities, and fishing areas **(026-001)**.

Retail Action Strategies Affecting Identified Subsheds

- N/A

4.2.2 Ward 3

Ward 3 is largely residential and located in the upper northwest portion of the District. It consists of a number of local commercial centers with shops and restaurants surrounded by clusters of dense apartment buildings and/or townhouses which spread to single-family homes. Only one CSO subshed (029-003) falls within Ward 3.

4.2.2.1 Office of Planning Documents Affecting Identified CSO Subsheds in Ward 3

Affected Subsheds: 029-003

Small Area Plans and Studies Affecting Identified Subsheds

- Glover Park Commercial District Study (DC OP, 2006d):
  - Affects CSO Subshed 029-003
  - An analysis to investigate existing retail, public realm, pedestrian mobility and parking circulation issues along Wisconsin Avenue within the Glover Park Commercial District in Northwest Washington to recommend appropriate and implementable improvements.
  - The commercial district is identified as having narrow sidewalks along parts, limiting safe and comfortable pedestrian movements, opportunities for outdoor seating, and public space enhancements including adequate street tree plantings
  - Providing improved and safer accessibility to this area is also a critical issue
  - Area-wide general recommendations include exploring the potential of widening of the sidewalks in selected locations to allow for improved street tree planting, a safer and accessible sidewalk environment, and shorter street crossings
  - The plan also recommended initiating discussions with DDOT, DPW, and DPR to widen sidewalks in certain areas, and to replace dead or dying street trees with new trees.

Comprehensive Plan Area Elements Affecting Identified Subsheds

- Rock Creek West Area Element (DC OP, 2006b):
  - Affects CSO Subshed 029-003
  - Describes the Glover Park area (029-003) as consisting of row house and garden apartment
  - Includes a policy to ensure that future development along Wisconsin Avenue is physically compatible with and architecturally sensitive to adjoining residential neighborhoods. Interface improvements include landscaping, screening, and additional green space improvements

Retail Action Strategies Affecting Identified Subsheds

- N/A

4.2.3 Ward 4

Ward 4 is largely residential. Located in the northern portion of the District, it is bisected by Georgia Avenue. Smaller, local commercial areas include Kennedy Street, NW in Brightwood (049-018) and portions of 14th Street. Brightwood is one of the largest neighborhoods in the city, sits in the middle of the ward, and is made up of a variety of townhouses, small apartment buildings, and comfortable single-family homes (049-018 and 049-019)(DC OP, no date c). In the Winter/Spring 2011 Ward 4 Development Summary prepared by the Office of Planning, several major public and private sector development projects were identified for the Brightwood area which may or may not affect possible future green infrastructure demonstration projects.

4.2.3.1 Office of Planning Documents Affecting Identified CSO Subsheds in Ward 4

Affected Subsheds: 049-018 and 049-019

Small Area Plans and Studies Affecting Identified Subsheds

- Kennedy Street Corridor Revitalization Plan (DC OP, 2008c):
  - Includes 049-018; Adjacent to 049-019.
  - Incorporates one-mile-long stretch of Kennedy Street corridor, extends from N. Capital St. on the east to Georgia Ave on the west, spanning the Brightwood Park and South Manor Park neighborhoods of Ward 4.
  - Kennedy St. has limited green space along the street. There are some mature shade trees, but corridor would benefit by more landscaping and planting of street trees.
  - Identifies the Missouri/Kansas/Kennedy intersection as a site in need of improved pedestrian and vehicular safety. Provision of additional green space seen as enhancing safety and aesthetics.
  - Highlights the need for additional green spaces, such as in left-over spaces in public right-of-way or empty lots. Most corner intersections (049-018) and south side of Kennedy St between 3rd and North Capital & area east of Missouri/Kansas (049-018, adjacent 049-019) have sidewalk dimensions greater than 20 feet, which can potentially provide areas for enhanced landscaping, etc.
  - For transportation, encourage “greening of the street” through continuous lines of trees & other landscape elements.

Comprehensive Plan Area Elements Affecting Identified Subsheds

- Rock Creek East Area Element (DC OP, 2006c)
  - Largely residential with many low and moderate density neighborhoods known for park-like ambiance, sense of community, open spaces, and family atmosphere. Includes row house and semi-detached neighborhoods such as Brightwood & Brightwood Park (049-018 and 049-019)
  - Shared goal of keeping Rock Creek East stable, healthy, and attractive, while retaining residential character, appearance, and historical continuity. Will require that steps are taken to conserve neighborhoods, enhance environmental quality, and provide effective transportation network.

- Residential is largest land use (33% total area, or 1,635 acres), with more than 90% single family/row homes. Low densities. Concentrations of more dense housing exist in Brightwood, Brightwood Park, and Petworth, with largest concentration of apartments along 14th Street corridor.
- Commercial and industrial uses make up just 2.5%. Retail/service businesses along Georgia Ave and Kennedy St NW.
- 18% open space (mostly Rock Creek Park and valleys).
- Limited/no reference to green infrastructure/LID.

Retail Action Strategies Affecting Identified Subsheds

- Kennedy Street Retail Action Strategy (DC OP, 2009b):
  - Includes 049-018. Adjacent to 049-019.
  - A neighborhood Retail Submarket Assessment and Demand Analysis for Kennedy St.
  - Notes that Kennedy St. is distinguished by its brick sidewalks; however, lots of residences with ground-floor retail have paved-over front yards and concrete predominates. There is opportunity to make the streetscape more inviting through regular plantings.

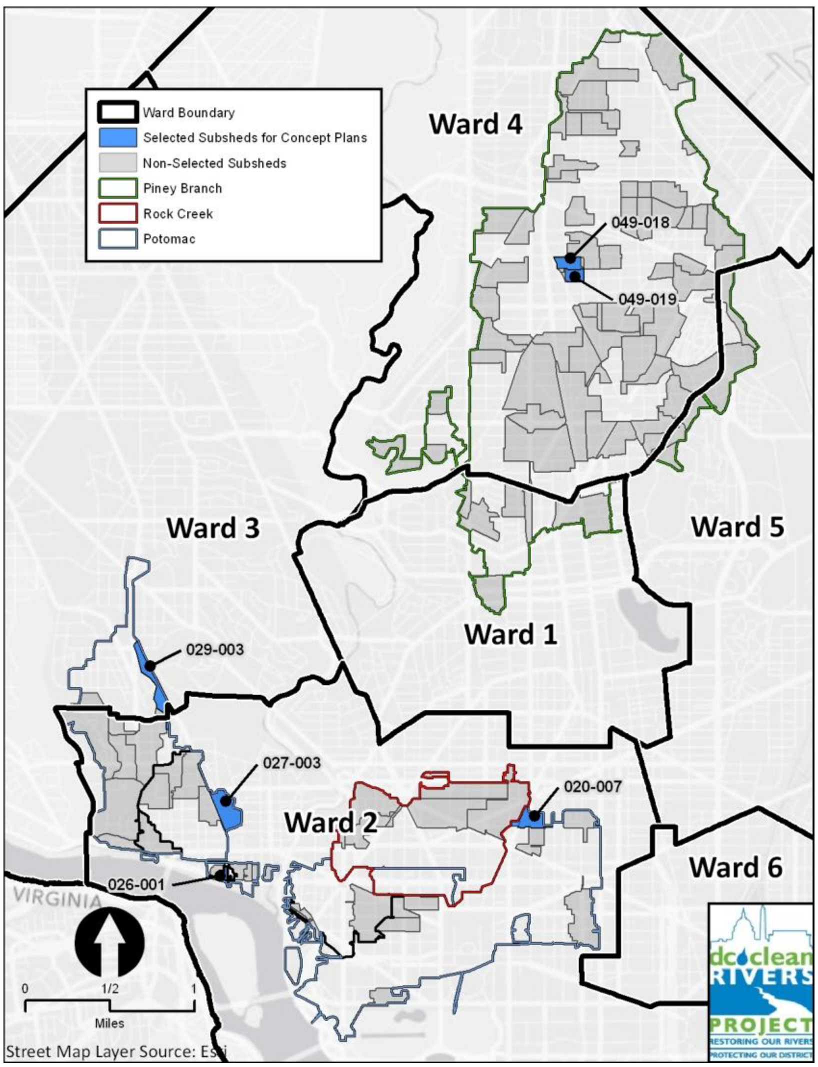

Figure 4-1. CSO Sample Subsheds by Ward, Source: WSSI

4.3 Green Infrastructure Federal and Local

4.3.1 Capital Space Plan

In 2006, the District's Department of Parks and Recreation (DPR) and Office of Planning (OP), the National Park Service (NPS), and the National Capital Planning Commission (NCPC) formed CapitalSpace to coordinate and maximize the management of the District's parks system. In 2010, the group released its CapitalSpace plan that provides a "vision for a beautiful, high-quality, and unified park system for Washington and offers six action-oriented ideas focused on key areas to help make the vision a reality." (NPCC et al, 2011).

Of the six ideas presented in the plan, one—*enhance urban natural areas*—incorporates the use of green infrastructure networks to improve air quality and water quality, and address climate change. Associated action items that are relevant to DC Water's green stormwater infrastructure pilots are as follows (see Table 4-6).

Table 4-6. Recommended CapitalSpace Actions to Enhance Urban Natural Areas As Related to DC Water's Green Stormwater Management Efforts

Recommendation	Action
Form an Urban Natural Areas Team (*ENV-1*)	Map the ecological functions, including existing wildlife habitats, wetlands, floodplains, tree canopy, etc., within the parks and an open-space system to ensure there is a unified inventory of existing green infrastructure and essential ecological functions within the parks system.
	Coordinate future research efforts being undertaken on natural resources by the National Park Service, including the Center for Urban Ecology, the District government, and other federal agencies such as the Department of Agriculture.
	Launch a District-wide ecosystem research consortium to apply new research strategies to measure and protect ecological functions.
Protect Ecological Functions (*ENV-2*)	Adopt clear, consistent, and shared goals among responsible agencies and adjacent jurisdictions for long-term resource management.
	Establish and implement a District-wide tree canopy goal that applies to local and federal parks.
	Adopt park management goals that support the conservation of native species, protect critical habitats, and increase biodiversity. Reintroduce native plants and eliminate exotic invasive species where feasible.
	Develop and map resource protection districts to minimize the impacts of urbanization and development on natural areas.
	Implement cooperative watershed management strategies with adjacent counties that engage stakeholders, leverage resources, and empower neighborhoods to limit pollution and stormwater run-off.
	Identify the role Washington's parks, open spaces, and rivers play in climate change, and adopt a climate adaptation plan for essential ecological functions as affected by global warming relative to floodplains and species migration.
	Identify the environmental corridors that create the physical connection of the park system within the city and connections to larger regional systems.
	Adopt park management goals that support restoration of the Anacostia and Potomac Rivers.
Synchronize Park Management Strategies among Jurisdictions (*ENV-3*)	Identify and rank parks and open spaces in need of preservation and restoration. Target funding for programming, research, and mitigation based on greatest need.
	Target off-site environmental mitigation efforts towards enhancing or restoring designated urban natural areas.
	Develop uniform standards and employ best management practices in all parks and natural areas for maintenance and operations, stormwater, water usage, pest management, and recreation programming.
Build a Green Infrastructure Network (*ENV-4*)	Design and build new green infrastructure to supplement existing gray infrastructure, when possible.
	Designate green infrastructure as a public utility in capital programs.
	Launch a Green-Parks Training Program which will train employees on sustainable land management techniques.
	Better connect green roof habitats to animal migration programs and patterns.

Source: Adapted from the CapitalSpace plan (NCPC, DC and NPS, 2010).

4.3.2 US Navy's Low Impact Development Policy

In late 2007, the US Navy announced a new LID Policy to guide stormwater management at its facilities. Starting in 2011, the policy calls for "no net increase" in the amount of stormwater volume and pollutant loads (nutrients and sediments) escaping into the surrounding ecosystem for all new Navy and Marine construction projects exceeding $750,000 and renovation projects of $5 million or more. Prior to 2011, the policy called for incorporating green infrastructure/LID practices where possible (Buranen, 2010).

4.4 Conclusions

The District's existing policies and plans highlight the opportunity for coordination and cooperation among agencies to build, monitor, measure, and maintain a green infrastructure network. DC Water, for example, should work with DDOE and DDOT to ensure that design guidelines being prepared for various green infrastructure techniques are compatible.

The Draft Climate Action Plan highlights the multifunctionality of green infrastructure. A single practice can provide many benefits, the sum of which provides more than the individual, seemingly disparate functions. The need to quantify such benefits and ensure such benefits are being delivered—especially when being used to meet regulatory requirements or when using public funds—is important. This desire to ensure that standards are synchronized and benefits are quantified is echoed in the federal-local CapitalSpace plan.

5 Regulations Affecting Green Infrastructure Stormwater Practices

Because DC Water is not a significant landholder within the District, its ability is limited in implementing green infrastructure practices on its own land. DC Water also does not control development or redevelopment within the District, meaning that it cannot mandate the implementation of green infrastructure projects District-wide. The District of Columbia does, however, have a number of regulations in place to encourage the use of green infrastructure practices on-site to control stormwater runoff volumes, including:

- Erosion and sediment control regulations on all new development and re-development to slow stormwater inputs and limit sediments and contaminants reaching the Anacostia, Rock Creek, and Potomac watersheds.
- The restriction of illegal storm sewer discharges and the location and correction of existing illegal connections to reduce bacterial contamination levels.
- Changes to the building codes in 2004 to allow for disconnected downspouts.
- An impervious surface charge implemented by DC Water to help reduce polluted stormwater runoff.

In addition, the District has prepared draft stormwater management regulations and an associated stormwater management guidebook, as well as a green area ratio element as part of its upcoming zoning updates that should positively influence the degree to which green infrastructure is integrated into stormwater management planning for both public and private development and redevelopment. The following is a summary of both existing and upcoming regulations most supportive of green infrastructure management.

5.1 District of Columbia Regulations

5.1.1 2013 Rule of Stormwater Management and Soil Erosion and Sediment Control

On October 7, 2011, the EPA approved a new MS4 stormwater permit for development and redevelopment projects $\geq$ 5,000 square feet within the District to retain the first 1.2 inches of rainfall on-site through the use of green infrastructure controls. The permit provided the District 18 months from the time of its issuance to update existing stormwater regulations, and also required the District to remove any barriers to implementation from other codes and regulations such as buildings, health, and road and transportation. Within 18 months, the District was also required to establish a fee-in-lieu program and a tracking and accounting system to verify that stormwater practices are implemented and maintained. Other measures within the permit required the District to:

- Plant a minimum of 4,150 trees yearly;
- Add a minimum of 350,000 square feet of green roofs on city properties;
- Develop and implement a stormwater retrofit strategy to manage runoff from 18 million square feet of impervious surfaces;
- Develop an ecosystem-based integrated pest management program that limits and restricts the use of fertilizers;
- Prevent more than 103,000 pounds of trash from being discharged to the Anacostia River annually; and

- Develop consolidated implementation plans to restore the Anacostia, Rock Creek, and Potomac watersheds.

Any incentives for achieving other environmental objectives such as air quality improvements and energy savings must be subject to the same level of plan review, installation, and maintenance requirements as stormwater controls (NPDES, 2011).

Prior to the new MS4 stormwater permit, laws and regulations governing stormwater management in the District included D.C. LAW 5-188, D.C. Code, Section 6-933 and 6-940 (The District of Columbia-Water Pollution Control Act of 1984, and subsequent Amendments) and DCMR 21, Chapter 5 (Sections 526-535: The District of Columbia-Storm Water Management Regulations). In expectation of the new MS4 permit, DDOE promulgated amended DCMR 21, Chapter 5 on July 19, 2013. The new stormwater management regulations feature a 1.2 inch retention standard for regulated development sites, along with a Stormwater Retention Credit (SRC) Trading Program to allow for flexibility in the placement of stormwater retrofits on other sites once a minimum amount of stormwater has been retained on-site.

5.1.2 2013 Stormwater Management Guidebook

In addition to preparing stormwater management regulations, the District has also developed an updated stormwater management guidebook to provide performance and design criteria for identified green infrastructure practices, as required by the new MS4 permit and stormwater management rule. The 2013 Stormwater Management Guidebook includes criteria for the following green infrastructure practices: green roofs, rain water harvesting, impervious surface disconnections, permeable paving, bioretention, filters, infiltration, open channels, ponds, wetland, storage, and proprietary practices. The document was finalized on July 19, 2013.

5.1.3 Upcoming Zoning Update – Green Area Ratio

Over the past several years, the District has been in a process of reviewing and updating its zoning code, which was originally enacted in 1958 (DC OP, no date). Through this process, the District identified its current zoning code as an impediment to green building practices, and has updated the code in June, 2013 to include a Green Area Ratio (GAR) element. The GAR requires new development or redevelopment/renovations over a particular size—with the exception of row dwellings, single-family homes, 2-unit condos or apartments, and accessory dwellings—to achieve a specified level of environmental performance per zone to meet the goals for stormwater runoff, air quality, and urban heat island reduction. Unlike the District’s stormwater goals which require a certain volume of runoff to be captures, the GAR’s standards are more qualitative and allow for flexibility in the implementation of green infrastructure practices such as trees, permeable pavers, and green roofs to achieve its environmental performance standards (DC OP, 2013).

5.1.4 Stormwater Management Enhancement Act of 2008

In 2009, the District adopted legislation allowing DDOE to modify their rate structure to assess stormwater fees based on the amount of impervious cover (such as roofs, paved sidewalks and roads, etc.) in order to address the costs of the District’s prior MS4 Permit. By doing so, the District shifted the costs of stormwater management as established under the Storm Water Permit Compliance Act of 2000 to properties that generate large volumes of stormwater runoff—such as commercial areas with large parking lots—providing incentives for new and existing development to reduce imperviousness or retrofit paved areas with green stormwater infrastructure practices. The legislation established a Stormwater User Fee Discount Program to provide property owners with reductions in their stormwater user fees for reducing the amount of impervious surface on site. Low- and fixed-income residents can also receive assistance to mitigate the impact of the fee.

5.1.5 Green Building Act of 2006

The Green Building Act of 2006 required the District's mayor to incorporate green building practices into its building code, which removed impediments to downspout disconnections, retaining rainwater on-site, green piping, and the use of waterless urinals. Other revisions included incorporating the use of LEED, ENERGY STAR, International Energy Conservation Code 2006, and ASHRAE 189.1 standards (DDOE & DC OP, no date; Majersik, 2009; Green Building Act of 2006).

5.1.6 Urban Forest Preservation Act of 2002

In 2003, the District adopted the Urban Forest Preservation Act of 2002, establishing an urban forest preservation program housed under DDOT that requires permits for Special Tree removals (e.g., those with a circumference of 55 inches or more) or replacements, and establishing a Tree Fund to be used to defray costs associated with this act (DDOT, 2003). In 2009, the regulation was further amended to establish an income-contingent program to assist lower income residents offset the costs of removing hazardous Special Trees (DDOT, 2009b).

5.2 Federal Regulations

5.2.1 Chesapeake Bay Total Maximum Daily Load of 2010

In December 2010, the EPA issued its biggest ever Total Maximum Daily Load (TMDL) for the Chesapeake Bay watershed under the authorization of the Clean Water Act. The TMDL was issued due to non-attainment of water quality standards for the Bay and the rivers feeding into it. The TMDL imposes maximum loadings for nitrogen, phosphorus and sediment for the Bay and its 92 tidal segments. This included the six states and the District of Columbia that drain into the Chesapeake.

To meet the requirements of the TMDL, the District of Columbia and the six states will have to substantially reduce non-point sources of pollutants (e.g., agriculture and stormwater runoff). Due to EPA's limited control over these activities under the Clean Water Act, the District and the states have instead developed "Watershed Implementation Plans" to chart out the activities each will employ to achieve the necessary reductions in as cost-effective a manner as possible. In the District, most of the reductions will be achieved through upgrades to the CSS, Blue Plains, and the Washington Aqueduct. The plan also incorporates a 1.2" retention stormwater volume standard that is consistent with the District's newly approved MS4 permit in order to account for additional reductions (DDOE, 2010a) (CBF, no date).

5.2.2 Total Maximum Daily Loads for the Anacostia, Potomac, and Rock Creek

Separate from the Chesapeake Bay TMDL, several others have been prepared for the District since 2003. As detailed in the District's 2010 Watershed Implementation Plan for the Chesapeake (DDOE, 2010a), these include TMDLs for:

- Fecal Coliform Bacteria in the Upper and Lower Anacostia River (2003)
- Organics and Metals in the Anacostia River and Tributaries (2003)
- Biochemical Oxygen Demand (BOD) in the Upper and Lower Anacostia River (2001)
- Total Suspended Solids (TSS) in the Upper and Lower Anacostia River (2002)
- Fecal Coliform Bacteria in Kingman Lake (2003)
- Total Suspended Solids, Oil and Grease and Biochemical Oxygen Demand in Kingman Lake (2003)
- Fecal Coliform Bacteria in Rock Creek (2004)
- Organics and Metals in the Tributaries to Rock Creek (2004)
- Fecal Coliform Bacteria in the Upper, Middle and Lower Potomac River and Tributaries (2004)
- Organics, Metals and Bacteria in Oxon Run (2004)
- Organics in the Tidal Basin and Washington Ship Channel (2004)
- Nutrients/Biochemical Oxygen Demand for the Anacostia River Basin in Maryland and the District (2008)
- Sediment/Total Suspended Solids for the Anacostia River Basin in Maryland and the District (2007)
- PCBs for Tidal Portions of the Potomac and Anacostia Rivers in the District of Columbia, Maryland and Virginia (2007)
- Trash for the Anacostia River Watershed, Montgomery and Prince George's Counties, Maryland and the District of Columbia (2010)

5.2.3 Energy Independence and Security Act of 2007

Section 438 of the Energy Independence and Security Act of 2007 requires federal agencies to reduce stormwater runoff from federal development and redevelopment projects of 5,000 square feet or greater in size to pre-development hydrology in regards to temperature, rate, volume, and flow duration. To assist federal agencies with implementing the requirements, the EPA produced a guidance document in 2009 which includes stormwater management requirements, appropriate control techniques, benefits of complying, and compliance scenarios which rely on green infrastructure practices. The guidance document outlines two options for federal developments to demonstrate that they are maintaining pre-development hydrology: manage the total volume of rainfall from the 95th percentile storm on-site (which, in the District, is 1.7 inches), or replicate pre-development hydrology by managing the total volume of rainfall on-site based on a site-specific hydrologic analysis (EPA, 2009a).

5.2.4 Emerging Issues: Post-Construction Stormwater Rulemaking

In 2009, the EPA announced its intent to modify and strengthen national stormwater regulations. Pulling from various state examples with strong performance-based stormwater programs and an influential National Research Council report (NRC, 2008), identified areas to address include:

- Developing performance standards for newly developed and redeveloped sites.
- Developing a set of consistent stormwater requirements for all MS4 systems and requiring stormwater retrofits in areas of existing development.

- Incorporating additional stormwater provisions that protect sensitive areas, such as highly erodible soils or steep slopes.
- Imposing additional requirements within the Chesapeake Bay watershed to further reduce the impacts of stormwater.
- Exploring the addition of transportation infrastructure-specific stormwater measures.

New stormwater regulations are currently slated to be proposed in December 2011 and finalized in November 2012 (EPA, 2009b) (EPA, 2011b). Such an approach is expected to advance green infrastructure practices nation-wide.

5.3 Conclusions

Both existing and anticipated local and federal regulations provide the District with incentives for pursuing green infrastructure. It plays a predominant role, for example, in the upcoming stormwater regulations as part of the District's new MS4 permit, and has been highlighted in the District's Watershed Implementation Plan for the Chesapeake Bay TMDL as a means for reducing pollutant levels of nitrogen, phosphorous, and sediment. The Green Area Ratio element, which is expected to soon be incorporated into the District's zoning laws, further encourages the use of green infrastructure to meet environmental performance objectives.

The intent of this review was to determine whether the overarching regulatory environment encourages green infrastructure. As such, it did not go into a detailed review of the various codes to determine whether and where discrepancies exist that may limit or deter the implementation of particular practices. As design criteria are established for the various green infrastructure practices, a thorough review of existing codes and regulations (e.g., building codes, Department of Health regulations) to ensure that practices can be safely and effectively implemented.

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6 Current Green Infrastructure Programs/Projects by District Agency

The District has gained much experience in implementing green infrastructure programs over the past decade. DDOT's experience in planning and installing Great Streets and green alleys has increased its knowledge in designing and implementing rain gardens, grass swales, tree box filters, vegetated filter strips, and pervious pavements in urban street rights-of-ways. Through its RiverSmart programs, DDOE has been extremely successful in voluntarily engaging home and business owners to implement green infrastructure practices on private property. And both DDOT—through its Urban Forestry Administration—and DDOE have successfully partnered with nonprofit groups such as Casey Trees and the Alliance for the Chesapeake Bay to expand their reach throughout the District. This chapter highlights the various programs that the District has already implemented.

6.1 District Department of Transportation

6.1.1 Great Streets Initiative

The Great Streets Initiative is a multi-agency initiative involving DDOT, OP, and the Deputy Mayor for Planning and Economic Development. Its goal is to revitalize major urban corridors in the district by improving transportation, catalyzing private investment, and providing environmental benefits through incorporating green infrastructure practices into the streetscape. The Great Streets Initiative affects about 22 miles of street corridors, with more than $200 million being invested in transportation, transit, streetscape, mixed use development projects, and storefront improvements. In 2008, the District set aside $95 million in Tax Increment Financing for neighborhood development projects (DC DMPED, no date) while DDOT's transportation investments have been slated for $150 million (DDOT, 2009a). Some projects have been partly funded by the American Recovery and Reinvestment Act of 2009 (ARRA). These include the Pennsylvania Avenue Great Streets Project, a $30 million construction project east of the Anacostia River, and the Nannie Helen Burroughs Avenue Great Streets Project, which also received joint grant from FHWA and the EPA under the Green Highway Partnership for the project's environmental elements (DDOT, no date).

To capture and treat stormwater runoff from ½ inch and, where possible, 1 inch rain events, the Great Streets Initiative incorporates green infrastructure practices such as permeable pavement, reducing paving in tree spaces, and utilizing innovative tree space design techniques. For example, the Nannie Helen Burroughs Avenue Great Street Project, which is 1.5 miles in length, covers a drainage area of 8.44 acres. Green infrastructure practices, which include 2 bioretention cells, 1 bioswale, 12 stormwater planters , and permeable concrete sidewalk, will capture and treat 2.13 acres, while 39 water quality catch basins will capture and treat 6.97 acres. Cost estimates for the improved stormwater management include $767,500 for the 39 water quality catch basins, $46,000 for 3 filter catch basins, and $438,000 for the additional green infrastructure practices (DDOT, 2010c). Table 6-1 lists all of the Great Streets projects within the District.

Table 6-1. Great Streets in the District

Great Street	Ward	Corridor Length	Estimated Cost
Georgia Avenue NW & 7th Street	4	5.6 miles	$7.9 million
North Capitol	5	~	~
Rhode Island Avenue NE	5	3 miles	undetermined
H St NE & Benning Road NE/SE	6,7	5 miles	$30 million
Minnesota Ave NE/SE	7	3.5 miles	$12.5 million
Nannie Helen Burroughs Ave NE	7	1.5 miles	$10 million
Pennsylvania Ave SE	7	2 miles	$30 million
North Capitol	5	~	~
Martin Luther King Jr. Ave SE & South Capitol St	8	4.5 miles	$11.5 million

Sources: Boese, 2010; DDOT 2010a
[1] Information obtained from individual Great Streets Framework Plans and Small Area Plans.

6.1.2 Green Infrastructure Demonstrations

In addition to the Great Streets Initiative, DDOT has implemented several other green infrastructure projects utilizing a variety of funding sources. For federally funded transportation construction projects, green infrastructure can be incorporated into the larger transportation project's funding allocation. Funding for stand-alone stormwater retrofit projects, however, is more limited, with projects typically funded through the local Stormwater Permit Compliance Enterprise Fund. ARRA funds through the Clean Water State Revolving Fund Green Reserve have also been used for green infrastructure and impervious surface removal projects. In 2010, DDOT had four staff positions funded from the Stormwater Compliance Enterprise Fund focused specifically on advancing the use of green infrastructure in DDOT projects.

Table 6-2 provides a list of known DDOT projects where green infrastructure practices have been incorporated (DDOT, 2010d).

Table 6-2. Green Alleys and Other Current Transportation Projects Involving the Use of Green Infrastructure

Name	Ward	Description
Q Street Green Alley	3	Design of green alley to reduce runoff volume, improve water quality, and improve pedestrian access (2009-2012)
14th Street NW Streetscape: Thomas Circle to Florida Ave	1	Design of sidewalk reconstruction, roadway resurfacing, new granite curb & gutter, new trees, bulbouts and LID devices
Green Alley Ward 3 & 4, Ashley Terrace + Rittenhouse at 34th	3 & 4	Construction of green alley; implementation of LID practices as part of the city's MS4 Permit
RiverSmart Washington, Quesada & 33rd St NW	4	Design to implement LID to maximum extent practicable in the sewershed and measure stormwater runoff reduction to quantify the impact of green infrastructure
RiverSmart Washington, Iowa Ave & Webster St NW	4	Design to implement LID to maximum extent practicable in the sewershed and measure stormwater runoff reduction to quantify the impact of green infrastructure
Green Alley – Upshur St at 22nd Street	5	Design to implement LID practices in green alley as part of the city's MS4 Permit
Green Alleys near Watts Brach	7	Design to implement LID practices as part of the city's MS4 Permit in several alleys near Watts Branch
Design of LID, BMP Water Quality Control	~	Construction for implementation of LID practices to manage stormwater from streets and sidewalk in public ROW at East Beach Drive, Erie Place, Fitch Place, and Fort D
Bio-Retention Cell Reconstruction	2	Re-construction of a bio-retention cell at the intersection of Rhode Island Avenue, Connecticut Avenue and M Street NW
11th Street South Bridge Project	2	Replacement of 11th Street bridge structure includes 8 bioretention areas to capture & treat 13.59 acres, 17 grass channels to slow and treat 7.91 acres, and roughly 90 water quality catch basins to treat 16.88 acres.
Benning Road NE Bridge	7	Kingman Island bioretention areas (2004). Monitored for pollutant removal through Howard University (2004 – 2006).
Irving Street Cloverleaf NE	5	Bioretention retrofits (2007)
I-295 SE	~	Grass swale retrofit (2007)
Nebraska Ave NW	4	Bioswales (2009)
Anacostia Riverwalk Trail SE/NE	~	Bioretention areas & bioswales (2008)
Ft DuPont St & Q St SE, Erie St SE	~	LID curb bumpouts for traffic calming (2009 – 2012)
East Beach Dr NW & Fitch Pl NE	~	Streetside stormwater management adjacent to park areas (2009 – 2012)
Tree space/public space retrofits	All	Impervious surface removal in tree space and public space, citywide (2009-2012)

Source: As reported on DDOT's web-based Dashboard, the District Transportation Access Portal Beta 2.0, the 2010 DDOT LID Action Plan, and from information obtained directly from DDOT.

6.1.3 DDOT's Urban Forestry Administration: Street Trees, Park Trees, and Planting Spaces

DDOT's Urban Forestry Administration (UFA) oversees the maintenance of the District's 144,000 street trees, 14,000 planting spaces, and park trees, and is also involved in development and permit review, enforcement, outreach and education, planning and policy, and serves as the State Forester's Office. The UFA is funded by DDOT through a general right-of-way usage fee, and has an annual budget of about $7 million (Corletta, 2010; O'Brien, 2011). The portion reserved for tree planting and tree maintenance is about 15% of the total budget.

On yearly average, the UFA plants about 4,000 trees, prunes 7,500 trees, and removes 2,000 trees as part of its street tree maintenance program under its regular budget. In 2010, UFA was awarded ARRA funds via the Clean Water State Revolving Fund for three coordinated projects to reduce stormwater runoff and increase the urban tree canopy within the District's combined sewer system: the Impervious Surface Reduction Project, the Green Median Renovation Project, and the Tree Canopy Renovation Project. Areas outside the CSS have also been identified and incorporated into the projects (DDOT, 2011a).

6.1.3.1 Impervious Surface Reduction Project

Timeline: 3/2010 – 3/2011
Funding: $1.45 million

The focus of the Impervious Surface Reduction Project was to remove impervious surfaces such as concrete around tree boxes, expand the size of existing tree boxes or link tree boxes together, plant larger canopy tree species, allow for curb cuts (where possible), and increase the soil area for root expansion in order to intercept additional stormwater runoff and provide other environmental benefits. In planting areas where it was not appropriate to plant trees, UFA created grassed swales. In total, the project removed 55,730 square feet of impervious surface and enhanced existing tree boxes at a cost of $862,000, or $15.48 per square foot (DDOT, 2011a; DC Gov, no date).

6.1.3.2 Green Median Renovation Project

Timeline: 4/2010 – 4/2011
Funding: $750,000

The Green Median Demonstration Project focused on removing impervious surfaces from selected medians within the CSS and retrofitting them with amended soils, structural soils, and low-maintenance plants. Where possible, curb cuts to allow stormwater to flow more easily from the streets into the green medians were also included. Potential sites were identified by the Office of Planning and then ranked based on complexity, environmental benefit, amount of impervious surface removed, and cost. UFA also identified locations where basic tree box expansions and greening could be done outside a larger planning process. After all were ranked, field inspections were conducted, and individual projects were sent out to contractors for completion based on their ranking. The final tree boxes and planting locations were added to a GIS database that is managed and maintained by UFA. In total, 28,322 square feet of green medians were created at a cost of $440,000, or $15.54 per square foot (DDOT, 2011a) (DC Gov, no date).

6.1.4 Tree Canopy Renovation Project

Timeline: 3/2010 – 3/2011
Funding: $2.05 million

This ARRA-funded project focused on removing dead/dying trees within the area of the District served by the CSS. Trees were removed, soils in the tree boxes amended, and new trees planted. Wherever possible, curb cuts were also added to allow water to infiltrate from the roads. In total 1,735 trees were removed and 2362 trees were planted.

6.2 District Department of the Environment

DDOE is developing a suite of voluntary programs to encourage the wide-spread adoption of green infrastructure practices within the District. Relying on social marketing research and the installation of demonstration projects, DDOE has effectively created a "RiverSmart" brand that is easily recognizable to District residents. There are five RiverSmart programs in total: RiverSmart Washington, RiverSmart Homes, RiverSmart Communities, RiverSmart Roofs, and RiverSmart Schools. While housed under DDOE, other public agencies such as DC Water and private groups have played critical partnership roles in the formation of these programs. DDOE has indicated a willingness to increase efforts and work with DC Water to identify a set of common measurable objectives in the portion of the District serviced by the combined sewer system. This in turn could provide DC Water with an option to quickly scale up efforts in targeted subsheds without having to create new, untested programs.

6.2.1 RiverSmart Homes and RiverSmart Communities

RiverSmart Homes, first piloted in the Pope Branch watershed in 2007, is a District-wide program that offers homeowners assistance and financial incentives for reducing stormwater runoff from their properties. Whereas new development and redevelopment projects are required to incorporate best stormwater management practices into their design, this program serves to educate and encourage homeowners of older properties of their impact on local waterways and provide incentives for treating and controlling stormwater on-site. Homeowners can receive up to $1,200 to adopt one or more of the following green infrastructure enhancements: shade trees, rain barrels, pervious pavers, rain gardens, or BayScaping. RiverSmart Homes is not the first effort by the district to encourage voluntary adoption of green infrastructure practices. In designing the program, however, DDOE sought to avoid several common problems that had plagued past implementation efforts:

- An inability for homeowners to transport materials (a large percentage of DC households don't own cars) ;
- A lack of understanding of the regulatory process for permits and installations; and
- A lack of understanding of how to properly install and/or maintain identified practices or find knowledgeable contractors (DDOE 2008).

Upon enrolling in the program, potential applicants are put into a queue until DDOE personnel can conduct a stormwater audit of the property, which also allows for DDOE to provide one-on-one educational information to the homeowner on stormwater pollution. Presently, DDOE completes about 1100 RiverSmart Home audits each year, which are conducted by 3 staff (DDOE, 2011c). Upon determining what green infrastructure practices are applicable to the particular property, homeowners can then select which to install, and DDOE or an authorized nonprofit partner provides assistance (currently Alliance for the Chesapeake Bay or, in the case of tree installations, Casey Trees) in identifying contractors. While DDOE will cover up to $1,200 of the installation, homeowners are expected to pay a small percentage (~10%) of the cost in order to ensure that they assume ownership of the installation (DDOE, no date a). Table 6-3 includes the expected break-down of co-payments for a RiverSmart Homes installation (DDOE, no date a).

Table 6-3. Break-down of Co-Payments for a RiverSmart Homes Installation (2011)

Green Infrastructure Practice	Estimated Cost for Homeowner	Total Estimated Cost, with Installation
Shade Tree	$50	$300
Rain Barrel	$30	$300
BayScaping (native plants)	$100	Up to $1,200, depending on size
Rain Gardens	$75	Up to $1,200, depending on size
Pervious Pavers	variable	DDOE pays the difference (up to $1,200) between conventional pavement and pervious pavers

Source: DDOE, no date a

Between 2007 and 2011, the RiverSmart Homes program installed 194 rain barrels, planted 910 trees, replaced 44 impervious surfaces, and installed 102 rain gardens and 212 BayScapes (DDOE, 2012). In 2011, DDOE announced an extension of this program to multi-family residences known as RiverSmart Communities. RiverSmart Communities aims to implement similar green infrastructure practices (rain gardens, BayScaping, rain barrels, shade trees, and pervious pavements) on a scale more suitable for larger developments. Project funding for RiverSmart Homes has been provided through EPA 319 grant funds (Pope Branch watershed pilot, 2008-2009), ARRA funds ($500,000 between 2009-2011), the Anacostia River Clean Up and Protection Fund, and MS4 funds (Guillaume, 2011; DDOE, 2011a; DDOE, no date b). Project funding for RiverSmart Communities comes from a Chesapeake Bay grant and 319 funds. DDOE’s budget for the next fiscal cycle includes MS4 funding of $350,000 for 1,000 rain barrels, $156,000 for 500 shade trees, and $500,000 for 300 landscaping projects under the RiverSmart Homes program, while the RiverSmart Communities budget has been set at $120,000 (Guillaume, 2011; Lemoine, 2011).

Appendix A provides examples of standard project waivers, homeowner care agreements, audit agreements, maintenance agreements, and the standard home inspection template used as part of the RiverSmart Homes program. A map showing the locations of RiverSmart installations is provided in Appendix C.

6.2.2 RiverSmart Rooftops

RiverSmart Rooftops is a green roof subsidy program open to both residential and commercial property owners that was initiated in 2007 to help incentivize green roofs. In 2007, the program offered a rebate of $3 per square foot through DC Greenworks, resulting in the installation of 8 green roofs (60,213 sq ft) at a total cost of $180,639 (Champion, 2011). From 2007-2008, the rebate increased to $5 per square foot, with a maximum of $20,000 available per project (DDOE 2011,d), providing a total of $126,645 in funding for 15 green roofs (25,249 sq ft) (Champion, 2011). From 2009-2011, the rebate increased to $7/square foot, and has resulted in 5 green roof projects (65,656 sq ft total) being funded for a total of $459,595 (Champion, 2011). This number includes funding for a parallel green roof program which was piloted in FY2010 to target large retrofit opportunities, which DDOE staff has identified as the most difficult constituents to reach. Administered through the Anacostia Watershed Society, the focus of the subsidy program is large commercial and multi-family buildings. Using ARRA stimulus awards, the budget was set at $500,000 (DDOE, 2009b). In addition, DDOE has also compiled an inventory of green roofs in the District. Through June 2010, approximately 600,000 sq ft of green roofs have been installed (Karimi, 2010). No readily available table providing locations and square footages of green roofs funded under the RiverSmart Rooftops currently exists. The District, through the Green DC Agenda program, has developed and will periodically update a Green Amenities map, which includes relatively current listings of all green roofs. In addition, DDOE is developing a stormwater management web tool that will provide locations and information on existing RiverSmart properties which should be available in the near future. For additional information on both, see Chapter 7.

6.2.2.1 Municipal Green Roofs Cost Share

While not a part of RiverSmart Rooftops, DDOE has also helped fund a municipal green roof cost share program starting in 2008. Table 6-4 provides a list of all municipal green roof projects that are or have been funded through this program (Champion, 2011).

Table 6-4. Municipal Green Roof Cost Share Program

Building	Project Year	Square Feet	Capital Costs
DOES	2012	24,623	$369,345
Woodson High School	2012	45,000	$1,215,000
Anacostia High School	2011	22,500	$607,500
Engine 30 Fire Station	2011	8,549	$176,995
Maury Elementary School	2011	1,700	$135,000
Wilson High School	2011	7,700	$199,303
Benning Library	2010	12,000	$399,997
Tenley Library	2010	3,864	$267,492
Shaw Library	2010	4,018	$282,633
University of the District of Columbia Buildings (6)	2010	92,000	$1,310,000
Engine 6 Fire Station	2010	5,640	$116,768
Bryant Street Pumping Station	2008	5,479	$110,000

Source: DDOE, no date e; DDOE, no date f; DC Greenworks, 2008

Table 6-5 provides a partial list of green roofs within the city, both as part of and in addition to those subsidized through DDOE's RiverSmart Rooftops program. In addition, the District maintains a Green Resources and Sites datalayer, available through the District's Data Catalogue and last updated for green roofs on August 2011, identifying 156 green roofs within the city (DC Data, no date). A full list of green roofs as reported by DDOE is available in Appendix B.

Table 6-5. Sample of Green Roofs in the District

Building/Address 1	Address 2	Square Feet
Franklin D. Reeves Center	2000 14th Street NW	
ASLA Headquarters	636 Eye Street NW	3,000
Main Interior Building	1849 C Street NW	6,500
SEIU Headquarters	1800 Massachusetts Ave NW	12,400
American University		
LAMB Public Charter School	1375 Missouri Ave NW	2,700
Trinidad Recreation Center	1310 Childress Street NE	5,400
Department of Transportation/JBG	1200 New Jersey Avenue SE	68,000
American Psychological Association/WRI	10 G Street, NE	3,000
Friends Committee on National Legislation	245 2nd Street, NE	1,200
District Dept of Employment Services		
Anacostia Gateway Office Building	1800 Martin Luther King Ave SE	10,500
Reeves Center	1 Judiciary Square	8,000
Alcohol Tobacco and Firearms Building	101 New York Ave NE	
Blake Building	1025 Connecticut Ave NW	
Smithsonian Zoo	2900 Cathedral Ave NW	

Source: DDOE, no date e; DDOE, no date f; DC Greenworks, 2008

6.3 RiverSmart Washington

RiverSmart Washington is a public-private sector project to evaluate whether the wide implementation of green infrastructure practices such as rain barrels, rain gardens, and permeable pavement can effectively reduce stormwater runoff in two distinct subsheds within Rock Creek. In an earlier "Green Build-out Model" prepared by Casey Trees and LimnoTech, widespread implementation of green infrastructure practices were predicted to reduce runoff by more than 50% in some areas. To test the model, DDOE and its partners are concentrating the implementation of such practices in two neighborhoods (one within the District's combined sewer area in Petworth, near MacFarland Middle School, and one in the separate sewer area in Chevy Chase, DC, near Lafayette Elementary School). Once installed, effectiveness in reducing the flow of runoff into Rock Creek will be measured and compared to a control site. If successful, DDOE may expand the project to other parts of the District.
Figure **6-1** and
Figure **6-2** show the two targeted neighborhoods. Table 6-6 and Table 6-7 provide summary statistics for the pilot project areas (DDOE, 2011e).

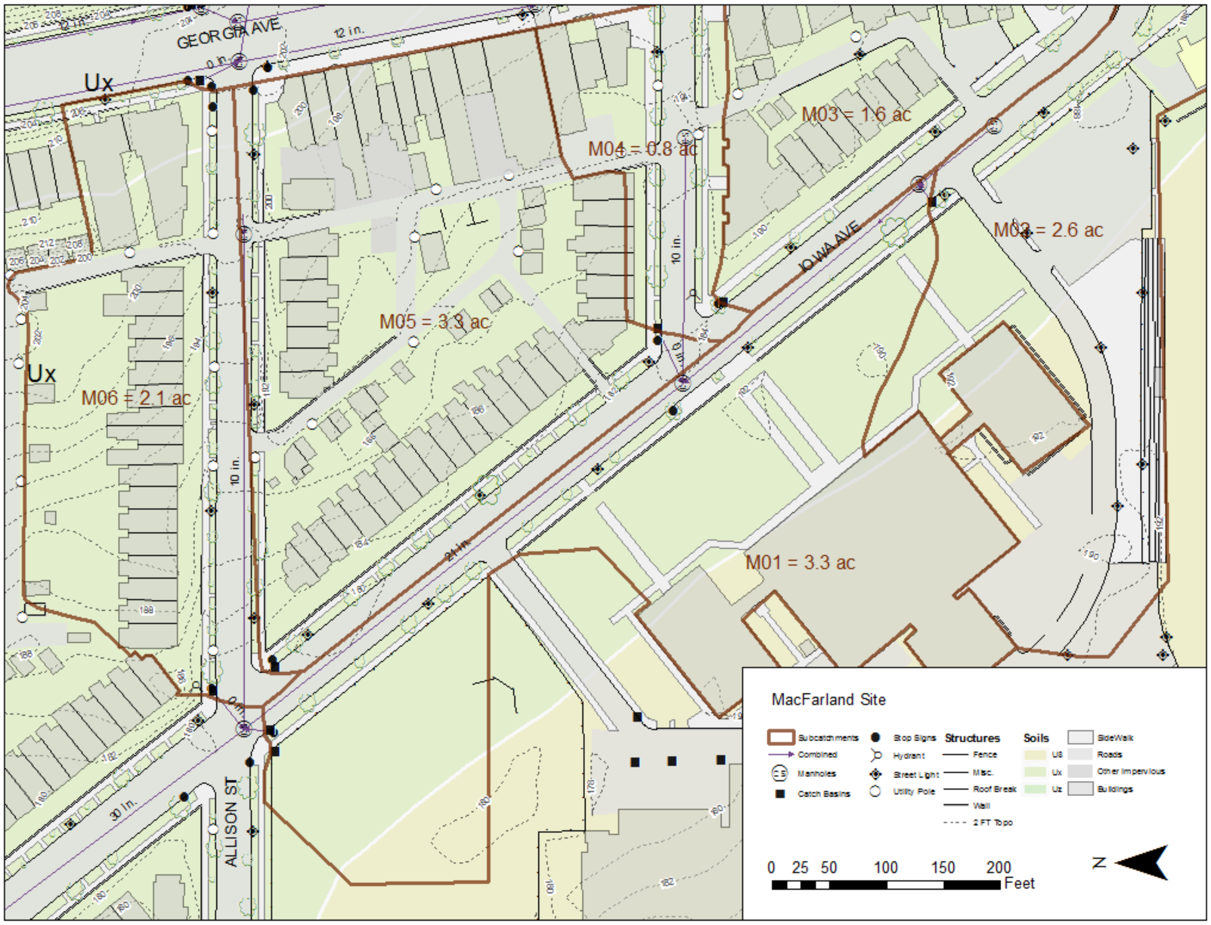

Figure 6-1. MacFarland MS CSO RiverSmart Washington Pilot Project Area
Source: DDOE, 2011e

Table 6-6. MacFarland MS CSO RiverSmart Washington Pilot Project Summary Statistics

Land Cover					
Total area =	**699,481**	**sf**	**16.06**	**acres**	
Pervious area =	**266,245**	**sf**	**6.11**	**acres**	**38.1%**
Impervious area =	**433,236**	**sf**	**9.95**	**acres**	**61.9%**
Total building area =	181,599	sf	(115 buildings)		
<2000 sf	*84,311*	*sf*	*(106 buildings)*		
>2000 sf	*97,288*	*sf*	*(9 buildings)*		
Total road area =	104,758	sf			
Alley	*19,526*	*sf*			
Intersection	*8,129*	*sf*			
Paved Drive	*6,232*	*sf*			
Road	*70,871*	*sf*			
Total parking lot area =	82,965	sf			
Total sidewalk area =	63,914	sf			
Pipe Dimension at Meter =	**30x24**	**in**			
Average Year Runoff =	**10,678,199**	**gal***			

Source: DDOE, 2011e

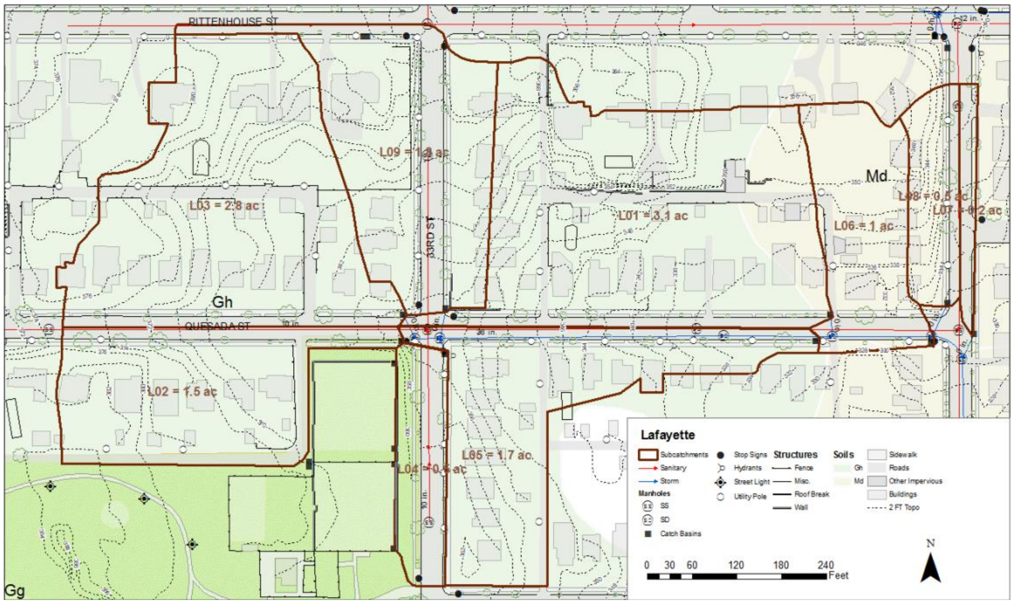

Figure 6-2. Lafayette MS4 RiverSmart Washington Pilot Project Area
Source: DDOE, 2011e

Table 6-7. Lafayette MS4 RiverSmart Washington Pilot Summary Statistics

Land Cover					
Total area =	**551,570**	**sf**	**12.66**	**acres**	
Pervious area =	**352,051**	**sf**	**8.08**	**acres**	**63.8%**
Impervious area =	**199,519**	**sf**	**4.58**	**acres**	**36.2%**
Total building area =	73,137	sf	(88 buildings)		
<2000 sf	*70,960*	*sf*	*(87 buildings)*		
>2000 sf	*2,177*	*sf*	*(1 buildings)*		
Total road area =	103,453	sf			
Alley	*27,527*	*sf*			
Intersection	*8,162*	*sf*			
Paved Drive	*983*	*sf*			
Road	*66,781*	*sf*			
Total parking lot area =	0	sf			
Total sidewalk area =	22,929	sf			
Pipe Dimension at Meter =	**36x36**	**in**			
Average Year Runoff =	**5,164,750**	**gal**			

Source: DDOE, 2011e

The RiverSmart Washington program, which is led by DDOE, includes DC Water, DDOT, the Rock Creek Conservancy, LimnoTech, and Casey Trees as partners. Homeowners and business owners within the targeted neighborhoods are encouraged to install one or more of the following green infrastructure practices, pending a site suitability analysis: rain gardens, bayscaping, pervious pavers, rain barrels, downspout disconnects, and shade trees. Within the District’s right-of-ways, the program will install a mix of bio-retention bump-outs, infiltration tree boxes, tree box plantings, and porous pavement along roads, sidewalks, and alleys. Descriptions of each are provided on the RiverSmart Washington website (Rock Creek Conservancy, 2011). DDOE, DC Water, and DDOT are each providing $1 million of funding to the project. The District has also received an $800,000 grant from the National Fish and Wildlife Foundation (DC Water, 2011b). Pre-implementation monitoring was undertaken by LimnoTech to serve as a baseline for future monitoring within each subshed (FORCE & LimnoTech, 2011).

6.3.1 RiverSmart Schools

RiverSmart Schools is a DDOE program that focuses on creating outdoor classrooms and learning areas on school grounds through the installation of native gardens and green stormwater infrastructure practices. The program began in 2002 under the name “Greener Schools, Cleaner Water,” and was originally developed to provide teachers with the resources and training necessary to install conservation sites on school ground for educational purposes. Sites were installed by non-profit groups, with teacher and student involvement. In 2009, the name was changed to complement DDOE’s RiverSmart Homes and Rooftop programs, and the program was expanded to better utilize school open space to more specifically address stormwater pollution. While the program still strives to reach five schools a year, two to three receive larger stormwater projects that also have an environmental education component, while the landscaping and educational projects for the other two to three schools are smaller. The design, site preparation, permitting, and construction are contracted out, and installation includes a two-year guarantee.

Funding for RiverSmart schools has come from a variety of sources. For example, the $120,000 Center City Public Charter School RiverSmart project, which was installed in 2010, was a private-public partnership between the District Department of the Environment, FedEx, National Fish & Wildlife Foundation and Center City Public Charter School, while Stokes Elementary was funded under a 319 grant (DDOE, no date c; DDOE, 2001a). Other private sources utilized by the RiverSmart program have included grants from the Chesapeake Bay Trust and Lowe’s and pro-bono work by D.C. Rock and Washington Gas, as well as the use of volunteer time. Currently, funding for program implementation is shared between MS4 and bag bill revenue, with staffing paid for through a Chesapeake Bay Implementation Grant. While the number of applicants is higher than the number of schools accepted each year (for example, in 2011 there were 16 applicants), the selection is capped at 5 due to a limited number of DDOE staff to run the program. With additional staff, the program could accept more schools per year (DDOE, 2011c). To date, 42 schools have participated through this program, as identified in Table 6-8.

In addition, the District’s Green Resources and Sites datalayer, available through the District’s Data Catalogue identifies 69 ‘schoolyard conservation sites’ as of September 2009, which includes both RiverSmart Schools up to that date as well as any other schoolyard conservation projects. The list of schoolyard conservation sites extracted from the District’s Green Resources and Sites datalayer is included in Appendix B.

Table 6-8. Existing RiverSmart Schools

School Name	Fiscal Year Completed	School Name	Fiscal Year Completed
Walker Jones Education Campus	2011	Miner Elementary School	2007
The SEED School	2011	Friendship PCS, Chamberlain Campus	2007
Kelly Miller Middle School	2011	Cesar Chavez Public Charter School for Public Policy	2006
Hardy Middle School	2011	Amidon Elementary School	2006
Phelps Architecture, Construction, and Engineering High School	2011	Moten Elementary School	2006
Center City Public Charter School, Trinidad Campus	2010	LaSalle Elementary School	2006
Elsie Whitlow Stokes Charter School	2010	Whittier Elementary School	2006
Benjamin Banneker High School	2010	Kamit Institute Charter School	2006
St. Peter's School	2010	John Burroughs Elementary School	2004
Anne Beers Elementary School	2009	Cardozo Senior High School	2004
Brent Elementary School	2009	Draper Elementary School	2004
Two Rivers Public Charter School	2009	Seaton Elementary School	2004
John Tyler Elementary School	2009	Theodore Roosevelt SHS	2004
JC Nalle Elementary School	2008	Maude Aiton Elementary School	2003
Miner Elementary School	2008	Backus Middle School	2003
Chamberlain Public Charter Elementary School	2008	Barnard Elementary School	2003
Shepherd Park	2008	Stoddert Elementary School	2003
Two Rivers Public School	2007	Harriet Tubman Elementary	2003
Shepherd Park Elementary School	2007	Ketcham Elementary School	2002
JC Nalle Elementary School	2007	PR Harris Elementary School	2002
		River Terrace Elementary School	2002

Source: DDOE, 2011a; DDOE, 2010c; DDOE, 2010b; DDOE, 2009c; DDOE, no date g

6.3.2 Other DDOE Funded Green Infrastructure Projects

In addition to the programs above, DDOE has been involved in other green infrastructure demonstration projects within the District using a variety of funds. A list of additional projects is provided in Table 6-9 (Champion, 2011).

Table 6-9. Additional DDOE Green Infrastructure Projects

Project Name	Project Type	Cost
Takoma Tennis Courts	Bioretention	$65,000
Casey Trees Bioretention	Bioretention	$70,000
Ft. View Rain Tanks	Infiltration	$63,000
Lafayette Spray Park	Harvest/reuse	$70,000
FEMS Green Tanks Engine 25 Fire Station	Harvest/reuse	$142,194
FEMS Green Tanks Engine 3 Fire Station	Harvest/reuse	$132,560
Woodson High School Green Toilets	Harvest/reuse	$885,000
Anacostia High School Green Toilets	Harvest/reuse	$500,000
Wilson High School	Harvest/reuse	$200,000

Source: DDOE, no date a

6.3.3 Stormwater Tracking of Private Installations

While DDOE and other District agencies have and will continue to participate in numerous green infrastructure projects, installations by private developers have continued to grow. A review of DDOE's plan review database, as of June 24, 2011, identified over 450 approved stormwater permits that included one or more green infrastructure technologies to reduce stormwater volumes (DDOE, 2011e). A series of maps showing the locations of these technologies approved can be found in Appendix C. With the issuance of the new MS4 permit, DDOE expects that this number will grow substantially, as upcoming regulations that are required as part of the new MS4 permit will effectively require new development and redevelopment projects to retrofit existing impervious surfaces to allow for stormwater retention. DDOE expects that additional staffing will be required to meet the additional Permit requirements." (DC DOE, 2011c).

6.4 DC Water and Sewer Authority

6.4.1 DC Water Facilities per Consent Decree

As part of the existing CSO Long Term Control Plan, DC Water allocated $3 million to install green infrastructure practices on its own facilities. In 2004 and 2006, DC Water retrofitted its Eastside and Bryant Street Pumping Stations with porous pavers, tree filters (at Bryant Street), vegetative swales (at Eastside), and additional pavement elimination (at Eastside) to divert stormwater from the combined sewer system and promote groundwater infiltration. Ongoing or proposed green infrastructure projects at other DC Water facilities include the following:

- The installation of bioretention cells and roof drain disconnects to dry wells at Fort Reno Reservoir
- Vegetation at Brentwood Reservoir
- Bioretention cells and vegetation at Fort Stanton Reservoir
- Permeable pavement, a bioretention cell, roof drain disconnects to dry wells, tree box filters, and vegetation at the Anacostia Pump Station.

In addition, DC Water has set aside $500,000 to monitor the effectiveness of the green infrastructure practices installed on DC Water facilities (DC Water, 2010b; DC Water, 2011b).

6.4.2 DC Water Supplemental Environmental Projects

As part of its CSO Consent Decree, DC Water is also funding an additional $1.7 million in supplemental environmental projects in collaboration with community groups. To date, DC Water has planted 4,766 trees between 2005 and 2007, and has installed rain gardens at Irving and North Capitol (DC Water, 2011b).

6.5 Conclusions

There are numerous agencies within the District that have established programs focused on various green infrastructure practices. DDOT's Urban Forestry Administration, for example, leads the District's tree planting, inventory, and maintenance efforts, and has established internal and external relationships with agencies/groups such as DC Water, DDOE, and Casey Trees to meet its goals and objectives. Through its Great Streets Initiative and green alleys programs, DDOT has experience implementing green infrastructure practices suitable for roads and street rights-of-way. DDOE, similarly, has successfully developed a series of RiverSmart programs to encourage tree plantings, permeable pavement, rain gardens, BayScaping, rain barrels, and green roofs throughout the District. Its name recognition is such that, even though DDOE does not spend much time marketing the project, RiverSmart Homes applicants must often be placed on a brief waiting list before DDOE staff can conduct an initial site visit. For RiverSmart Schools, the number of schools wanting to participate in the program exceeds current staff capacity. It will be necessary for DC Water to either try to work through these existing programs, or, if working separately, ensuring that DC Water's efforts don't hinder the programs already in existence at other organizations.

Working through existing programs would allow DC Water to benefit from the expertise and knowledge already gained through these programs in the implementation phase. It would be expected that DC Water would be able to target the efforts of particular programs to implementation areas. For example, DC Water could work with DDOE to target additional funding for green roofs into pilot CSO sheds. DDOT could similarly fund DDOT to target certain areas as part of its Great Streets initiative (or, as indicated in DDOT's Low Impact Development Action Plan, its future green streets program). The manner of such coordination would need to be worked out in further detail.

If working separately, DC Water should still coordinate with other agencies to ensure that design criteria are consistent throughout agencies, and that standard maintenance procedures are followed. Efforts should be made to collect information through monitoring and project tracking are also implemented in a way that benefits the needs of multiple agencies.

Current tracking procedures utilized for the different programs vary widely. For example, DDOT has established a fairly strong GIS-based inventory system of all of its trees, making it easy to locate trees and identify tree planting opportunities. DDOE's RiverSmart program is currently updating much of its data on existing project locations, and the actual dataset being developed was not available for review. For private installations captured through DDOE's stormwater permitting process, one limitation of project tracking procedures is that not all projects approved for development are necessarily built. Current GIS-based tracking efforts and datasets are discussed further in Chapter 7.

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7 Tracking and Planning for Green Infrastructure within the District

7.1 Developing a Green Infrastructure Database: Identifying Requirements

Geographic information systems (GIS) are an effective way to track and monitor green infrastructure practices. By integrating GIS systems with existing databases, records for individual stormwater green infrastructure practices can be accessed visually and data can be queried by nearest location or by drainage area in order to conduct inspections, monitor performance, or prioritize retrofit opportunities within a given drainage area.

To be most effective, a green infrastructure GIS database should include, at a minimum, some basic design information such as the BMP type, BMP description, size, location, property type, watershed/subwatershed, status, date installed, date verified, and date last inspected. Additional desirable information includes the acreage of the contributing drainage area, verifying engineer, verifying company, future planned inspection date, BMP photos, BMP maintenance agreements, and specific design characteristics of the structure. Table 7-1 provides a list of desired minimum attributes and descriptions for use in a green infrastructure database, while Table 7-2 provides a list of additional attributes that a more robust GIS database might include. Attributes in Table 7-2 would also allow for volume reductions to be modeled. In addition to these tables, EPA has drafted new guidance on developing and implementing post-construction monitoring which should be consulted when developing database attributes (EPA, 2011e).

Table 7-1. Desired Minimum GIS Attributes for Use in a Green Infrastructure Database

Category	Attribute	Description
Basic	Project Number	ID number unique to the individual green infrastructure practice, regardless of whether it is one of multiple practices associated with the same project
Basic	Project Type	Type of green infrastructure practice (e.g., bioretention cell)
Basic	Project Type II	More specific classification of green infrastructure practices (e.g., residential rain garden, bioretention cell in median strip)
Basic	Project Identifier	Name of building or associated development project; each project can have more than one green infrastructure practice associated with it
Basic	Number of BMPs	Number of green infrastructure practices on a particular project
Basic	Project Description	Brief description of BMP to distinguish it from other possible BMPs on the same site (e.g., bioretention cell 1, bioretention cell 2)
Basic	Project Location	Map/GPS coordinates or street address
Basic	Parcel Number	Parcel ID number
Basic	Land Use Type	Residential, multi-family residential, commercial, industrial, local government building, federal, park, street, etc.
Basic	Drainage Area	Drainage area served (in acres)
Basic	Project Size	Total size of installed green infrastructure practice (e.g., total square footage of green roof)
Basic	In-service date	Date the green infrastructure practice is operational. Can also be referred to as the as-built date, or date the structure was built
Basic	Vegetation	Yes or no, as to whether practice is vegetated
Basic	Owner	Responsible entity for maintenance
Basic	Project Status	Planned, under construction, in service, retired
Basic	Monitored Site	Yes/No as to whether the project is monitored over time
Maintenance/ Inspection	Inspection Date	Tracks the date of each inspection
Maintenance/ Inspection	Inspection Report	Identifies any repairs needed, maintenance required, or items to monitor over time

Source: Adapted from the Center for Watershed Protection and Portland Bureau of Environmental Services (CWP, 2000) (Portland BES, 2010).

Table 7-2. Advanced GIS Attributes for Consideration in the Preparation of a Green Infrastructure Database

Category	Attribute	Description
Basic	Project Number	Unique ID number, could be coded by BMP type
Basic	Maintenance Agreement	Identification number of maintenance agreement, or link to specific document
Basic	Design Approval	Agency who approved the design
Basic	Design Approval Date	Date approved
Basic	Certification PE Name	Name of principal engineer who certified the project
Basic	Certification Company	Company of principal engineer that certified the project
Basic	Pre-development land use	Land use in drainage area before development/redevelopment
Basic	Impervious Cover (Pre-)	Percent impervious cover in the drainage area before development/redevelopment
Basic	Post-development Land Use	Drainage area land use after development/redevelopment
Basic	Impervious Cover (Post-)	Percent impervious cover in the drainage area after development/redevelopment
Basic	Drainage Area Slope	Average drainage area slope
Basic	Required Retention Volume	Required retention volume (SWRv or WQTv) in cubic feet
Basic	Designed Retention Volume	Designed/achieved retention volume in cubic feet
Basic	Conveyance Width	Conveyance width (in feet), if vegetated swale or other conveyance practice
Basic	Underdrain Present	Yes or no, as to whether a project has an underdrain
Basic	Underdrain Size	Underdrain size (e.g., pipe diameter)
Basic	Outlet Connection	Type of connection from the practice outlet (e.g., directly to sewer, to connected impervious, to disconnected impervious, to pervious)
Basic	Photos	Photos of installed practice
Maintenance/ Inspection	Maintenance Access	Method for access and easement ID number or code
Maintenance/ Inspection	Inspectors	Name of inspector(s) for each inspection
Maintenance/ Inspection	Inspection Repairs	List of repairs to be completed and level of urgency
Maintenance/ Inspection	Inspection Maintenance Items	List of items requiring maintenance, as determined by the inspection
Maintenance/ Inspection	Inspection Monitoring Items	Identifies items not deemed a problem but should be monitored over time
Maintenance/ Inspection	Repair Date	Date of repair for each item
Maintenance/ Inspection	Repair Description	Type of repair/contractor hired
Maintenance/ Inspection	Repair Cost	Cost of maintenance

Source: Adapted from the Center for Watershed Protection and Portland Bureau of Environmental Services (CWP, 2000) (Portland BES, 2010).

7.2 Sources of Existing/Future Information

Various agencies play a role in the tracking and monitoring of green infrastructure projects within the District. While the Office of the Chief Technology Officer (OCTO) coordinates the sharing of GIS data amongst agencies and the public, information important to the location of existing green infrastructure projects comes in many forms—not all of which is currently conducive to displaying in a GIS format. The following sections describe existing information captured by DDOE, DDOT, and other District of Columbia agencies that serve to locate or identify existing stormwater best management green infrastructure practices. It also identifies three pending or future information sources that should prove useful to DC Water in the evaluation and selection of green infrastructure projects.

7.2.1 DDOT – Tree Inventory and Asset Management

DDOT's Urban Forestry Administration (UFA) maintains a dynamic tree inventory and utilizes asset management integration to follow work orders. In 2002, an ArcGIS tree inventory system was populated with the help of a citizen-based tree inventory led by Casey Trees, which inventoried 109,000 street trees (Howard, 2004). UFA and Casey Trees use the street tree inventory to coordinate activities between their organization and other District agencies. Figure 7-1 provides a screen shot of the ArcGIS Tree Inventory structure. Feature attributes reported for each tree include information on the tree space (length, width, presence/absence of wires, curbs, or sidewalk), tree type, tree condition, and ownership, as well as the date it was last evaluated.

Figure 7-2 provides a snapshot of UFA's asset management integration system, known as Cityworks®, which it uses to track open street tree work orders. Cityworks®, which is a GIS-centric asset management system, enables UFA to maintain and grow its inventory of tree box spaces, track transitional service requests and work assignments, and manage tree-related contracted services. Cityworks® is also used to track other transportation related projects, as discussed below.

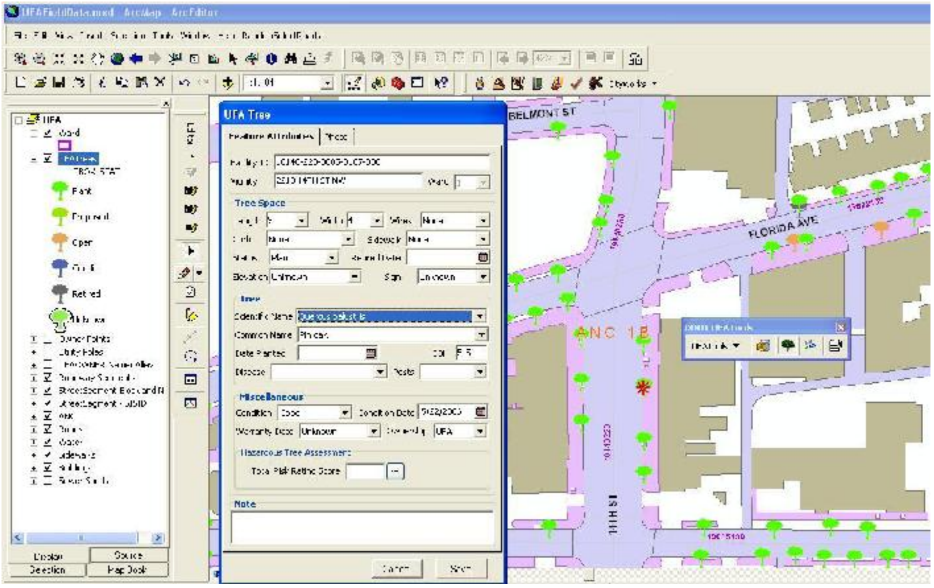

Figure 7-1. UFA's Dynamic Tree Inventory
Source: Corletta, 2010

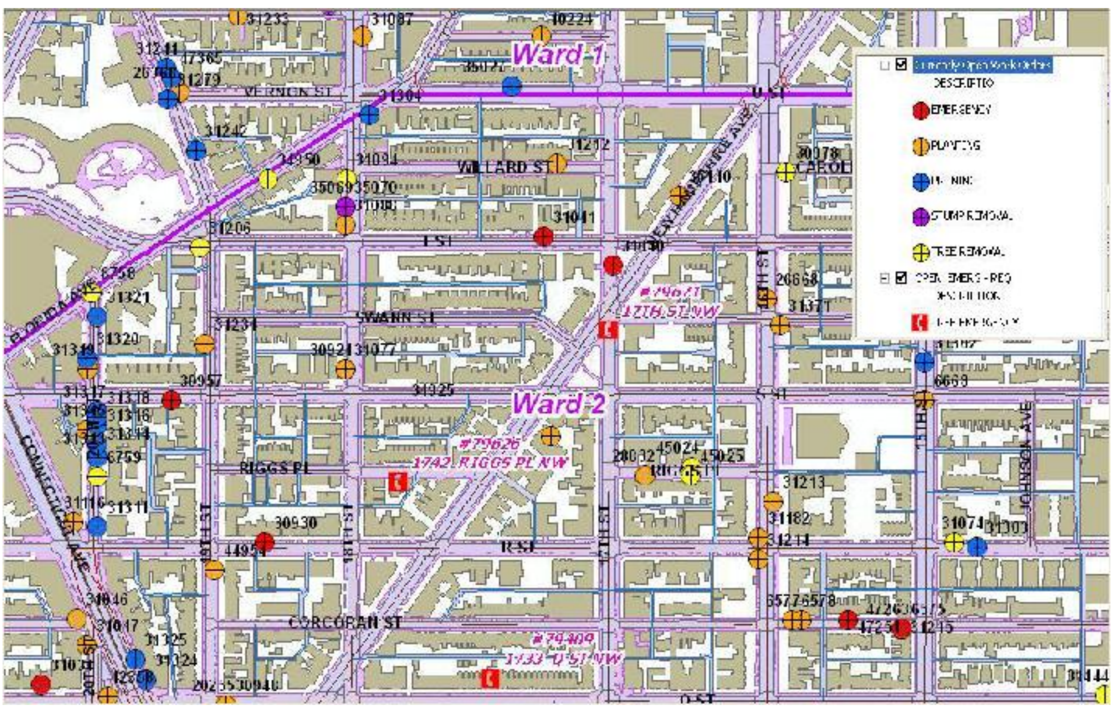

Figure 7-2. UFA's Asset Management Integration
Source: Corletta, 2010

7.2.2 DDOT – Capital Improvement Projects

DDOT is responsible for identifying and developing transportation related projects for the District's Capital Improvement Program (CIP) and the annual Capital Budget. DDOT makes a list of projects available through its web-based Dashboard site that are either in the design or construction phase. DDOT is also undergoing a multi-year phased implementation a GIS-based, web-accessible work order management system known as the Cityworks® Maintenance Management System to manage assets, issue service requests and work orders, and handle inspections for all assets under DDOT's responsibility. First utilized successfully by DDOT's UFA, the department began implementing the system department-wide in 2008. While Cityworks® is currently utilized solely by DDOT, other places, like the City of Omaha/Douglas County, UT, and Charlotte, NC, are utilizing the system to synchronize and share database and management systems across departments. Information provided by DDOT for this review includes projects listed under its "unconstrained" federal obligation plan for FY 2011 - 2016.

7.2.3 DDOE – Stormwater Plan Review Tracking

DDOE manages land-disturbing activities to prevent soil erosion and sedimentation of the District's waterways through the review of construction and grading plans for stormwater management, erosion and sediment control, and floodplain management submitted for private and public development projects. As part of this function, the department maintains a plan review database which includes a project description and categories for the stormwater management type and best management practices used. While the square footage of provided for the amount of area disturbed, the square footage or acreage of the drainage area covered by the best management practice is not.

7.2.4 Green DC Agenda – Green Amenities

The Green Amenities GIS database, which was developed by DDOE as part of the Green DC Agenda, identifies "green locations" within the District. Information was collected for 28 different types of green features with the assistance of knowledge experts and reliable 3rd party resources such as nonprofits and the DC Green Building Council. Of the 28 categories included, those that either identify existing green infrastructure sites or may have a bearing on the location of future green infrastructure features include the following:

- Green roofs – green roofs on public and private buildings
- RiverSmart projects – homes or buildings that feature watershed-friendly practices
- Special trees – trees recognized for their special ecological, aesthetic, or community value
- Tree planting sites – sites where significant tree planting has been undertaken
- Ecological action zones (places where residents and local organizations are actively improving the environment)
- Ecological restoration sties – significant sites where wetlands, streams, and native habitats are being restored
- Wetlands – wetland areas identified or restored by the District
- Green cultural sites – cultural destinations with an ecological dimension
- Aquatic habitats – locations with significant fish populations
- Schoolyard conservation sites – sites with tree plantings, gardens, and outdoor environmental education areas

Information is stored as point data, and includes a brief site description, locational data, and the date of the last update, and can be viewed as a GIS shapefile. Some limitations of the data include incomplete reporting of the square footage of existing green roofs; a lack of reporting on RiverSmart projects (only 7 in total are included); and incomplete data, in general. The shapefile does, however, provide a good first overview of green features within the District, and has been partly updated since initially prepared in 2009. The information is readily available online as part of the DC GIS Data Catalogue.

7.2.5 DC Data Catalogue – Additional

In addition to the information above, the District provides access to 485 datasets from multiple agencies through its online Data Catalogue (http://data.dc.gov/). In reviewing the existing datasets, the following list was identified as being useful for the selection and identification:

- DC Comprehensive Plan Planning Areas
- Completed Construction Projects 2002 – 2010 (transportation), and current construction projects (2011)
- DC Department of Consumer and Regulatory Affairs (DCRA) – List of vacant, exempt, and blighted properties
- DC Community Gardens – Shows the location of community gardens within DC
- Street Trees from DDOT
- Military Locations – Military installation locations
- Other Historic Areas – Other Historic Areas in DC
- Parks – National Parks in DC from NPS Map A
- Registered Property – The dataset contains attributes of registered properties from the Office of Tax and Revenue
- Registered Vacant Property – The dataset contains locations and attributes of registered vacant properties from the Office of Tax and Revenue (OTR)
- DDOT Public Space Permits – DC Department of Transportation Public Space above ground permit locations
- Architect of the Capitol Areas – The dataset contains locations and attributes of the Architect of the Capitol jurisdiction boundary
- Buildings – Building footprints with firewalls
- DC Government locations – DC Government agency/office locations
- Floodplains – Five datasets which include FEMA's 2010 Flood Insurance Rate Maps (FIRM), base flood elevation measurements for AE flood zone determination, cross section terrain information as part of the flood plain work, map tiles representing FEMA flood maps, and flood walls and other structures that protect and buffer water features
- GSA Federal sites – The dataset contains locations and attributes of GSA owned or leased buildings
- Historic Districts – Historic Districts officially designated by the District of Columbia and National Historical Sites & National Historical Parks within the District of Columbia
- Historic Sewer Survey – Exhibit chart showing streets & avenues of the cities of Washington and Georgetown, improved under the Board of Public Works, D.C. : Nov. 1st 1873
- Historic Street Lines – L'Enfant Plan Historic Street Linework
- Historic Streets – L'Enfant Plan Historic Streets.
- Landmark Areas – Contains locations and attributes of all known Landmark Areas.
- Metro Stations – Complete (also has metro bus stops, lines, and parking areas as separate options)
- Railroads – Polygons representing planimetric railroads, originally captured in 1999 and updated in 2005 and 2008

- Recreation Parks – Digital representation of DPR's properties, parks, and landholdings including NPS transfers.
- Roads – Polygons representing planimetric roads, originally captured in 1999 and updated in 2005 and 2008
- Sidewalks – Polygons representing planimetric sidewalks, originally captured in 1999 and updated in 2005 and 2008
- Subwatersheds – Subwatersheds in DC
- Subwatersheds, Anacostia River – Larger scale subwatersheds for the Anacostia River that differ for the existing subwatersheds downloaded from the USGS in scale and detail
- Wooded Areas – Polygons representing planimetric wooded areas, last updated in 2008

7.2.6 Green DC Agenda – LID Tracking Database

As part of the Green DC Agenda, the District intends to develop a Low Impact Development Tracking Database to track existing LID/green infrastructure practices installed throughout the District by all Agencies, with DDOT identified as the lead agency. While the status of this database is still identified as "upcoming," its development could prove very useful to DC Water in the identification, selection, tracking, and monitoring of green infrastructure pilots installed not just by DC Water but by other District agencies (DDOE, no date d).

7.2.7 DDOE Stormwater Management Web Tool (Pending)

DDOE is currently developing a stormwater management web tool to allow District residents to record information and locations of green stormwater practices on their properties in order to receive credits as part of the stormwater discount program. The tool will also provide locations and information on existing RiverSmart homes, communities, schools, and rooftops that can be updated by property owners (DDOE, no date b).

7.2.8 DDOEO MS4 Permit Tracking (Future)

As part of its new MS4 permit, the District is required to establish/update and maintain a formal site plan review and post-construction verification process, as well as track the on-site retention performance of installed practices. In addition, for each retrofit project, the District must estimate the potential volume reduction and, for specific pollutants, the potential pollutant load reduction achieved for each major waterbody, and coordinate with major Federal landholders to track pollutant reductions from relevant federal actions.

7.3 Conclusions

While it is possible to develop a draft base layer of point data identifying known green infrastructure projects within identified implementation areas, the amount of information that can currently be collected for each project is limited. Previously, green infrastructure practices employed by District agencies were done on a more voluntary level, with limited need to track projects over time. As the District moves to requiring such projects as part of its MS4 permit and to evaluating its use in meeting the District's CSO LTCP requirements, a more robust GIS database system is desirable.

Several opportunities exist for collaboration amongst the District's various agencies. The District's new MS4 permit, which requires the District to track on-site retention performance of installed green infrastructure practices, will require DDOE to evaluate their current database and tracking requirements in order to make sure that sufficient information is being obtained. DDOT's Cityworks® Maintenance Management System, which is being used to inventory and track the health and maintenance needs of street trees within the District, could provide a standard platform within which information is synchronized and shared across agencies. The development of a LID tracking database, which has been identified as a task under the Green DC Agenda, furthers the need for coordination amongst agencies to build a shared GIS system.

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8 Summary and Conclusions

EPA has recently increased its focus on identifying integrated solutions to control wet-weather flow pollution problems (EPA, 2011f). DC Water's interest in pursuing green infrastructure as part of its long term efforts to control combined sewer overflows fits within this context and is supported by existing studies, policies, regulations, and programs within the District. The establishment of a large-scale green infrastructure program in the Rock Creek and Potomac CSO subsheds could be implemented as an adaptive CSO management approach into the District's long term control plan.

8.1 Green Infrastructure Studies

Existing studies within the District suggest that the added storage provided by green stormwater infrastructure controls has the potential to decrease runoff volumes entering the combined sewer system. Local studies on the applicability of specific green infrastructure practices (see Chapter 2) have been largely positive, with the exception of some concerns identified in a rain barrel study prepared for DC Water in 2001-2002. To address this, it is suggested that DC Water coordinate with DDOE's RiverSmart Homes program to determine the effectiveness of its rain barrel program.

To date, local monitoring results collected as part of this review include the following practices: bioretention, rain barrels, and green roofs. Modeling scenarios have been prepared for green roofs, tree plantings, tree boxes, rain gardens, rain barrels, cisterns, permeable pavement, and curbless islands. It is anticipated that additional discussions with local and federal agencies would provide access to additional studies and modeling scenarios of use by DC Water, and future efforts to synthesize monitoring results within the District would be beneficial.

DC Water should further consider coordinating monitoring efforts with other local and federal agencies. It may be possible to evaluate existing RiverSmart Homes, RiverSmart Schools, federal green infrastructure projects (such as the Navy Yard's green infrastructure projects), and other District and federal projects to determine their current effectiveness in relieving pressures on the CSS. This would expand the District's knowledge on the performance of specific green infrastructure practices.

8.2 Policies, Plans and Regulations

The District has numerous policies and plans that are supportive of green infrastructure. These include Green DC Agenda initiatives such as the Climate Protection Initiative, Urban Tree Canopy Goal, and DDOT LID Action Plan; the Green Jobs Initiative; DDOT Sustainability Plan; and DDOE Wildlife Action Plan. Federal plans supportive of the green infrastructure within the District include the CapitalSpace Plan and the US Navy's LID Policy. Chapter 3 provides a description of each, as well as associated measurable actions, where applicable.

While not directly involved in the implementation of green infrastructure projects, the District's Office of Planning exerts great control over the plan review process through its planning documents. To determine whether or not existing plans were compatible with DC Water's desire to implement green infrastructure on a large-scale, a review was conducted of the existing small area plans, comprehensive plan area elements, and retail action strategies in Wards 1, 2, 3, and 4. While the area served by the combined sewer system extends beyond this area, the focus of the review was to determine whether or not supporting language existed to warrant pilot projects in the nine Tier 8 CSO sub-sheds identified through the pilot subshed selection process identified in Technical Memo 3 (CSO subsheds 020-007, 026-001, 027-003, 029-003, 049-018, and 049-019).

Existing and upcoming federal and local regulations further encourage the use of green infrastructure management to control stormwater runoff. These include erosion and sediment control regulations, changes to the building codes to allow for disconnected downspouts, an impervious surface charge, as well as upcoming regulations to implement a Green Area Ratio and new stormwater requirements that are compatible with the District's new MS4 permit and Chesapeake Bay Watershed Implementation Plan. However, any efforts by the various District agencies to work together when developing design criteria for various practices would go far to make sure that practices are implemented and maintained in a consistent manner, increasing the likelihood of success District-wide. When designing criteria, existing regulations and codes should be reviewed to ensure that conflicts do not exist.

8.3 Current Programs, Practices and Tracking Efforts

Numerous green infrastructure practices are currently being utilized in the District. At DDOT, the Urban Forestry Administration has developed a strong tree planting and maintenance program which is leading efforts to increase the city's urban tree canopy to 40% by 2036. Other DDOT projects, such as its Great Streets initiative, have increased the use of rain gardens, grass swales, tree box filters, vegetated filter strips, and pervious pavements in urban street rights of way. At DDOE, emphasis has been placed on installing best management practices such as trees, green roofs, rain barrels, rain gardens, BayScaping, and pervious pavers on private (residential, commercial, institutional) and public (schools, fire stations, libraries) properties to reduce and treat stormwater runoff. These programs provide an opportunity for DC Water to collaborate with other agencies and pool resources.

Existing and planned programs such as DDOE's RiverSmart programs, DDOT's Great Streets initiative and possible green streets program, and DDOT's tree planting projects should be viewed by DC Water as implementation opportunities. DDOE RiverSmart, for example, has already worked through numerous administrative items, has established standards project waivers and agreements, and has worked out third party relationships with non-profits to oversee certain programmatic procedures. Through the RiverSmart program, DDOE has also started to work through items such as providing legal determination that ensures that all RiverSmart Homes practices are treated as taxable donations (DDOE, No Date b).

The tracking of green infrastructure projects to date has varied amongst agencies. The District could benefits as a whole from establishing more consistent performance measures and criteria. Developing a uniform, geospatially-referenced database to track current and future green infrastructure practices would be ideal to evaluate and track performance over time. Suggestions for database attributes were provided in Chapter 6, and reflect the types of information needed for use in a more regulated (versus voluntary) environment.

8.4 Next Steps

This technical memo provides much of the background necessary to understand the District's existing green infrastructure framework. Next steps for DC Water include the development of an agency and interagency roadmap for implementing green infrastructure on a large scale. It is suggested that DC Water coordinate its efforts with existing programs, looking for ways to increase the presence of existing programs within implementation watersheds, as well as identifying necessary monitoring and tracking needs up front so that programs could be adjusted accordingly. Identified opportunities include the following:

- Utilizing existing District programs to implement DC Water's projects
- Coordinating with other agencies, both federal and local, to develop a set of uniform standards for green stormwater infrastructure practices.
- Implementing joint research projects on green infrastructure practices on both federal and local land that addresses the needs of DC Water and other agencies to evaluate and monitor multiple benefits.
- Studying/monitoring existing RiverSmart Homes, RiverSmart Schools, federal green infrastructure projects (such as the Navy Yard's green infrastructure projects), and other District and federal projects to determine their current effectiveness in relieving pressures on the CSS.
- Adopting clear, consistent performance measures District-wide that meet the needs of DC Water and other agencies to track both regulatory and voluntary requirements.
- Developing a uniform, geospatially-referenced database that's used internally by multiple agencies to track current and future green infrastructure practices that includes attributes necessary to evaluate and track performance over time.
- Jointly funding green infrastructure projects in areas that are beneficial to multiple local and national government agencies.

An additional next step includes the development of a green infrastructure base layer for use by DC Water as it moves forward. While such a layer will not provide the full utility of a GIS layer as described in Chapter 7, it will provide the agency with a starting point when identifying existing green infrastructure projects in possible locations.

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Appendix A RiverSmart Homes: Sample Project Waivers, Agreements, and Inspection Template

AGREEMENT BETWEEN
THE ALLIANCE FOR THE CHESAPEAKE BAY AND

____

(Name of Property Owner)

The Alliance for the Chesapeake Bay (ACB) has been tasked by the District of Columbia Department of the Environment (DDOE) to install landscaping practices as a part of their their RiverSmart Homes Program. The practices could include installation of rain gardens, Bayscaping, and replacing impervious surfaces with pervious surfaces.

_______________________________________(Name of Property Owner) at

____(Address of Property Owner) (the Property Owner) has been audited by DDOE and has agreed to participate in this program.

This agreement between ACB and the Property Owner shall describe the agreement between the parties concerning this demonstration project. For the purposes of this agreement, the Best Management Practices (BMPs) are defined as follows:

- "Rain garden" is defined as: An area that is designed to accept storm water from a rooftop or other impervious surface and allow it to infiltrate into the ground. The rain garden is designed to accept rain water from a point and, during large rain events, to accept overflow using sheet flow into the surrounding land without the use of an under drain attached to the sewer system. The rain garden is landscaped with native plants from the mid-Atlantic region that are adapted to be occasionally inundated. Rain gardens must not disturb existing trees and/or their roots covered by the District's Tree Preservation Act.
- "Bayscaping" is defined as: An area that is landscaped using native plants from the mid-Atlantic region that are suitable to the site conditions. The Bayscaped area will be designed to use plants adapted to the site's environmental conditions so that they will require little to no watering, fertilizer or pesticides once established and, when possible, will provide habitat and food for wildlife. The Bayscaped area will include a variety of plants and plant heights, plants with deep roots, and a layer of mulch to encourage storm water retention and uptake.
- "Permeable pavement" is defined as: An area of 150-180 square feet that is covered with pavement or other hard surface that permits water penetration into the soil. Permeable pavement may consist of any porous surface materials which are installed, laid, or poured such as paving stones, cement, or asphalt.

Responsibilities of ACB, through its contractors:

1. Educate Property Owners about RiverSmart Homes program
2. Meet with Property Owners to ensure they understand the project and the maintenance required with it
3. Work with property owners to schedule installations

4. Install rain gardens, Bayscaped yards, and replace impermeable surfaces with permeable surfaces (BMPs)
5. To ensure the homeowner's proper use and maintenance of rain gardens, Bayscaped yards, and permeable surfaces, and monitor these installations for not less than six months and up to one year.
6. It is understood that the ACB contractor has general liability insurance not less than $1 million to cover contractor activities on the property

Responsibilities of the Property Owner:

1. Allow access to the site by ACB representatives and their contractors
2. Allow photos to be taken before, during and after installation of all projects
3. Make their property accessible for watershed friendly garden tours for one year following installation
4. Display a sign on their property, once these best management practices are installed, explaining what the landscaping features are, their benefit to water quality, and that they were funded through a grant from DDOE.
5. Maintain the BMPs, including adequate watering of any installed plants and weeding at least four times a year;
6. Allow ACB representatives access to the rain garden, Bayscaped yard, and/or pervious surface for up one year after installation to inspect for proper maintenance.
7. Inform ACB representatives of any surface or subsurface property conditions such as pipes, cables or other obstructions or hazards on the property

Indemnification

The Property Owner agrees to indemnify and hold harmless ACB and all of its officers, agents and servants against any and all claims of liability or lawsuits arising from or based on, or as a consequence of or result of, any act, omission or default of the ACB, its employees or its subcontractors, in the performance activities piloting the RiverSmart Homes program.

FOR THE ALLIANCE FOR THE CHESAPEAKE BAY (ACB):

ACCEPTED BY:

SIGNATURE: ____
DATE: ____________________

FOR PROPERTY OWNER:

ACCEPTED BY: ____

SIGNATURE: ____
DATE: ____________________

RiverSmart Homes
Clean Water Starts in Your Yard

DISTRICT DEPARTMENT OF THE ENVIRONMENT

AUDIT AGREEMENT

I, Owner or Owner's Authorized Agent of ____,
(Address of participating property)

gives the District Department of the Environment (DDOE), the United States Environmental Protection Agency (EPA), or an authorized agent permission to inspect my property for participation in the RiverSmart Homes Program at an interim phase of completion as well as after final completion of the project. The RiverSmart Homes Program provides funds to participating homeowners to demonstrate landscape enhancements also known as low impact development (LID) including the installation of rain barrels, pervious pavers, rain gardens, BayScaping, and shade trees on residential property, in order to reduce the rate of stormwater to the District's water bodies and to improve their water quality.

I agree to allow DDOE to conduct a storm water audit to provide a list of opportunities, and techniques to reduce the rate of storm water to the municipal storm sewer. I understand that if I agree to install RiverSmart Homes landscape enhancements, I will be contacted by the Alliance for the Chesapeake Bay (ACB), DC Greenworks, and/or Casey Trees to access my property for consultations, installations, and monitoring. I realize that all RiverSmart Homes practices require co-payments which permit up to $1,200 in landscaping that reduces stormwater runoff to help the District's streams and rivers. I understand that all work must be completed within eight months of the storm water audit by a District of Columbia licensed contractor in order to receive grant funding towards the LID landscape enhancements installed on my property. I recognize that there may be a possibility for scheduled tours to view the LID landscape enhancements installed on my property as a part of being a demonstration site. Furthermore, I understand that funding is subject to availability and is not guaranteed.

My acceptance of the RiverSmart Homes Program funds from DDOE is acknowledgement that in no event will the District of Columbia or any of its officers, agents, employees or servants be liable for any work or services performed or not performed, or for any claims of liability or lawsuits arising from or based on, or a consequence of or result of, any act or omission resulting from the storm water audit and acceptance of these funds for the LID practices.

I have read, understood, and agree to the terms and conditions above:

____
Property Owner or Owner's Authorized Agent

______________________________ ____________________
Signature Date

GOVERNMENT OF THE DISTRICT OF COLUMBIA
Adrian M. Fenty, Mayor

FORCE LETTERHEAD

Date

Name
Address

Dear ________________:

Your rain garden, rain barrel, and bayscaping are now in! The design, planting, and construction were paid for by a “Green Yards/Clean Streams” grant from the District of Columbia Department of the Environment. This work will be an example of how people can make changes in their own yards to help protect our streams.

We hope that this will be an asset to you and your neighborhood for many years to come. To make sure the garden stays beautiful and healthy and that everything works as it should, you will need to take care of it. Here is a list of what needs to be done.

Please sign below to indicate your willingness to care for the garden and rain barrel.

If you have any questions or problems with the project, please call me at (202) 363-1320.

Sincerely yours,

Beth Mullin
Executive Director

I agree to take care of my garden and rain barrel following the instructions included with this letter.

Name: __________________________   Date: __________________

RAIN GARDEN AND BAYSCAPING CARE INSTRUCTIONS

First Two Weeks after planting

- Water all plants every day for the first 14 days after planting

First Two Years

- Water plants regularly if there has not been a significant recent rainfall (mid-March through December)
- Cover any bare spots with mulch
- Weed the garden area and around planted trees as needed (at least 4 times a year)
- Watch out for erosion and repair it before soil and mulch wash away
- Replace any broken stakes or wires
- Keep an eye on trees and shrubs for pests or disease and call the District of Columbia Cooperative Extension Service at (202) 274-7115 to find out how to handle the problem

Each Year in Late Winter (February to Early March)

- Prune dead branches from trees and shrubs

Every Spring (April 15-May 30)

- Take out all dead and dying plants (remember that many of your plants naturally die back each year and return in the Spring)
- Put in new plants to replace dead ones. Please plant only native perennial plants that are adapted to the conditions appropriate to your garden. If you have questions, please contact DDOE at 202-535-2246
- Add new mulch (every two to three years, take out old mulch before adding new

Every Fall (October 1-Novemebr 30)

- Remove stakes from tree(s) two years after planting
- Take out all dead and dying plants
- Put in new shrubs or trees to replace dead ones. Again, please plant only native trees and shrubs that are adapted to your garden's conditions

Watering Tips

A heavy soaking 2-3 times a week is needed, if it has not rained heavily. A soaker hose or gentle spray that waters slowly is best. New plants need about an inch of water a week. To see if watering is needed, clear away the mulch and poke a stick or screwdriver into the soil. If it does not go down 6 inches, you need to water.

RAIN BARREL MAINTENANCE AND CARE INSTRUCTIONS

Please also read carefully the brochure that came with your barrel.

Every Spring (when temperatures are high enough to avoid frozen barrels)

- Turn the diverter valve on your rain barrel to "collect" so that rain water enters your barrel
- Close the drain at the base of the barrel (unless you have a soaker hose attached to the spigot
- Clean your filter bag (attached to the diverter valve on the rain barrel)

Monthly

- Clean your filter bag (attached to the diverter valve on the rain barrel)

Every Winter (when temperatures are low enough to freeze water in the barrel)

- Turn the diverter valve on your rain barrel to "bypass" so that rain water does not enter your barrel
- Open the drain at the base of the barrel

REMEMBER: BEFORE IT RAINS ITS TIME TO DRAIN – EMPTY YOUR RAIN BARREL BEFORE EVERY PREDICTED RAIN EVENT

We understand the desire to keep rainwater in your barrel to water your plants, but a rain barrel can only collect as much rain as it has space to hold. If your rain barrel is empty it will be more effective at keeping stormwater pollution out of our drains and sewers. Again – before it rains it's time to drain so that your barrel will capture the maximum amount of rain, will be less likely to overflow, and will help you prevent pollution to our local streams and waterways!

RiverSmart Homes
Clean Water Starts in Your Yard

DISTRICT DEPARTMENT OF THE ENVIRONMENT

Inspection Report for Landscaping Features

Site Address: ________________________ **Name of Reviewer:** ________________

Contractor: ________________________ **Date of Site Visit:** ________________

Type of Installation: __________________

BayScaping Specifications (check if completed):

( ) BayScape gardens must replace existing lawn area and encompass a minimum of 120 square feet. If the area is less than 120 square feet, justification for size constraints must be submitted to ACB.
Comments:____
____

( ) Native plants to the Chesapeake Bay region must be used in creation of BayScape gardens. Some non-native, non-invasive plant exceptions may be made, but must be approved by ACB prior to use.
Comments:____
____

( ) Plant material must total 34 gallons for 120 square feet (size of perennials can be substituted at a 2 quart: 1 gallon equivalency).
Comments:____
____

( ) Completed BayScape gardens should have at minimum a 2-3" hardwood mulch layer.
Comments:____
____

Rain Garden Specifications (check if completed):

( ) The rain garden location must be a minimum of 10 feet away from any existing foundation or retaining wall.
Comments:____
____

( ) The bioretention soil mix ratio must be 50% concrete sand, 25% topsoil, 25% compost/leaf mulch
Comments:____
____

( ) If the downspout is piped to the rain garden, then the pipe must be at least a 2% grade down and away from the house.
Comments:____
____

( ) Rain garden depth must be a minimum of 18-24"
Comments:____
____

( ) Completed rain gardens should have a 2-3" hardwood mulch layer.
Comments:____
____

( ) If a downspout drains to the rain garden, there should be a 3 square foot area of river rock at its outlet.
Comments:____

( ) Native plants to the Chesapeake Bay region must be used. Some non-native, non-invasive plant exceptions may be made, but must be approved by ACB prior to use.
Comments:____

( ) Plant material must total at least 22 gallons (size of perennials can be substituted at a 2 quart: 1 gallon equivalency). Each rain garden must have a minimum of 2-3 shrubs at 3 gallons each.
Comments:____

( ) Excavated soil should be used in berm construction. The berm must be compact and level to provide sheet overflow.
Comments:____

( ) If the additional excavated soil can stay on site and is placed on a grass or lawn area then the area must be reseeded and straw mulched; if the additional excavated soil is used to create a bed or placed on existing soil then the area must be mulched with 2-3" of hardwood mulch. If there is no suitable location on site for the additional excavated soil, then it must be hauled away.
Comments:____

Replacement of impervious surface (check if completed):

( ) Must remove existing impervious surface (i.e.: concrete or asphalt)
Comments:____

( ) Final installed product must be pervious (either pervious pavers or planting beds/grass)
Comments:____

Follow Up Action (if necessary): ____

Appendix B List of Green Roofs and Schoolyard Conservation Sites as Reported in the District's Green Resources and Sites Data Layer

Building/Address 1	Address 2	Square Feet
1015 Half Street SE	1015 Half St SE	
11 Story Condominum	1117 10th St. NW	10,230
3 story Condo	2120 Wyoming Ave NW	
Affordable Housing	2025 Fendall Street SE	6,740
Akridge Office Buliding	700 6th St. NW	10,778
Alta Condominium	1133 14th St. NW	4,500
American Chemical Society	1155 16th St NW	
American Legacy Foundation	1724 Massachusetts Ave NW	
American Psycological Association	10 G St NE	3,000
American Society of Landscape Architects Headquarters Bldg	636 I St NW	
American University	4400 Massachusetts ave nw	6,000
American University - Mary Graydon Center	4400 Massachusetts Ave NW	9,600
American University - Media Production Center	4400 Massachusetts Ave NW	8,900
Anacostia Gateway Office	1800 Martin Luther King Jr Ave SE	
Anacostia Gateway Office	1800 Martin Luther King Jr Ave SE	10,000
Anacostia Senior High School	1601 16th St SE	
APA and World Resources Institute	10 G St NE	
Apt Building 912-915 12th ST NE	915 12th Street NE	
Ariel Rios Federal Building-EPA (GSA)	1200 Pennsylvania Avenue NW	
ASLA Headquarters Bldg	636 Eye Street NW	3,300
ATF	101 New York Ave. NE	12,000
Bearden Arts Center	1341 H Street NE	1,507
Belmont Lofts Condo Bldg	1330 Belmont Road NW	3,600
Benning Library	3935 Benning Rd NE	
Bogdan Builders Residential	1224 R St NW	6,000
British Embassy	3100 Massachusetts Ave NW	3,900
Building	620 F St. NW	
Building	1107 Eye Street NW	16,021
Building	3300 K street NW	
Cannon House Office Building, AOC	25 INDEPENDENCE AVENUE SE	
Casey Trees / DC Greenworks	1425 K Street NW	3,500
Columbia Heights Rec. Center	1480 Girard St NW	1,000
Commercial Bldg	1201 First St NE	
Commercial Bldg	1234 H St NE	
Commercial Bldg	1275 First St NE	
Commercial Bldg	145 N St NE	
Commercial Bldg	1200 19th Street NW	16,759
Commercial Buuilding	1600 Maryland Ave NE	
Commerical Building	1050 K St NW	
condos	1302 Gallaudet Street NE	1,500
Consolidated Forensics Lab	418 4th Street SW	
Court House	451 Indiana Ave. NW	
DC Armory	2001 East Capitol St SE	
DC Rec Center at Trinidad	1310 Childress St NE	
DC Rec Center at Trinidad	1310 Childress Street NE	5,000

Building/Address 1	Address 2	Square Feet
DCG Greenroof	3030 12th ST NE	36
Department of Employee Services	4058 Minnesota Ave NE	
Dept of Employment Services	4058 Minnesota Avenue NE	
DPW Garage	200 Bryant St NW	
DPW Maintenance Facility	1827 West Virginia Ave NE	
DPW solid waste transfer station	3200 Benning Rd NE	
Dreyfus Office Building	1101 New York Ave NW	25,000
Earth Conservation Corps	2000 Half St SW	
Earth Conservation Corps	2000 Half street SW	3,000
Earth Day Park, DOE (GSA)--built 1995	800 Independence Ave SW at 395 Freeway	
EPA West (GSA)	1201 Pennsylvania Avenue NW	
Federal Trade Commission	600 Pennsylvania Avenue NW	
FEMS Engine 30	50 49th St NE	
FEMS Engine 6	1300 New Jersey Ave NW	
Fendall Street Condos	2025 Fendall St SE	
FOB 10A (GSA)	800 Independence Ave SW	
Forrestal Bldg, DOE (GSA)	1000 Independence Ave SW	
Franies-Perkins Bldg, DOL (GSA)	200 Constitution Ave NW	
Franklin D. Reeves Center	2000 14th Street, NW	4,000
Friends Committee on National Legislation	245 2nd St NE	
Friends Cte on Nat'l Legislation	245 Second Street NE	1,400
Galludet Univeristy Garage	800 Florida Ave NE	3,000
Galludet University	800 Florida Ave NE	600
General Scott Condos	1 Scott Circle NW	7,500
Georgetown Heights	2501 Wisconsin Ave. NW	5,200
Harbourside Garage	2900 K street NW	
Harvard Hall	1650 Harvard ST NW	20,000
HD Woodson Senior High School	5500 Eads St NE	
Hotel	201 Florida Avenue NE	13,132
Human Rights Campaign	1640 Rhode Island Avenue NW	2,000
IRS Building (GSA)	1111 Constitution Ave NW	
J Edgar Hoover Bldg, FBI-(GSA)	935 Pennsylvania Ave NW	
JBG / DOT Headquarters	1200 New Jersey Ave SE	69,000
JBG / US Dept. Transportation	1200 New Jersey Ave SE	
JBG Lousiana Ave	51 Louisiana Ave.,. NW	12,466
Latin American Montessori School	1375 Missouri Ave NW	
Lofts 11	1125 11th St., NW	2,800
Logan Station condos	1200 R St NW	
Mary Switzer Building	330 C St S.W.	
Mi Casa Condos	1917 Capitol Avenue NE	1,500
Nationals Park	1500 South Capitol St SE	6,317
Nationals Park	1st and N ST SE	6,317
New 4 story building	235 Carroll St., NW	9,540
New 9 story building	1209 13 St., NW	3,420
New Building	801 17th Street NW	11,249
New Building	111 K Street NE	2,640

Building/Address 1	Address 2	Square Feet
New Building	3417 Mass Ave., NW	2,528
New Commercial Building	1999 K Street NW	8,933
New Community Building	3531 Georgia Ave NW	1,600
New Office Building	900 Massachusetts Avenue NW	11,399
Office Building	1015 Half Street SE	
One Judiciary Square	441 4th Street, NW	8,000
Overlook Lofts	1454 Belmont St NW	2,600
Pepco Substation	1020 33rd street NW	2,000
Police Training Academy	4665 Blue Plains Dr, SW	15,000
Polinger	1200 First St NE	
Private Residence	611 M Street NE	1,270
Regency House Senior Center	5201 connecticut Avenue NW	6,000
Renovation of Existing Building	1200 19 Street NW	
Residential	1213 G St NE	
Residential	1430 Independence Ave SE	
Residential	1439 W Street NW	
Residential	2724 Chain Bridge Road NW	
Residential	3214 Sherman Ave NW	
Residential	3511 Idaho Ave NW	
Residential	417 H Street NE	
Residential	421 H Street NE	
Residential	616 East Capitol St NE	
Residential	631 7th Street NE	
Residential	2846 Davenport St NW	830
Residential Bldg	1721 Seaton St NW	
Residential Bldg	1771 Church St NW	
Residential Bldg	419 4th St NE	
Residential Bldg	929 S St NW	
Residential Bldg	1310 K Street SE	2,060
Residential/Com. Building	1353 U Street NW	1,300
Residential/Commercial	2160 CALIFORNIA STREET NW	
Resources for the Future	1616 P st NW	4,000
Restoration and Addition on school	1375 Missouri Ave., NW	2,682
Riggs LaSalle Rec. Center.	501 Riggs Road NE	1,000
Robert Kennedy Bldg, DOJ--(GSA)	950 PENNSYLVANIA AVENUE NW	
SEIU	1800 Massachusetts Ave NW	12,400
SEIU	1800 Massachusetts Ave NW	21,000
Seven Story Apt Building	4100 George Avenue NW	5,573
Shaw Library	945 Rhode Island Ave NW	
Sidwell Friends School	3825 Wisconsin Ave. NW	7,000
Smithsonian ZOO	3001 Connecticut Ave NW	6,500
Smithsonian ZOO (Bamboo)	3001 Connecticut Ave NW	480
Smithsonian ZOO (OTTER)	3001 Connecticut Ave NW	672
St Alban's School	3001 Wisconsin Ave. NW	5,080
Supreme Court	1 1st ST NE	
Swiss Ambassador's Residence	2900 Cathedral Ave. NW	7,000

Building/Address 1	Address 2	Square Feet
Tenley Town Library	4200 Wisconsin Ave NW	
UCC 911 Call Center	2700 Martin Luther King Jr Ave SE	
UCC 911 Call Center	2700 Martin Luther King Jr Ave SE	5,000
UDC Bldg retrofits	4200 Connecticut Ave NW	
UDC plaza garage	4200 Connecticut Ave NW	
Underground Utility	1119 F Street NW	
Urban Ecology Center (USPS)	314 Carroll St. NW	7,000
US Dept of the Interior	1849 C St NW	
US Dept of the Interior	1849 C ST NW	10,000
US Tax Court Fountain--built 1973	400 Second St NW	
US Tax Court Plaza--built 1972	400 Second St NW	
US Tax Court roof	400 Second St NW	
USDA	1400 Independence Ave SW	2,100
USDA	1400 Independence Ave SW	136
Walter Reed Medical Center	6900 Georgia Ave NW	10,000
Wheeler Building	1120 19th St NW	
Wilbur J. Cohen Bldg (GSA)	330 Independence Ave SW	
Woodrow Wilson Senior High School	3950 Chesapeake St NW	
WWF	1250 24th St NW	

Name	Address	Description
Aiton Elementary School	533 48th Place NE	10 beds w/ shrubs, native plants, flowers. Tree planting as a riparian buffer along the Watt's Branch stream. Vegetable garden.
Amidon Elementary	401 Eye Street SW	Planted perennials, shrubs, small trees. Native flower garden; beautification. (Note: the back garden got mowed down)
Anacostia Senior High	1601 16th Street SE	Tree planting and native plant memorial garden.
Anne Beers Elementary	3600 Alabama Ave SE	Anne Beers' "Garden of Discovery" butterfly-design labyrinth and 100 milkweed and nectar plants funded by Rotary Club and DDOE.
Backus Middle (Closed)	5171 South Dakota Ave NE	Parking lot garden placed near drains to help reduce runoff. Raised beds, butterfly garden; tree planting.
Bancroft Elementary	1755 Newton Street NW	Rain garden, native plants, raised beds with herbs, vegetables and flowers, asphalt removal, a variety of trees.
Barnard Elementary	430 Decatur Street NW	Rain garden, portable planters for alphabet garden in whisky barrels and two large garden boxes filled with shrubby plants and flowers.
Benjamin Banneker Academic High School	800 Euclid Street NW	Courtyard tree boxes
Bowen Elementary	101 M Street SW	Tree plantings, transplanting of shrubs and perennials, removal of dead shrubs and trees, and filling/regrading of pot-holes and sunken areas.
Brent Elementary	301 North Carolina Ave SE	Butterfly, vegetable and flower gardens with related books and curriculum. Renovation and reconstruction of schoolyard ongoing, with stormwater mitigation.
Brookland Elementary	1150 Michigan Ave NE	Grates catch and slow rainwater, coconut fiber logs help stabilize soil, and a small channel along path directs run-off toward a newly constructed rain garden. Extensive student involvement.
Brown Junior High	850 26th Street NE	Tree and bulb planting, storm drain marking, and recycling program.
Cardozo Senior High	1200 Clifton Street NW	Peace Garden with two beds each 70 ft by 5 ft, with outdoor benches, a composting area, and a new compass. New trees.
Center City -Trinidad Campus	1217 West Virginia Ave NE	Series of theme projects that include rain gardens, buffer planting, bird habitat garden and butterfly garden.
Cesar Chavez Public Charter School for Public Policy - Capitol Hill	701 12th Street SE	Garden project, in conjunction with the after-school environmental club, to include edibles and flowers.
Cesar Chavez Public Charter School for Public Policy - Parkside Campus	3701 Hayes Street NE	Tree planting, beautification, native flower gardens. Rock pathway with plants and an outdoor classroom area that is still being developed.
Children's Studio School	1301 V Street NW	Teachers and parents constructed a large container garden with flowers, vegetables and herbs, mostly from seed. Related classroom curriculum.
Community Preschool of the Palisades	5200 Cathedral Ave NW	Native plantings, organic vegetables and curriculum using tools such as rain barrel, solar lighting, weather station, and composter to demonstrate garden care and sustainability methods.
Coolidge High School	6315 5th Street NW	Tree Planting.
DC Bilingual Public Charter	1420 Columbia Road NW	Students care for garden. Workshops connect site to curriculum in reading, math, and science. Relationship with local working farm.

Name	Address	Description
Draper Elementary School	6201 5th Street NW	Trees, memorial garden; butterfly and herb gardens, wildflowers, and fruit. Two built-in boxes with annuals, perennials and shrubbery.4,500 sq ft of asphalt removed.
Eaton Elementary	3301 Lowell Street NW	Eleven trees have been planted, including Japanese lilac, redbud, and American holly. Parents have organized a summer watering schedule.
Elsie Whitlow Stokes Comm.	3700 Oakview Terrace NE	Annual "Planting Peace" project. Classes have planted window boxes, bulbs, and native bushes, built birdhouses, created wildlife habitat, and built a stepping stone path.
Emery Elementary	1720 First Street NE	Butterfly garden, two large garden beds with vegetables and herbs, lettuce and herbs, flowers, and composing areas.
Francis Scott Key Elementary	5001 Dana Place NW	Tree planting.
Friendship School - Chamberlain Campus	1345 Potomac Ave SE	Outdoor learning classroom. Habitat garden for pollinators and song birds with benches and a sundial. Over 500 species of native plants.
Garrison Elementary	1200 S Street NW	Students helped build four raised garden beds and planted herbs and other plants.
Harriet Tubman Elementary	3101 13th Street NW	Inner courtyard raised beds; native garden; pond w/ wetland plants and fish; benches.
Hart Middle	601 Mississippi Ave SE	Tree and bulb planting, and storm drain marking.
Hendley Elementary	425 Chesapeake Street SE	Invasives and trash replaced with sand boxes, flower garden and grasses. Students test soil and water quality in the schoolyard.
Horace Mann School	4430 Newark Street NW	Asphalt removed; 6 theme beds: a butterfly garden, bird station, berry garden, sensory garden, and herb garden. Vegetable beds. 60 ft-walled garden with native plants.
Janney Elementary	4130 Albermarle Street NW	After school programs design and plant gardens. Students care for site. Informal curriculum tie-in.
JC Nalle Elementary	219 50th Street SE	Butterfly and caterpillar garden in shape of a butterfly. Walking paths. 500 plants of 21 different species.
Jefferson Junior High	801 7th Street SW	Trees and native plant garden borders, storm drain marking.
John Burroughs Elementary	1820 Monroe Street NE	Butterfly garden. 10-12 whiskey barrels filled with herbs, "sensory plants," and flowering plants. Pathways, trees, additional garden beds.
John Ross Elementary	1730 R Street NW	New playground with Low Impact Development (LID) practices, porous pavers in parking lot, and underground holding chamber.
KAMIT Institute	100 Peabody Street NW	Wetbeds, raised garden beds, small trees planted in courtyard, composters, rain barrel.
Ketcham Elementary	1919 15th Street SE	Two front entry rain gardens--memorial to teacher and several students who died during September 11th tragedies.
Kimball Elementary	3375 Minnesota Ave SE	Composting and garden program. Students participate in planting, harvesting, and eating vegetables their garden. Also forest and pollinator gardens. Greenroof art kiosk.
LaSalle-Backus Education Campus	501 Riggs Road NE	Native butterfly and memorial garden. Creative stormwater strategies.
Leckie Elementary	637 Third Street NE	Leckie 9/11 Memorial Garden Club. Garden is planted with bulbs and perennials and is maintained by school staff.
Lowell School	1614 Kalmia Road NW	Hands-on outdoor classroom with daylighted stream and native riparian vegetation, native edible gardens and wetlands. curriculum connections, stewardship.

Name	Address	Description
Ludlow-Taylor Elementary	659 G Street NE	Class courtyard garden project. Over 500 spring blooming bulbs. Garden incorporated into autism program education.
Maime D. Lee School	100 Gallatin Street NE	Beautifying courtyard and building perimeter. Windowsill plantings to demonstrate germination, propagation and care of living things.
Maret School	3000 Cathedral Ave NW	Community garden with raised beds and pumpkin patch built by faculty, staff, and students. Heirloom plants, open-pollinated seeds.
Marie Reed Elementary	2200 Champlain Street NW	Students and teachers grow and care for garden from seed to harvest. Study of birds, butterflies, moths and other wildlife that visit the site.
McKinley Technology High	151 T Street NE	Tree planting and green house.
Melvin Sharpe Health School	4300 13 Street NW	Students and staff converted a portion of their schoolyard into "Nature's Retreat" for trees, plants, and wildlife.
Miner Elementary	601 15th Street NE	Peace garden and an outdoor learning lab. 450 species of flowers and grasses. Science Club participation.
Moten Elementary	1565 Morris Road SE	Trees and shrubs planted through partnerships with non-profit and local government agencies.
Murch Elementary	4810 36th Street NW	Beautification projects and landscaping. With Casey Trees, over 100 trees such as willow oak, crape myrtle, red maple, and cherry planted on the site.
P. R. Harris Elementary	4600 Livingstone Road SE	Near Oxon Run, school rain gardens help collect runoff from parking lot and filter urban pollutants. Tree boxes.
Paul Public Charter School	5800 8th Street NW	Courtyard with Shakespeare Garden, formal plantings and flower beds referenced in Shakespeare's plays. Trees. Vegetables for "Foods from our School Community" project.
Peabody Elementary School	425 C Street NE	Replaced asphalt with trees and vegetable, herb, and flower gardens. Also butterfly garden.
River Terrace Elementary	420 34th Street NE	Rain garden collects runoff from school's rooftop. Incorporates native trees, flowers, and grasses.
Seaton Elementary	6201 5th Street NW	Outdoor Laboratory with vegetation for urban wildlife. Raised beds, new trees, natural grasses and flowers, and wetland pond with aquatic plants.
SEED Public Charter School	4300 C Street SE	Tree planting and wetland nursery project growing spartina grasses.
Shepherd Park Elementary	7800 14th Street NW	3 terraces along Jonquin St reduce erosion and provide habitat for insects and birds. Also grow native grasses, perennials and edibles. Tree planting.
Sidwell Friends Middle	3825 Wisconsin Ave NW	Constructed wetland treats all building wastewater on site, green roof, and in raised garden beds. Outdoor classroom projects. Building as teaching tool. First secondary school in US to earn LEED green building Platinum rati
Smothers Elementary	4300 13th Street NW	2 detached downspouts that drain into small rain gardens, and tree plantings.
Sousa Elementary	3650 Ely Place SE	Two raised garden boxes with native plants and 4 birdhouses. Marked storm drains surrounding school.
St. Peters Interparish School	422 Third Street SE	
Stanton Elementary	2701 Naylor Road SE	Butterfly and reading garden.
Stoddert Elementary	4001 Calvert Street, NW	3 wildflower gardens including native plant, insect and bird garden, composting area, an arbor entrance and a stepping stone walking path.

Name	Address	Description
Theodore Roosevelt High	4301 13th Street NW	8 new trees to check erosion on hillside. Butterfly and vegetable gardens, two rain gardens, and pond with habitat and food for wildlife.
Thurgood Marshall Academy Public Charter High	2427 Martin Luther King Ave SE	Prominently displayed front garden with eighteen beds. Vegetables such as squash, cherry and zebra tomatoes, eggplants, cucumbers and green bell peppers. Herb garden. Outdoor classroom.
Two Rivers School	1227 Fourth Street NE	2, 272 sq ft of asphalt removed to installed semi-porous pavers.
Watkins Elementary	420 12th Street SE	
Whittier Elementary School	6201 5th Street NW	Butterfly garden, rain gauge, bird feeders, bird baths, benches for students, and interpretive stepping stones trail.

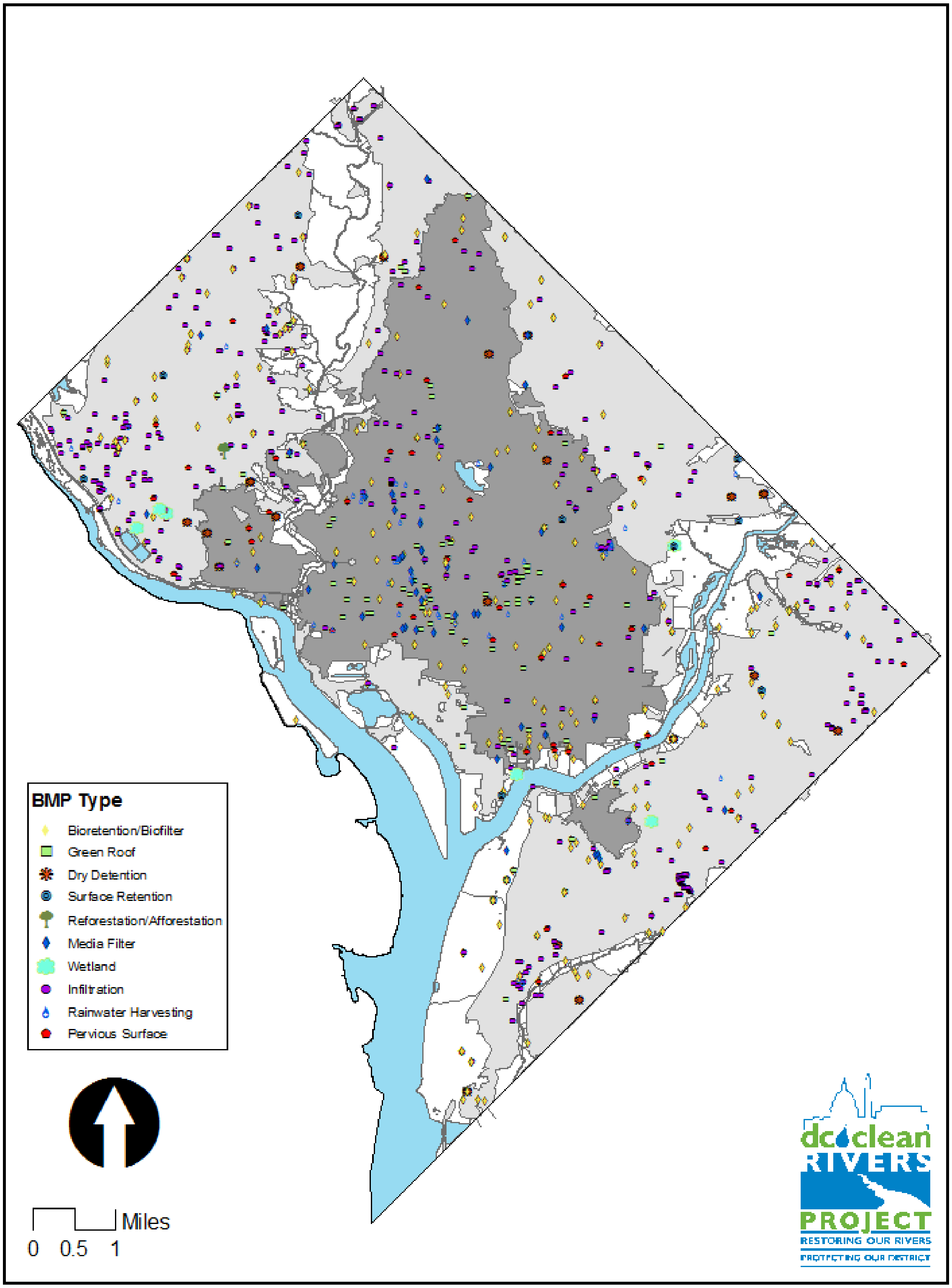

Figure C-1. Location of Approved Stormwater Permits Utilizing Aboveground Green Infrastructure/LID Technologies

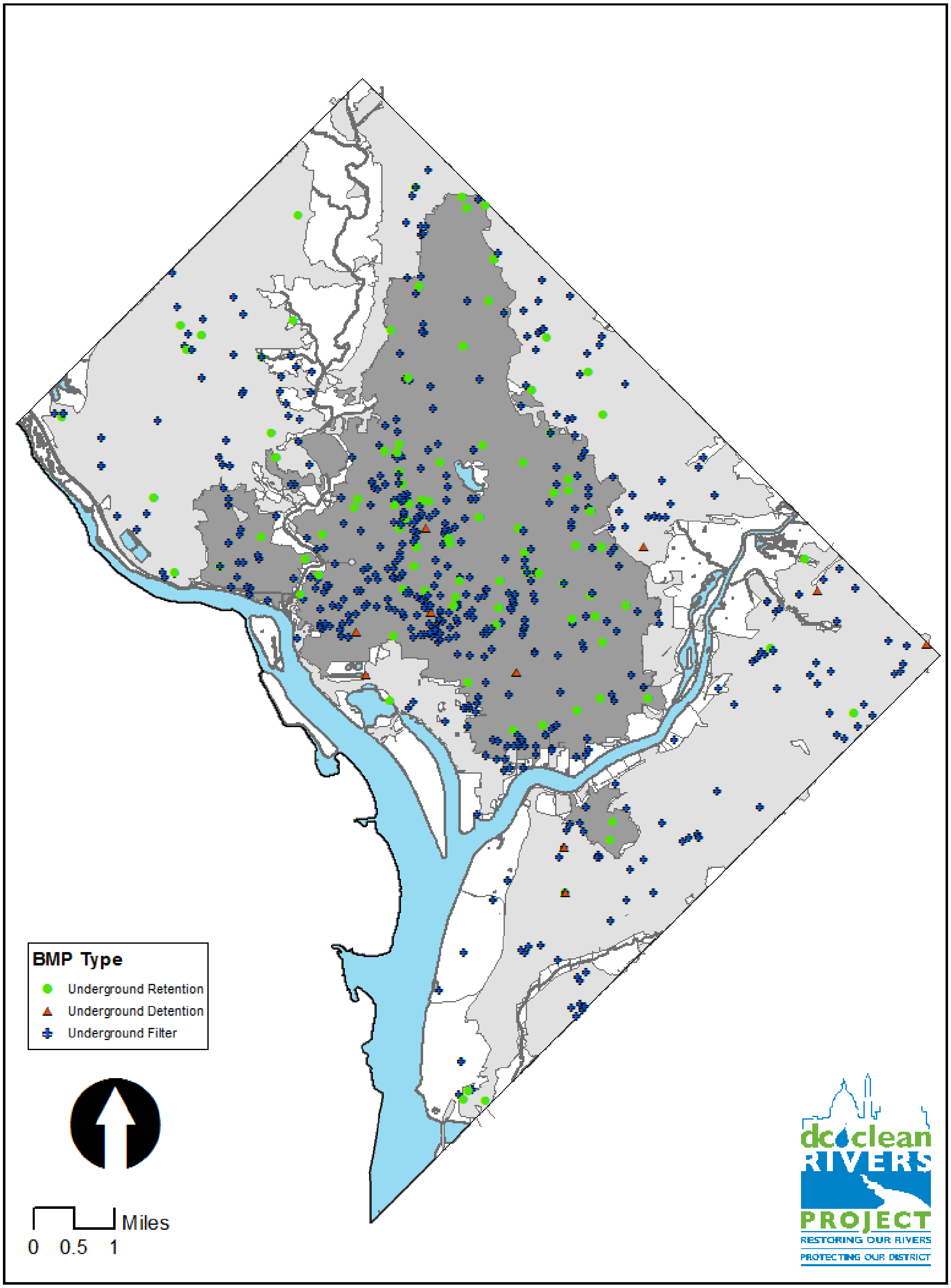

Figure C-2. Location of Approved Stormwater Permits Utilizing Belowground Green Infrastructure/LID Technologies

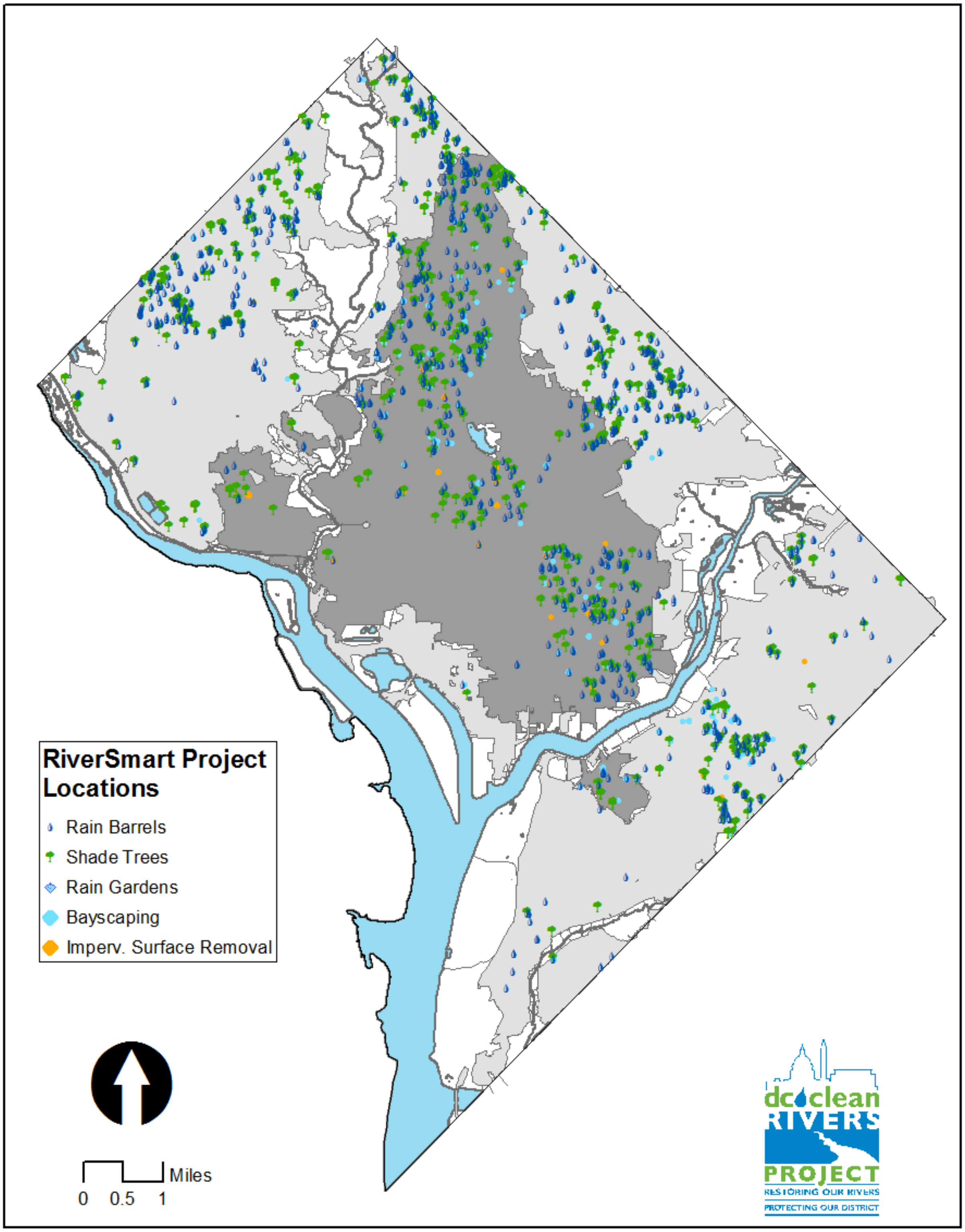

Figure C-3. Location of Approved Stormwater Permits Utilizing Manufactured Devices or Other Green Infrastructure Technologies

Table C-1. Total Number of Approved Stormwater Permits and Associated BMPs in the District of Columbia

	Service Area			
	MS4	CSS	Undef.[3]	Total
Total no. approved permits[1]	683	691	83	1457
Total no. BMPs[2]	974	973	130	2077
BMPs by Type (BMP CODE used in Query)				
Aboveground				
Bioretention/Biofilter (BI, BS, BW, BF, BR)	168	109	33	310
Green Roof (GR)	16	65	2	83
Dry Detention (DB, DC, DN, DP)	15	6	2	23
Surface Retention (RL, RP)	8	1	5	14
Reforestation/Afforestation (RF)	1	0	0	1
Media Filter (FB, FC, FH, FL, FO, FP, FS, FV)	17	37	1	55
Wetland (WB, WC, WM, WU)	4	1	3	8
Infiltration (IB, IT, IW)	366	90	23	479
Rainwater Harvesting (RW)	9	40	2	51
Pervious Surface (PA, PC, PG, PT, PM, PP)	27	36	0	63
Underground				
Underground Retention (RT, RV)	20	75	4	99
Underground Detention (DT, DU)	5	6	1	12
Underground Filter (FU)	183	339	34	556
Manufactured & Other Devices				
Manufactured Devices	126	157	19	302
Other/Uncategorized (OT)	9	11	1	21

Source: Data evaluated from list of Stormwater Permits obtained from DDOE (2011e).

Notes: [1] This analysis pertains to stormwater permits involving green infrastructure techniques to reduce the volume of stormwater reaching the CSS. Approved stormwater permits which only affected water quality without providing a water quantity benefit, such as a stand-alone oil and water separator, were excluded from this count. [2] A single permit may have more than one associated BMP. [3] Undefined includes permit locations that do not fall within either the MS4 or CSS service areas. [4] Manufactured devices include both above and underground devices. Of these, 75 were identified as having water quality benefits only, 47 as having known volume reduction benefits, and 180 with no or unspecified volume reduction benefits.

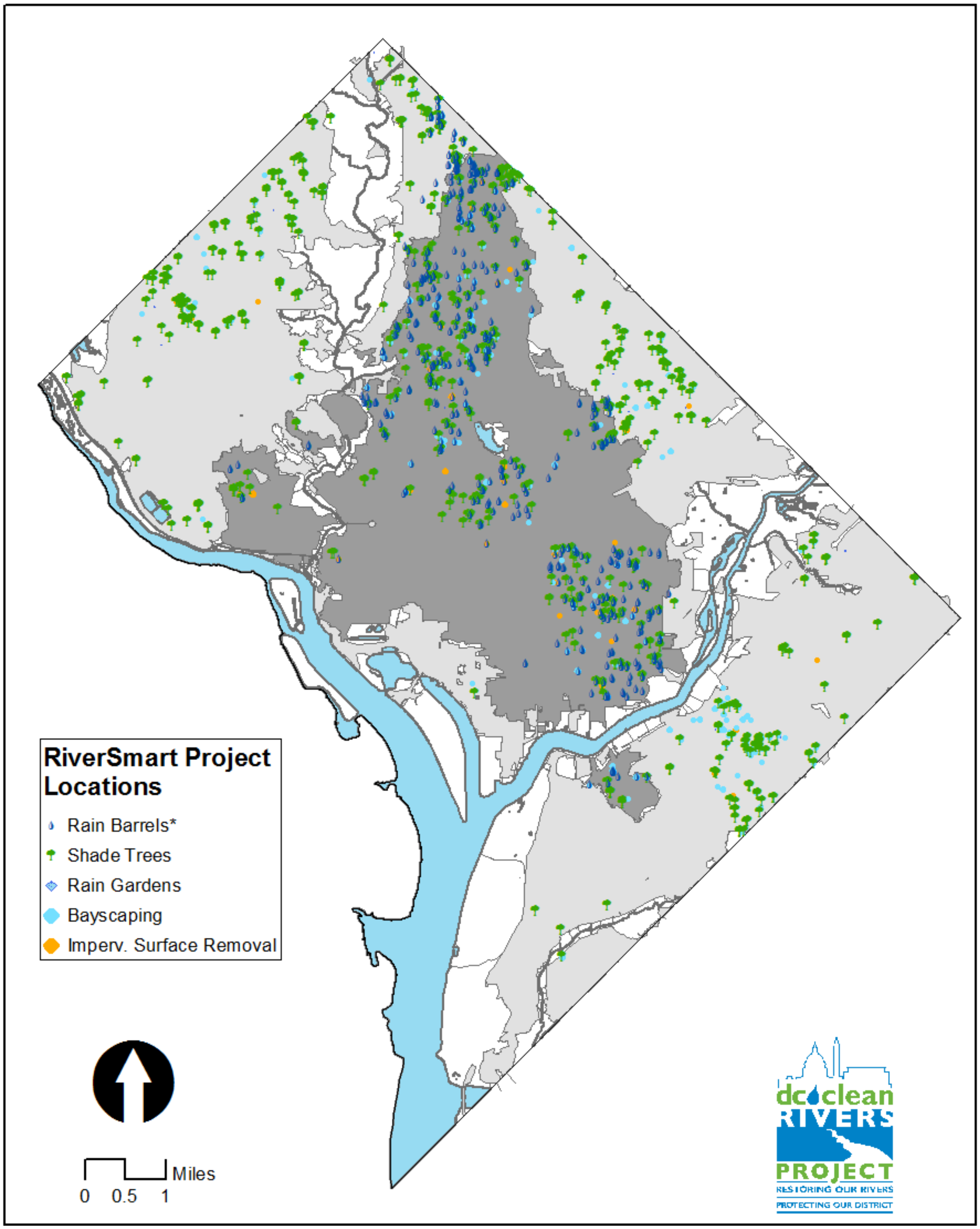

Figure C-4. Location of DDOE RiverSmart Project Installations

Note: *Rain barrel locations within the MS4 Service Area are not shown in this map. Locations are shown utilizing data provided by DDOE (2012).

Appendix - H
Technical Memorandum No. 5 – Green Infrastructure Experience – Foreign and Domestic Case Studies

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

TECHNICAL MEMORANDUM NO.5: GREEN INFRASTRUCTURE EXPERIENCE - INTERNATIONAL AND DOMESTIC CASE STUDIES

July 9, 2012

Prepared for:

Prepared by:

Program Consultants Organization
Blue Plains Advanced Wastewater Treatment Plant
5000 Overlook Avenue, SW
Washington, DC 20032

Distribution

To:	Carlton Ray DC Water
From:	Ray Hyland DC Clean Rivers Project
Prepared By:	DC Clean Rivers Project Wetland Studies and Solutions, Inc.
Reviewed By:	Donal Barron DC Clean Rivers Project

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1 Introduction

Nearly one third of the District of Columbia (the District), or approximately 12,000 acres, is served by combined sewers. These sewers were constructed in the late 1800s and early 1900s and were designed to handle both stormwater runoff and sanitary waste. They perform well in dry weather or during light rainfall, but during significant rainfall they become overwhelmed by the volume of the combined flow and overflow to nearby streams and other waterways. This is called combined sewer overflow (CSO) and poses significant health and ecological concerns. The CSO problem is not unique to the District. Many cities, mostly in the northeast, mid-Atlantic and mid-west, have similar problems. In fact, there are over 770 CSO communities currently regulated by the U.S. Environmental Protection Agency (EPA) and seeking ways to best reduce and/or eliminate their CSOs. For large cities, deep underground storage is usually a significant element of the solution. Other solutions include green infrastructure, system storage, increasing treatment capacity, and sewer separation. Most Long Term Control Plans (LTCPs) for CSO control will include some combination of these solutions.

Under a Consent Decree entered in March 2005, DC Water is required to implement projects for the capture and storage of CSOs during rain events that exceed the capacity of the combined sewer system. These projects include construction of deep underground storage tunnels, rehabilitation of pump stations, limited separation, and small scale green infrastructure projects on facilities owned by DC Water.

The Consent Decree requires control of CSOs for all three of the District's main waterways - the Anacostia River, Potomac River, and Rock Creek. The largest efforts and the most resources are targeted towards projects to reduce CSOs affecting the Anacostia River, which receives the largest volume of CSOs during a year of average rainfall. The Anacostia River is a relatively stagnant waterbody due to a long residence time that is affected by the tide. Therefore, the Anacostia River is more dramatically affected by CSOs and is the most impaired of the three targeted waterbodies. Consequently, the Consent Decree implementation schedule for the Anacostia River is highly aggressive and requires significant infrastructure to be constructed by 2018 to help reduce CSOs. This work is well underway and includes major tunnel segments, a dewatering pump station, an enhanced clarification facility, and diversion structures.

CSO controls in the Potomac River and Rock Creek watersheds also require construction of underground storage facilities, which need to be in place by 2025. In order to achieve these deadlines, facility planning for each of the tunnels must start no later than 2015 and 2016, respectively. The Consent Decree also contains a provision requiring the evaluation of green infrastructure solutions to potentially reduce the size of the storage facilities. The purpose of green infrastructure would be to prevent or delay stormwater from entering the combined sewer system. For example, paved or impervious surfaces would be replaced by green (usually vegetated) pervious surfaces that allow stormwater to infiltrate rather than flowing directly into the system.

DC Water views this requirement as an opportunity to fully explore the potential for green infrastructure in the District and, in particular, in the Potomac River and Rock Creek watersheds where dollars spent on green infrastructure could be expected to yield corresponding savings in the amount spent on storage facilities or "gray" infrastructure, such as tunnels. This is in line with current national trends in CSO control. The EPA has issued guidelines and has shown public support for CSO control solutions that incorporate green infrastructure. In addition, recent Consent Decrees have allowed for more comprehensive green infrastructure components with implementation schedules that allow for adequate testing and installation.

DC Water plans to follow a similar path and aspires to be a leader in green infrastructure solutions. In addition to CSO volume control, green infrastructure provides many other benefits such as improved water quality, enhanced wildlife habitat, a reduction in the heat island effect, increased property values, and an increase in the number of "green" jobs. These are known as the "triple bottom line" benefits. Green infrastructure also provides a highly visible CSO solution that typically garners public support. While the construction of gray infrastructure (i.e., storage tunnels) results in a CSO control solution that can be easily quantified, the benefits of green infrastructure are not as highly visible and do not provide as many peripheral improvements.

In order to advance this green infrastructure objective, DC Water needs to make progress on a number of fronts.

- **Re-evaluate EPA's Consent Decree.** DC Water has begun a dialogue with EPA to reopen their Consent Decree and negotiate a time extension for the work in the Potomac River and Rock Creek watersheds. This is necessary to allow DC Water to implement green infrastructure projects. Implementing green infrastructure will be challenging given existing constraints in the District, such as institutional conflicts and lack of control over public space. Adequate time is necessary to resolve institutional issues, design, construct, and monitor the projects. The existing Consent Decree does not allow enough time for this process, therefore an extension is needed to implement green infrastructure.
- **Public Outreach.** DC Water has begun a public and stakeholder outreach process, including meeting with District agencies to standardize design guidelines and resolve institutional issues to allow implementation of green infrastructure in public space.
- **Green Infrastructure Research.** DC Water is working to prepare and document the necessary research to support the case for implementing green infrastructure to control stormwater and subsequently reduce the size and scale of gray infrastructure required (i.e., storage tunnels). This research is being documented in series of technical memorandums that explore the important aspects of the planned approach and make the case for implementation of green infrastructure on a large scale. These technical memos will eventually be compiled into a document which will be a supplement to DC Water's LTCP for CSO control. Following is a list of technical memorandum (TM) that are either completed, in preparation, or planned.
    - TM 1: Public Participation Plan
    - TM 2: Approach to Hydrological and Hydraulic Modeling
    - TM 3: Green Infrastructure Project plan
    - TM 4: District Green Infrastructure Experience
    - TM 5: Green Infrastructure Experience – International and Domestic Case Studies
    - TM 6: Green Infrastructure Technologies
    - TM 7: Screenings Assessment (Sewershed Characterization)
    - TM 8: Quantifying Added Benefits of Green Infrastructure
    - TM 9: Private Property Issues
    - TM 10A: Institutional Issues – Identification of Issues and Obstacles
    - TM 10B: Institutional Issues – Identification of Possible Solutions

- TM 10C: Institutional Issues – Selection of Remedies
- TM 10D: Institutional Issues – Legislation and MOUs
- TM 11: Sensitive Areas Evaluation
- TM 12: Final Report on Demonstration Projects
- TM 13: Basis for Cost Estimating
- TM 14: Alternatives and Water Quality Standards Evaluation

The purpose of TM 5 is to outline the research and work that has been done in the United States and around the world to advance the implementation of green infrastructure. Since there is almost an infinite amount of information available, the primary focus of TM 5 is to extract information that is most applicable to the work being undertaken by DC Water and the unique challenges that are faced in an urban environment.

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2 Green Infrastructure and the Regulatory Environment

Green infrastructure is increasingly being used to help meet the demands to better regulate CSOs and sanitary sewer overflows (SSOs). By reducing or mitigating the effects of stormwater runoff, green infrastructure provides a means for communities to comply with regulations related to the Clean Water Act, National Pollutant Discharge Elimination System (NPDES), LTCPs, consent decrees, and total maximum daily loads (TMDLs). Green infrastructure can often help meet these requirements in a more economically feasible manner than traditional gray infrastructure approaches. Many communities have also experienced additional benefits from implementing green infrastructure, such as neighborhood beautification, wildlife habitat, and community revitalization. As the push for green infrastructure increases, government agencies at all levels are stepping in to help guide decision making, provide incentive programs, and establish sound technical data by which to move forward.

2.1 Federal Support for Green Infrastructure

Since 2007, the EPA has actively engaged public and private partners to promote the implementation of sustainable stormwater infrastructure and adaptive management for CSO programs. In 2007, EPA and four partner organizations (the National Association of Clean Water Agencies, the Association of States and Interstate Water Pollution Control Administrators [now the Association of Clean Water Administrators], the Natural Resources Defense Council [NRDC], and the Low Impact Development Center) signed a Statement of Intent to promote green infrastructure as an environmentally preferable approach to stormwater management. Since that time, American Rivers and the Water Environment Federation have also joined the coalition. Some of the strategies developed and implemented in support of green infrastructure are discussed below.

2.1.1 Green Infrastructure Action Strategy

The Partners for Green Infrastructure include American Rivers, the Association of State and Interstate Water Pollution Control Administrators, the Low Impact Development Center, the National Association of Clean Water Agencies, the NRDC, and the EPA. In 2008, this group developed the Green Infrastructure Action Strategy that details a wide variety of efforts that will be pursued over the years by the partner organizations to reduce stormwater runoff, CSOs, and nonpoint source pollution. The Action Strategy covers seven broad categories, including research, outreach and communications, tools, regulatory support, economic viability and funding, demonstration projects, and partnerships. The primary goal of this strategy is to promote the benefits of using green infrastructure in mitigating overflows from combined and separate sewers and reducing runoff.

2.1.2 Community Partnerships

EPA renewed its commitment to green infrastructure in 2011 with the release of “A Strategic Agenda to Protect Waters and Build More Livable Communities Through Green Infrastructure” (Strategic Agenda) and the initiation of ten community partnerships. The updated Strategic Agenda focuses on five main objectives that were selected to encourage communities to adopt green infrastructure solutions, including community partnerships, green infrastructure within the regulatory context, outreach and information exchange, financing, and capacity building. The full Strategic Agenda, results, and products can be found at http://epa.gov/greeninfrastructure.

At the same time the Strategic Agenda was updated, several local communities were recognized for their leadership in the implementation of green infrastructure. These communities' demonstrated continued innovation and removal of key barriers associated with project initiation. EPA recognized the following "model communities", including the District, for their commitment to green infrastructure:

Region 1:	City of Chelsea, MA
Region 2:	Onondaga County, NY
Region 3:	Anacostia River Watershed (includes the District)
Region 4:	City of Jacksonville, FL
Region 5:	Northeast Ohio Regional Sewer District
Region 6:	City of Austin, TX
Region 7:	Kansas City, MO
Region 8:	Denver, CO
Region 9:	Los Angeles, CA
Region 10:	Puyallup Tribe, WA

In early 2012, EPA announced the availability of $950,000 in technical assistance available to partner communities for projects that facilitate the use of green infrastructure to protect water quality. Letters of interest were solicited through April 2012 and it is anticipated that 10 to 20 community partner projects will be funded.

2.1.3 Policy Memorandums

The EPA has also developed several policy memorandums that clarify regulatory programs such as enforcement, drinking water, and water permitting in relation to the implementation of green infrastructure. For example, in 2011, the EPA's Office of Water and Office of Enforcement and Compliance Assurance issued a joint memorandum which encouraged EPA regions to assist their states and local partners in pursuing comprehensive solutions, such as green infrastructure, to Clean Water Act waste and stormwater obligations. Additionally, several memos have been released that promote the integration of green infrastructure approaches in NPDES stormwater permits, Total TMDLs, and CSO LTCPs.

2.2 State and Local Support for Green Infrastructure

States are recognizing that green infrastructure can reduce the volume and occurrence of CSOs, while at the same time contributing to more livable communities and infrastructure cost savings. Therefore, several states and communities are beginning to incorporate green infrastructure approaches into their LTCPs. Additional federal support for this has come through the EPA's release of the updated EPA Green LTCP-EZ Template, which small CSO communities can use to assess the potential for green infrastructure controls to eliminate or reduce CSOs in their communities. The following information summarizes how several communities that have incorporated green infrastructure into their LTCPs.

2.2.1 Cleveland, OH

Cleveland's consent decree requires that the Northeast Ohio Regional Sewer District (NEORSD) supplement its gray infrastructure controls with $42 million in green infrastructure projects that can capture 44 million gallons of wet weather flow each year. The use of additional green infrastructure projects may be proposed to reduce the scope of gray infrastructure projects. NEORSD has weighted the supplemental community and social values of green infrastructure heavily and is targeting green infrastructure projects primarily toward low-income neighborhoods in hopes of revitalizing these neglected areas. Vacant lots in particular will be utilized for green infrastructure. Green infrastructure is being used to not only reduce the hazards associated with CSOs, but also to improve the health, welfare, and socioeconomic conditions of these low-income communities.

2.2.2 Cincinnati, OH

Cincinnati's original consent decree was established in 2004, but amended in 2012 to allow for a phased Wet Weather Implementation Plan which would help reduce the economic burden on residents. The amended plan allows the Metropolitan Sewer District of Greater Cincinnati (MSD) more flexibility to implement green infrastructure technologies. MSD is currently conducting a three year study to evaluate the effects of green solutions in the Lick Run watershed on the west side of Cincinnati. The outcome of this study will help MSD propose adequate green for gray infrastructure substitutions in their LTCP.

2.2.3 Louisville, KY

In 2009, Louisville amended their 2005 consent decree to incorporate the use of green infrastructure to help solve the city's CSO problem. Louisville has committed to implementing 19 green infrastructure demonstration projects which include green roofs, green streets, and urban reforestation to help reduce stormwater runoff. The city will spend $1.5 million over two years to implement these demonstration projects. The city sewer department will conduct a six year study to monitor the demonstration projects and evaluate their function. At that time, the city may propose additional green infrastructure controls. Louisville has also implemented a wide scale rain barrel program, distributing hundreds of rain barrels to residents.

2.2.4 Kansas City, MO

Kansas City's consent decree requires the use of green infrastructure, including rain gardens, permeable pavement, and green roofs, to supplement and replace some gray infrastructure to reduce CSOs. In 2011, the city agreed to initiate a pilot project to implement green infrastructure in a 100-acre basin to retain 300,000 gallons of stormwater at an approximate cost of $3.7 million. The results of this study will be used to implement green infrastructure projects on a larger scale in a 744-acre basin. Upon completion of the pilot studies, the city may then develop a green infrastructure project proposal for the entire combined sewer system for submittal to EPA.

2.2.5 New York, NY

In 2008, New York modified their consent decree to include green infrastructure in addition to gray infrastructure approaches to reduce and eliminate CSOs. In 2010, the city released a Green Infrastructure Plan to initiate widespread adoption of green roofs, bioswales, and other green infrastructure technologies to absorb or delay stormwater runoff. The New York State Department of Environmental Conservation (DEC) and New York City Department of Environmental Protection (DEP) have recently finalized an adaptive management approach agreement that includes: 1) constructing green infrastructure citywide in order to manage 10% of the runoff from impervious surfaces by 2030, 2) constructing $2 million of green infrastructure demonstration projects in three neighborhoods, 3) constructing $3.4 billion in gray infrastructure ($1.8 billion has already been incurred), and 4) publishing 11 LTCPs for the control of CSOs by 2017. The DEC has agreed to eliminate and/or defer many gray infrastructure projects in order to provide the DEP time to build and monitor green infrastructure projects in their place.

2.2.6 St. Louis, MO

St. Louis began updating its original (1999) LTCP in 2002 and submitted it to the Missouri Department of Natural Resources in 2004. This submittal was later disapproved by EPA and then updated again over the next several years. St. Louis's updated LTCP was approved in 2011. Updates included water quality modeling, alternatives analysis, and other items necessary to meet required changes to the state's water quality standards. The city's most current LTCP includes a combination of source control technologies, sewer separation, storage tunnels, and green infrastructure to meet CSO and water quality requirements. The city's selected green infrastructure plans will involve $100 million in green infrastructure investments over a period of 23 years. Pilot projects will initially be used to gauge green infrastructure success, with an end goal of reducing CSO overflow volumes to the Mississippi River by 10 percent.

2.2.7 Syracuse, NY

Onondaga County, home to the city of Syracuse, was placed under an Amended Consent Judgment (ACJ) in 1998 to reduce and eliminate the occurrences of CSOs. Green infrastructure was more recently incorporated in the ACJ as part of an amendment to the ACJ in 2009. The county has plans to invest $78 million in green infrastructure from 470 acres of developed land, which will capture 6.3% of the annual CSO volume (250 million gallons). In combination with gray infrastructure improvements, this plan will allow for capture of 95% of rainfall volume by 2018. Green infrastructure initiatives include rain barrel distribution to homeowners, urban forestry, and a green infrastructure fund that provides grants to developers implementing green improvement projects in districts serviced by combined sewer systems.

2.2.8 Philadelphia, PA

Philadelphia updated their LTCP in 2009 with the Green City, Clean Waters plan (approved in 2011) which is the City's 25 year plan to protect and enhance watersheds by managing stormwater with green infrastructure. The City evaluated a number of alternative implementation approaches and determined that a green stormwater infrastructure-based approach would provide the maximum environmental, economic, and social benefits in the most efficient timeframe. At the end of the 25 year implementation period, Philadelphia will have invested $2.4 billion to initiate the largest green stormwater infrastructure program in the country. This program will capture 85% of the combined sewage collected in the combined sewer system during rain events. With both public and private partners, the vision is to green at least one third of existing impervious areas over the next 25 years, turning them into "Greened Acres" that will filter and store the first one inch of runoff.

3 Green Infrastructure Case Studies: North America

The following case studies look in detail at ongoing efforts in North America to incorporate green infrastructure. This list is not exhaustive, but represents a variety of methods and programs that various communities have employed to better utilize green infrastructure. While successes are highlighted, barriers and failures that these communities have experienced are also explored to provide better insight while moving forward in the District.

The NRDC has created scoring criteria known as the Emerald City Criteria that rates cites based on six key actions that communities should take to maximize green infrastructure investment and become “Emerald Cities”. These six actions include:

- Develop a long-term green infrastructure plan to lay out the city’s vision, as well as prioritize infrastructure investment.
- Develop and enforce a strong retention standard for stormwater to minimize the impact from development and protect water resources.
- Require the use of green infrastructure to reduce or otherwise manage runoff from some portion of impervious surfaces as a complement to comprehensive planning.
- Provide incentives for residential and commercial property owners to install green infrastructure, spurring private owners to take action.
- Provide guidance or other affirmative assistance to accomplish green infrastructure through demonstration projects, workshops and “how-to” materials and guides.
- Ensure a long-term, dedicated funding source is available to support green infrastructure investment.

As of 2011, 14 cities in North America had been rated based on the Emerald City Criteria and were given a score out of six points, based on the actions listed above. For example, the District received an Emerald City score of 5 out of 6. Scores are listed for each city discussed in this report that has received an Emerald City evaluation.

For each of the North American case studies explored in this section, the following information is provided:

- **Overview:** A summary of how the city has used green infrastructure or plans to implement it.
- **Emerald City Criteria:** Scoring based on a maximum of 6 possible points.
- **Regulatory Drivers:** Fundamental regulations that are driving green infrastructure implementation in the city. These are often coupled with additional ecologic, economic, and social drivers.
- **Policies:** Discussion of policies or regulations that each city has implemented to require the use of green infrastructure in various circumstances.
- **Programs and Initiatives:** Discussion of programs, initiatives, and incentives that encourage voluntary participation in green infrastructure implementation.
- **Funding:** A discussion of what source or combination of funding sources each city uses to implement green infrastructure programs.

- **Implementation:** How green infrastructure programs have been implemented, including information on operations and maintenance, partnerships, successes and failures.

3.1 Chicago, Illinois

Overview

Chicago ranks among the leaders in green infrastructure implementation. Often cited for their progressive green roof program, including a 20,300 square foot demonstration project that sits atop City Hall, Chicago has combined several other green infrastructure initiatives to address environmental, social, and economic concerns throughout the city. To date, over 5.5 million square feet of green roofs have been installed on nearly 500 buildings and over 600,000 trees have been added to the urban tree canopy. Additional green infrastructure practices have been incorporated into alley, streets, and buildings. Municipal regulations adopted in 2008 have the potential to divert over 50 million gallons of stormwater annually.

Emerald City Criteria

3 out of 6: Incentives for private party actions; retention standard; guidance or other affirmative assistance to accomplish green infrastructure within the City.

Regulatory Drivers

Like many urban centers, Chicago faces the challenge of aging infrastructure and CSO regulation through their consent decree, which is the main regulatory driver behind green infrastructure implementation. While Chicago has initiated the construction of a large underground tunnel/reservoir to supplement storage for their combined sewer system, this project is many years away from completion. In the meantime, the city has turned to green infrastructure to help mitigate stormwater runoff, as well as provide other benefits. Green infrastructure is viewed as a cost effective means to achieve citywide goals related to reducing green house gases, reducing the urban heat island effect, and addressing the city's efforts to advance its triple bottom line (achieving a healthy environment, thriving economy, and improved quality of life).

Policies

In 2008, Chicago adopted a Stormwater Management Ordinance which is currently the driving policy behind much of the green infrastructure development in the city. This ordinance required that redevelopment that disturbs 15,000 square feet or more, or creates a parking area of 7,500 square feet or more must detain at least the first ½ inch of rain on site. The developer also has the choice to reduce the prior imperviousness of the site by 15 percent.

Programs and Initiatives

Chicago utilizes many green infrastructure technologies across the city to achieve stormwater and other goals. These practices include green roofs, rain barrels, cisterns, permeable pavement, rain gardens, infiltration trenches/vaults, vegetated swales street trees, planter boxes, and stream buffers. The city runs several initiatives that have been successful in addressing their environmental, social, and economic concerns.

Green Roof Program: Chicago's green roof initiative is world renown and has been implemented extensively on municipal buildings and schools. Nearly 500 green roofs, totaling over 5.5. million square feet, have been installed citywide. Incentives for building green roofs are offered through the city's Green Roof Grant Program ($5,000 awarded to 72 small scale and residential green roofs) and the Green Roof Improvement Fund (up to $100,000 awarded to projects within the city's Central Loop District).

Figure 3-1. Green roof on Chicago's City Hall building (Source: City of Chicago)

Green Alleys and Sustainable Streets: The city has also worked extensively to green their alleys and streetscapes. An initiative known as Greening Chicago's Alleys uses permeable pavement to retrofit traditional impervious alley construction to improve infiltration, reduce runoff, and reduce flooding. The Chicago Department of Transportation (CDOT) initially tested this initiative through several pilot projects which proved successful and provided cost savings. To date, over 150 green alleys have now been installed. The city has also produced a "Green Alley Handbook", which describes the program, project implementation, and examples from the pilot projects. CDOT has found that the cost of implementing green alleys is no more than that of traditional alleys and that the pervious pavement used required little maintenance and has a life expectancy of 25 to 35 years.

CDOT is also integrating green infrastructure into its streets through the Sustainable Streetscape Program. This initiative utilizes techniques such as pervious pavement, vegetated swales, and rain gardens to treat and infiltrate stormwater runoff. Pervious pavement has been used extensively in CDOT projects. A more recent pilot project will look at the effects of multiple green infrastructure techniques working together in a comprehensive Sustainable Streetscape project along 1.5 miles of streets in the city's southeast side.

Urban Forests and Stream Protection: The Urban Forest Agenda helps maintain and enhance the urban tree canopy, which the city has deemed an important mitigating factor to both reduce the urban heat island effect and reduce stormwater runoff through interception and absorption of rainfall. The city spends between $8 million and $10 million annually to plant between 4,000 and 6,000 trees, with a goal of achieving 20 percent canopy coverage by 2020. Incentives are also offered to residents and businesses to improve the availability and affordability of tree plantings.

Chicago has also made an effort to conserve and enhance existing green infrastructure such as streams and riparian land. Since 1998, the city has built or expanded nine parks along the Chicago River, restored 4,000 feet of stream banks, and implemented 13 miles of river walk features.

Rainblocker Program: This initiative uses a combination of inlet restrictor valves and downspout disconnection to slow and reduce the amount of stormwater that enters the combined sewer system. The primary goal of this program is to prevent sewer backups. – cost $75 million. An initial $7.8 million grant from the Federal Emergency Management Agency (FEMA) was obtained for a pilot study conducted in areas that were experiencing frequent basement flooding. Inlet restrictor valves were installed in stormwater catch basins in order to shrink the accessible pipe size, thus regulating and slowing the water entering the main sewer line from the street. The streets act as a temporary holding basin for stormwater. While obvious problems have been encountered with flooding and driving hazards, the projects have reduced the number of basement backups, which is seen as a net positive result. To date, the city has spent over $75 million to install inlet restrictor valves and promote downspout disconnection by homeowners. While the program is still considered a "work in progress", the overall results are encouraging and the city continues to work on remedies, such as a help hotline to report clogged rainblockers.

Funding

Chicago does not have a dedicated stormwater fee to fund green infrastructure initiative, which restricts the city in some ways from providing incentives for implementation. Despite this, Chicago has been innovative in their funding strategies and green infrastructure programs are run through various departments that each have their own financial support. Green infrastructure funding comes through the general fund, various grants, the water enterprise fund, and the sewer enterprise fund. Additionally, the city has established a Green Permit Program which provides developers an incentive to utilize green infrastructure. "Green" projects benefit from expedited permitting and lower permit fees, thus providing both time savings and direct financial savings. The Illinois EPA has funded millions of dollars worth of green infrastructure projects across the state, including several in Chicago, through their Illinois Green Infrastructure Grant Program for Stormwater Management (IGIG).

Figure 3-2. Constructing a green alley in Chicago.
(Source: City of Chicago)

Implementation

Both implementation and financing of Chicago's green infrastructure initiatives have been the result of multi-jurisdictional cooperation and coordination. For example, CDOT leads the Green Alleys and Sustainable Streetscape programs, while tree plantings are primarily the responsibility of the

Department of Streets and Sanitation's Bureau of Forestry. The Chicago Park District is also actively involved in many green infrastructure projects. Additionally, implementation of green infrastructure projects serves a variety of city goals and regulatory requirements, thus garnering widespread support for incorporating these relatively new technologies into city planning.

Pilot projects have been essential for demonstrating how green infrastructure practices can be integrated into the city's landscape, while at the same time have allowed for monitoring and community outreach opportunities. Monitoring data has helped show the multiple benefits of green infrastructure. For example, data collected from the green roof at City Hall shows that the roof reduces stormwater runoff by 50 percent, while at the same time saving the City $5,500 annually on heating and cooling costs. Finally, pilot projects and community outreach have helped familiarize the development community with green infrastructure implementation, which in turn results in more efficient project construction and overall cost savings.

3.2 Philadelphia, Pennsylvania

Overview

In 2008, Mayor Michael Nutter pledged to make Philadelphia the number one green city in America. From this pledge, sprung Greenworks Philadelphia which set ambitious goals to meet 15 sustainability targets in the areas of energy, environment, equity, economy, and engagement by 2015. This atmosphere has set the stage for progressive stormwater management and use of green infrastructure to meet multiple city goals and objectives. Philadelphia is currently on track to develop one of the most extensive green infrastructure networks in the country. This stems from a combination of regulatory requirements, incentive programs, collaboration amongst municipal agencies, extensive resident outreach, and multiple demonstration projects.

Emerald City Criteria

6 out of 6: Long term green infrastructure plan; retention standard; requirement to use green infrastructure to reduce some portion of the existing impervious surfaces; incentives for private party actions; guidance or other affirmative assistance to accomplish green infrastructure within the city; dedicated funding source for green infrastructure.

Regulatory Drivers

Philadelphia's LTCP has an aggressive goal that calls for conversion of 34 percent of impervious area (approximately 9,500 acres) to pervious area utilizing green infrastructure in the next 20 years. These facilities will serve to capture the first 1 inch of rain and will cost approximately $100 million. The city views its investment in green infrastructure as a savings on the cost of maintaining and replacing much of its existing gray infrastructure. Green infrastructure is used where possible to meet Clean Water Act goals, as well as provide a healthier urban environment for city residents. Philadelphia has recognized the multiple benefits of green infrastructure and uses this approach to meet social, economic, and environmental goals as well.

Policies

The Green City, Clean Waters plan was recently approved by the state and will require the retrofit of nearly 10,000 acres of impervious surfaces within the city. This plan relies on green infrastructure to manage the majority of the city's required CSO reductions and will cost more than $1.67 billion to implement. EPA will partner with the city to provide technical assistance in identifying and promoting innovative green infrastructure designs, as well as implement several demonstration projects that combine green infrastructure with community outreach, education, and neighborhood revitalization.

Philadelphia's 2006 Stormwater Management Regulations require on-site management of the first one inch of rainfall on all new development or redevelopment projects with at least 15,000 square feet of disturbance. These regulations encourage infill by providing exemptions for redevelopment projects. Development on vacant lots or infill areas helps reduce overall imperviousness of a given area. Channel protection and flood control standards have also been incorporated to require the slow release of the one-year, 24-hour storm event. Redevelopment projects are exempt from this if they can reduce the original impervious surface area by 20 percent. The Philadelphia Stormwater Management Guidance Manual has been created to assist developers in meeting the stormwater management regulation requirements. The success of these stormwater regulations is a collaborative effort, as projects are required to obtain approval for water, sewer, and stormwater before zoning permits are considered. These requirements and early approval process help streamline a successful decentralized stormwater management approach.

Partnerships among city agencies has allowed for additional promotion of green infrastructure projects. For example, a streamlined review of stormwater management plans has been instituted between the Department of Licenses and Inspections and the City Planning Commission. Fast track review is also allowed for projects that have disconnected 95 percent or more of their impervious area from the sewer system. Additionally, Operations and Maintenance (O&M) agreements are required in advance of any new development receiving a building permit. These agreements outline what stormwater management techniques will be used in the development and exactly how and when it will be serviced.

Figure 3-3. CSO during a rain event.
(Source: Philadelphia Water Department)

Programs and Initiatives

Watershed-Based Stormwater Management Plans: In 1978, the state enacted the Pennsylvania Stormwater Management Act, which requires the development of watershed-based stormwater management plans. The Darby–Cobbs Watershed Stormwater Management Plan was developed in 2004 and applies to city property, requiring that the first inch of rain be captured and infiltrated from all new impervious surfaces. This watershed-based plan aims to prevent flooding, improve and preserve water quality, and fulfill the city's state and federal obligations for stormwater management.

Green Roof Tax Credit: Several technical and financial incentives exist to encourage the use of green infrastructure in Philadelphia. For example, the city offers tax credits of 25 percent of all costs incurred to construct a green roof, up to $100,000. The green roof must cover at least 50 percent of the building's rooftop or 75 percent of eligible roof top space. This is a one-time credit.

Stormwater Fees: The city's stormwater fees are also structured to encourage green infrastructure and reductions in impervious area. Rather than charging property owners based on their water meter readings, stormwater fees are based on impervious area and the estimated amount of runoff generated from a given site. Higher fees are charged to properties with a higher ratio of impervious area to gross property area. Discounts (up to 100 percent of the fee) are offered for residents that reduce impervious cover using green infrastructure. For large properties with the potential to incur very high stormwater fees, the city offers free technical assistance to property owners through site inspections and design recommendations to decrease impervious areas. This incentive-based approach has helped raise awareness of local environmental impacts and responsibility for urban stormwater management.

Figure 3-4. Philadelphia green roof project.
(Source: Philadelphia Water Department)

Demonstration Projects: The city has implemented dozens of demonstration projects on public land in order to monitor the effects of green infrastructure and provide community outreach and awareness. Most of these project are targeted at combined sewer areas and some are targeted at areas affected by sediment and other pollutants regulated by TMDLs. Many projects demonstrate how low impact redevelopment is feasible in an urban environment. These projects balance development costs and water pollution controls with projects that enhance community aesthetics, quality of life, sustainability, and environmental education. Some ongoing projects include the Sulzberger Middle School Demonstration Project, Mill Creek Housing Project, Woodstock Street Vacant Lot Reclamation, University of Pennsylvania Partnership School, and Neighborhood Transformation Initiative Vacant Lot Greening.

Mill Creek Redevelopment Project: The Mill Creek Redevelopment Project is a notable pilot project in west Philadelphia. State grant funding allowed for the redevelopment of this 12.6 acre site, calling for the demolition of 440 failing public housing units and construction of 360 new units. The redevelopment was combined with green stormwater management techniques designed to prevent 100% of runoff generated by the new development from leaving the site. The Philadelphia Housing Authority is a project partner and has a $35 million plan to build additional low-income housing in the Mill Creek community that will also utilize green stormwater management BMPs and continue to develop a environmentally friendly landscape fabric.

Model Neighborhood Program: The Model Neighborhoods program is a collaborative effort between the city and several community groups to retrofit 14 neighborhoods with green infrastructure BMPs. These demonstration projects will transform the neighborhoods into model stormwater management communities, with the end goal to have these innovative practices become a standard part of the city’s required procedures. This program received an overwhelming number of responses from neighborhoods interested in being included in the project.

Voluntary Programs: The city also offers several voluntary stormwater management programs including free rain barrels and workshops on proper use and installation, access to instructions on building rain gardens, clean stormwater tips, and detailed information on green home projects such as downspout disconnection, porous paving, green roofs, and reducing impervious surfaces.

Funding

Funding for green infrastructure implementation in Philadelphia comes from a variety of public and private sources. Private developers and property owners are being required to contribute significantly to the green infrastructure movement through the city’s new stormwater requirements, as well as their stormwater utility fees. Public bond issue funds will also account for a large portion of green infrastructure funding. However, these public funds cannot be spent on projects contained wholly or partially on private property, which creates a challenge especially in the case of commercial rooftops and parking lots, alleys, and private roadways. The city is investigating ways to get around this issue by using private land (i.e., alleys), to convey runoff to public right-of-ways where BMPs can be installed using city funds.

State and federal grants and loans are also being utilized to implement green infrastructure. For example, the city has secured a $30 million loan from the Pennsylvania Infrastructure Reinvestment Authority (PENNVEST), which administers the state’s Clean Water Revolving Loan fund, to invest in three neighborhood scale demonstration projects. These funds will cover the design and construction costs to retrofit four blocks in each neighborhood with green infrastructure such as street trees, sidewalk planters, and street bump-outs.

Implementation

Central to green infrastructure implementation in Philadelphia is the Green City, Clean Waters plan, which calls for retrofitting one third of the city's impervious surfaces to pervious "greened acres" in the next 25 years. This will reduce the annual CSO volumes by nearly 8 billion gallons per year and the majority of these reductions will come from green infrastructure implementation – rather than gray. While most of these retrofits will occur on public, city-owned property (approximately 45 percent), the plan also leverages private investment in green infrastructure to meet these ambitious goals. The new stormwater management rules will require stricter on-site stormwater management for private-sector new development and redevelopment.

The primary focus of the Green City, Clean Waters plan is on city streets, sidewalks and right-of-ways, as these make up a majority of the impervious surface cover in combined sewer areas. Ongoing demonstrations projects that focus on tree pits, sidewalk planters, curb bump outs, and pervious pavement will be monitored closely at multiple scales to gauge the resulting CSO reductions and water quality improvements. Schools are also a target for demonstration projects. While they only make up a small component of the sewershed, the high visibility of demonstration projects at schools is an attractive asset. Half of all city schools are slated for green infrastructure retrofits over the next 20 years.

Figure 3-5. Philadelphia green street project.
(Source: Philadelphia Water Department)

The city has placed an emphasis on adaptive management as part of its green infrastructure approach. Detailed project tracking, mapping, monitoring, and assessment will help the city measure progress against set goals and adapt its strategies as necessary to continue to meet those goals. A large part of this will include performance monitoring of individual green infrastructure retrofits. The city is currently developing a comprehensive monitoring plan to ensure that BMPs are functioning as expected. Components of this monitoring plan include tracking rainfall, CSO discharges, sewer flows, surface waters, groundwater, both natural and engineered systems, and hydraulic/hydrologic modeling.

3.3 Portland, Oregon

Overview

Green infrastructure initiatives have been ongoing in the city of Portland for nearly 20 years. Portland has become a leader in the green infrastructure movement and has implemented multiple projects, programs, and policies that can be used as examples for the rest of the country. The city has a diverse mix of green infrastructure regulations and incentives which encourage implementation on both new development and existing facilities. Portland has done extensive research and modeling to determine the sizing and condition of their existing gray sewer infrastructure and has been able to identify problem areas in which green infrastructure could best be targeted. All together, these programs and data have been continually refined over the years to provide a highly successful green stormwater management strategy for the city.

Emerald City Criteria

5 out of 6: Retention standard; requirement to use green infrastructure to reduce some portion of the existing impervious surfaces; incentives for private party actions; guidance or other affirmative assistance to accomplish green infrastructure within the city; dedicated funding source for green infrastructure.

Regulatory Drivers

Portland's regulatory incentives to promote green infrastructure stem from managing CSOs. The city's approach is to both manage stormwater on-site at a lot level and reduce the stormwater burden on the existing sewer system. The city recently completed their Big Pipe project which will add additional gray infrastructure capacity; however, green infrastructure will still be used to ensure that CSOs are eliminated or reduced to an acceptable level. Beyond volume control, Portland's motivation to reduce CSOs stems from ecological concerns – specifically, within the Willamette River where important habitat for salmon, trout, and other organisms has been compromised due to pollution.

Policies

Portland's Stormwater Management Code and Manual incorporate fairly stringent regulations for all development or redevelopment that includes over 500 square feet of impervious surfaces, or existing properties that propose new stormwater discharge off-site, to comply with both pollution reduction and flow control requirements. Qualifying projects must mimic predevelopment hydrologic conditions through on-site infiltration wherever practicable. Additionally, the city's MS4 permit contains language that prioritizes green infrastructure projects and requires the city to create a stormwater quality retrofit strategy to achieve water quality goals.

The city has instituted a Green Building Policy that requires green building practices to be incorporated in the design, construction, remodeling, and operation of all municipal facilities. This policy promotes green infrastructure to achieve these requirements. For example, all new municipal buildings are required to have a green roof that covers at least 70 percent of the roof area. Additionally, all new city-owned facilities must register and certify for the US Building Council's Leadership in Energy and Environmental Design (LEED) at the Gold level.

Portland has also adopted a Green Street Resolution, which incorporates the use of green streets in both public and private development to "manage stormwater, enhance neighborhood livability, improve the function of the right of way, provide habitat corridors, and promote connectivity between Portland neighborhoods". All infrastructure projects in the right-of-way that are funded by the city must incorporate green street facilities. Additionally, city funded development, redevelopment, or enhancement that does not trigger the Stormwater Manual regulations but requires a street opening permit or occurs in the right-of-way must pay the equivalent of 1% of construction funds into a One Percent for Green Fund.

Programs and Initiatives

Downspout Disconnect Program: Portland recently completed an impressive 20 year Downspout Disconnection Program that provided technical assistance and incentives to landowners in targeted areas to help them disconnect their downspout from the combined sewer system. Over $10 million has been spent on this initiative. This program resulted in 56,000 downspout disconnects, thus removing over 1 billion gallons of rain water from the combined sewer system annually. It is estimated that this reduction has saved $250 million in gray infrastructure costs. This program initially began with pilot projects that helped identify issues such as discrepancies with local building codes, safety issues, setbacks, infiltration requirements, and target areas.

Private Property Retrofits: The city's Downspout Disconnect Program is now being followed up with a program to target localized stormwater issues such as basement flooding. The Private Property Retrofit Program is a voluntary program that provides private property owners design and implementation assistance to manage and infiltrate stormwater on-site. Facilities such as rain gardens, stormwater planters, swales, pervious pavement, and ecoroofs are utilized.

Clean River Rewards: This program provides stormwater utility discounts to property owners for up to 100 percent of their on-site stormwater management charges. For single-family residential properties, the discount is calculated based on runoff managed from rooftops. For commercial, industrial, and multi-family residential properties, the discount is calculated based on runoff managed from rooftops and paved surfaces. Over 60 percent of ratepayers are eventually expected to participate in this program.

Figure 3-6. Portland green street project.
(Source: Portland Bureau of Environmental Services)

Green Streets Program: Approximately 40 to 45 percent of runoff associated with CSOs in Portland is generated from public streets. Portland's Green Streets Program is a coordinated effort between multiple city agencies that seeks to incorporate green street facilities into both public and private developments. The city has prioritized this use of green infrastructure and formalized a process to review capital improvement projects and other municipal project plans to identify how green streets can best be implemented. Widespread acceptance of this technique has been primarily a result of identifying overlapping goals and beneficial outcomes that can be realized across jurisdictions. Similar to other successful program initiatives, the Green Streets Program began with a series of pilot projects that were closely monitored and evaluated for larger scale implementation.

Floor Area Bonus for Roof Gardens and Ecoroofs: This program allows builders and developers to increase the floor area of a given building if a roof garden or ecoroof is included as part of the design. The incentive is innovative in that it stimulates additional private development, but does so in a sustainable manner. The additional green roof implementation has allowed for further market growth for green infrastructure and added to nearly 300 ecoroofs throughout the city. The city also provides an ***Ecoroof Grant Program*** that offers grants of up to $5 per square foot for ecoroof installation. A "Portland Ecoroof Handbook" was published in 2009, followed by a guide for homeowner in 2010.

Treebate Program: Portland's Treebate Program provides rebates to residents for planting trees on their residential property. A rebate of up to $40 for non-native trees and $50 for native trees can be obtained. The rebate is provided as a credit on residents utility bills. This initiative is scheduled to run from 2010 to 2014 and is publicized by many local home and garden centers. In the first year, the city estimated that 1,000 trees were planted as part of the Treebate Program.

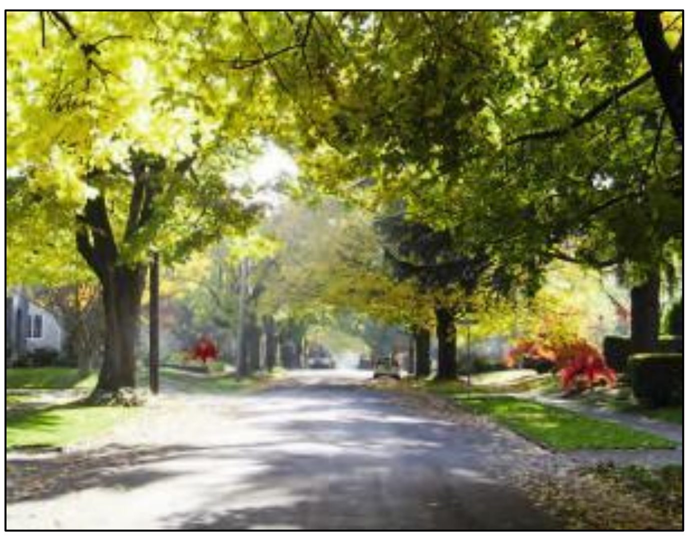

Figure 3-7. Portland urban trees.
(Source: Portland Bureau of Environmental Services)

Community Watershed Stewardship Grants: This program is a partnership between the city and Portland State University. Grants of up to $10,000 are provided to community groups to implement projects that improve watershed health, such as ecoroofs, vegetated swales, stream restoration, and downspout disconnection. Since 1995, over $885,000 has been awarded to implement 192 projects.

Funding

Portland funds their stormwater and wastewater programs through a variety of sources, including operating capital, direct payment by ratepayers, public utility fees (including stormwater management utility fees), and system development charges. Stormwater management fees are based on rates per square foot of impervious area. Portland has one of the highest combined stormwater and sanitary rates in the country, with average fees of $53 per month in 2011. The city has also instituted a Stormwater System Development Charge (SSDC), which charges a fee for all new residential, commercial, and industrial developments. Fees are based off of impervious surface coverage and type of stormwater management (on-site vs. offsite) and can be reduced by installing green infrastructure or otherwise reducing the area of impervious surfaces.

The city has dedicated significant capital improvement funds to the implementation of green infrastructure. In 2011, $1.5 million was used to support innovative watershed improvement projects – especially those that demonstrated innovative practices and/or contributed to multiple city goals. The city's Green to Grey Initiative has slated $48 million over four years to be invested in green infrastructure such as green roofs, green streets, tree plantings, and protecting high quality natural areas. Green streets are currently a high priority and another $20 million in capital improvement funds has been dedicated through 2013 to construct Green Streets in high priority areas.

In 2005, Portland received funds from the EPA to evaluate the feasibility of implementing a credit trading system for stormwater volume control. While developing a stormwater trading program was determined to be cost prohibitive, the study did help Portland identify several market-based programs, including the Ecoroof Grant Program, that could be used to motivate and engage private investment in green infrastructure. The amount of private engagement and incentives put forth by the city is one differentiator that has helped make their green infrastructure initiatives such a huge success.

Implementation

Portland has structured its approach to green infrastructure initiatives with an open mind and this innovation and willingness to experiment has been a major key to their success. Initially, projects are approached at a small demonstration or pilot project scale in order to monitor results and work through unforeseen issues at the onset. Successful projects garner support and project partners and can evolve more easily into official policy and widespread implementation. Additionally, extensive project monitoring has allowed the city to continuously adapt its green infrastructure technologies, thus constantly improving with experience. Finally, an emphasis has been placed on community engagement which has helped with project implementation and encouraging residents to take ownership for greening the city. While the city is primarily responsible for operation and maintenance of green infrastructure BMPs, activities such as gardening and landscape maintenance in private/residential areas are often taken on by homeowners.

Portland has focused on programs that meet multiple goals – primarily improving water quality, reducing runoff volume, and improving habitat. Projects and BMPs that meet multiple goals are favored more heavily and encouraged through the city's various incentive programs. For example, pervious pavement is not promoted as heavily as other green infrastructure techniques, such as vegetated swales or rain gardens, that involving plants that provide wildlife and help mitigate the heat island effect.

3.4 Kansas City, Missouri

Overview

Kansas City has more recently engaged in green infrastructure implementation to reduce stormwater runoff. A very successful rain garden campaign was one of the initial green infrastructure initiatives started by Kansas City in 2005, and since that time, several other programs and policies have been put in place. A large scale green infrastructure pilot project broke ground in 2011 and is expected to be one of the largest of its kind in the country. Overall, green infrastructure programs are still in the development stages in Kansas City and lack a long-term vision and stable funding source.

Emerald City Criteria

2 out of 6: Incentives for private party actions; guidance or other affirmative assistance to accomplish green infrastructure within the city.

Regulatory Drivers

In 2010, Kansas City entered into a consent decree with the EPA to address CSOs and eliminate all sanitary sewer discharges. While some green infrastructure programs were ongoing in Kansas City prior to this agreement, the consent decree is the primary regulatory driver for more recent green infrastructure initiatives. By 2025, the city is tasked with reducing CSO discharges by 5.4 billion gallons per year – at an estimated cost of $2.5 billion.

Policies

Kansas City's main guidance document pertaining to stormwater runoff and CSOs is their Overflow Control Plan, which was created in 2008. This plan outlines the use of $28 million for pilot projects to evaluate the effectiveness of green infrastructure over the course of five years. In 2008, the city also developed a Manual of Best Management Practices for Stormwater Quality, which addresses both volume control and treatment trains for water quality improvements. Similar to Philadelphia, Kansas City is taking a triple bottom line (environmental, social, and economic health) approach to incorporate green concepts into city operations.

The city has recently adopted several policies that address stormwater management. Their stream buffer ordinance became effective in 2009 and requires a minimum 100 foot buffer along all streams in order to protect streams, improve water quality, conserve wildlife habitat, and provide flood water conveyance. The Green Solutions Policy directs city departments to incorporate green solutions into all projects, programs, and policies. City construction and renovation projects are required to comply with the U.S. Green Building Council's LEED Silver standards or higher. Additionally, the city's Economic Development and Incentives Policy promotes sustainability and green building in any development projects that receive financial support from the city.

Programs and Initiatives

10,000 Rain Gardens: The 10,000 Rain Gardens initiative predates the city's consent decree and was started back in 2005. The program seeks to implement rain gardens to address CSOs and stormwater runoff, as well as train residents and staff. The program uses extensive outreach to educate residents on the use of rain gardens, vegetated swales, and rain barrels and create awareness of how individuals, businesses, and municipal groups can help solve stormwater management problems.

Approximately $5 million was budgeted in the city's Overflow Control Plan for this campaign, however, this money has yet to be appropriated and the program currently lacks capacity.

Middle Blue River Basin Pilot Project: This large scale pilot project will implement green infrastructure retrofits across a 100 acre neighborhood in order to monitor the effects on the receiving combined sewer outfall. An 86 acre control area will also be evaluated with no green infrastructure implementation. Green solutions include catch basin retrofits, curb extension swales, street trees, permeable pavement, green roofs, and stormwater planters. Structural repairs to the gray sewer system are also anticipated. The city will be responsible for installing and maintaining the green infrastructure retrofits.

This is one of the largest green infrastructure/CSO control pilot projects in the country and consists of extensive public outreach, including public meetings and a website, and monitoring. Results of the study will help Kansas City determine the effectiveness of green infrastructure in reducing runoff and guide the design and implementation of green solutions citywide. The project broke ground in June 2011 and is scheduled to be complete by 2017. Kansas City estimates that the green infrastructure practices will potentially save the city $10 million in capital costs compared to the cost to only implement gray solutions.

Green Impact Zone Initiative: This initiative seeks to combine resources in a specific city area to revitalize the community with regards to housing, jobs, energy efficiency, and wellness, using sustainability as a catalyst for the transformation. The Green Impact Zone consists of a 150 square block area that is in severe economic decline. A quarter of the lots are vacant and one sixth of the homes are abandoned. Median home prices in this zone are less than $30,000. In addition to housing programs, weatherization, employment training, energy initiatives, and neighborhood outreach, the Green Impact Zone will seek to incorporate green infrastructure into all redevelopment.

Figure 3-8. Green Impact Zone rain garden installation.
(Source: Green Impact Zone of Missouri)

Funding

Both a stormwater utility fee and dedicated sales tax exist to fund the city's stormwater program. However, these funding sources do not adequately cover all expenses required to fully operate the program. The stormwater utility was established in 1999 and assesses fees based on a property's total impervious area. Monthly fees are relatively low and average $2.50 per month for a typical residential property owner. Credits are offered for maintaining pervious areas or installing stormwater detention features; however, with the low initial monthly fees, these credits do not provide a huge incentive for residents to implement green infrastructure.

Implementation

Funding for green infrastructure initiatives is uncertain, therefore, Kansas City's program implementation is slightly unstable at this time. Additionally, the city does not have a strong incentives program to encourage development of these technologies in the private sector. To date, Kansas City has not integrated green infrastructure into long range city planning, which also hinders widespread application. Kansas City has only recently turned to green infrastructure as a means to reduce stormwater runoff and program approaches are still in their infancy, therefore, initial efforts can still be refined to develop a more comprehensive program.

3.5 Pittsburgh, Pennsylvania

Overview

Pittsburgh is a city recovering from an industrial past and a declining population. The city has begun to incorporate green infrastructure into city programs, not only as a means to manage stormwater runoff, but also to attain citywide goals related to beautification, community revitalization, and redevelopment of vacant lots. Green infrastructure implementation is still in the early stages, however, and exists primarily as an effort to reduce CSOs throughout the region. A few policies and ordinances have been put in place, as well as several demonstration projects and an emphasis on sustainable building.

Emerald City Criteria

1 out of 6: Retention standard.

Regulatory Drivers

Pittsburgh's green infrastructure implementation has been primarily targeted at reducing CSOs. This stems from a 2004 consent decree signed by city of Pittsburgh, Pittsburgh Water and Sewer Authority, Pennsylvania Department of Environmental Protection, and the Allegheny County Health Department. The city is also using green infrastructure as one of the primary components of a "restorative development" initiative which has been designed to restore habitat, beautify land, increase green space, and raise property values.

Policies

A city stormwater ordinance was enacted in 2007 which established stormwater reduction standards for properties greater than 10,000 square feet. Per this ordinance, the first one inch of rainfall must be detained on-site using either infiltration, evapotranspiration, or rainwater harvesting. This ordinance was enhanced in 2010 to state that all publically funded projects must use green infrastructure to retain the first 1.5 inches of rainfall to the maximum extent practical.

The city has determined that illegal surface stormwater connections to sanitary sewers are one of the leading contributors to sewage basement backups and sanitary sewer overflows. Therefore, Pittsburgh has enacted a local ordinance which requires disconnection of all illegal surface stormwater connections to city sanitary and establishes provisions for dye testing to determine if storm or surface water is entering the sanitary sewer system.

To encourage infiltration and work across jurisdictions, Allegheny County has modified its plumbing code to allow for downspout disconnection. Further, workshops have been held throughout the county to offer technical guidance on successful downspout disconnection. Workshops have been targeted toward municipal staff, homeowners, and landscape professionals.

Programs and Initiatives

Pittsburgh is a city recovering from industrial blight and environmental degradation. Many existing city programs seek to restore fundamental environmental attributes such as open space and greenways. For example, the Greenways for Pittsburgh program began in 1979 with a goal of designating various vacant lots within the city as green space and greenways. More recently, the Department of City Planning is developing an Open Space, Parks, and Recreation Plan, which is part of the city's first comprehensive plan, and will address issues of open space connectivity, acquisitions, management, and maintenance. These plans are more general in nature; however, the city has initiated several programs specific to green infrastructure implementation.

Figure 3-9. Existing green infrastructure in Pittsburgh. (Source: City of Pittsburgh)

Green Infrastructure Network: This group was established to encourage use of green infrastructure and track existing green infrastructure projects in the region. The Green Infrastructure Network is a partnership of more than 35 public and private organizations and government units who recognize the benefits of using green infrastructure to manage stormwater. Members help catalog green infrastructure projects and are developing standardized monitoring protocols that will help measure their effectiveness.

Green Up Pittsburgh: This program started as a pilot project funded through a Community Development Block Grant and has now grown into a citywide project to stabilize city-owned vacant lots with the goal of reducing blight and public safety hazards, instilling community pride, and encouraging environmental values. To date, the program has turned over 120 vacant lots into green spaces and gardens. The city's Garden Waiver Program allows residents to maintain the land while the city maintains legal liability for the parcel.

Figure 3-10. Pittsburgh community garden.
(Source: City of Pittsburgh)

East Liberty Green Vision: This pilot project is the nation's first green overlay plan for a distressed urban district. The project seeks to balance the natural and built environment to create sustainable neighborhoods in currently blighted areas. The redevelopment offers opportunities to incorporate green infrastructure retrofits into new community plans. The end result is a rebuilt urban infrastructure that provides a healthier, safer community with less impact on the environment. Green buildings and streets are incorporated to both reduce stormwater runoff and provide energy efficiency. BMPs such as street trees, tree trenches, planting and infiltration beds, and permeable pavement were incorporated in the design to collect the first one inch of rainfall.

Green Buildings: Pittsburgh is ranked eighth in the country for the number of LEED certified buildings. The city has completed a high-profile series of green building projects, including the David L. Lawrence Center, which is the world's first LEED certified convention center. Pittsburgh's Phipps Conservatory and Botanical Gardens is also undergoing a major renovation and will eventually be covered by a 15,000 square foot green roof. To encourage green building, the city provides a 20 percent height and floor density bonus for LEED certified buildings. Additionally, any publically funded project costing more than $2 million or measuring greater than 10,000 square feet must attain LEED Silver certification.

Tree Pittsburgh: This program began with an inventory of street trees throughout the city, followed by a cost benefit analysis to determine the benefit of urban trees in terms of stormwater management, reduced energy costs for cooling, and improvements in property value. From this program came Treevitalize Pittsburgh, a public-private partnership to help restore urban tree cover, educate citizens about planting trees, and build capacity among local governments to understand the benefits of urban trees. Treevitalize Pittsburgh will plant 20,000 trees throughout the region.

Stream and Watershed Restoration: The Nine Mile Run Stream Restoration project was completed in 2006. This $7.7 million project was a joint effort between the city and the U.S. Army Corps of Engineers. The stream was one of the few watercourses in Pittsburgh that had not been piped below the city. Upon project completion, excessive stormwater flow during wet weather events threatened to compromise the restored stream segment. Additional funds were sought for repairs and measures have been taken throughout the watershed to alleviate some of the stormwater runoff, including the installation of over 1,320 rain barrels. The Panther Hollow watershed is an ecologically sensitive area within the Nine Mile Run project area and additional funds have been secured to conduct watershed restoration here, including implementation of green infrastructure.

Funding

The city has used a combination of demonstration projects, incentive programs, and capital funds to implement green infrastructure programs. Many projects meet multiple city goals, such as urban revitalization and community beautification; therefore, residents have been actively engaged in these projects. Incentives such as the green building density bonus have also been used to derive private investment in green infrastructure. Capital improvement projects are funded partially by a service charge, as well as a Distribution Infrastructure System Charge which is imposed on all water bills to cover major infrastructure upgrades. The capital improvement budget was doubled from $20 million in 2009 to $41.7 million in 2010.

Implementation

Pittsburgh currently has a limited array of incentives and programs geared at green infrastructure implementation. The city is still working to achieve more fundamental goals, such as comprehensive planning to incorporation open space, and has much to work out in the way of meshing green infrastructure strategies with existing regulations. The city's stormwater ordinance is a major step toward more comprehensive green infrastructure implementation.

3.6 Seattle, Washington

Overview

Seattle has over a decade of experience working with green infrastructure and has evolved a highly successful program through a combination of pilot projects and internal codes and regulations. Municipal regulations now require that green infrastructure be used to the maximum extent feasible on all new development and redevelopment project. The city also seeks to meet multiple goals with green infrastructure implementation, including ecological restoration, community beautification, and economic viability. Seattle provides several incentive programs and local initiatives that encourage the use of green infrastructure on multiple levels, including extensive outreach to the community and individual homeowners. Pilot projects implemented over the past 10 to 15 years have been key to developing Seattle's green infrastructure programs, as these projects have allowed the city to monitoring and assess project successes and failures and therefore translate this information to the rest of the city.

Emerald City Criteria

3 out of 6: Incentives for private party actions; guidance or other affirmative assistance to accomplish green infrastructure within the city; dedicated funding source for green infrastructure.

Regulatory Drivers

Seattle's green stormwater management program is driven by a variety of factors. Certainly, CSO control and NPDES permit requirements play a large part in the city's extensive green infrastructure requirements, but beyond that water quality, habitat, and providing visible community amenities are also drivers. The city sets priorities for investing public resources in areas of high ecological sensitivity in order to meet multiple goals. The city's stormwater regulations are also consistent with the state's Growth Management Act (GMA) which requires that regulations affecting critical areas protect the functions and values of those areas.

Policies

The city's Stormwater Code requires that projects implement green infrastructure to the maximum extent feasible. This means that green infrastructure must be fully implemented, constrained only by the "physical limitations of the site, practical considerations of engineering design, and reasonable considerations of financial costs and environmental impacts". The code contains very detailed information on site evaluations, design and implementation, installation, operations and maintenance, and enforcement. Four Director's Rules are also included within the Stormwater Code, including the Source Control Technical Requirements Manual, the Construction Stormwater Control Technical Requirements Manual, the Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual, and the Stormwater Code Enforcement Manual.

The Seattle Green Factor is a landscaping requirement that applies to new development in commercial and residential areas. The Green Factor requires that property owners achieve 30 percent parcel vegetation using green infrastructure. Permit applicants in designated zones must demonstrate that their proposed project meets the Green Factor by using a scoring system that is designed to encourage the use of larger plants, permeable paving, green roofs, preservation of trees and other green BMPs. The Green Factor encourages the use of green infrastructure, while at the same time meeting goals of the city's Comprehensive Plan and neighborhood plans related to community beautification and pedestrian-oriented neighborhood centers.

Figure 3-11. Street swale and pervious pavement in Seattle neighborhood. (Source: Washington State University)

The City has adopted a Comprehensive Drainage Plan, which outlines how to manage stormwater in Seattle. This plan divides surface water management into four primary areas: stormwater and flow control, landslide mitigation, aquatic resources protection (water quality), and aquatic resources protection (habitat). The drainage plan contains the policy guidance, levels of service and direction for capital and operating programs for each of these four areas.

The city Stormwater, Grading, and Drainage Control Codes were recently updated to stay current with urban stormwater runoff management and require the use of green infrastructure. These requirements are a condition of the city's NPDES stormwater discharge permit. Minimum requirements now include both stormwater flow control and treatment for development projects, installation of green infrastructure to the maximum extent feasible, and additional enforcement measures. An in-lieu fee program has also been instituted that allows developers to pay a fee in place of using detention vaults for flow control. Revenue from this fee will be used to address restoration priorities in targeted basins, as well as incorporating green infrastructure into capital improvement projects.

Programs and Initiatives

Green Stormwater Infrastructure Program: This program supports green infrastructure implementation at multiple levels – from the individual lot level to large scale development projects. The Green Stormwater Infrastructure Program is the city's overarching guidance on creating green infrastructure. A city website provides a host of information on stormwater code compliance, incentives, natural drainage projects, and the Residential RainWise Program.

Natural Drainage System (NDS) Projects: These projects take an innovative approach to street design by redesigning traditional residential streets to involve plants, trees, and soils to infiltrate, absorb, and filter stormwater runoff instead of curbs and gutters. Vegetated swales, rain gardens, stormwater cascades, and small wetlands are used throughout these projects. Several NDS projects have been implemented on both public and private properties. Monitoring has shown total runoff volume reductions up to 99 percent.

This program did face some initial challenges from the city's emergency and transportation departments, which feared that the innovative designs would compromise the safety and integrity of the road systems. These agencies were able to work out a compromise to NDS design that accommodated sustainable stormwater management, ecological goals, and infrastructure integrity. Two technical manuals, the Stormwater Flow Control and Water Quality Treatment Technical Requirement Manual and the Seattle Right-of-Way Improvement Manual have come from studies related to these NDS projects.

Green Alleys are incorporated throughout the city as a means to address stormwater management. Much of this work has been modeled after the success that Chicago has had with their green alleys program. In 2010, the city, in conjunction with the International Sustainability Institute, People for the Puget Sound, and the American Institute of Architects Seattle sponsored a Green Alleys Competition that encouraged submittals to design Seattle's best Green Alley.

Green Roofs: Seattle is one of the nation's leaders in green roof implementation. A 2010 report found that 62 green roofs (nearly 360,000 square feet) exist in the city and more are on the way. Both the Stormwater Code and the Green Factor Program are responsible for much of the growth of the green roof movement in Seattle. Green roofs are also being implemented to meet LEED Certification standards. The city is currently monitoring four green roof projects to determine the extent to which green roofs can infiltrate and detain stormwater.

Stormwater Facility Credit Program: The city has developed a Stormwater Facility Credit Program to encourage reductions in impervious areas on privately owned property. This credit is applied to a resident's drainage bill if their property has a fully functioning, well maintained stormwater system, such as a rain garden, permeable pavement, or other infiltration system. These credits typically apply to commercial, industrial, and multi-family properties. Single family residential properties may apply for the Residential RainWise Program, discussed below.

Residential RainWise Program: This program encourages private property owners to manage stormwater on-site through incentives, educational materials, workshops, and discounted utility fees. Green infrastructure BMPs such as downspout disconnection, tree plantings, rain gardens, and use of permeable pavement are all encouraged by this program. Rebates are offered for installing BMPs such as rain gardens or cisterns.

Figure 3-12. Residential cistern at Seattle home.
(Source: Seattle Residential RainWise Program)

Pilot Projects: Over the past 20 years, Seattle has launched a number of high-profile green infrastructure pilot projects to collect stormwater runoff and reduce the amount of impervious surfaces throughout the city. These projects have had varying degrees of success and the city continues to learn from their implementation and monitoring.

- **Viewlands Cascade Drainage System:** This project replaced a narrow, partially concrete ditch with a series of wide, stepped pools in order to infiltrate runoff and reduce overall volume. This project was relatively expensive to install and overall, resulted in reducing runoff volumes by slightly more than one-third.

- **2nd Avenue Street Edge Alternative (SEA) Street:** This project was completed in 2001 and involved a complete retrofit of the street and its drainage system to reduce impervious surfaces and install stormwater detention ponds. Again, the goal was to infiltrate and reduce overall stormwater runoff volumes. The 2nd Avenue SEA Street project was highly successful and prevented discharge of all dry season flow and 98 percent of the wetland season runoff. Community outreach and engagement was also a contributing factor to this project's success. The total project cost was $850,000, which included a large design and outreach budget due to the need to work closely with residents on the pilot project.
- **High Point Redevelopment:** This project was conducted in the Seattle Housing Authority's largest family community with a goal of replacing the original 716 worn out public housing units with mixed income housing. The project was funded through a variety of funding sources, including $35 million from the U.S. Department of Housing and Urban Development. Sustainable design, including NDS, pedestrian friendly streets, and tree and open space preservation and enhancement were all part of the project. Over four miles of vegetated swales run through the development and a retention pond cleans surface runoff as well as serves as a natural amenity for the community. This pilot project demonstrates that urban development and ecological performance can be achieved simultaneously.

Figure 3-13. High Point redevelopment project.
(Source: The High Point Neighborhood)

- **Swale on Yale:** This project uses bioswales and other stormwater management to treat approximately 190 million gallons of stormwater annually that would normally flow into a local lake. The project is designed to divert stormwater from roads and sidewalks into a series of widened planting areas between the sidewalk and the roadway. The swales infiltrate and treat the stormwater flow before it reaches the lake by gravity flow. Construction began in April 2012 with an estimated total project cost of $10 million. A portion of these funds are coming from a state stormwater grant.
- **Ballard Roadside Rain Gardens:** This project was constructed to reduce the frequency of CSOs in the Salmon Bay watershed. The city retrofitted 10 city blocks with roadside rain gardens and swales in order to detain and infiltrate 50,000 gallons of stormwater runoff at a

cost of $1.9 million. The project had an expedited schedule and therefore, infiltration rates and proper site assessment were not fully considered during implementation. Additionally, limited community outreach was conducted. This has resulted in underperformance and resident's dissatisfaction. The city has invested significant additional time and funds to fix the problems and engage the residents. While the problems were ultimately fixed and roadside retention continues to be an important green infrastructure tool, the need for adequate assessment, review time, and community outreach was reaffirmed by this project.

Funding

CSO funding has traditionally come through the city's Drainage and Wastewater Fund for capital improvement projects, which is funded primarily through the sale of revenue bonds. More recently, the city has increased cash contributions to the public utility department's operating budget to supplement this funding. Property owners are also charged a stormwater fee based on each property's impact on the drainage system. Residential properties are assessed a fee based on parcel size, while nonresidential properties are charged based on the amount of impervious surface on their parcel. Last year, residential drainage bills ranged from approximately $134 to $300 per year and nonresidential bills ranged from approximately $20 to $67 per 1,000 square feet of impervious surface.

Implementation

The city views green infrastructure as an overall asset for stormwater management, therefore, it is included in most major capital improvement projects. This helps the city attain multiple environmental, economic, and social goals. Seattle's considerable experience with green infrastructure design and construction through their many pilot projects has allowed them to track project costs and determine that many green infrastructure BMPs are less costly than traditional stormwater infrastructure. For example, the city estimates that NDS projects cost approximately 10 to 20 percent less than traditional curb and gutter street redevelopment.

The city has also employed a variety of O&M strategies on their green infrastructure projects since 1999. Initially, projects incorporated extensive homeowner involvement to provide or supplement maintenance. The city has since taken on a more formal maintenance role through memorandums of agreement (MOAs) and other methods. Homeowner involvement is still highly encouraged to maintain aesthetically pleasing landscapes and the city has developed several guides that are publically available to assist the community. The city also has their own O&M manuals, field checklists, and reporting guidance for green infrastructure projects.

3.7 Milwaukee, Wisconsin

Overview

Milwaukee has implemented several green infrastructure programs to compliment deep tunnel infrastructure geared at reducing CSOs. The city's vision is for integrated watershed management and an ambitious goal of attaining zero overflows, zero basement backups, and overall improved stormwater management. This approach has emphasized a shift to more regional and watershed based planning, including a program to purchase and protect land upstream of the city to allow for flood attenuation and infiltration that will help protect valuable gray infrastructure downstream.

Emerald City Criteria

5 out of 6: Retention standard; requirement to use green infrastructure to reduce some portion of the existing impervious surfaces; incentives for private party actions; guidance or other affirmative assistance to accomplish green infrastructure within the city; dedicated funding source for green infrastructure.

Regulatory Drivers

Milwaukee began implementing green infrastructure projects in 2002, prior to any state or federal regulatory drivers. Since that time, green infrastructure has been used to address CSOs in a strategy that combines deep tunnel gray infrastructure with green infrastructure to meet multiple objectives. The city's goal is to eliminate all CSOs, as well as meet triple bottom line goals similar to those laid out by the city of Philadelphia.

Policies

Milwaukee has instituted very few regulatory requirements for green infrastructure. The city must comply with state regulations that require a 40 percent reduction in total suspended solids that enter waterways of the state. However, at the municipal level there are few requirements. The city does have runoff requirements for development and redevelopment projects that include an increase of one-half acre or more of impervious surface, permeable pavement, vegetated roofs, or wherever the disturbed area is two acres of greater; however, this situation does not occur frequently. City properties are also required to reduce their runoff by 15 percent and city businesses are encouraged to do the same.

The Milwaukee Metropolitan Sewer District (MMSD) has revised their stormwater management manual to include volume control, impervious surface reduction, and standard O&M requirements. These changes reflect updates to their Stormwater Management Rules, which were revised extensively in 2010, particularly with regards to the technical guidance section.

In 2001, the city modified their Code of Ordinances to allow for downspout disconnection, provided they meet certain criteria, such as appropriate discharge spouts and impacts on neighboring properties. Residents are now encouraged to divert runoff from their downspouts away from the combined sewer system.

Programs and Initiatives

Rain Garden Program: Milwaukee began their rain garden program in 2002 with a pilot project in the Village of Shorewood, where a public/private partnership was formed to install 60 rain gardens. Since that time, the rain garden program continues to move forward and currently includes public outreach, workshops, demonstration projects, and an implementation guide. MMSD also has a rain garden grant program that provides funds for residents to purchase rain garden plants.

Green Roof Installations: As of 2011, 5.6 acres of green roofs had been installed across the city. One example is the 809 Broadway Building green roof installation at the Milwaukee City Hall. This project was completed in 2007 and is estimated to reduce stormwater runoff from the building by 50 percent. MMSD provided a $35,200 grant through their Stormwater Best Management Practices program to assist with project costs. In addition to stormwater benefits and energy cost reductions, the expected extended life of the green roof is projected to save the city an additional $84,000.

MMSD continues to implement and fund green roof projects. In 2010, 2.6 acres of green roofs were installed through their Regional Green Roof Initiative and another 1.7 acres were slated for completion in 2011. MMSD has a matching fund program of approximately $5 million that will help retrofit buildings with green roofs. These installations will provide additional monitoring opportunities to determine more precisely what the benefits of green roofs are within the city.

Downspout Disconnection Program: The city encourages nearly all residents to disconnect their downspouts, especially if they are currently connected to the combined sewer system. Residents are instructed to redirect runoff from their homes and buildings to rain barrels, rain gardens, and other pervious areas. MMSD has partnered with local retailers to provide rain barrel kits that homeowners can purchase for their disconnected downspout.

Figure 3-14. Downspout disconnect to stormwater planter.
(Source: U.S. EPA)

Greenseams™: Greenseams™ is a land acquisition program run by MMSD and The Conservation Fund. The program purchases undeveloped, privately owned land in areas of projected high growth and maintains the land in its natural state to provide flood storage and infiltration capacity. In the past 10 years, this program has protected over 2,000 acres of land in a four county region that includes Milwaukee. MMSD views this as an important means to protect their infrastructure from flooding and damages potentially worth hundreds of millions of dollars.

Water Quality Initiative: This initiative is a partnership between MMSD, the Wisconsin Department of Natural Resources, and the Southeastern Wisconsin Regional Planning Commission to establish a combined planning effort to address water quality issues throughout the region. Through this partnership the MMSD 2020 Facilities Plan was developed, which establishes investments and improvements to be made in order to reduce SSOs, provide adequate treatment, and improve water quality. This plan identified green infrastructure as an important tool to reduce stormwater runoff and improve non-point source pollution.

Public Outreach: Outreach and education have played a large role in green infrastructure programming throughout the city. MMSD funds many community workshops geared at green roof installation, rain garden installation, and downspout disconnections. H2OCapture.com is a website geared at educating residents on how to capture and infiltrate stormwater at all levels. The website provides examples of pilot projects, a map of green infrastructure projects in the region, a discussion forum, and resources to help implement projects.

Figure 3-15. Stormwater box at Pabst Brewery, Milwaukee.
(Source: H2OCapture)

Funding

Many green infrastructure projects are funded through MMSD's capital budget, which is financed through property taxes and based on property value. For 2011, the capital budget included $1 million designated for green infrastructure projects. MMSD's operating budget is funded through sewer service charges. Additional revenue is gained through the sale of fertilizer derived from sludge.

Implementation

MMSD has dedicated capital funds to multiple projects to promote downspout disconnection, rain garden implementation, and green roof installation. Several community outreach programs exist that have been successful in expanding the use of green infrastructure to the private sector. MMSD has also done extensive monitoring and modeling of these green infrastructure projects to evaluate their effectiveness on multiple scales. This data collection and modeling results has been useful in disseminating information to the public and driving more widespread acceptance as green infrastructure as a useful stormwater management tool.

3.8 Toronto, Ontario

Overview

Toronto is positioned on the shores of Lake Ontario, which like many urban water bodies has been negatively affected by polluted stormwater runoff. In order to combat this pollution, the city currently uses a combination of green infrastructure and tanks and tunnels to manage stormwater runoff. Two large underground tanks have been installed at Toronto's Eastern Beaches to store CSOs and stormwater for treatment before being released to Lake Ontario. More recently, a storage tunnel has been installed along the Western Beaches. The city has incorporated green and gray infrastructure improvements into its long range planning and has methodically set up various pilot projects throughout the city to test the effectiveness of green infrastructure and structure these programs to be effective at larger scales.

Emerald City Criteria

4 out of 6: Long term green infrastructure plan; retention standard; incentives for private party actions; guidance or other affirmative assistance to accomplish green infrastructure within the city.

Regulatory Drivers

Toronto is listed as an Area of Concern (AOC) within the Great Lakes region, due primarily to urban stormwater pollution and its effects on Lake Ontario and its tributaries. As a result of this listing, the city established a Remedial Action Plan (RAP) in 1987 that outlines plans to clean up pollution and restore environmental attributes of Lake Ontario and the surrounding watersheds. This driver has led the city to develop complementary goals of eliminating the effects of wet weather flows and achieving ecosystem restoration within the watershed.

Policies

The city's Wet Weather Flow Master Plan (WWFMP) is a long term plan that implements measures to reduce and eliminate the adverse effects of wet weather flows over the next 25 years. The plan addresses water quality and quantity, natural areas and wildlife, and sewer systems. A key component to this plan is public outreach and raising awareness about stormwater pollution. Plan implementation is estimated at over $1 billion and includes a combination of green and gray infrastructure strategies to manage stormwater and sewers.

In 2007, the city adopted Wet Weather Flow Management Guidelines to provide additional guidance for property owners and designers to implement the WWFMP on new development and redevelopment projects. The guidelines also establish performance objectives for water quality and water quantity control. These guidelines are flexible in that the city will consider any innovative approach to achieve the required performance standards. This flexibility allows developers to utilize an array of green infrastructure techniques. Sites must maintain the pre-development volume of overland runoff, allowing a maximum of 50 percent runoff of the annual precipitation. Additionally, a minimum of 0.20 inches of rain must be detained on-site during a storm event.

Programs and Initiatives

Toronto Green Standard: This program establishes a two-tiered set of green performance standards and guidance for new public and private development projects. Tier 1 standards are mandatory for all new planning applications and Tier 2 standards are voluntary and include a higher level of environmental performance. As an incentive for participating in Tier 2 standards, the city will refund 20 percent of all development charges related to planning review and permits. Standards include items related to energy efficiency, clean air, pedestrian infrastructure, urban heat island reduction, stormwater retention, water quality, and tree protection.

Green Roofs: Toronto has several programs in place that encourage the use of green roofs. Two green roofs were initially constructed at City Hall and a city community center. This was followed by a comprehensive study that looked at the potential benefits of implementing green roofs throughout the city. The results of this study indicated that implementation would provide significant economic and environmental benefits. From this sprung the city's green roof strategy and the Green Roof Bylaw, requiring and governing the construction of green roofs in Toronto. Now all new buildings and retrofits with more than 21,500 square feet of floor area require a green roof. The city estimates that since the bylaw went into effect more than one million square feet of green roofs have entered the planning phase. The city has also implemented an Eco-Roof Incentive Program that provides grants to property owners wishing to install green roofs.

Figure 3-16. Toronto green roof examples.
(Source: City of Toronto Green Roofs)

Downspout Disconnection: This began as a voluntary program in 1988. City council provided free downspout disconnection to all property owners whose downspouts were connected to the combined or separate sewer system. The city found it to be one of the most effective source control methods for stormwater. City council has now passed a bylaw making it mandatory for property owners to disconnect their downspouts. Financial assistance (up to $500) is available to cover the costs of labor and materials for low income homes. Exemptions are only allowed in cases where disconnection is not technically feasible or where it would cause a hazardous condition. Property owners are encouraged to redirect their downspout to a rain barrel, grassed area, or garden. This mandatory program began in 2011 and it is anticipated that all portions of the city will be phased in by 2016.

Rainwater Harvesting: The city currently supports rainwater harvesting as part of their WWFMP. The requirement to detain a minimum of 0.20 inches of rainwater on-site has encouraged property owners to utilize rainwater harvesting. In 2006, the Ontario Building Code was amended to allow for use of recycled rainwater using dual plumbing inside buildings. The city is currently working on demonstration projects at Exhibition Place and the Metro Zoo to evaluate the use of this BMP at a larger scale.

Urban Forestry: In 2005, the Parks, Forestry, and Recreation Strategic Plan set a goal to increase the city's tree canopy from approximately 20 percent coverage to approximately 30 to 40 percent coverage over the next 50 years. Between 2004 and 2009, the city and other partners planted nearly 500,000 trees throughout the city to work towards this goal. With immediate intense growth pressures facing the city, doubling the tree canopy will help increase shade, reduce the urban heat island effect, and reduce stormwater runoff.

Funding

Toronto has conducted detailed studies on multiple green infrastructure programs and how they can potentially save the city money in the long run. For example, it is estimated that they city's downspout disconnect program has saved the city approximately $140 million to date in infrastructure costs. By mandating these disconnections, the city has effectively transferred the cost to property owners, adding a further cost savings. Similarly, by establishing the Toronto Green Standard, the city estimates that six percent of Toronto's roofs will be green roofs – a cost savings of $100 million in stormwater costs and $40 million in capital costs, mostly derived from private investment. Toronto implements stormwater management projects with revenue coming from the sale of water, a wastewater levy, and other miscellaneous funding sources; however, private funding through mandated programs is a large source of funding for green infrastructure. Additionally, since 2002, the city has issued annual rate increases of approximately nine percent.

The city has also created an Environmental Protection Reserve Fund, with the purpose of funding the development of Toronto's Climate Change Action Plan and several other projects. These monies have been used to expand the city's tree canopy program, as well as fund climate and risk assessment studies.

Implementation

Toronto has implemented green infrastructure programs as a cost-effective means to address stormwater runoff and CSOs. The city has incorporated these strategies into their long range planning and WWFMP in order to compliment other ongoing gray infrastructure strategies. In Toronto, green infrastructure programs have typically started out as pilot or demonstration projects to provide the city time to evaluate performance, review city codes, and measure success. Projects are then expanded into city-wide programs. Mandated green infrastructure implementation has help saved the city considerable costs.

4 Green Infrastructure Case Studies: Europe

Similar to the United States, much of Europe's infrastructure is based on combined sewer systems. Problems of overflows are arising due to rapid urbanization, increased impervious surfaces, and lack of stormwater management. Combined sewer systems are overburdened and undersized. The cost of land in urban centers, as well as the difficulties of urban construction, make conventional end-of-the-pipe stormwater BMPs economically and politically prohibitive. Therefore, many European cities have turned to more micro-scale, decentralized systems that are approached comprehensively at a watershed level. Key to the success of these projects are innovative strategies, demonstration projects, cooperative financing, and incentive programs geared at the private sector.

4.1 Berlin, Germany

The Biotype Area Factor (BAF) program in Berlin is an innovative green infrastructure program that requires individual parcels to mitigate stormwater impacts on-site. The BAF was developed in the 1980s and introduced as a regulatory document in 1994. Berlin has taken the approach that incremental, decentralized green infrastructure projects can cumulatively have a large effect on sustainable stormwater management. This program focuses on reducing impervious surfaces and replacing them with green infrastructure that can provide additional benefits of evapotranspiration, filtering, improving air quality, and providing wildlife habitat. The program is implemented at the neighborhood scale and projects are monitored and evaluated to determine the level of progress being made and apply lessons learned while moving forward. Developers can chose among various green infrastructure techniques, such as green roofs and permeable pavement, and choose those that are most beneficial for their plans and the future development's users.

4.2 Lyon, France

Lyon has taken a primarily green approach to reducing CSOs, due to the enormous cost and disruption of building new tunnels or relief sewers. Beginning in the 1990's, the city developed a decentralized approach to stormwater management as part of their water and sewer master plan. The approach encourages infiltration and green infrastructure, and places the stormwater management burden primarily on private entities. For example, stormwater from all private impervious surfaces must be infiltrated as close to the source as possible. In commercial and industrial areas, stormwater from rooftops must be infiltrated. Stormwater management BMPs are encouraged to mimic a site's natural hydrology and facilities must blend into their urban surroundings. Typically, infiltration techniques such as rain barrels, rain gardens, and infiltration wells are used. Private residents are responsible for constructing, operating, and maintaining these systems. The city encourages participation through extensive education and outreach, as well as inspections.

4.3 Sustainable Urban Drainage Systems (SUDS) Programs

SUDS are a sequence of management practices, control structures, and strategies that efficiently and sustainable drain surface water with a focus on reducing pollution and minimizing the impact on local water bodies. SUDS are primarily being implemented in the United Kingdom and are equivalent to green infrastructure BMPs or integrated management practices (IMPs). SUDS provide an integrated approach to urban stormwater management that focuses equally on water quantity, water quality, and biodiversity. SUDS are typically made up of one or more stormwater control methods that incorporate filter strips and swales, permeable surfaces and filter drains, infiltration devices, and basins and ponds. Sustainable case studies are found across Europe as highlighted in the following summaries.

4.3.1 London, England

The 2012 London Olympic Park is a 617 acre site in East London that houses new infrastructure for the Olympic development center, including the Olympic Stadium, Aquatics Center, International Broadcast Center, Press Complex, and many other facilities and related transportation routes. The site was formerly an industrial/commercial development with known contamination and abundant demolition waste. Upon site remediation, the city sought to employ SUDS into the project design. The primary techniques used are porous asphalt throughout pedestrian areas, wetlands, swales, filter strips, detention ponds, and rainwater harvesting. SUDS were incorporated into landscaping features to create visual amenities and provide habitat. Several internal and external stakeholders were involved in site decision making, therefore local, regional, and national coordination was vital to project implementation.

Figure 3-17. Rendering of London Olympic Park.
(Source: Construction Source)

4.3.2 Dublin, Ireland

The Greater Dublin Strategic Drainage Study (GDSDS) was completed in 2005 and conducted a detailed assessment of Dublin's existing drainage system. Like many urban centers, drainage design in Dublin had been conducted with an end goal of getting surface water away from a given site as quickly as possible to reduce flooding. The GDSDS noted the inherent flaw in this type of drainage design and recommended strategies to integrate flood risk reduction and water quality improvements through SUDS. The GDSDS surface water drainage guidance seeks to mimic the runoff characteristics of an undeveloped "greenfield" site through a series of four criteria that address: 1) river water quality protection, 2) river regime protection, 3) level of service (flooding) for the site, and 4) river flood protection. Dublin has also been investigating the use of constructed wetlands as a means to treat and detain stormwater runoff, while at the same time provide habitat and other ecological benefits.

4.3.3 Dunfermline, Scotland

The Dunfermline Eastern Expansion (DEX) is a 2 square mile tract of green space that is slated for mixed use development (industrial, commercial, residential, recreational) over the next 20 years. The Scottish Environmental Protection Agency (SEPA) had concerns not only about the additional stormwater that the site would generate, but also its contribution the watershed immediately downstream which already experiences significant flooding. For these reasons, SUDS was made a planning condition and BMPs such as filter drains, swales, extended detention basins, wetlands, infiltration basins, and permeable pavement have been incorporated into the design. DEX is now the largest site in the UK to use SUDS. The major residential developer, along with two local universities, will conduct monitoring of the system's effectiveness over a five year period. Costs to maintain the system will also be carefully tracked. While many benefits are anticipated from the SUDS design, the highway authority was initially unwilling to adopt SUDS for road drainage. This barrier was eventually overcome and treatment systems adjacent to the development's roads are now a large component of the design.

Figure 3-18. Green detention basin at DEX roundabout.
(Source: University of Abertay Dundee)

4.3.4 Malmo, Sweden

Augustenborg is a densely populated inner city neighborhood in Malmo, which was served by a combined sewer system that experienced heavy flooding and basement backups during rain events. Swedish climate change research predicts significantly more rain and runoff over the next 10 to 20 years that will serve to exacerbate these challenges. To solve these problems, the city implemented an open stormwater system that utilizes a treatment train of green roofs, swales, vegetated channels, ponds, and small wetlands to convey, infiltrate, and treat stormwater. This system has been in place since 2001 and functions efficiently to handle 90 percent of the stormwater runoff from impervious surfaces and attenuate peak flows for even the 10-year rainfall. A secondary goal of the project was community revitalization, as the work was focused on an older section of the city with degrading infrastructure. Therefore, community participation and outreach was a vital component of the project's success. Design needs were balanced carefully with residents concerns that open space and courtyard areas would be taken over by unusable areas of open water. The extensive implementation of green roofs helped to alleviate this concern significantly.

4.4 Sustainable Water Management Improves Tomorrow's Cities Health (SWITCH) Program

SWITCH is a research project funded by the European Union that took place from 2006 to 2011. The focus of the project was innovation in sustainable urban water management, particularly translating this information into the future needs of cities. With cities around the world facing a range of global and regional pressures, including population growth, industrialization, and climate variability, managing water resources will become increasingly hard. One of the major research outcomes of the SWITCH project was that a shift in paradigms from a gray to green approach is essential to the future of stormwater management. The project recognized that green infrastructure not only provides an aesthetic amenity to urban centers, but also provides important ecological and stormwater functions that cannot be duplicated by gray infrastructure. While this project reviewed drinking water, wastewater, and stormwater management, the three are often intertwined and integrated planning for future needs is necessary. One of the major outcomes of the SWITCH project was the development of the "SWITCH approach", which includes features such as:

- **Learning Alliances:** Multi-stakeholder alliances are a good way to bring together key organizations into a forum where they can discuss the issues at hand and guide and support the development of project implementation.
- **Strategic Planning Process:** City-wide strategic planning will help develop long term goals and strategies to implement sustainable urban water management. Cities should consider environmental, economic, and physical implications of various water management options.
- **Early Action Demonstration:** Pilot projects that represent potential urban water management options should be implemented early on in order to monitor and learn from these projects before up-scaling to a local, regional, or global level.
- **Training Toolkit:** Development of a training toolkit within the city learning alliance is a good way to maximize the impact of the SWITCH approach and disseminate important information to residents, organizations, and other stakeholders.

The SWITCH project engaged stakeholders in 12 cities around the world, including Lima, TelAviv, Beijing, Hamburg, and Bogota. Demonstration projects were implemented in several of these cities with the purposed of translating results to larger scale programs and policies. Several important lessons about stormwater management came from the SWITCH research. First, solutions for urban stormwater management are typically selected based on the local priority of removing stormwater from a defined area; however, these solutions often overlook the impacts on a larger urban scale. For example, taking stormwater from one area and transporting downstream may overburden the existing infrastructure at another location, thereby damaging infrastructure in a different locale. Additionally, these solutions often provide immediate volume control, but do not address polluted waters that are diverted into receiving streams and rivers. Second, an array of stormwater management BMPs must be available to adapt to a range of environmental and socio-economic conditions. Threats and impacts to stormwater control strategies should be evaluated in the short and long term. Finally, a key finding from the SWITCH research showed that one of the primary challenges to stormwater source control was not technical knowledge, but institutional decision making. A more integrated planning process can often help reconcile institutional barriers and bring about common goals and objectives.

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5 Green Infrastructure Case Studies: Africa, Asia, South America

Green infrastructure in the developing world is primarily implemented as a means for rainwater harvesting, due to the water shortage and demand for clean water. With populations continuing to grow, especially in underserved developing countries, and our freshwater supplies limited and becoming degraded, green infrastructure can play a completely different role in rainwater harvesting. The reuse of stormwater presents an opportunity for use at a household level, as well as a municipal level for irrigation, drinking water, non-potable uses, cooling systems, generating electricity, and groundwater recharge. These benefits are heightened in economically challenged countries where resources are scarce and a lack of adequate water and wastewater management affects day to day farming, health, and infrastructure.

5.1 Accra, Ghana

Accra is the capital of Ghana and one of the largest cities in the country. The city is rapidly growing as the country's urban population is expected to more than double in size by 2020. This, coupled with a virtually unplanned infrastructure system, make water, wastewater, and stormwater management a growing concern. At the forefront of these concerns is access to a clean and reliable drinking water supply, followed by available resources for adequate irrigation and wastewater management.

Figure 3-19. Typical drainage canal in Accra.
(Source: International Development Research Centre)

Stormwater management and implementation of adequate drainage systems is much less of a concern in a developing city such as Accra. However, better stormwater management will help achieve improvements in both drinking water and wastewater capacity. For example, most drainage of stormwater takes place through natural drains (unlined) that also handle a large part of the wastewater drainage. These systems are not large enough to hand both inputs, which leads to frequent flooding of certain areas. Additionally, as the region continues to develop, soils will become less permeable and result in increased runoff and added burden on the drainage system. Therefore, Accra is currently exploring SUDS projects to help reduce stormwater runoff, as well as developing a green belt around the city where urban agriculture can be maintained and utilize rainwater harvesting techniques. Existing projects have utilized irrigation cisterns to grow maize, as well as underground storage tanks to supply water at car washes.

5.2 Katsukunye, Zimbabwe

Katsukunye is located just over 100 miles from Harare, Zimbabwe, the country's capitol and largest city. The region's adverse hydrologic features, including rocky terrain and saline groundwater, combined with an arid climate have led to perennial water shortages which hindered daily life in this community to the point where local schools and the health clinic were on the verge of being shut down. The nearest drinking water supply was nearly two miles away. The community has now turned to rainwater harvesting to solve some of these problems. The Rainwater Harvesting Association of Zimbabwe, in collaboration with the Mvuramanzi Trust, has implemented a pilot project which uses granite rocks to feed stormwater runoff into a large storage tank. This project was conducted in 2001 and was highly successful in improving social, environment, and health conditions in the community. The village has also taken steps to form a committee that manages water use and has developed a demand management protocol to allocate water.

5.3 Rakai, Uganda

Uganda has undergone significant economic and population growth over the past 20 years, which has put a strain on already stressed clean drinking water supplies, such as springs, shallow wells, and boreholes. Rakai is a region with highly mineralized groundwater, which forces reliance on alternative sources of water such as swamps. Thus, starting in 1997, the region has turned to rainwater harvesting to supplement these scare water supplies.

Figure 3-20. Rainwater jar in Rakai.
(Source: International Rainwater Catchment Systems Association)

A women's group from Kenya trained two groups from the Rakai district in the skills of water jar construction. These small (185 gallon) water storage jars collect water from roofs and supplement the community's potable and non-potable water supply. Water is stored in the jars until after the rainy season when all other sources have been completely depleted. After the tank is filled it is locked up for maximum security. This effort provides an inexpensive (jars cost around $70), entrepreneurial endeavor for women throughout the community, as well as a means to obtain additional clean water. The women's groups have gone on to train other groups on making the jars and now build the tanks for profit.

5.4 Dongtan City (Shanghai), China

Dongtan is slated to be the world's first "eco-city" and is located on the island of Chongming in Shanghai, China. The area is currently comprised primarily of agricultural land and sits strategically close to the city of Shanghai. Dongtan is three quarters the size of Manhattan and seeks to implement sustainable design, renewable energy, green infrastructure, and social responsibility in a community that invites a range of commercial and leisure investments. The project is backed by the mayor of Shanghai and the Chinese Premier. The first phase of Dongtan was scheduled to be completed in 2010; however, the project has fallen behind schedule. This phase is expected to include urban and ecological parks and other leisure facilities. Stormwater and rainwater capture will be a central landscape feature to support life in the city. Dongtan has the potential to serve as a model for new, sustainable urban development; however, the project has been met with some resistance due to the fact that the planned construction is located in an area of wetlands that serve as home for migratory birds along the Yangtze River.

Figure 3-21. Rendering of Dongtan City.
(Source: Arup)

5.5 Gansu Province, China

The Gansu Province in located in central China and is one of the driest and poorest regions of the country. Rainwater harvesting has traditionally been the primary source of water supply for residents in this region. Underground, clay-lined cisterns were typically used to collect runoff; however, in dry years these systems could not be relied upon to provide adequate water supply. In 1995, after a terrible drought, the Gansu Research Institute for Water Conservancy implemented the 1-2-1 project, which, until that point had only been carried out as pilot projects. The 1-2-1 project provided each family with one clay tiled roof catchment, two upgraded cement water cellars, and plastic sheeting for diverting rainwater runoff from one field. The project cost approximately $12 million and assisted nearly one million people in obtaining a sufficient water supply. These costs were provided in part by the local government and in part by community donations.

5.6 Beijing, China

Beijing has been using rooftop rainwater harvesting techniques for thousands of years; however, widespread promotion of rainwater harvesting has more recently become a city priority. Pilot projects have been put into place over the past 10 to 15 years, using pervious pavement and roadside swales to collect runoff and store it in ponds for treatment and reuse. The 2008 Beijing Olympics spurred more intense rainwater harvesting practices – perhaps inspired by the Beijing Olympic National Stadium that was designed with many large scale rainwater reuse practices. Rainwater was used for flushing toilets, cooling towers, fire infrastructure, and irrigation of green space throughout the stadium (at a capacity of 90,000 spectators). Agriculture, however, remains the largest consumer of water in Beijing. The Beijing Agricultural Bureau has helped to promote rainwater harvesting in greenhouses by placing service extension offices in each district and providing subsidies to those who use rainwater harvesting. In residential areas, waterscapes are required to reclaim rainwater.

Figure 3-22. Residential waterscape in Beijing. (Source: Sherwood Institute)

5.7 Ampara District, Sri Lanka

Several pilot projects have been conducted by the Lanka Rainwater Harvesting Forum (LRWHF) throughout Sri Lanka in order to promote research, development, and technologies related to rainwater harvesting. In 2007, a pilot project was launched in the Ampara District to improve water supplies and prevent contaminated water related illnesses. The Ampara District is located in southeastern Sri Lanka and is characterized by a tropical climate with a long dry season. Coastal towns especially are densely populated and limited land availability has resulted in cross contamination of sanitary and drinking water resources. The rainwater harvesting program consisted of a combination of community outreach and education, construction of large scale demonstration rainwater harvesting systems, job training, construction of small scale (residential) demonstration rainwater harvesting systems, O&M training, and project research and monitoring. Large scale demonstration tanks were installed at ten schools and small scale tanks and piping were installed at 140 residential properties. Five masons were trained to install the systems and O&M training was provided to the recipients to ensure that they could properly maintain the systems. This pilot project lasted for nine months, during which time it was monitored, and was the second phase of another successful project that was implemented from 2005 to 2006.

5.8 Khon Kaen, Thailand

Thailand’s National Jar Programme is aimed at providing clean drinking water to rural populations through rainwater harvesting techniques. The rainfall jars are similar to rain barrels, but made of concrete and clay, and range in size from 132 gallons to over 500 gallons. Jars are relatively inexpensive to construct and transport and most rural households have at least two jars in place, the service life of which is estimated to be 20 years. The total cost of a 500 gallon jar, including installation is less than $50. Jars were initially provided to residents at subsidized rates (cost share through the government) or, in some cases, for free. A national mass media campaign help to promote use of the jars widely, and eventually commercial production of the jars replaced the government-subsidized jars. Rainfall jars have proven highly successful over the past 20 years and are used widely, especially throughout northeast Thailand and communities such as Khon Kaen. Khon Kaen University conducted extensive research on the National Jar Programme during the initial stages of the work.

5.9 Belo Horizonte, Brazil

Belo Horizonte was the first modern planned city in Brazil. This meant that streets were laid out on a grid, pipes and other infrastructure was planned, and space was dedicated to parks and courtyards to create a vibrant living environment. Despite this planning, the city grew quickly starting in the 1950s and water management focused primarily on keeping up with the growing population. Drinking water in Belo Horizonte is clean and reliable; however, wastewater infrastructure is lacking and there are many illegal connections to the storm sewer system. Sewage in streams and groundwater has become a problem, as well as flooding. The SWITCH program set up several research and demonstration projects in Belo Horizonte to help get urban water management back on track. Demonstration projects have included infiltration trenches, constructed wetlands, and rainwater harvesting. Monitoring, modeling, and additional research have focused on the technical aspects of the projects, as well as costs and hydrologic impacts. Stakeholder meetings and community outreach were also an integral part of these demonstration projects.

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6 Conclusion

Green infrastructure is being implemented around the world to address various concerns related to stormwater management. In North American and Europe, green infrastructure is being used to help manage stormwater in urban environments. In Africa and other developing regions around the world, green infrastructure is being used as a means for rainwater harvesting, helping to provide potable drinking water and water for irrigation. Green infrastructure is also utilized for various social, environmental, and economic benefits such as community beautification, wildlife habitat, neighborhood revitalization, and a lower cost alternative to many traditional gray infrastructure systems.

This report summarizes green infrastructure case studies from around the globe in search of common goals, drivers, successes, and barriers to program implementation. In North America, the recent push to implement green infrastructure stems from several drivers including CSO reduction, NPDES permit requirements, flood control, and other community sustainability goals. Many communities are in the infancy of program development, while others have a decade or more of experience with green infrastructure implementation. The conclusion of this report summarizes some of the challenges, as well as keys to success, that are common to the case study communities and cities across the country. These observations and lessons learned will provide a framework for project implementation in the District moving forward.

6.1 Challenges to Green Infrastructure Implementation

6.1.1 Technical Challenges

While resolving technical challenges is not one of the most pressing issues associated with the implementation of green infrastructure, they still present somewhat of a barrier in the urban environment. Past green infrastructure projects have been applied primarily to new development and generally on a small scale. Often, models to predict the effectiveness of green infrastructure measures were still being developed when LTCPs were being prepared and have advanced significantly since that time. New models have been created and more data has become available; however, minimal data exists on the application of green infrastructure in urban retrofit situations on a large scale. Many communities have implemented urban pilot projects and collected detailed monitoring data, but this has generally been at the lot level or neighborhood scale. This makes it difficult to predict the exact performance, cost, and volume reduction benefit of green infrastructure on a large scale. As a result, there is uncertainty as to the practicability of green infrastructure implementation in heavily developed urban areas.

6.1.2 Regulatory Challenges

Regulatory challenges associated with green infrastructure implementation are present at multiple levels, starting with federal regulations. In the face of ever changing regulations, jurisdictions such as the District are challenged with outdated LTCPs and updates to address the newest data and technologies. Managing stormwater runoff and reducing CSOs requires a huge financial investment and municipalities find themselves taking risks on proposed green solutions that are not typically as “tried and true” as their gray alternatives. At the state and local level, stormwater regulations must be revised to require the use of green infrastructure on site. Local codes and ordinances must also be reviewed to ensure support of water quality goals. Revising or creating a local stormwater regulation that requires the use of green infrastructure can be challenging from both a political and logistical standpoint.

6.1.3 Funding Challenges

Any comprehensive stormwater management program will required a dedicated funding source to be successful. This is one of the first steps (and challenges) that a municipality must take to ensure viability of the program. Some cities have relied on grants, loans, or other outside sources of funding to implement their programs and the instability of these funding sources makes it extremely difficult to set up long term programs and policies. Many municipalities have turned to a stormwater fee, which is a more reliable source. However, establishing a stormwater fee presents challenges in itself, such as developing a fair rate system, providing for public comment, and implementation through the jurisdiction.

6.1.4 Institutional Challenges

Institutional barriers present the main challenge to green infrastructure implementation, particularly in the urban environment. Widespread application of green infrastructure would require construction on streets, sidewalks, parking lots, parks, and a whole range of public and private property throughout the District. One individual agency cannot require or regulate this implementation. Instead, cross-agency cooperation and policy continuity would need to be established. This represents a significant undertaking for any urban municipality. Nonetheless, cities such as Chicago and Philadelphia are finding ways to coordinate across jurisdictions, either through committees or urban design teams, to ease the transition to green infrastructure and institute this approach citywide. In most cases the city government is implementing the green infrastructure. DC Water has a unique challenge because it is not a city department but a separate entity having to rely on inter-agency cooperation.

6.2 Successful Approaches to Green Infrastructure Implementation

This report reviews case studies from around the world that highlight how green infrastructure has been implemented with some degree of success. The cities which have most successfully and comprehensively instituted green infrastructure have incorporated several common actions into their approach. Among these are integrated policies and goals, innovative programs and initiatives, and incentives that engage the private sector to implement green infrastructure approaches.

6.2.1 Integrated Planning and Goals

Many of the case study communities have been successful in setting up integrated programs that pull together multi-jurisdictional goals and engage various local agencies. These programs do not limit the scope of their stormwater program to only volume reduction or water quality, but focus on a variety of environmental, social, and economic goals valued by many different stakeholders. Some communities, for example Philadelphia, have taken a “triple bottom line” approach to valuing and understanding the implications of green and gray infrastructure to address CSOs in their watersheds. In Philadelphia, the triple bottom line assessment found that green infrastructure approaches provide a wide array of important environmental and social benefits to the community that are not provided by more traditional alternatives. In many communities, a focus on more than one goal or objective appeals to multiple stakeholder groups and helps garner more widespread support for programs or initiatives.

An integrated municipal approach is also needed to more easily implement green infrastructure programs or policies at the local level. Review and coordination among various municipal departments should be done early on in the process. For example, review of any associated development codes and/or ordinances to assess consistency with new stormwater regulations needs to be completed prior to implementing these regulations. It is important to identify and address any inconsistencies between policies or regulatory mechanisms. For example, Chicago has a Green Urban Design process that looks at the continuity of ordinances across eight municipal departments and developed a plan to better align all development ordinances. Pilot projects are also often useful for identifying these inconsistencies at an early stage.

Green infrastructure is an investment and many of the case study communities view the benefits of implementing green infrastructure holistically as more than just short term stormwater management. Long term community and environmental benefits can also be seen from investing in a hybrid of green and gray infrastructure. This type of vision requires a long term planning approach, especially while working with vegetated systems that require time to grow and reach maximum performance potential for stormwater management. A long term green infrastructure plan can help lay out the city’s vision, as well as prioritize infrastructure investments. A systematic approach is often desirable, beginning with mapping out existing assets and needs and prioritizing target implementation areas or goals.

6.2.2 Innovative Programs and Policies

Most successful cities have integrated multiple policies, programs, and initiatives to achieve green infrastructure goals. This integration has occurred at various institutional levels and provides overall support for green infrastructure. At the ground level, policies and regulations have been put in place that require the use of green infrastructure, while at the same time innovative demonstration projects are being implemented to garner public support and raise community awareness. In addition, a separate funding source is often established to contribute toward green infrastructure projects.

Innovative programs and policies are being targeted at both public and private sector development. Public sector programs and policies can be set up internally by government agencies. Private sector programs and policies apply to private development and private property owners and typically include residential and commercial properties. Common public program/policy approaches observed in the case studies included demonstration projects, street retrofits, capital improvement projects, local code review/revision, and education and outreach. Common private program/policy approaches included new or revised stormwater regulations, stormwater fees, and fee-based or other incentive programs. It should be noted that several of these programs and policies are typically used together and are complimentary of each other. The greenest cities implement a wide range of stormwater management programs and various approaches that target both the public and private sector.

Stormwater regulations are one of the key drivers for successful green infrastructure implementation in the case study communities. While new regulations or codes cannot solve all water quality problems since they typically only apply to new development or redevelopment, these regulations set a foundation for projects moving forward. Stormwater regulations need to be coupled with larger land use planning strategies and comprehensive plans.

Many communities have found that demonstration projects are a good way to introduce new green infrastructure techniques to the community, while at the same time they can internally monitor the success of a given project for potential integration into larger policies or programs. While long term pilot projects have been monitored for several years in progressive communities like Portland and

Seattle, there is little monitoring data from large scale projects or widespread applications. Pilot projects do, however, give municipal staff time to determine the logistics of implementing green infrastructure practices, including design, construction and maintenance, permitting protocols, and cost. Although costs for green infrastructure projects may ultimately be higher than that of traditional projects at the pilot phase, these costs are typically lower as the practice becomes more widespread.

Community outreach has been a large component of many of the successful community case studies. Outreach and education programs help convey the benefits of green infrastructure to the general public and portray the value of stormwater as a resource. Education and outreach programs use websites, signage, brochures, and other public forums to reach the public and disseminate information. These programs often combine the environmental, social, and aesthetic benefits of green infrastructure to highlight community beautification projects or those that promote wildlife habitat – in addition to providing stormwater management benefits.

6.2.3 Private Engagement

Several case study cities have successfully engaged the private sector in using green infrastructure in new development and retrofit opportunities. This engagement is achieved through either regulatory requirements or incentive-based programs. This has allowed the cities to share some of the financial burden of implementing green infrastructure.

Stormwater fees are a common means used to generate revenue to address CSOs and stormwater management. Stormwater fees are often used to implement both gray and green infrastructure projects. Increasingly, these fees are being directed more proportionally toward those property owners that are creating the most runoff entering the combined system. For example, stormwater fee rates are often charged per area of impervious surface contained on a given property. One incentive seen frequently throughout the case studies was the use of stormwater fee discounts for property owners who voluntarily reduced impervious surfaces and instead implemented green infrastructure. This incentive only appears to be successful in communities where the stormwater fees are high enough to incentivize a discount.

Other successful incentive programs include the use of fast track permitting, review processes, or other development incentives such as a density bonus in exchange for implementing green infrastructure. For example, Portland’s Floor Area Bonus Program allows builders and developers to increase the square footage of a building if a roof garden or ecoroof is part of the design. In Philadelphia, fast track permit review is instituted for stormwater management plans. Fast track review is also allowed for projects that have disconnected 95 percent or more of their impervious area from the sewer system.

Some cities have established small grant funds dedicated to implementing green infrastructure or other watershed improvement projects. These funds typically provide a portion of total project funding in order to subsidize the overall project costs. Chicago’s Green Roof Grant Program provides up to $5,000 per roof for small scale green roof projects and their Green Roof Improvement Fund provides up to $100,000 for larger green roof projects in targeted areas. Another example is Portland’s Community Watershed Stewardship Grants, which provide up to $10,000 to community groups for watershed improvement projects that include rain gardens, ecoroofs, and downspout disconnection.

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Appendix - I
Technical Memorandum No. 6 – Green Infrastructure Technologies

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DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

TECHNICAL MEMORANDUM NO. 6: GREEN INFRASTRUCTURE TECHNOLOGIES

May 4, 2012

Prepared for:

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1 Introduction

The purpose of this report is to provide a concise summary of select Green Infrastructure (GI) Technologies that are deemed to be the most relevant for use in the District of Columbia as part of DC Water's proposed Green Infrastructure Program. This primarily relates to the suitability of these practices for use in an urban environment to provide volume reductions to aid in reducing the occurrence of Combined Sewer Overflow (CSO) events.

There are a wide range of potential GI technologies currently in use throughout the country, and many of these include numerous design variations. There are likewise hundreds, if not thousands, of documents and design manuals available that describe these GI technologies in detail. The intent of this report, therefore, was to select and summarize important aspects of the relevant practices, rather than to provide a detailed design document. Review of this report will enable DC Water staff to quickly discern the practices that may be of most use for a particular application. Detailed design specifications developed by others can then be consulted to implement the selected technology.

With the above considerations in mind, review of available GI technologies has resulted in the selection of the following for inclusion in this report:

1) **Bioretention**
2) **Pervious Pavements**
3) **Soil System Detention**
4) **Vegetated Swales**
5) **Green Roofs**
6) **Rainwater Harvesting**
7) **Blue Roofs**
8) **Filter Systems**

The report is organized with a separate chapter for each technology. Within each chapter are sections that provide an overview of some important aspects of the technology that were developed to assist DC Water staff in selecting the desired practice. The sections that are included are described below, along with a brief summary of the type of information that is provided:

1) **Description** – Provides an overview of the technology.

2) **Feasibility Considerations** – This section describes some basic parameters relating to the proposed site that should be considered when deciding whether or not the technology is appropriate for the intended application.

3) **Basic Design Elements –** Though not intended to provide detailed design specifications, this section does include more general design parameters and some typical ranges for these parameters.
4) **Important Construction Considerations –** There are some basic construction guidelines that can impact the success of the technology before it is even put into

practice. This section outlines steps that should be taken to prevent premature failure and/or to ensure the practice performs as intended.

5) **Operation and Maintenance** – This section provides guidance concerning some recommended measures to keep the technology operating efficiently and to prevent premature failure.

6) **Performance Criteria** – Ranges of some typical performance for volume reduction and pollutant removal (for total phosphorus and total nitrogen) are provided. There are numerous design options that can determine the effectiveness of the technologies. This section provides overall ranges to aid in gauging the overall potential for the practice.

7) **Cost** – Various sources of cost information were reviewed in order to provide a range of typical values for each technology.

8) **Applicability to DC Water** – This section provides a brief analysis of how the technology can benefit DC water, specifically in terms of feasibility in an urban environment, as well as the potential for providing effective volume reductions.

9) **Detailed Design References** – As discussed above, the intent of this document was to provide an overview of the technologies, not detailed design information. This type of guidance is available through various sources, several of which are provided for reference.

10) **Example Applications** – This section provides a few schematics and photos as examples of applications in use in similar situations.

2 Bioretention

2.1 Description

Bioretention is a practice whereby runoff is collected in shallow depressions and is allowed to infiltrate through an engineered soil media consisting of sand, soil, and organic matter. The cell is planted with suitable vegetation capable of withstanding the hydrologic extremes (periods of inundation followed by periods of dryness, which are a result of the high sand content). The surface of the facility is covered by a layer of mulch and, depending on the permeability of the in-situ soils, often includes an underdrain that collects and discharges water to a suitable outlet. Water quality and quantity benefits are achieved through physical filtering, biological, and chemical mechanisms, as well as through retention, absorption and infiltration.

Bioretention facilities can be known by many names, including bioretention basins, bioretention filters, or rain gardens, among others. These names are sometimes based on the size (with rain gardens typically referring to smaller scale facilities) and/or functionality (without or without underdrains), but all act in the same manner. A primary benefit of bioretention facilities is that they can be tailored to fit the specific situation, even in tight urban settings and/or along roadways. They also provide an aesthetically pleasing alternative for the treatment of stormwater that can be integrated into the landscape.

Figure 2-1. Curb-extension bioretention facility (Source: UACDC LID Design Manual for Urban Areas)

2.2 Feasibility Considerations

As with any LID practice, there are constraints to be considered with the use of bioretention facilities. Some of the more important considerations include:

2.2.1 Contributing Drainage Area

Publications recommend no more than 2 acres (ac.) drain to the facility with no more than 50% impervious cover for typical bioretention facilities. However, in urban situations, drainage areas tend to be much smaller (2,500 s.f. to 1 ac.) and contain up to 100% impervious areas. Larger drainage areas can be accommodated (up to a maximum of 5 ac.) if other limitations are taken into account in the design. Flow splitters can be utilized to divert larger storms around the facility to accommodate larger contributing drainage areas and/or to isolate the desired treatment volume – a typical situation in urban settings.

2.2.2 Available Space

Bioretention facilities can be tailored to fit the available space – one of the big advantages of this practice. The overall footprint will be determined in conjunction with other design parameters, such as design depth, soil infiltration rate, and desired level of treatment. However, 3-6% of the contributing drainage area is a rule of thumb. Much smaller ratios are achievable with high infiltration rate media[1], but this sacrifices the volume reduction benefits of bioretention facilities.

Figure 2-2. Small bioretention facility retrofitted in a busy urban setting. (Source: Nevue Ngan Associates)

[1] *Higher sand content or proprietary media, such as Filterra.*

2.2.3 Topography

Generally, bioretention facilities function best on sites where the slope is in the 1-5% range. They can, however, also be used in steeper situations (10-20%) through the use of terracing practices.

2.2.4 Available Hydraulic Head

For systems draining to a stormwater conveyance through an underdrain, there must be a sufficient difference in elevation to make sure the underdrain flows freely and does not inhibit the flow through the filter bed media.

2.2.5 In-Situ Soils

The lack of permeability of the soils present on the site does not inhibit the use of bioretention practices. This is a particularly important point in urban settings where compacted fill is commonplace. Underdrains are supplied when soil infiltration rates are unacceptably low (typically less than 0.50 in/hr), or can be included and capped off to provide a back-up should in-situ infiltration rates worsen over time. Another option is to employ a raised underdrain outlet that provides for some storage to allow the opportunity for infiltration (i.e. Internal Water Storage, or IWS), but does not rely on it.

Figure 2-3. Bioretention planter box in Washington, D.C.
(Source: ceNEWS)

2.2.6 Water Table

It's important to make certain that the seasonably high groundwater elevation is a minimum of 2 ft below the bottom of the facility. This will inhibit the potential for groundwater contamination, as well as the potential for high groundwater levels to inhibit the proper draining of the facility.

2.2.7 Pollutant Hotspots

Use of bioretention to treat runoff from land uses with the potential for high pollutant levels should be avoided, or pretreatment provided that is tailored to the type of pollutant expected.

2.2.8 Utility Conflicts

As with other practices, conflicts with utilities (both under and above ground) should be avoided.

2.2.9 Location

Bioretention facilities should not be located within 100-yr floodplains or in areas that receive a baseflow. Care should also be taken to keep these practices away from buildings and water supply wells – distances of 10 and 100 ft are cited, respectively, but depend on the particular design parameters (size of the facility, type of soils, etc.). In urban settings, they can be placed immediately adjacent to buildings if the buildings are waterproofed and/or an impermeable liner is used.

2.3 Basic Design Elements

Bioretention facilities can be designed to fit the available site and to meet the specific water quality/quantity requirements. Thus, there are numerous design variations. However, there are some basic elements that each typically has in common, as summarized in the following table.

Table 2-1. Bioretention Typical Design Elements

Design Element	Typical Values
Drainage Area	1-3 ac
Ponding Depth	6-12 in. (lower reduces maintenance costs and allows more diverse vegetation)
Soil Matrix Composition	85-88% sand, 8-12% fines, 3-5% organic. 2-6 in/hr initial infiltration rate.
Soil Matrix Depth	2-6 ft. Deeper for facilities with trees; 3 ft typical
In-Situ Infiltration Rate	> than 0.5 in/hr
Gravel Bed	As necessary for underdrain or for storage, 12-18 in
Underdrain	6 in schedule 40 PVC with 3/8 in perforations
Geotextile Fabric	Non-woven, along sides and above underdrain only with gap-graded sand/gravel filter above the gravel bed
Mulch Top Layer	3-in., double shredded hardwood
Side Slopes	< 3:1
Vegetation	Suited to hydrologic regime and soil depth
Bypass/Flow Splitter	As necessary to ensure design flow or volume is not exceeded
Drawdown Time	Within 24 hrs

2.4 Important Construction Considerations

There are important construction guidelines that must be followed to prevent failure of the facility before it is even put into service. Some of the more common and easily undertaken measures to avoid mistakes include:

- It is imperative that bioretention facilities be protected from sediment laden inflows during site construction. Ideally, the facilities should be built as a last step and after the contributing drainage area has been fully stabilized.

- Construction traffic on the facility footprint should be avoided to minimize soil compaction. This is especially important for facilities that will employ infiltration.

- It may be helpful to rip or scarify the bottom of the facility 6-12 in to promote infiltration.

- Perform infiltration tests on a batch of the soil media to ensure it infiltrates at an acceptable rate. Multiple tests are necessary to achieve a stable infiltration rate that will be representative of what can be expected – the rate tends to decline with each test until an equilibrium rate is achieved. While a mix of the proper proportions of sand, fines, and organic matter should be sufficiently permeable, it is sometimes difficult to ensure that the material has been mixed in the correct proportions, and sieve analyses fail to account for the permeability effect of platy particle shapes (mica or leaf mulch can reduce permeability after several flood/dry cycles). Testing prior to placement can avoid the costly removal and replacement of material after the facility fails.

- Place the soil media in 12 inch lifts and flood to provide hydraulic compaction. Add additional material as necessary to ensure the proper design elevation is achieved.

- Provide irrigation of newly planted vegetation until sufficiently established (at least through 1 growing season). Also consider watering options during drought conditions in areas where aesthetics is a concern.

2.5 Operation and Maintenance

If properly designed and constructed, bioretention facilities require little maintenance to keep them functioning properly. Inspections during the first year following installation are of particular importance. Particular items to look for include:

- The most obvious sign of a problem is excessive ponding of water that takes longer than 24-48 hours to drain (faster time in urban, highly visible areas). If this occurs, it can generally be attributed to two causes:

    1) The filter media (or the underdrain) were not designed and/or installed properly.
    2) The media has been clogged with sediment after construction.

If proper procedures were followed during design and construction, then the second cause is most likely.

- Inspect inflow areas to see if a sediment accumulation is obvious on the surface of the facility. If there is evidence of sedimentation, inspect the side slopes of the facility, as well as the contributing watershed, to determine the source and correct as necessary. Remove accumulated sediment and replace mulch cover.

- Ensure the mulch layer is intact and completely covers the surface of the facility as it provides significant filtering benefits, trapping much of the incoming sediment loads. For urban settings with a higher potential for heavy metal deposition, replace the mulch on an annual basis.

- Inspect the vegetation and replace dead plants as necessary. Adjust plant species if it is determined a particular type is not doing well.

2.6 Performance Criteria

Bioretention facilities can provide effective water quality and volume reduction benefits. With the various design options regarding facility sizes and configurations comes differences in the anticipated removal rates. Generally speaking, smaller facilities provide lower efficiencies than larger, deeper facilities. The following chart provides anticipated ranges, with smaller, urban facilities at the lower end (note that pollutant removal represents total mass loading resulting from treatment as well as from volume reduction – Source: *VA SWM BMP Design Specifications*):

Table 2-2. Bioretention Range of Typical Performance

Parameter	% Reduction
Volume Reduction (1" Storm)	40 -80
Total Phosphorus (TP)	55 - 90
Total Nitrogen (TN)	64 - 90

2.7 Cost

A variety of sources and literature were reviewed to determine the average costs for bioretention system construction and materials. These costs vary based primarily on the type of application (i.e., residential vs. commercial or industrial site) and whether the project is a retrofit or new construction. Residential bioretention, or rain gardens, typically cost between \$5 and \$12 per square foot to install. Larger scale commercial, industrial, or institutional projects that involve more complex design, an underdrain system, amended soils, and use of heavy equipment may run more in the range of \$15 to

$60 per square foot to install. Retrofit projects, especially in urban areas, will generally have even higher costs due to site constraints and existing infrastructure.[2]

2.8 Applicability to DC Water

Bioretention facilities can be designed and adapted to fit the available space and are, therefore, well suited for use in urban areas. They can provide significant volume and pollutant reductions and represent a good opportunity to reduce the occurrence of CSO events.

2.9 Detailed Design References

Detailed design methods are available in published documents and manuals that are periodically updated to keep abreast of advances in technology. While there are literally hundreds of such detailed design manuals, two are particularly clear and complete, and are from nearby regions:

- Virginia Department of Conservation and Recreation (DCR), Virginia Stormwater BMP Clearinghouse - http://vwrrc.vt.edu/SWC/StandardsSpecs.html.

- North Carolina Division of Water Quality, Stormwater Best Management Practices Manual - http://portal.ncdenr.org/web/wq/ws/su/bmp-manual.

It is important to make certain that the selected design options are acceptable to the District Department of the Environment (DDOE) prior to implementation and are in accordance with DDOE design guidance. DDOE is currently in the process of revising current guidance documents and adopting the runoff reduction methodology used by the Virginia Department of Conservation and Recreation (as communicated in an email from Rebecca Stack, DDOE, 3/19/12).

2.10 Example Applications

The following figures provide some typical schematics and photos of facilities that would be more relevant in confined, urban settings and, thus, would be more applicable to DC Water:

[2] Cost Estimate Sources: DC Department of the Environment Riversmart Program, Water Environment Research Foundation, U.S. EPA, Low Impact Development Center, Virginia Polytechnic Institute, Pennsylvania Department of Environmental Protection, Southeast Michigan Council of Governments

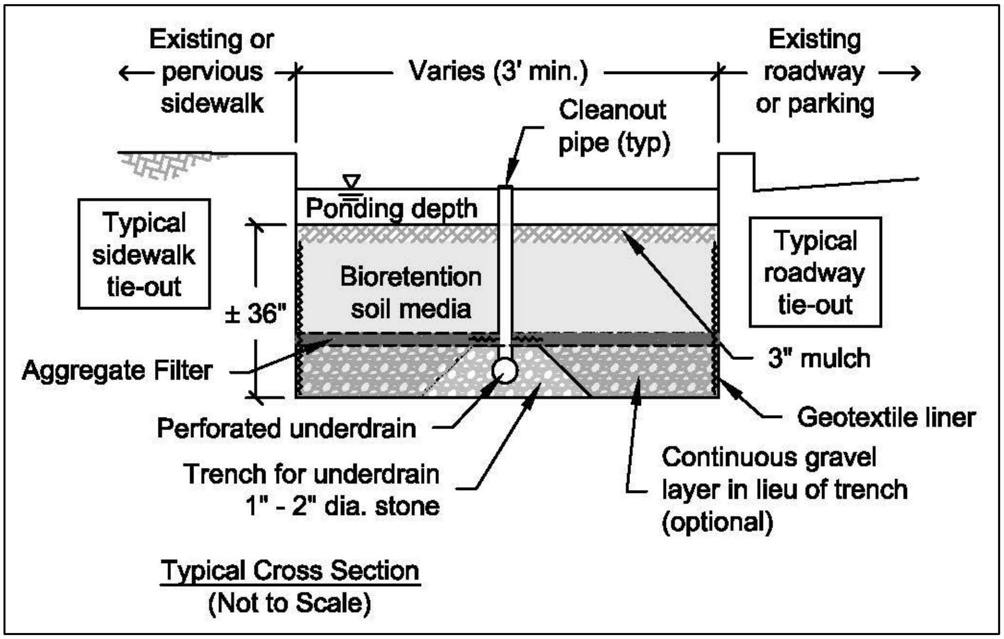

Figure 2-4. Schematic of a typical bioretention cell adjacent to a roadway. (Source: Wetland Studies and Solutions, Inc.)

Figure 2-5. Typical bioretention planter box adjacent to a building. (Source: City of Portland SWM Manual)

Figure 2-6. Bioretention planters adjacent to a roadway in Richmond, VA. (Source: Wetland Studies and Solutions, Inc.)

Figure 2-7. Bioretention planter in an urban courtyard. (Source: Portland SWM Manual)

Figure 2-8. Bioretention in a parking lot island.
(Source: NCDENR Stormwater BMP Manual)

Figure 2-9. Bioretention facility treating parking lot and rooftop.
(Source: Wetland Studies and Solutions, Inc.)

3 Pervious Pavement

3.1 Description

Pervious Pavement can come in different forms, but generally provides the same type of function that replaces impervious, traditional paving surfaces with materials that provide the necessary structural support while allowing rainfall to infiltrate into the underlying gravel base and soil strata. The specific design of pervious pavement systems can vary, but there are basic elements that include:

- Surface (wearing) Course
- Leveling Course (not always necessary depending on the type of pavement)
- Aggregate Storage Layer (for structural support and water storage)
- Underdrain and/or Overflow Structure
- Filter Fabric or Choker Course

The basic types of pervious pavement include porous concrete, porous asphalt, interlocking concrete pavers, and various types of grid systems made of concrete or plastic that incorporate gravel (or soil and grass) in the void spaces. For the concrete and asphalt pavements, permeability is achieved through exclusion of fine aggregate in the pavement mixes – thereby creating a media with connected porous space. Concrete pavers rely on a portion of the surface area being open and filled with a porous material (gravel without fines).

For each type of pavement, water quality and quantity benefits are realized through filtration, storage, and infiltration of stormwater. However, given the additional requirement to provide structural paving surfaces, proper and careful siting and design is essential to the long term success and functionality of this practice. In addition to the structural and environmental benefits, pervious pavement systems can provide additional aesthetic appeal through the use of various color and pattern options that are available (primarily concrete pavers, although colored pervious concrete is also available).

Figure 3-1. Pervious paver shoulders along a residential street (Source: LID Manual for Michigan)

3.2 Feasibility Considerations

There are constraints related to the use of pervious pavements that must be considered to ensure long-term functionality is achieved. Some of these constraints relate to the structural function of the pavements and particular attention must be paid to them. Some of the more important considerations include:

3.2.1 Location

Pervious pavement is not intended for high speed roads. Although it can be designed to support heavy loads and/or heavy traffic volumes, it may be advisable to use conventional paving materials in the drive aisles with pervious pavement on the shoulders or in parking stalls.

3.2.2 Contributing Drainage Area

In general, pervious pavements are intended to provide treatment of the stormwater that falls directly on the surface. However, it is acceptable to receive runoff from adjacent, impervious areas (especially in instances where drive aisles are traditional pavement) that are no more than twice the area of the pervious pavement itself. Although not recommended, it is possible to have stable, pervious areas drain as sheet flow onto pervious pavements, provided there is effective filtering of organic matter and sediment to prevent clogging. Point discharges onto pervious pavements are not recommended as there is a high likelihood of localized clogging due to sediment influx.

Figure 3-2. Run-on from traditional asphalt pavement. (Source: LID Manual for Michigan)

3.2.3 Available Space

A major benefit of the use of previous pavements is that they require no additional space as they can typically replace conventional paving materials wherever they are used on the site (with the exceptions of high speed or heavy load areas noted above).

3.2.4 Topography

For sites where the in-situ soils are sufficiently permeable, a soil (subgrade) slope of 0.5% or less is desirable to promote infiltration. For more steeply sloped applications, internal berms or baffles can provide effective "flattening" of the slope. Ideally, the flatter the overall pavement slope the better to not only aid infiltration, but to also minimize the chance of shifting of the pavement surface and/or sub-base. Slopes of several percent or less (up to a 5% maximum) are cited in the literature.

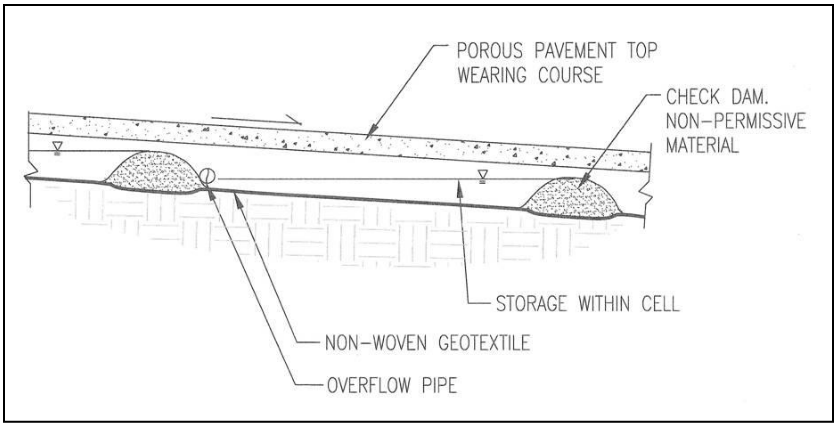

Figure 3-3. Schematic depicting internal berms for sloped applications. (Source: 2012 Draft LID Manual for Puget Sound)

3.2.5 Available Hydraulic Head

For systems draining to a stormwater conveyance through an underdrain, there must be a sufficient difference in elevation to make sure the underdrain flows freely and does not inhibit the flow through the pavement. A several foot difference in hydraulic head may be required. To aid in drainage, underdrains should be designed with a nominal positive slope of at least 0.5%.

3.2.6 In-Situ Soils

Low permeability of soils on the site does not inhibit the use of pervious pavement practices. Given that subgrades for pavements require structural support and become more compacted over time as a result of the intended use, requiring permeable in-situ soils would be problematic. Underdrains are thus acceptable and can be capped off to provide a back-up should in-situ infiltration rates worsen over time. As with bioretention practices, another option is to employ a raised underdrain outlet that provides for some storage to allow the opportunity for infiltration, but does not rely on it.

3.2.7 Water Table

It's important to make certain that the seasonably high groundwater elevation is a minimum of 2 ft below the bottom of the pavement. This will inhibit the potential for groundwater contamination, as well as the potential for high groundwater levels to inhibit the proper draining of the pavement subgrade. Whereas ponding in other GI Technology applications may occasionally be acceptable, making certain this does not occur on paved surfaces is of particular importance.

3.2.8 Pollutant Hotspots

As with other infiltration practices, use of pervious pavements in areas where stormwater hotspots are likely to drain to the pavements is discouraged.

3.2.9 Utility Conflicts

Given that many utilities are located adjacent to or within paved areas, particular care to consider their locations should be exercised. Utilities may be located under pervious pavement areas, but certain utilities such as electric and communication need special waterproof protection if located within the gravel bed.

3.2.10 Freeze/Thaw

It is suggested that storage volume for the 10-yr storm be provided in the gravel base below the pavement material to minimize freeze/thaw damage.

3.2.11 Location

Care should be taken to minimize a hydraulic connection to adjacent buildings. Required setbacks will largely depend on the scale of the pervious pavement application. Placement adjacent to overhanging trees or other vegetation should be avoided as this becomes a source for potential clogging.

3.2.12 Maintenance Commitment

The owner of the pervious pavement must be made aware of and be willing to accept and perform the necessary maintenance activities to keep the pavement functioning properly. This includes regular activities, such as vacuum sweeping, as well as making certain that activities that are often associated with the maintenance of traditional pavement, such as the application of sand and salt in winter or sealing or recoating, are strictly prohibited. The frequency of vacuum sweeping can be adjusted based upon site specific loading rates of debris, dirt, and leaves.

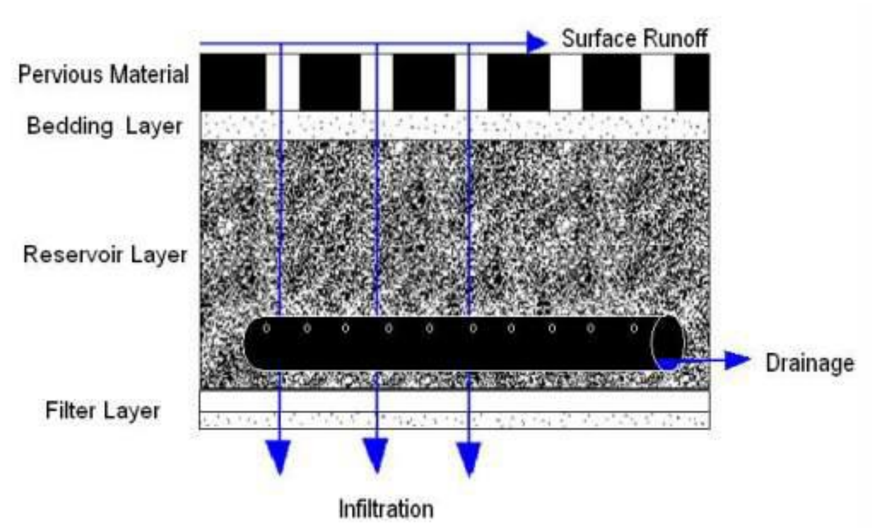

Figure 3-4. Typical cross-section of pervious pavement.
(Source: VA SWM BMP Design Specifications)

3.3 Basic Design Elements

In addition to the design of pervious pavements to meet the desired hydraulic performance, the proper design to meet the necessary structural requirements of the intended application is essential. While the details of structural pavement design are beyond the scope of this manual, there are some basic design parameters to consider, as summarized as follows:

Table 3-1. Pervious Pavement Typical Design Elements

Design Element	Typical Values
Drainage Area	Limit run-on from other areas; provide pre-treatment if unavoidable.
Surface Course	Concrete, Asphalt, Concrete Pavers, Reinforced Grid Systems
Surface Course Thickness	Concrete: 5-8” Asphalt: 3-4” Pavers: 3” All are typical values that can vary.
Base Course	Uniformly graded, clean, washed crushed stone (typically No. 57 stone).
Base Course Depth	Typically 8”to 36”, depending on structural and SWM requirements.
Longevity	Concrete: 20-30 yrs Asphalt: 15-20 yrs Pavers: 20-30 yrs
In-Situ Infiltration Rate	> 0.5 in/hr (without underdrain). Do not use over fill soils without a liner.
Depth to Groundwater	2 ft minimum, up to 4 ft preferable to prevent ponding on pavement surface.
Underdrain	4 in schedule 40 PVC with 3/8 in perforations
Geotextile Fabric	Impermeable liner required over fill or areas with high potential for contamination.
Pavement Slope	Bottom of subgrade - 0.5% or less. Surface – flat as possible, but no more than 5%.
Overflow Protection	Various design options to prevent surface ponding in significant (100 year) events. Design should prevent the upper 6 in of the pavement from becoming saturated.
Surface Clogging	Repave or install drop inlets (Concrete and Asphalt). Replace stone jointing materials (Pavers).

3.4 Important Construction Considerations

As with other infiltration practices, long term success of a pervious pavement facility can only be achieved by close attention to careful construction procedures. Many failures can be directly attributed to a failure to adhere to important construction guidelines. Some of the most important considerations include:

- Pervious pavement (as well as other practices that require infiltration) should be installed toward the end of the construction period, to the extent possible, to prevent sediment or landscaping soils/mulch deposition on either the pavement bed or surface.

- Pervious pavement can be placed on locations where temporary sediment basins or traps were employed, provided they are not excavated any closer than 24 in from the planned bottom elevation of the pavement reservoir layer. Upon removal of the basin and sediments, the bed can be excavated to its final grade. This same general approach can be used as the overall site is being developed – do not grade the pavement bed to the final elevation until adjacent site areas are fully stabilized.

- Avoid over-compaction of the subgrade to the extent practicable through the use of proper equipment and construction techniques. If possible, limit equipment tracking over the bed by excavating from the side. In larger applications, the site can be split into smaller, temporary cells that will facilitate this approach. Upon completion, scarify the bottom of the pavement bed 6-12 in to promote infiltration.

- Install a choker course between the native soil and aggregate bedding layer (typically comprised of a 2-4 in layer of No. 8 stone covered by 6-8 in layer of course sand). While a geotextile membrane can be used for this purpose, they can in some instances clog (if not correctly selected) more readily than the choker course.

- Inspect the aggregate used for the reservoir and bedding material to ensure it is washed and is free of fines that can lead to clogging.

- Placement of pervious pavement requires specialized skills and experience and should only be performed by qualified and experienced contractors.

Figure 3-5. Placement of pervious concrete.
(Source: Wetland Studies and Solutions, Inc.)

3.5 Operation and Maintenance

If properly designed and constructed, pervious pavements require manageable amounts of maintenance and good housekeeping practices to keep them functioning properly. These include:

- Vacuum the pavement once or twice a year to remove debris, leaves, or fines and other debris. In areas of high usage or significant tree cover, this can be necessary 4-12 times per year.

- Prevent tracking of sediments by construction or other vehicles to the extent practicable. Do not store mulch, topsoil, or any other materials that contain fines on the pavement surface. Remove any sediment deposition as soon as possible to prevent it from being ground into the pavement surface.

- Inspect adjacent areas to ensure vegetation coverage is complete and stabilize any areas of bare soil that may contribute sediment.

- Do not use sand or other abrasives on the pervious pavement or on other adjacent surfaces that may allow it to migrate to the pervious pavement.

Figure 3-6. Red maple seeds lodged in pores of permeable asphalt. (Source: Wetland Studies and Solutions, Inc.)

- For large pervious pavement applications, small damaged areas can be repaired with conventional paving materials without a significant loss of functionality. However, the potential for reduced performance should be considered when deciding whether to replace larger damaged areas with new pervious pavements. Repair of concrete pavers can be accomplished by removal and replacement of the blocks and fines within the open spaces.

- Sealants must never be used (primarily an issue for pervious asphalt applications).

- While many publications indicate that pervious pavements actually tend to promote snow melt, experience at Wetland Studies and Solutions, Inc. (WSSI) indicates the opposite can be true, as shown below. This should be taken into account if this could be an issue for the particular application. While deicers can be used (preferably other than salt), use should be minimized to the extent practical due to the potential for groundwater infiltration. Our experience is that in freezing rain or sleet, pervious pavements freeze more rapidly than conventional pavements, leading to potentially hazardous conditions.

Figure 3-7. Pervious concrete parking lot in snow – note coverage compared to conventional paving materials.
(Source: Wetland Studies and Solutions, Inc.)

3.6 Performance Criteria

Pervious pavements can provide effective water quality and volume reduction benefits. With the various design options regarding facility sizes and configurations comes differences in the anticipated removal rates. Generally speaking, smaller facilities provide lower efficiencies than larger, deeper facilities. The following chart provides anticipated ranges, with smaller, urban facilities at the lower end (note that pollutant removal represents total mass loading resulting from treatment as well as from volume reduction – Source: *VA SWM BMP Design Specifications*):

Table 3-2. Pervious Pavement Range of Typical Performance

Parameter	% Reduction
Volume Reduction (1" Storm)	45 -75
Total Phosphorus (TP)	59 - 81
Total Nitrogen (TN)	59 - 81

3.7 Cost

A variety of sources and literature were reviewed to determine the average costs for pervious pavement construction and materials. These costs vary depending on the technology employed and materials used. Generally, these applications range between $2 and $15 per square foot. Porous asphalt is the least expensive application (between $0.60 and $7 per square foot) and some research cites these costs as only 15% to 25% higher than standard asphalt costs. Pervious concrete is slightly more expensive at $2 to $13 per square foot. Pervious pavers are generally the most expensive application and range between $6 and $15 per square foot.[3]

3.8 Applicability to DC Water

Pervious pavements can be utilized to replace conventional paving materials in many applications where traffic speeds and volumes are not excessive, such as parking lots, roadway shoulders, alleys, courtyards, etc. They have the potential to provide substantial volume reductions, particularly when designed with a thicker gravel base to provide storage. Volume reduction and timing of runoff can help reduce the occurrence of CSO events.

3.9 Detailed Design References

Detailed design options are available in published documents and manuals that are periodically updated to keep abreast of advances in technology. While there are literally hundreds of such detailed design manuals, two are particularly clear and complete, and are from nearby regions:

- Virginia Department of Conservation and Recreation (DCR), Virginia Stormwater BMP Clearinghouse - http://vwrrc.vt.edu/SWC/StandardsSpecs.html.

- North Carolina Division of Water Quality, Stormwater Best Management Practices Manual - http://portal.ncdenr.org/web/wq/ws/su/bmp-manual.

It is important to make certain that the selected design options are acceptable to the District Department of the Environment (DDOE) prior to implementation and are in accordance with DDOE design guidance. DDOE is currently in the process of revising current guidance and adopting the runoff reduction methodology used by the Virginia Department of Conservation and Recreation (as communicated in an email from Rebecca Stack, DDOE, 3/19/12).

3.10 Example Applications

The following provide some typical schematics and photos of facilities that would be more relevant in confined, urban settings, and thus would be more applicable to DC Water:

[3] Cost Estimate Sources: DC Department of the Environment Riversmart Program, Water Environment Research Foundation, U.S. EPA, Low Impact Development Center, Maryland Department of the Environment, Fairfax County, City of Portland

Figure 3-8. Reinforced grid system.
(Source: SWM Handbook for Northern Kentucky)

Figure 3-9. Pervious concrete in parking lot stalls.
(Source: SWM Handbook for Northern Kentucky)

Figure 3-10. Reinforced turf used for overflow parking.
(Source: LID Manual for Michigan)

Figure 3-11. Colored pervious concrete.
(Source: LID Manual for Michigan)

Figure 3-12. Porous and conventional asphalt.
(Source: LID Manual for Michigan)

Figure 3-13. Pervious concrete residential street.
(Source: City of Seattle Stormwater Manual)

Figure 3-14. Pervious pavers in parking area.
(Source: Wetland Studies and Solutions, Inc.)

4 Soil System Detention

4.1 Description

A significant contributing factor in the degradation of water quality and increase in stormwater runoff volume in urban situations is the compaction of soil. Often by necessity, soils in developed areas require compaction in order to provide support for infrastructure like roads, parking lots, sidewalks, utilities, etc. Thus, even when not covered with impermeable asphalt or concrete, soils in urban settings often behave much like impermeable surfaces and provide few of the benefits of an undisturbed soil profile. These benefits begin with the ability to infiltrate stormwater, which provides the opportunity for nutrient, sediment, and pollutant adsorption, biofiltration, the transmission and storage of water within the soil, the microbial decomposition and uptake of pollutants. A "healthy" soil profile also promotes vigorous vegetation growth, mitigating the increase in runoff volumes through evapotranspiration. Healthy and robust vegetation also reduces pollution through a reduction in the amount of fertilizers, herbicides, and pesticides that must be used to try to keep plants growing in harsh, urban settings.

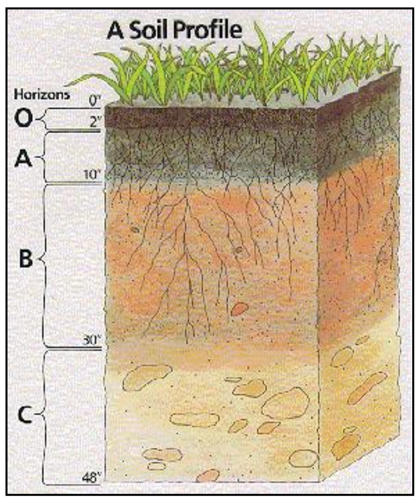

Figure 4-1. A healthy soil profile.
(Source: LID Manual for Michigan)

There are several options to provide for and/or restore many of the lost functions of a healthy, uncompacted soil profile. These options include:

4.1.1 Soil Amendments

Soil amendments involve the physical mixing of composted materials into compacted soils in order to improve the soil porosity and to incorporate organic matter to facilitate plant growth. Amended soils retain more water, thereby reducing runoff volumes, and support vigorous plant growth. The depth to which the soil is amended is dependent upon the contributing impervious area (maximum of 100% of the amended soil area) and is recommended to be from 6 to 24".

4.1.2 Structural Soils

Structural soils were developed at Cornell University and are sold under the trade name CU-Structural Soil™. Since its original development, other products have become available, such as Stalite Structural Soil. Structural soils can be used as a base under pavements to provide structural support while also providing an effective growing medium to facilitate and enhance the growth of adjacent trees. The reservoir can also be sized to accommodate virtually any size storm event (subject to site constraints). CU-Structural Soils™ consist of uniformly graded, crushed rock aggregate that is “coated” with a heavy clay loam or loam through the use of a tackifier. Carolina Stalite is a similar product except the aggregate is comprised of a lightweight expanded slate that, because of the rough surface texture, does not require a tackifier. The chemical properties of the expanded slate also allow the use of a soil with a lower clay content (a sandy clay loam is specified). For both products, the rock comprises the structural framework to support the pavement loads while the voids and soil provide a media that allows for air, water, and nutrients to support healthy root growth.

Figure 4-2. CU-Structural Soil™
(Source: Cornell University – Urban Horticulture Institute)

4.1.3 Silva Cells

Silva Cells (manufactured by Deep Root Partners, L.P.), have a similar function as structural soils to facilitate tree growth while providing support for pavements. This system differs in that the structural integrity is provided by a fiberglass/plastic framework (with galvanized tubes to provide additional structural integrity) that provides room for soil within the posts of the framework. Since the framework provides the necessary structural support, the soils can be compacted to the optimum density to facilitate plant growth. The soil media can also provide stormwater detention.

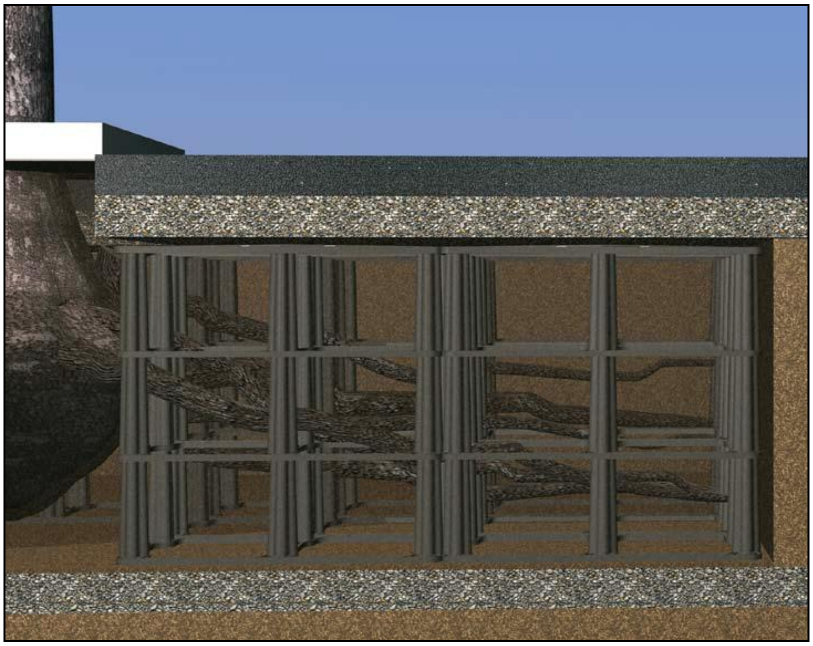

Figure 4-3. Silva Cell under roadway (soil not shown for clarity)
(Source: Deep Root Partners L.P.)

4.2 Feasibility Considerations: Soil Amendments

The use of these soil practices is largely dictated by the feasibility of being able to work within the footprint where it is to be implemented. There are considerations that should be taken into account as discussed below:

4.2.1 Location

Soil amendments can be applied wherever disturbance of the top 6-24-in of the soil can be performed without damage to utilities or existing tree roots from adjacent trees. Potential uses include residential and/or commercial lawns to enhance rooftop disconnection or to improve infiltration in compacted soils. They can also be employed in vegetated swales (especially along highway rights-of-way) or filter strips to improve their runoff reduction (and associated pollutant removal) performance.

4.2.2 Contributing Drainage Area

The contributing drainage area is not necessarily limited, especially in applications such as a roadside ditch (where the hydraulic conveyance of the ditch would dictate). In general, however, it is recommended that the amount of impervious area draining to the practice be limited to twice that of the surface area of the amended soils. The less the amount of impervious area, the shallower the necessary depth of the soil amendment.

4.2.3 Available Space

No additional space is required as they can be employed wherever vegetated areas exist or are proposed. Residential and commercial lawns represent the most likely locations.

4.2.4 Topography

Soil amendments are not as effective in areas where the slope exceeds 5%. Slopes greater than 5% may require terracing and the practice is not recommended for slopes greater than 10%.

4.2.5 In-Situ Soils

Unlike other practices where poor soils may limit their use, soil amendments are generally not necessary in well draining soils (hydrologic soil groups A and B).

4.2.6 Utility Conflicts

Any required excavation must consider the possibility of utility conflicts.

4.3 Feasibility Considerations: Structural Soil or Silva Cells

4.3.1 Location

Both of these proprietary practices can be employed wherever trees are planted adjacent to or within parking lots, sidewalks, courtyards, low-use access roads, or any other location where paved surfaces limit suitable soil volumes to support healthy tree growth. Structural soils have also been utilized to provide reinforced turf areas that allows for heavy loads while maintaining healthy turf growth.

4.3.2 Contributing Drainage Area

The primary benefit of these practices is to support the vigorous and healthy growth of trees in confined, urban settings where sufficient volumes of soil to allow root growth are often lacking. However, the reservoir size can also be designed to accommodate storms of virtually any size (depending on the size of the contributing drainage area). Care should be taken to ensure the growing media can contain the runoff without prolonged inundation of the tree roots (more than 48 hours). Underdrains may be required when underlying soils are not sufficiently permeable. Care must also be taken to ensure water does not rise to the level of the pavement surface, as discussed in Chapter 2 – Pervious Pavements.

4.3.3 Available Space

No additional space is required as they can be placed wherever pavement exists or proposed adjacent to tree planting areas.

4.3.4 Topography

No restrictions. Can be used wherever trees are intended adjacent to paved areas. For very steep applications, the bottom of the storage reservoir can be terraced to promote better infiltration (where applicable).

4.3.5 In-Situ Soils

In soils that do not drain well, it may be necessary to provide an underdrain. For structural soil applications, the infiltration rate is very high and thus care must be taken to ensure that the tree roots are not inundated for extended periods (more than 48 hours). This can be accomplished by limiting the contributing drainage area, providing an underdrain, or by ensuring the “pit” is sufficiently deep to accept the inflow without unacceptable inundation. Silva Cell soils use available soils (silt/loam is preferable) and are compacted to the optimal density to promote tree growth (i.e., compaction is not necessary for structural support). Thus, the infiltration rate will be much slower and thus may not require an underdrain.

4.3.6 Water Table

Use in areas with high water tables (within 2 ft of the bottom of the media) could impact tree growth and thus should be avoided, unless trees suited to this condition are selected or it is determined the soil depth is sufficient for the particular tree species.

4.3.7 Utility Conflicts

Any required excavation must consider the possibility of utility conflicts. Local utility owners should be consulted regarding requirements associated with any required horizontal or vertical clearance or other special measures that may be required. The fact that utilities pass through these practices is not problematic, as long as it is approved by the utility owner.

4.3.8 Set-Backs

Care should be taken to minimize a hydraulic connection to adjacent buildings without proper waterproof protection. A distance of 10 ft from buildings is generally recommended for most practices where detention is provided.

4.4 Basic Design Elements

There are recommended design specifications for soil amendments. More detailed information can be obtained in the literature cited in Section 4.9. However, a summary is provided in the following table (Source: *VA SWM BMP Design Specifications*):

Table 4-1. Soil System Detention Typical Design Elements

Design Element	Typical Values
Drainage Area	Limit run-on from impervious areas to a maximum of twice the area of the

	amended soils.
Soil Testing	Recommended before soil amendment to determine if it is required, and after to determine if the desired goals were achieved.
Recommended Compost Depth and Tilling Depth (lower for B soils, higher for C/D soils)	Varies depending on the ratio of impervious area (IA) to the surface area of the amended soils (SA). • For a ratio of 0.00 - 2” to 4” of compost tilled to a depth of 6” to 10” • For a ratio of 0.50 - 3” to 6” of compost tilled to a depth of 8” to 12” • For a ratio of 0.75 - 4” to 8” of compost tilled to a depth of 15” to 18” • For a ratio of 1.00 - 6” to 10” of compost tilled to a depth of 18” to 24”
Compost Specifications	Provided by a member of the U.S. Composting Seal of Testing Assurance (STA) program. Local providers can be found at www.compostingcouncil.org.

4.4.1 Structural Soils

Specific design information for these proprietary products can be found at the websites provided in Section 4.9. A few technical details are provided in the following table:

Table 4-2. Typical Design Elements for CU Structural Soils™ (CU) and Stalite Structural Soils (SS)

Design Element	Typical Values
Structural Framework	CU: Crushed stone, ¾” to 1 ½” SS: Expanded slate, ¾” to #4 screen size
Soil	CU: Approved heavy clay loam or loam, with a minimum clay content of 20%, 2-5% organic matter. SS: Approved sandy clay loam
Tackifier	CU: Gelscape® hydrogel SS: None required
Compaction	Both: To 95% standard proctor
Underdrain	The need must be assessed to prevent unacceptable inundation of tree roots.

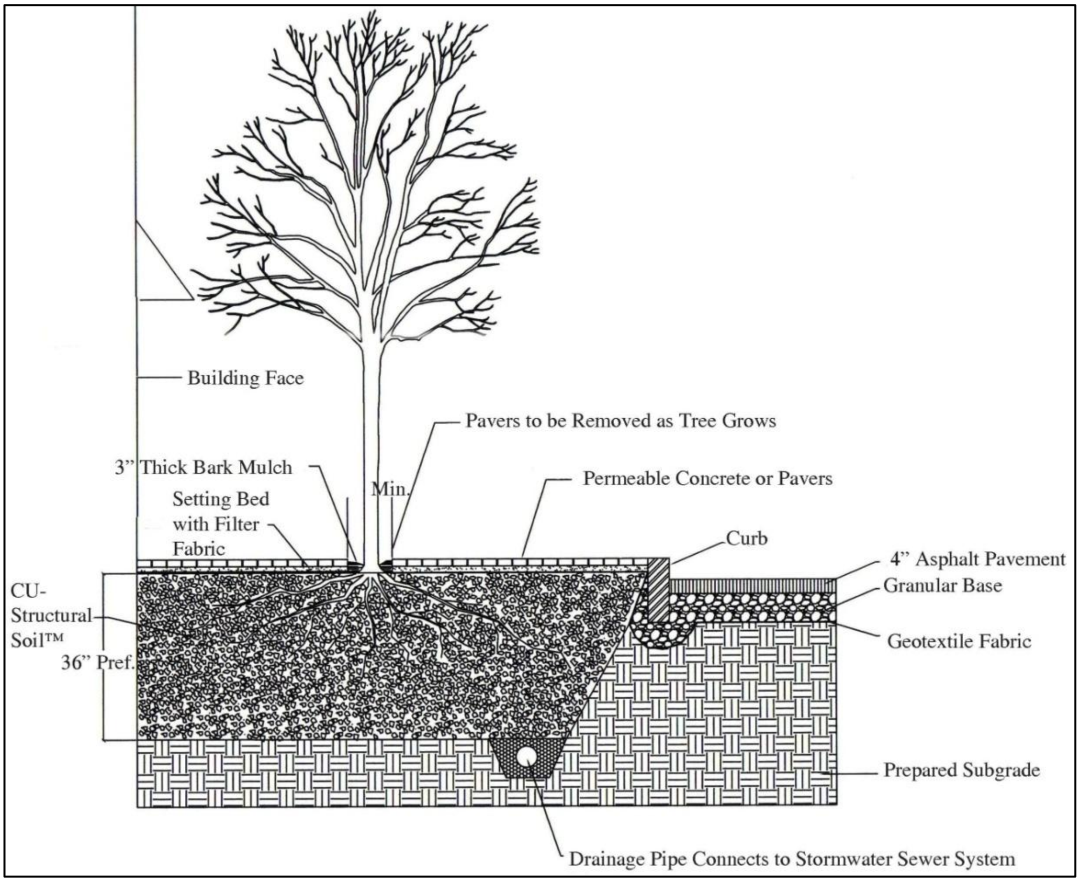

Figure 4-4. Typical CU-Structural Soil™ application incorporating pervious pavement. (Source: Cornell University – Urban Horticulture Institute)

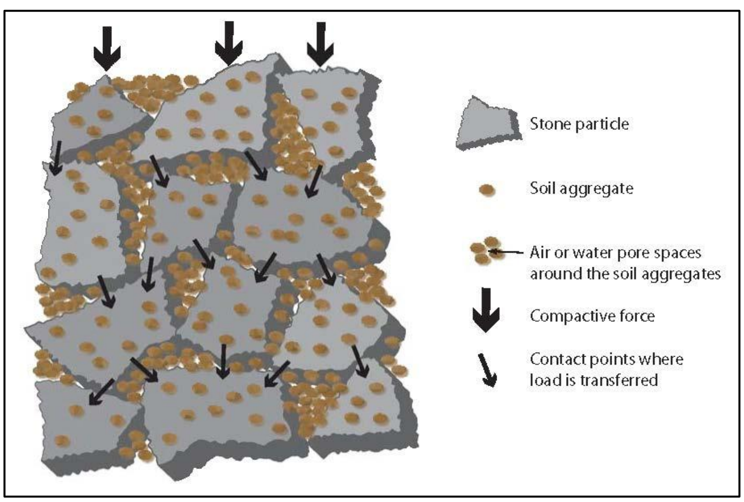

Figure 4-5. Schematic of structural soil composition. (Source: Virginia Tech – Susan Downing Day and Sarah Beth Dickinson)

4.4.2 Silva Cells

Specific design information for this proprietary product can be found at the website provided in Section 4.8. A few technical details are provided in the following table:

Table 4-3. Silva Cell Typical Design Elements

Design Element	Typical Values
Structural Framework	Modules consisting of fiberglass reinforced, chemically-coupled, impact modified polypropylene and galvanized steel tubes
Soil	Framework provides 92% void space that is filled and compacted with soil to provide optimal conditions for tree growth only – not necessary for structural support.
Underdrain	The need must be assessed to prevent unacceptable inundation of tree roots.

Figure 4-5. Installation of Silva Cells at Lincoln Center (Source: Deep Root Partners L.P.)

4.5 Important Construction Considerations

Recommended construction practices for the proprietary soil systems are available from the sources cited in Section 4.9. Some suggestions for application of soil amendments are provided below:

- Soils should be dry prior to tilling.
- Confirm there are no utility or tree root conflicts prior to soil disturbance.
- For smaller applications in residential lawns to enhance downspout disconnections, soil to be tilled with a small roto-tiller to the specified depth.
- For larger applications, soils to be ripped with solid shank ripper to the specified depth (2-3 ft if possible). Silt fencing may be required.
- Add compost at the specified rate and roto-till into the surface.
- Level the surface and cover with seed and mulch or sod to establish grass cover as quickly as possible. Test the soil to determine if lime is necessary and provide irrigation until the vegetation is well established.

4.6 Operation and Maintenance

Specifics regarding operation and maintenance of the proprietary soil systems can be found in the sources cited in Section 4.9. There are few required maintenance items associated with the care of soil amendments beyond initial efforts to ensure vegetation becomes well established:

- Inspect after large rain events for the first 6 months to ensure there is no erosion. Repair and re-seed any bare areas as necessary.
- Water as necessary for the first growing season until a vigorous stand of vegetation is achieved.
- Make certain the owners of the amended soil areas are aware of the practice and the goals behind keeping the area from becoming overly compacted.

4.7 Performance Criteria

Soil amendments act to increase the level of pollutant removal performance when used in conjunction with other practices. Estimates are provided in the following table Source: *VA SWM BMP Design Specifications*):

Table 4-4. Soil Amendments Range of Typical Performance Associated with Listed Practices

Soil Amendments with…	% Reduction[1]	
	No Soil Amendment	With Soil Amendment
Rooftop Disconnection	25	50
Filter Strip	Always recommended	50
Grass Swale	10	30

[1] Represents level of volume reduction (1" storm) and associated reduction in pollutant load as a result of this volume reduction (i.e. no BMP treatment provided).

It would be expected that the proprietary soil systems would provide similar removal efficiencies as bioretention or pervious pavement practices as they function in a similar manner. Thus, estimates of the potential removal rates that can be expected are provided in the following table (Source: *VA SWM BMP Design Specifications*):

Table 4-5. Proprietary Soil Systems Range of Estimated Performance

Parameter	% Reduction
Volume Reduction (1" Storm)	40 -80
Total Phosphorus (TP)	55 - 90
Total Nitrogen (TN)	40 - 90

4.8 Cost

A variety of sources and literature were reviewed to determine the average costs for soil system detention construction and materials. The cost of implementing soils amendments varies based primarily on the size of the project and the land use of the project area. Suburban or agricultural soil amendment projects applied to larger tracts of land are very inexpensive and can be implemented for as little as $0.10 to $0.75 per square foot. In more urban settings or smaller plots of land, soil amendments will typically cost between $1 and $5 per square foot to implement.

CU structural soils are generally sold for $40 to $47 per ton. Silva cell installation (not including surrounding paving or plant material) typically costs between $14 and $18 per cubic foot.[4]

4.9 Applicability to DC Water

Soil amendments would be applicable to DC Water as they can be applied in any area where vegetated, compacted soils exist and trees and/or utilities are not in conflict. Application in residential lots, parks, and cemeteries may be of particular benefit, especially if combined with

[4] Cost Estimate Sources: Virginia Polytechnic Institute, Fairfax County, Pennsylvania Department of Environmental Protection, Low Impact Development Center, Southeast Michigan Council of Governments, City of Redmond, Cornell University, Deep Root Partners, L.P.

rooftop disconnection, rain barrels, or other practices. Amended soils effectively hold and treat stormwater runoff, reducing the volume as well as pollutant loading.

Structural soil systems have the potential to provide a significant benefit to DC Water. This benefit is two-fold: first, structural soils can be employed under paved areas (sidewalks, courtyards, parking lots, roadway shoulders, etc.) and can include a reservoir capable of storing virtually any sized rainfall event (within the limitations of specific site constraints). They can also be effectively combined with pervious pavements (pavers, concrete, and/or asphalt) to facilitate infiltration of stormwater runoff. The stormwater management potential for these systems can provide beneficial reductions in stormwater volumes, as well as delays in the timing of the runoff – both can assist in reducing the occurrence of CSO events.

Secondly, unlike the use of other practices that provide detention in gravel reservoirs or soil (such as pervious pavements), these systems also provide an effective means for growing trees in harsh, urban environments. Healthy urban trees provide essential environmental, cultural, and aesthetic benefits. In addition, vigorous and healthy trees can transpire significant amounts of water during the growing season (up to 200 gallons per day for a mature tree on a hot day). However, urban trees decline when the limited room for root growth is depleted. Structural soils can provide the necessary media to allow roots to expand under pavements, enabling impermeable hardscapes and healthy trees to effectively co-exist.

4.10 Detailed Design References

Detailed design options are available in published documents and manuals that are periodically updated to keep abreast of advances in technology. These include the following sources:

- Virginia Department of Conservation and Recreation (DCR), Virginia Stormwater BMP Clearinghouse - http://vwrrc.vt.edu/SWC/StandardsSpecs.html.
- For CU Structural Soils™: Urban Horticulture Institute at Cornell University - http://www.hort.cornell.edu/uhi/outreach/index.htm#soil .
- For Silva Cells: Deep Root Partners, L.P. - http://www.deeproot.com/products/silva-cell/silva-cell-overview.html
- For Stalite Structural Soils - http://permatill.com

It is important to make certain the selected design options are acceptable to the District Department of the Environment (DDOE) prior to implementation and are in accordance with DDOE design guidance. DDOE is currently in the process of revising current guidance and adopting the runoff reduction methodology used by the Virginia Department of Conservation and Recreation (as communicated in an email from Rebecca Stack, DDOE, 3/19/12).

4.11 Example Applications

The following provide some typical schematics and photos of applications of the soil system detention practices:

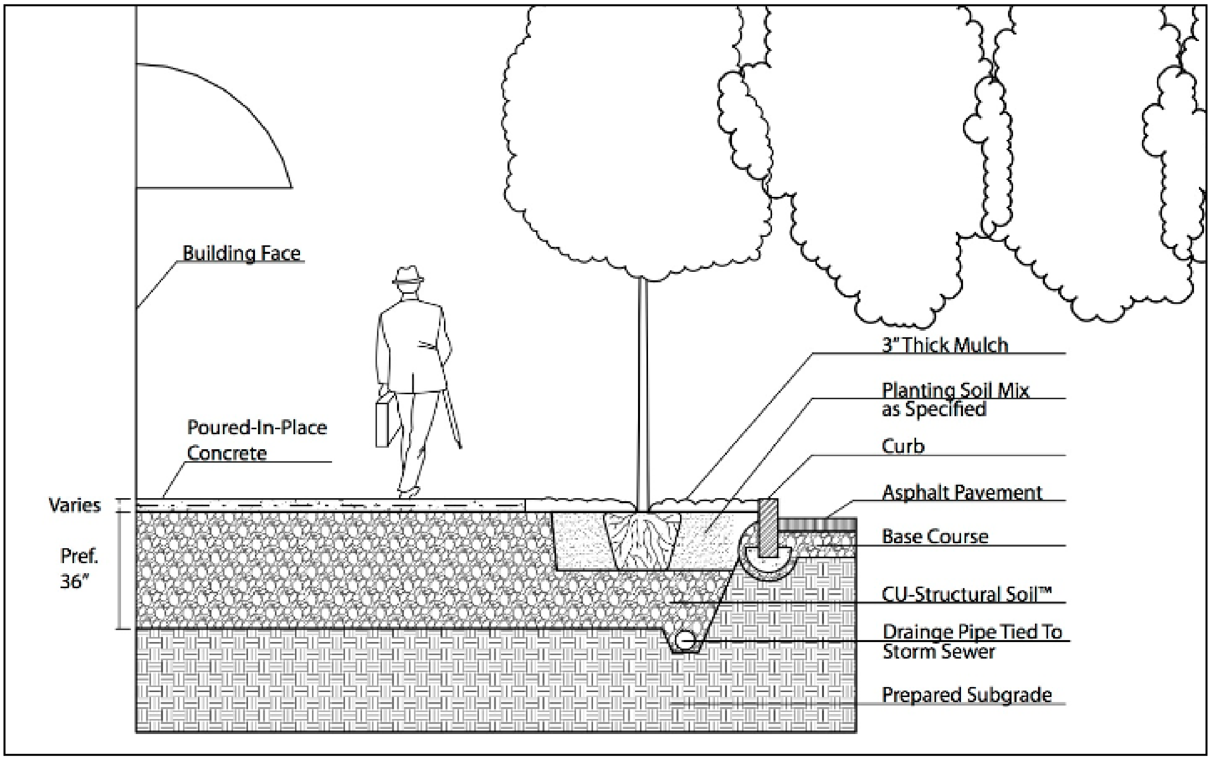

Figure 4-6. Typical CU-Structural Soil™ application.
(Source: Cornell University – Urban Horticulture Institute)

Figure 4-7. Structural soil adjacent to a building.
(Source: Cornell University – Urban Horticulture Institute)

Figure 4-8. Utilities placed within Silva Cells.
(Source: Deep Root Partners L.P.)

Figure 4-9. Silva Cells adjacent to a roadway.
(Source: Deep Root Partners L.P.)

Figure 4-10. View of amended soils.
(Source: VA SWM BMP Design Specifications)

5 Vegetated Swales

5.1 Description

A vegetated swale is a shallow, linear channel planted with a variety of vegetation to slow, filter, and infiltrate stormwater runoff. These channels are designed to filter water through the vegetation and, if sufficiently permeable, through the underlying soils. A permeable, engineered soils mix can also be included where in-situ soils are not permeable in order to provide some additional stormwater volume reduction and pollutant removal opportunities. In this instance, an underdrain or aggregate layer is also included. Vegetated swales can provide a less costly alternative to traditional curb and gutter conveyance systems and are typically used along linear, impervious features such as roads, driveways, and parking lots, or used as pre-treatment conveyance channels to other structural BMPs. Depending on the intended functionality, these systems can range from a simple channel lined with turf grass, to a more complex swale containing an engineered soil mix, underdrain, check dams, and diverse landscaping design.

Vegetated swales are known by various names, including bioswales, dry swales, wet swales, grass channels, grass swales, and biofiltration swales. These names typically vary based on design intent and are primarily influenced by soil type and extent of soil amendments, vegetation used, and period of intended ponding or saturation. Vegetated swales are typically designed as flow-through systems with little detention or storage. However, an underlying aggregate layer and/or check dams can be employed to slow flow and enhance infiltration capacity.

Figure 5-1. Vegetated swale (bioswale) in High Point, WA.
(Source: American Planning Association – Washington Chapter)

Similar to bioretention facilities, a primary benefit of vegetated swales is their use in high density urban areas and along roadways where space for green infrastructure facilities is limited. Vegetated swales can also provide an aesthetically pleasing landscape feature and enhance wildlife habitat, depending on the types of vegetation used.

5.2 Feasibility Considerations

As with any LID practice, there are constraints to be considered with the use of vegetated swales. Some of the more important considerations include:

5.2.1 Contributing Drainage Area

It is generally recommended that the maximum contributing drainage area to a vegetated swale be 5 acres or less; however, larger drainage areas may be accommodated by appropriate sizing of the swale. A swale serving a drainage area of more than 10 or 20 acres may be difficult to design due to the anticipated high volume and velocity of flow. In this situation, the capacity to treat and infiltrate runoff is greatly reduced. In settings where a larger drainage area is served, check dams can be implemented to help slow flow and allow for increased infiltration. A series of inlets or diversions can also be used to convey treated water to an outlet.

5.2.2 Available Space

Vegetated swales are generally narrow, linear features that are conducive for use in high density areas, or constrained situations such as along roadways, sidewalks, utilities, parking lots, or driveways. Depending on the amount of impervious cover and other design parameters, vegetated swales should be approximately 3 to 15% of the size of the contributing drainage area.

5.2.3 Topography

Vegetated swales are generally limited to a longitudinal slope of less than 5%; however, a gradient between 1 to 2% is preferable. The slope should be as flat as possible to minimize velocities and improve filtration capacity. If slopes are greater than 2%, check dams may be required to reduce velocity. If slopes are less than 1%, ponding may occur in undesirable locations. Permeable soils and an underdrain may help in these situations. Alternatively, this practice can be combined with pocket wetland areas.

5.2.4 Available Hydraulic Head

For systems with a filter bed and/or underdrain, sufficient hydraulic head is needed to ensure free flow between the inflow point and the downstream receiving water or storm drain invert. Vegetated swales with both a filter bed and underdrain typically require 3 to 5 feet of hydraulic head.

Figure 5-2. New residential street uses a vegetated swale to capture runoff. (Source: U.S. EPA)

5.2.5 In-Situ Soils

Low permeability of soils on the site does not inhibit the use of vegetated swales, although they do determine whether soil amendments or an underdrain will be required for appropriate performance. Highly impermeable soils may require the use of both to improve infiltration capacity. Check dams may also be used to slow flows and enhance infiltration capacity.

5.2.6 Water Table

The bottom of the vegetated swale should be a minimum of 2 feet above the seasonally high groundwater table (4 ft is recommended) to ensure proper infiltration and to inhibit the potential for groundwater contamination.

5.2.7 Pollutant Hotspots

Use of vegetated swales to treat runoff from land uses with the potential for high pollutant levels should be avoided. This will help reduce the risk of hydrocarbons, trace metals, and other pollutants migrating into the groundwater.

5.2.8 Utility Conflicts

Ensure that appropriate horizontal and vertical clearance is available between utilities and swale alignment. Utilities can cross vegetated swales if they are specially protected (i.e., double casing, concrete encasement, armor rock, kevlar blanket, etc.). Owners of the utilities should be consulted to determine their requirements.

5.2.9 Location

Vegetated swales should not be located within areas that receive a baseflow or dry weather flows. Local setbacks should be determined; however, as a general rule vegetated swales should be set back at least 10 feet from building foundations, 50 feet from septic system fields, and 100 feet from water supply wells. Additionally, when used along roads, the bottom elevation of the swale should be at least one foot below the invert of the road bed.

Figure 5-3. Parking lot with vegetated swale.
(Source: City of Portland)

5.3 Basic Design Elements

Vegetated swales can be designed to fit a variety of site constraints, as well as to meet specific water quality/quantity requirements. Swales are typically located based on site topography and natural features and are best implemented in areas of continuous landscape. There are numerous design variations; however, there are some basic elements that each typically has in common, as summarized in the following table.

Table 5-1. Vegetated Swale Typical Design Elements

Design Element	Typical Values
Drainage Area	< 5 acres (more possible with additional design considerations)
Ponding Depth	6-12 inches (may be increased by using check dams)
Soil Matrix Composition	85-88% sand, 8-12% fines, 3-5% organic. 2-6 in/hr initial infiltration rate.
Soil Matrix Depth	18-36 inches (4-12 inches topsoil)
In-Situ Infiltration Rate	< 0.5 in/hr (without underdrain)
Choking Layer	2-4 inches sand over 2 inch layer choker stone laid above underdrain stone
Gravel Storage Layer	As necessary for underdrain or for storage, 9 - 12 in
Underdrain	6 in schedule 40 PVC with 3/8 in perforations
Geotextile Fabric	Non-woven, immediately above underdrain only
Longitudinal Slope	1% - 2% (up to 5% with check dams), unless combined with pocket wetlands in flatter systems
Side Slopes	< 3:1
Bypass/Flow Splitter	As necessary to ensure design flow is not exceeded
Vegetation	Suited to flow velocity, hydrologic regime, and soil depth
Check Dams	As necessary, use non-erosive material (i.e., riprap, wood)
Drawdown Time	Within 6-24 hours, depending on design intent

5.4 Important Construction Considerations

Following some basic construction guidelines is necessary to insure the swale performs as intended. Some of these include:

- It is imperative that vegetated swales be protected from sediment laden inflows during site construction, especially those that include a permeable soil matrix. Ideally, the swales should be built as a last step and after the contributing drainage area has been fully stabilized. Any accumulated sediment in the channel should be removed during the final stages of grading.

- Construction traffic on the swale footprint should be avoided to minimize soil compaction. This is especially important for swales that rely on the permeability of the in-situ soils. Excavation work should occur from the sides of the swale.

- It is helpful to rip or scarify the bottom of the swale to a depth of one foot to promote infiltration. Soil amendments, such as compost, can also be incorporated during this process.

- If applicable, place the soil media in 12 in lifts and flood to provide hydraulic compaction. Add additional material as necessary to ensure the proper design elevation is achieved.

- If using check dams, the top of each check dam should be constructed level at the design elevation. Check dams should be underlain with filter fabric and firmly anchored into the side-slopes to prevent scour and erosion.

- Provide irrigation of newly planted vegetation until sufficiently established.

5.5 Operation and Maintenance

Once vegetation has been established in the swale, minimal maintenance is needed to maintain proper function. Annual inspections following installation should be conducted to determine a need for maintenance such as sediment removal, re-vegetation, and stabilization. Particular items to look for include:

- Ensure that the desired coverage of turf or other vegetation has been achieved. Re-seed or vegetate any areas necessary.

- Remove any accumulated sediment. If excessive sedimentation is evident, inspect the side slopes and other features of the swale, as well as the contributing watershed, to determine the source and correct as necessary.

- Inspect check dams for evidence of undercutting or erosion; remove any trash or debris that may have accumulated.

- Check inflow and outlet points for clogging and remove any debris. Make sure there is appropriate outfall protection and/or energy dissipation at inflows.

5.6 Performance Criteria

Vegetated swales can provide effective water quality and volume reduction benefits. With the various design options regarding size, configuration, and vegetation comes differences in the anticipated removal rates. A flatter swale will allow for more infiltration, as will a swale with check dams and/or highly permeable soils (engineered or otherwise), to improve volume reduction rates. Generally speaking, a longer, continuous swale allows for maximum filtering to occur. Additionally, a swale that is planted with more dense, native plants as opposed to mowed turf grass will have a higher pollutant removal capacity. The following chart provides anticipated ranges, with steeper, less vegetated swales at the lower end and flatter, more densely vegetated swales at the higher end (note that pollutant removal represents total mass loading resulting from treatment as well as from volume reduction – Source: *VA SWM BMP Design Specifications*):

Table 5-2. Vegetated Swale Range of Typical Performance

Parameter	% Reduction	
	Turf grass with non-engineered soils	Turf/meadow grass with engineered soils
Volume Reduction (1" Storm)	10 - 20	40 - 60
Total Phosphorus (TP)	24 - 32	52 - 76
Total Nitrogen (TN)	28 - 36	55 - 74

5.7 Cost

A variety of sources and literature were reviewed to determine the average costs for vegetated swale construction and materials. These costs vary widely due to the range of project applications and design components; however, the general range is $20,000 to $30,000 per acre of impervious area treated. A simple, turf grass vegetated swale would be at the lower end of this range, while a more complex bioswale would fall at the upper end of this range. Swales requiring highly engineered soils or other more complex design considerations can cost much more.[5]

5.8 Applicability to DC Water

The use of vegetated swales is highly applicable for urban environments and is therefore an important practice for DC Water. It will take a "cultural" change to convince residents to accept such a feature in areas where they are accustomed to traditional landscape treatments. They are ideally suited for use along roadways and thus can be effective in treating these impervious surfaces. When an engineered soils mix is included, significant volume reduction can also be achieved to reduce the occurrence of CSO's and thus reduce additional runoff storage requirements.

5.9 Detailed Design References

Detailed design options are available in published documents and manuals that are periodically updated to keep abreast of advances in technology. While there are literally hundreds of such detailed design manuals, two were found to be clear and complete, and are from nearby regions:

- Virginia Department of Conservation and Recreation (DCR), Virginia Stormwater BMP Clearinghouse - http://vwrrc.vt.edu/SWC/StandardsSpecs.html.
- North Carolina Division of Water Quality, Stormwater Best Management Practices Manual - http://portal.ncdenr.org/web/wq/ws/su/bmp-manual.

It is important to make certain the selected design options are acceptable to the District Department of the Environment (DDOE) prior to implementation and are in accordance with DDOE design

[5] Cost Estimate Sources: DC Department of the Environment Riversmart Program, Water Environment Research Foundation, U.S. EPA, Maryland Department of the Environment, Southeast Michigan Council of Governments

guidance. DDOE is currently in the process of revising current guidance and adopting the runoff reduction methodology used by the Virginia Department of Conservation and Recreation (as communicated in an email from Rebecca Stack, DDOE, 3/19/12).

5.10 Example Applications

The following provide some typical schematics and photos of vegetated swales in confined, urban settings that are applicable to DC Water:

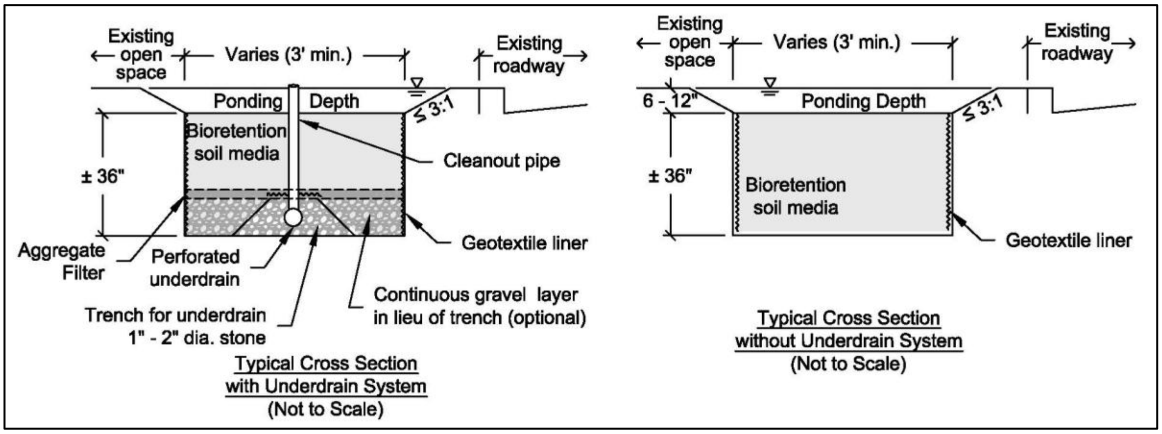

Figure 5-4. Schematic of typical vegetated swale with and without underdrain system. (Source: Wetland Studies and Solutions, Inc.)

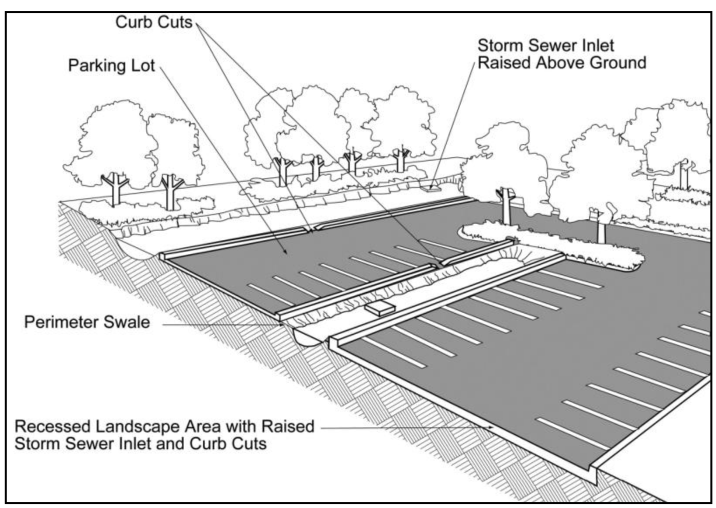

Figure 5-5. Schematic of a typical parking lot swale drainage. (Source: Northern Illinois Planning Commission)

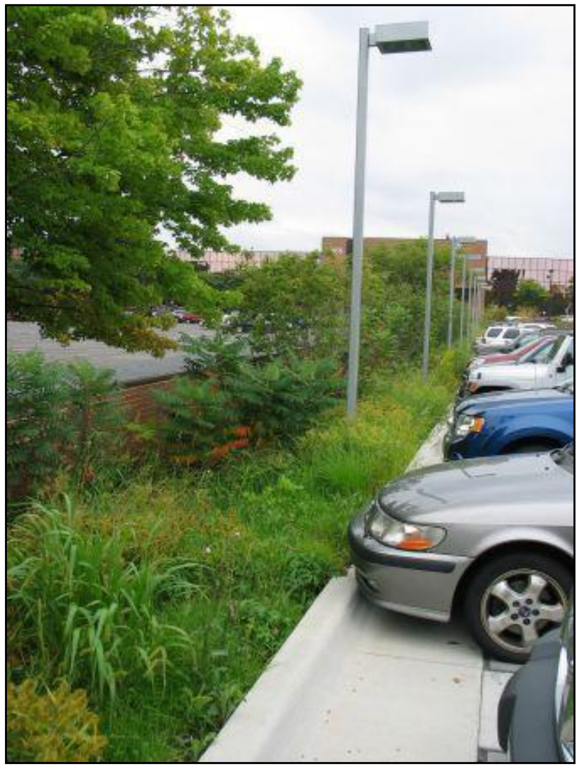

Figure 5-6. Typical parking lot vegetated swale.
(Source: Southeast Michigan Council of Governments)

Figure 5-7. Wet swale and controlled canal in Champaign, IL.
(Source: University of Illinois, Department of Urban and Regional Planning)

Figure 5-8. Vegetated swale with check dams.
(Source: Delaware Department of Transportation)

Figure 5-9. Residential vegetated swale, Seattle, WA.
(Source: Seattle Public Utilities)

6 Green Roofs

6.1 Description

Green roofs, also known as vegetated roofs, living roofs, or ecoroofs, are vegetated roof surfaces underlain with a permeable soil layer, drainage matrix, and waterproof base layer that protects the roof's structural surface from moisture. Roof tops typically generate one of the highest sources of stormwater runoff in urban areas. Green roofs can be used to reduce stormwater volume through retention and detention, reduce peak runoff rates, improve water quality, provide wildlife habitat, and mitigate the urban heat island effect. Research also shows that green roofs provide an economic benefit by conserving energy and providing a longer lifespan than traditional roofs (as green roofs are protected from UV radiation and extreme changes in temperature).

Green roofs systems are generally separated into two types: extensive and intensive, which are differentiated primarily on the depth of the growing media, vegetation types, and planned usage. Extensive systems have a relatively shallow growing media (4 to 8 inches), which is planted with a variety of hardy, drought tolerant vegetation. Extensive systems are much lighter and economically feasible than intensive systems. Intensive systems contain a deeper growing media (up to 4 feet), which can be planted with a wide range of trees, shrubs, and herbaceous vegetation. These systems generally involve more landscape maintenance and irrigation. Intensive systems are not as widely used and are often difficult to implement in retrofit situations.

Figure 6-1. Green roof at Wetland Studies and Solutions, Inc. office, Gainesville, VA (Source: Wetland Studies and Solutions, Inc.)

6.2 Feasibility Considerations

Perhaps more than any other LID practice, there are significant limitations on the use of green roofs that must be considered. Some of the more important include:

6.2.1 Structural Capacity of the Roof

The most significant consideration when assessing the feasibility of a green roof is the required structural capacity of the roof, which must not only support the additional stormwater, but also the weight of the soil, biomass, and other structural components of the roof. Extensive green roofs require 15 to 30 lbs per square foot, while intensive green roofs require 35 to 100 lbs per square foot. A structural engineer or architect should be involved with the roof assessment to determine whether the building's structural capacity is sufficient.

6.2.2 Roof Slope

The benefits of stormwater treatment and retention are maximized on a relatively flat roof (approximately 1 to 2%); however, with appropriate design, a green roof can be installed on roofs with slopes of up to 45%. Technical precautions, such as baffles, grids, or strips should be used to prevent slippage and erosion on slopes over 17%.

Figure 6-2. Sloped green roof at 5404 Wisconsin Ave, Chevy Chase, MD. (Source: Capitol Greenworks)

6.2.3 Roof Access

Green roofs do require occasional maintenance and inspection, so appropriate access to perform these tasks (as well as deliver construction materials) should be factored into the feasibility assessment and design. Access can typically be achieved by an interior stairway with roof hatch or trapdoor with minimum dimensions of 16 square feet in area.

6.2.4 Roof Type

Green roofs can be installed on a variety of roof types. Typically, concrete, wood, or metal sheeting is a preferred substructure. Exposed treated wood, uncoated galvanized steel, or other surfaces containing pollutants are not recommended due to the risk of those toxins leaching through the soil media to the plants.

6.2.5 Setbacks

Care should be taken when siting a green roof in the vicinity of rooftop electric and HVAC systems. Appropriate firebreaks should be installed around these systems, as well as other roof penetrations or openings (i.e., skylights). A 2-foot wide vegetation-free zone (i.e., gravel strip or concrete slab) is recommended around the perimeter of the roof and a 1-foot wide vegetation-free zone should be maintained around all roof penetrations/openings. On larger roof tops, it is recommended that vegetation-free zones be installed every 130 feet to provide access ways.

6.2.6 Irrigation

An extensive green roof is generally planted with drought-tolerant, hardy species and will only require irrigation during planting and maintenance over the first 2 years. After the roof is established, annual rainfall should be sufficient to maintain to vegetation. Irrigation requirements for an intensive green roof are more involved, as this vegetation will consist of larger trees, shrubs, and herbaceous species. If considering an intensive green roof, an adequate number of irrigation units and appropriate water supply may need to be accounted for.

6.2.7 Local Building Codes

Local planning and zoning authorities should be consulted to ensure that the green roof complies with all local building codes and that the necessary permits are obtained. Design components, such as roof drains and overflow devices, may have specific requirements.

Figure 6-3. Franklin D. Reeves Center green roof in Washington D.C. (Source: dc greenworks)

6.3 Basic Design Elements

Green roofs can be designed for a variety of settings, including commercial, residential, and industrial facilities. Specific volume reduction, peak rate mitigation, and water quality improvements are determined by the basic design elements. These elements vary by project; however, some of the basic elements that each project typically has in common are summarized in the following table.

Table 6-1. Green Roof Typical Design Elements

Design Element	Typical Values
Structural Roof Capacity	15 – 30 lbs/square foot (extensive); 35 – 100 lbs/square foot (intensive)
Roof Slope	0 – 25% (treatment is maximized on flat roofs)
Deck Layer	Concrete, wood, metal, plastic, gypsum, composite
Waterproofing Layer	100% waterproof – methods vary
Insulation Layer	Methods vary – installed above or below waterproofing layer
Root Barrier	Methods vary – do not use pesticides, metals, or other chemicals
Drainage Layer	1 – 2 inches washed granular material (gravel, recycled polyethylene, etc.)
Root Permeable Filter Fabric	Needled, non-woven, polypropylene geotextile
Growing Media (extensive)	4 – 8 inches deep
Growing Media (intensive)	8 inches - 4 feet deep
Growing Media Composition	80 – 90% lightweight inorganic, 20% organic (well-aged compost)
Water Retention Capacity	< 30%
Vegetation (extensive)	Mostly non-native, slow-growing, shallow-rooted, perennial, hardy plants
Vegetation (intensive)	Fewer limitations – herbs, forbs, grasses, shrubs, trees

6.4 Important Construction Considerations

There are important construction guidelines that must be followed to ensure success of a green roof project. Given the diversity of green roof designs and applications, construction will be slightly different in each situation. However, following are some general construction considerations:

- The roof deck should be constructed with the appropriate slope and material. If constructing a retrofit project, conduct the appropriate testing to ensure that the structural capacity is adequate to support the additional loading associated with the green roof.

- A waterproof membrane is a vital component of a green roof and protects the roof deck material from moisture and root damage. During construction, ensure that the waterproof membrane is thoroughly checked for gouges, tears, or stretching and is tested for leaks prior to placement of overlying materials. Many waterproofing layers are also root resistant; however, if using a membrane that is not root resistant, an additional root barrier has to be installed.

- After the waterproof membrane is installed, a flood test should be conducted to ensure that that they system is water tight and functional. It is generally recommended to place at least 2 inches of water over the membrane for a period of 48 hours to test the integrity of the waterproof barrier.

- Roof drains or outlets should be installed throughout the green roof to drain surplus water accumulation as necessary. The number and location of roof outlets will vary depending on the design and size of the project. Outlets should be kept free of debris and vegetation at all times. Inspection chambers may be installed over roof outlets to aid in inspection.

- A lightweight growing media, containing no more than 20% organic content, should be mixed prior to installation and then spread evenly over the filter fabric layer below. The timing of planting depends on the local climate and season; however, if planting will not occur immediately, the growing media should be covered to prevent the growth of weeds. Care should also be taken to limit foot and construction traffic over the growing media to reduce compaction.

- Vegetation considerations vary depending on extensive or intensive green roof design. Extensive green roofs generally include plants that can withstand harsh solar radiation, wind exposure, extreme temperature fluctuations, and limited root growth. Therefore, varieties such as sedum and low growing grasses and wildflowers are typically used. Irrigation is only necessary until the extensive green roof becomes established. Vegetation on intensive green roof systems can be more diverse, due to a deeper growing medium that supplies more consistent nutrients and water. Native vegetation can be used more readily, including varieties of perennials, herbs, grasses, trees, and shrubs. Long term irrigation measures need to be incorporated into intensive green roof construction. Subsurface or drip irrigation methods are preferred.

Figure 6-4. Placement of growing media at Wetland Studies and Solutions, Inc. (Source: Wetland Studies and Solutions, Inc.)

6.5 Operation and Maintenance

Because green roofs are comprised of several important layers and components, proper operation, maintenance, and inspections are necessary to maintain a functioning system. Inspections during construction and at least twice a year during the growing season following construction are of particular importance. Items to look for include:

- Vegetation requires routine inspection and maintenance to ensure that dead and dying plants are removed and invasive species are weeded out. Replace/replant as necessary to repair bare areas. Slow release fertilizer is also recommended annually for the first five years after the green roof is installed (this is not recommended if the green roof is being used for water quality improvement). The use of herbicides, pesticides, and fungicides is discouraged due to potential harm they could cause the waterproof membrane.

- Ensure that adequate irrigation is provided immediately after planting and until the green roof vegetation has fully established. In situations where an irrigation system cannot be installed, hand watering may be necessary. Intensive green roof systems typically require a permanent irrigation system and regular water application. Inspect automatic controls, such as the rain shutoff sensor, on permanent irrigation systems.

- Inspect the waterproof membrane for leaks. If a leak is suspected, flood testing and/or an electric leak survey (i.e. electric field vector mapping) can be used to pinpoint the exact location of the leak and to facilitate making localized repairs.

- Inspect roof drains, spouts, gutters and other components of the roof drainage system for clogs. Remove any debris or foreign material immediately to ensure proper drainage.

6.6 Performance Criteria

Green roofs can provide effective water quality and volume reduction benefits. With the various design options regarding roof size, growth media, and vegetation comes differences in the anticipated removal rates. Note that typically, pollutant removal is provided through a reduction in runoff volume, not through treatment processes. The following chart provides anticipated ranges for **extensive** green roofs, which are more commonly used for development and redevelopment sites (note that pollutant removal represents total mass loading resulting from volume reduction only as no removal from treatment is credited – Source: *VA SWM BMP Design Specifications*):

Table 6-2. Green Roof Range of Typical Performance

Parameter	% Reduction
Volume Reduction (1" Storm)	45 - 60
Total Phosphorus (TP)	45 - 60
Total Nitrogen (TN)	45 - 60

6.7 Cost

A variety of sources and literature were reviewed to determine the average cost for green roof construction and materials. These costs vary widely depending on the application; however, a general range is between $6 and $90 per square foot of impervious area treated. Within this range, extensive green roof systems typically cost between $8 and $20 per square foot and intensive green roofs generally run between $15 and $50 per square foot.[6]

6.8 Applicability to DC Water

With rooftops representing a significant portion of the impervious area in urban settings, application of green roofs can potentially provide a benefit in terms of runoff reduction. However, there are structural requirements that must be met, which is not always possible in retrofit situations. In addition, buildings that are privately owned will require approval, which may not be easily obtained.

[6] Cost Estimate Sources: DC Department of the Environment Riversmart Program, Water Environment Research Foundation, U.S. EPA, Low Impact Development Center, Center for Clean Air Policy, Southeast Michigan Council of Governments, New York City Department of Environmental Protection, City of Seattle, Great Lakes Water Institute

6.9 Detailed Design References

Detailed design options are available in published documents and manuals that are periodically updated to keep abreast of advances in technology. While there are literally hundreds of such detailed design manuals, two were found to be clear and complete, and are from nearby regions:

- Virginia Department of Conservation and Recreation (DCR), Virginia Stormwater BMP Clearinghouse - http://vwrrc.vt.edu/SWC/StandardsSpecs.html.

- North Carolina Division of Water Quality, Stormwater Best Management Practices Manual - http://portal.ncdenr.org/web/wq/ws/su/bmp-manual.

It is important to make certain the selected design options are acceptable to the District Department of the Environment (DDOE) prior to implementation and are in accordance with DDOE design guidance. DDOE is currently in the process of revising current guidance and adopting the runoff reduction methodology used by the Virginia Department of Conservation and Recreation (as communicated in an email from Rebecca Stack, DDOE, 3/19/12).

6.10 Example Applications

The following provide some typical schematics and photos of green roof applications:

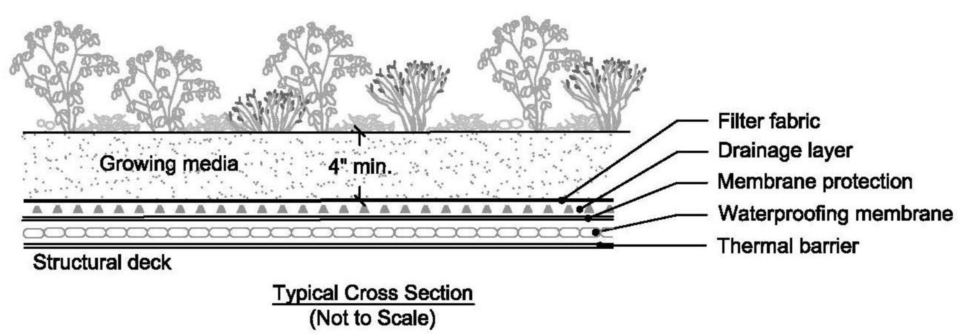

Figure 6-5. Green roof with membrane liner system – typical cross section. (Source: Wetland Studies and Solutions, Inc.)

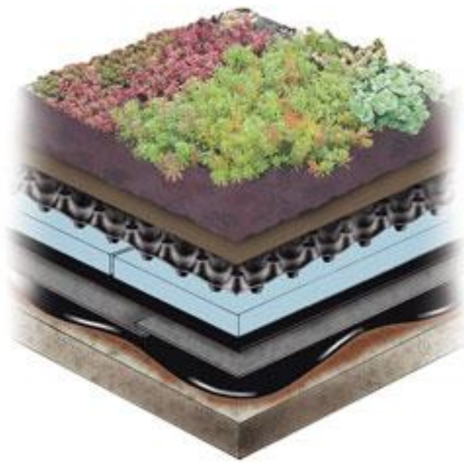

Figure 6-6. Example profiles for extensive (left) and intensive (right) green roof systems. (Source: American Hydrotech, Inc.)

Figure 6-7. Cannon House Office Building green roof demonstration project, Washington, DC. (Source: Capitol Greenroofs)

Figure 6-8. Green roof on a commercial building at 1425 K Street NW, Washington, DC. (Source: dc greenworks)

Figure 6-9. Green roof on City Hall, Chicago, IL. (Source: City of Chicago)

Figure 6-10. Green roof at Ohio EPA building, Columbus, OH.
(Source: The Ohio State University)

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7 Rainwater Harvesting

7.1 Description

The practice of rainwater harvesting includes the storage of stormwater for later reuse on the site. The types of suitable uses can include such non-potable demands as landscape irrigation, use in toilets and urinals, use in cooling towers, exterior washing applications, supply for replenishing water fountains or other features, or sprinkler systems. Use of stormwater for these purposes can reduce the volume of runoff from the site and reduces the demand from potable sources.

While the specific design and type of rainwater harvesting systems can vary significantly, there are basic components that most have in common (more specifics are provided in Section 7.3:

- Rooftop
- Collection/conveyance system
- Screen and first-flush diverter
- Cistern/storage system
- Distribution system
- Overflow system

Figure 7-1. Cistern for toilet use at Wetland Studies and Solutions, Inc. (Source: Wetland Studies and Solutions, Inc.)

Rainwater can be stored in tanks or cisterns made of fiberglass, concrete, plastic, brick, or other materials. They can be located above or below ground and can be sized to contain various volumes to meet the desired goals of the project.

The practice of harvesting rainwater is ideally suited for urban situations – while space is limited, this practice can be designed to fit in the urban landscape and many of the re-use applications are suitable for high density, urban environments where higher water demands exist. An important consideration, however, is that certain re-uses require and are subject to review and approval from the local regulatory authority.

7.2 Feasibility Considerations

While suited for use in urban areas, there are constraints that must be considered to determine the feasibility of employing rainwater harvesting techniques:

7.2.1 Location

Rainwater harvesting cisterns and/or other storage vessels can be easily integrated into development sites, especially when accounted for in the design process. Even as retrofits, cisterns can be placed within or on buildings (assuming sufficient structural support is available), outside adjacent to buildings, or underground. They can also be designed creatively to enhance the aesthetics of a building.

7.2.2 Rooftop Material

The quality of water running off of the roof will be determined in large part by the type of roofing material. Roofs made from materials that may add pollutants to the runoff, such as tar and chip, painted roofs, galvanized metal roofs, asphalt seal coated roofs, etc, should be avoided.

7.2.3 Contributing Drainage Area

It is preferable to only capture rainwater from rooftops to limit the amount of pollutants and debris that must then be filtered out. The size of the cistern or other tank will be dictated by the amount of impervious roof area, the level of demand, and available space.

7.2.4 Available Hydraulic Head

The hydraulics of the system and intended uses of the harvested water play an important role in siting and design. There are losses associated with the collection and movement of water through inlets and pipes that will determine pumping requirements. While locating the cistern in a low spot in the site will facilitate gravity flow of water into the tank, it will increase pumping requirements to distribute the collected water to the point of use. Thus, it is important to make sure the desired goals of the rainwater harvesting system can be achieved before implementation.

7.2.5 Available Space

As discussed above, placement of storage vessels for the collection of rainwater can be tailored to fit the available space.

Figure 7-2. Cistern located in a stairwell.
(Source: Nevue Ngan Associates)

7.2.6 Topography

Site topography does not impact the potential for using rainwater harvesting techniques, provided a level foundation can be provided. It should be considered, however, as it relates to the necessary hydraulic head requirements discussed above.

7.2.7 In-Situ Soils

Soils can play a role in the design of the system in regards to the structural support of the tank. In addition, soil pH should be considered as it may impact the selection of the cistern material in underground applications.

7.2.8 Water Table

For underground tanks, it is preferable to place it in locations above the water table. If this is not possible, buoyancy and the potential for inflow must be considered.

7.2.9 Utility Conflicts

Any required excavation for the installation of the cistern and/or the associated piping must consider the possibility of utility conflicts.

7.2.10 Set-Backs

Care should be taken to minimize a hydraulic connection to adjacent buildings without proper waterproofing protection. This may be relevant for cistern overflow devices.

7.2.11 Hot-Spot Land Uses

The use of cisterns may be helpful in preventing rooftop runoff from flowing through contaminated areas on the site.

7.3 Basic Design Elements

Each of the basic components of a rainwater harvesting system has design elements to consider, as described below:

7.3.1 Rooftop

An ideal rooftop will be made of a smooth, non-porous material that readily drains to the outlet point. The type of roof material should be considered in determining the intended use of the harvested water – potentially polluting materials may require expensive treatment of the harvested water prior to use.

7.3.2 Collection/Conveyance System

The conveyance system includes gutters and downspouts, as well as any associated piping necessary to route the captured runoff to cisterns. Aluminum downspouts and gutters are typically recommended in sloped roof systems and must be able to accommodate the desired storm event. In flat roof systems, ductile iron or PVC, depending on code requirements are typically used.

7.3.3 Screen and First-Flush Diverter

Prior to entering the cistern, runoff must pass through a screen or filter to remove any debris, such as leaves, twigs, sediment, insects, etc. that may have collected on the rooftop. These screens and filters should be low maintenance or maintenance free devices. First-flush diverters are suggested and intended to allow a very small amount of the beginning of the rain event (up to 0.06”) to bypass the system, thereby keeping pollen, dust, or other collected materials from entering the cistern. However, systems have been known to operate without such diverters.

7.3.4 Cistern/Storage System

The storage tank can be made of a variety of materials that, depending on the location, should adhere to certain criteria. Those located aboveground should be UV and impact resistant and either be opaque or located out of direct sunlight to inhibit algal growth. Tanks located below ground must be capable of supporting soil and/or vehicular loads as necessary. All components of the system should be sealed with nontoxic and waterproof materials. Tanks should have an opening to allow entry for maintenance and inspection, and this access point must be kept sealed to prevent unauthorized access.

Figure 7-3. Multiple underground cisterns in series. (Source: VA SWM BMP Design Specifications)

7.3.5 Distribution System

Depending on the end use, most distribution systems will require a pump. Distribution lines should be installed below the frost line.

7.3.6 Overflow System

Cisterns or other water storage tanks must be equipped with an overflow mechanism that allows for the release of water from storm events that exceed the capacity of the tank. While a pumped system may be required, gravity flow is preferred. Overflow paths should be to stable outlets that take into consideration the location of buildings or other areas where occasional flow would not be desirable.

7.4 Important Construction Considerations

Rainwater harvesting systems should be installed by a qualified, experienced contractor. A licensed plumber is required to connect the system components to the plumbing system.

7.5 Operation and Maintenance

The level of required maintenance is dependent upon the use – systems that simply provide supplemental irrigation do not require as much maintenance as systems that supply water for indoor uses. Recommended maintenance items include the following:

- Keep gutters and downspouts free of debris.
- Inspect and clean pre-screening devices and first flush diverters.
- Inspect and clean the tank and other system components.
- Inspect the structural integrity of the tank, pump, pipes, and electrical system.
- Inspect the overflow area to ensure it remains stable.

7.6 Performance Criteria

The volume reduction depicted in the following table assumes that there is sufficient demand to utilize the entire volume from the design storm and that no overflow will occur. Simulations using historic rainfall data and use estimates are necessary to select the appropriate design storm and to appropriately size the cistern. Note that pollutant removal is determined on a mass load basis by the amount of runoff that is prevented from being released. No reduction based on treatment is credited (Source: *VA SWM BMP Design Specifications*):

Table 7-1. Rainwater Harvesting Range of Typical Performance

Parameter	% Reduction
Volume Reduction	90
Total Phosphorus (TP)	90
Total Nitrogen (TN)	90

The 90% reduction (vs. 100%) is a gross estimate to account for first flush diverters (≤ 0.06 inches).

7.7 Cost

A variety of sources and literature were reviewed to determine the average costs for rainwater harvesting systems construction and materials. The costs vary widely due to the range of project applications and installation components. Generally, these costs range from $0.50 to $30 per gallon of rainwater stored. While applications such as rain barrels typically cost $2 to $4 per gallon stored, a cistern will ranged between $0.50 and $4 per gallon stored. Additional components for water reuse, such as irrigation or facility toilets/gray water, will add to the cost. These types of projects can range from $20 to $30 per gallon stored – especially if they are retrofit projects.[7]

7.8 Applicability to DC Water

Rainwater harvesting is directly applicable for use by DC Water. It is well suited to urban environments and can be tailored to fit the available space (although retrofits inside existing buildings can be problematic). In addition, urban settings with high density uses can create sufficient demand to provide a use for the collected runoff. This not only reduces demand from potable sources, but can also effectively reduce the runoff from the site – reducing required storage for CSO events.

7.9 Detailed Design References

Detailed design options are available in published documents and manuals that are periodically updated to keep abreast of advances in technology. While there are literally hundreds of such detailed design manuals, the following are particularly clear and complete, and are from a nearby region:

- Virginia Department of Conservation and Recreation (DCR), Virginia Stormwater BMP Clearinghouse - http://vwrrc.vt.edu/SWC/StandardsSpecs.html.

- Virginia Rainwater Harvesting & Use Guidelines developed by the Virginia Department of Health - http://www.vdh.virginia.gov/EnvironmentalHealth/ONSITE/technicalresources/documents/2011/pdfs/VDH%20Rainwater%20Use%20Guidelines%20V2011_03.pdf

It is important to make certain the selected design options are acceptable to the District Department of the Environment (DDOE) prior to implementation and are in accordance with DDOE design guidance. DDOE is currently in the process of revising current guidance and adopting the runoff reduction methodology used by the Virginia Department of Conservation and Recreation (as communicated in an email from Rebecca Stack, DDOE, 3/19/12).

There is another consideration that could require a waiver from DDOE as it relates to the requirements contained in the 2009 Uniform Statewide Building Code. There is a restriction contained within the Code that limits the storage of rainwater for irrigation purposes to a duration of 24 hrs and the storage of rainwater for use within buildings to a duration of 72 hours. Again, localities can issue waivers to these restrictions in many instances.

7.10 Example Applications

The following are some examples of cistern applications:

[7] Cost Estimate Sources: DC Department of the Environment Riversmart Program, Water Environment Research Foundation, U.S. EPA, Southeast Michigan Council of Governments, Monterey County, Sustainable Cities Institute, Green Affordable Housing Commission

Figure 7-4. Multiple underground cisterns in series.
(Source: LID Manual for Michigan)

Figure 7-6. Aesthetically pleasing metal cistern.
(Source: Nevue Ngan Associates)

Figure 7-7. Irrigation cistern at Wetland Studies and Solutions, Inc. (overflow to rain garden). (Source: Wetland Studies and Solutions, Inc.)

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8 Blue Roofs

8.1 Description

Blue roofs are a form of rooftop detention in which rainfall is collected, temporarily stored, and gradually released through a controlled-flow system off a building's roof. Water is ponded for a short period of time, typically in a series of trays or cells (often filled with gravel ballast), to help reduce peak runoff volume (and potentially total volume in warm weather) and discharge frequencies. Runoff from a blue roof is controlled by weirs or orifices that are attached to roof drains to slow flow into the facility's storm drains or roof leaders or to be stored for beneficial reuse. Temporary water storage on a blue roof provides an added benefit of temperature regulation through evaporative cooling in warmer months. Along with light colored building materials, the implementation of blue roofs can help reduce the urban heat island effect.

Blue roofs provide many of the same stormwater benefits of a green roof (although green roofs provide additional environmental benefits such as wildlife habitat), but cost considerably less. Blue roofs are an ideal green infrastructure candidate in urban areas where rooftops comprise the majority of impervious surface at a given site. Installation and maintenance of a blue roof is relatively easy and does not require much more work than a standard roof, although there are some structural requirements that must be taken into account. Installation of a blue roof is expected to extend the life of the roof membrane due to a reduction in temperature swings resulting from evaporative cooling and reduced sunlight exposure.

Figure 8-1. Blue roof trays, New York, NY.
(Source: New York City Housing Authority)

8.2 Feasibility Considerations

To a lesser extent than with green roofs, use of blue roofs does require careful consideration of the structural capacity of the roof, along with other considerations as discussed below:

8.2.1 Structural Capacity of the Roof

The required structural capacity of the roof depends primarily on how much water is to be detained by the blue roof system. Generally, a blue roof is designed to detain up to 3-4 inches of rainfall, which would add 15 to 20 lbs per square foot (one inch of ponded stormwater on a rooftop adds approximately 5 lbs per square foot of loading). If loading capacity is limited, the detention volume can be reduced. These requirements are typically less than that of a green roof, which requires additional capacity for soil media and vegetation. A structural engineer or architect should be involved with the roof assessment to determine whether the building's structural capacity is sufficient.

Figure 8-2. Check dams installed to control flow on sloped portion of roof, Brooklyn, NY. (Source: New York City Department of Environmental Protection)

8.2.2 Roof Slope

Blue roofs are typically implemented on roofs with a relatively flat slope (less than 2%). Maximum storage volume is available on roofs with slopes between one half and 2%. Special modifications, such as check dams, that help mitigate slope and evenly distribute ponded water are required on slopes greater than 2%.

8.2.3 Roof Access

Blue roofs require occasional maintenance and inspection, so appropriate roof access is required to perform these tasks. Blue roof systems typically consist of modular storage trays or cells and adequate access must be available to transport these materials to the rooftop and replace if necessary. Because of their modular nature, blue roof systems can often complement other rooftop usage, such as urban agriculture, decking, solar panels, rainwater recycling, and mechanical equipment.

8.2.4 Roof Type

Blue roofs can be installed on a wide variety of roof types. Metal roof panels are not typically recommended for blue roofs due to their required slope (generally a minimum of 2%).

8.2.5 Roof Drains

Roof drains and scuppers should be sized and installed appropriately for the blue roof's designated design. Additionally, roof drains should be located away from trees if possible to prevent clogging from leaf litter.

8.2.6 Local Building Codes

Consult with local planning and zoning authorities to ensure that the blue roof complies with all local building codes and that the necessary permits are obtained. Design components such as roof drains and overflow devices may have specific requirements.

8.3 Basic Design Elements

Blue roofs can be designed to fit a variety of settings, especially in high density, urban areas where space is constrained and rooftops are contributing significantly to stormwater runoff. Specific detention amounts, peak rate mitigation, and volume reduction are determined by the basic design elements. While these designs vary from project to project, some of the basic elements are outlined in the following table.

Table 8-1. Blue Roof Typical Design Elements

Design Element	Typical Values
Structural Roof Capacity	15 – 20 lbs/sf
Roof Slope	< 2%
Ponding Depth	2 – 4 inches typical, but variation is easy to achieve
Deck Layer	Variable
Waterproofing Layer	100% waterproof – methods vary
Insulation Layer	Methods vary – installed above or below waterproofing layer
Ballast Layer	Optional, depending on design. Depth and material vary (typically washed gravel)
Roof Drains	Min. 2 drains for < 10,000 sf of area; min. 4 drains for >10,000 sf of area
Drawdown Time	Maximum 24 hours, typically

8.4 Important Construction Considerations

There are important construction guidelines that must be followed to ensure success of the blue roof project. Given the diversity of blue roof designs and applications, construction will be slightly different in each situation. However, following are some general construction considerations:

- The roof deck should be constructed of with the appropriate slope and material. If implementing a retrofit project, conduct the appropriate analysis to ensure that the structural capacity is adequate to support the additional loading associated with the blue roof. Many localities require that traditional roof designs be based on a load of 30 lbs per square foot. Therefore, properly designed traditional roofs are typically structurally capable of holding detained stormwater loads associated with a blue roof system.

- A waterproof membrane is a vital component of a blue roof and protects the roof deck material from moisture. During construction, ensure that the waterproof membrane is thoroughly checked for gouges, tears, or stretching prior to placement of overlying materials.

- After the waterproof membrane is installed, a flood test should be conducted to ensure that that they system is water tight and functional. It is generally recommended to place at least 2 inches of water over the membrane for a period of 48 hours to test the integrity of the waterproof barrier.

- Roof drains and leaders should be sized and installed throughout the blue roof system in accordance with the design. Roof drains and volumetric weirs appropriate for use on a blue roof are available both commercially and customized through various manufacturers. At a minimum, two roof drains should be installed for a roof area of less than 10,000 square feet and four roof drains should be installed for a roof area of greater than 10,000 square feet. Roof areas exceeding 40,000 square feet should have at least one drain for every 10,000 square feet. Controlled flow roof drains are sized to appropriately convey the desired volume and flow from the roof during a storm. Ensure that weir controlled roof drains are tamper proof to prevent unauthorized or unintentional modifications. Additionally, strainers should be installed around drain inlets to prevent clogging from leaf litter and other debris.

Figure 8-3. Strainers or screens help prevent debris from clogging roof drains. (Source: New York City Department of Environmental Protection)

- All blue roofs installations should include emergency overflow roof drains or scuppers, which should be located at the desired ponding depth based on the structural capacity analysis.

8.5 Operation and Maintenance

Blue roofs should be monitored closely during the first year after installation to ensure that the system is effective and determine whether any modifications are necessary. It is recommended that blue roofs be inspected semi-annually under dry conditions and as needed after rain events. After the first year of monitoring and maintenance, these frequencies can be modified for site specific conditions. Particular items to look for include:

- Inspect roof drains, spouts, gutters and other components of the roof drainage system for clogs. Remove any debris or foreign material immediately to ensure proper drainage. Additionally, check roof drains after snow and/or ice events to ensure that blockage has not occurred due to a build-up.

- Inspect the waterproof membrane for leaks. If a leak is suspected, flood testing and/or an electric leak survey (i.e. electric field vector mapping) can be used to pinpoint the exact location of the leak and to facilitate making localized repairs. Because most blue roofs are comprised of modular systems that can be moved as necessary, repair and maintenance of the waterproof layer can be performed with ease.

- Blue roofs should be inspected within 24 hours after significant rain events to ensure that the specified ponding depths and drainage times are being achieved. This will also verify that standing water does not persist for more than 24 hours.

8.6 Performance Criteria

Blue roofs primarily provide a benefit through detention and reduction of peak discharge frequencies. At a minimum, blue roofs should be designed to reduce the peak flow of the rooftop runoff to meet local stormwater goals. It may be desirable to design for larger, less frequent storms. Additionally, minor reductions in stormwater volume may be seen through evaporation. More significant volume reductions may be seen if the blue roof is combined with a secondary BMP such as an infiltration trench, rain garden, green roof, or alternative method to reuse/recycle the water.

8.7 Cost

A variety of sources and literature were reviewed to determine the average cost for blue roof construction and materials. Generally, averages costs for a blue roof range between $5 and $8 per square foot of impervious area treated.[8]

8.8 Applicability to DC Water

With rooftops representing a significant portion of the impervious area in urban settings, application of blue roofs can potentially prove to be beneficial in assisting with CSO's through the delay of the timing of runoff. However, most blue roof installations have confined to public buildings. When compared to green roofs, a blue roof incentive program for the private sector would likely not be successful as they lack the added benefits of green roofs.

8.9 Detailed Design References

Detailed design options are available in published documents and manuals that are periodically updated to keep abreast of advances in technology. Blue roof systems are not as commonly used or referenced as their green counterparts; however, two references were found to be clear and complete and could easily be translated to projects in the Washington, DC region:

- New York City Department of Environmental Protection, Guidelines for the Design and Construction of Stormwater Management Systems - www.nyc.gov/html/dep/html/stormwater/stormwater_management_construction.shtml

- Fairfax County Department of Public Works and Environmental Services, Public Facilities Manual - www.fairfaxcounty.gov/dpwes/publications/pfm/.

It is important to make certain the selected design options are acceptable to the District Department of the Environment (DDOE) prior to implementation and are in accordance with DDOE design guidance. DDOE is currently in the process of revising current guidance and adopting the runoff reduction methodology used by the Virginia Department of Conservation and Recreation (as communicated in an email from Rebecca Stack, DDOE, 3/19/12).

[8] Cost Estimate Sources: DC Department of the Environment Riversmart Program, Water Environment Research Foundation, U.S. EPA, Center for Clean Air Policy, New York City Department of Environmental Protection

8.10 Example Applications

The following provide some typical schematics and photos of blue roof applications:

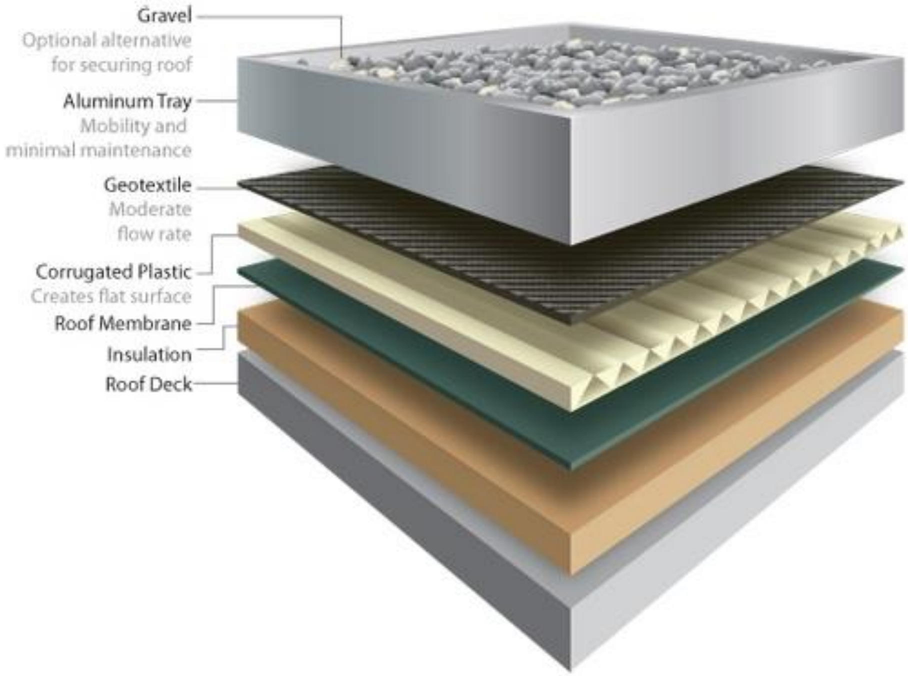

Figure 8-4. Example profile for blue roof system. (Source: Hazen and Sawyer)

Figure 8-5. Typical blue roof modular tray with gravel ballast. (Source: New York Department of Environmental Protection/Hazen and Sawyer)

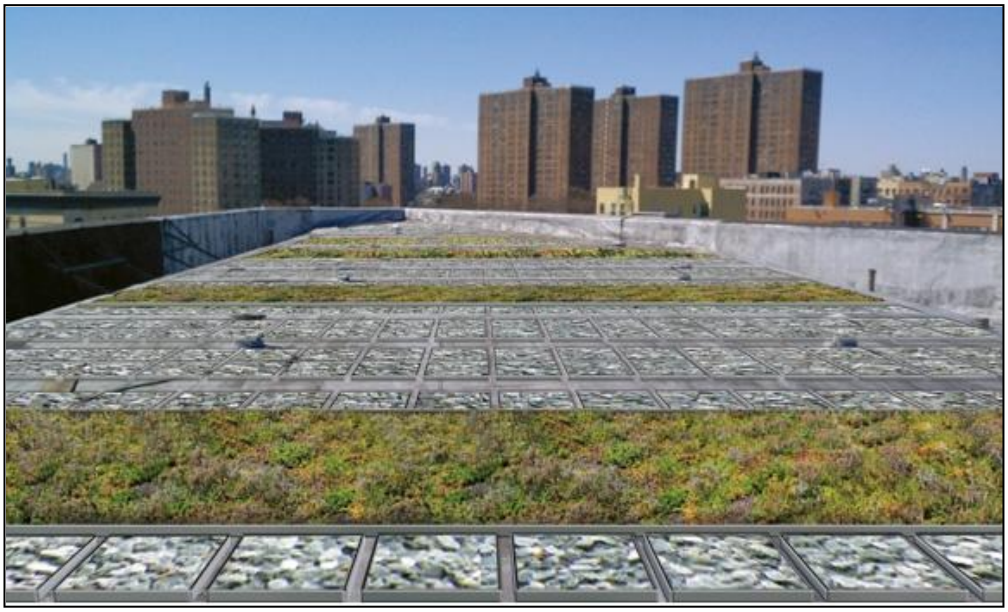

Figure 8-6. Blue roof installed in combination with green roof, New York, NY. (Source: New York Department of Environmental Protection/Hazen and Sawyer)

Figure 8-7. Installation of a waterproof membrane during blue roof construction. (Source: New York City Department of Environmental Protection)

9 Filter Systems

9.1 Description

Filter systems are structures or excavated areas containing sand, organic matter, or other materials that capture, temporarily store, filter, and treat pollutants such as sediment, nutrients, metals, and hydrocarbons. These systems are useful for treating stormwater on small, highly impervious sites – especially in ultra-urban areas where sufficient space for practices such as bioretention may not available. The filter system often consists of a pre-treatment or settling cell and a filter bed that contains sand or organic material. Filtered stormwater is typically collected in an underdrain and returned to the storm drainage system. Pollutant removal occurs primarily through physical processes, including gravitational settling, straining, filtration, and adsorption in the filter media. Microbial films sometimes form on the top of the filter media, which adds a biological removal component.

There are a wide variety of filter systems and applications. The major categories include sand filters, organic media filters, and proprietary filters. These systems can be designed as surface or subsurface, vegetated or non-vegetated, and with infiltration (no underdrain) or without infiltration (underdrain) – to name a few variations. Filter systems are beneficial in their pollutant removal capability; however, provide little to no runoff reduction. In addition to their applicability in tight, urban areas, filter systems can often be used to provide special treatment at known stormwater hotspots such as parking lots, gas stations, roadways, car washes, fleet storage areas, maintenance facilities, or industrial sites.

Figure 9-1. Surface filter system.
(Source: Portland SWM Manual)

9.1.1 Sand Filters

Sand filters can be designed as either surface or subsurface systems that infiltrate stormwater down through a sand media and filter out pollutants. The effluent is either infiltrated into the ground or collected in an underdrain and discharged. Surface sand filters are typically constructed off-line and only treat the desired water quality volume. However, some surface sand filters are installed in the bottom of dry detention ponds or combined with other BMPs. On-line surface sand filters are often used as perimeter treatment around parking lots or other impervious surfaces. In this case, stormwater flow enters the system through grates at the edge of the perimeter. These perimeter systems are a good treatment option in areas with low topographic relief since little hydraulic head is required.

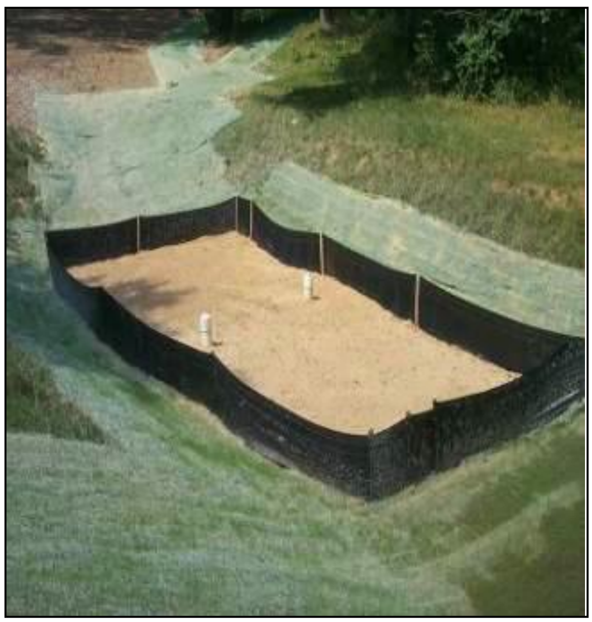

Figure 9-2. Surface sand filter during construction (Source: Chesapeake Bay Stormwater Network)

Subsurface sand filters work similarly, but are installed underground and are typically more expensive to construct. The trade off with a subsurface system is that they take up very little space and are therefore well suited to ultra-urban areas. Subsurface sand filters are generally designed with a flow splitter that bypasses larger storm events around the filter.

9.1.2 Organic Filters

Organic filters work similarly to surface sand filters; however, the sand is replaced with an organic filtering medium such as peat (typically mixed with sand) or compost. While sand is a good medium for removing total suspended solids, organic filters can achieve higher pollutant removal for metals and hydrocarbons. For example, peat has been shown to remove slightly more total phosphorus, copper, cadmium, and nickel than sand. Care should be taken in placement of an organic filter, as recent research has shown that organic media can leach nitrate and phosphorus back into discharge water, making it a poor choice when the filter is placed near a water body sensitive to nutrient loadings.

9.1.3 Proprietary Filters

There are many proprietary filter devices available that can provide excellent filtering capacity for specific pollutants of concern. For example, Filterra® (manufactured by Americast) uses a sand filter and has been approved by several states as a designated treatment system for suspended solids, oil, and phosphorus; and the Arkal Pressurized Stormwater Filtration System (manufactured by Zeta Technology, Inc.) uses disk filters and has been approved by the U.S. EPA's Environmental Technology Verification (ETV) Program for sediment removal. Many similar products are available in the U.S.

Figure 9-3. Filterra® planters.
(Source: Filterra)

9.2 Feasibility Considerations

Filter systems can be implemented on a wide range of land types and under various conditions. The major limiting factor is typically price, as the practice is not always cost-effective given the area served. However, there are certain situations (i.e., hotspot runoff treatment, ultra-urban areas) where a filter system is the best or only choice. Following are some considerations that should be taken into account when considering a filter system:

9.2.1 Available Hydraulic Head

One of the biggest constraints for filter systems is the available hydraulic head on a site. Depending on the specific project design, it is recommended that 2 to 10 feet of hydraulic head be available since most filter systems require gravity flow through the filter. Therefore, filter systems are difficult to implement on sites with relatively flat topography. As discussed previously, one exception is a perimeter or surface sand filter system which can be installed on sites with minimal available head.

9.2.2 Depth to Water Table and Bedrock

A minimum depth of 2 feet is recommended between the seasonally high water table and/or bedrock and the bottom of the filtering system. Completely enclosed systems are not subject to this constraint, provided the potential impact of inundation is accounted for (buoyancy, discharge configuration, etc.).

9.2.3 Contributing Drainage Area

The maximum contributing drainage area to a filter system is 5 acres; however, one acre or less is preferred. A maximum drainage area of 2 acres is recommended for subsurface or perimeter filter systems. It is also recommended that the surrounding drainage area be as close to 100% impervious as possible. Larger drainage areas and/or drainage areas with higher pervious percentages tend to contribute more sediment and debris which clogs the filter system. On a larger site, multiple filters should be used throughout the site for treatment.

9.2.4 Available Space

Filter systems require very little space, which is one benefit of using them in urban areas or other constrained settings. Sand and organic filters typically use about 2% to 3% of the contributing drainage area. Perimeter systems generally consume less space. Subsurface filters use no surface area except for their manholes or other access points, which can be designed for traffic loadings.

9.2.5 Pollutant Hotspots

Filter systems are one of a few stormwater BMPs recommended to treat runoff from land uses with the potential for high pollutant levels.

9.2.6 In-Situ Soils

The permeability of soils on site may inhibit the use of certain types of filter systems. Many filter systems include an impermeable liner and an underdrain to convey treated runoff. Infiltration filter systems do not employ an underdrain and allow some or all of the treated water to infiltrate into the subsoil. In this situation, permeable soils are required for proper filter system function. If suitable soils are not present on the site they may be amended to provide adequate drainage.

9.2.7 Utility Conflicts

As with other practices, conflicts with utilities (both under and above ground) should be avoided.

9.2.8 Setbacks

It is recommended that unlined filter systems be placed at least 10 feet from building foundations. If an impermeable liner is used, they may be placed in closer proximity to buildings. Infiltration filter systems should also be located at least 100 feet from a water supply well.

9.3 Basic Design Elements

Depending on the filter system used and treatment required, there are various design options. However, a summary of some of the basic elements for filter system design is provided in the following table:

Table 9-1. Filter System Typical Design Elements

Design Element	Typical Values
Drainage Area	< 5 acres; close to 100% impervious surfaces
Type of Filter	Varies based on available space, hydraulic head, and level/type of pollutant removal desired
Media Composition	Sand: clean, washed concrete sand; individual grains 0.02 – 0.04 inches in diameter
	Organic: peat/sand mixture or leaf compost (leaf compost should be mature with no visual appearance of leaf matter; dry bulk density of 40 to 50 lbs; pH of 6 to 8; Cation Exchange Capacity ≥ 50 meq/100 grams of dry weight)
	Proprietary: varies by system and treatment goals
Depth of Filter Media	Minimum 12 – 18 inches
Underdrain	Varies – 4 inch min. diameter; HDPE smooth or corrugated flexible-wall pipe; 1/8 – 3/8 inch perforations; slotted underdrain preferred (vs. round-holes) to reduce clogging; lateral spacing < 10 feet
Filter Fabric	Needled, non-woven, polypropylene geotextile
Surface Cover	Surface systems: 3 inch layer of topsoil on top of non-woven filter fabric (vegetation and/or pea gravel inlets optional) Subsurface systems: Pea gravel layer on top of coarse, non-woven fabric
Drawdown Time	40 hours

9.4 Important Construction Considerations

There are important construction guidelines that should be followed to prevent failure of the filtering system and ensure optimal performance. Given the diversity of filter system designs and applications, construction will be slightly different in each situation. However, following are some general construction considerations:

- Ensure that all portions of the contributing drainage area have been completely stabilized prior to the installation of filter systems. Excessive sediment input can easily clog the system.

- During construction, install proper erosion and sediment controls (such as silt fence) around the filter to reduce sediment input. All stormwater runoff should be diverted around the filter system as it is being constructed. Soil stabilization should occur as soon as possible using hydro-seed, sod, mulch, or other techniques.

- Filter system should have a flow splitter or overflow device installed so that larger storms may safely bypass the system.

- Consider installing a pre-treatment cell or forebay in filter systems if sediment input or other debris is a concern and where site conditions allow.

- Control the flow velocity entering the filter by using a level spreader or similar device.

- If implementing an impermeable liner, check for leaks prior to installing the filter media. It is recommended that inlet and outlets be temporarily plugged while the structure is filled to the brim with water. Maximum allowable leakage is 5% of the water volume in a 24 hour period.

- Filter media should be installed in 12 inch lifts up to the design elevation. Ensure that construction equipment accesses the structure from the perimeter to reduce compaction and that the material is hand raked where possible. Upon reaching final grade, clean water should be added to the filter system and allowed to drain completely, hydraulically compacting the filter media. After 48 hours of drying this process should be repeated.

- Install filter fabric, topsoil, pea gravel inlets, and/or vegetation and permanently seed any unstabilized areas immediately.

9.5 Operation and Maintenance

Filter systems require regular inspections and maintenance. The most common maintenance issues are removal of accumulated sediment, replacing filter media, and relieving any surface clogging. Research has shown that filter systems are highly effective upon initial installation, but efficiency rapidly decreases as sediment accumulates. Periodic inspections should be conducted, particularly after heavy rainfall events. Items to look for during the inspections include:

- Inspect for excessive sediment accumulation. Generally, if accumulation has exceeded 6 inches the sediment needs to be cleaned out.

- Ensure that inlets, outlets, underdrains, and flow splitters are clear of debris and accumulated sediment.

- Ensure that standing water is not ponding for more than 48 hours after a storm. If this is the case, then maintenance actions need to be taken.

- Inspect the contributing drainage area for any sources of sediment or unstable areas.

- Inspect the integrity of observation wells and cleanout pipes. Remove any debris or accumulated sediment.

- Check that the filter bed remains level and rake if necessary.

- Remove any trash or other debris from the filter bed.

- Till, aerate, and replace the filter media as necessary.

9.6 Performance Criteria

As previously discussed, filter systems provide effective water quality benefits, but virtually no volume reduction unless the system is combined with another practice. Depending on the design of the filter system and the filter media used, this practice can provide varying levels of pollutant removal capacity and can target pollutants such as nutrients, suspended solids, hydrocarbons, and heavy metals. Most filter systems will, at a minimum, reduce phosphorus and nitrogen - two commonly targeted pollutants. Reduction estimates for these pollutants are provided in the following table (note that pollutant removal represents total mass loading resulting from treatment only as no volume reduction is provided – Source: *VA SWM BMP Design Specifications*):

Table 9-2. Filter System Range of Typical Performance

Parameter	% Reduction
Volume Reduction (1" Storm)	0
Total Phosphorus (TP)	60 - 65
Total Nitrogen (TN)	30 - 45

9.7 Cost

A variety of sources and literature were reviewed to determine the average costs for filter system installation and materials. Due to a range of applications and system configurations, these costs vary widely and can range between $17,000 and $136,000 per acre of impervious area treated. Multi-chamber filter systems will generally fall at the upper end of this range ($70,000 to $136,000 per acre of impervious area treated) due to their complexity and material requirements. Surface filter systems fall at the lower end of the spectrum ($25,000 to $35,000 per acre of impervious area treated), while subsurface and perimeter filter systems are slightly more expensive ($20,000 to $40,000 per acre of impervious area treated). Proprietary filters vary by manufacturer and type of treatment system. One commonly used proprietary system is the Filterra® tree box filter, which costs approximately $24,000 per acre of impervious area treated.[9]

9.8 Applicability to DC Water

The applicability of filter systems to reduce stormwater runoff volume would be limited as they are generally only useful for water quality improvements. However, they are very useful in ultra-urban areas where space is limited (or in the case of subsurface filter systems, non-existent) to provide water quality treatment. Filter systems are one of the few practices that are recommended for use in pollution hotspots and can be adapted to treat specific pollutants of concerns in targeted locations. Proprietary filter systems may be of particular use in these situations, as they are typically designed for very specific purposes.

9.9 Detailed Design References

Detailed design options are available in published documents and manuals that are periodically updated to keep abreast of advances in technology. While there are literally hundreds of such detailed design manuals, these are particularly clear and complete, and are from nearby regions:

- Virginia Department of Conservation and Recreation (DCR), Virginia Stormwater BMP Clearinghouse - http://vwrrc.vt.edu/SWC/StandardsSpecs.html.

- North Carolina Division of Water Quality, Stormwater Best Management Practices Manual - http://portal.ncdenr.org/web/wq/ws/su/bmp-manual.

- Virginia Department of Conservation and Recreation (DCR), Virginia Stormwater Management Handbook - http://dcr.cache.vi.virginia.gov/stormwater_management/documents/Chapter_3-12.pdf

- United States Environmental Protection Agency, Storm Water Technology Fact Sheet, Sand Filters - http://water.epa.gov/scitech/wastetech/upload/2002_06_28_mtb_sandfltr.pdf

It is important to make certain the selected design options are acceptable to the District Department of the Environment (DDOE) prior to implementation and are in accordance with DDOE design guidance. DDOE is currently in the process of revising current guidance and adopting the runoff reduction methodology used by the Virginia Department of Conservation and Recreation (as communicated in an email from Rebecca Stack, DDOE, 3/19/12).

9.10 Example Applications

The following provide some typical schematics and photos of filter systems that may be applicable to DC Water:

[9] Cost Estimate Sources: U.S. EPA, Low Impact Design Center, Maryland Department of the Environment, Southeast Michigan Council of Governments

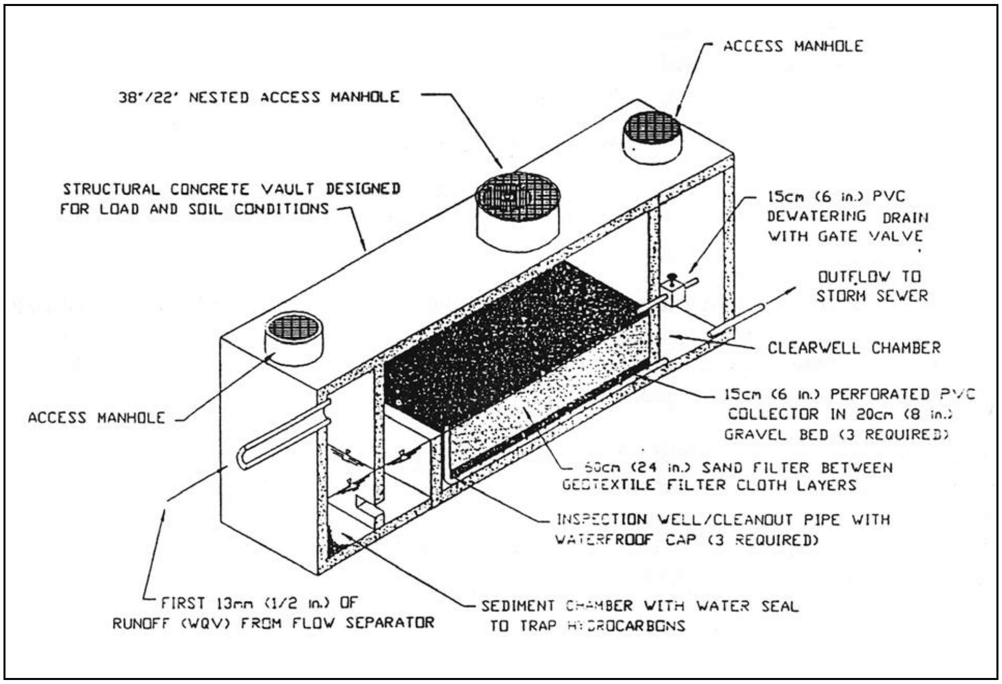

Figure 9-4. Schematic of Washington D.C. underground vault sand filter. (Source: VA DCR SWM Handbook)

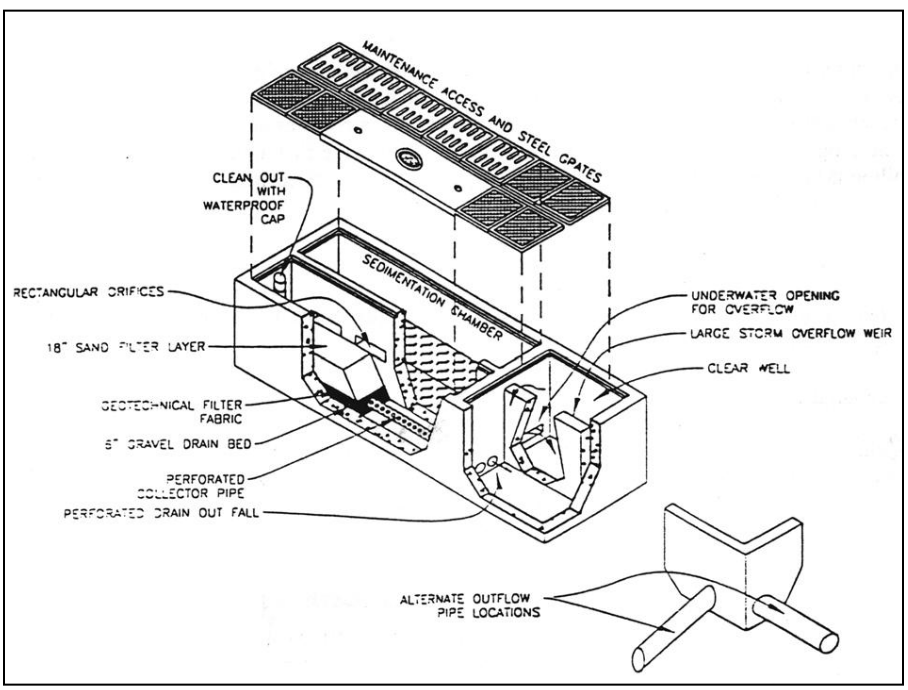

Figure 9-5. Schematic of precast Delaware sand filter. (Source: VA DCR SWM Handbook)

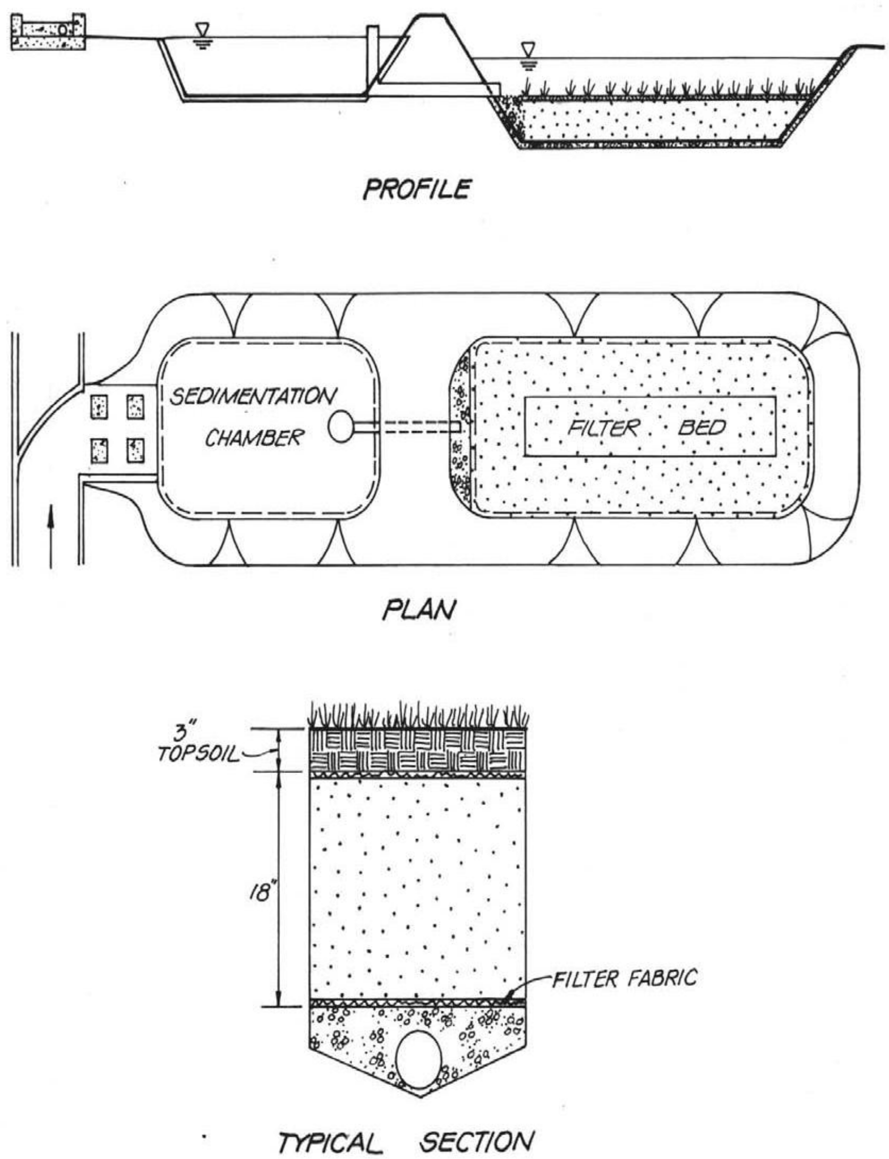

Figure 9-4. Schematic of typical surface sand filter.
(Source: Claytor and Schueler, 1996)

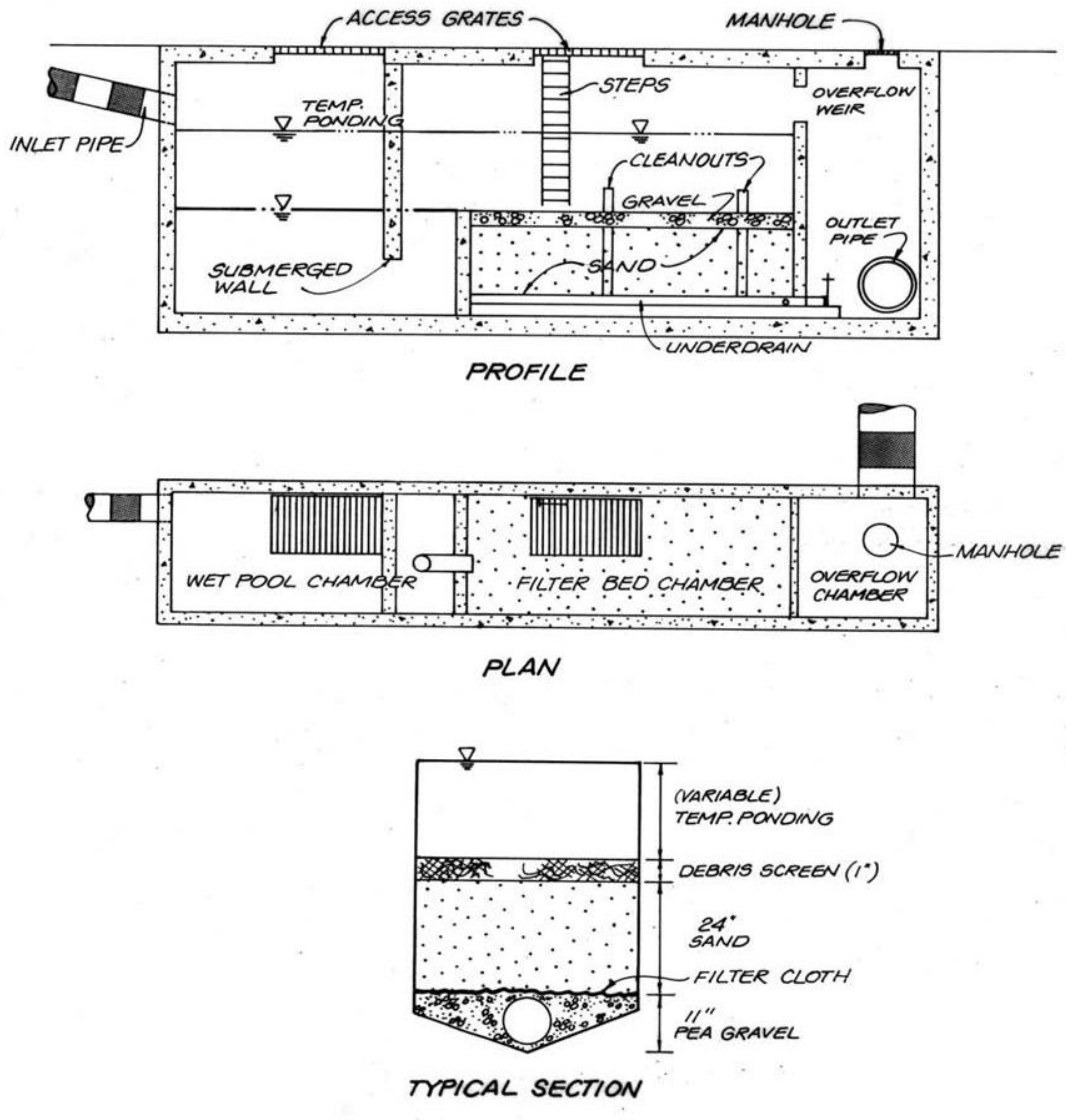

Figure 9-5. Schematic of typical subsurface sand filter. (Source: Claytor and Schueler, 1996)

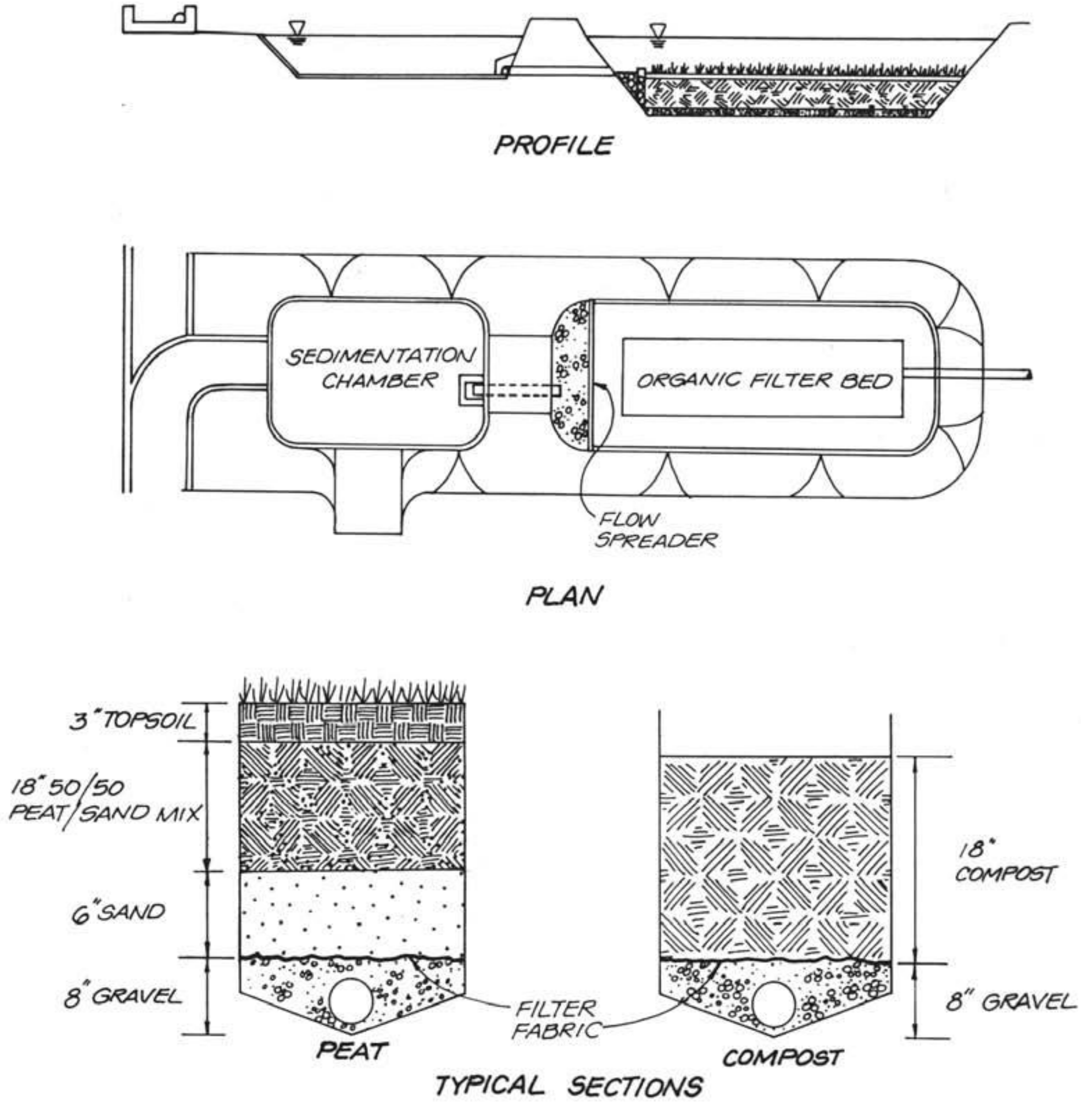

Figure 9-6. Schematic of typical peat/sand organic filter. (Source: Claytor and Schueler, 1996)

Figure 9-7. Perimeter filter system.
(Source: Chesapeake Bay Stormwater Network)

Figure 9-8. Access for maintenance of perimeter filter system.
(Source: LID Manual for Michigan)

Figure 9-9. Sand filter application with vegetation.
(Source: Virginia DCR Stormwater Design Manual)

Figure 9-10. Example of proprietary filter system – FlowGard® Perk Filter (vault style).
(Source: KriStar)

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Wetland Studies and Solutions, Inc. Gainesville, VA.

Appendix - J
Technical Memorandum No. 7 – Green Infrastructure Screening for the Potomac River and Rock Creek

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Technical Memorandum No. 7: Green Infrastructure Screening Analysis for the Potomac River and Rock Creek

July 11, 2012

dc water is life

District of Columbia
Water and Sewer Authority
Washington, DC

dc clean RIVERS PROJECT
RESTORING OUR RIVERS
PROTECTING OUR DISTRICT

GREELEY AND HANSEN

in association with

LimnoTech
Wetland Studies and Solutions, Inc.

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC CLEAN RIVERS PROJECT

TECHNICAL MEMORANDUM NO. 7: GREEN INFRASTRUCTURE SCREENING ANALYSIS FOR THE POTOMAC RIVER AND ROCK CREEK

July 11, 2012

Program Consultants Organization
Blue Plains Advanced Wastewater Treatment Plant
5000 Overlook Avenue, SW
Washington, DC 200321

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Executive Summary

Purpose

The District of Columbia Water and Sewer Authority (DC Water) is implementing a Long Term Control Plan (LTCP or DC Clean Rivers Project, DCCR) to control combined sewer overflows (CSOs) to the District's waterways. The DCCR is comprised of a variety of projects including pumping station rehabilitations, targeted sewer separation, low impact development at DC Water facilities and a system of underground storage/conveyance tunnels to controls CSOs. The DCCR is being implemented in accordance with a Consent Decree signed by DC Water, the District and the U.S Government that specifies the schedule for implementation. Projects on the Anacostia River are first in the schedule and DC Water is implementing those projects in accordance with the Decree.

The tunnel projects for the Potomac River and Rock Creek are later in the schedule and facility planning for those projects is scheduled to start in 2015 and 2016, respectively. For CSO control in the Potomac and Rock Creek sewersheds, there is an opportunity to implement Green Infrastructure (GI). GI projects may allow downsizing or elimination of the tunnels or may be coupled with a different type of gray infrastructure to provide control of CSOs. In addition, GI may offer other societal and economic benefits to the District.

The practicability and long term effectiveness of GI for CSO control is not proven to a sufficient degree given the magnitude of investment required for GI to control CSOs in the Potomac and Rock Creek. As a result, DC Water proposes to construct GI demonstration projects on a scale large enough to evaluate the practicality and efficacy of GI for CSO control.

The purpose of this memorandum is to assess the feasibility of implementing GI by itself or in combination with gray infrastructure in order to control CSOs. This assessment has been prepared based on currently available information on GI. The proposed GI demonstration project will provide information necessary to select the CSO control plan for the Potomac and Rock Creek sewersheds that provides the best overall benefit to the District.

Sewershed Characterization

To assess the type, level, and cost of GI implementation in the District, GIS data was obtained from DC GIS. GIS data was evaluated for each CSO sewershed in the Potomac and Rock Creek drainage areas, including:

- Land ownership types (both public and private)
- Land use (commercial, residential, and institutional)
- Development density (low to high)
- Land cover (such as roads and alleys, buildings, and sidewalks).

Detailed information is included in the report and summary results are shown in Table ES-1.

Table ES-1. Summarized Sewershed Characteristics

Parameter	*Potomac Sewer Shed*	*Piney Branch Sewer Shed*
Total Acres	5,356	2,329
Impervious Acres	3,283	1,215
% Imperviousness	61%	52%
Public Impervious Area (ac)		
Alley	182	103
Buildings	255	57
Parking Lots	67	27
Paved Drives	53	20
Roads	738	300
Intersections	301	90.6
Sidewalks	455	138
Subtotal Public	2,051 (62%)	736 (61%)
Private Impervious Area (ac)		
Buildings - Commercial, High Density Residential	436	59
Buildings - Mixed Use	11	0.3
Buildings - Low and Low-Medium Density Residential	601	361
Parking Lots	140	48
Paved Drives	44	11
Subtotal Private	1,232 (38%)	479 (39%)

Green Infrastructure Bases for Evaluation

Information was collected from the literature, other projects and from other District experience to assess reasonable ranges of GI implementation, efficacy and cost to construct. There is recognition that application of GI on a large scale for CSO control is not a well defined and tested area of practice.

Applicable GI technologies were selected based on the sewershed characterization, review of aerial mapping and physical surveys of the drainage areas. Based on this review, the following technologies were selected as representative of the range of viable technologies in terms of cost, effectiveness and applicability:

- Pervious Pavement
- Bioretention
- Green Roofs
- Cisterns

- Street Trees
- Downspout Disconnection and Rain Barrels

Other GI technologies may also be feasible and are proposed to be investigated as part of the GI demonstration project.

Implementation of GI to treat impervious area was considered at application rates of 0%, 15% and 30%. The GI was sized to treat the first 1.2” from the impervious area. This is consistent with the new MS4 permit issued to the District. GI technologies were not assumed to improve the quality of the runoff, which is a conservative assumption. The GI technologies assumed to be implemented for the various impervious area types are shown in Table ES-2.

Table ES-2. Summarized Sewershed Characteristics

Public Space		Private Space	
Location	**Assumed GI Measure**	**Location**	**Assumed GI Measure**
Alley	Perv. pavement	Bldgs: com. flat roof	Green roof
Bldgs: flat roof	Green roof	Bldgs: com. pitched roof	Cistern/rain bar./reuse
Bldgs: pitched roof	Cistern/rain bar./reuse	Bldgs: mixed flat roof	Green roof
Parking lot	Perv. Pavement	Bldgs: mixed pitched roof	Cistern/rain bar./reuse
Paved Drives	Perv. Pavement	Bldgs: low/med density	Downspout disconnect
Roads	Perv. Pavement	Parking lot	Perv. pavement
Roads	Bioretention	Paved drives	Perv. Pavement
Sidewalks	Perv. pavement		
Sidewalks	Trees		

Model Development

As part of the evaluation of the original LTCP, DC Water analyzed over 50 years of hourly rainfall data at Ronald Reagan National Airport to identify an average rainfall period. The years 1988, 1989 and 1990 were selected as the average rainfall period. This period was chosen because annual precipitation from these three years represents dry (30”/yr), wet (50”/yr) and average (40”/yr) rainfall conditions compared to the long term average for the District.

For this GI screening analysis, the SWMM5 hydrologic model was used for runoff simulation. GI practices are represented in SWMM5 as “LID controls.” LID controls were used in the model for the Piney Branch and Potomac River areas of the combined sewer area. SWMM5 is a lumped parameter model that assumes uniformity across a single subshed. This means that LID controls were designed to represent the total of all GI practices contained within the subshed instead of representing each GI practice separately. GI practices were grouped into the four following LID control categories based on their general design and purpose:

- Rain Barrels
- Cisterns
- Bioretention
- Porous Pavement

For the hydraulic model of the collection system, DC Water used the MIKE URBAN Model from DHI, formerly the Danish Hydraulic Institute. DC Water has used the MIKEURBAN Model and its predecessor (the MOUSE Model) for all of its hydrologic and hydraulic analysis dating back to 1998. The models were applied to support a wide range of projects and studies including development of the original LTCP. The MOUSE Model incorporating both hydrologic and hydraulic modeling capabilities was selected by DC Water in 1998 to support development of the LTCP. MOUSE was chosen at the time because it had the capability to directly simulate Real Time Control (RTC) operations, a feature that was not then available in the widely used Storm Water Management Model (SWMM). The SWMM5 runoff model was developed based on the runoff portion of the MIKE URBAN, and results were compared to the MIKE URBAN model to ensure consistency with previous model runs.

Climate change has not been modeled explicitly. However, a safety factor of 20% has been applied to the sizing of the gray controls to account for uncertainties such as climate change.

Green Infrastructure Screening Results

The feasibility of using GI alone and in hybrid green/gray infrastructure blends was evaluated to provide CSO control for the Potomac and Rock Creek sewer sheds. Several scenarios have been identified for evaluation to assess the potential cost and viability of GI for implementation as part of the DC Water LTCP. These scenarios are:

- Scenario 1 – 15% to 30% GI Implementation and Downsize Tunnels
- Scenario 2 – Alternative Gray and GI Controls
- Scenario 3 – Turner Construction Proposal
- Scenario 4 – GI plus Challenge plus MS4 Permit Implementation

This evaluation is based on literature review and experience of other GI pilots and programs currently in operation or in planning. The analysis assumes that the institutional issues of implementing GI in an urban environment on a widespread scale will be addressed. As GI is an emerging technology and is being continuously refined and the technologies are becoming more advanced, the analysis conducted recognizes the uncertainty in the predictions of the effectiveness and cost evaluations of GI.

The scenarios identified in this section do not represent the complete range of possible alternatives that may be viable. Other viable alternatives exist and the identification and evaluation of these alternatives will be performed as part of the GI demonstration project.

Scenario 1 – 15% to 30% GI Implementation and Downsize Tunnels

This scenario involves applying GI to 15% and 30% of impervious area and adjusting the storage volume of the Potomac and Rock Creek Tunnels to provide the necessary degree of CSO control. The results are shown in Table ES-3 and Figure ES-1. For various levels of GI application, the gray CSO controls were sized to provide the same degree of control as the LTCP (4 overflows/average year on the Potomac and 1 overflow/average year at Piney Branch), as well as 12 overflows per average year. This was done to assess the range of response in the system. The data show that the estimated cost ranges for hybrid green/gray solutions are within the same cost range as the LTCP, given the accuracy with which costs can be predicted at this time.

Table ES-3. Scenario 1 Results

	Green							Gray						Green + Gray	
				Unit Cost ($M/Ac.)		Cost Range ($M)		CSO predictions (Av Yr)		Tunnel		Cost Range ($M)		Total Cost ($M)	
% GI	Total Ac.	Imp Ac.	Imp Ac. Tr'd	Low	High	Low	High	# CSOs	Vol. (mg)	Vol. (mg)	Dia. (ft)	Low	High	Low	High
Potomac															
0% LTCP	5,488	3,283	-	-	-	-	-	4	79	58	33	475	772	475	772
15%	5,488	3,283	492	0.11	0.46	55	230	4	65	45	30	437	710	492	940
15%	5,488	3,283	498	0.11	0.46	55	230	12	170	18	19	358	581	413	811
30%	5,488	3,283	985	0.15	0.60	150	600	4	60	34	26	405	658	555	1,257
30%	5,488	3,283	985	0.15	0.60	150	600	12	165	17	18	354	575	503	1,174
Piney Branch															
0% LTCP	2,329	1,215	-	-	-	-	-	1	0.9	8	22	114	174	114	174
15%	2,329	1,215	182	0.11	0.44	20	81	1	0.8	5.5	18	88	135	108	215
15%	2,329	1,251	182	0.11	0.44	20	81	12	15	0.8	7	54	81	74	162
30%	2,329	1,251	365	0.12	0.50	46	182	1	1	4.5	17	85	130	131	312
30%	2,329	1,251	365	0.12	0.50	46	182	12	13	0.5	6	48	72	93	255

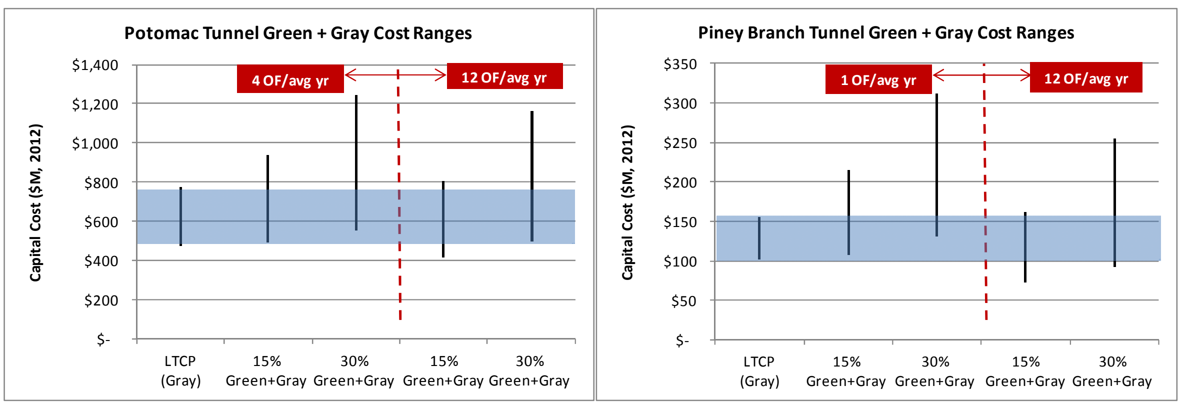


Figure ES-1. Scenario 1 Estimated Cost Ranges

Scenario 2A – Alternative Gray and GI Controls for the Potomac

This scenario involved combining GI with different gray controls than those specified in the LTCP. This scenario for alternative gray controls for the Potomac is based on the following concepts:

- Maximize Tunnel Storage through Treatment During Rain Events
  The LTCP was based on dewatering the Potomac Tunnel after the rain event with a maximum dewatering time of 59 hours. This made it difficult to empty the tunnel due to back to back rain events, resulting in the need to add storage volume. As part of the Total Nitrogen Removal/Wet Weather Plan, DC Water is constructing the Blue Plains Tunnel, a 225 mgd Blue Plains Tunnel Dewatering Pumping Station (BPTDPS) and a 225 mgd Enhanced Clarification Facility (ECF, a type of high rate treatment). The BPTDPS is being designed to

be expandable to 500 mgd by adding pumps. Similarly, the ECF is being configured to be expandable to 500 mgd by adding modular treatment units. For this alternative, the Potomac Tunnel dewatering rate was programmed so that the tunnel could be dewatered whenever the combined flow in the Potomac Force Mains was less than 400 mgd. The BPTDPS dewatering rate was also increased to 300 mgd from 225 mgd, and the ECF capacity was increased to 300 mgd from 225 mgd. The net effect of these changes is to maximize space in the tunnel for storage during back to back rain events and during large rain events.

- Use the Gray Controls to Intercept the Largest CSOs
  The largest CSOs on the Potomac are CSO 020, 021, 022 and 024. These are the outfalls at the end of the major interceptors serving Rock Creek and the large downtown drainage areas in the Potomac. This alternative therefore routes the tunnel to intercept these CSOs, thereby shortening its length, but also increasing its diameter.

- Use GI and Alternative Gray Controls for Smaller CSOs
  This alternative uses GI and sewer separation to address the farthest upstream CSOs on the Potomac. Because they have relatively small drainage areas, this alternative involves separating CSO 025 and 026. CSO 027, 028 and 029 are controlled using GI.

  The results are shown in Table ES-4 and Figure ES-2. The data show that the estimated cost ranges for hybrid green/gray solutions are within the same cost range as the LTCP, given the accuracy with which costs can be predicted at this time.

Table ES-4. Scenario 2A Results

Green for CSO 027, 028 and 029															Gray						Green + Gray	
											Unit Cost ($M/imp ac)		Cost range ($M)		CSO Predictions (Avg yr)		Tunnel		Cost Range ($M)		Total Cost ($M)	
Line	% GI	CSO 027 Imp. ac	CSO 027 %GI	CSO 028 Imp. ac	CSO 028 %GI	CSO 029 Imp ac	CSO 029 %GI	Total Acres	Imp Acres	Imp Ac Treated	Low	High	Low	High	# CSOs	Vol (mg)	Vol. (mg)	Dia (ft)	Low	High	Low	High
1	0% (LTCP)							5,488	3,283						4	79	58	33	475	772	475	772
2	Varies	104	30%	13	30%	164	60%	515	281	134	$0.11	$0.44	$15	$59	4	71	21	28	466	758	481	817
3	Varies	104	15%	13	15%	164	30%	515	281	67	$0.11	$0.44	$7	$29	12	209	9	18	322	523	329	552

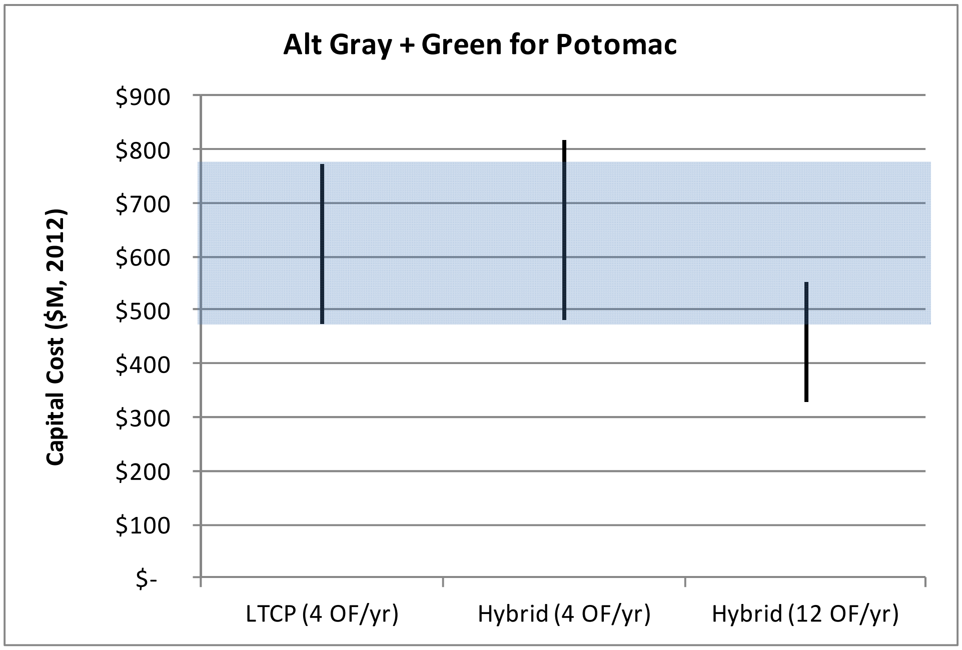


Figure ES-2. Cost Ranges for Green and Alternative Gray Controls for Potomac River

Scenario 2B – Alternative Gray and GI Controls for Piney Branch

Because of the large diversion capacity of the sewers in Rock Creek, Piney Branch has a relatively small CSO volume and a low activation frequency. Depending on the degree of implementation, GI can eliminate or greatly reduce the size of the gray CSO controls. With GI implemented, remaining CSO volume to be captured by the gray controls becomes so small that it is neither practical nor cost effective to construct tunnel storage. As a result, the alternative controls evaluated for this scenario consisted of:

- Implementing GI at a rate of 30% of the impervious area at 1.2" capture
- Increasing the weir height at the existing diversion chamber to divert more flow to the interceptor
- Constructing a small storage basin to control any remaining CSOs

The results are shown in Table ES-5 and Figure ES-3. The data show that the estimated cost ranges for hybrid green/gray solutions are within the same cost range as the LTCP, given the accuracy with which costs can be predicted at this time.

Table ES-5. Scenario 2B Results

Green								Gray						Green + Gray	
				Unit Cost ($M/Ac.)		Cost Range ($M)		CSO Predictions (Av Yr)		Tunnel		Cost Range ($M)		Total Cost ($M)	
% GI	Total Ac.	Imp Ac.	Imp Ac. Tr'd	Low	High	Low	High	# CSOs	Vol. (mg)	Vol. (mg)	Dia. (ft)	Low	High	Low	High
0% (LTCP)	2,329	1215	-	-	-	-	-	1	0.9	8.0	22	114	174	114	174
30%	2,323	1215	365	0.12	0.50	45	91	1	1.0	2.5	N/A	44	68	90	250
30%	2,329	1215	365	0.12	0.50	46	91	12	13.0	0.5	N/A	13	20	58	202

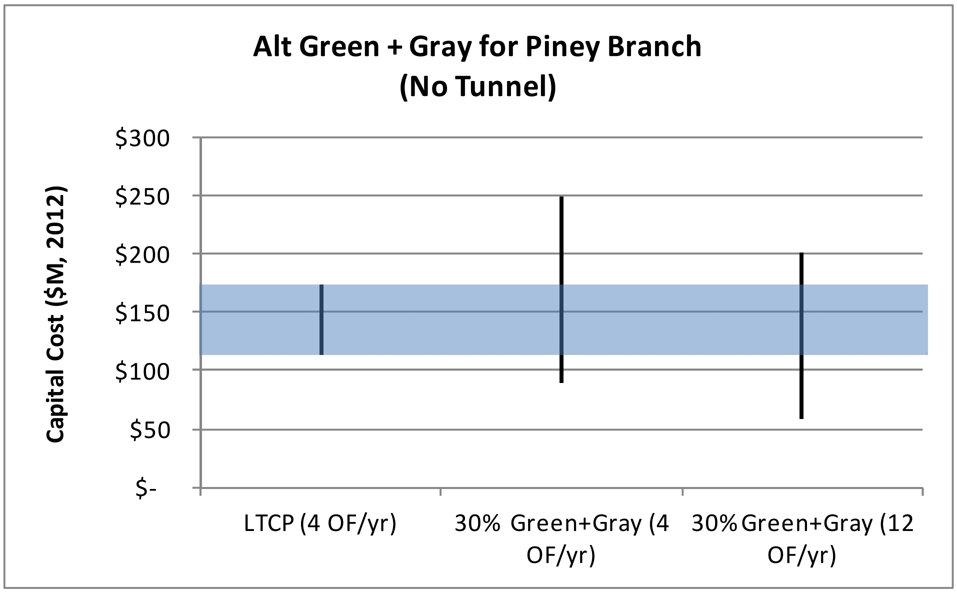


Figure ES-3. Cost Ranges for Green and Alternative Gray Controls for Piney Branch

<u>Scenario 3 – Turner Construction LID Proposal</u>

Turner Construction submitted an unsolicited proposal to DC Water titled *Conceptual Process to Expedite, Fund, and Execute a Cleanup Program for the Anacostia River*, March 10, 2011. The Turner proposal outlines an overall plan to clean up the Anacostia River, including CSO's. For CSO control, the plan proposed a Green Storage System consisting of pervious pavement roadways and alleys with a deep bed gravel system to store rainwater. The system would release water to the combined sewer system at a rate Blue Plains could handle. The system would be capable of storing 250 million gallons (mg) and could reportedly be completed by 2017-2021.

Using the costs and capacities provide in the proposal, the quantity of pervious pavement required to match the capacity of the LTCP for the Potomac and Piney Branch was calculated as summarized in Table ES-6. While not as well defined as the other scenarios, the Turner Proposal illustrates there are innovative green alternatives to providing CSO control that merit further evaluation.

Table ES-6. Turner Construction Proposal Storage Volume and Cost

Item	Potomac	Piney Branch
LTCP Tunnel Storage Volume (mg)	58	9.5
LTCP Cost Range ($M) (-20%/+30%)	$493 - $801	$102 - $156
Alleys + Secondary Roads (ac)	955	444
Acres required to achieve LTCP storage at 0.2 mg/ac	290 (30%)	48 (11%)
Green Storage System Cost @ $976,000/ac ($M)	$283	$47

<u>Scenario 4 – GI plus Challenge plus MS4 Permit Implementation</u>

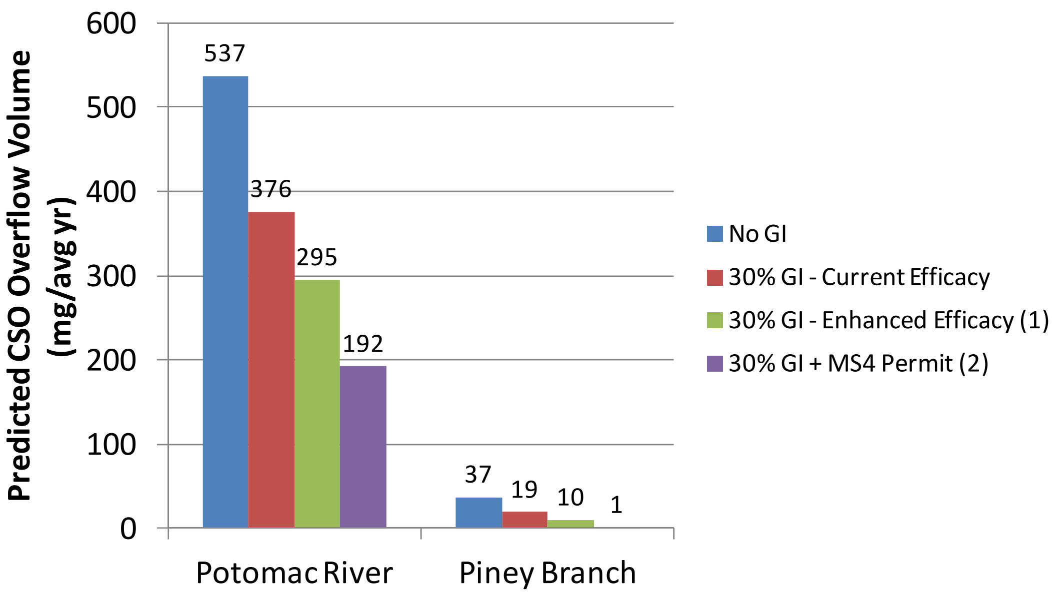
This scenario looks into the future to predict the impact of current and future programs. It includes the following major components:

- GI Implementation
  This scenario includes implementation of GI on a large scale in the CSO area. A 30% implementation rate on impervious area was assumed.

- Challenge Program
  In the early stages of development for new technologies, costs are often high, while performance or capacity can be variable. GI is in the early stages of development. A potential way to improve GI and stretch the limits of the technology would be for DC Water to sponsor a Green Infrastructure Challenge Program. The Green Infrastructure Challenge Program would solicit proposals from interested parties (public and private) to find cost effective solutions to manage runoff and advance the state of the art. For this analysis, the challenge program and other advancements in the state of the art was assumed to improve GI capture rate by 50% over current performance.

- MS4 Permit Implementation
  The new MS4 permit issued to the District requires capture of the first 1.2” from private and non-Federal development/redevelopment, and the first 1.7” from Federal properties. The District is applying these storm water capture requirements in both the combined and separate sewer areas. Over time, as new development and redevelopment occur, these requirements will substantially enhance the reduction of runoff in the CSO area using GI and other techniques. For this analysis, it was assumed that the MS4 permit requirements would result in the coverage of an additional 30% of impervious area at 1.2" capture over time.

Figure ES-4 below shows how future advancements in GI could provide CSO reduction in the Potomac and Piney Branch sewersheds. The results show that the predicted Potomac CSOs are close to the degree of control provided by the gray CSO controls (remaining CSOs of 192 mg/avg yr vs. 79 mg/avg yr for LTCP). For Piney Branch, the Scenario 4 controls are predicted to achieve an equivalent degree of control as the LTCP.



Notes:
1. Assumes GI effectiveness enhanced by 50% due to new technology/advancements
2. Assumes MS4 Permit covers additional 30% of impervious area at 1.2" over time

Figure ES-4. Scenario 4 Potential Impacts

Findings

The following are findings of this technical memorandum:

- The magnitude of the investment required to control CSOs in the Potomac and Rock Creek sewersheds is large, more than $800 M in 2012 dollars and more than $1 billion at the time of disbursement.
- In addition to reducing runoff which is the direct cause of CSOs, GI offers other social, economic and environmental benefits to the District beyond that of conventional gray infrastructure
- GI is a relatively new technology and has not been commonly applied on a large scale for CSO control in a developed city. The practicability and long term effectiveness of GI for CSO control is not proven to a sufficient degree given the magnitude of investment required for GI to control CSOs in the Potomac and Rock Creek.
- Four scenarios have been identified that include either all green or green/gray hybrid solutions to provide CSO control for the Potomac River and Rock Creek. The scenarios include alternatives providing the same degree of control as the LTCP, as well as different degrees of control.

- The four scenarios identified in this report are not the only alternatives to provide green and green/gray solutions for CSO control. Combinations of the identified scenarios and other scenarios exist and these remain to be evaluated.

- The estimated cost of the alternative green and green/gray solutions is within the cost range predicted for the LTCP, based on the accuracy of current estimates.

- In order to generate the necessary information to refine the uncertainty associated with GI, DC Water proposes to plan, design, and construct GI demonstration projects on a large scale to evaluate the practicality and efficacy of GI for CSO control.

- Since this Screening Analysis has demonstrated that there are viable green and green/gray hybrid solutions to CSO control, it is worth implementing the demonstration projects to develop the information necessary to evaluate and select the CSO control plans for the Potomac and Rock Creek that will provide the best overall environmental and ancillary benefits.

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1 Introduction

1.1 Purpose

The District of Columbia Water and Sewer Authority (DC Water) is implementing a Long Term Control Plan (LTCP or DC Clean Rivers Project, DCCR) to control combined sewer overflows (CSOs) to the District's waterways. The DCCR is comprised of a variety of projects including pumping station rehabilitations, targeted sewer separation, low impact development at DC Water facilities and a system of underground storage/conveyance tunnels to controls CSOs. The DCCR is being implemented in accordance with a Consent Decree signed by DC Water, the District and the U.S Government that specifies the schedule for implementation. Projects on the Anacostia River are first in the schedule and DC Water is implementing those projects in accordance with the Decree.

The tunnel projects for the Potomac River and Rock Creek are later in the schedule and facility planning for those projects is scheduled to start in 2015 and 2016, respectively. For CSO control in the Potomac and Rock Creek drainage areas, there is an opportunity to implement Green Infrastructure (GI). GI projects may allow downsizing or elimination of the tunnels, or may be coupled with a different type of gray infrastructure to provide control of CSOs. In addition, GI may offer other societal and economic benefits to the District.

The practicability and long term effectiveness of GI for CSO control is not proven to a sufficient degree given the magnitude of investment required for GI to control CSOs in the Potomac and Rock Creek areas. As a result, DC Water proposes to construct GI demonstration projects on a scale large enough to evaluate the practicality and efficacy of GI for CSO control.

The purpose of this technical memorandum is to assess the feasibility of implementing GI by itself or in combination with gray infrastructure in order to control CSOs. This assessment has been prepared based on currently available information on GI. The proposed GI demonstration project will provide additional information that will allow refinement of this analysis.

1.2 Background

1.2.1 Long Term Control Plan

Like many older cities in the United States, the sewer system in the District is comprised of both combined sewers and separate sanitary sewers. A combined sewer carries both sewage and runoff from storms. Modern practice is to build separate sewers for sewage and storm water, and no new combined sewers have been built in the District since the early 1900's. Approximately one-third of the District (12,478 acres) is served by combined sewers. The majority of the area served by combined sewers is in the older developed sections of the District.

In the combined sewer system, sewage from homes and businesses during dry weather conditions is conveyed to the District of Columbia's Advanced Wastewater Treatment Plant at Blue Plains (Blue

Plains), which is located in the southwestern part of the District on the east bank of the Potomac River. There the wastewater is treated to remove pollutants before being discharged to the Potomac River. When the capacity of a combined sewer is exceeded during storm events, the excess flow, which is a mixture of sewage and storm water runoff, is discharged to the Anacostia and Potomac Rivers, in addition to Rock Creek and tributary waters through outfalls. This excess discharge during storm events is called CSO. A total of 53 CSO outfalls are listed in DC Water's National Pollutant Discharge Elimination System (NPDES) Permit issued by the United States Environmental Protection Agency (EPA).

Communities with combined sewer systems are required to prepare long term plans for control of CSOs in accordance with the 1994 CSO Policy at Section 402 (q) of the Clean Water Act. In accordance with the CSO Policy and its NPDES permit requirements, DC Water submitted a Draft LTCP to EPA in 2001. After an extensive public participation program which generated over 2,300 comments on the Draft LTCP, DC Water submitted a Final LTCP to EPA in 2002. The Final LTCP is shown on Figure 1-1. The D.C. Department of the Environment (formerly Department of Health) and EPA approved the Final LTCP and determined that CSOs remaining after implementation of the plan would not cause or contribute to the exceedance of water quality standards, subject to post construction monitoring. Regulatory agencies also determined that the CSOs remaining after implementation of the plan would comply with total maximum daily loads (TMDLs) established for the receiving waters.

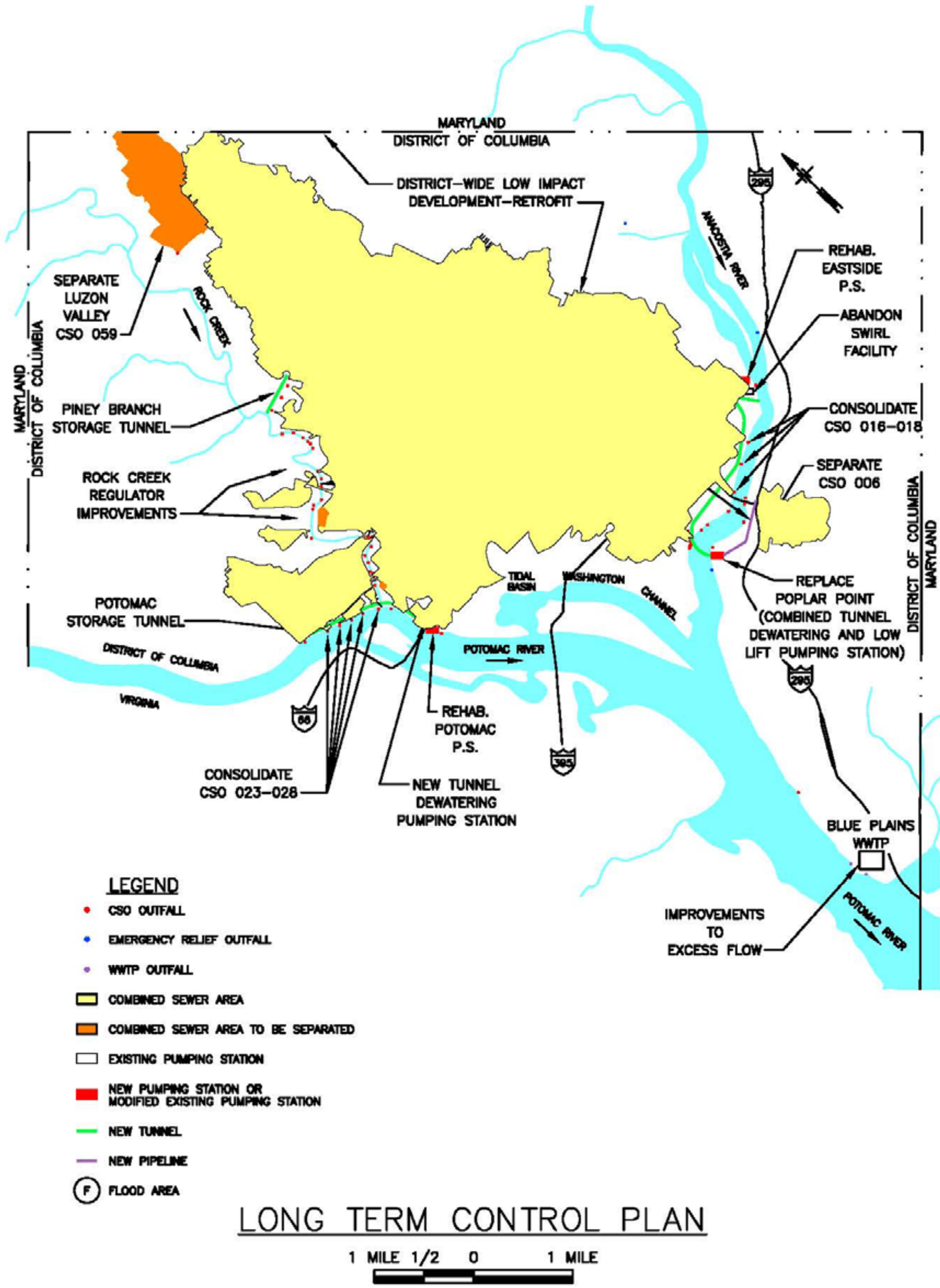

Figure 1-1. DC Clean Rivers Project

1.2.2 Total Nitrogen Removal/ Wet Weather Plan

On April 5, 2007, EPA issued a modification to DC Water's NPDES permit. The permit modification included a total nitrogen effluent limit for Blue Plains of 4.689 million pounds per year. The total nitrogen limit was developed by EPA to achieve the goals of the Chesapeake Bay Program for nutrient reductions. In addition to meeting the new effluent limit for total nitrogen, DC Water had existing NPDES Permit requirements for treating wet weather flows at Blue Plains. The latter requirement is part of DC Water's LTCP for the combined sewer system.

When the LTCP was finalized in 2002, there was no effluent limit for total nitrogen in DC Water's NPDES permit for Blue Plains and the LTCP. The imposition of the new total nitrogen limit could require a modification to the LTCP and its implementation schedule. DC Water conducted evaluations to assess the impact of adding the new total nitrogen effluent limit on top of the LTCP and existing NPDES permit requirements for treating wet weather flows. On October 12, 2007, DC Water submitted its Final Total Nitrogen Removal/Wet Weather Plan (TN/WW Plan) to EPA.

Under the LTCP and the NPDES permit existing at the time, Blue Plains was rated for an annual average flow of 370 mgd. During wet weather events, flows up to 740 mgd receive complete treatment for up to 4 hours. After the first 4 hours, the complete treatment capacity is reduced to 511 mgd to protect the biological process. Additional flows of up to 336 mgd that exceed the complete treatment capacity of the plant receive excess flow treatment, which consists of screening, grit removal, primary treatment and disinfection before being discharged to the Potomac River. This provides a total treatment capacity of 1076 mgd for the first four hours and 847 mgd thereafter.

The TN/WW Plan modified the plant treatment capacities and the handling of flows during wet weather. The major components of the TN/WW Plan are as follows:

- Complete treatment capacity – Blue Plains will provide complete treatment up to 555 mgd for the first four hours and 511 mgd thereafter. In accordance with the existing NPDES permit, combined sewer system flow (CSSF) conditions (i.e., wet weather events) exist and start when plant influent flow is greater than 511 mgd. CSSF conditions stop four hours after plant influent flow drops below 511 mgd or 4 hours has elapsed since the start of CSSF conditions, whichever occurs last.

- Enhanced nitrogen removal (ENR) – ENR facilities will be constructed with capacity to provide complete treatment for the flow rates identified above and to meet the new total nitrogen effluent limit.

- Enhanced Clarification Facility (ECF) – A 225 mgd ECF facility will be constructed at Blue Plains.

- Tunnel to Blue Plains and System Storage Volume – A new tunnel will be constructed from Poplar Point to Blue Plains. The total tunnel system storage volume will be increased from 126 mg to 157 mg. This new tunnel segment will not only serve as a flow equalization facility but will also permit a reduction in the capacity of the ECF and the peak flow rates that receive complete treatment at the Plant.

- Outfall Sewer Overflow to Blue Plains Tunnel – Connections between the existing Outfall Sewers on the influent side of Blue Plains and the tunnel to Blue Plains will be constructed. These facilities will allow flow from the collection system that exceeds the complete treatment capacity of the plant to overflow into the tunnel.

- Tunnel Dewatering Pumping Station – Under the Final LTCP, a tunnel dewatering pumping was proposed to be constructed at the tunnel terminus at Poplar Point. As part of the TN/WW plan, the same tunnel dewatering pumping station is relocated to the new terminus of the tunnel at Blue Plains. The pumping station will be sized to have a minimum firm capacity of 225 mgd, equal to the capacity of the ECF. In addition, the facility will have the ability to dewater the tunnel system up to the new ECF and be able to discharge ECF effluent to complete treatment and discharge at Outfall 002 or at Outfall 001. Figure 1-2 shows the TN/WW plan.

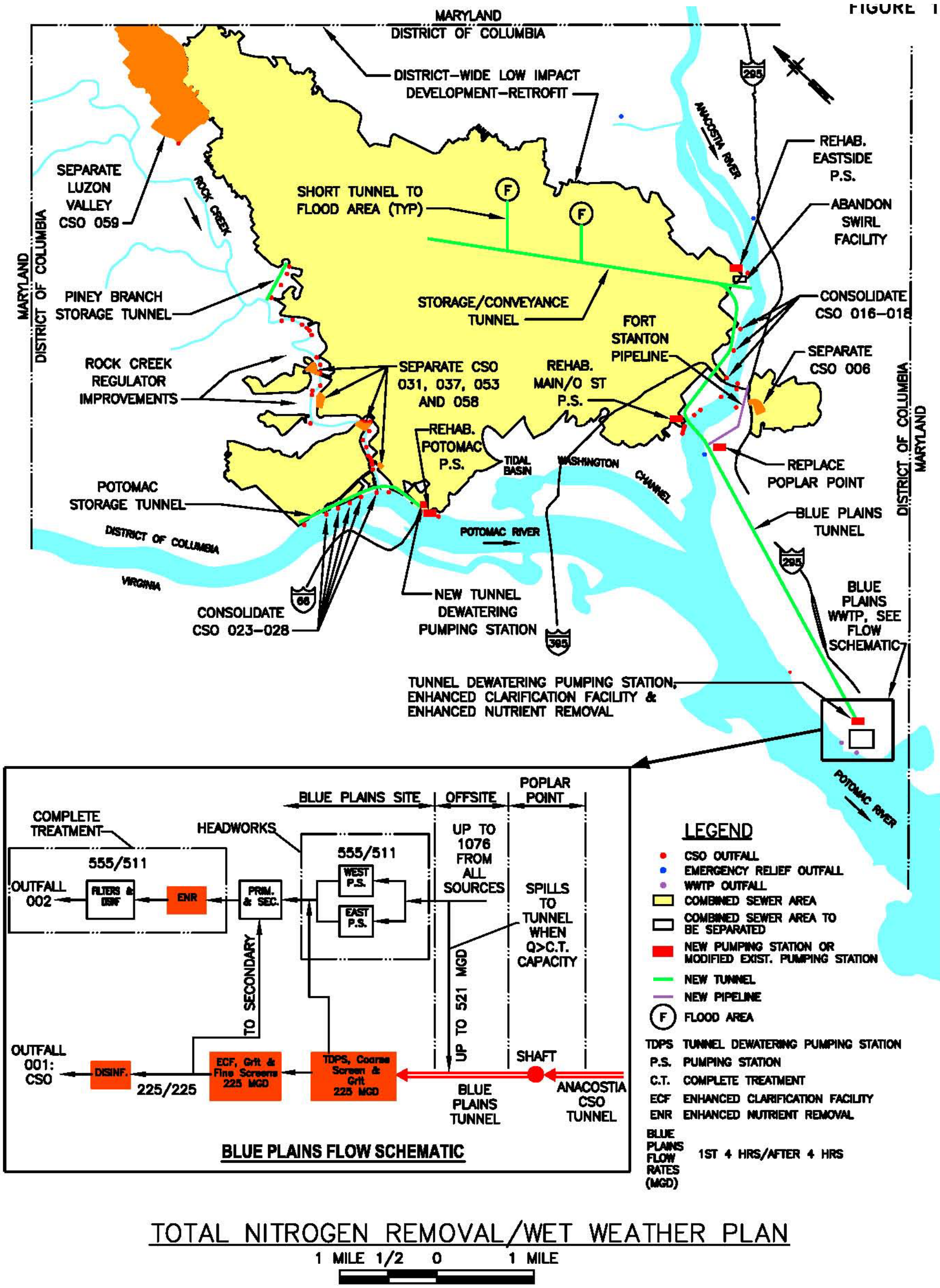

Figure 1-2. TN/WW Plan

1.3 Regulatory Requirements

1.3.1 NPDES Permit

EPA has issued DC Water a permit (Permit No. DC0021199) authorizing discharges from Blue Plains and the combined sewer system in accordance with the permit conditions. The permit has an effective date of September 30, 2010 and an expiration date of September 30, 2015. The NPDES permit includes a variety of requirements that affect the operation and maintenance of the combined sewer system.

1.3.2 Consent Decrees

DC Water has entered into two consent decrees (CD) related to its CSO program. Each of these decrees is described below:

Three-Party Consent Decree - Civil Action No. 1:00CV00183TFH and No. 02-2511 (TFH)
DC Water and the District of Columbia entered into this CD with the United States Government and certain citizen plaintiffs to resolve allegations regarding the combined sewer system (CSS). The CD was lodged with and entered by the court on June 25, 2003 and October 10, 2003, respectively. The CD provides a schedule for implementation of various operation and maintenance-type items associated with DC Water's Nine Minimum Controls Program. In addition, the CD provides a schedule for replacement of the inflatable dams in the CSS and for rehabilitation of DC Water's pumping stations.

Long Term Control Plan Consent Decree - Civil Action No. 1:CV00183TFH
DC Water and the District of Columbia entered into this CD with the United States Government. The CD was entered by the court on March 23, 2005, and provides a schedule for implementation of the LTCP.

1.4 CSO Controls in LTCP Consent Decree

The LTCP Consent Decree specifies the schedule for implementation of the DCCR. The major requirements of the decree are described in the following subsections.

1.4.1 Anacostia River Projects

The Anacostia River Project components included in the LTCP Consent Decree are summarized in Table 1-1.

Table 1-1. Anacostia River Projects in LTCP Decree

Component	Description
Anacostia River	
Rehabilitate Pumping Stations[(1)]	Rehabilitate existing pumping stations as follows: • Interim improvements at Main and 'O' Street Pumping Stations necessary for reliable operation until rehabilitation of stations is performed. • Rehabilitate Main Pumping Station to 240 mgd firm sanitary capacity. Screening facilities for firm sanitary pumping capacity only. • Rehabilitate Eastside and 'O' Street Pumping stations to 45 mgd firm sanitary capacity. • Interim improvements at existing Poplar Point Pumping Station necessary for reliable operation until replacement pumping station is constructed as part of storage tunnel
Storage Tunnel from Poplar Point to Northeast Boundary Outfall[(2)]	49 million gallon storage tunnel between Poplar Point and Northeast Boundary. Tunnel will intercept CSOs 009 through 019 on the west side of the Anacostia. Project includes new tunnel dewatering pump station and low lift pumping station at Poplar Point.
Storage/Conveyance Tunnel Parallel to Northeast Boundary Sewer[(2)]	77 million gallon storage/conveyance tunnel parallel to the Northeast Boundary Sewer. Also includes side tunnels from main tunnel along West Virginia and Mt. Olivet Avenues, NE and Rhode Island and 4th St N.E. to relieve flooding. Abandon Northeast Boundary Swirl Facility upon completion of main tunnel.
Outfall Consolidation[(2)]	Consolidate the following CSOs in the Anacostia Marina area: CSO 016, 017 and 018
Separate CSO 006[(2)]	Separate this CSO in the Fort Stanton Drainage Area
Ft Stanton Interceptor[(2)]	Pipeline from Fort Stanton to Poplar Point to convey CSO 005, 006 and 007 on the east side of the Anacostia to the storage tunnel.

Notes:

(1). Required by Three Party Consent Decree

(2). Required by LTCP Consent Decree

As a result of the TN/WW Plan, DC Water has added 31 mg of storage to the Anacostia Tunnel system for a total of 157 mg of storage. This was accomplished by extending the tunnel from Poplar Point to Blue Plains and constructing the tunnel dewatering pumping station at Blue Plains in lieu of Poplar Point. These and other changes to the LTCP are not reflected in the LTCP Decree. DC Water and the U.S. Government are working on modifications to the LTCP Decree to conform the decree to the TN/WW Plan.

Based on the current level of planning, the Anacostia River Projects have been divided into 15 contract divisions to facilitate implementation. There is one contract division proposed for each of the three major tunnel segments and their associated shafts, and one division proposed for the three branch tunnels and their associated shafts. The diversion structures for the NEBBT are included in the branch tunnels contract division based on proximity to the shafts. The other ten contract divisions are comprised of near-surface diversion structures, associated diversion sewers, junction sewers and tunnel overflow structures. The planned contract divisions are listed in Table 1-2. Figure 1-3 shows the contract divisions and the current status of implementation.

Table 1-2. Planned Contract Divisions for Anacostia River Projects

Contract Division	Description
A	Blue Plains Tunnel and Main Outfall Sewer Diversion
B	Tingey Street Diversion Sewer for CSOs 013 and 014
C	CSO 019 Overflow and Diversion Structures
D	Joint Base Anacostia-Bolling Overflow and Potomac Outfall Sewers Diversion
E	M Street Diversion Sewer (CSOs 015, 016, and 017)
F	CSO 018 Diversion Sewer
G	CSO 007 Diversion Sewer
H	Anacostia River Tunnel
I	Main Pumping Station Diversions and Main Outfall Sewers Diversion
J	Northeast Boundary Tunnel
K	Northeast Boundary Branch Tunnels
L	Northeast Boundary Diversions
M	Mt. Olivet Road Diversions
Y	Blue Plains Tunnel Dewatering Pumping Station and Enhanced Clarification Facility
Z	Poplar Point Pumping Station Replacement

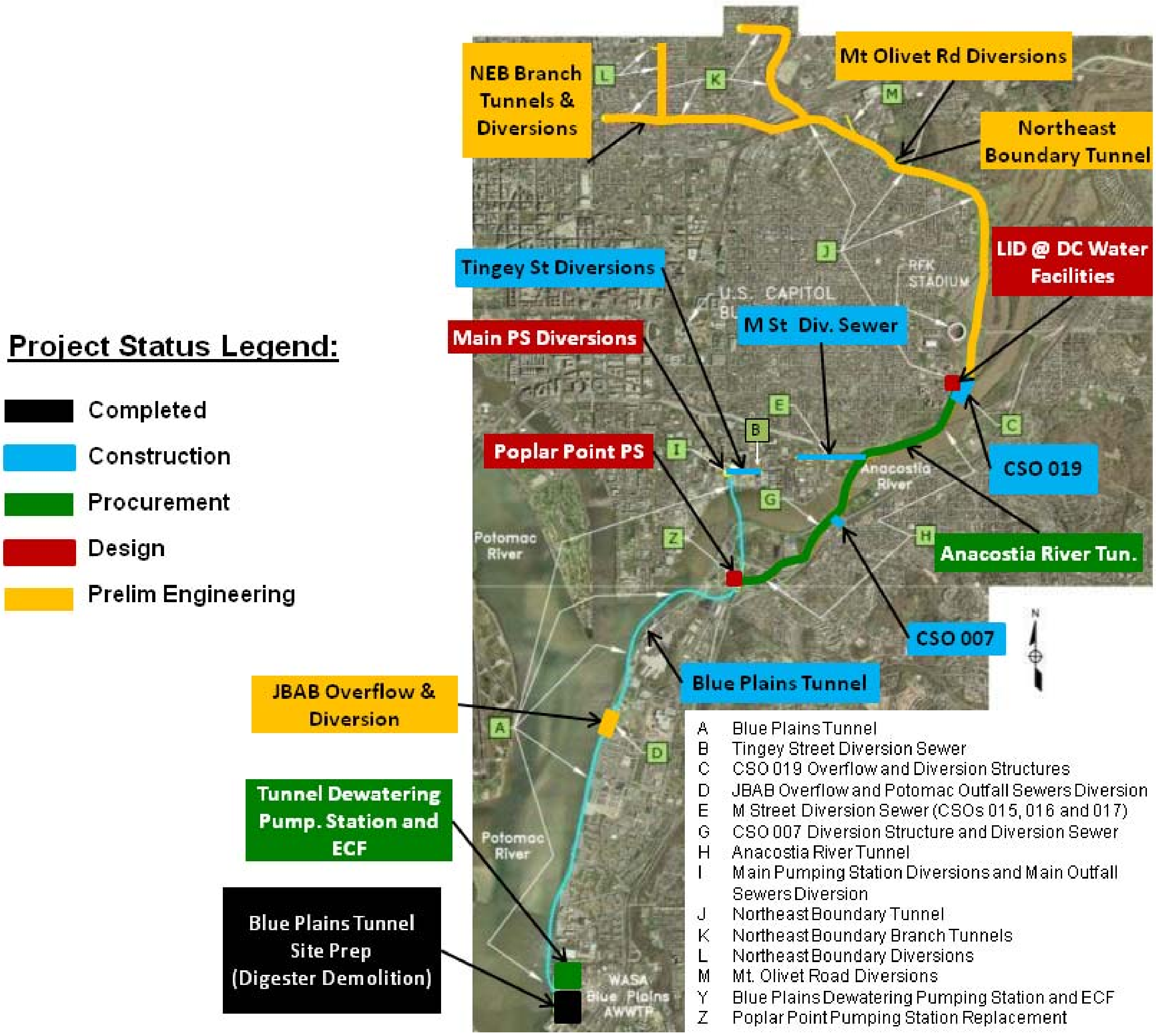

Figure 1-3. Anacostia River Project Status (as of July 2012)

1.4.2 Potomac River Projects

The control measures selected for the Potomac River are predicted to limit overflows to four events per average year. The principal control measures include rehabilitation of the Potomac Pumping Station and construction of a storage tunnel from west of the Key Bridge, along the Potomac River waterfront terminating just downstream of the Kennedy Center at the Potomac Pumping Station. The tunnel will intercept the Georgetown CSOs and the large CSOs downstream of Rock Creek. A new pumping station would be constructed at Potomac Pumping Station to dewater the tunnel. In addition, the LTCP will consolidate and close all CSOs between the Key Bridge and Rock Creek to remove the impact of these CSOs on the Georgetown waterfront area

The major elements of the Final LTCP for the Potomac River Projects are summarized in Table 1-3 and are shown on Figure 1-4.

Table 1-3. Potomac River Projects

Component	Description	Status (as of July 2012)
Potomac River		
Replace Inflatable Dams (1)	Replace inflatable dams at Potomac River CSOs where these are installed	Completed
Rehabilitate Potomac Pumping Station (1)	Rehabilitate station to firm 460 mgd pumping capacity	Potomac Pumping Station has achieved a firm capacity of 425 mgd. Work is on going to resolve the pumping capacity at the station
Outfall Consolidation (2)	Consolidate CSOs 023 through 028 in the Georgetown Waterfront Area.	Future work
Potomac Storage Tunnel (2)	58 million gallon storage tunnel from Georgetown to Potomac Pumping Station. Includes tunnel dewatering pumping station	Future work

Notes:
(1). Required by Three Party Consent Decree
(2). Required by LTCP Consent Decree

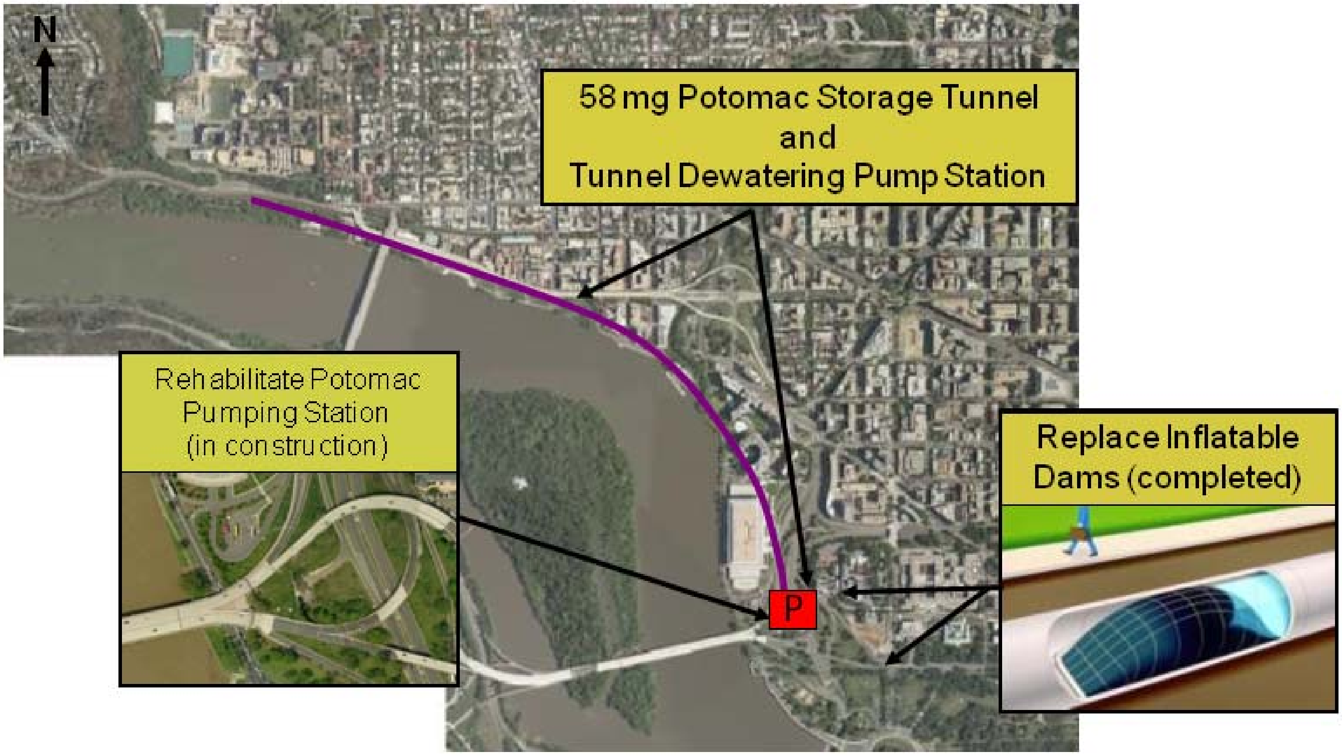

Figure 1-4. Potomac River Projects Status (as of July 2012)

1.4.3 Rock Creek Projects

The control measures in the LTCP for Rock Creek are predicted to limit Piney Branch overflows to one per average year. The remaining overflows in Rock Creek will be controlled to 4 events per average year. The principal control measures include separation of four CSOs, construction of a storage tunnel at Piney Branch, and monitoring and regulator improvements to four CSOs south of Piney Branch.

The major elements of the Final LTCP for Rock Creek are summarized in Table 1-4 and are shown on Figure 1-5.

Table 1-4. Rock Creek Projects

Component	Description	Status (as of July 2012)
Rock Creek		
Separate Luzon Valley	Separation CSO 059	Completed
Separation	Separate CSOs 031, 037, 053, and 058.	Completed
Monitoring at CSO 033, 036, 047 and 057	Conduct monitoring to confirm prediction of overflows. If overflows confirmed, then perform the following: • Regulator Improvements: Improve regulators for CSO 033, 036, 047 and 057. • Connection to Potomac Storage Tunnel: Relieve Rock Creek Main Interceptor to proposed Potomac Storage Tunnel when it is constructed	Regulator improvements are in construction
Storage Tunnel for Piney Branch (CSO 049)	9.5 million gallon storage tunnel	Future work

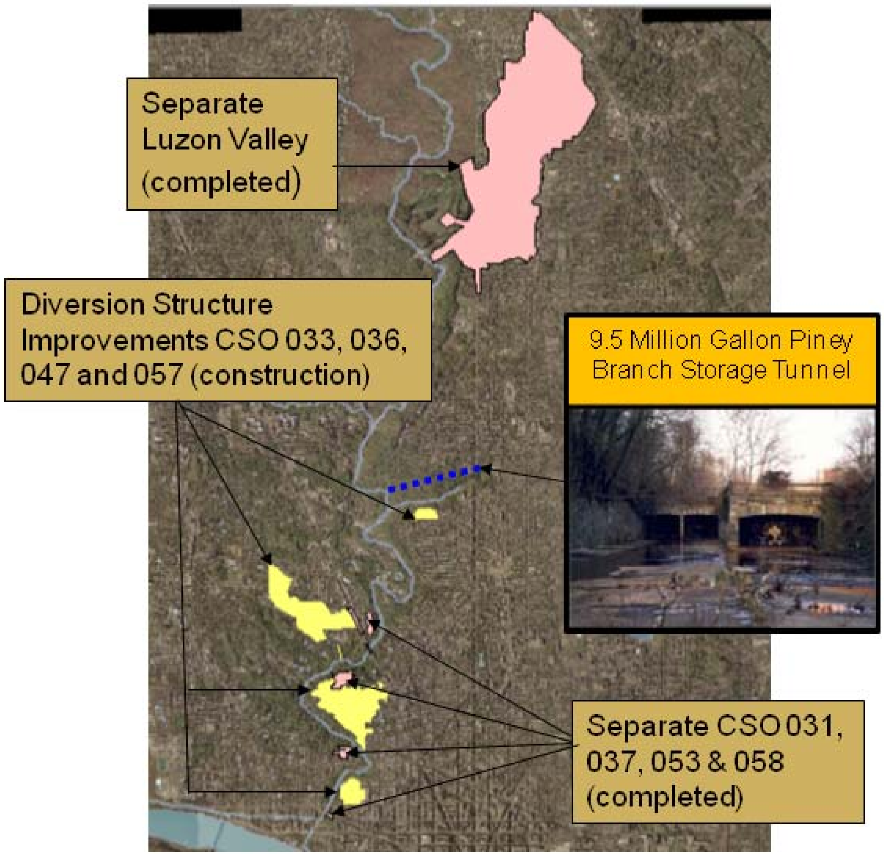

Figure 1-5. Rock Creek Projects Status (as of July 2012)

1.4.4 System-Wide Improvements

The LTCP also includes the following system-wide improvements:

- Low Impact Development Retrofit (LID-R) at DC Water Facilities – the Decree requires DC Water to construct $3 M of LID at DC Water facilities and to evaluate the effectiveness of these measures. The projects are currently in design.

- Excess Flow Treatment Improvements at Blue Plains – the Decree required the addition of four new primary clarifiers and improvement to the excess flow treatment control and operations. Because of the TN/WW plan, these improvements have been deleted and are scheduled to be replaced by a new 225 mgd enhanced clarification facility (ECF).

1.4.5 Consent Decree Schedule

There are numerous deadlines and interim milestones in the LTCP Decree. Major deadlines are summarized in Table 1-5.

Table 1-5. Key Deadlines in LTCP Consent Decree

Item	Deadline Type	Deadline
Anacostia River Projects		
Inflatable dam rehabilitations	Place in Operation	Completed-2004
Main, O St, Eastside Pumping Station Rehabilitation	Place in Operation	Completed-2008
CSO 006 Separation	Place in Operation	Completed -2010
Tunnel from Blue Plains to RFK Stadium	Place in Operation	March 23, 2018
Complete System	Place in Operation	March 23, 2025
Potomac River Projects		
Inflatable dam rehabilitations	Place in Operation	Completed - 2004
Potomac Pumping Station Rehabilitation	Place in Operation	In progress
Potomac Tunnel	Start Facility Plan Award Design Contract Award Construction Contract Place in Operation	March 23, 2015 March 23, 2018 March 23, 2021 March 23, 2025
Rock Creek Projects		
Luzon Valley Sewer Separation		Completed - 2002
Separate CSO 031, 037, 053, 058		Completed - 2011
Rock Creek Regulator Improvements		October 4, 2013
Piney Branch Tunnel	Start Facility Plan Award Design Contract Award Construction Contract Place in Operation	March 23, 2016 March 23, 2019 March 23, 2022 March 23, 2025
System-Wide		
LID-R at DC Water Facilities	Place in Operation	March 18, 2014

1.5 Predicted CSO Reduction

The D.C. Department of the Environment (formerly Department of Health) and EPA approved the Final LTCP and determined that CSOs remaining after implementation of the plan would not cause or contribute to the exceedance of water quality standards, subject to post construction monitoring. Regulatory agencies also determined that the CSOs remaining after implementation of the plan would comply with total maximum daily loads (TMDLs) established for the receiving waters. Table 1-6 shows the CSOs predicted as a result of implementation of the DCCR.

Table 1-6. Predicted CSOs

Item	Anacostia River	Potomac River	Rock Creek	Total
CSO Overflow Volume (mg/avg. yr.)				
1996 – DC Water formed	2,142	1,063	49	3,254
2012 – After inflatable Dams and Pumping Station rehabilitations	1,258	654	48	1,960
2025 – LTCP in Place	54	79	5	138
% Reduction	98%	93%	90%	96%
Number of Overflows (#/avg. yr.)				
1996 – DC Water formed	82	74	30	
2012 – After inflatable Dams and Pumping Station rehabilitations	75	74	30	
2025 – LTCP in Place	2	4	1 / 4 (1)	

Notes:

(1) One overflow per average year at Piney Branch, four overflows per average year at other Rock Creek CSOs

2 Sewershed Characterization

This section describes the characteristics of the combined sewersheds that are tributary to the Potomac River, Rock Creek, and Piney Branch. The purpose is to define the land use characteristics for each CSO sewershed in order to support the assumptions used for green infrastructure implementation and cost in this screening analysis.

2.1 Collection System Overview

A schematic of the major conveyance pipelines and pumping stations in DC Water's collection is shown on Figure 2-1. It is convenient to think of the drainage areas and CSS as being divided into two subsystems - an Anacostia system and a Potomac/Rock Creek system. The Northeast Boundary, Navy Yard, Fort Stanton, and Tiber Creek drainage areas are part of the Anacostia system. The other drainage areas are part of the Potomac/Rock Creek system, with the B St/NJ Ave drainage area serving as a link between the Anacostia and Potomac/Rock Creek systems. The ratio of maximum design capacity to dry weather capacity of the two systems is significantly different. Prior studies indicate this factor is approximately two for the Northeast Boundary Trunk Sewer. However, this factor is typically significantly higher for trunk sewers and interceptors serving the Potomac/Rock Creek system, allowing them to carry more wet weather flow before discharging to receiving waters.

When the sewer system was constructed, Rock Creek was recognized as having little assimilative capacity. As a result, the sewer system in Rock Creek was designed with a large diversion capacity which results in relatively few overflows to the stream. Large interceptors were constructed which convey flows out of Rock Creek to the Potomac River and ultimately Potomac Pumping Station. Once the capacity of Potomac Pumping Station and the associated sewers is exceeded, the flows from the Rock Creek Interceptors can overflow to the Potomac River as CSO. As a result, the effective drainage area of the Potomac Tunnel includes all Rock Creek and Potomac combined sewer areas.

Potomac Pumping Station is the facility serving the Potomac and Rock Creek drainage areas which conveys flow to Blue Plains for Treatment. This station pumps wastewater from the Potomac/Rock Creek system to Blue Plains via two force mains that cross under the Anacostia River at the confluence with the Potomac River. It also conveys wastewater from surrounding jurisdictions that enter the District via the Rock Creek Main Interceptor and the Potomac Interceptor.

The CSOs discharging to the Potomac and Rock Creek are summarized in Table 2-1 and their drainage areas are shown on Figure 2-2.

Table 2-1. Potomac and Rock Creek CSO Outfalls

NPDES No.	Location	Status	
		In Service	Abandoned or Separated
Potomac CSOs			
001	Blue Plains	x	
003	Bolling Air Force Base, at Giavanolli and Chanute, SW	x	
020	Rock Creek Parkway and Independence, NW	x	

NPDES No.	Location	Status: In Service	Status: Abandoned or Separated
021	Rock Creek Parkway and C St., NW	x	
022	Rock Creek Parkway and G St., NW	x	
023	Abandoned		x
024	South of 30th and K Streets, NW	x	
025	South of 31st and K Streets, NW	x	
026	Wisconsin Avenue and Water Street, NW	x	
027	33rd and Water Sts., NW	x	
028	Key Bridge and Whitehurst Freeway, NW	x	
029	Adjacent to C&O Canal, aligned with 38th St. NW	x	
030	Separated (Formerly Foxhall & Canal, NW)		x
	Total	**11**	**2**
Rock Creek CSOs			
031	Separated (Formerly Rock Creek Pkwy & Pennsylvania Avenue, NW.)		x
032	26th and M Street, NW.	x	
033	Across street from St. Francis Jr. High and aligned with N St., NW.	x	
034	Just west of St. Francis Jr. High and north of N St., NW	x	
035	P St. Bridge and Rock Creek Parkway	x	
036	22nd Street, South of Q Street NW.	x	
037	Separated (Formerly Waterside Dr. and Rock Creek Parkway)		x
038	Between arch footbridge and Connecticut Ave., north of Kalorama Circle, NW.	x	
039	Connecticut Avenue Bridge and Rock Creek Parkway, NW.	x	
040	Aligned with Biltmore Rd., between Connecticut Ave and Ellington Bridge.	x	
041	Beach Dr. and Ontario Pl., NW	x	
042	Harvard St. and Beach Dr NW.	x	
043	Upstream of Harvard St. and Beach Dr NW.	x	
044	Kenyon Street and Beach Dr., NW.	x	
045	North of Beach Dr. and Walbridge Pl, NW.	x	
046	Piney Branch Parkway and Park Road, NW.	x	
047	Piney Branch Parkway and Ingleside Terrace	x	
048	South of Piney Branch Parkway and 17th St.	x	
049	North of Piney Branch Parkway and 17th St.	x	
050	Rock Creek Parkway and L St., NW	x	
051	Across Rock Creek Pkwy, aligned with Olive St., NW.	x	

NPDES No.	Location	Status	
		In Service	**Abandoned or Separated**
052	Between P & Penna. Ave Bridges, aligned with O Street, NW.	x	
053	Separated (Formerly Q St. Bridge and Rock Creek Parkway, NW.)		x
054	Massachusetts Ave & Rock Creek Parkway, NW.	x	
056	Normanstone Dr. and Rock Creek Parkway, NW.	x	
057	Separated (Formerly 28th Street and Rock Creek Parkway, NW)		x
058	Connecticut Ave & Rock Creek Parkway, NW.	x	
059	Separated (Formerly Luzon valley)		x
060	North of P St. Bridge & Rock Creek Pkwy, NW	x	
	Total	**24**	**5**

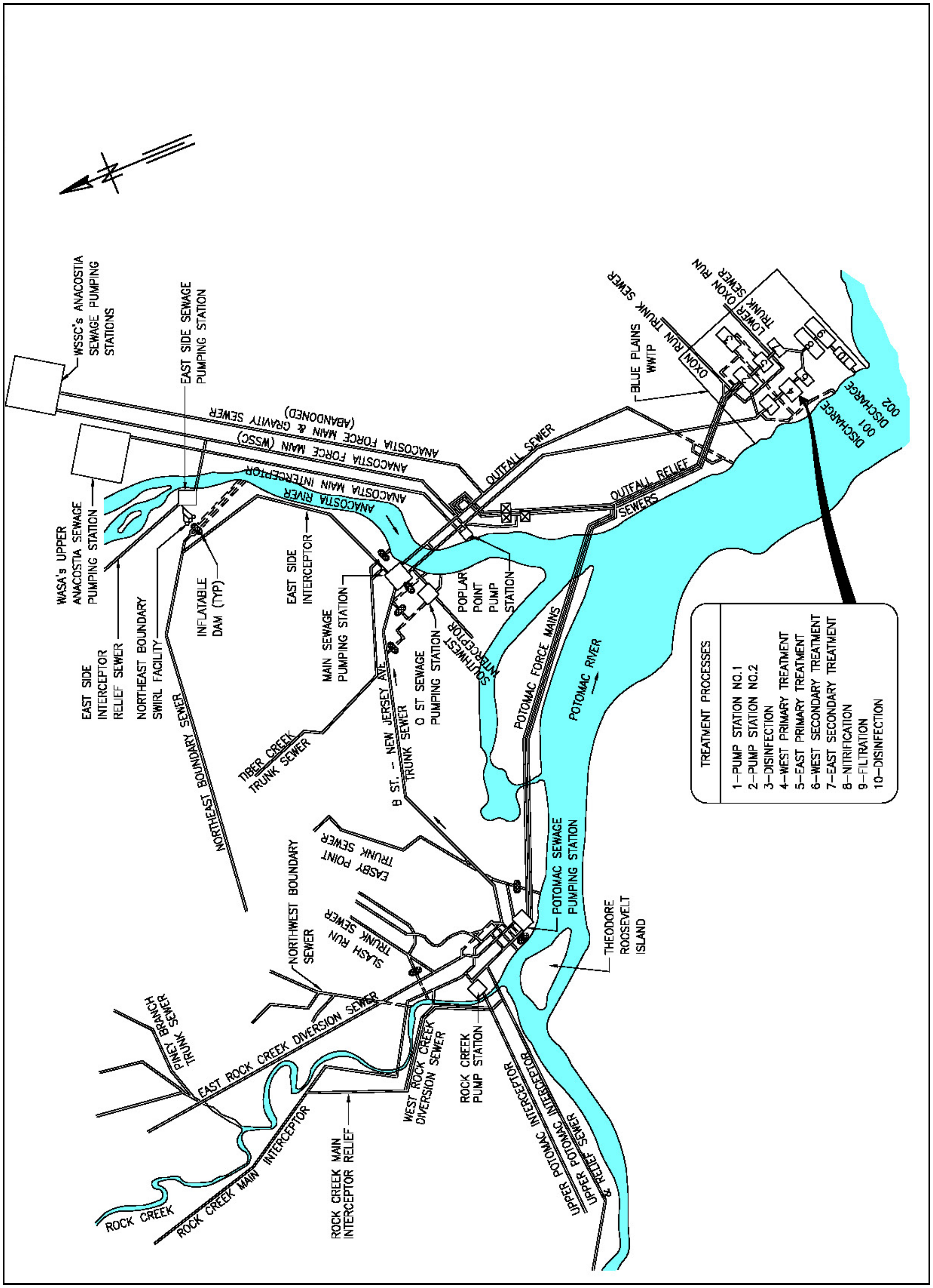

Figure 2-1. Combined Sewer System Schematic

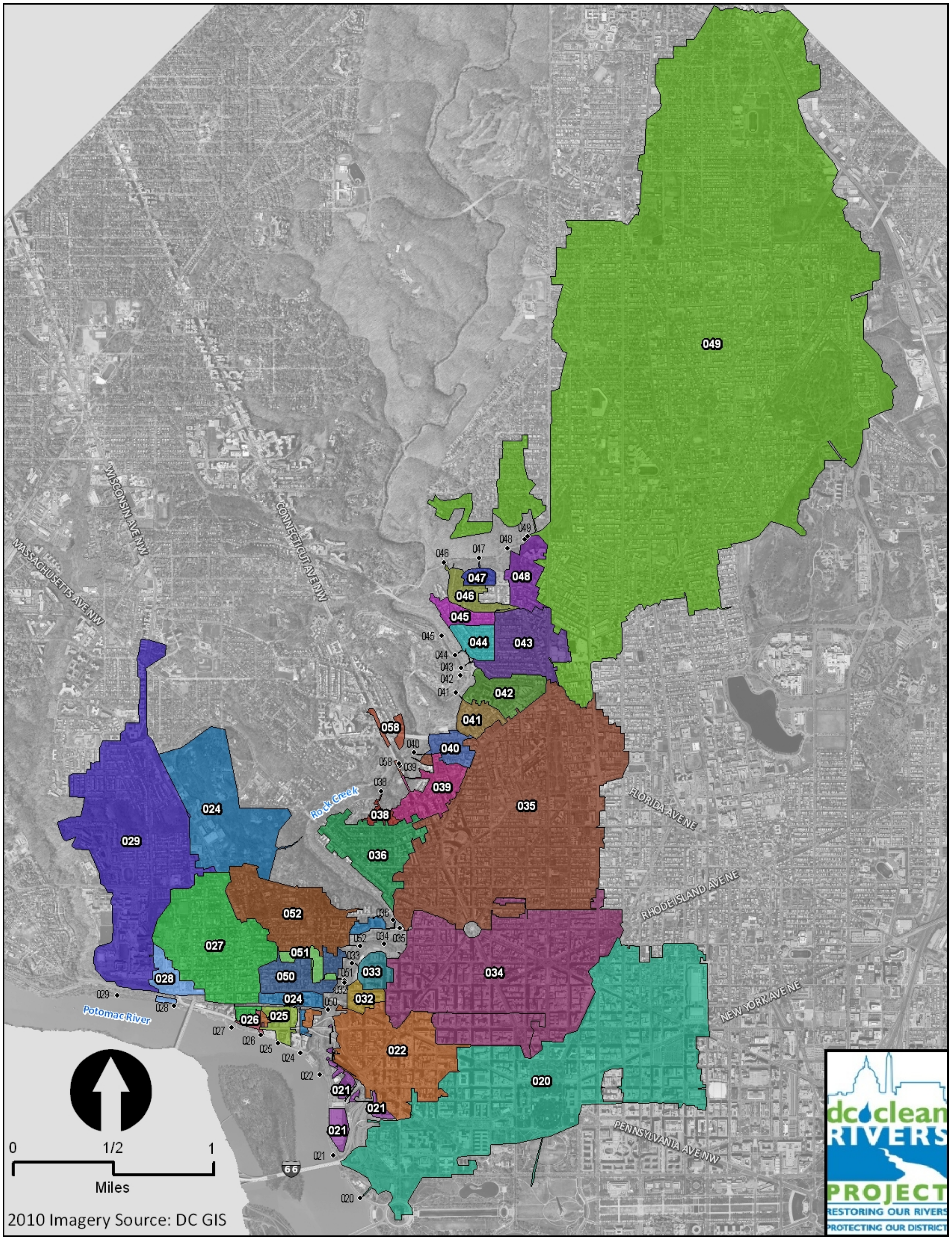

Figure 2-2. Potomac River, Rock Creek, and Piney Branch Sewersheds and CSO Outfalls

2.2 Methodology

To assess the type, efficacy, and cost of GI implementation throughout the District, GIS data from DC GIS was evaluated for each CSO sewershed, including:

- Land ownership types (both public and private)
- Land use (commercial, residential, and institutional)
- Development density (low to high)
- Land cover (such as roads and alleys, buildings, and sidewalks)

For each sewershed, impervious areas were divided into separate land use, ownership, and density categories. By combining land cover and land use, a new database of categories was created to focus on only impervious areas with a potential for GI implementation. These categories allowed different GI technologies to be applied at varying levels in each category. The basis for this evaluation is described in detail in Section 3.

2.3 Land Use Characterization

Rock Creek eventually feeds into the Potomac River, with the confluence occurring near Theodore Roosevelt Island. The neighborhoods within the sewershed include Mt. Pleasant, Dupont Circle, West End, Downtown, Foggy Bottom and Georgetown. Piney Branch is a small tributary to Rock Creek with little-to-no natural baseflow. The majority of the flow in Piney Branch can be attributed to separate stormwater flow and CSO overflows. The sewershed drainage area is predominantly drained by the Piney Branch trunk sewer and drains to CSO-049. The neighborhoods within the sewershed include Brightwood Park and Petworth.

Rock Creek and Potomac sewersheds are highly urbanized areas. With the exception of Rock Creek Park, the sewersheds are a dense mixture of impervious public (roads, sidewalks and alleys), residential, and commercial areas. The Rock Creek and Potomac sewersheds are 68 percent impervious.

The Piney Branch (CSO-049) sewershed is comparatively less urbanized with only 52 percent of the total area being impervious. It is also largely residential, whereas 30 percent of the impervious area is considered low-density private buildings.

Both Piney Branch and Potomac and Rock Creek sewersheds have similar land ownership, with 61 percent of the impervious area being public space. Although Potomac and Rock Creek have comparatively less residential area, the commercial impervious building area is greater at 14 percent.

Figures 2-3 presents the percent distribution of impervious land use categories for Potomac River and Rock Creek sewersheds. Figure 2-4 shows the percentages for Piney Branch sewershed. For detailed acreage for each category by CSO, see Table 2-2 at the end of this section.

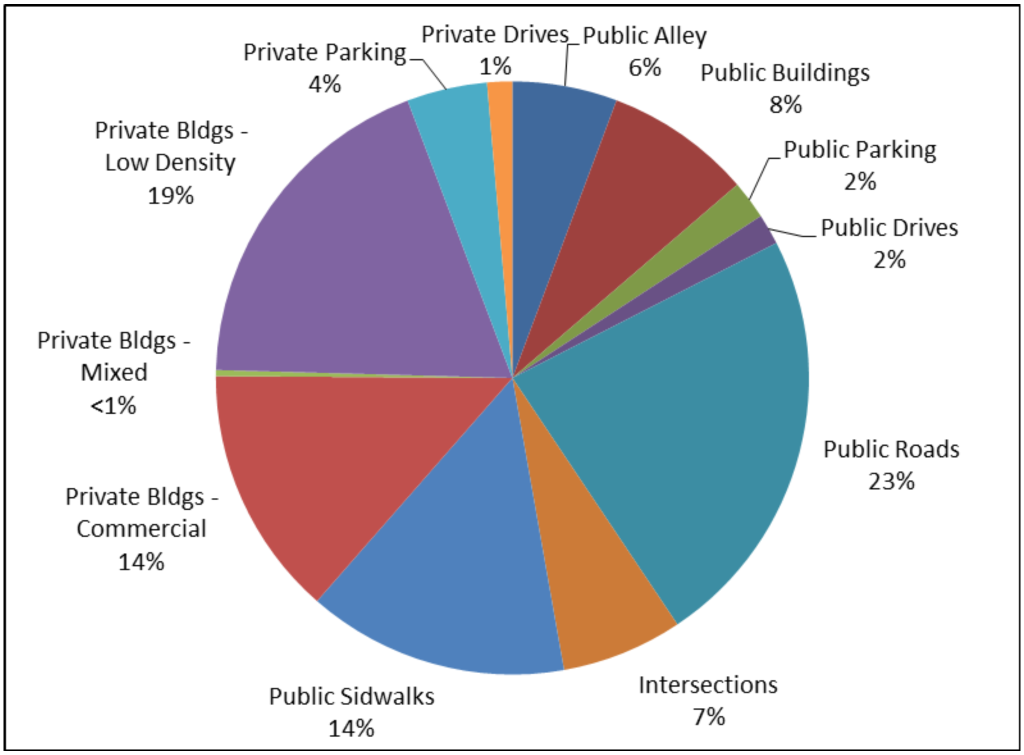

Figure 2-3. Impervious Land Use for Rock Creek and Potomac River Sewersheds

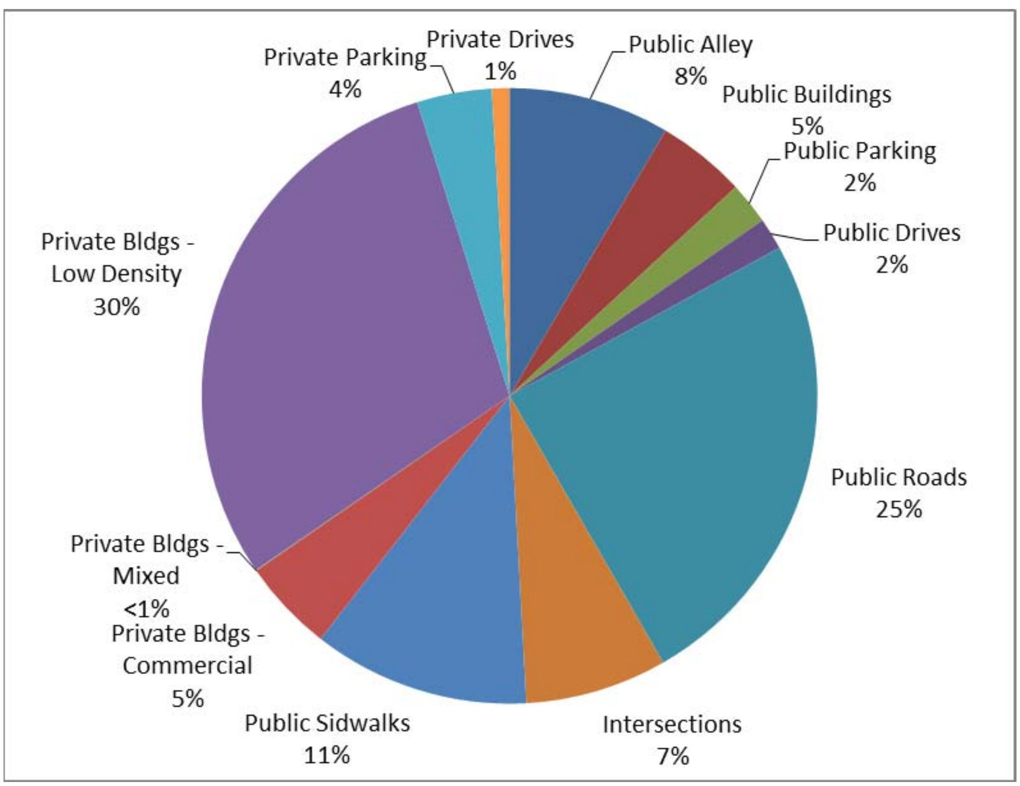

Figure 2-4. Impervious Land Use for Piney Branch Sewershed

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Table 2-2. CSO Sewershed Impervious Acreage

CSO Sewershed	Total Acres	Impervious Acres	% Impervious	Public (Acres)							Private (Acres)				
				Alley	*Buildings*	*Parking Lot*	*Paved Drives*	*Roads*	*Intersections**	*Sidewalks*	*Buildings - Commercial, High Density Residential*	*Buildings - Mixed Use*	*Buildings - Low and Low-Med. Density Res.*	*Parking Lot*	*Paved Drives*
CSO 020	595	450	76%	11.4	76.2	15.6	7.6	105.4	34.2	83.7	97.0	0.1	5.7	9.1	3.9
CSO 021	24	19	81%	0.0	6.3	0.2	0.5	0.7	4.1	3.4	0.1	3.5	0.0	0.0	0.5
CSO 022	199	158	79%	4.5	16.6	1.2	1.5	38.9	13.5	25.9	38.5	3.4	4.0	6.5	3.6
CSO 023	0	0	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSO 024	175	62	36%	1.0	7.7	5.0	5.1	7.6	2.0	7.4	14.4	0.0	1.8	7.5	2.6
CSO 025	15	12	79%	0.2	0.5	0.1	0.1	2.0	0.1	1.7	4.2	2.1	0.0	0.2	0.7
CSO 026	3	3	86%	0.1	0.0	0.0	0.0	1.1	0.0	0.3	1.0	0.1	0.0	0.0	0.0
CSO 027	164	104	64%	3.1	10.1	2.4	0.7	19.4	5.5	17.5	14.6	0.3	25.6	3.5	1.4
CSO 028	21	13	61%	0.0	1.6	0.7	0.7	3.1	0.7	2.6	1.8	0.0	0.9	0.6	0.1
CSO 029	330	164	50%	8.4	24.8	6.3	6.3	32.7	12.0	21.0	3.9	0.0	40.3	4.7	3.8
CSO 032	13	10	82%	0.4	0.0	0.0	0.0	2.3	2.1	1.3	3.7	0.0	0.1	0.1	0.1
CSO 033	16	12	74%	0.8	1.1	0.7	0.1	1.3	0.1	1.9	5.5	0.0	0.0	0.2	0.5
CSO 034	393	338	86%	17.2	11.8	1.1	2.7	66.9	30.4	49.2	127.3	0.2	10.9	17.0	3.1
CSO 035	551	399	72%	19.2	22.1	4.8	3.2	85.9	66.4	55.9	51.3	0.5	59.8	27.0	3.3
CSO 036	75	45	60%	0.8	7.9	0.9	1.8	9.4	4.1	5.9	0.1	0.0	8.5	2.5	3.1
CSO 038	6	3	51%	0.1	0.1	0.1	0.1	0.9	0.2	0.4	0.0	0.0	0.8	0.2	0.2
CSO 039	39	26	66%	0.7	1.2	0.4	0.5	5.4	6.9	3.5	0.3	0.0	4.1	1.5	0.9
CSO 040	18	13	72%	0.8	0.1	0.2	0.0	2.5	2.5	1.5	0.7	0.0	4.1	0.9	0.0
CSO 041	25	15	61%	0.7	0.5	0.4	1.0	3.1	2.4	1.8	0.5	0.0	3.9	0.4	0.2
CSO 042	38	24	63%	0.8	0.0	0.0	0.1	4.3	8.3	3.0	0.9	0.0	4.3	1.5	0.4
CSO 043	73	49	67%	2.9	4.1	0.0	0.4	10.7	5.1	6.0	3.1	0.0	13.1	2.9	0.3
CSO 044	19	11	59%	1.3	0.0	0.0	0.0	2.1	0.4	0.8	0.0	0.0	6.7	0.0	0.0
CSO 045	16	10	60%	1.0	0.0	0.0	0.0	2.0	0.2	0.9	0.2	0.0	4.8	0.0	0.3

				Public (Acres)							Private (Acres)				
CSO Sewershed	*Total Acres*	*Impervious Acres*	*% Impervious*	*Alley*	*Buildings*	*Parking Lot*	*Paved Drives*	*Roads*	*Intersections**	*Sidewalks*	*Buildings - Commercial, High Density Residential*	*Buildings - Mixed Use*	*Buildings - Low and Low-Med. Density Res.*	*Parking Lot*	*Paved Drives*
CSO 046	20	11	54%	1.0	0.5	0.2	0.1	3.1	0.7	1.3	0.0	0.0	4.0	0.1	0.0
CSO 048	33	17	51%	0.4	2.2	0.1	0.1	3.5	1.6	1.9	0.2	0.0	4.5	1.9	0.2
CSO 049	2,329	1,215	52%	103	57	27	20	300	90.6	138	59	0.3	361	48	11
CSO 050	38	27	70%	0.5	1.3	0.0	0.1	6.1	1.7	4.7	4.3	0.0	6.0	1.5	0.3
CSO 051	12	8	65%	0.0	0.2	0.0	0.0	1.8	0.3	1.7	0.2	0.0	3.3	0.3	0.1
CSO 052	104	58	55%	1.9	1.1	0.0	0.3	13.4	3.7	9.7	2.2	0.0	21.9	1.3	2.3
CSO 053	5	4	65%	0.0	0.0	0.0	0.0	0.7	0.9	0.5	0.5	0.0	0.1	0.5	0.3
CSO 054	0	0	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSO 055	0	0	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSO 056	0	0	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CSO 058	7	5	68%	0.1	0.0	0.0	0.0	2.3	1.0	1.0	0.0	0.0	0.2	0.3	0.1
TOTAL	5,356	3,283	61%	182	255	67	53	738	301	455	436	11	601	140	44

*Intersections were not counted as potential impervious areas for GI implementation

3 Green Infrastructure Bases for Evaluation

3.1 Introduction

This section describes the range of GI assumed to be implemented, the assumed performance of the technologies and the basis for estimating costs. Information was collected from the literature, other projects and from other District experience in order to perform the evaluation. There is recognition that application of GI on a large scale for CSO control is not a well defined and tested area of practice.

This data was used in combination with the gray CSO control alternatives to evaluate green and green/gray hybrid solutions for CSO control.

3.2 Technologies

Applicable GI technologies were selected based on the sewershed characterization, review of aerial mapping and physical surveys of the drainage areas. Based on this review, the following technologies were selected as representative of the range of viable technologies in terms of cost, effectiveness and applicability:

- Pervious Pavement
- Bioretention
- Green Roofs
- Cisterns
- Street Trees
- Downspout Disconnection and Rain Barrels

Other GI technologies may also be feasible and these are proposed to be investigated as part of the GI demonstration project.

3.3 Efficacy and Degree of Implementation

The new MS4 permit issued to the District requires capture of the first 1.2" from private and non-Federal development/redevelopment, and the first 1.7" from Federal properties. The District is applying these storm water capture requirements in both the combined and separate sewer area. In order to be consistent with this analysis, GI technologies were sized to capture the first 1.2" from the impervious area treated. GI technologies were not assumed to improve the quality of the runoff, which is an extremely conservative assumption.

Application of GI was considered in the range of 0%, 15% and 30% of impervious area treated. For example, GI applied to 15% of the impervious area means that sufficient GI was installed to treat 15% of the impervious area at 1.2" of rainfall. Similarly, GI applied at a rate of 30% means that sufficient GI was installed to treat 30% of the impervious area at 1.2" of rainfall.

The GI technologies assumed to be implemented for the various impervious area types are summarized below:

Public Property

- Alleys

  For this land use it is assumed that the GI technology to be implemented will be pervious pavement. Alleys in public rights of way have long been deemed an appropriate location for this technology and it is assumed that this technology can be implemented on a widespread scale over the sewersheds.

- Buildings

  For public buildings, both green roofs and cisterns are suitable for implementation. Each technology is suitable for a different building roof type. For example, green roofs are suitable for flat roofs while cisterns are more suitable for pitched roofs.

- Parking Lots and Paved Drives

  For parking lots and paved drives, pervious pavement is considered the most suitable GI technology for implementation. This technology has long been used in similar applications and can be implemented over a widespread area of the sewer shed.

- Roads

  For roads Pervious Pavement and Bioretention are considered suitable GI technology for implementation, and can be implemented over a widespread area of the sewer shed.

- Sidewalks

  Similar to the analysis of the roads, two GI Technologies are considered suitable for implementation. These are Pervious Pavement and Street Trees.

Private Property

- Buildings – Commercial and High Density Residential

  For private buildings of this occupancy, both green roofs and cisterns are suitable for implementation. For green roofs on flat roof types, it is assumed that the technology is implemented over an extensive roof area, while cisterns are assumed to be implemented on pitched roofs.

- Buildings – Mixed Use

  For mixed use buildings, the GI technologies to be implemented are the same as for commercial and high density residential buildings where both green roofs and cisterns are suitable for implementation.

- Buildings – Low and Low-Med Density Residential

  For low and low-med density residential land use, the most commonly accepted GI technology to be implemented is downspout disconnection with rain barrels.

- Parking Lots and Paved Drives
  For private area parking lots and paved drives, pervious pavement is considered the most suitable as was the case for public parking lots.

Tables 3-1 and 3-2 show the assumed degree of application of GI for the 15% and 30% degrees of application.

Table 3-1. GI Application in Potomac Combined Sewer Area

Space	Location	Assumed GI Measure	Total Impervious Area (ac)	15% GI		30% GI	
				% of Imp Area Treated	Imp Area Treated (ac)	% of Imp Area Treated	Imp Area Treated (ac)
Public Space	Alley	Perv. pavement	184	10%	18	35%	64
	Bldgs: flat roof	Green roof	144	0%	-	10%	14
	Bldgs: pitched roof	Cistern/rain bar./reuse	113	20%	23	24%	27
	Parking lot	Perv. Pavement	68	15%	10	35%	24
	Paved Drives	Perv. Pavement	53	15%	8	35%	19
	Roads	Perv. Pavement	375	10%	37	35%	131
	Roads	Bioretention	375	25%	94	50%	187
	Sidewalks	Perv. pavement	367	10%	37	44%	161
	Sidewalks	Trees	92	25%	23	50%	46
	Misc.	Bioretention					
		Subtotal Public	**1,770**		**250**		**674**
Private Space	Bldgs: com. flat roof	Green roof	222	1%	2	2%	4
	Bldgs: com. pitched roof	Cistern/rain bar./reuse	222	5%	11	10%	22
	Bldgs: mixed flat roof	Green roof	5	1%	0	2%	0
	Bldgs: mixed pitched roof	Cistern/rain bar./reuse	5	10%	1	20%	1
	Bldgs: low/med density	Downspout disconnect	612	35%	214	40%	245
	Parking lot	Perv. pavement	144	10%	14	20%	29
	Paved drives	Perv. Pavement	47	10%	5	20%	9
		Subtotal Private	**1,256**		**247**		**310**
		Intersections	**301**				
		Grand Total	**3,283**	**15%**	**497**	**30%**	**985**

Table 3-2. GI Application in Piney Branch Combined Sewer Area

Space	Location	Assumed GI Measure	Total Impervious Area (ac)	15% GI		30% GI	
				% of Imp Area Treated	Imp Area Treated (ac)	% of Imp Area Treated	Imp Area Treated (ac)
Public Space	Alley	Perv. pavement	103	10%	10.29	35%	36.00
	Bldgs: flat roof	Green roof	32	0%	0.00	1%	0.32
	Bldgs: pitched roof	Cistern/rain bar./reuse	25	15%	3.75	20%	5.00
	Parking lot	Perv. Pavement	27	15%	4.02	25%	6.69
	Paved Drives	Perv. Pavement	20	15%	3.04	25%	5.06
	Roads	Perv. Pavement	150	10%	14.99	20%	29.98
	Roads	Bioretention	150	20%	29.98	41%	61.46
	Sidewalks	Perv. pavement	111	10%	11.07	44%	48.71
	Sidewalks	Trees	28	25%	6.92	50%	13.84
		Subtotal Public	**645**		**84**		**207**
Private Space	Bldgs: com. flat roof	Green roof	30	1%	0.30	1%	0.30
	Bldgs: com. pitched roof	Cistern/rain bar./reuse	30	5%	1.48	5%	1.48
	Bldgs: mixed flat roof	Green roof	0	1%	0.00	2%	0.00
	Bldgs: mixed pitched roof	Cistern/rain bar./reuse	0	10%	0.02	20%	0.03
	Bldgs: low/med density	Downspout disconnect	361	25%	90.32	40%	144.52
	Parking lot	Perv. pavement	48	10%	4.77	20%	9.54
	Paved drives	Perv. Pavement	11	10%	1.13	20%	2.25
		Subtotal Private	**480**		**98**		**158**
		Grand Total	**1,125**	**15%**	**182**	**30%**	**365**

3.4 Unit Costs for GI

Unit costs for the implementation of each of the GI technologies identified above were based on reviews of local, regional, and national sources of data to determine reasonable cost ranges for implementing the selected GI practices. Due to the urban nature of the project area and the associated complications that are likely to occur (including issues such as existing infrastructure and utilities, limited construction access, and smaller project footprints), it was generally assumed that implementation costs would be at the higher end of documented construction costs. It was also assumed that most, if not all, of the GI work would be in the form of retrofits (as opposed to new construction) which also adds considerably to project costs as a result of the above-mentioned constraints. A comprehensive list of sources reviewed during this cost analysis is provided in Appendix B.

3.4.1 Pervious Pavement

This application includes demolition of existing pavement, excavation, installation of 3 feet of base rock, an underdrain system that ties into the existing storm sewer, and installation of permeable pavers (as opposed to pervious asphalt or concrete). It should be noted that hard surface demolition, excavation, and installation of an underdrain system are costly components of this application, but were assumed to be necessary for proper functioning in an urban environment with poorly draining soils. Depending on the intended usage and structural requirements of the pervious pavement, costs may be slightly higher or lower than the average costs used in this analysis (i.e., sidewalks will require less base rock than roads). For consistency, an average cost of $30.00/square foot was used for all pervious pavement applications in this analysis. In addition to regional and national cost data, the costs from several pervious pavement projects in Washington, D.C. were reviewed in detail to determine actual local costs (data was provided by the Low Impact Development Center) for construction.

3.4.2 Green Roof

Green roof costs were based on the implementation of an "extensive" green roof system, which generally have a relatively shallow growing medium (4 to 8 inches), and are planted with a variety of hardy, drought tolerant vegetation. Due to use of drought tolerant vegetation, it was assumed that long term irrigation would not be necessary. It was also assumed that green roof installation would occur as retrofit projects on existing, flat roofs and that no significant, additional structural reinforcement would be required. This assumption was deemed to be reasonable because extensive green roofs have a shallow growing medium, which adds considerably less weight than that of an "intensive" green roof system. Project costs from other major urban centers such as New York City and Seattle, as well as comprehensive cost data from the Water Environment Research Foundation (WERF), were determined to be most representative of applications in Washington, D.C. and, therefore, were weighted more heavily in the green roof cost analysis.

3.4.3 Bioretention Cells

It was assumed that bioretention cells would be implemented primarily in a linear fashion along existing roads and sidewalks to collect runoff from these impervious surfaces. Installation of these cells would require retrofitting the existing paved areas to create curb-contained bioretention. Therefore, this application includes demolition of existing pavement, excavation, installation of an underdrain system, and use of appropriate engineered soils and plantings to facilitate proper drainage. It should be noted that hard surface demolition, excavation, and installation of an underdrain system are costly components of this application, but were deemed to be necessary for proper functioning in an urban environment. In addition to regional and national cost data, the costs from several bioretention projects in Washington, D.C. were also reviewed to determine actual local costs (data was provided by the Low Impact Development Center) for construction. Comprehensive bioretention costs provided by WERF and the California Stormwater Quality Association were also determined to represent similar applications to those potentially implemented in Washington, D.C. and, therefore, were also weighted more heavily in the cost analysis.

3.4.4 Street Trees

The costs for street trees were based on a 6 ft x6 ft x 6 ft in-curb planter vault constructed in-situ, retrofitted into an existing sidewalk. Costs were based on previous engineering experience and similar applications implemented in Washington, D.C.

3.4.5 Downspout Disconnection with Rain Barrel

This application was assumed to include both materials and installation costs to disconnect a typical downspout and direct runoff to a plastic rain barrel. Rain barrels were generally assumed to range in size from 50 to 150 gallons (typical residential rain barrels are around 50 to 60 gallons). It was assumed that rain barrels could be installed at multiple downspouts on a given home or facility. Several sources of local, regional, and national data were reviewed to determine appropriate costs. Local, regional, and national costs reviewed in this analysis did not vary as widely as some of the other practices.

3.4.6 Cistern

Cistern costs were based on the installation of a metal cistern designed for non-potable, exterior water re-use. The cost includes a small pump system that would allow for use in outdoor irrigation, washing cars, etc. Cistern sizing can vary widely and it was assumed that the transportation and installation of the cistern would not require any extensive excavation, mobilization, or delivery costs. It was also assumed that the cistern would be installed outside the given facility. The cost to retrofit the interior of a building to accommodate a cistern system can be much more costly.

3.4.7 Summary of Costs

GI practices can treat runoff from rain that falls on the practice itself as well as runoff from other areas that drain to the GI practice. For example, pervious pavement can handle rainfall that falls on the pavement as well as runoff from other impervious areas that is directed to the pervious pavement. Table 3-3 summarizes the assumed costs of the GI measures and converts these costs to dollars per impervious acre treated.

Table 3-3. Costs of GI Measures

GI Practice	Const. Cost	Unit	Constr. Cost ($/acre installed)	Constr. cost ($/imp Ac Treated)	Rounded Capital Cost ($/imp ac treated)	Comments
Pervious Pavement (pavers)	$ 30.00	SF	$ 1,306,800	$ 290,400	$ 407,000	Assumes 9” depth of effective storage layer, 60% void space which stores 3.37 gal/sf. System treats 4.5 sf of impervious area per sf of pervious pavement at 1.2”rain. Retrofit installation with underdrain tied into existing SW system, demo existing road/alley.
Bioretention Cells	$ 42.00	SF	$ 1,829,520	$ 101,640	$ 143,000	Assumes 36” depth of effective storage layer, 60% void space which stores 13.46 gal/sf. System treats 18 sf of impervious area per sf of bioretention at 1.2”rain. Retrofit installation with underdrain tied into existing SW system, demo existing road/alley.
Green Roof (extensive)	$ 27.00	SF	$ 1,176,120	$ 1,176,120	$ 1,647,000	Green Roof sized to treat 1.2", extensive green roof.
Street Trees	$ 18.00	cf	$ 180,000	$ 201,667	$ 282,000	Assumes 6’x6’x6’ tree pit.
Rain Barrels, Downspout Disconnect	$ 22.44	CU FT	$ 97,749	$ 97,749	$137,000	
Cisterns/Rain barrels	$ 5.00	GAL	$ 162,914	$ 162,914	$ 228,000	

Notes:

1. Capital cost = 1.4 x construction cost and includes legal, fiscal, engineering, construction management, legal and administrative costs.
2. ENR CCI = 9291, June 2012

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4 Collection System Modeling

This section describes the use of DC Water's hydrologic and hydraulic model to predict sewer system response to various green infrastructure/gray infrastructure CSO control scenarios. This section presents a brief background on the models employed followed by discussions of the model development and the model application.

4.1 Background

Hydrologic and hydraulic models are computer simulation tools used by planners and engineers to evaluate rainfall and runoff relationships in urban areas. The hydrologic model simulates the major components of the hydrologic cycle; that is, the physical processes of rainfall, evapotranspiration, storage, and runoff. The response of urban neighborhoods to rainfall is determined by the relative degree of imperviousness (e.g., rooftops, parking lots, roads, etc.) and the infiltration capabilities of the soils. The hydraulic model simulates the movement of runoff and sewer flows through the below-ground network of pipes and other infrastructure that make up the sewer system. Flow through the sewer system is determined by the capacity of pipes, pumps, and other hydraulic control structures, and backwater conditions.

Hydrologic and hydraulic models are calibrated based on observed rainfall and flow data. The model parameters (e.g., infiltration rate, slope, roughness coefficient, etc.) are adjusted in calibration to an optimal point where the ability of the model to simulate the volume and timing of runoff events is maximized. Independent validation of models is done by gauging the ability of the model to simulate a separate group of rainfall/runoff events without adjustment of the model parameters. Model calibration and validation provide confidence in the ability of the models to "predict" the response of the system under a variety of conditions. This is particularly true when the calibration and validation data sets include a wide variety of rainfall and flow conditions.

Identifying a dataset that represents average rainfall conditions for use in the hydrologic model is a fundamental first step in model development. As part of the evaluation of the original LTCP, DC Water analyzed over 50 years of hourly rainfall data at Ronald Reagan National Airport to identify an average rainfall period. The years from 1988 to 1990 were selected as the average rainfall period. This period was chosen because annual precipitation from these three years represent dryer conditions, wetter conditions, and average conditions compared to the long term average for the District. Table 4-1 compares the rainfall for these three years to the long term average.

Table 4-1. Annual Average Rainfall Conditions in the District

Statistic	1988	1989	1990	1988-1990 Avg	Long Term Avg[1]
Annual Rainfall (inches)	31.74	50.32	40.84	40.97	38.95
No. Events > 0.05 inches[2]	61	79	74	71	74
Average Storm Duration (hours)[2]	9.6	11.2	9.6	10.1	9.9
Average Maximum Intensity (in/hr)	0.15	0.18	0.15	0.16	0.15
Maximum Intensity (in/hr)	1.32	1.31	1.25	1.29	1.30
Percentile[3]	14th	90th	68th	68th	--

Notes: 1. Ronald Reagan National Airport hourly data, 1949-1998
2. Individual events separated by a minimum of 6 hours with no rain.
3. Percentile is based on total annual rainfall.

DC Water has used the MIKE URBAN Model and its predecessor (the MOUSE Model) for all of its hydrologic and hydraulic analyses dating back to 1998. Both models are products of DHI, formerly the Danish Hydraulic Institute (www.dhigroup.com).The models were applied to support a wide range of projects and studies including development of the original LTCP for the CSS. The MOUSE Model incorporating both hydrologic and hydraulic modeling capabilities was selected by DC Water in 1998 to support development of the LTCP. MOUSE was chosen at the time because it had the capability to directly simulate Real Time Control (RTC) operations, a feature that was not then available in the widely-used Storm Water Management Model (SWMM).

During model development, sewersheds for both the CSS and the municipal separate storm sewer system (MS4) in the District were delineated based on sewer maps and topography. Hydrology parameters in the hydrologic model (e.g., pervious vs. impervious, infiltration, etc.) were based on available soil, land use, and zoning maps. Hydraulic controls (e.g., regulators, pump stations, outfalls, inflatable dams, etc.) were based on drawings, pump curves, operations documents, and other studies.

Model calibration and validation was based on rainfall and flow records in the CSS collected during 1999-2000. This included 24 rainfall events for model calibration and another 20 rainfall events for model validation. Several rain gages in the District and observed rainfall at DC National Airport were used to drive the hydrologic model. The hydrologic model was calibrated ahead of the hydraulic model. Overall, the emphasis of calibration and validation was placed on developing a mass balance of flow at Blue Plains, and a reasonable representation of the frequency and volume of CSO discharges.

Since the original model was developed to support the LTCP, a number of software upgrades and model improvements have been made. DHI upgraded the MOUSE model engine to the current incarnation of MIKE URBAN in 2003. The upgrade to MIKE URBAN improved the model application in several ways. It was able to be applied in a continuous simulation mode, a very important consideration where long multiple year simulations are required. MIKE URBAN also included GIS-based software. This made it easier to use GIS data sets for impervious surfaces (e.g., roads, sidewalks, parking lots, etc.) and soils more spatially and directly. In addition, DC Water had its sewer maps (i.e., counter maps) digitized and developed as a geodatabase that could be directly linked to MIKE URBAN. The result of this update was a much improved representation of surface conditions across the CSS in the hydrologic model. In addition, the pipe network in the hydraulic model was based on better information on pipe slopes, diameters, roughness, and other relevant characteristics. New and more robust flow data from suburban jurisdictions and from the District's separate sewer system were also integrated into the model boundary conditions. Figures 4-1 and 4-2 provide a visual representation of the model elements and the land cover for Potomac and Piney Branch sewersheds, respectively.

MIKE URBAN was recalibrated during the period 2005-2006 based on metered flow data for the collection system and Blue Plains. This flow data was supplemented with point rainfall data at National Airport and other District of Columbia stations, with radar rainfall estimates on a square kilometer basis available for some key rainfall events.

Since this recalibration, the MIKE URBAN model has continued to be employed in a number of capacities for DC Water. The model has been used for emergency operations planning, Inter Municipal Agreement (IMA) negotiations, multi-jurisdictional use facilities planning and cost allocation, the Anacostia Facilities Plan, the updated LTCP/Total Nitrogen-Wet Weather Plan, the Federal Triangle and other flood studies, and quarterly NPDES reporting of CSO estimates.

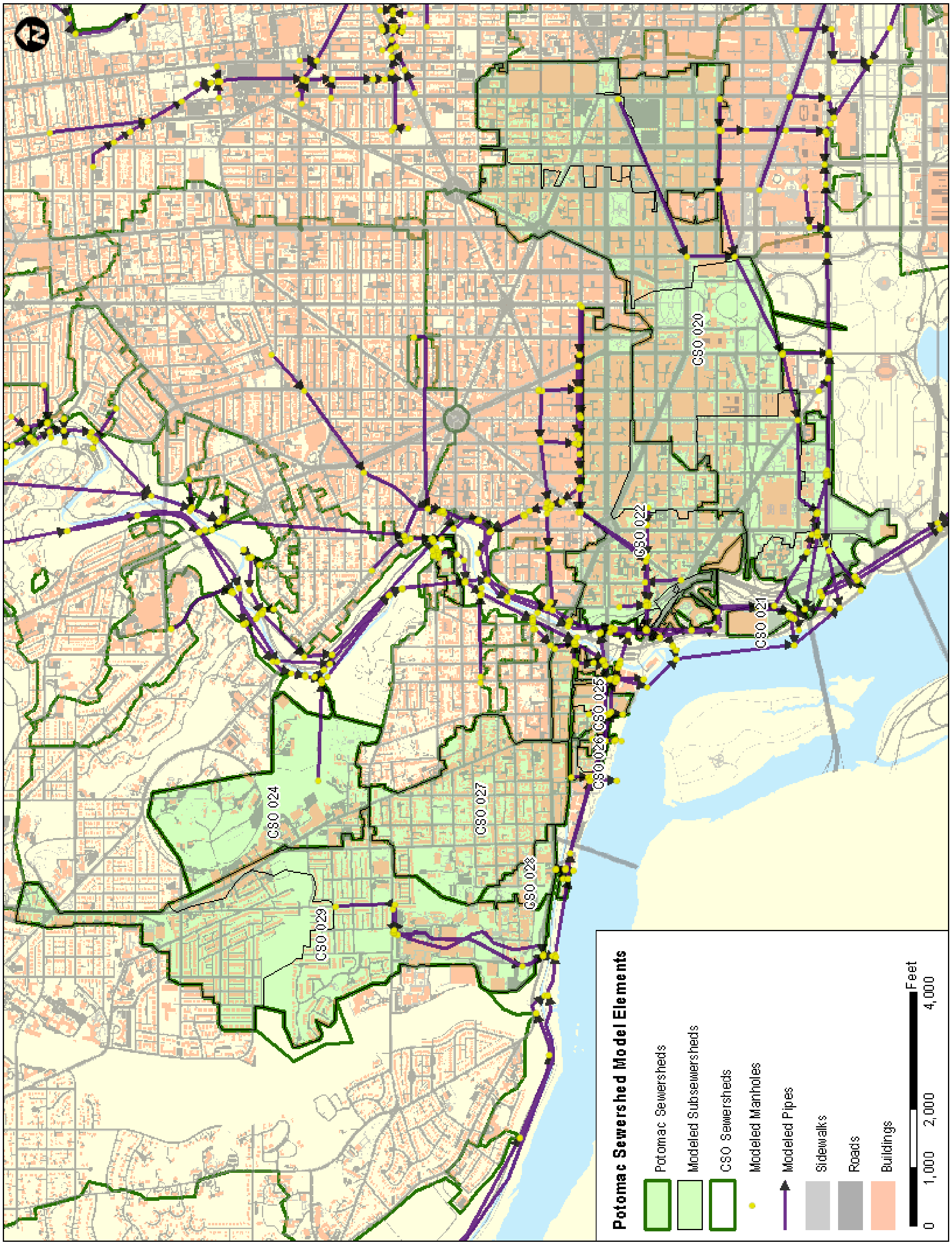

Figure 4-1. Potomac Sewershed Model Elements

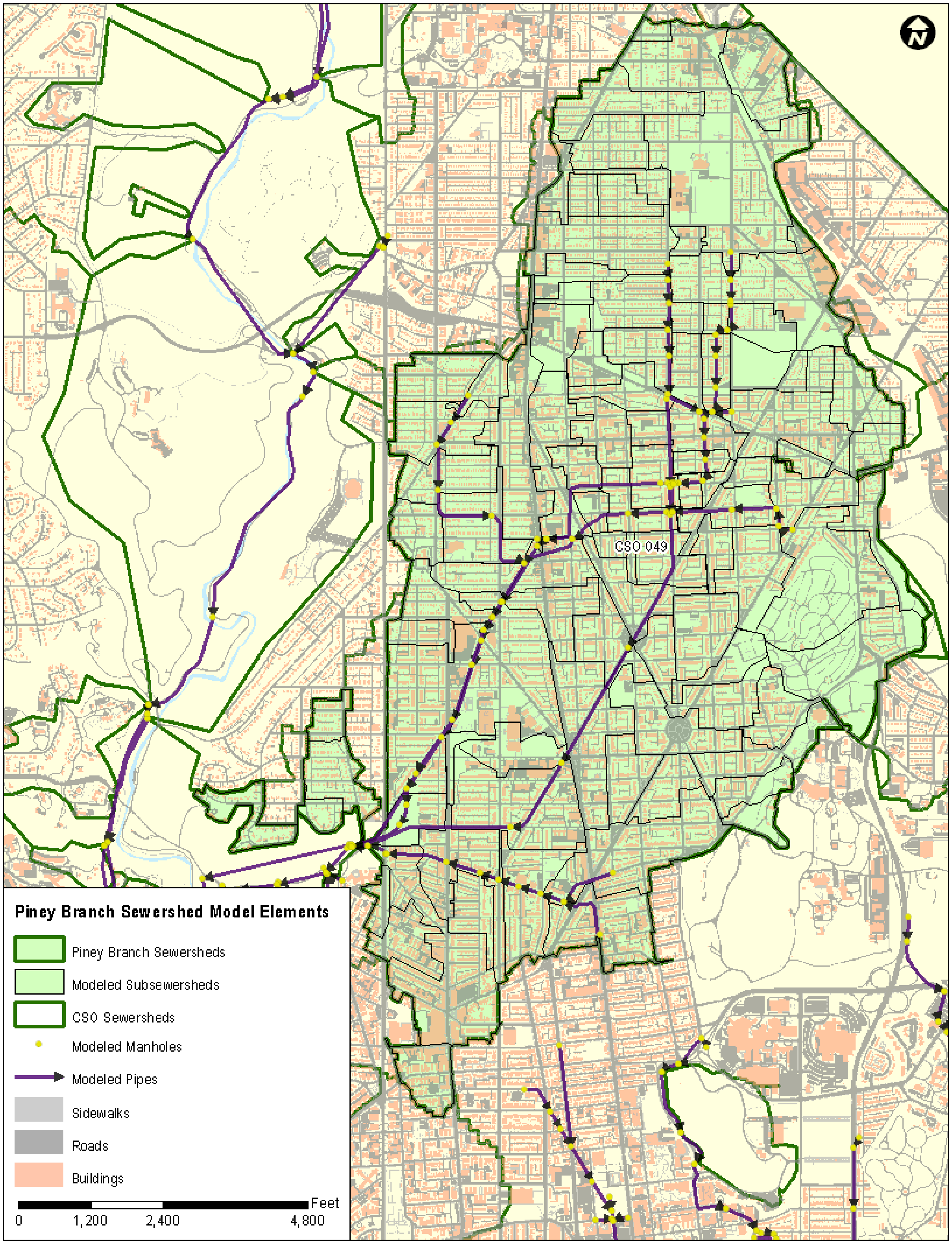

Figure 4-2. Piney Branch Sewershed Model Elements

For DC Water's analysis of green infrastructure potential, a suite of modeling software packages (including MIKE URBAN and SWMM5) were evaluated to identify the best modeling tool to utilize. The results of this evaluation are presented in Technical Memorandum No. 2, Approach to Hydrologic and Hydraulic Modeling. This evaluation resulted in the selection of EPA's SWMM5 runoff engine to perform the hydrologic evaluation and to be paired with the existing MIKE URBAN hydraulic model. EPA SWMM5 features options for explicit characterization and simulation of specific green infrastructure practices that the MIKE URBAN hydrologic model does not.

4.2 Model Development

For this green infrastructure screening analysis, the SWMM5 hydrologic model was used for runoff simulation and the existing hydraulic portion of the MIKE URBAN model was used to model flow through the collection system. The SWMM5 runoff model was developed based on the runoff portion of the MIKE URBAN model as described below, and results were compared to the MIKE URBAN model to ensure consistency with previous model runs.

Historically, the purpose of the MIKE URBAN model was to predict combined sewer volumes and overflows entering receiving waters from the DC Water combined sewer service area. Developing a model for green infrastructure simulation requires finer subsewershed, pipe, and manhole resolution than previously existed in the MIKE URBAN runoff model. To accommodate this, the Piney Branch sewershed was redelineated to a higher resolution of 101 geographically separate model subsewersheds. Potomac model subsewersheds were deemed to be of sufficient resolution that finer delineations were unnecessary. There are 138 modeled subsewersheds throughout the Piney Branch and Potomac sewersheds with a median area of 19 acres. Ninety percent (90%) of the modeled subsewersheds are less than 140 acres.

Existing runoff parameters from MIKE URBAN were converted to SWMM5 runoff parameters. Parameters were copied when the exact analog to the MIKE URBAN parameter existed in SWMM5. Other parameters were converted to match as closely to the parameters in MIKE URBAN and then checked for consistency. Horton infiltration parameters were updated based on NRCS SSURGO soil data for the model area.

In order to effectively model water loss within green infrastructure practices, evapotranspiration (ET) was refined so that it could be applied to green infrastructure practices and the model in general. In MIKE URBAN, evapotranspiration was applied only to water in storage, which was a representation of green infrastructure practice storage. SWMM5 does not have an option to apply ET solely to a practice; instead it is applied to the model as a whole. ET for SWMM5 was based on daily temperatures and climate at the Ronald Reagan Washington National Airport using a modified Thornwaite approach. Of the several accepted methods that could be used to approximate ET, this approach provided results most similar to the MIKE URBAN runoff model.

The models were run for the 1988-1990 period for validation. Time series output from both SWMM5 and MIKE URBAN runoff models was used as an input to the MIKE URBAN hydraulic model. Several metrics were used to compare the two models and insure the SWMM5 model was consistent with the MIKE URBAN runoff model including runoff volume, overflow volume, and frequency of CSO overflows.

4.3 Model Application

Green infrastructure practices are represented in SWMM5 as "LID controls." LID controls were used in the model for the Piney Branch and Potomac River areas of the combined sewer area. SWMM5 is a lumped parameter model that assumes uniformity across a single modeled sewershed. This means that LID controls were designed to represent the total of all green infrastructure practices contained within the modeled sewershed instead of representing each green infrastructure practice separately. This is common practice in a lumped parameter model.

Green infrastructure practices are grouped into the four following LID control categories based on their general design and purpose:

- Rain Barrels
- Cisterns
- Bioretention
- Porous Pavement

Each type of LID control treats runoff from a specific area and drainage areas do not overlap. In SWMM5, each of the contributing areas to the four types of LID control is simulated as a separate subcatchment. Each type of impervious cover exists throughout the Potomac and Rock Creek sewersheds leading to a generally uniform distribution of LID controls. The modeling analysis focused on aggregate area of each impervious cover type without regard to public or private ownership. For scenarios that examine a high level of green infrastructure control, it is possible that opportunities for private green infrastructure implementation could be limited. In these cases, it is assumed that opportunities exist on public-owned property to compensate for the lack of opportunity on private property, and runoff passes through public property before entering the collection system.

In SWMM5, runoff from the surface to be treated by an LID control is routed to the control before entering the hydraulic model (MIKE URBAN). For example, if the scenario calls for 30% green infrastructure treatment, 30% of the contributing area from the variety of types of impervious surfaces is routed to LID controls identified for the specific type of impervious surface. Runoff not entering an LID control flows directly to the hydraulic model. Figure 4-3 shows the modeling framework used by SWMM5 to route flow to LID controls.

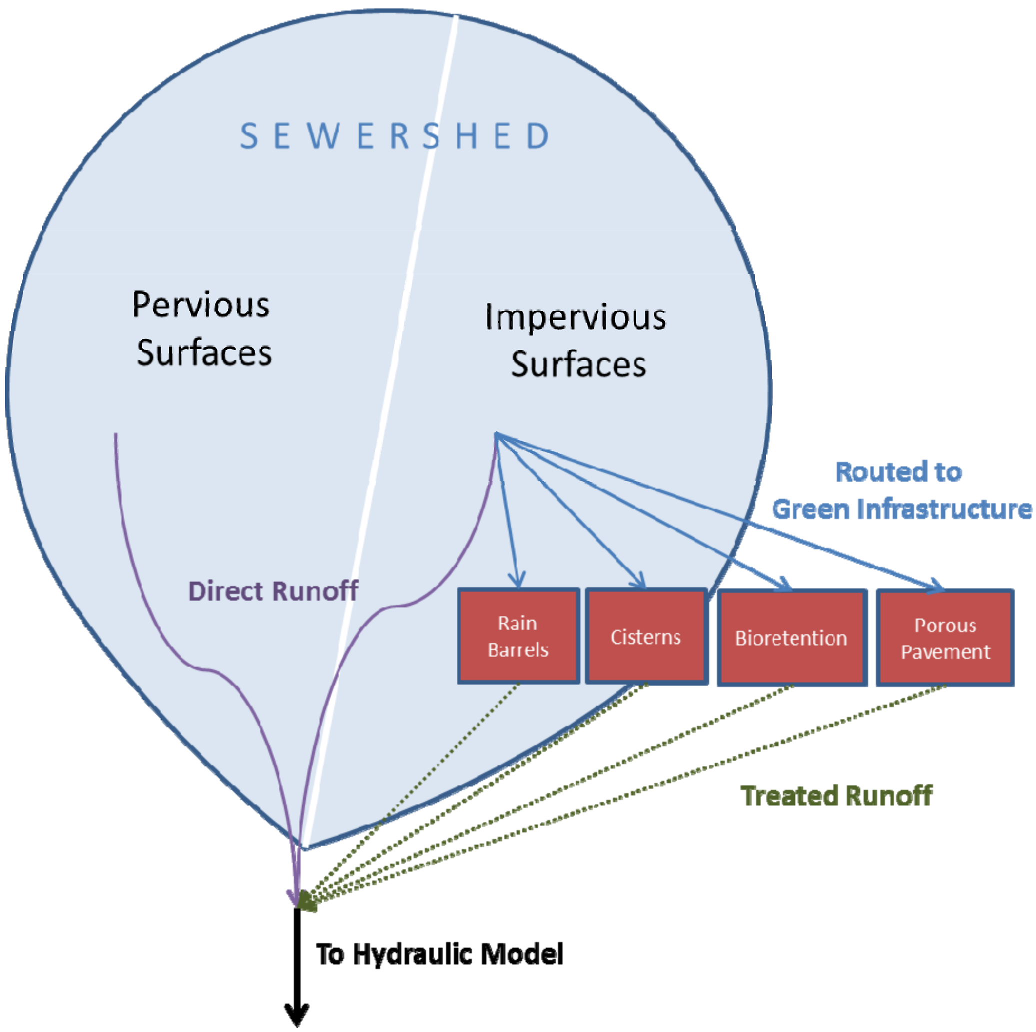

Figure 4-3: SWMM5 LID control routing

SWMM5 represents LID controls as shown in Figure 4-4. All LID controls use the same framework, with runoff entering the LID through the surface layer and passing to other layers or out of the LID practice through ET, overflow, underdrain, or infiltration based on parameters defined for each LID practice.

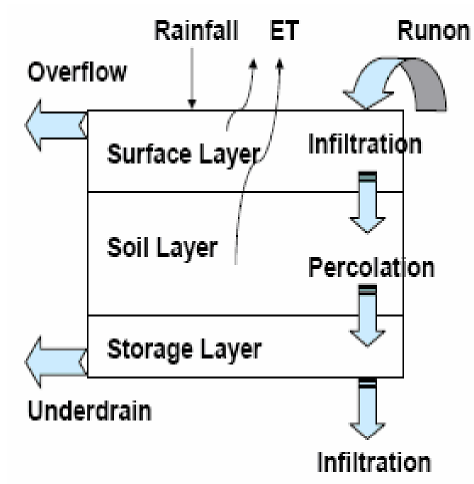

Figure 4-4. SWMM5 LID Control Representation

Each LID control is sized to completely contain the runoff volume produced from a 1.2 inch storm over the area treated. Other LID control parameters are determined based on accepted literature values for the types of LID controls and design guidelines used in the Concept Plan (see Technical Memorandum No. 3). Table 4-2 shows the LID control parameters used in the SWMM5 runoff model. Bioretention cell and porous pavement parameters for infiltration and underdrains varied due to site-specific soil conditions and infiltration potential across the modeled area.

Table 4-2. SWMM5 LID Practice Parameters

Parameter	Units	Rain Barrel	Cistern	Bioretention Cell	Porous Pavement
Surface					
Storage depth	in			6	0.1
Surface slope	%			0	1.9
Soil/Pavement					
Thickness	in			24	6
Porosity	frac			0.3	0.2
Field Capacity	frac			0.105	0.105
Wilting Point	frac			0.047	0.047
Conductivity	in/hr			1.18	100
Conductivity Slope				7	7
Suction Head	in			1.4	1.4
Storage					
Height	in	36	36	18	36
Void Ratio				0.67	0.67
Infiltration	in/hr			Varies	Varies
Clogging Factor				0	0
Drain					
Drain Coef.	in/hr	0.25	0.25	Varies	Varies
Drain Exponent		0.5	0.5	0.5	0.5
Drain Offset	in	0	0	Varies	Varies
Drain Delay	hr	0	0		

Infiltration from each of the LID controls into the underlying soil is assumed to occur at a rate equal to the Horton method minimum infiltration rate for the subsewershed within which it is contained. This is a conservative assumption and accounts for probable soil compaction under the LID control.

Each LID control has a simulated underdrain. The underdrain diameter and height from the bottom of the control are optimized to allow the control to drain or infiltrate within 48 hours of the end of the storm and allow the water surface elevation in the control to remain below the surface of the practice. Rain barrels and cisterns do not have infiltration and the underdrains are simulated at the bottom of the control. Underdrain outflow from rain barrels is assumed to drain to the surface of the subshed where the rain barrel is located. Underdrain outflow from the other practices is assumed to flow directly into the collection system.

Various implementation scenarios were simulated to evaluate the expected runoff reduction and resulting tunnel size resulting from implementing various distributions of LID practices described above. The specific scenarios, the modeling approach, and the modeling results are presented in Section 5.

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5 Green/Gray Screening Results

5.1 Introduction

This chapter assesses the feasibility of using GI alone and in hybrid green/gray infrastructure blends versus traditional gray infrastructure for CSO control for the Potomac and Rock Creek sewer sheds. Several scenarios have been identified for evaluation to assess the potential cost and viability of GI for implementation as part of the DC Water LTCP. These scenarios are:

- Scenario 1 – 15% to 30% GI Implementation and Downsize Tunnels
- Scenario 2 – Alternative Gray and GI Controls
- Scenario 3 – Turner Construction LID Proposal
- Scenario 4 – GI plus Challenge plus MS4 Permit Implementation

This analysis evaluated four scenarios for various levels of implementation of GI throughout the Potomac and Rock Creek sewer sheds. As outlined in Chapter 4, a modeling analysis was carried out to determine the potential reduction in size of the proposed gray infrastructures with varying levels of implementation of GI across the sewer sheds. This evaluation is based on literature review and experience of other GI pilots and programs currently in operation or in planning. The analysis assumes that the institutional issues of implementing GI in an urban environment on a widespread scale will be addressed. As GI is an emerging technology and is being continuously refined and the technologies are becoming more advanced, the analysis conducted recognizes the uncertainty in the predictions of the effectiveness and cost evaluations of GI. The levels of uncertainty in the effectiveness are outlined in previous sections and the uncertainty in the cost evaluations are explained in the following sections.

The scenarios identified in this section do not represent the complete range of possible alternatives that may be viable. Other viable alternatives exist and the identification and evaluation of these alternatives will be performed as part of the GI demonstration project.

5.2 Scenario 1 – 15% to 30% GI Implementation and Downsize Tunnels

5.2.1 Description

This alternative involves applying GI to 15% and 30% of impervious area and adjusting the storage volume of the Potomac and Rock Creek Tunnels to provide the necessary degree of CSO control. Simulation of the 15% and 30% green infrastructure implementation and tunnel downsizing scenarios consisted of editing the runoff model inputs to reflect a 1.2” green infrastructure capture rate and editing the hydraulic model to simulate smaller Potomac and Piney Branch tunnel sizes. Green infrastructure storage elements were introduced to the SWMM runoff model catchments for the Potomac and Piney Branch sewersheds, such that 15% and 30% of the impervious area in these sewersheds, respective to the appropriate scenario, would capture the first 1.2” of rainfall. Varying the Potomac and Piney Branch tunnel sizes in the hydraulic model involved reducing tunnel segment diameters to simulate various tunnel sizes, including scenarios that removed the tunnels completely. GI was applied using the techniques described in Section 3.

When the sewer system was constructed, Rock Creek was recognized as having little assimilative capacity. As a result, the sewer system in Rock Creek was designed with a large diversion capacity which results in relatively few overflows to the stream. Large interceptors were constructed which convey flows out of Rock Creek to the Potomac River and ultimately Potomac Pumping Station. This interceptor system is shown on Figure 5-1. Once the capacity of Potomac Pumping Station and the associated sewers is exceeded, the flows from the Rock Creek Interceptors can overflow to the Potomac River as CSO. As a result, the effective drainage area from the Potomac Tunnel includes all Rock Creek and Potomac combined sewer areas. These areas are shown on Figure 5-2. Therefore, when GI was applied to evaluate the impact on eth Potomac Tunnel, it was applied to all Rock Creek and Potomac sewersheds, including Piney Branch. When GI was applied to assess the impact on the Piney Branch Tunnel, it was applied to Piney Branch only.

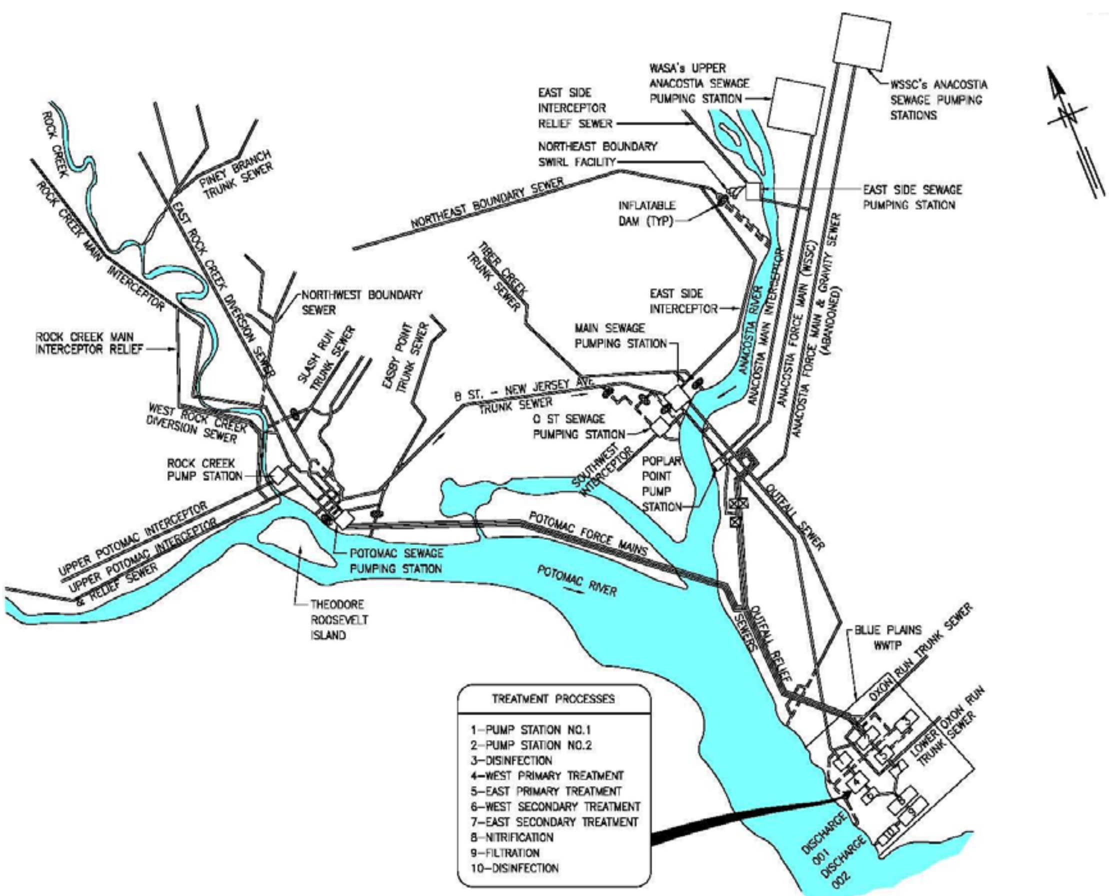


Figure 5-1. Sewer System Schematic

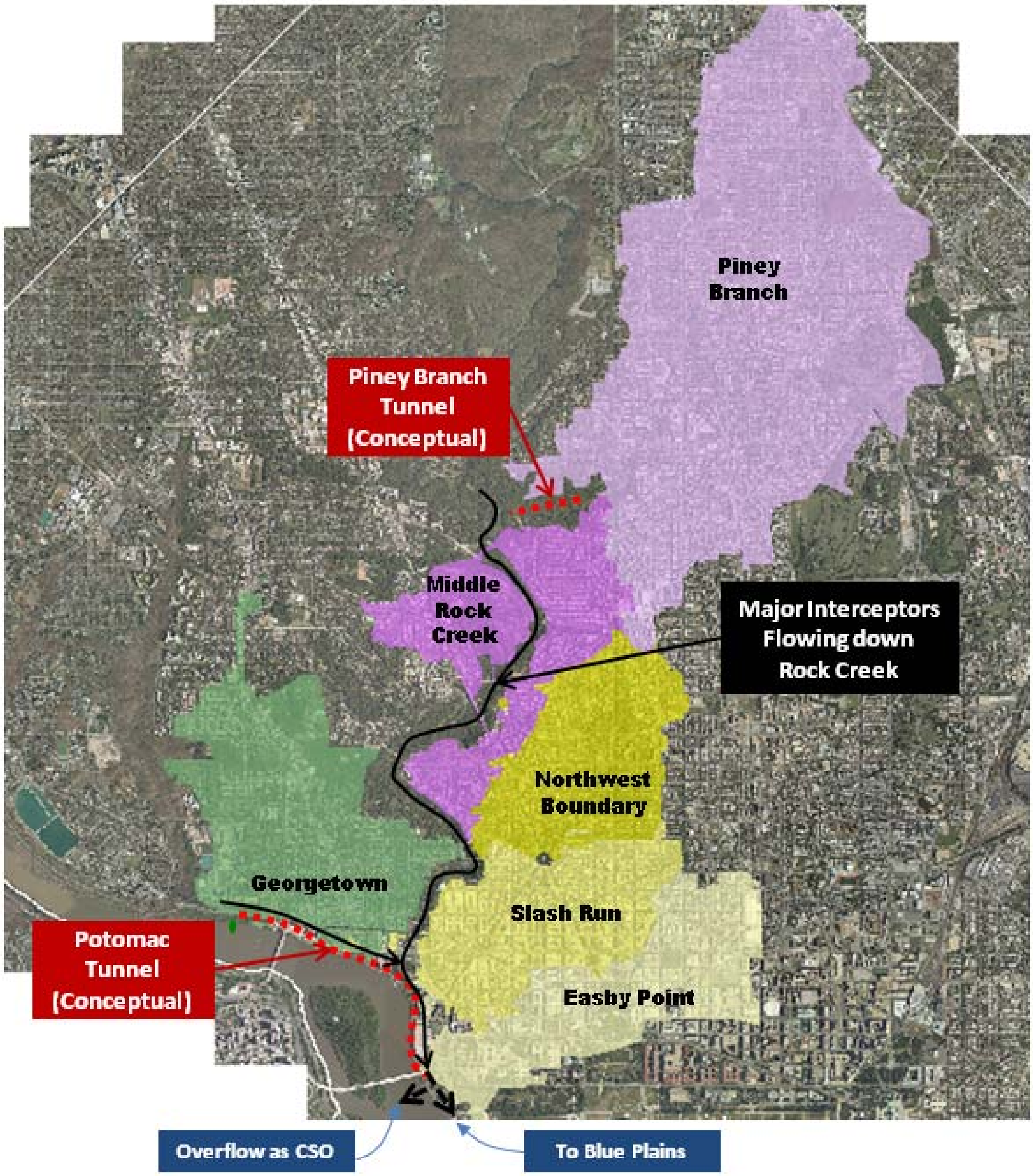


Figure 5-2. Drainage Areas Serving Potomac and Piney Branch Storage Tunnels

Once the GI and gray facilities were sized using the model, cost estimates were prepared for the coupled gray and green controls required to meet various degrees of CSO control.

5.2.2 Results

The predicted sizing of the gray facilities, the CSO control performance and the estimated costs are shown in Table 5-1. For various levels of GI application, the gray CSO controls were sized to provide the same degree of control as the LTCP (4 overflows/average year on the Potomac and 1 overflow/average year at Piney Branch), as well as 12 overflows per average year. This was done to assess the range of response in the system. As part of the demonstration projects, DC Water will evaluate the predicted water quality in the receiving water of various GI/gray controls.

Table 5-1. Scenario 1 Results

Green								Gray						Green + Gray	
				Unit Cost ($M/Ac.)		Cost Range ($M)		CSO predictions (Av Yr)		Tunnel		Cost Range ($M)		Total Cost ($M)	
% GI	Total Ac.	Imp Ac.	Imp Ac. Tr'd	Low	High	Low	High	# CSOs	Vol. (mg)	Vol. (mg)	Dia. (ft)	Low	High	Low	High
Potomac															
0% LTCP	5,488	3,283	-	-	-	-	-	4	79	58	33	475	772	475	772
15%	5,488	3,283	492	0.11	0.46	55	230	4	65	45	30	437	710	492	940
15%	5,488	3,283	498	0.11	0.46	55	230	12	170	18	19	358	581	413	811
30%	5,488	3,283	985	0.15	0.60	150	600	4	60	34	26	405	658	555	1,257
30%	5,488	3,283	985	0.15	0.60	150	600	12	165	17	18	354	575	503	1,174
Piney Branch															
0% LTCP	2,329	1,215	-	-	-	-	-	1	0.9	8	22	114	174	114	174
15%	2,329	1,215	182	0.11	0.44	20	81	1	0.8	5.5	18	88	135	108	215
15%	2,329	1,251	182	0.11	0.44	20	81	12	15	0.8	7	54	81	74	162
30%	2,329	1,251	365	0.12	0.50	46	182	1	1	4.5	17	85	130	131	312
30%	2,329	1,251	365	0.12	0.50	46	182	12	13	0.5	6	48	72	93	255

Figures 5-3 and 5-4 show the estimated cost ranges for each of the alternatives for GI implementation as compared with the LTCP. The data show that the estimated cost ranges for hybrid green/gray solutions are within the same cost range as the LTCP, given the accuracy with which costs can be predicted at this time.

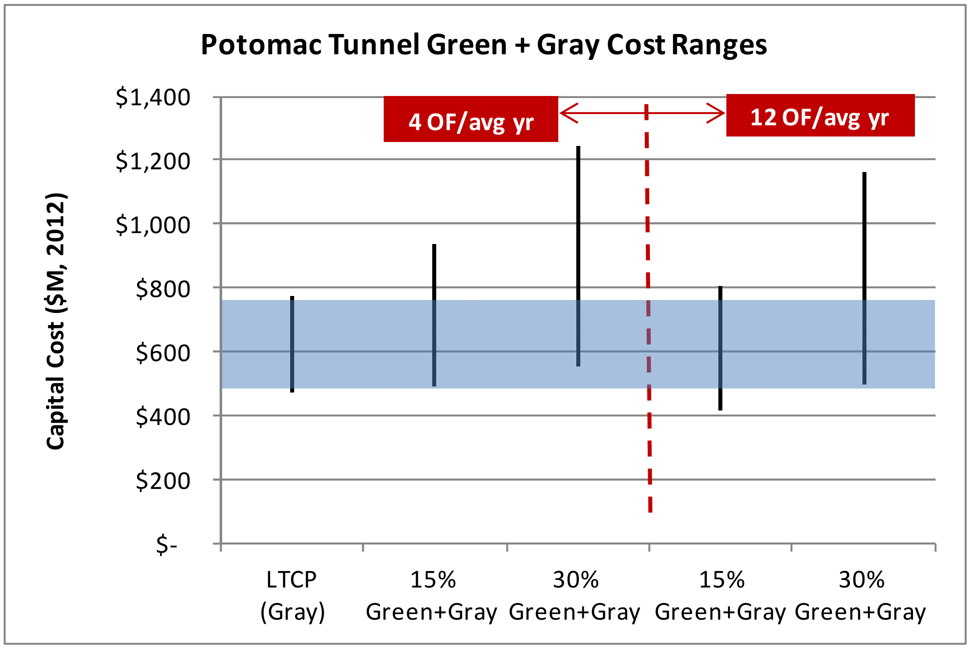


Figure 5-3. Cost Ranges for Potomac GI and Gray Infrastructures

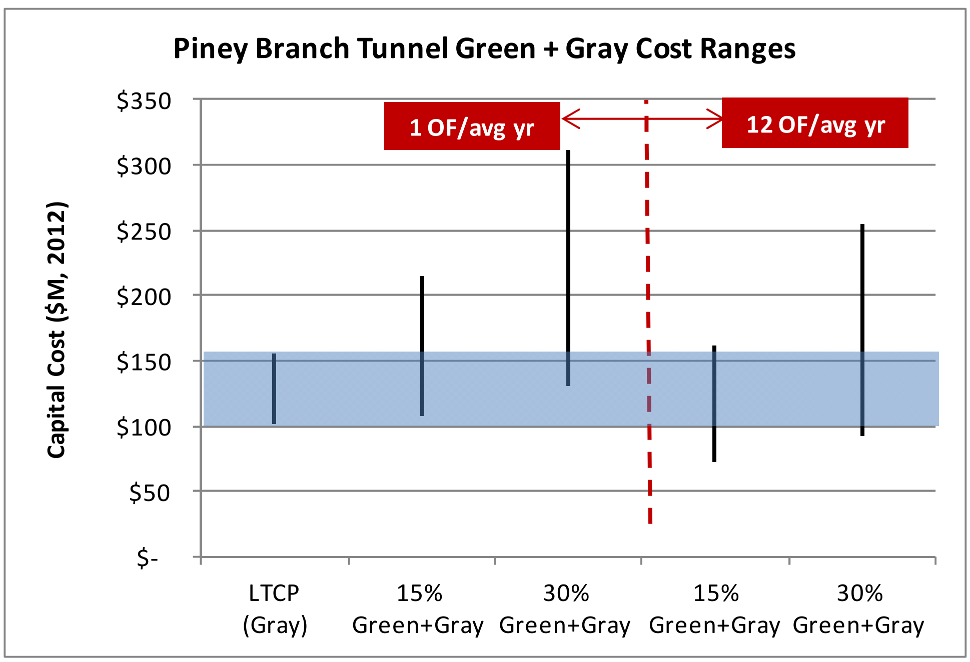


Figure 5-4. Cost Ranges for Piney Branch GI and Gray Infrastructures

The basis for these cost estimates are provided in Appendix B, and the detailed cost estimates are provided in Appendix C.

5.3 Scenario 2A – GI and Alternative Gray Controls For Potomac River

5.3.1 Description

The LTCP requires the rehabilitation of Potomac Pumping Station, consolidation of CSO's 023 through 028, and construction of a 58 million gallon storage tunnel from Georgetown to Potomac Pumping Station to control CSOs. Figure 5-5 shows how the Potomac Tunnel and associated facilities connect with Blue Plains schematically. The figure also shows the Blue Plains Tunnel, Blue Plans Tunnel Dewatering Pumping Station and Enhanced Clarification Facility (high rate treatment) being constructed at Blue Plains.

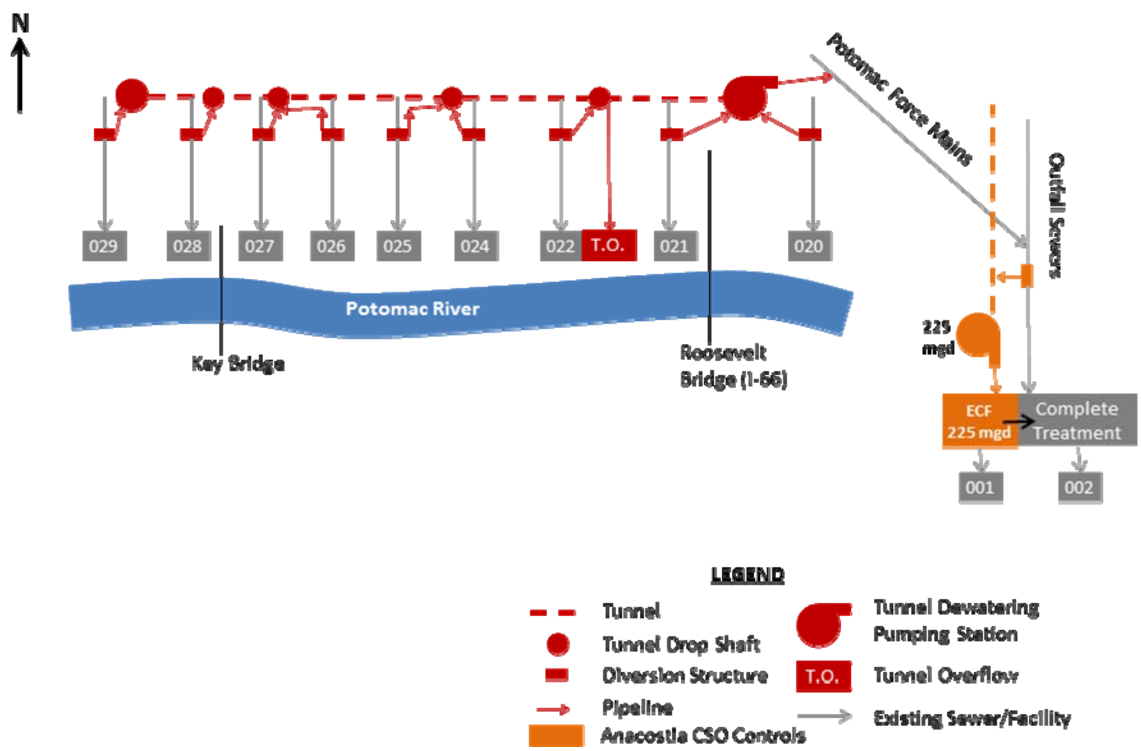


Figure 5-5. LTCP Potomac Tunnel Schematic

The scenario for alternative gray controls for the Potomac is based on the following concepts:

- Maximize Tunnel Storage through Treatment During Rain Events
  The LTCP was based on dewatering the Potomac Tunnel after the rain event with a maximum dewatering time of 59 hours. This made it difficult to empty the tunnel due to back to back rain events, resulting in the need to add storage volume. As part of the TN/WW Plan, DC

Water is constructing the Blue Plains Tunnel, a 225 mgd Blue Plains Tunnel Dewatering Pumping Station (BPTDPS) and a 225 mgd ECF facility. The BPTDS is being designed to be expandable to 500 mgd by adding pumps. Similarly, the ECF is being configured to be expandable to 500 mgd by adding modular treatment units. For this alternative, the Potomac Tunnel dewatering rate was increased from 60 mgd to 300 mgd, and dewatering logic was programmed so that the tunnel could be dewatered whenever the combined flow in the Potomac Force Mains was less than 400 mgd. The BPTDPS dewatering rate was also increased to 300 mgd from 225 mgd, and the ECF capacity was increased to 300 mgd from 225 mgd. The net effect of these changes is to maximize space in the tunnel for storage during back to back rain events and during large rain events.

- Use the Gray Controls to Intercept the Largest CSOs
  The largest CSOs on the Potomac are CSO 020, 021, 022 and 024. These are the outfalls at the end of the major interceptors serving Rock Creek and the large downtown drainage areas in the Potomac. This alternative therefore routes the tunnel to intercept these CSOs, thereby shortening its length, but also increasing its diameter.

- Use GI and Alternative Gray Controls for Smaller CSOs
  This alternative uses GI and sewer separation to address the farthest upstream CSOs on the Potomac. Because they have relatively small drainage areas, this alternative involves separating CSO 025 and 026. CSO 027, 028 and 029 are controlled using GI in accordance with the application rates in Table 5-2.

Table 5-2. GI Application Rates for CSO 027, 028 and 029

CSO Outfall No.	% GI Application for 4 CSO Overflows/avg yr	% GI Application for 12 CSO Overflows/avg yr
027	30%	15%
028	30%	15%
029	60%	30%

Because of the built-up and dense development in CSO 027's sewershed, it is anticipated that GI by itself will not provide the degree of control necessary. As a result, the cost estimates prepared for this alternative include allowances for constructing a diversion to the Upper Potomac Interceptor Relief Sewer to provide the necessary degree of CSO control.

Figure 5-6 shows the GI and Alternative Gray Controls schematically and Figure 5-7 shows the controls on a site plan.

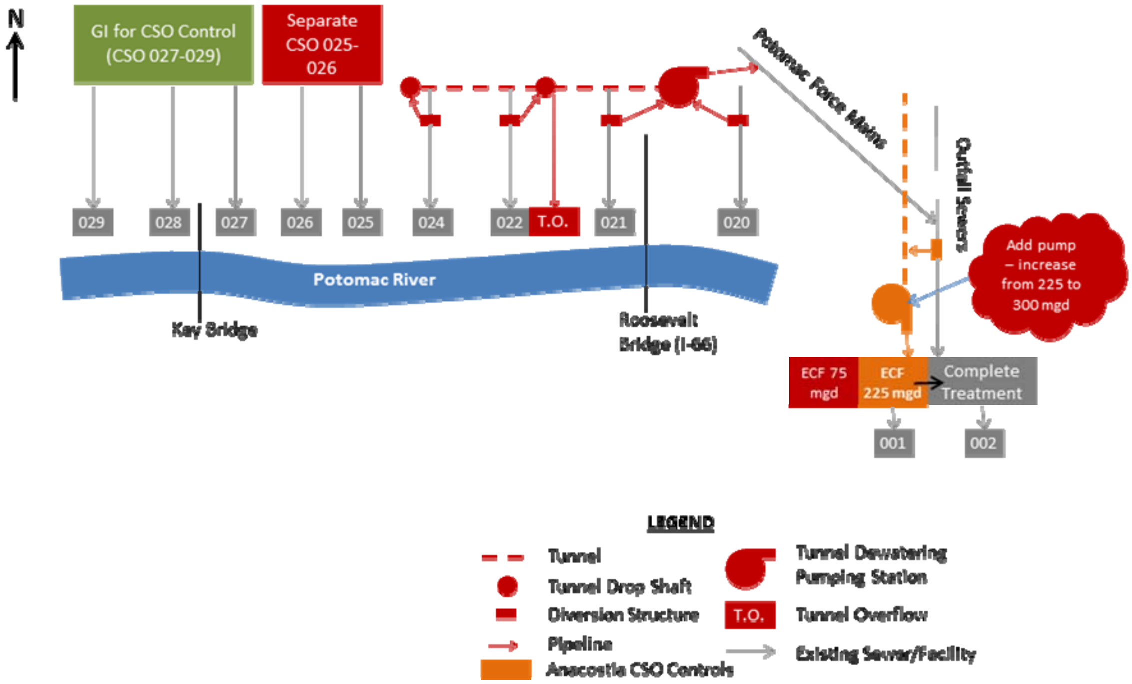


Figure 5-6. Green and Alternative Gray Controls for Potomac River

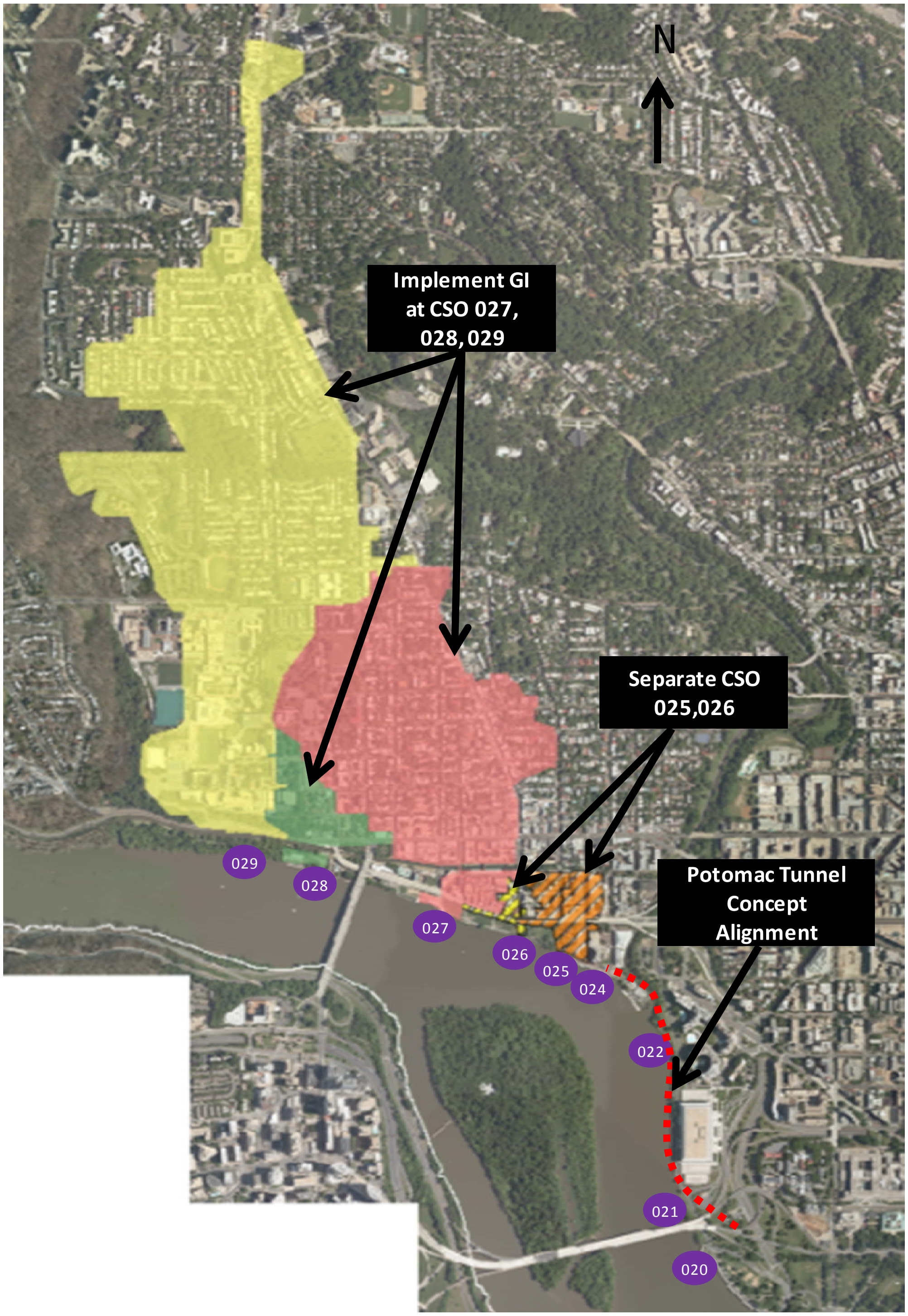


Figure 5-7. Green and Alternative Gray Controls for Potomac River

5.3.2 Results

The predicted sizing of the gray facilities, the CSO control performance and the estimated costs are shown in Table 5-3. For various levels of GI application, the gray CSO controls were sized to provide the same degree of control as the LTCP (4 overflows/average year), as well as 12 overflows per average year.

Table 5-3. Scenario 2A Results

Green for CSO 027, 028 and 029															Gray						Green + Gray	
											Unit Cost ($M/imp ac)		Cost range ($M)		CSO Predictions (Avg yr)		Tunnel		Cost Range ($M)		Total Cost ($M)	
Line	% GI	CSO 027 Imp. ac	CSO 027 %GI	CSO 028 Imp. ac	CSO 028 %GI	CSO 029 Imp ac	CSO 029 %GI	Total Acres	Imp Acres	Imp Ac Treated	Low	High	Low	High	# CSOs	Vol (mg)	Vol. (mg)	Dia (ft)	Low	High	Low	High
1	0%							5,488	3,283						4	79	58	33	475	772	475	772
2	Varies	104	30%	13	30%	164	60%	515	281	134	$0.11	$0.44	$15	$59	4	71	21	28	466	758	481	817
3	Varies	104	15%	13	15%	164	30%	515	281	67	$0.11	$0.44	$7	$29	12	209	9	18	322	523	329	552

Figures 5-8 shows the estimated cost ranges for the alternatives for GI implementation as compared with the LTCP. The data show that the estimated cost ranges for hybrid green/gray solutions are within the same cost range as the LTCP, given the accuracy with which costs can be predicted at this time.

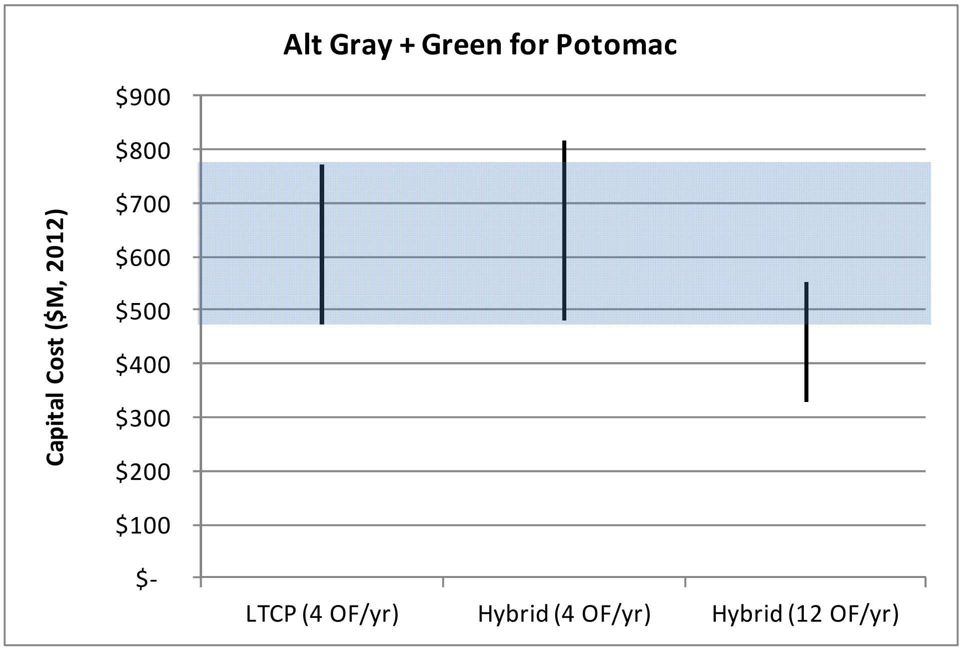


Figure 5-8. Cost Ranges for Green and Alternative Gray Controls for Potomac River

5.4 Scenario 2B – GI and Alternative Gray Controls For Piney Branch

5.4.1 Description

Because of the large diversion capacity of the sewers in Rock Creek, Piney Branch has a relatively small CSO volume and a low is w activation frequency. Depending on the degree of implementation, GI can eliminate for greatly reduce the size of the gray CSO controls.

With GI implemented, remaining CSO volume to be captured by the gray controls becomes so small that it is neither practical nor cost effective to construct tunnel storage. As a result, the alternative controls evaluated for this scenario consisted of:

- Implementing GI at a rate of 30% of the impervious area at 1.2" capture
- Increasing the weir height at the existing diversion chamber to divert more flow to the interceptor
- Constructing a small storage basin to control any remaining CSOs

Figure 5-9 shows the conceptual tunnel layout from the LTCP, while Figure 5-10 shows the alternative gray controls when coupled with GI.

Figure 5-9. Piney Branch Tunnel Concept from LTCP

Figure 5-10. Green and Alternative Gray Controls for Potomac River

5.4.2 Results

The predicted sizing of the gray facilities, the CSO control performance and the estimated costs are shown in Table 5-4. For various levels of GI application, the gray CSO controls were sized to provide the same degree of control as the LTCP (1 overflows/average year, as well as 12 overflows per average year.

Table 5-4. Scenario 2B Results

Green								Gray						Green + Gray	
				Unit Cost ($M/Ac.)		Cost Range ($M)		CSO Predictions (Av Yr)		Tunnel		Cost Range ($M)		Total Cost ($M)	
% GI	Total Ac.	Imp Ac.	Imp Ac. Tr'd	Low	High	Low	High	# CSOs	Vol. (mg)	Vol. (mg)	Dia. (ft)	Low	High	Low	High
0% (LTCP)	2,329	1215	-	-	-	-	-	1	0.9	8.0	22	114	174	114	174
30%	2,323	1215	365	0.12	0.50	45	91	1	1.0	2.5	N/A	44	68	90	250
30%	2,329	1215	365	0.12	0.50	46	91	12	13.0	0.5	N/A	13	20	58	202

Figures 5-11 shows the estimated cost ranges for the alternatives for GI implementation as compared with the LTCP. The data show that the estimated cost ranges for hybrid green/gray solutions are within the same cost range as the LTCP, given the accuracy with which costs can be predicted at this time.

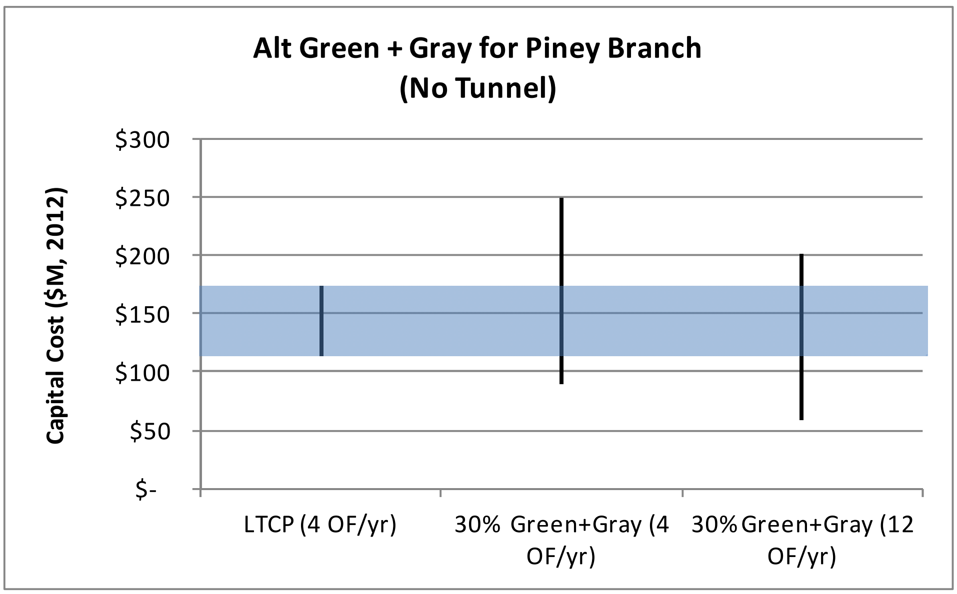


Figure 5-11. Cost Ranges for Green and Alternative Gray Controls for Piney Branch

5.5 Scenario 3 – Turner Construction Pervious Pavement Proposal

5.5.1 Background

Turner Construction submitted an unsolicited proposal to DC Water titled *Conceptual Process to Expedite, Fund, and Execute a Cleanup Program for the Anacostia River*, March 10, 2011. The Turner proposal outlines an overall plan to clean up the Anacostia River, including CSO's. The elements of the plan as identified in the proposal are summarized in Table 5-5.

Table 5-5. Summary of Turner Construction Proposal Elements

No.	Item	Cost per Turner Plan ($ M)	Purpose
1	Conceptual planning and sampling	$0.9	
2	Pilot programs	$20.0	Not germane to GI. To develop a method for handling and disposing of material dredged from the Anacostia River
3	Dredging operations	$200.0	Not germane to GI. Remove contaminated sediments from Anacostia.
4	Plant construction	$25.0	Not germane to GI.
5	Capping operations in river	$20.8	Not germane to GI. Cap contaminated sediments in Anacostia.
6	Six site cleanup, improvements, etc.	$194.0	Not germane to GI.
7	Pervious roadways, alleys, parking	$910.4	CSO control
8	Contingencies, escalation, agencies	$298.2	
9	Overhead, insurance, bond, fees	$165.2	
10	Total	$1,834.5	

Item No. 7 in the plan is called the Green Storage System and is described as follows:

- Scope:
  - Construct pervious pavement roadways and alleys with a deep bed gravel system to store rainwater. System would release water to the combined sewer system (CSS) at a rate Blue Plains could handle.
  - Porous pavement system would be constructed on residential streets and alleys and other impervious areas, not major thoroughfares.
  - Capable of storing 250 million gallons (mg). For comparison the entire Anacostia, Potomac, and Rock Creek Tunnels have a storage volume of 224.5 mg.
  - Includes the use of a high speed paver laying process.
- Schedule:
  - The proposal indicates the Green Storage System could be completed in the range of 2017-2021.

5.5.2 Results

The Turner Construction proposal calls for work to be performed in the residential streets. The GIS system was used to analyze the location of primary roads, secondary roads and alleys in the District. Figure 5-12 and Table 5-6 summarize the results from the GIS.

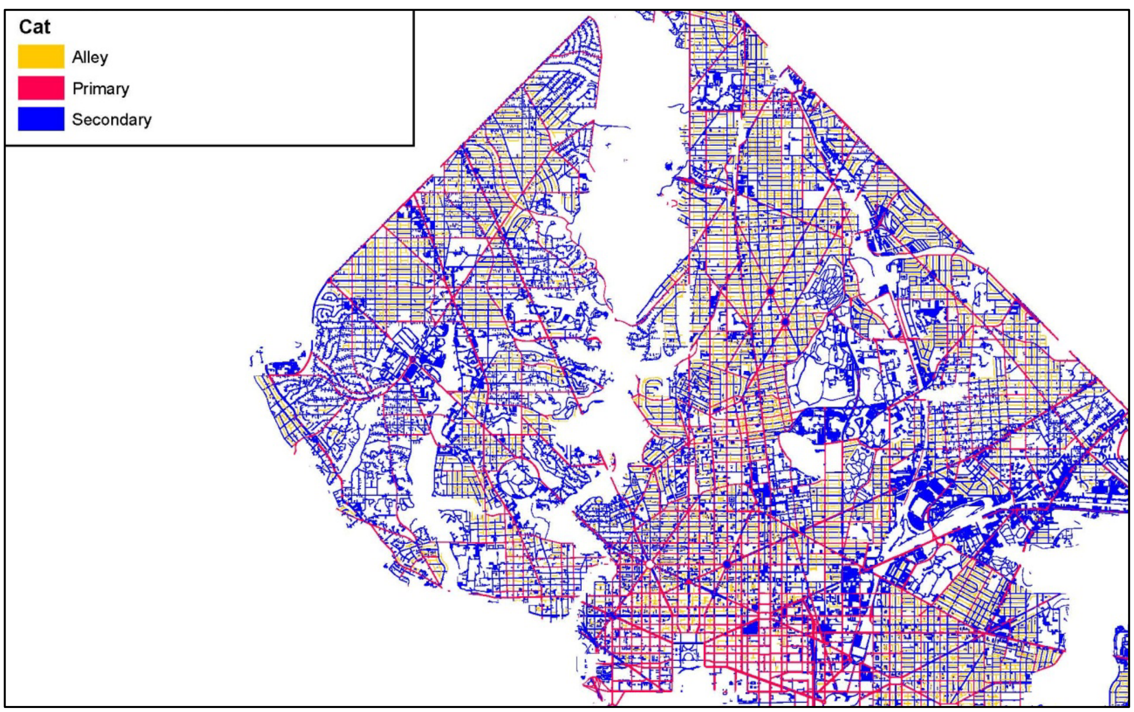


Figure 5-12. Roads and Alleys in DC

Table 5-6. Roadway Areas Available in CSO Areas

Parameter	Potomac CSS	Piney Branch CSS
Total Drainage Area (ac)	5,488	2,329
Impervious Drainage Area (ac)	3,283	1,215
Alleys (ac)	182	103
Secondary Roads (ac)	773	341
Subtotal (Alleys +Secondary Roads) (ac)	955 (29% of Imp. Area)	444 (37% of Imp. Area)
Primary Roads (ac)	452	133
Grand Total Roads	**1,407 (42% of Imp. Area)**	**577 (47% of Imp. Area)**

The Turner Construction proposal did not have a detailed breakdown of how the proposed costs were derived or what typical costs used were, such as $/sf, $/acre, or $/gallon stored. By back calculating numbers, it appears that the proposal used costs of approximately $22/sf, $976,000/acre, and $5/gallon stored. The calculations to determine the costs used can be found in Appendix C. Using these costs and the associated roadway areas, the storage volume and cost for the Turner Construction proposal can be found in Table 5-7.

Table 5-7. Turner Construction Proposal Storage Volume and Cost

Item	Potomac	Piney Branch
LTCP Tunnel Storage Volume (mg)	58	9.5
LTCP Cost Range ($M) (-20%/+30%)	$493 - $801	$102 - $156
Alleys + Secondary Roads (ac)	955	444
Acres required to achieve LTCP storage at 0.2 mg/ac	290 (30%)	48 (11%)
Green Storage System Cost @ $976,000/ac ($M)	$283	$47

While not as well defined as the other scenarios, the Turner Proposal illustrates there are innovative green alternatives to providing CSO control that merit further evaluation.

5.6 Scenario 4 – GI Plus Challenge Program Plus MS4 Permit Program

5.6.1 Description

This scenario looks into the future to predict the impact of current and future programs. It includes the following major components:

- GI Implementation
  This scenario includes implementation of GI on a large scale in the CSO area. A 30% implementation rate on impervious area was assumed.

- Challenge Program
  In the early stages of development for new technologies, costs are often high, while performance or capacity can be variable. GI is in the early stages of development. As a growing number of universities and government programs engage in research that supports the design and implementation of GI, the advancement of existing GI performance and development of new more effective GI will drive costs ever lower, while improving performance. Five or ten years from now, as GI projects are readied for design or construction in the Potomac and Piney Creek sewersheds, new more efficient green technologies may be utilized, that are not available today.

  A potential way to foster competition and stretch the limits of green technology would be for DC Water to sponsor a Green Infrastructure Challenge Program. The Green Infrastructure Challenge Program would solicit proposals from interested parties (government, universities, and private entities such as businesses) to find cost effective solutions to water quality and stormwater issues while blending green and gray technologies. The Challenge Program would utilize the storage capacity of the GI to eliminate or reduce the scope of gray infrastructure. The remaining hybrid green-gray blend would meet all water quality standards, but also provide sustainable ancillary benefits for the community for the same, or even lesser, cost of gray infrastructure alone. Figure 5-13 below demonstrates how a Challenge Program may be organized, who would be involved in the decision making process, how the project may be funded and ultimately how the advanced green technology and reduced gray infrastructure can meet all water quality needs.

  For this analysis, the challenge program and other advancements in the state of the art was assumed to improve GI capture rate by 50% over current performance.

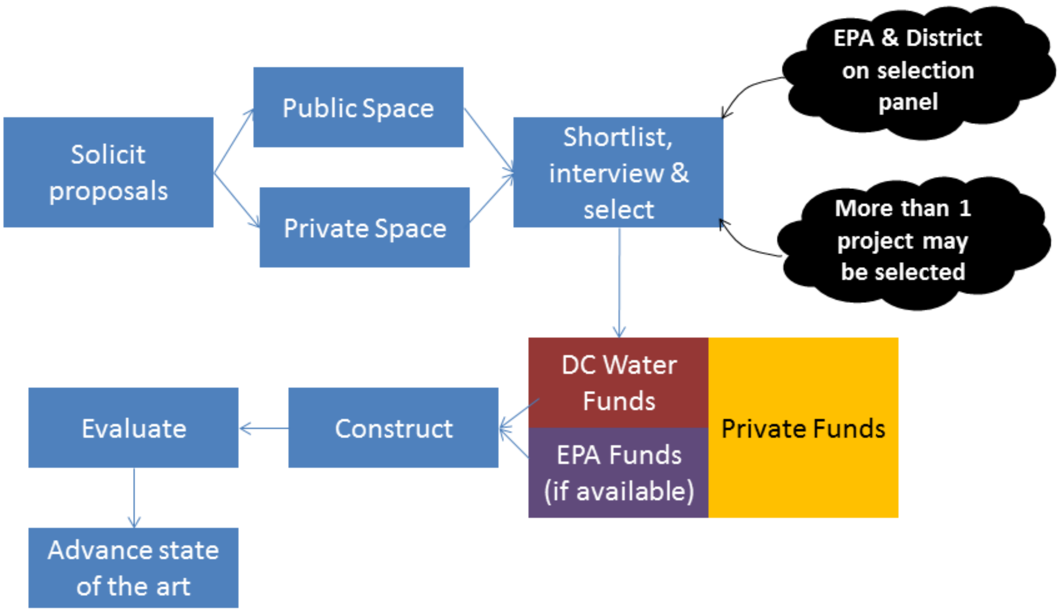
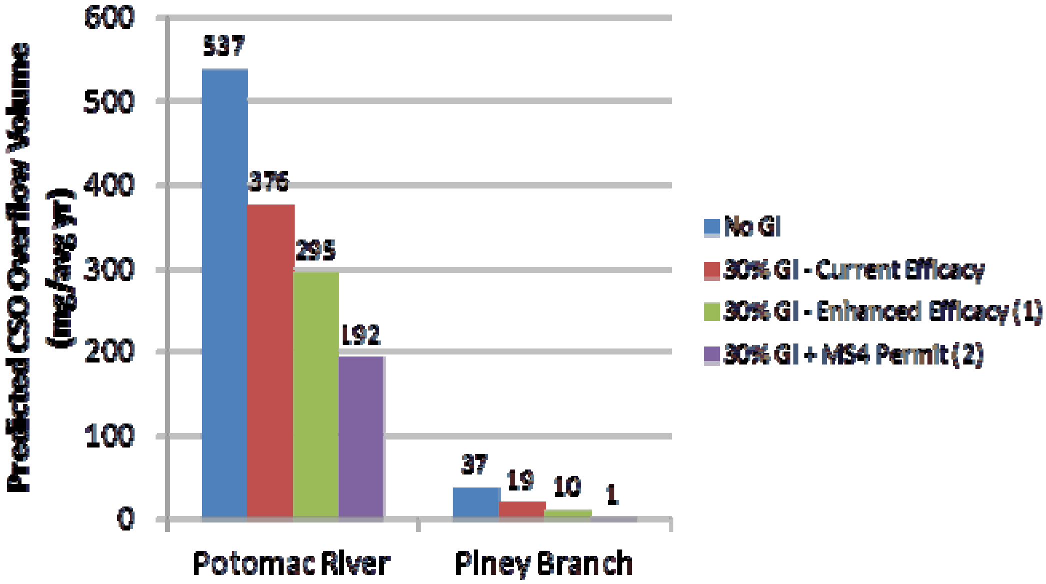


Figure 5-13. Challenge Program Conceptual Approach

- MS4 Permit Implementation
  The new MS4 permit issued to the District requires capture of the first 1.2" from private and non-Federal development/redevelopment, and the first 1.7" from Federal properties. The District is applying these storm water capture requirements in both the combined and separate sewer area. Over time, as new development and redevelopment occur, these requirements will substantially increase the reduction of runoff in the CSO area using GI and other techniques. For this analysis, it was assumed that the MS4 permit requirements would result in the coverage of an additional 30% of impervious area at 1.2" capture over time.

5.6.2 Results

Figure 5-14 below shows how future advancements in green infrastructure could provide CSO reduction in the Potomac and Piney Branch sewersheds. The results show that the predicted Potomac CSOs are close to the degree of control provided by the gray CSO controls (remaining CSOs of 192 mg/avg yr vs. 79 mg/avg yr for LTCP). For Piney Branch, the Scenario 4 controls are predicted to achieve the same degree of control as the LTCP.



Notes:

1. Assumes GI effectiveness enhanced by 50% due to new technology/advancements
2. Assumes MS4 Permit covers additional 30% of impervious area at 1.2" over time

Figure 5-14. Scenario 4 Potential Impacts

6 Findings

The tunnel projects for the Potomac River and Rock Creek are later in the schedule and facility planning for those projects is scheduled to start in 2015 and 2016, respectively. For CSO control in the Potomac and Rock Creek, there is an opportunity to implement GI. GI projects may allow downsizing or elimination of the tunnels, or may be coupled with a different type of gray infrastructure to provide control of CSOs. In addition, GI may offer other societal and economic benefits to the District. The purpose of this technical memorandum is to assess the feasibility of implementing GI by itself or in combination with gray infrastructure in order to control CSOs. The following are findings of this report:

- The magnitude of the investment required to control CSOs in the Potomac and Rock Creek sewersheds is large, more than $800 M in 2012 dollars and more than $1 billion at the time of disbursement.

- In addition to reducing runoff which is the direct cause of CSOs, GI offers other social, economic and environmental benefits to the District beyond that of conventional gray infrastructure

- GI is a relatively new technology and has not been commonly applied on a large scale for CSO control in a developed city. The practicability and long term effectiveness of GI for CSO control is not proven to a sufficient degree given the magnitude of investment required for GI to control CSOs in the Potomac and Rock Creek.

- Four scenarios have been identified that include either all green or green/gray hybrid solutions to provide CSO control for the Potomac River and Rock Creek. The scenarios include alternatives providing the same degree of control as the LTCP as well as different degrees of control.

- The four scenarios identified in this report are not the only alternatives to provide green and green/gray solutions for CSO control. Combinations of the identified scenarios and other scenarios exist and these remain to be evaluated.

- The estimated cost of the alternative green and green/gray solutions is within the cost range predicted for the LTCP, based on the accuracy of current estimates.

- In order to generate the necessary information to refine the uncertainty associated with GI, DC Water proposes to plan, design, and construct GI demonstration projects on a large scale to evaluate the practicality and efficacy of GI for CSO control.

- Since this Screening Analysis has demonstrated that there are viable green and green/gray hybrid solutions to CSO control, it is worth implementing the demonstration projects to develop the information necessary to evaluate and select the CSO control plans for the

Potomac and Rock Creek that will provide the best overall environmental and ancillary benefits that would be realized through the use of GI on a large scale.

Appendix - A
Sewershed Characterization

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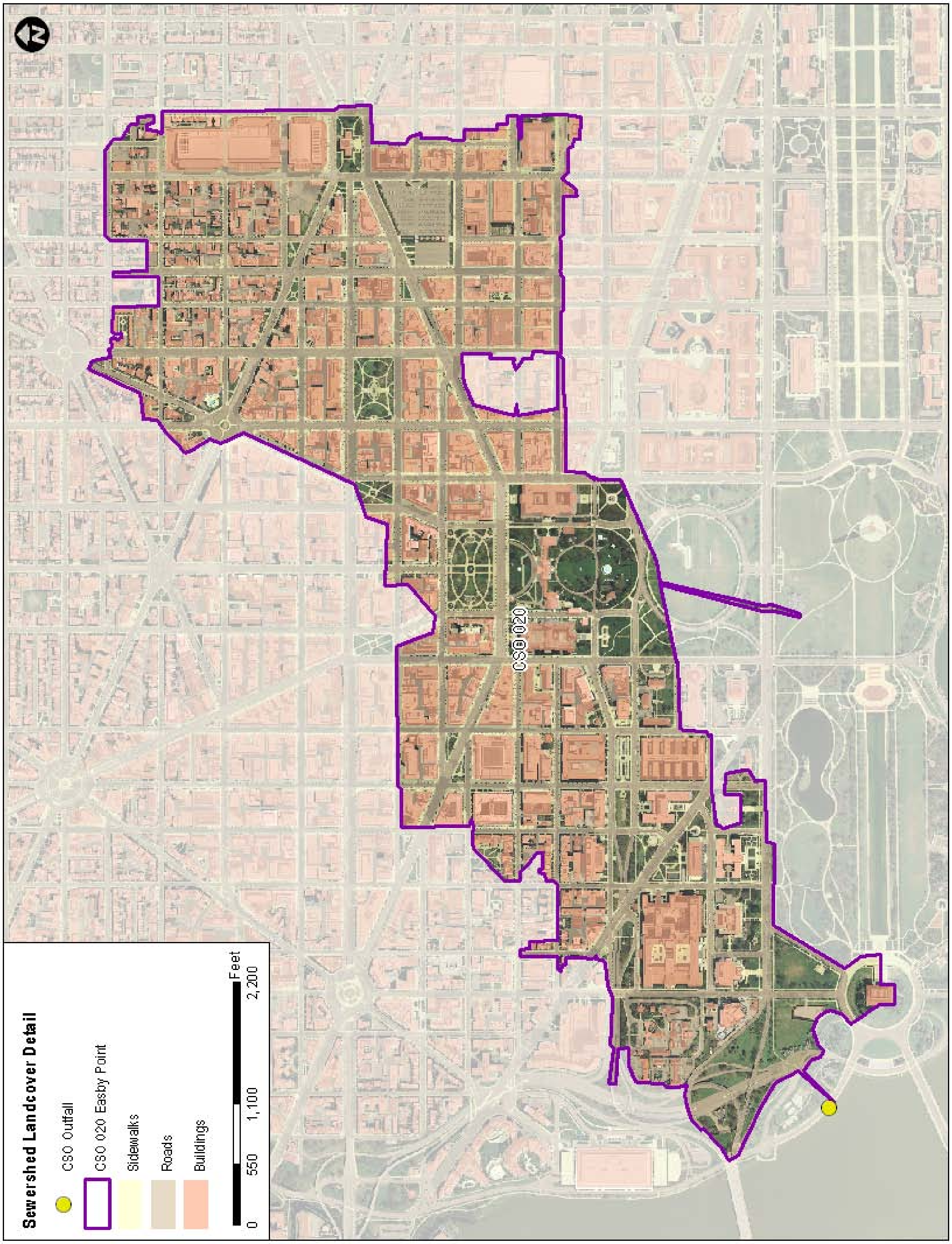

Figure A-1. Sewershed Characteristics - CSO 020, Easby Point

Figure A-2. Sewershed Characteristics - CSO 021, Potomac Pumping Station

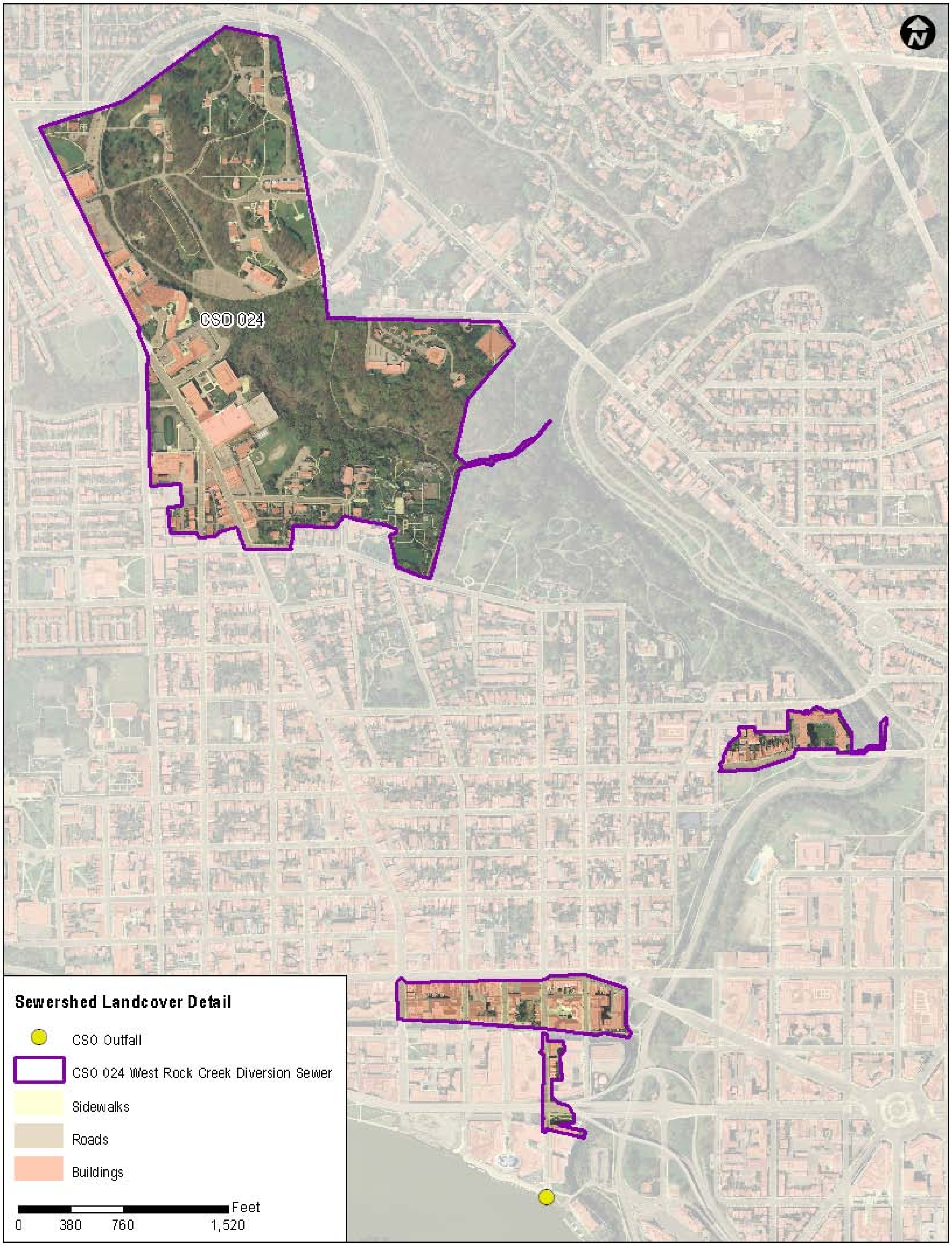

Figure A-3. Sewershed Characteristics - CSO 024, West Rock Creek Diversion Sewer

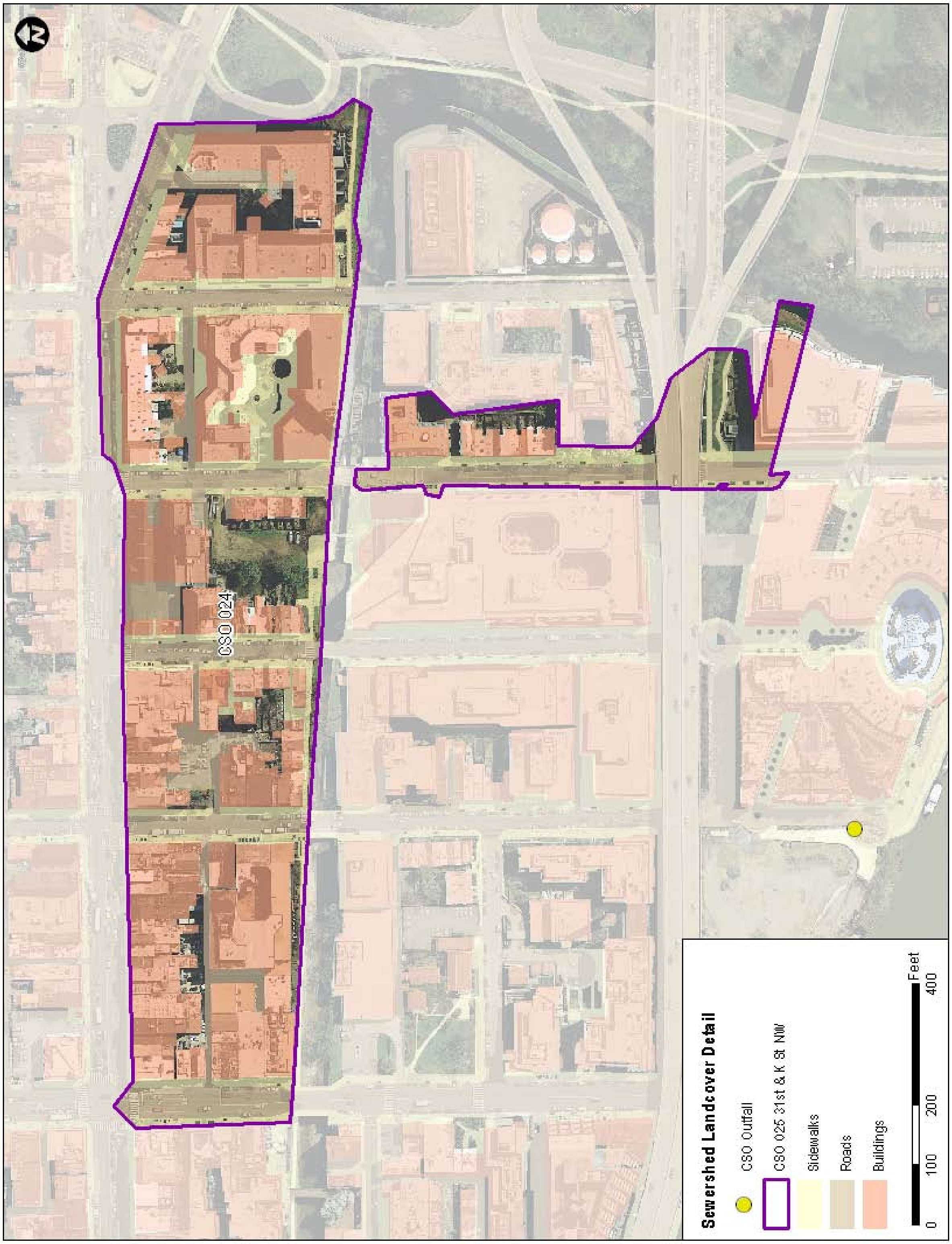

Figure A-4. Sewershed Characteristics - CSO 025, 31st & K St NW

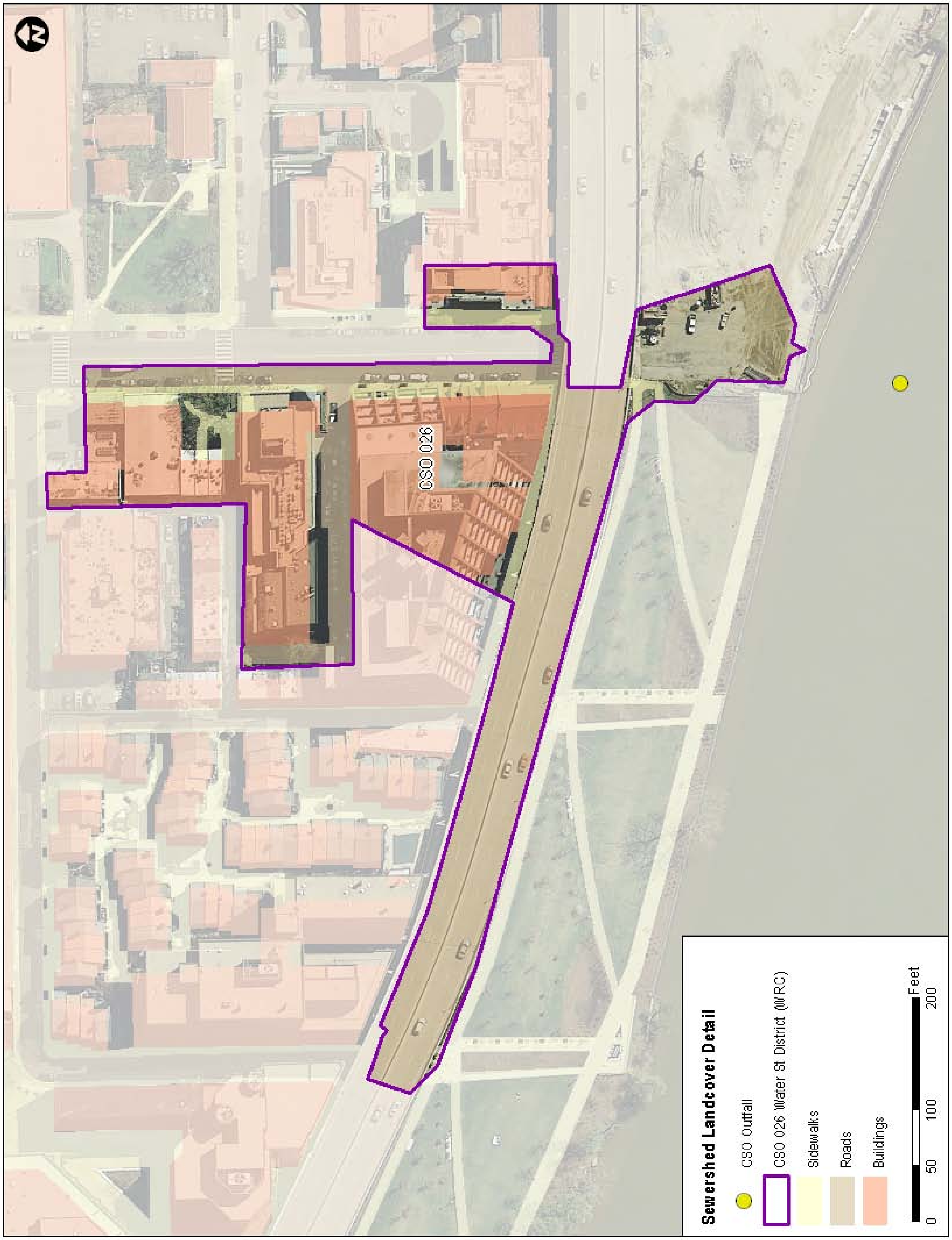

Figure A-5. Sewershed Characteristics - CSO 026, Water St District (WRC)

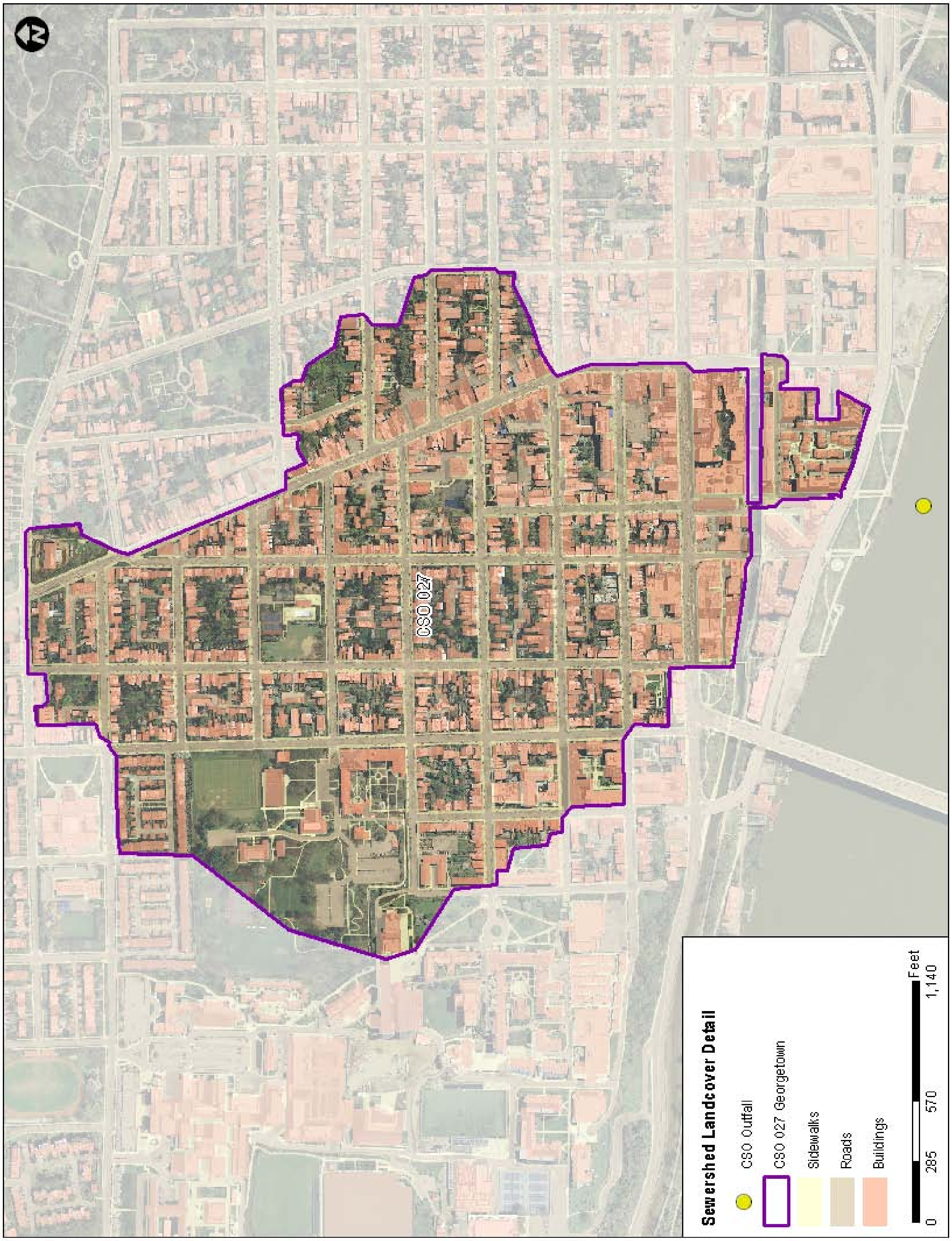

Figure A-6. Sewershed Characteristics - CSO 027, Georgetown

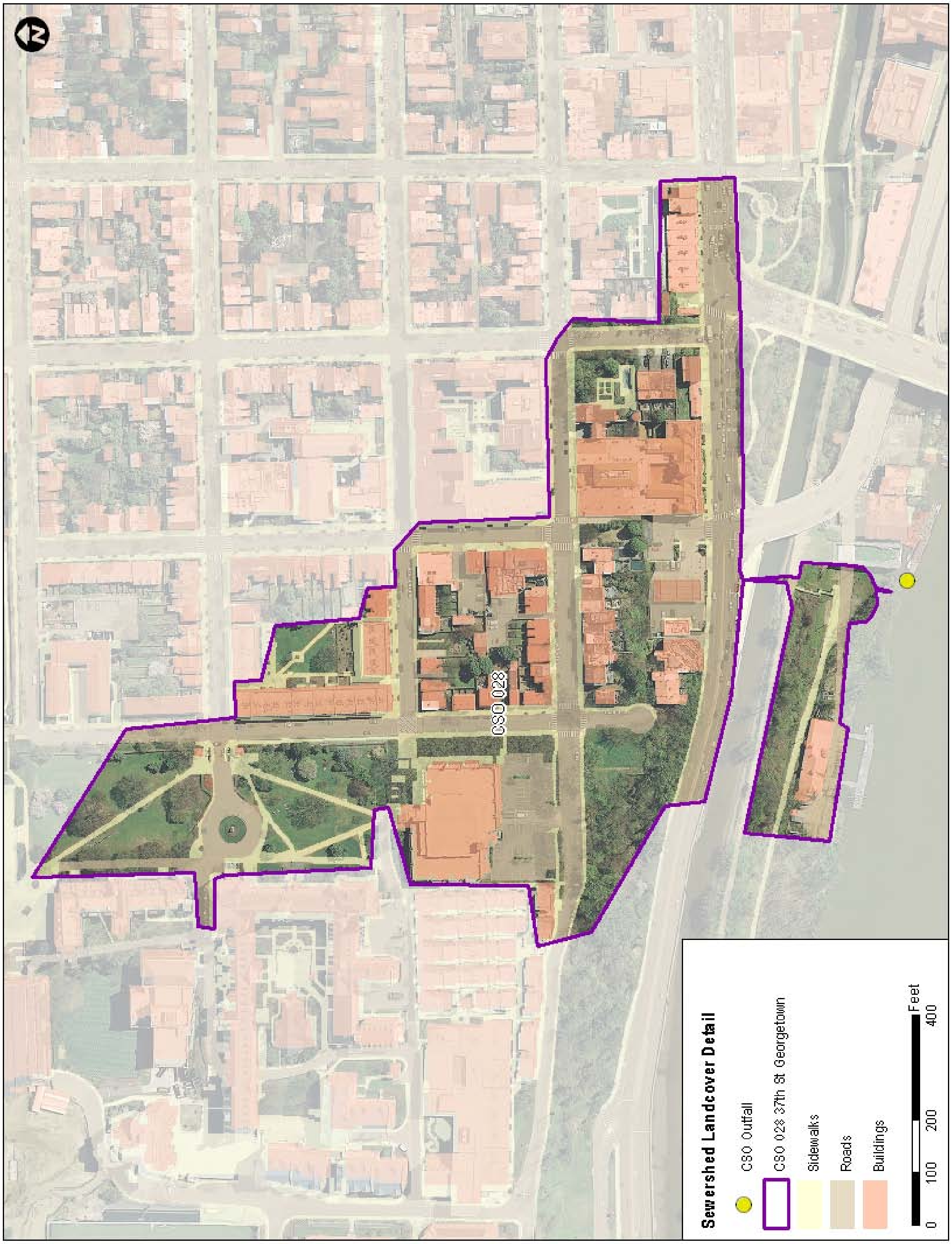

Figure A-7. Sewershed Characteristics - CSO 028, 37th St - Georgetown

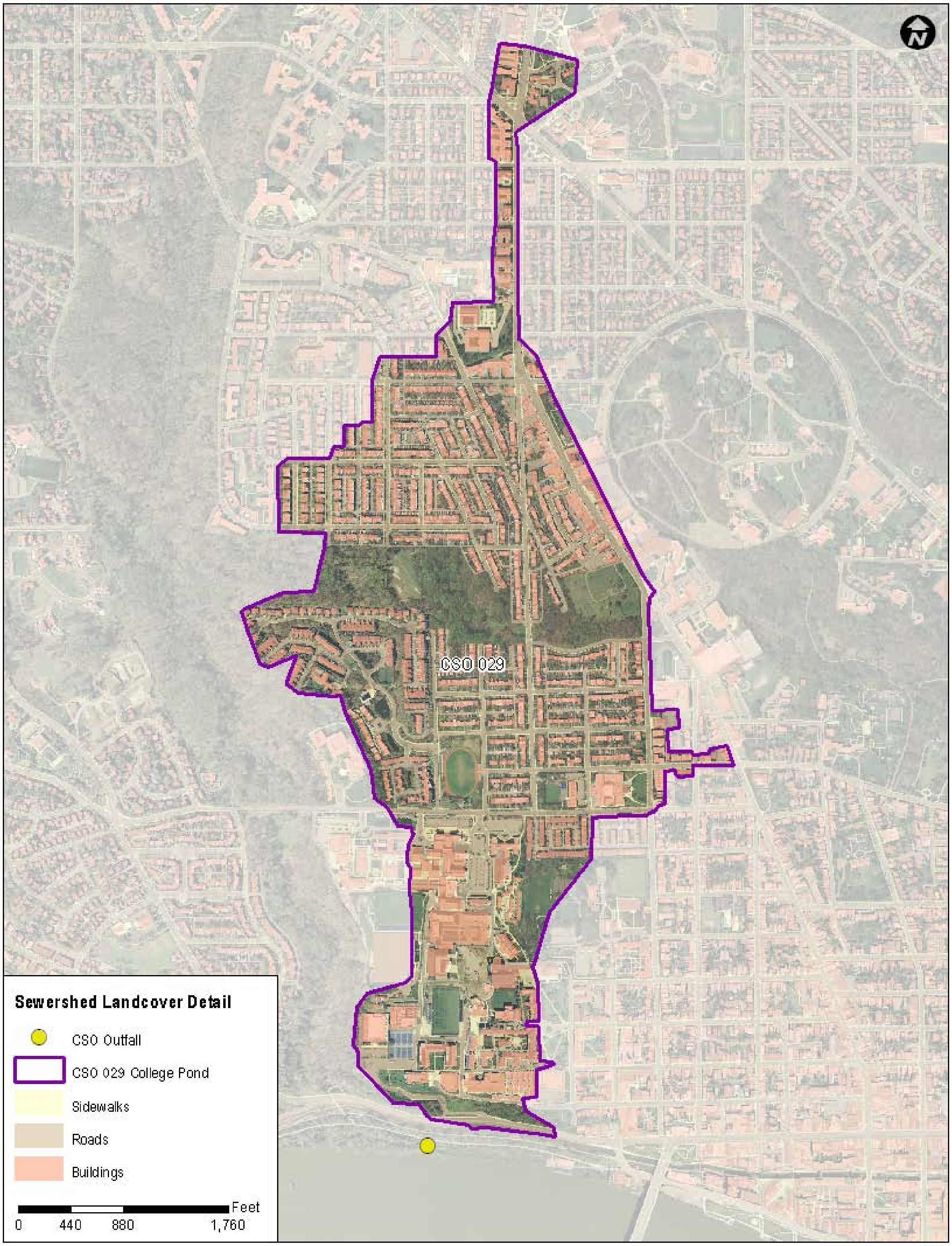

Figure A-8. Sewershed Characteristics - CSO 029, College Pond

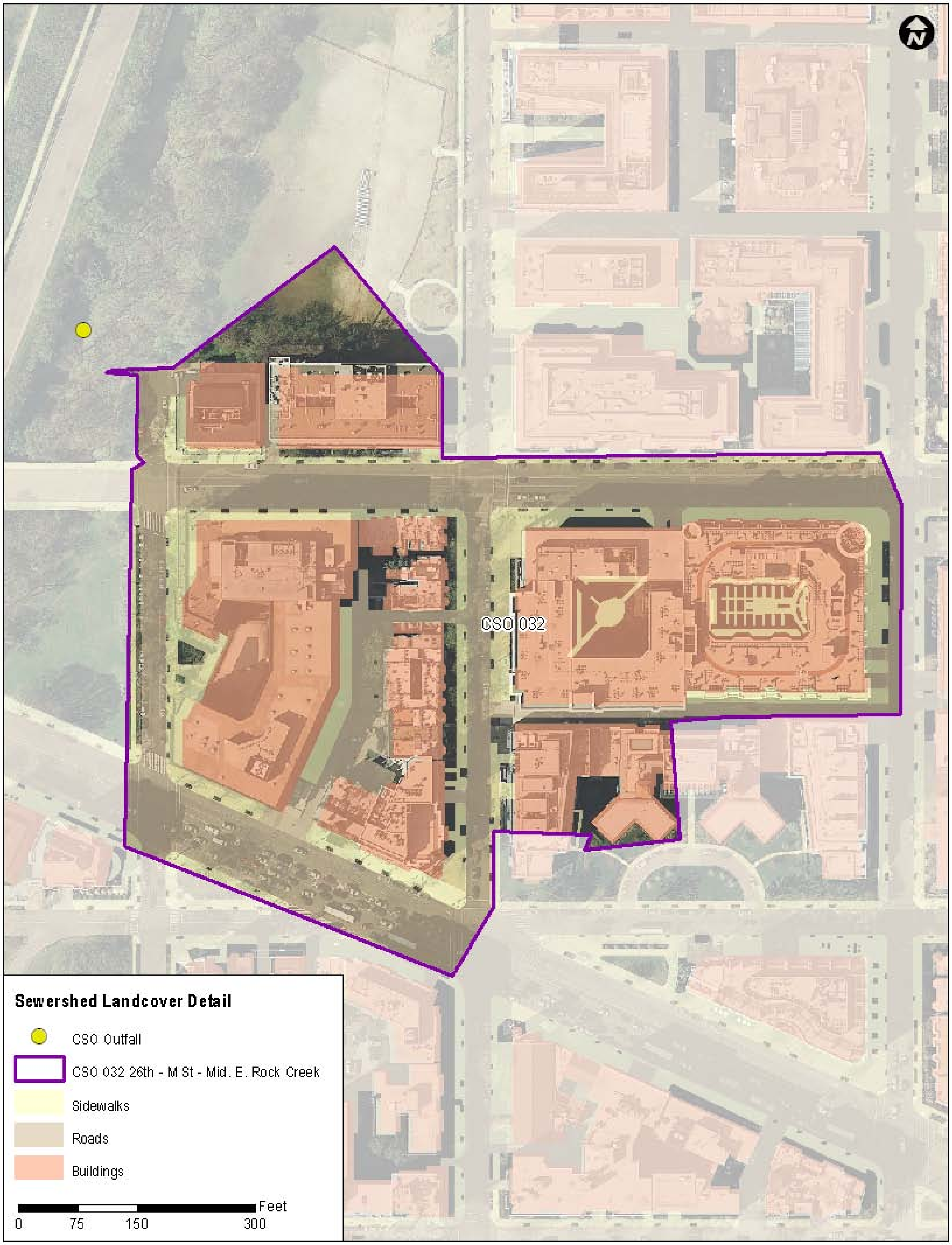

Figure A-9. Sewershed Characteristics - CSO 032, 26th – M St – Mid E. Rock Creek

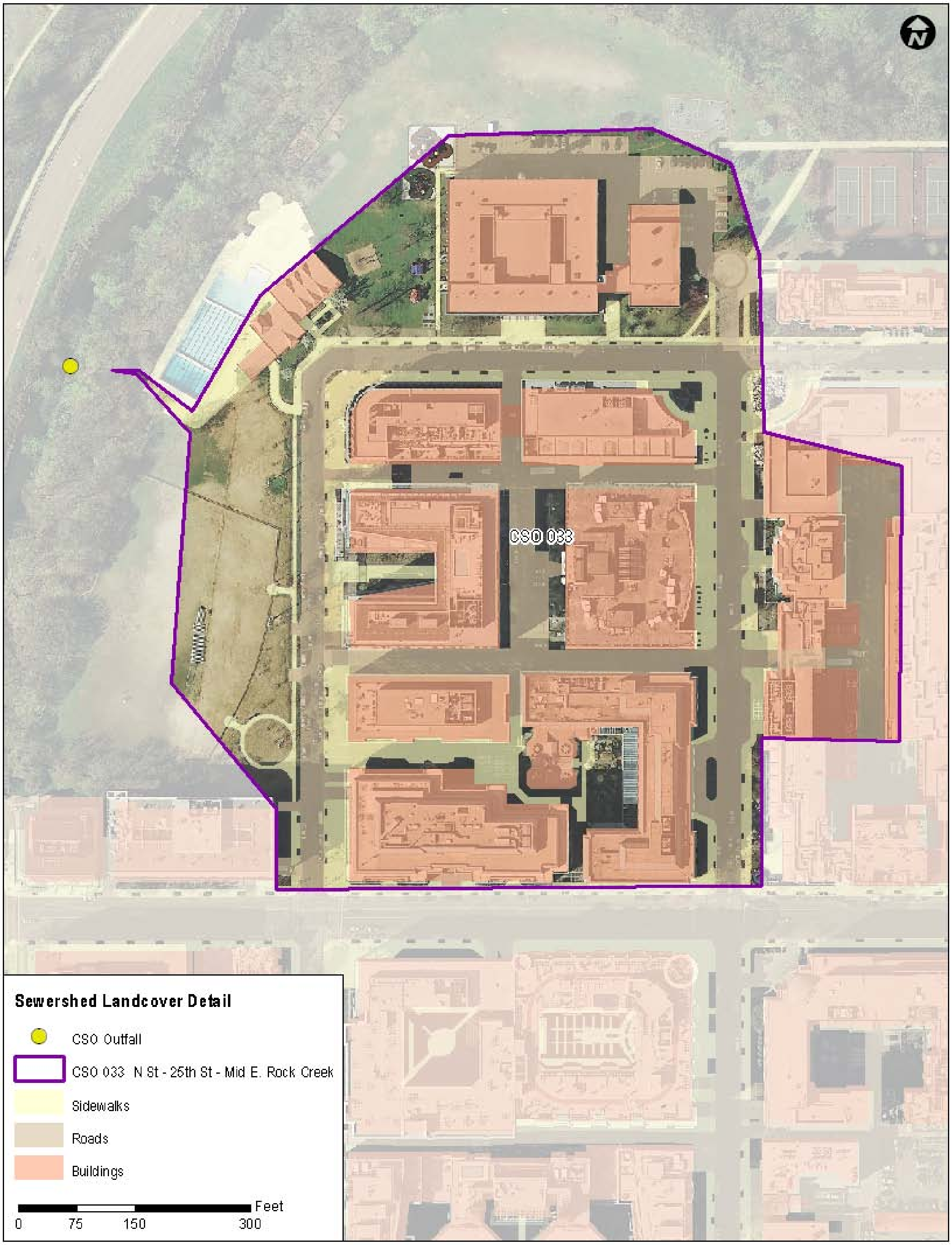

Figure A-10. Sewershed Characteristics - CSO 033, N St – 25th St – Mid E Rock Creek

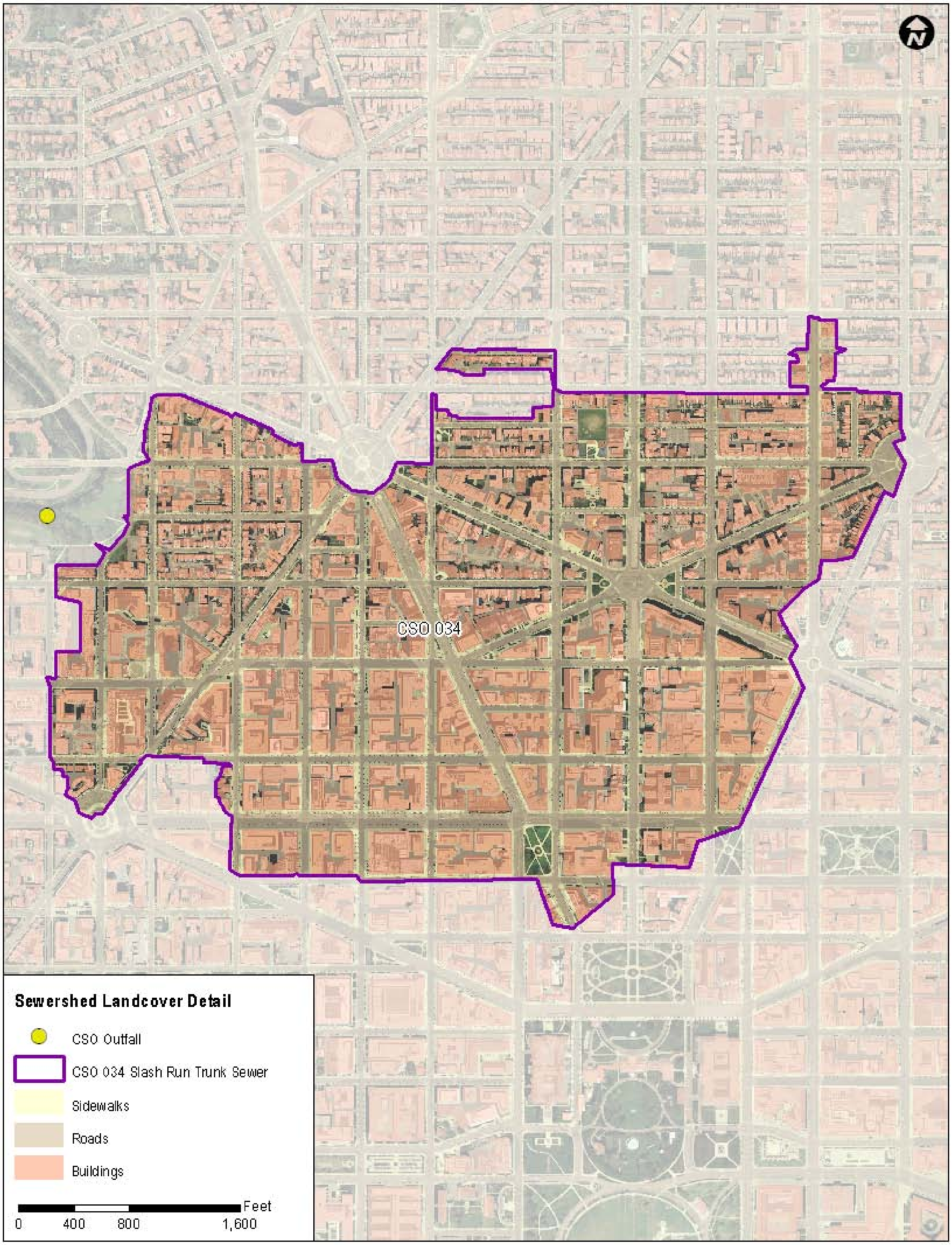

Figure A-11. Sewershed Characteristics - CSO 034, Slash Run Trunk Sewer

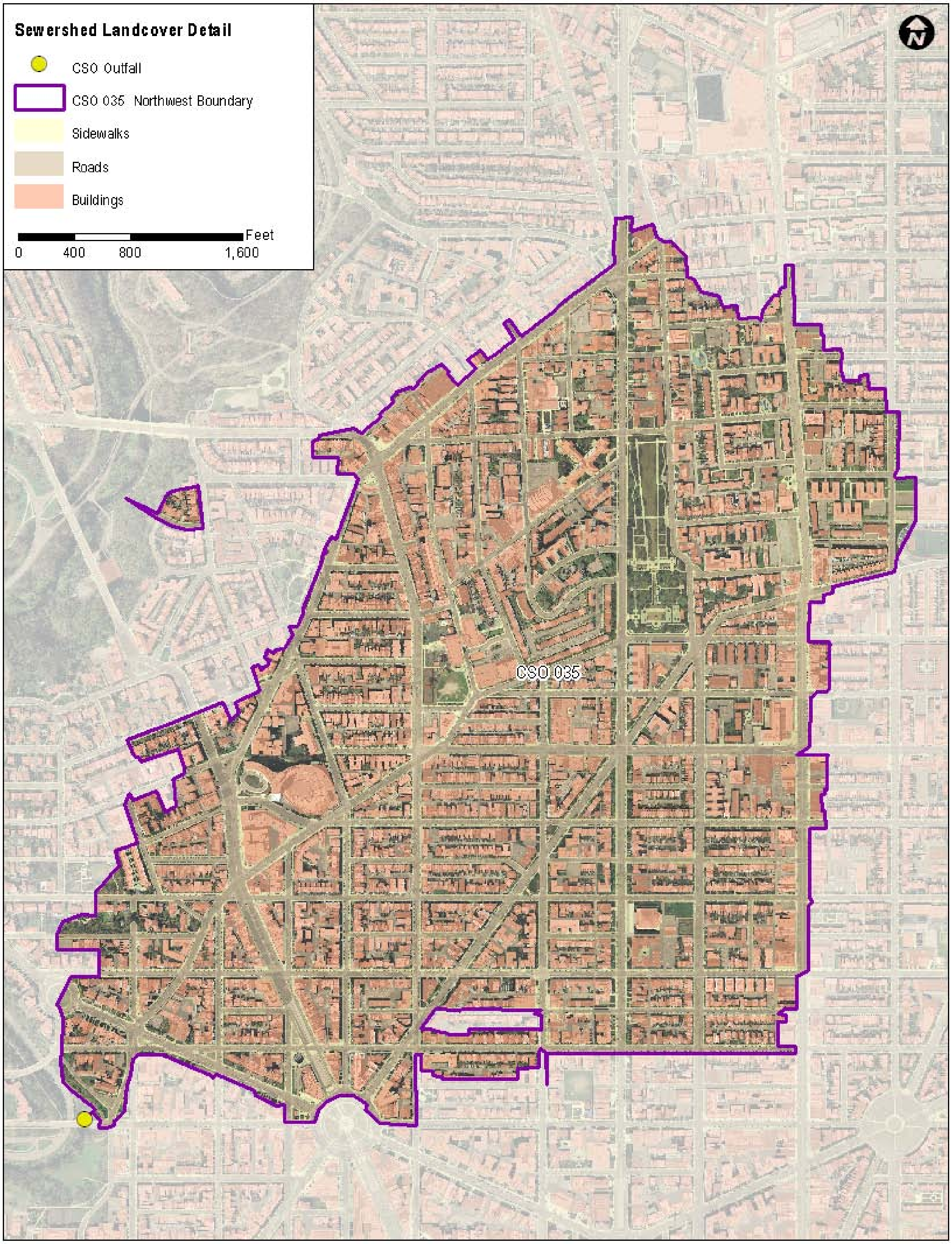

Figure A-12. Sewershed Characteristics - CSO 035, Northwest Boundary

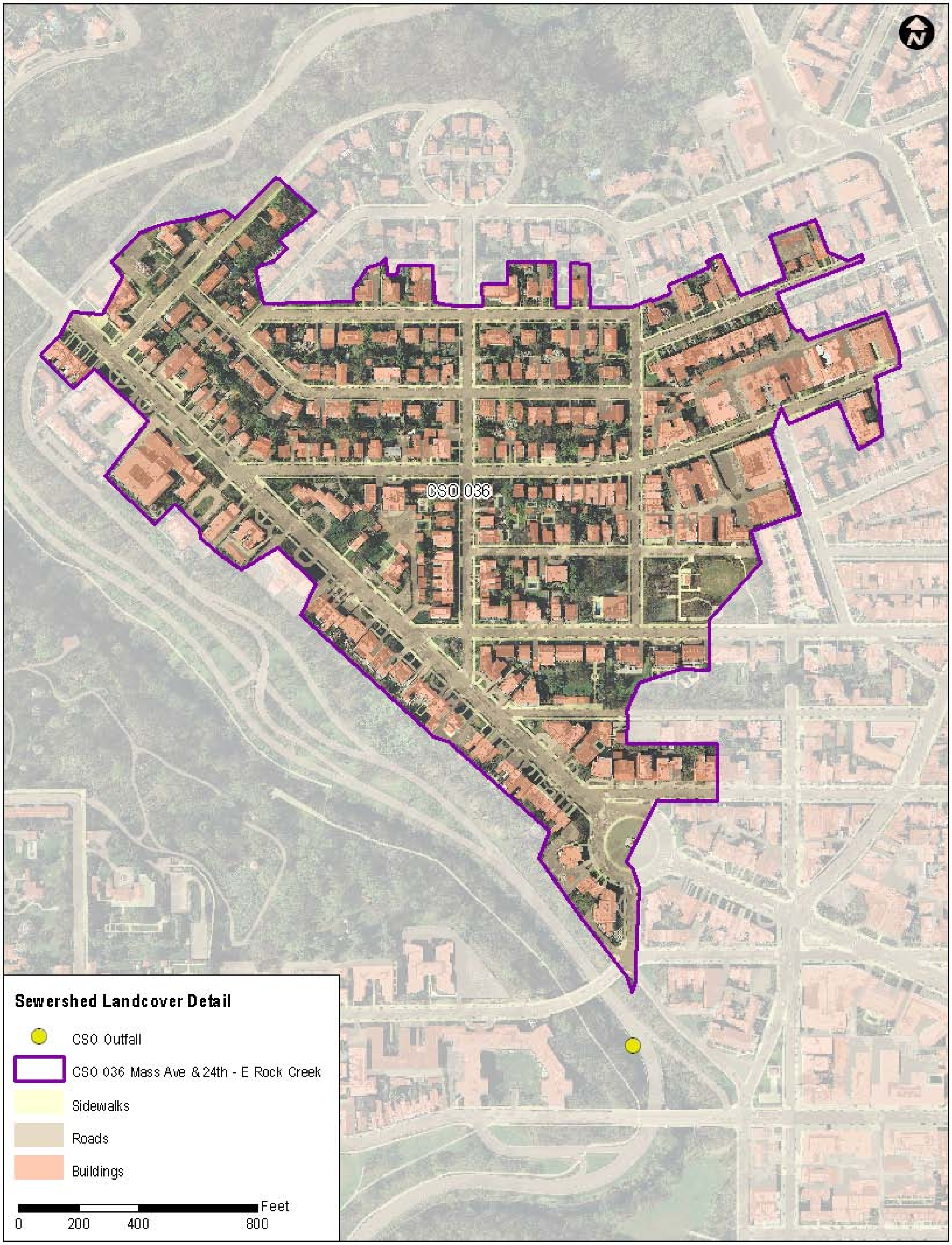

Figure A-13. Sewershed Characteristics - CSO 036, Mass Ave & 24th – E. Rock Creek

Figure A-14. Sewershed Characteristics - CSO 038, Kalorama Circle E – E. Rock Creek

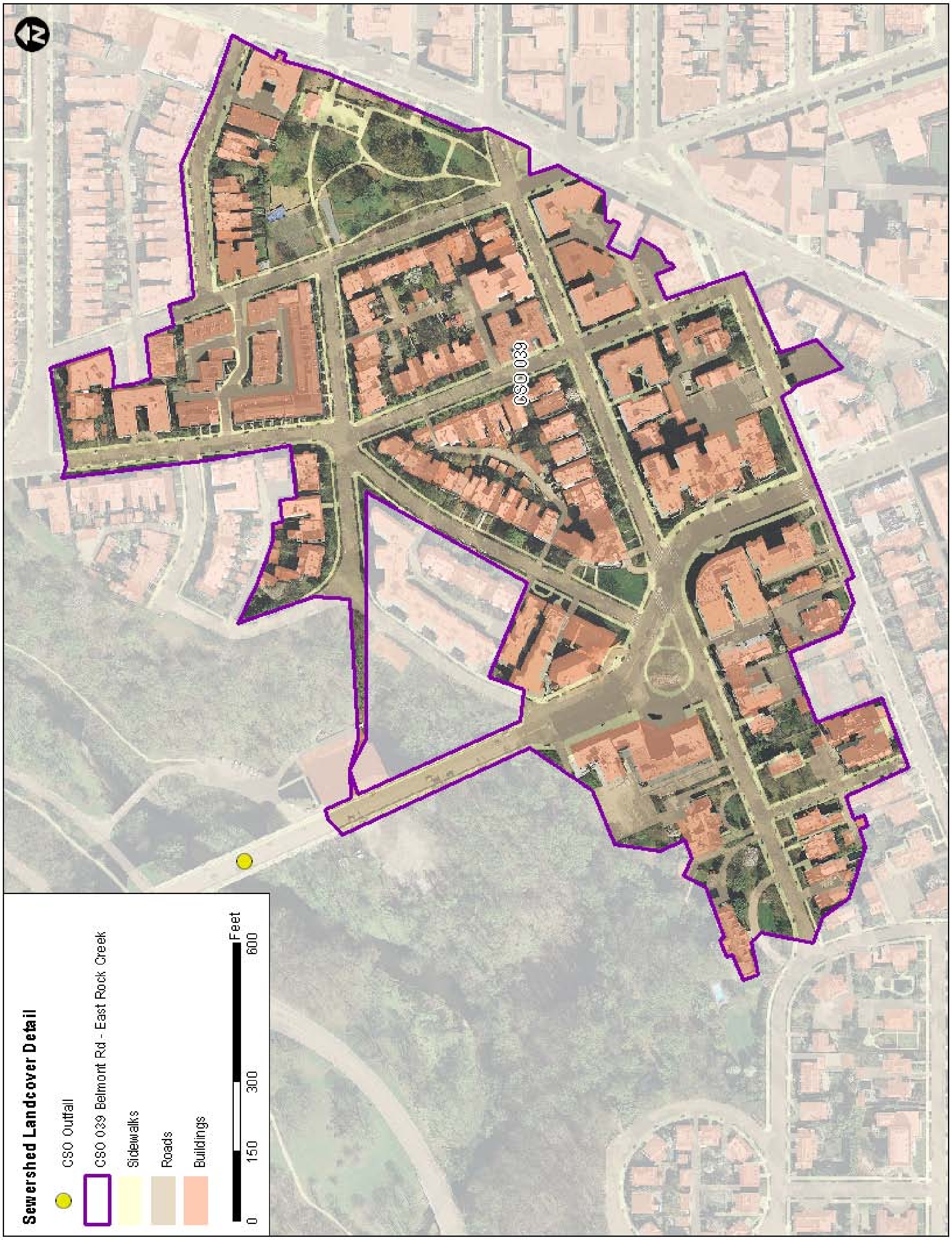

Figure A-15. Sewershed Characteristics - CSO 039, Belmont Rd – East Rock Creek

Figure A-16. Sewershed Characteristics - CSO 040, Biltmore St – East Rock Creek

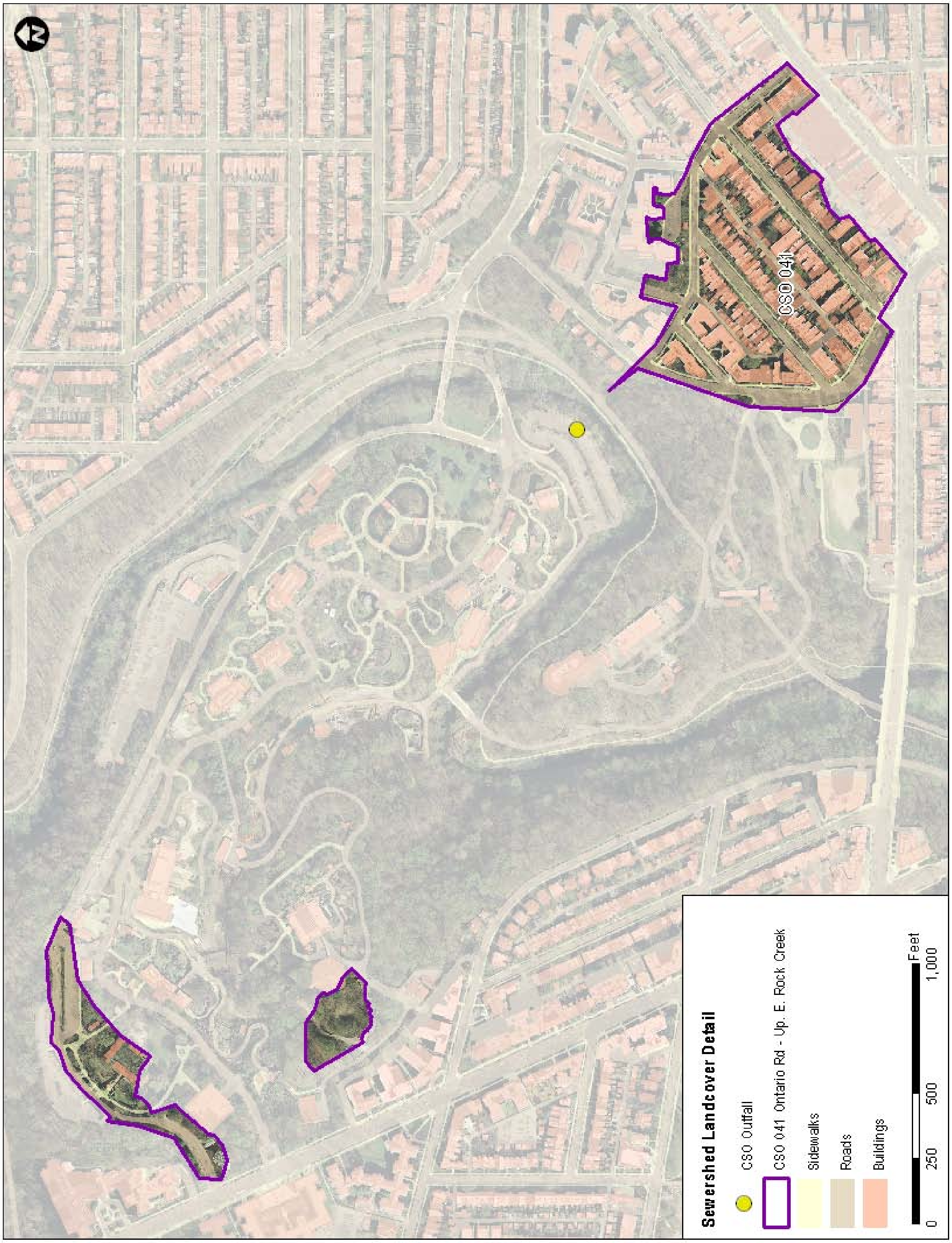

Figure A-17. Sewershed Characteristics - CSO 041, Ontario Rd – Up. E. Rock Creek

Figure A-18. Sewershed Characteristics - CSO 042, Quarry Rd – Up. E. Rock Creek

Figure A-19. Sewershed Characteristics - CSO 043, Irving St. – Up. E. Rock Creek

Figure A-20. Sewershed Characteristics - CSO 044, Kenyon St – Up. E. Rock Creek

Figure A-21. Sewershed Characteristics - CSO 045, Lamont St. – Up. E Rock Creek

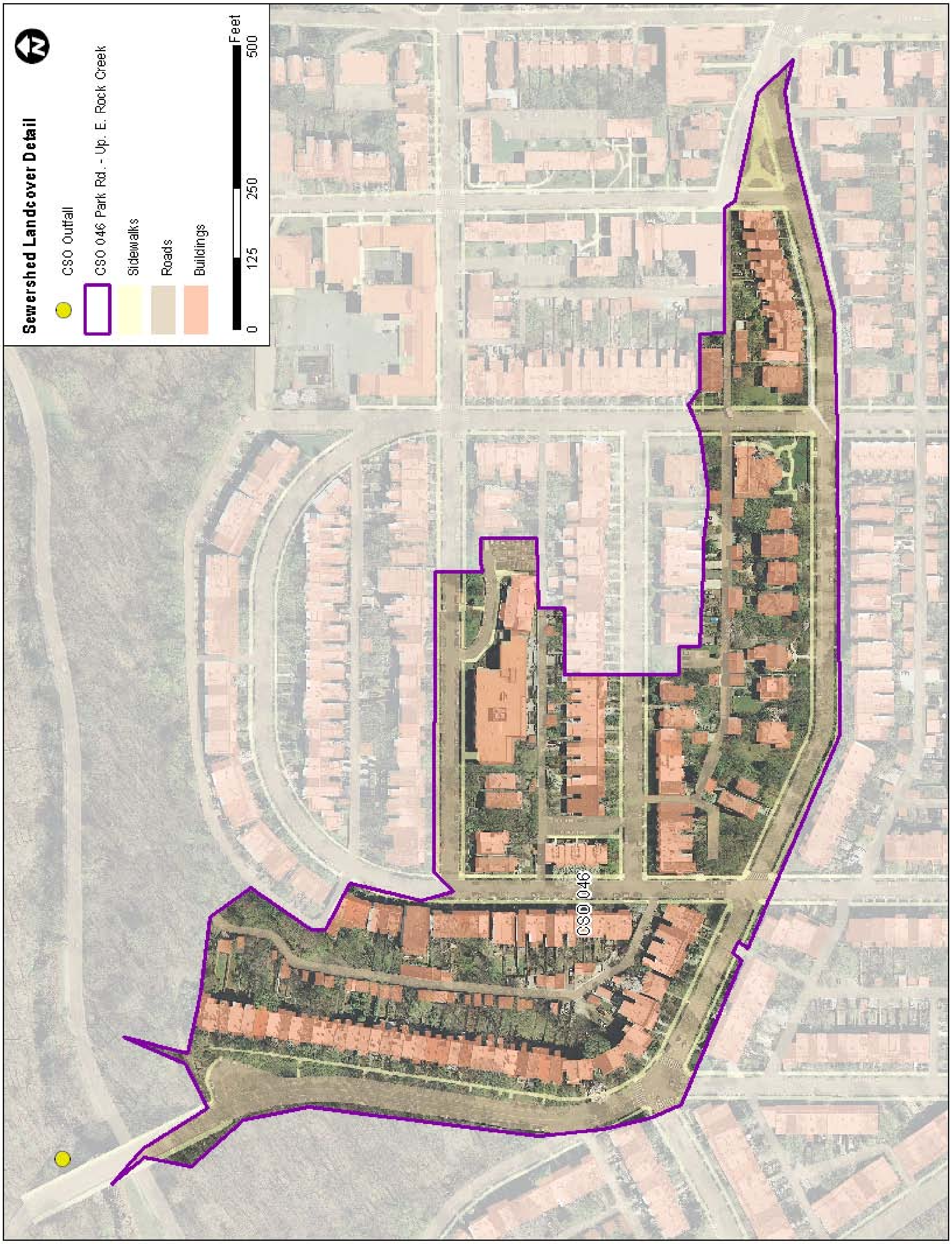

Figure A-22. Sewershed Characteristics - CSO 046, Park Rd – Up. E. Rock Creek

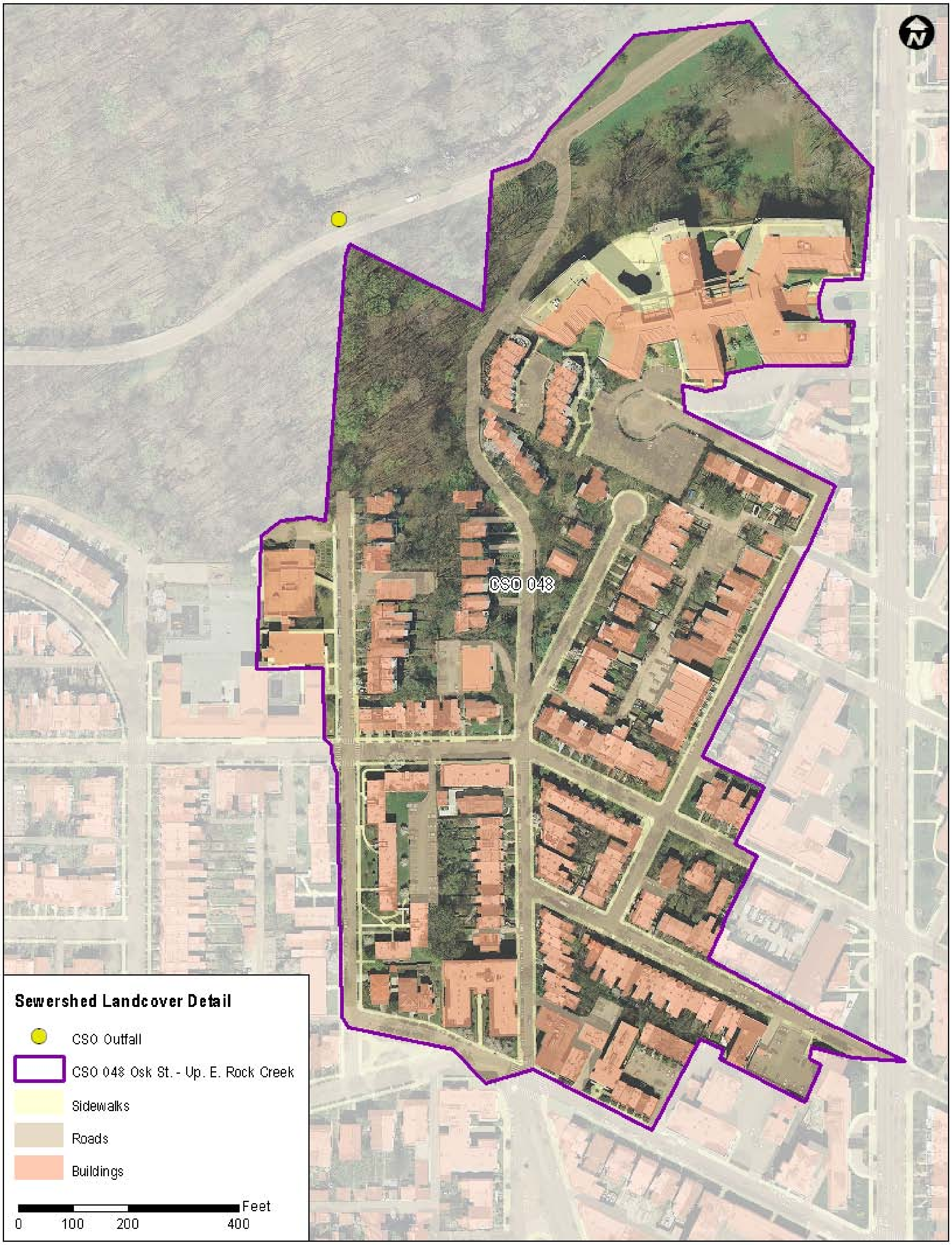

Figure A-23. Sewershed Characteristics - CSO 048, Oak St – Up. E. Rock Creek

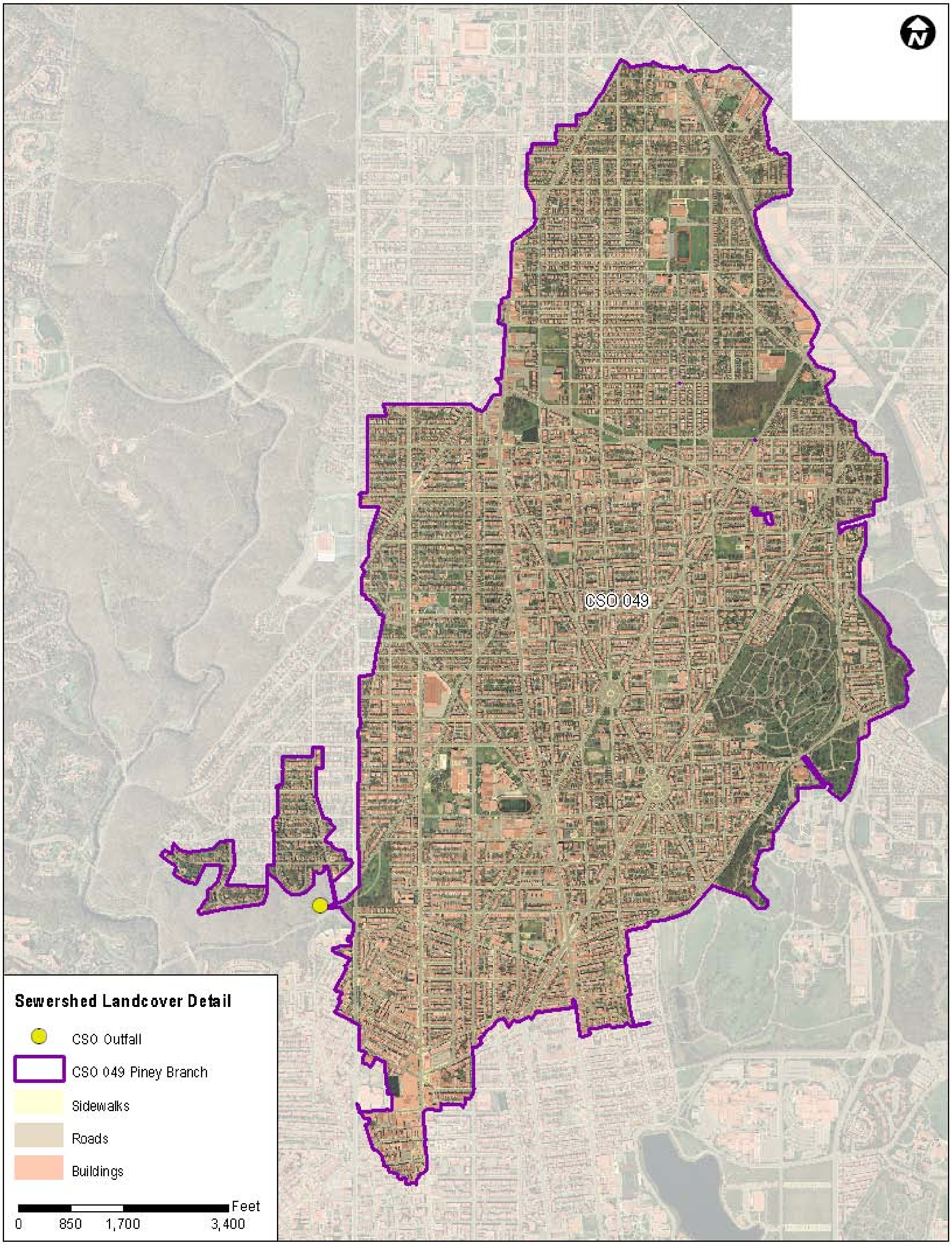

Figure A-24. Sewershed Characteristics - CSO 049, Piney Branch

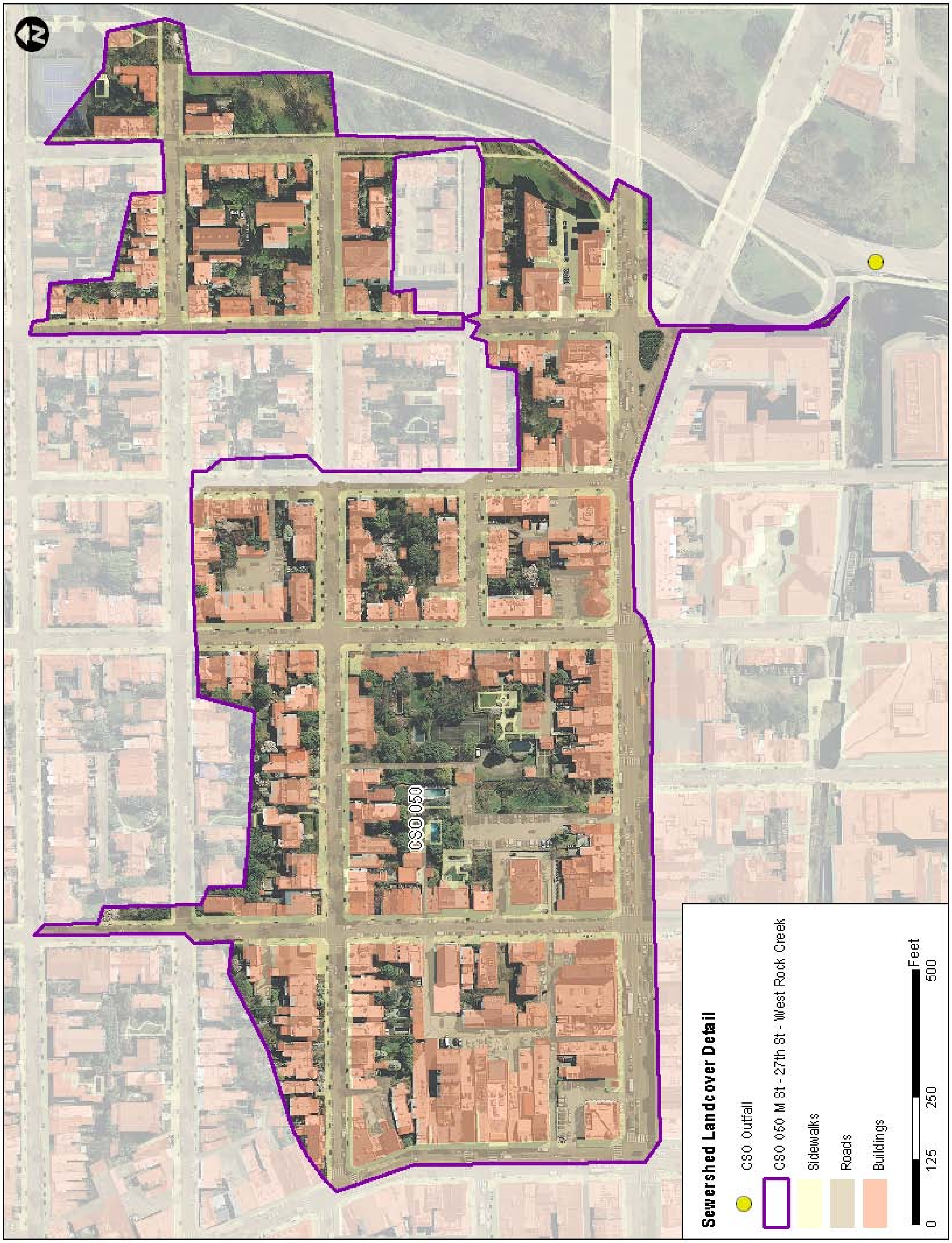

Figure A-25. Sewershed Characteristics - CSO 050, M St – 27th St – West Rock Creek

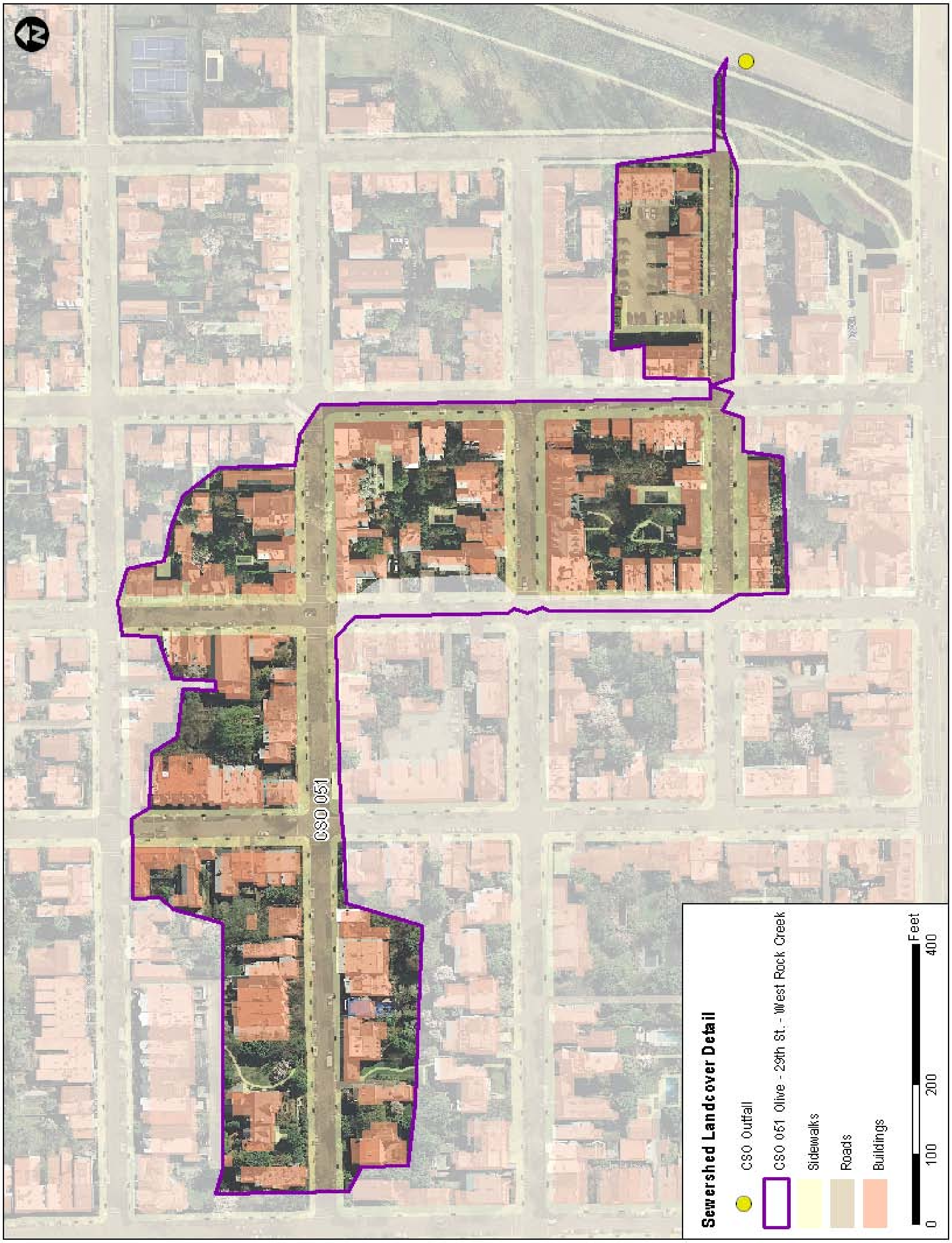

Figure A-26. Sewershed Characteristics - CSO 051, Olive – 29th St – West Rock Creek

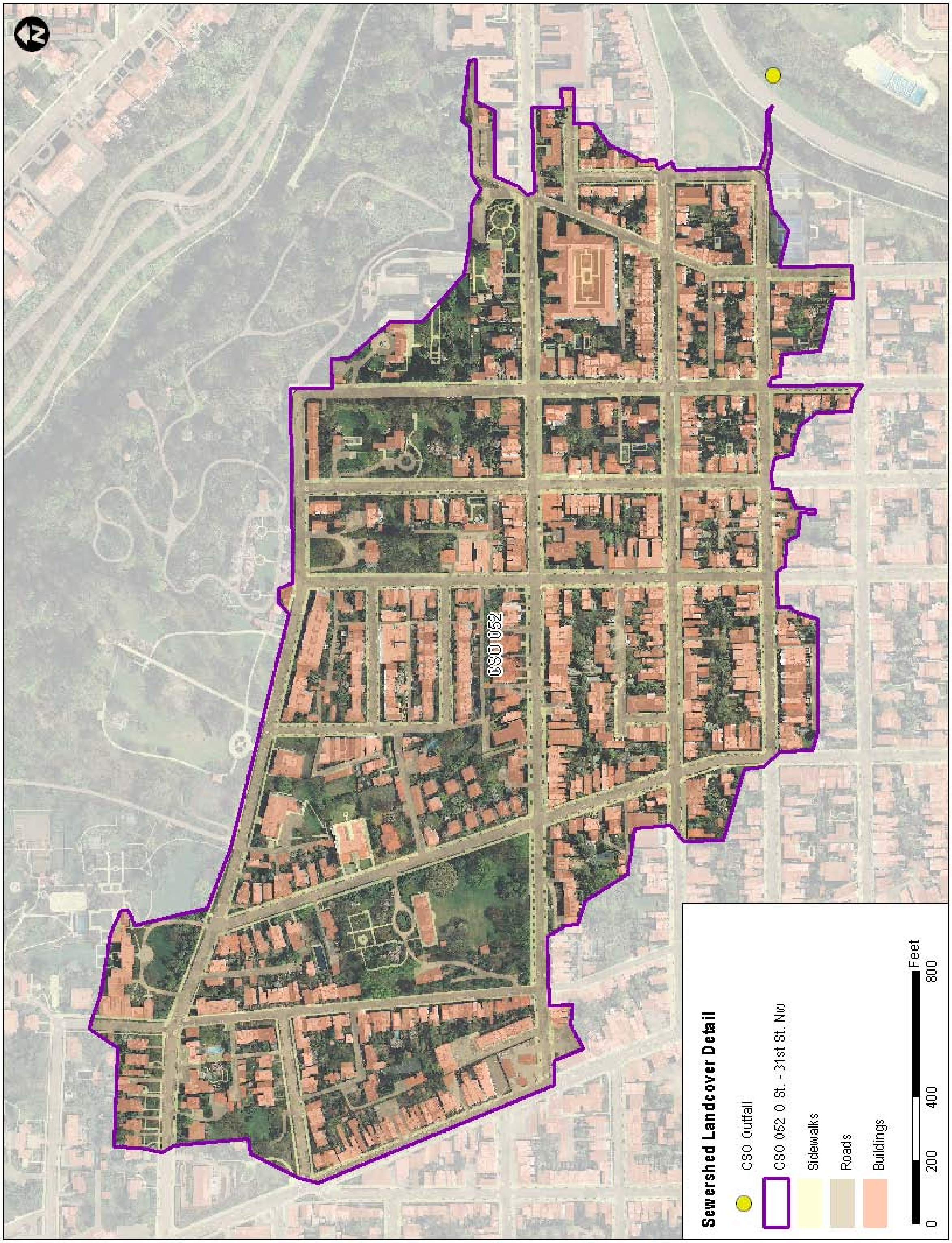

Figure A-27. Sewershed Characteristics - CSO 052, O St – 31st St NW

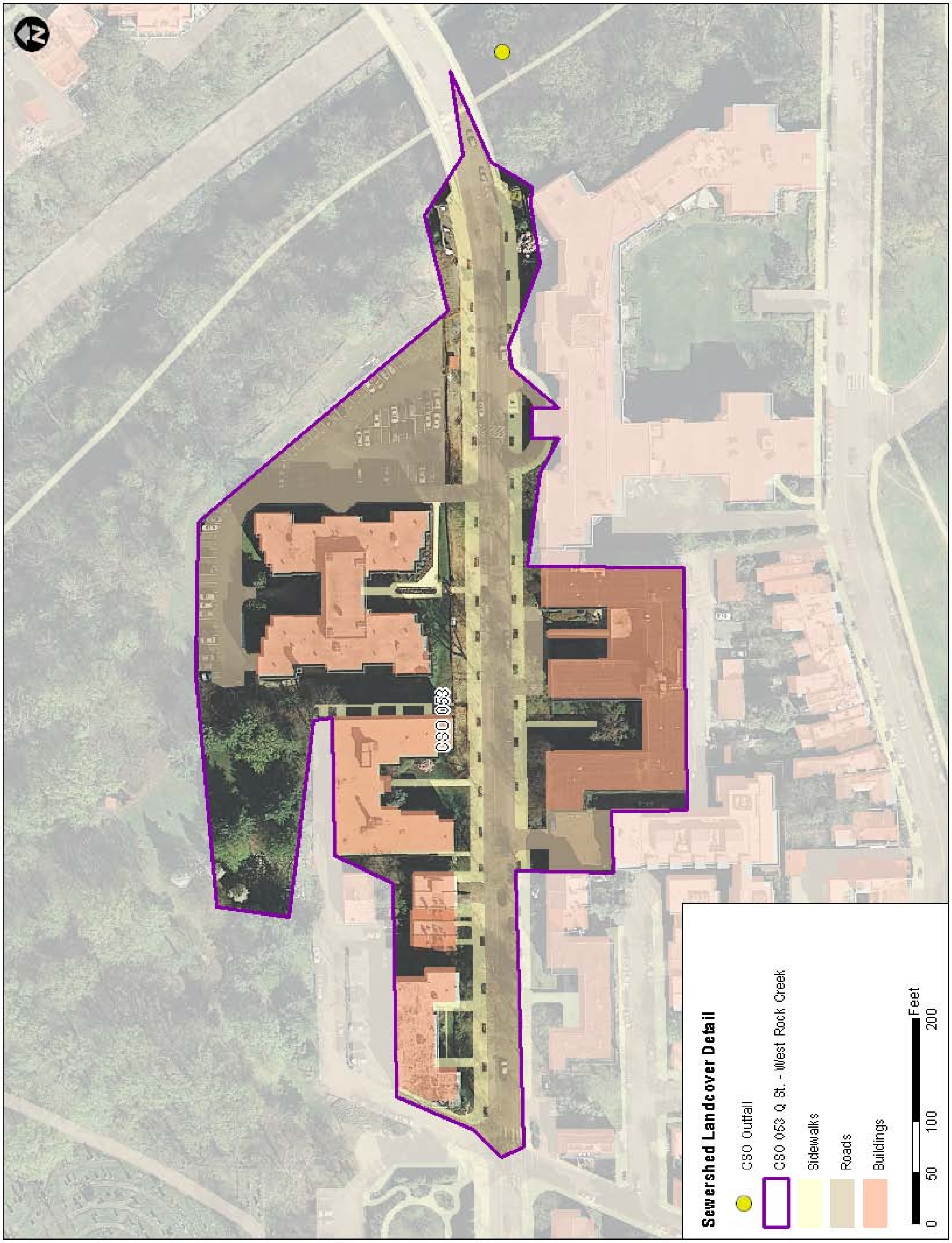

Figure A-28. Sewershed Characteristics - CSO 053, Q St – West Rock Creek

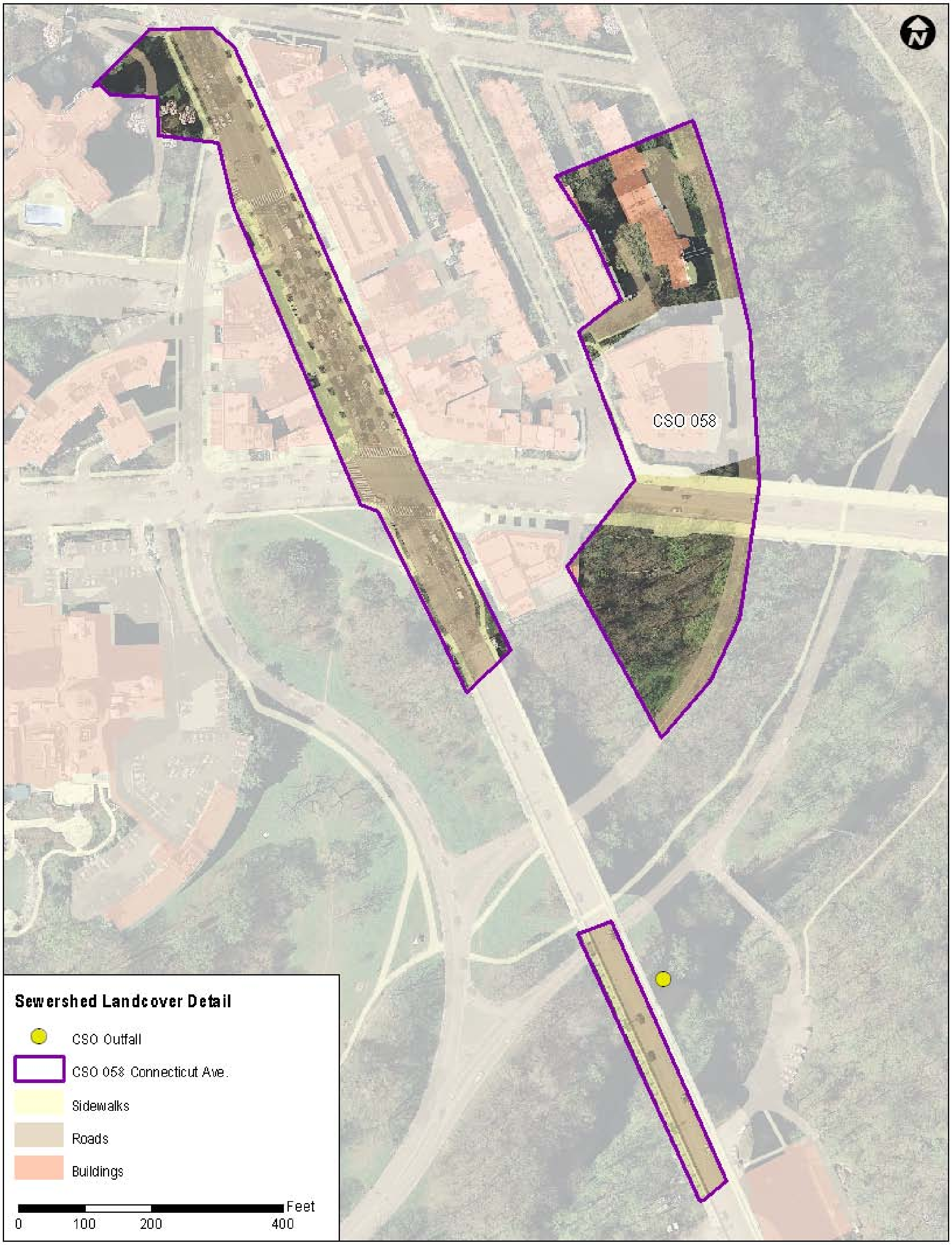

Figure A-29. Sewershed Characteristics - CSO 058, Connecticut Ave

Appendix - B
Bases for Cost Estimates

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Appendix B
Basis For Cost Opinions

1. GENERAL

In order to compare the alternatives, cost opinions including construction, capital, and operating and maintenance costs were prepared for each alternative carried forward. This appendix provides the bases for cost opinions.

In accordance with the Association for the Advancement of Cost Engineering definitions (AACE, 1997), cost opinions included in this document are considered to be concept screening level estimates, with an expected accuracy of -50% - +100% for green infrastructure and -20% - 30% infrastructure . Cost opinions are of this accuracy because alternatives have been prepared with a minimum of detailed design data for the purposes of relative comparison. This type of analysis is appropriate for comparisons between control programs.

2. CONSTRUCTION COSTS

2.1 Methodology

The following cost bases were used for the preparation of construction cost opinions:

- <u>Construction Cost Index</u> - The Engineering News Record (ENR) Construction Cost Index (CCI) for June 2012 was 9291, which has been used as the basis for all costs prepared herein.

- <u>Approach to Estimating Construction Costs</u>- costs have been prepared using the following resources:
    - Generic facility and treatment plant cost curves such as:
        - *Construction Costs for Municipal Wastewater Treatment Plants: 1973-1982* (EPA, 1978)
        - *Manual - Combined Sewer Overflow Control*, (EPA 1993a)
        - *Cost Estimating Manual – Combined Sewer Overflow Storage and Teratment* (EPA, 1976)
        - *Pumping Station Design* (Sanks, 1998).
    - Unit costs in dollars per gallon or cost per linear foot obtained from other projects. Costs have been adjusted for relative characteristics such as complexity or location using engineering judgment.
    - Cost data from similar facilities:
        - Costs from other studies
        - Engineer's estimates of construction cost

    - Bid tabulations from similar projects. Where bid tabulations were available, the second and third bidder's unit prices were considered in addition to the low bidders unit prices.
  - Where facilities are unique or customized and cost curve type data does not exist was not applicable, conceptual layouts of facilities were prepared and costs were estimated by performing takeoffs to estimate quantities.

- Calculation Procedure - the following calculation procedure was used for construction costs:

Table 1
Calculation Procedure For Construction Cost Opinions

Line Number	*Description*	*Calculation Procedure*
1	Subtotal of Construction Line Items	--
2	Construction Contingencies	30% x Line 1
3	**Total Construction Cost**	Sum of Lines 1 and 2

2.2 Conveyance Pipelines

Costs for pipelines were developed using manufacturer's costs for pipes and unit costs in Means and other estimating references. Costs include manholes, sediment and erosion, and thrust restraint for force mains. A pipe depth of 20 feet in an urban congested area was assumed.

Table 2
Unit Construction Costs for Pipelines

Pipe Diameter	*Unit Cost ($/linear foot)*
Gravity Sewers	
18”	$584
24”	$665
30”	$756
36”	$854
42”	$961
48”	$1,065
54”	$1,178
60”	$1,308
66”	$1,417
72”	$1,534
78”	$1,658
84”	$1,818
90”	$1,975
96”	$2,140
102”	$2,440
108”	$2,653
114”	$2,956
120”	$3,024

Pipe Diameter	*Unit Cost ($/linear foot)*
126”	$3,355
132”	$3,494
138”	$3,862
144”	$3,934
Force Mains	
12”	$452
16”	$639
18”	$702
24”	$817
30”	$897
36”	$826
42”	$906
48”	$979
54”	$1,102
60”	$1,206
66”	$1,323
72”	$1,428
78”	$1,557
84”	$1,766
90”	$1,911
96”	$2,091

2.3 Pumping Stations

Cost data for pumping stations were obtained from actual facilities, EPA cost curves, and Sanks (see references). This construction cost data are plotted on Figure 2. A best-fit polynomial equation whose values were greater than or equal to most of the plotted values was developed. The equation for construction cost as a function of flow rate (MGD) was determined to be:

$$\text{Cost} = 0.0954(\text{mgd})^2 + 246.41(\text{mgd}) + 3760.7$$

2.4 Tunnels

Cost data for tunnels were based on current DC Clean Rivers Project construction contract costs for the Anacostia River Projects and these costs were revised to reflect the actual ground in the proposed Potomac and Piney Branch Tunnel locations. The cost data for tunnels are based on fixed costs which do not change with tunnel configuration include plant erection, assembly disassembly of TBM, removal of TBM and break in/out facilities. Variable costs which vary with tunnel length and diameter include, labor, construction equipment, removal of utilities, site cleanup , construction materials and sub-contractors fees,

Table 3
Construction Cost Data for Tunnels in Rock

	Cost Model for Rock Tunnels by TBM- Per DCCR Project							Test @ Div H		
	Modified from Div H 100% Estimate per notes									
	Assumes systematic lining during excavation is not req'd.							12,424 @ 23 ft		9,100 @ 34 ft
		(000)		Soil	Completent Rock	Not-so-good rock		competent	not-so-good	
1	Fixed Costs for tunnel									
	Erect Plant	$ 624								
	Assemble TBM	$ 445								
	Dis-assemble/Remove	$ 520								
	Break-in/out facilities	$ 717								
			$ 2,306	$2.3 million	$1.6 million	$1.6 million	Excludes break-in/out	$ 1,600	$ 1,600	$ 1,600
2	Fixed costs for certain finish diameter									
	TBM & equip	$ 7,870								
	TBM & equip	$ 10,507								
			$ 18,377							
		23 ft diameter	$ 799	$800,000/ftØ	$800,000/ftØ	$800,000/ftØ	Use same cost	$ 18,400	$ 18,400	$ 27,200
	For tunnel range: 10 ft to 30 ft finish diameter									
	For 2nd tunnel using same equipment, use only $150,000/ftØ									
3	Variable costs by tunnel length (diameter not a factor)									
	Labor	$ 4,302								
		$ 5,962								
	Equipment	$ 9,866								
		$ (7,870)								
		$ 13,173								
		$ (10,507)								
	Remove utilities/clea	$ 1,387								
	Instrumentation	$ 4,115					use 50% for instrumentation in rock			
			$ 20,428							
		Div H = 12,424 lf	$ 1,644.24							
			$ 1,017				competent rock @ 65 lf/day			
		temp support	$ 200				temp support			
				$ 1,217	$1220/lf of tunnel		total for competent rock	$ 15,157		$ 11,102
			$ 1,479				rock needing continuous support @ 40 lf/day			
		temp support	$ 400				temp support			
				$ 1,879		$1880/lf of tunnel	total for not-so-good rock		$ 23,357	
4	Variable costs by tunnel diameter and length									
	Material	$ 10,695								
		$ 15,963								
			$ 26,658							
	for 23 ft Ø:	Div H = 12,424 lf	$ 2,146							
		per ft Ø:	$ 93.29	$93/ftØ/lf						
	concrete line 22 ft @ 12" @$1,200/cy =		$3,150/lf	for tunnel Ø from 15 ft to 25 ft: use $140/ftØ				$ 40,005	$ 40,005	
	concrete line 34 ft @18" @ $1200/cy		$7,350/lf	for tunnel Ø from 25 ft to 35 ft: use $215/ftØ						$ 66,521
5	Variable costs by square of diameter and length:									
	Subcontractors	$ 2,421								
		$ 3,628								
			$ 6,049							
	for 23 ft Ø:	Div H = 12,424 lf	$ 487							
		per ft Ø:	$ 0.92	$0.90/ftØ^2/lf						
	50% of this is hauling, and 50% is dump fee				$0.45/ftØ^2/lf	$0.45/ftØ^2/lf	assume no dump fee for rock, use 50%	$ 2,958	$ 2,958	$ 4,734
6	Tunnel Indirect Costs									
		$ 46								
		$ 401								
		$ 65								
		per month	$ 512							
	12,424 in 15 months =	830 ft/mo	$ 616.87	$620/lf of tunnel						
			$ 379.61		$380/lf of tunnel		competent rock @ 65 lf/day	$ 4,721		$ 3,458
						$620/lf of tunnel	rock needing continuous support @ 40 lf/day		$ 7,703	
7	Overhead and Profit									
		$ 173,961								
	plus tunnel indirects	$ 7,664								
	total cost		$ 181,625							
	S/T indirects	$ 80,448								
	less tunnel indirects	$ (7,664)								
	total indirects		$ 72,784							
		Percent total	40.1%	40% of total co	40% of total cost	40% of total cost		$ 33,136	$ 34,528	$ 45,846
8	Escalation									
	These numbers are based on 2012 work									
			Use:	3%/year	3%/year	3%/year		$ 104	$ 116	$ 144
9	Contingency									
	concept design (no design or geotech)			40%	40%	40%		$ 46,433	$ 51,467	
	30% design			30%	30%	30%				
	60% design			25%	25%	25%				
	90% design			20%	20%	20%				
	Bid-level			15%	15%	15%				
								$ 162,515	$ 180,133	$ 160,605

Table 4
Construction Cost Data for Tunnels in Soil

	Cost Model for Soil Tunnels by TBM-Per DCCR Project					Test @ Div H				
	(Info from Div H 100% Estimate)					lf	Ø			
	Assumes continuous support using precast segments.					12424	23	15,200 @ 20 ft	ft	11,300 @ 20 ft
		(000)		Use		(000)				
1	Fixed Costs for tunnel									
	Erect Plant	$ 624								
	Assemble TBM	$ 445								
	Dis-assemble/Remove	$ 520								
	Break-in/out facilities	$ 717								
			$ 2,306	$2.3 million		$ 2,300		$ 2,300	$ 2,300	$ 2,300
2	Fixed costs for certain finish diameter									
	TBM & equip	$ 7,870								
	TBM & equip	$ 10,507								
			$ 18,377							
		23 ft diameter	$ 799	$800,000/ftØ		$ 18,400		$ 16,000	$ 11,200	$ 16,000
	For tunnel range: 10 ft to 30 ft finish diameter									
	For 2nd tunnel using same equipment, use only $150,000/ftØ									
3	Variable costs by tunnel length (diameter not a factor)									
	Labor	$ 4,302								
		$ 5,962								
	Equipment	$ 9,866								
		$ (7,870)								
		$ 13,173								
		$ (10,507)								
	Remove utilities/clear	$ 1,387								
	Instrumentation	$ 4,115								
			$ 20,428							
		Div H = 12,424 lf	$ 1,644.24	$1650/lf of tunnel		$ 20,500		$ 25,080	$ 18,645	$ 18,645
4	Variable costs by tunnel diameter and length									
	Material	$ 10,695								
		$ 15,963								
			$ 26,658							
	for 23 ft Ø:	Div H = 12,424 lf	$ 2,146							
		per ft Ø:	$ 93.29	$93/ftØ/lf		$ 26,575		$ 28,272	$ 14,713	$ 21,018
5	Variable costs by square of diameter and length:									
	Subcontractors	$ 2,421								
		$ 3,628								
			$ 6,049							
	for 23 ft Ø:	Div H = 12,424 lf	$ 487							
		per ft Ø:	$ 0.92	$0.90/ftØ^2/lf		$ 5,915		$ 5,472	$ 1,993	$ 4,068
6	Tunnel Indirect Costs									
		$ 46								
		$ 401								
		$ 65								
		per month	$ 512							
	12,424 in 15 months =	830 ft/mo	$ 616.87	$620/lf of tunnel		$ 7,703		$ 9,424	$ 7,006	$ 7,006
7	Overhead and Profit									
		$ 173,961								
	plus tunnel indirects	$ 7,664								
	total cost		$ 181,625							
	S/T indirects	$ 80,448								
	less tunnel indirects	$ (7,664)								
	total indirects		$ 72,784							
		Percent total	40.1%	40% of total cost		$ 32,557		$ 34,619	$ 22,343	$ 27,615
8	Escalation									
	These numbers are based on 2012 work									
			Use:	3%/year		$ 103	2 yrs	$ 109	$ 70	$ 87
9	Contingency									
	concept design (no design or geotech)			40%		$ 45,621				
	30% design			30%						
	60% design			25%						
	90% design			20%						
	Bid-level			15%						
						$ 159,673		$ 121,276	$ 78,270	$ 96,739

2.5 Tunnel Drop Shafts

Drop shafts will be required to convey flow from the elevation of the outfalls (near grade) down to tunnel level. Drop shafts were based on the vortex drop design based on pilot studies by Jain and Kennedy (Jain and Kennedy, 1983) for the Milwaukee CSO tunnel system. The drop shafts typically include:

- Tangential inlets – an approach channel designed to even out the flow streamlines and to force the flow into a spiral pattern. The costs were based on conceptual layouts and quantity takeoffs of the tangential inlets.
- Drop shafts – vertical drop shafts where the CSO falls downward in a spiral pattern. The spiral pattern is designed to allow air to escape up the central core, preventing bulking of the flow. It also dissipates the energy gained by the flow when falling vertically. The costs were based on costs estimates developed for the Blue Plains Tunnel and Anacostia river Tunnel design.
- Deaeration chamber – chamber at the bottom of the drop shaft where air is allowed to escape before the CSO enters the main tunnel. The costs for the deaeration chamber were based on quantity takeoffs and layouts for deep shafts used for the Blue Plains Tunnel and Anacostia river Tunnel design.

Preliminary layouts were prepared for 75, 200 and 1500 mgd facilities, and quantity takeoffs and cost estimates were prepared as shown in Table 5.

Construction cost curves as a function of flow rate in mgd (Figure 4) were developed for each of the three components of the tunnel drop shafts. The derived equations are as follows:

$$\text{Cost} = 2{,}544.5(\text{mgd}) + 1{,}000{,}000 \qquad \text{(tangential inlets)}$$

$$\text{Cost} = 15.299(\text{mgd})^2 - 757.09(\text{mgd}) + 78{,}960 \qquad \text{(drop shafts)}$$

$$\text{Cost} = 3.804(\text{mgd})^2 + 158.65(\text{mgd}) + 14{,}544 \qquad \text{(deaeration chambers)}$$

2.6 Unit Costs for GI

Unit costs for the implementation of each of the GI technologies identified above were based on reviews of local, regional, and national sources of data to determine reasonable cost ranges for implementing the selected GI practices. Due to the urban nature of the project area and the associated complications that are likely to occur (including issues such as existing infrastructure and utilities, limited construction access, and smaller project footprints), it was generally assumed that implementation costs would be at the higher end of documented construction costs. It was also assumed that most, if not all, of the GI work would be in the form of retrofits (as opposed to new construction) which also adds considerably to project costs as a result of the above-mentioned constraints.

<u>Pervious Pavement</u>

This application includes demolition of existing pavement, excavation, installation of 3 feet of base rock, an underdrain system that ties into the existing storm sewer, and implementation of permeable pavers (as opposed to pervious asphalt or concrete). It should be noted that hard surface demolition, excavation, and installation of an underdrain system are costly components of this application, but were assumed to be necessary for proper function in an urban environment with poorly draining soils. Depending on the intended usage and structural requirements of the pervious pavement, costs may be slightly higher or lower than the average costs used in this analysis (i.e., sidewalks will require less base rock than roads). For consistency, an average cost of $30.00/square foot was used for all pervious pavement applications in this analysis. In addition to regional and national cost data, the costs from several pervious pavement projects in Washington, D.C. were reviewed in detail to determine actual local costs (data was provided by the Low Impact Development Center) for construction.

<u>Green Roof</u>

Green roof costs were based on the implementation of an “extensive” green roof system, which generally have a relatively shallow growing medium (4 to 8 inches), and are planted with a variety of hardy, drought tolerant vegetation. Due to selection of drought tolerant vegetation, it was assumed that long term irrigation would not be necessary. It was also assumed that green roof installation would occur as retrofit projects on existing, flat roofs and that no significant, additional structural reinforcement would be required. This assumption was deemed to be reasonable because extensive green roofs have a shallow growing medium, which adds considerably less weight than that of an “intensive” green roof system. Project costs from other major urban centers such as New York City and Seattle, as well as comprehensive cost data from the Water Environment Research foundation (WERF), were determined to be most representative of applications in Washington, D.C., and therefore were weighted more heavily in the green roof cost analysis.

<u>Bioretention Cells</u>

It was assumed that bioretention cells would be implemented primarily in a linear fashion along existing roads and sidewalks to collect runoff from these impervious surfaces. Installation of these cells would require retrofitting the existing paved areas to create curb-contained bioretention. Therefore, this application includes demolition of existing pavement, excavation, installation of an underdrain system, and use of appropriate engineered soils and plantings to facilitate proper drainage. It should be noted that hard surface demolition, excavation, and installation of an underdrain system are costly components of this application, but were deemed to be necessary for proper function in an urban environment. In addition to regional and national cost data, the costs from several bioretention projects in Washington, D.C. were also reviewed to determine actual local costs (data was provided by the Low Impact Development Center) for construction. Comprehensive bioretention costs provided by WERF and the California Stormwater Quality Association were also determined to represent similar applications to those potentially implemented in Washington, D.C., and therefore were also weighted more heavily in the cost analysis.

Street Trees

The costs for street trees were based on a 6 ft x6 ft x 6 ft in-curb planter vault constructed in-situ, retrofitted into an existing sidewalk. Costs were based on previous engineering experience and similar applications implemented in Washington D.C.

Downspout Disconnect with Rain Barrel

This application was assumed to include both materials and installation cost to disconnect a typical downspout and direct runoff to a plastic rain barrel. Rain barrels were generally assumed to range in size from 50 to 150 gallons (typical residential rain barrels are around 50 to 60 gallons). It was assumed that rain barrels could be installed at multiple downspouts on a given home or facility. Several sources of local, regional, and national data were reviewed to determine appropriate costs. Local, regional, and national costs reviewed in this analysis did not vary as widely as some of the other practices.

Cistern

Cistern costs were based on the installation of a metal cistern designed for non-potable, exterior water re-use. The cost includes a small pump system that would allow for use in outdoor irrigation, washing cars, etc. Cistern sizing can vary widely and it was assumed that the transportation and installation of the cistern would not require any extensive excavation, mobilization, or delivery costs. It was also assumed that the cistern would be installed outside the given facility. The cost to retrofit the interior of a building to accommodate a cistern system can be much more costly.

Summary of Costs

GI practices can treat runoff from rain that falls on the practice itself as well as runoff from other areas that drain to the GI practice. For example, pervious pavement can handle rainfall that falls on the pavement as well as runoff from other impervious areas that is directed to the pervious pavement. Table 3-2 summarizes the assumed costs of the GI measures and converts these costs to dollars per impervious acre treated.

3. CAPITAL COSTS

Engineering, construction management, construction inspection and administrative costs were calculated as a percentage of the construction cost to obtain the total opinion of capital cost. Percentages for these items were obtained from DC WATER based on current construction projects in the sewer and water system. The following percentages of construction cost were used to estimate capital costs:

Table 5
Capital Cost Percentages

Line Number	*Description*	*Calculation Procedure*	*Net Impact*
1	Total Construction Cost	--	
2	Program Management	5% x Line 1	
3	Design Engineering	9% x Line 1	
4	Construction Management	12% x Line 1	
5	Office Engineering During Construction	2% x Line 1	
6	O & M Services	2% x Line 1	
7	Startup	2% x Line 1	
8	**Total**	Sum of Lines 1 through 7	
9	Contingency	10% x Line 8	
			Equivalent to Capital Cost = 1.40 x Construction Cost

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DC Clean Rivers Project
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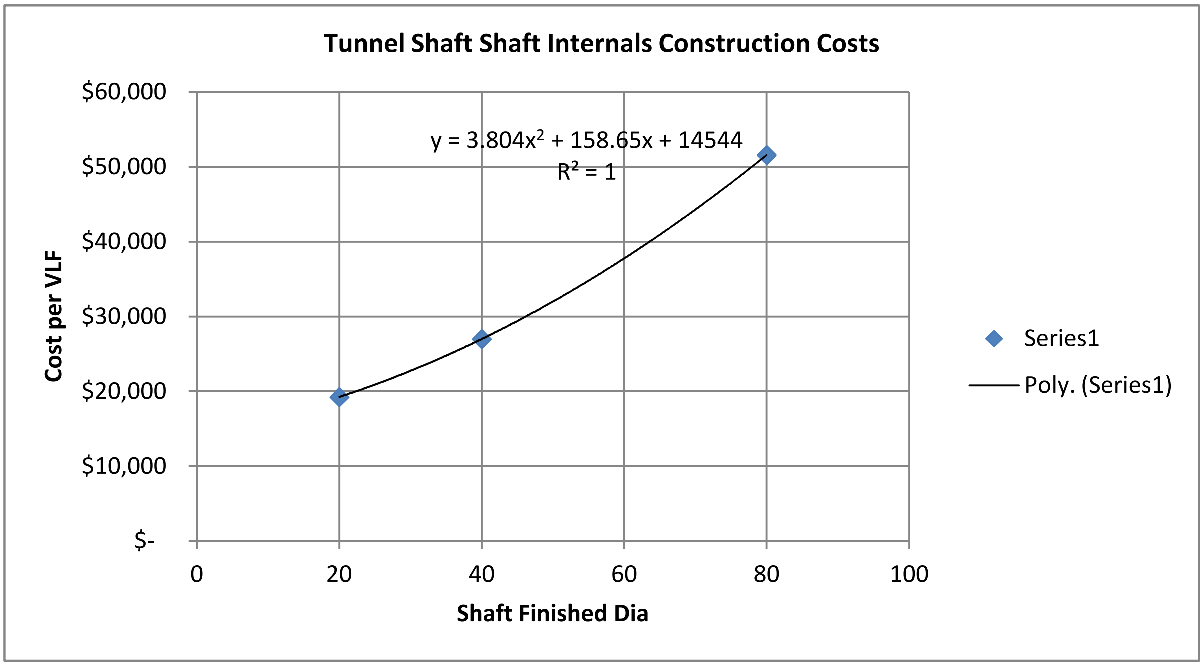
Tunnel Shaft Internals Construction Costs

Figure 1



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DC Clean Rivers Project
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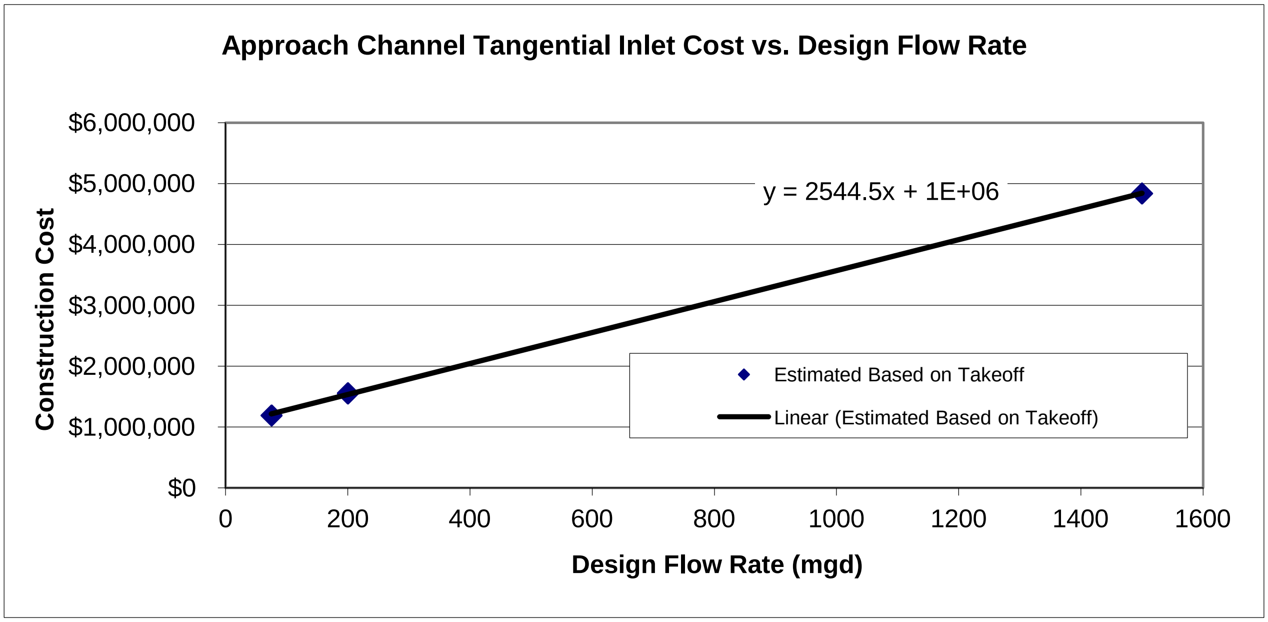
Approach Channel and Tangential Inlet Construction Costs

Figure 2



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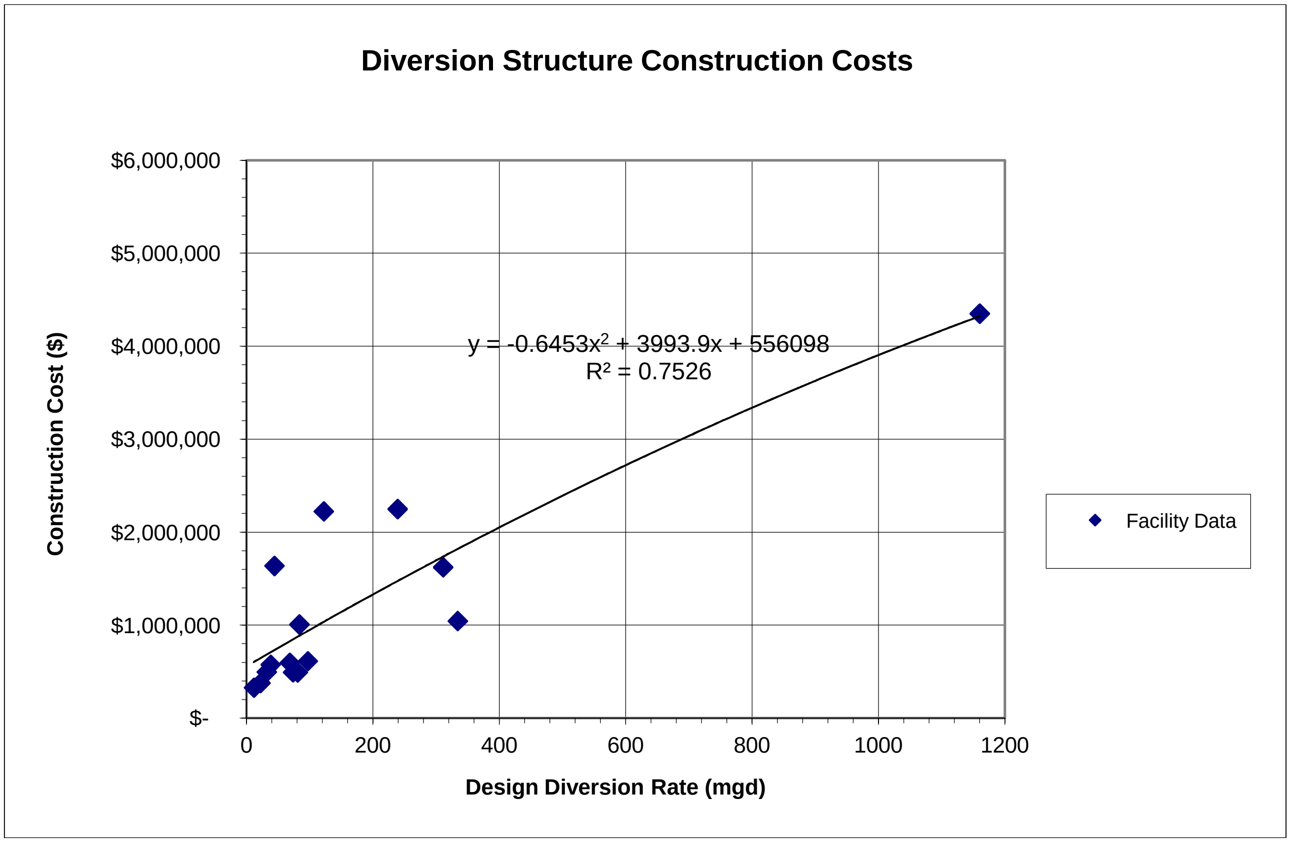
DC Clean Rivers Project
Technical Memorandum No. 7
Diversion Structure Construction Costs

Figure 3



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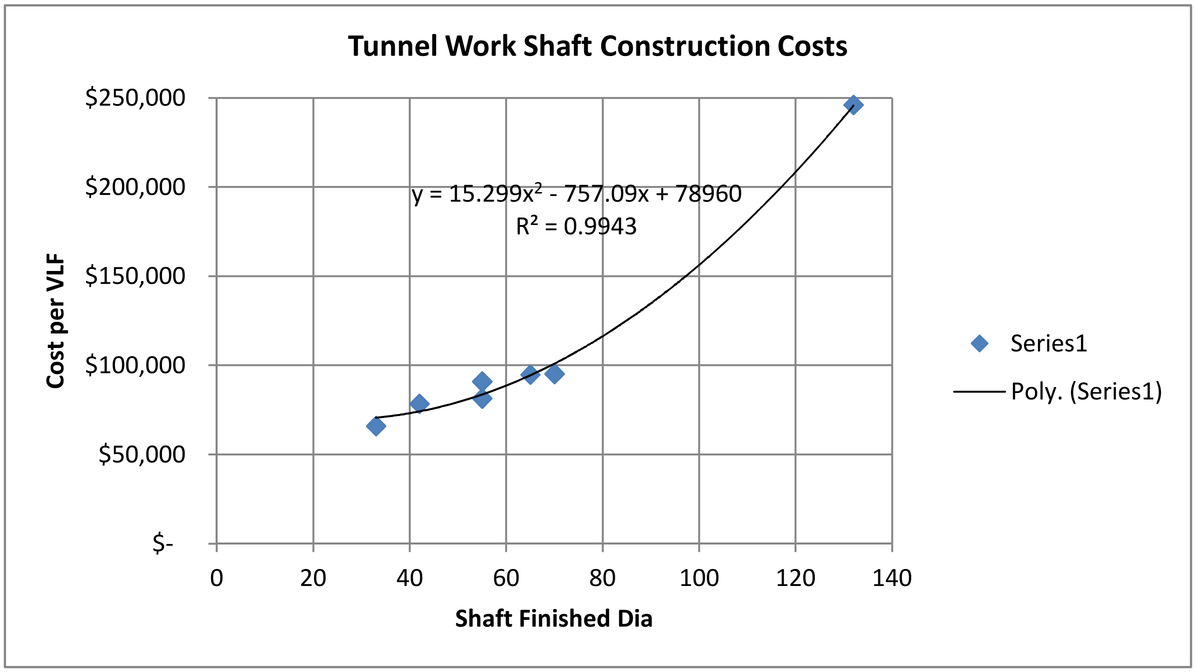
Appendix B - Basis For Cost Opinions
Tunnel Work Shaft Construction Costs

Figure 4



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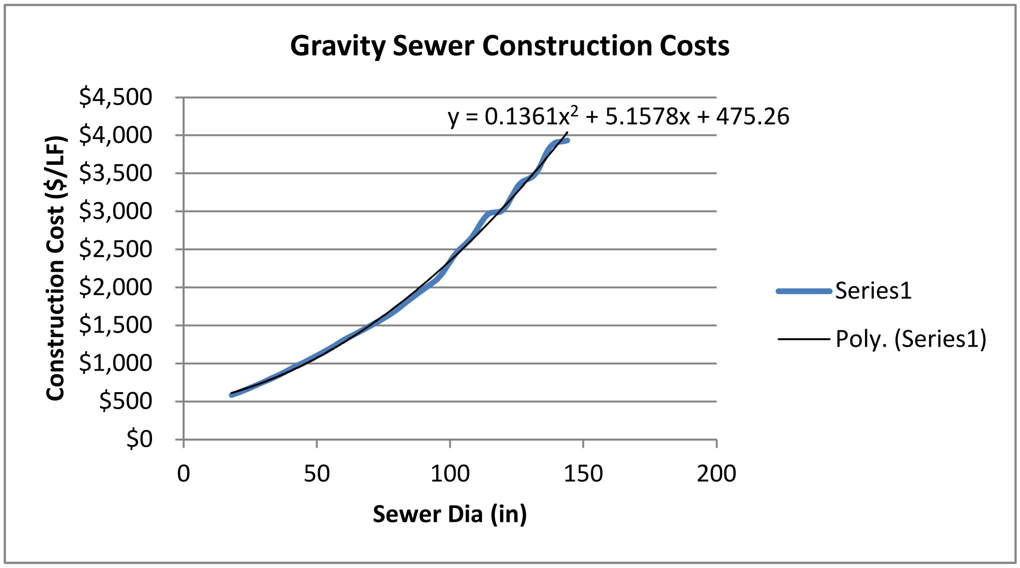
Appendix B - Basis For Cost Opinions
Gravity Sewer Construction Costs

Figure 5



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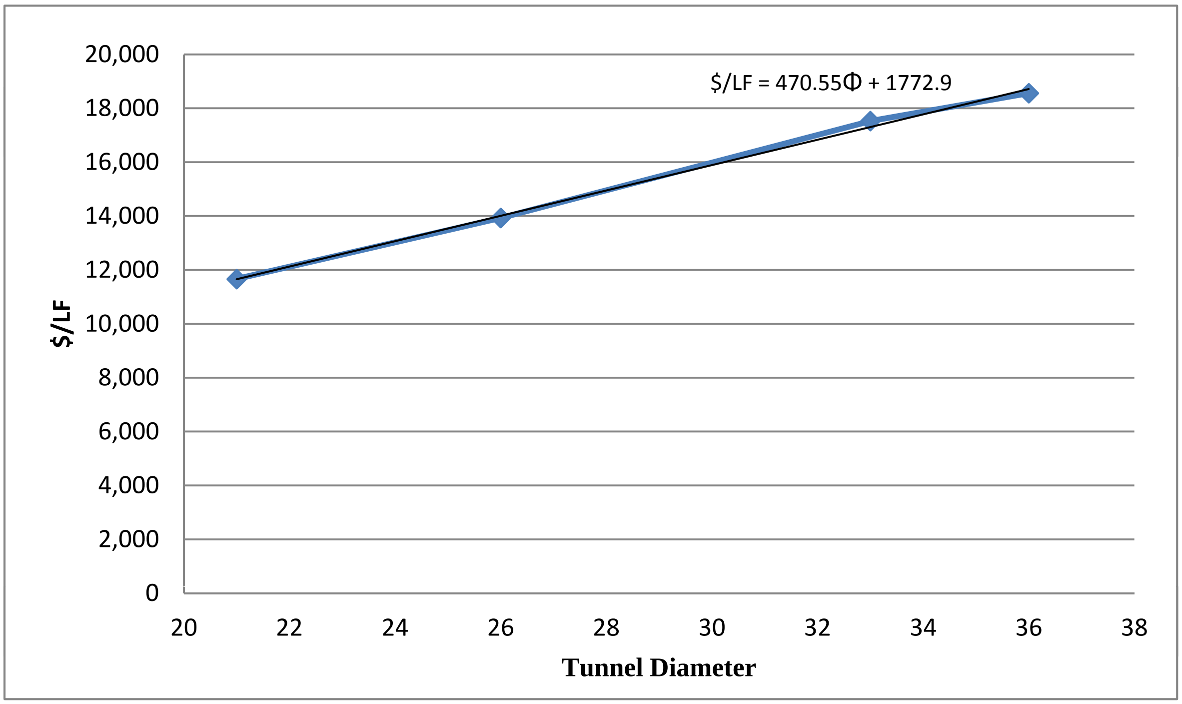
Appendix B - Basis For Cost Opinions
Tunnels in Soil Construction Costs, L= 9,100 ft

Figure 6



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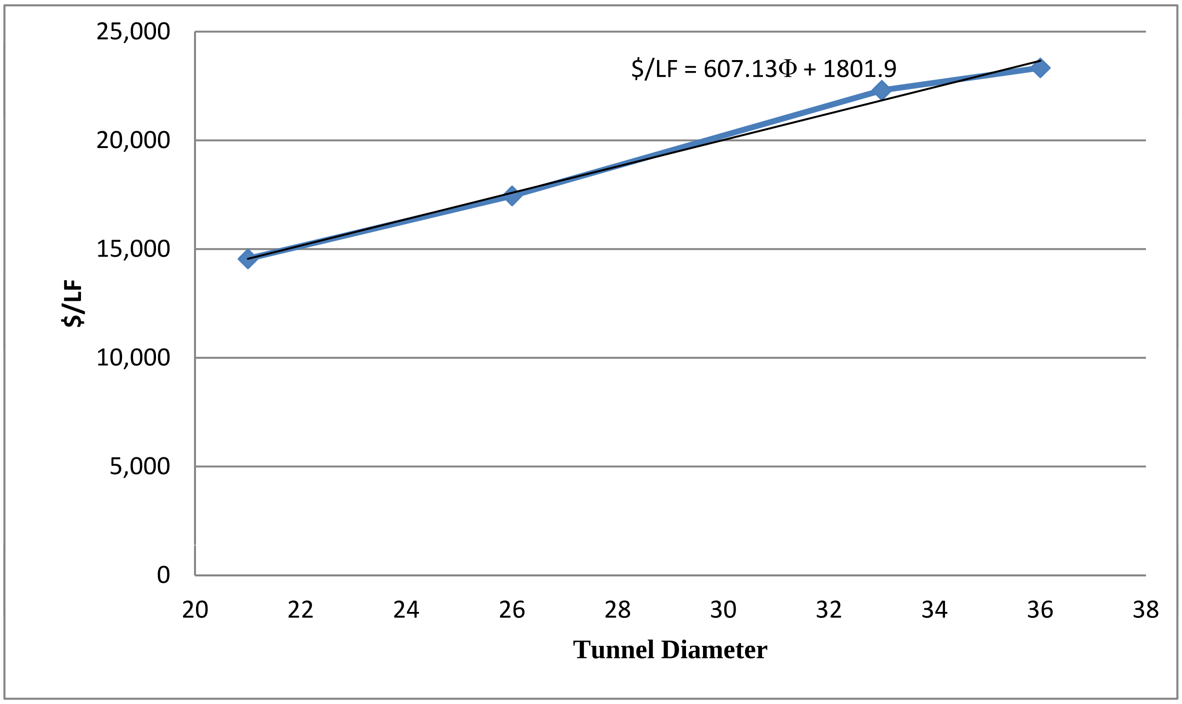
Appendix B - Basis For Cost Opinions
Tunnels in Soil Construction Costs, L= 4,500 ft

Figure 7



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DC Clean Rivers Project
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Infrastructure Costs
TABLE 1- RESULTS

Practice	Cost Range	Low Cost	Mean Cost	High Cost	2012 Low Cost	2012 Mean Cost	2012 High Cost	Unit	Source
Green Roof Costs									
Green Roofs - part extensive/intensive	$31.80		$ 31.80		$ -	$ 39.11	$ -	sf impervious area treated	WSSI installation
Green Roofs	$8 - $16	$ 8.00	$ 12.00	$ 16.00	$ 9.27	$ 13.91	$ 18.55	sf impervious area treated	Michigan LID
Green Roofs	$30.00		$ 30.00		$ -	$ 30.00	$ -	sf impervious area treated	NYC DEP
Green Roof - extensive	$6 - $43	$ 6.00	$ 24.50	$ 43.00	$ 6.18	$ 25.24	$ 44.29	sf impervious area treated	CCAP
Green Roof	$23.00		$ 23.00		$ -	$ 23.00	$ -	sf impervious area treated	TM-3
Green Roof	$15 - $20	$ 15.00	$ 17.50	$ 20.00	$ 20.76	$ 24.22	$ 27.68	sf impervious area treated	LID Center/ED&C
Green Roof - extensive	$8 - $20	$ 8.00	$ 14.00	$ 20.00	$ 8.00	$ 14.00	$ 20.00	sf impervious area treated	GLWI
Green Roof	$10 - $50	$ 10.00	$ 30.00	$ 50.00	$ 10.00	$ 30.00	$ 50.00	sf impervious area treated	City of Seattle
Green Roof	$10 - $25	$ 10.00	$ 17.50	$ 25.00	$ 10.00	$ 17.50	$ 25.00	sf impervious area treated	EPA/greenroof.com
Green Roof	$8 - $15	$ 8.00	$ 11.50	$ 15.00	$ 9.27	$ 13.33	$ 17.39	sf impervious area treated	MMSD
Green Roof - extensive		$ 9.50	$ 11.75	$ 14.00	$ 12.40	$ 15.33	$ 18.27	sf impervious area treated	CWP (Chicago data)
Green Roof - extensive		$ 10.00	$ 12.50	$ 15.00	$ 11.94	$ 14.93	$ 17.91	sf impervious area treated	CWP (Portland BES)
Green Roof (4" soil layer - extensive)		$ 13.40	$ 16.45	$ 19.50	$ 16.00	$ 19.64	$ 23.28	sf impervious area treated	NC State
Green Roof		$ 20.00	$ 25.00	$ 30.00	$ 22.51	$ 28.14	$ 33.77	sf impervious area treated	Sarasota County (WERF)
AVERAGE PER SQUARE FT TREATED		**$ 9.79**	**$ 19.82**	**$ 23.75**	**$ 12.39**	**$ 22.02**	**$ 26.92**		
AVERAGE PER ACRE TREATED		**$ 426,452**	**$ 863,421**	**$ 1,034,550**	**$ 539,899**	**$ 959,405**	**$ 1,172,711**		
Green Roof - extensive		$ 144	$ 225	$ 300	$ 171.94	$ 268.66	$ 358.22	cubic ft treated	CWP
Rainwater Harvesting Costs									
Rain Barrel (132 gal)	$2.27		$ 2.27			$ 2.27		gallon stored	TM-3
Rain Barrel	$2.50 - $3.30	$ 2.50	$ 2.90	$ 3.30	$ 2.81	$ 3.26	$ 3.71	gallon stored	Michigan LID
Rain Barrel			$ 1.27			$ 1.47		gallon stored	MMSD
Rain Barrel (includes installation)		$ 1.67	$ 3.34	$ 5.35	$ 2.00	$ 3.99	$ 6.39	gallon stored	CWP
Plastic Cistern (200 gal) (includes installation)			$ 2.65			$ 2.98		gallon stored	Sarasota County (WERF)
AVERAGE						**$ 2.80**			
Cistern	$0.80 - $3.34	$ 0.80	$ 2.07	$ 3.34	$ 0.96	$ 2.47	$ 3.99	gallon stored	CWP
Cistern (metal, non-potable use, installed)			$ 4.00			$ 4.50		gallon stored	Sarasota County (WERF)
Irrigation Cistern	$3.88		$ 3.88		$ -	$ 4.77	$ -	gallon stored	WSSI installation
Cistern (fiberglass to steel)	$0.50 - $4.00	$ 0.50	$ 2.25	$ 4.00	$ 0.61	$ 2.77	$ 4.92	gallon stored	GAHC
Cistern (fiberglass to steel)	$0.70 - $4.00	$ 0.70	$ 2.35	$ 4.00	$ 0.74	$ 2.49	$ 4.24	gallon stored	Monterey County
Cistern (fiberglass to steel)	$0.50 - $4.00	$ 0.50	$ 2.25	$ 4.00	$ 0.50	$ 2.25	$ 4.00	gallon stored	Sustainable Cities Institute
							$ 4.40		
Pervious Pavement Costs									
Pervious Pavement	$15.00		$ 15.00			$ 15.00		square foot	TM-3
Concrete Pavers	$7.10		$ 7.10		$ -	$ 8.73	$ -	square foot	WSSI installation
Concrete Paving Blocks	$5 - $10	$ 5.00	$ 7.50	$ 10.00	$ 6.72	$ 10.08	$ 13.44	square foot	LID Center
Pervious Concrete (includes base rock)	$11		$ 11.00		$ -	$ 13.53	$ -	square foot	City of Portland
Concrete Paving Blocks (installed/no drain)			$ 15.85		$ -	$ 19.49	$ -	square foot	Fairfax County
Permeable Alley						$ 40.00		square foot	LID Center - Lafayette
Permeable Pavers			$ 10.00			$ 11.94		square foot	CWP (Hathaway and Hunt)
Porous Pavement			$ 6.50			$ 9.55		square foot	US EPA
Permeable Pavers (no underdrain)			$ 13.36			$ 15.95		square foot	NC State
AVERAGE			**$ 11.29**			**$ 16.03**			
Permeable Pavement (w/o sand, veg)	$217,800		$ 217,800		$ -	$ 224,334.00	$ -	acre impervious area treated	MDE report
Permeable Pavement (w/ sand, veg)	$304,920		$ 304,920		$ -	$ 314,067.60	$ -	acre impervious area treated	MDE report
Porous Pavement	$81700 - $174000	$ 81,700.00	$ 127,850	$ 174,000.00	$ 94,712.69	$ 148,213.19	$ 201,713.69	acre impervious area treated	MMSD
AVERAGE						**$ 228,871.60**			
Permeable Pavers		$ 96.00	$ 120	$ 144.00	$ 114.63	$ 143.29	$ 171.94	cubic ft treated	CWP
Bioretention									
Bioretention	$32.40		$ 32.40			$ 32.40		square foot	TM-3
Commercial rain garden	$10 - $40	$ 10.00	$ 25.00	$ 40.00	$ 14.69	$ 36.71	$ 58.74	square foot	LID Center
Bioretention	$11		$ 11.00			$ 11.33		square foot	Viginia Tech
Bioretention						$ 64.00		square foot	LID Center - Lafayette
Bioswale						$ 43.00		square foot	LID Center - Lafayette
Curb contained bioretention (underdrain)			$ 33.34			$ 37.52		square foot	Sarasota County (WERF)
Bioretention (commercial/industrial/urban)		$ 10.00	$ 25.00	$ 40.00	$ 13.05	$ 32.62	$ 52.19	square foot	California BMP Handbook
AVERAGE						**$ 36.80**			
Bioretention - retrofit, urban	$52,500		$ 52,500.00			$ 54,075.00		acre impervious area treated	MDE report
Rain garden - new build	$113,256		$ 113,256.00					acre impervious area treated	WSSI installation
Bioretention - new build	$13,000 - $30,000	$ 13,000.00	$ 21,500.00	$ 30,000.00	$ 15,070.56	$ 24,924.39	$ 34,778.22	acre impervious area treated	MMSD
Water Quality Swale	$160,301		$ 160,301				$ -	acre impervious area treated	WSSI installation
Bioswale	$30,000		$ 30,000		$ -	$ 30,900.00	$ -	acre impervious area treated	MDE report
Bioretention (urban retrofits)		$ 19,900.00	$ 25,400	$ 41,750.00	$ 23,761.64	$ 30,328.93	$ 49,851.68	acre impervious area treated	CWP
Bioretention (ultra urban)			$ 10,000			$ 11,940.52		acre impervious area treated	FHWA
Curb contained bioretention (underdrain, retrofit)			$ 103,356			$ 116,328.09		acre impervious area treated	Sarasota County (WERF)
Curb contained bioretention (underdrain)			$ 89,028			$ 100,201.80		acre impervious area treated	Sarasota County (summary)
Curb contained bioretention (underdrain)			$ 48,441			$ 54,520.77		acre impervious area treated	Sarasota County (RS Means)
AVERAGE					**$ 19,416.10**	**$ 46,145.39**	**$ 42,314.95**		
Bioretention/rain garden	$5 - $7	$ 5.00	$ 6.00	$ 7.00	$ 5.63	$ 6.75	$ 7.88	cubic ft storage	Michigan LID
Small Bioretention retrofit		$ 25.00	$ 30.00	$ 40.00	$ 29.85	$ 35.82	$ 47.76	cubic ft treated	CWP
Soil Systems									
CU Structural Soils	$35 - $42	$ 35.00	$ 38.50	$ 42.00	$ 39.39	$ 43.33	$ 47.27	ton	Cornell University
Silva Cells (installed, not including tree, paving)*	$14 - $18	$ 14.00	$ 16.00	$ 18.00	$ 14.00	$ 16.00	$ 18.00	cubic ft	Deep Root Partners
Stormwater Tree Pits		$ 58.00	70	$ 83.00	$ 69.26	$ 83.58	$ 99.11	cubic ft treated	CWP
In Curb Planter Vaults - prefabricated (6x6x6)			$ 40,018.00			$ 46,391.83		acre impervious area treated	Sarasota County (summary)
In Curb Planter Vaults - in-situ installation (6x6x6)			$ 155,827.00			$ 180,646.20		acre impervious area treated	Sarasota County (summary)
CU Structural Soils w/ Trees - sidewalk retrofit	$21.64 - $31.31	$ 21.64	$ 26.48	$ 31.31	$ 29.95	$ 36.65	$ 43.34	square foot	City of Olympia demonstration

Appendix - C
Cost Estimates

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DISTRICT OF COLUMBIA
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DC Clean Rivers Project
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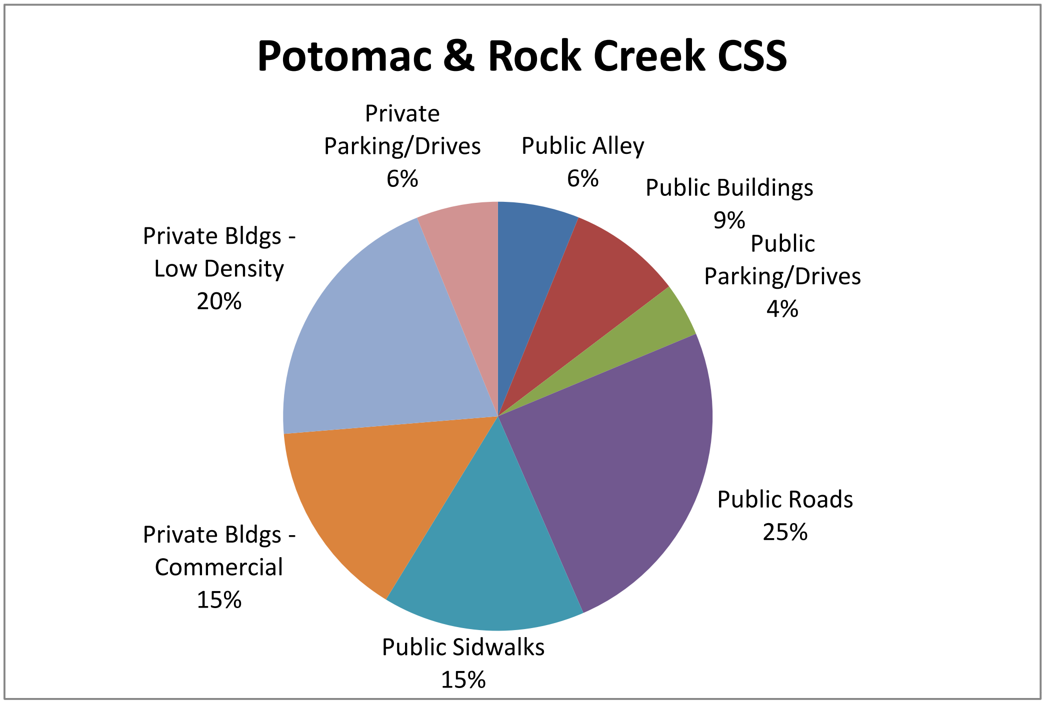
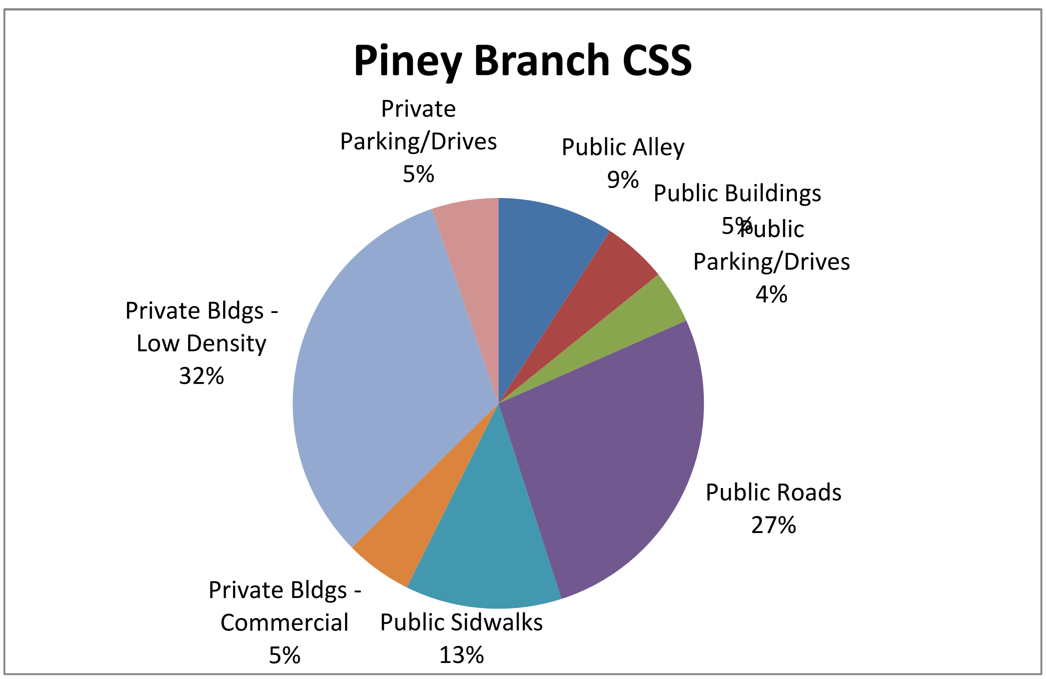
SCENARIO 1- COST ESTIMATES AND RESULTS
FIGURE 1- SEWERSHED LAND USE





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DC Clean Rivers Project
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SCENARIO 1- COST ESTIMATES AND RESULTS
TABLE 1- SUMMARY

Summary Table

Potomac		Piney Branch	
Summary -15%		**Summary -15%**	
% Green Technology Implementation	14.9%	**% Green Technology Implementation**	15.0%
Total Imperv. Area with LID (Ac)	489	**Total Imperv. Area with LID (Ac)**	182
Total Cost	$ 111,750,025	**Total Cost**	$ 40,309,213
Cost per Impv. Acre Treated	$ 228,359	**Cost per Impv. Acre Treated**	$ 221,399
Summary - 30%		**Summary - 30%**	
% Green Technology Implementation	29.6%	**% Green Technology Implementation**	30.0%
Total Imperv. Area with LID (Ac)	971	**Total Imperv. Area with LID (Ac)**	365
Total Cost	$ 289,835,342	**Total Cost**	$ 91,133,843
Cost per Impv. Acre Treated	$ 298,532	**Cost per Impv. Acre Treated**	$ 249,553

TABLE 2- 15% GI Implementation

Potomac & Rock Creek	Public Space								
Area	Alley	Buildings	Buildings	Parking Lot	Paved Drives	Roads	Roads	Sidewalks	Sidewalks
LID Technology	Pervious Pavement	Green Roof (Flat roof)	Cistern (Pitched Roof)	Pervious Pavement	Pervious Pavement	Pervious Pavement	Bioretention	Pervious Pavement	Trees
Unit cost of LID Technology ($/imp Acre)	$ 406,560	$ 1,646,568	$ 228,080	$ 406,560	$ 406,560	$ 406,560	$ 142,296	$ 406,560	$ 282,333
% Implementation of LID Tech	10%	0%	20%	15%	15%	10%	25%	10%	25%
Total Imp Area (Ac)	182	143	112	67	53	369	369	364	91
Total % coverage of LID Area (Goal =15%)								14.9%	
Total Area Treated (Ac)	18.24	0.00	22.45	10.08	7.99	36.92	92.30	36.37	22.73
Total Cost	$ 7,415,123	$ -	$ 5,119,684	$ 4,099,302	$ 3,247,984	$ 15,009,852	$ 13,133,620	$ 14,786,920	$ 6,417,934

Potomac & Rock Creek	Private Space						
Area	Buildings - Commercial, High Density Residential	Buildings - Commercial, High Density Residential	Buildings - Mixed Use	Buildings - Mixed Use	Buildings - Low& Low-med density	Parking lot	Paved Drives
LID Technology	Green Roof (Flat roof)	Cistern (Pitched Roof)	Green Roof (Flat roof)	Cistern (Pitched Roof)	Downspout D/S Rainbarrel	Pervious Pavement	Pervious Pavement
Unit cost of LID Technology ($/imp Acre)	$ 1,646,568	$ 228,080	$ 1,646,568	$ 228,080	$ 136,848	$ 406,560	$ 406,560
% Implementation of LID Tech	1%	5%	1%	10%	35%	10%	10%
Total Imp Area (Ac)	218	218	5	5	601	140	44
Total % coverage of LID Area (Goal =15%)							
Total Area Treated (Ac)	2.18	10.89	0.05	0.53	210.27	14.00	4.37
Total Cost	$ 3,587,288	$ 2,484,529	$ 86,566	$ 119,910	$ 28,775,024	$ 5,690,071	$ 1,776,217

Total Impervious Area Available (Ac)	3283
Imp Ac LID Applied	489
% LID Applied	15%
Total Capital Cost	$ 111,750,025
Avg $/imp ac	$ 228,359

TABLE 3-30% GI Implementation

Potomac & Rock Creek	Public Space										Private Space						
Area	Alley	Buildings	Buildings	Parking Lot	Paved Drives	Roads	Roads	Sidewalks	Sidewalks		Buildings - Commercial, High Density Residential	Buildings - Commercial, High Density Residential	Buildings - Mixed Use	Buildings - Mixed Use	Buildings - Low& Low-med density	Parking lot	Paved Drives
LID Technology	Pervious Pavement	Green Roof (Flat roof)	Cistern (Pitched Roof)	Pervious Pavement	Pervious Pavement	Pervious Pavement	Bioretention	Pervious Pavement	Trees		Green Roof (Flat roof)	Cistern (Pitched Roof)	Green Roof (Flat roof)	Cistern (Pitched Roof)	Downspout D/S Rainbarrel	Pervious Pavement	Pervious Pavement
Unit cost of LID Technology ($/imp Acre)	$ 406,560	$ 1,646,568	$ 228,080	$ 406,560	$ 406,560	$ 406,560	$ 142,296	$ 406,560	$ 282,333		$ 1,646,568	$ 228,080	$ 1,646,568	$ 228,080	$ 136,848	$ 406,560	$ 406,560
% Implementation of LID Tech	35%	10%	24%	35%	35%	35%	50%	44%	50%		2%	10%	2%	20%	40%	20%	20%
Total Imp Area (Ac)	182	143	112	67	53	369	369	364	91		218	218	5	5	601	140	44
Total % coverage of LID Area (Goal =30%)								29.6%									
Total Area Treated (Ac)	63.84	14.28	26.94	23.53	18.64	129.22	184.60	160.03	45.46		4.36	21.79	0.11	1.05	240.31	27.99	8.74
Total Cost	$ 25,952,929	$ 23,520,183	$ 6,143,621	$ 9,565,039	$ 7,578,629	$ 52,534,481	$ 26,267,240	$ 65,062,447	$ 12,835,868		$ 7,174,577	$ 4,969,059	$ 173,132	$ 239,820	$ 32,885,742	$ 11,380,141	$ 3,552,434

Total Impervious Area Available (Ac)	3283
Imp Ac LID Applied	971
% LID Applied	30%
Total Capital Cost	$ 289,835,342
Avg $/imp ac	$ 298,532

TABLE 4- 15% GI Implementation

Piney Branch	Public Space										Private Space						
Area	Alley	Buildings	Buildings	Parking Lot	Paved Drives	Roads	Roads	Sidewalks	Sidewalks		Buildings - Commercial, High Density Residential	Buildings - Commercial, High Density Residential	Buildings - Mixed Use	Buildings - Mixed Use	Buildings - Low& Low-med density	Parking lot	Paved Drives
LID Technology	Pervious Pavement	Green Roof (Flat roof)	Cistern (Pitched Roof)	Pervious Pavement	Pervious Pavement	Pervious Pavement	Bioretention	Pervious Pavement	Trees		Green Roof (Flat roof)	Cistern (Pitched Roof)	Green Roof (Flat roof)	Cistern (Pitched Roof)	Downspout D/S Rainbarrel	Pervious Pavement	Pervious Pavement
Unit cost of LID Technology ($/imp Acre)	$ 406,560	$ 1,646,568	$ 228,080	$ 406,560	$ 406,560	$ 406,560	$ 142,296	$ 406,560	$ 282,333		$ 1,646,568	$ 228,080	$ 1,646,568	$ 228,080	$ 136,848	$ 406,560	$ 406,560
% Implementation of LID Tech	10%	0%	15%	15%	15%	10%	20%	10%	25%		1%	5%	1%	10%	25%	10%	10%
Total Imp Area (Ac)	103	32	25	27	20	150	150	111	28		30	30	0	0	361	48	11
Total % coverage of LID Area (Goal =15%)								15.0%									
Total Area Treated (Ac)	10.29	0.00	3.75	4.02	3.04	14.99	29.98	11.07	6.92		0.30	1.48	0.00	0.02	90.32	4.77	1.13
Total Cost	$ 4,182,014	$ -	$ 855,562	$ 1,632,453	$ 1,234,818	$ 6,094,755	$ 4,266,328	$ 4,500,457	$ 1,953,323		$ 487,586	$ 337,698	$ 2,661	$ 3,686	$ 12,360,762	$ 1,938,754	$ 458,173

Total Impervious Area Available (Ac)	1215
Imp Ac LID Applied	182
% LID Applied	15%
Total Capital Cost	$ 40,309,031
Avg $/imp ac	$ 221,398

TABLE 5- 30% GI Implementation

Piney Branch	Public Space										Private Space						
Area	Alley	Buildings	Buildings	Parking Lot	Paved Drives	Roads	Roads	Sidewalks	Sidewalks		Buildings - Commercial, High Density Residential	Buildings - Commercial, High Density Residential	Buildings - Mixed Use	Buildings - Mixed Use	Buildings - Low& Low-med density	Parking lot	Paved Drives
LID Technology	Pervious Pavement	Green Roof (Flat roof)	Cistern (Pitched Roof)	Pervious Pavement	Pervious Pavement	Pervious Pavement	Bioretention	Pervious Pavement	Trees		Green Roof (Flat roof)	Cistern (Pitched Roof)	Green Roof (Flat roof)	Cistern (Pitched Roof)	Downspout D/S Rainbarrel	Pervious Pavement	Pervious Pavement
Unit cost of LID Technology ($/imp Acre)	$ 406,560	$ 1,646,568	$ 228,080	$ 406,560	$ 406,560	$ 406,560	$ 142,296	$ 406,560	$ 282,333		$ 1,646,568	$ 228,080	$ 1,646,568	$ 228,080	$ 136,848	$ 406,560	$ 406,560
% Implementation of LID Tech	35%	1%	20%	25%	25%	20%	41%	44%	50%		1%	5%	2%	20%	40%	20%	20%
Total Imp Area (Ac)	103	32	25	27	20	150	150	111	28	0	30	30	0	0	361	48	11
Total % coverage of LID Area (Goal =30%)								30.0%									
Total Area Treated (Ac)	36.00	0.32	5.00	6.69	5.06	29.98	61.46	48.71	13.84		0.30	1.48	0.00	0.03	144.52	9.54	2.25
Total Cost	$ 14,637,049	$ 524,068	$ 1,140,749	$ 2,720,755	$ 2,058,030	$ 12,189,509	$ 8,745,973	$ 19,802,009	$ 3,906,646		$ 487,586	$ 337,698	$ 5,322	$ 7,373	$ 19,777,220	$ 3,877,508	$ 916,346

Total Impervious Area Available (Ac)	1215
Imp Ac LID Applied	365
% LID Applied	30%
Total Capital Cost	$ 91,133,843
Avg $/imp ac	$ 249,553

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TABLE 6- GI UNIT COSTS AND EFFECTIVE USE

Green Infrastructure Practice	2012 Constr Cost	Unit	Cost/ac installed	Assumed Depth of porpus material (ft)	Void Space	Volume per SF (gal/sf)	Volume per SF of rain @ 1.2" (gal)	Total SF treated per SF of GI practice (sf)	Tree pit volume @ 6'x6'x6' (gal)	Runoff Volume for 1.2" rain(gal/ac)	# Imp ac treatred by 1 tree (ac)	Cost per tree	Volme per ac runoff at 1.2" (gal/ac)	Unit Construction cost ($/imp Ac Treated)	Unit Capital Cost ($/imp Ac)	Assumptions
Pervious Pavement (pavers)	$ 30.00	SF	$ 1,306,800	0.75	0.6	3.37	0.748	4.5						$ 290,400	$ 406,560	Retrofit, ultra-urban, underdrain used to tie into existing SW system, demo existing road/alley.
Bioretention Cells	$ 42.00	SF	$ 1,829,520	3	0.60	13.46	0.748	18.0						$ 101,640	$ 142,296	Retrofit, ultra-urban, underdrain used to tie into existing SW system, demo existing sidewalk/road.
Green Roof (extensive)	$ 27.00	SF	$ 1,176,120					1.0						$ 1,176,120	$ 1,646,568	Green Roof sized to treat 1.2", extensive green roof.
Street Trees	$ 18.00	cf	$ 180,000						1,616	32,583	0.0496	$ 10,000		$ 201,667	$ 282,333	Assume constructed in-situ, 6 x 6 x 6 in-curb planter vault.
Rain Barrels, D/S Disconnect	$ 22.44	CU FT	$ 97,749										32,583	97,749	$ 136,848	1.2" rain (0.1 ft) over 43,560 sf (acre) = 4,356 cu. ft.
Cisterns/Rain barrels	$5.00	GAL	$162,914										32,583	$ 162,914	$ 228,080	Based on 1.2" rainfall.

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TABLE 7- SEWERSHED LAND USE

SEWERSHED CHARACTERSTICS				Public Land Use							Private Land Use					REMARKS
				Alley	Buildings	Parking Lot	Paved Drives	Roads		Sidewalks	Buildings - Commercial, High Density Residential	Buildings - Mixed Use	Buildings - Low and Low-Med. Density Res.	Parking Lot	Paved Drives	
CSO Sewershed	Total Acres	Impervious Acres	% Impervious	Total Acres	Total Acres	Total Acres	Total Acres	Total Acres	Total Length	Total Acres	Total Acres	Total Acres	Total Acres	Total Acres	Total Acres	
Potomac	1,525	985	65%	28.7	143.9	31.5	22.5	210.9	230,294	163.4	175.4	9.5	78.4	32.1	16.6	
CSO 020	595	450	76%	11.4	76.2	15.6	7.6	105.4	97,507	83.7	97.0	0.1	5.7	9.1	3.9	
CSO 021	24	19	81%	0.0	6.3	0.2	0.5	0.7	1,050	3.4	0.1	3.5	0.0	0.0	0.5	
CSO 022	199	158	79%	4.5	16.6	1.2	1.5	38.9	43,089	25.9	38.5	3.4	4.0	6.5	3.6	
CSO 023	0	0	N/A	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	
CSO 024	175	62	36%	1.0	7.7	5.0	5.1	7.6	9,838	7.4	14.4	0.0	1.8	7.5	2.6	
CSO 025	15	12	79%	0.2	0.5	0.1	0.1	2.0	2,994	1.7	4.2	2.1	0.0	0.2	0.7	
CSO 026	3	3	86%	0.1	0.0	0.0	0.0	1.1	1,487	0.3	1.0	0.1	0.0	0.0	0.0	
CSO 027	164	104	64%	3.1	10.1	2.4	0.7	19.4	25,915	17.5	14.6	0.3	25.6	3.5	1.4	
CSO 028	21	13	61%	0.0	1.6	0.7	0.7	3.1	3,735	2.6	1.8	0.0	0.9	0.6	0.1	
CSO 029	330	164	50%	8.4	24.8	6.3	6.3	32.7	44,679	21.0	3.9	0.0	40.3	4.7	3.8	
Rock Creek	3,831	2,298	60%	153.7	111.2	35.7	30.7	527.5	672,205	291.2	260.3	1.0	522.4	107.9	27.1	
CSO 031	N/A	N/A	N/A	0.0	0.0	0.0	0.0	0.0		0.0	0	0	0	0.0	0	SEPARATED
CSO 032	13	10	82%	0.4	0.0	0.0	0.0	2.3	1,999	1.3	3.7	0.0	0.1	0.1	0.1	
CSO 033	16	12	74%	0.8	1.1	0.7	0.1	1.3	1,767	1.9	5.5	0.0	0.0	0.2	0.5	
CSO 034	393	338	86%	17.2	11.8	1.1	2.7	66.9	71,185	49.2	127.3	0.2	10.9	17.0	3.1	
CSO 035	551	399	72%	19.2	22.1	4.8	3.2	85.9	99,145	55.9	51.3	0.5	59.8	27.0	3.3	
CSO 036	75	45	60%	0.8	7.9	0.9	1.8	9.4	12,745	5.9	0.1	0.0	8.5	2.5	3.1	
CSO 037				0.0	0.0	0.0	0.0	0.0	1,848	0.0	0.0	0.0	0.0	0.0	0.0	SEPARATED
CSO 038	6	3	51%	0.1	0.1	0.1	0.1	0.9	1,332	0.4	0.0	0.0	0.8	0.2	0.2	
CSO 039	39	26	66%	0.7	1.2	0.4	0.5	5.4	7,241	3.5	0.3	0.0	4.1	1.5	0.9	
CSO 040	18	13	72%	0.8	0.1	0.2	0.0	2.5	3,023	1.5	0.7	0.0	4.1	0.9	0.0	
CSO 041	25	15	61%	0.7	0.5	0.4	1.0	3.1	4,040	1.8	0.5	0.0	3.9	0.4	0.2	
CSO 042	38	24	63%	0.8	0.0	0.0	0.1	4.3	6,066	3.0	0.9	0.0	4.3	1.5	0.4	
CSO 043	73	49	67%	2.9	4.1	0.0	0.4	10.7	13,823	6.0	3.1	0.0	13.1	2.9	0.3	
CSO 044	19	11	59%	1.3	0.0	0.0	0.0	2.1	2,743	0.8	0.0	0.0	6.7	0.0	0.0	
CSO 045	16	10	60%	1.0	0.0	0.0	0.0	2.0	2,686	0.9	0.2	0.0	4.8	0.0	0.3	
CSO 046	20	11	54%	1.0	0.5	0.2	0.1	3.1	4,086	1.3	0.0	0.0	4.0	0.1	0.0	
CSO 047	N/A	N/A	N/A	0.0	0.0	0.0	0.0	0.0	1,174	0.0	0.0	0.0	0.0	0.0	0.0	SEPARATED
CSO 048	33	17	51%	0.4	2.2	0.1	0.1	3.5	5,703	1.9	0.2	0.0	4.5	1.9	0.2	
CSO 049	2,329	1,215	52%	102.9	56.8	26.8	20.2	299.8	386,784	138.4	59.2	0.3	361.3	47.7	11.3	
CSO 050	38	27	70%	0.5	1.3	0.0	0.1	6.1	8,115	4.7	4.3	0.0	6.0	1.5	0.3	
CSO 051	12	8	65%	0.0	0.2	0.0	0.0	1.8	2,687	1.7	0.2	0.0	3.3	0.3	0.1	
CSO 052	104	58	55%	1.9	1.1	0.0	0.3	13.4	20,394	9.7	2.2	0.0	21.9	1.3	2.3	
CSO 053	5	4	65%	0.0	0.0	0.0	0.0	0.7	985	0.5	0.5	0.0	0.1	0.5	0.3	
CSO 054	N/A	N/A	N/A	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	
CSO 055	0	0	N/A	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	
CSO 056	0	0	N/A	0.0	0.0	0.0	0.0	0.0	-	0.0	0.0	0.0	0.0	0.0	0.0	
CSO 057				0.0	0.0	0.0	0.0	0.0	9,902	0.0	0.0	0.0	0.0	0.0	0.0	SEPARATED
CSO 058	7	5	68%	0.1	0.0	0.0	0.0	2.3	2,477	1.0	0.0	0.0	0.2	0.3	0.1	
	TOTALS	3,283		182	255	67	53	738		455	436	11	601	140	44	

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TABLE 1- RESULTS

	Green										Gray							Total Cost		
Line	% GI Application of Imp Area at 1.2" (Public & Private)	Total Acres	Imp Acres	Imp Ac Treated	Avg Unit Cost ($M/imp AC)	Avg GI Cost ($M)	Low Unit Cost $M/imp Ac(-50% cost)	Low Green Cost ($M)	Hi Unit Cost $M/imp Ac (+100% cost range)	Hi Green Cost ($M)	# CSOs/ Avg Yr	CSO Overflow vol (mg/avg yr)	Tunnel Volume (mg)	Tunnel Dia (ft)	Grey Cost ($M)	Low Cost (-20% cost)	High Cost (+30% cost range)	Avg	Low	High
Potomac Tunnel																				
1	0%	5,488	3,283								4	79	58	33.0	$ 594	$ 475	$ 772.2	$ 594	$ 475	$ 772
2	15%	5,488	3,283	492	$ 0.23	$ 112	$ 0.11	$ 56	$ 0.46	$ 225	4	65	48	30.0	$ 546	$ 437	$ 709.8	$ 658	$ 493	$ 934
3	15%	5,488	3,283	492	$ 0.23	$ 112	$ 0.11	$ 56	$ 0.46	$ 225	12	170	19	19.0	$ 447	$ 358	$ 581.1	$ 559	$ 414	$ 806
4	30%	5,488	3,283	985	$ 0.30	$ 294	$ 0.15	$ 147	$ 0.60	$ 587	4	60	36	26.0	$ 506	$ 405	$ 657.8	$ 800	$ 552	$ 1,245
5	30%	5,488	3,283	985	$ 0.30	$ 294	$ 0.15	$ 147	$ 0.60	$ 587	12	165	17	18.0	$ 442	$ 354	$ 574.6	$ 736	$ 500	$ 1,162
Piney Branch Tunnel																				
6	0%	2,329	1,215								1	0.9	8	22.0	120	$ 102	$ 156.0	$ 120	$ 102	$ 156
7	15%	2,329	1,215	182	$ 0.22	$ 40	$ 0.11	$ 20	$ 0.44	$ 80	1	0.8	6	18.0	104	$ 88	$ 135.2	$ 144	$ 108	$ 215
8	15%	2,329	1,215	182	$ 0.22	$ 40	$ 0.11	$ 20	$ 0.44	$ 80	12	15.0	1	7.0	63	$ 54	$ 81.9	$ 103	$ 74	$ 162
9	30%	2,329	1,215	365	$ 0.25	$ 91	$ 0.12	$ 45	$ 0.50	$ 182	1	1.0	5	17.0	100	$ 85	$ 130.0	$ 191	$ 130	$ 312
10	30%	2,329	1,215	365	$ 0.25	$ 91	$ 0.12	$ 45	$ 0.50	$ 182	12	13.0	1	6.0	56	$ 48	$ 72.8	$ 147	$ 93	$ 254

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SCENARIO 1 - COST ESTIMATES AND RESULS
FIGURE 1- POTOMAC COST RANGES

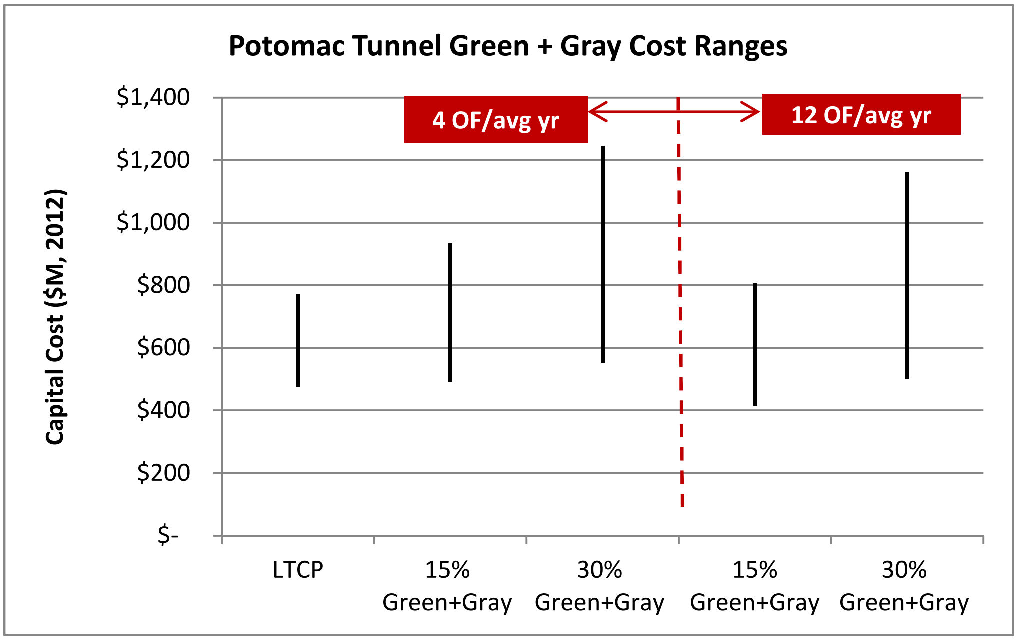

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FIGURE 2- PINEY BRANCH COST RANGES

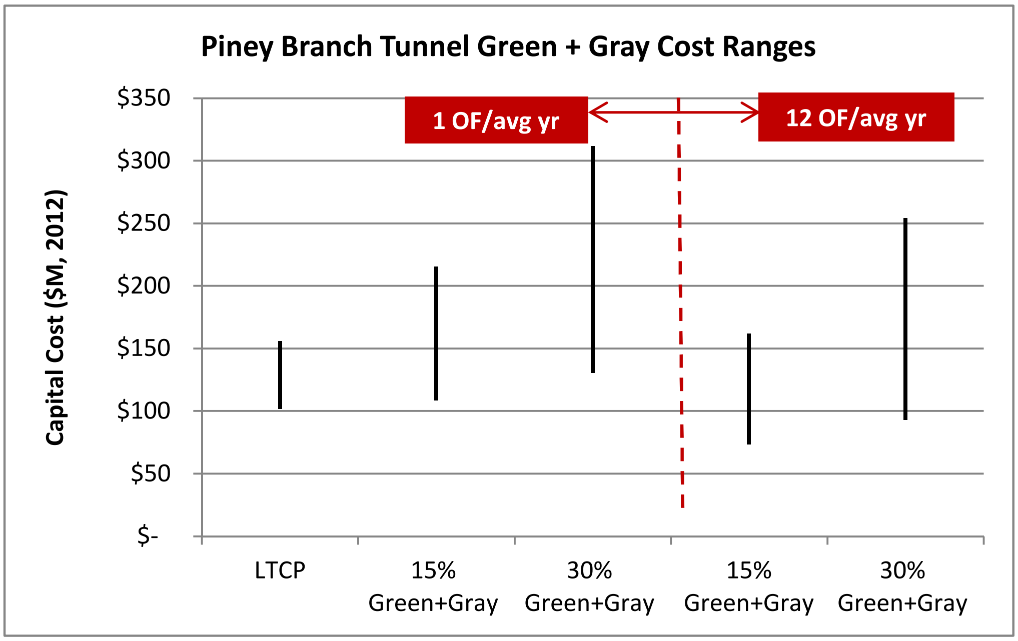

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TABLE 2- POTOMAC TUNNEL SIZE

Potomac

Line	Tunnel Capacity	Diameter	Length				
	Req'd Storage Gal	ft	ft	Prov Storage Cu Ft	Prov Storage Gal	Difference Req'd - Prov	# of CSO Overflows
1	58,000,000	33	9100	7779271.5	58188951	-188,951	4 per ave year

Potomac

Line	Tunnel Capacity	Diameter	Length				
15% implementation	Req'd Storage Gal	ft	ft	Prov Storage Cu Ft	Prov Storage Gal	Difference Req'd - Prov	# of CSO Overflows
2	45,000,000	30	9100	6429150	48090042	-3,090,042	4 per ave year
3	18,000,000	19	9100	2578803.5	19289450	-1,289,450	12 per ave year

Potomac

Line	Tunnel Capacity	Diameter	Length				
30% implementation	Req'd Storage Gal	ft	ft	Prov Storage Cu Ft	Prov Storage Gal	Difference Req'd - Prov	# of CSO Overflows
4	34,000,000	26	9100	4829006	36120965	-2,120,965	4 per ave year
5	17,000,000	18	9100	2314494	17312415	-312,415	12 per ave year

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TABLE 3- POTOMAC TUNNEL LF COSTS

Cost Model for Rock Tunnels by TBM
Modified from Div H 100% Estimate per notes
Assumes systematic lining during excavation is not req'd.

Line -1
9.1 ,000 ft Length
33 ft Diameter

No.	Item		(000)		Soil	Completent Rock	Not-so-good rock	Cost item	Rock Type: Competent $,000	Rock Type: Not so good $,000
1	Fixed Costs for tunnel									
	Erect Plant		$ 624							
	Assemble TBM		$ 445							
	Dis-assemble/Remove		$ 520							
	Break-in/out facilities		$ 717							
				$ 2,306	$2.3 million	$1.6 million	$1.6 million	1	$ 1,600	$ 1,600
2	Fixed costs for certain finish diameter									
	TBM & equip		$ 7,870							
	TBM & equip		$ 10,507							
				$ 18,377						
		23 ft diameter		$ 799	$800,000/ftØ	$800,000/ftØ	$800,000/ftØ	2	$ 28,764	$ 28,764
	For tunnel range: 10 ft to 30 ft finish diameter									
	For 2nd tunnel using same equipment, use only $150,000/ftØ									
3	Variable costs by tunnel length (diameter not a factor)									
	Labor		$ 4,302							
			$ 5,962							
	Equipment		$ 9,866							
			$ (7,870)							
			$ 13,173							
			$ (10,507)							
	Remove utilities/cleanup		$ 1,387							
	Instrumentation		$ 4,115							
				$ 20,428						
		Div H = 12,424 lf		$ 1,644.24						
				$ 1,017						
		temp support		$ 200						
					$ 1,217	$1220/lf of tunnel		3	$ 11,071	$ 17,096
				$ 1,479						
		temp support		$ 400						
					$ 1,879		$1880/lf of tunnel			
4	Variable costs by tunnel diameter and length									
	Material		$ 10,695							
			$ 15,963							
				$ 26,658						
	for 23 ft Ø:	Div H = 12,424 lf		$ 2,146						
		per ft Ø:		$ 93.29	$93/ftØ/lf					
	concrete line 22 ft @ 12" @$1,200/cy =		$3,150/lf		for tunnel Ø from 15 ft to 25 ft: use $140/ft Ø					
	concrete line 34 ft @18" @ $1200/cy		$7,350/lf		for tunnel Ø from 25 ft to 35 ft: use $215/ft Ø			4	$ 64,565	$ 70,434
5	Variable costs by square of diameter and length:									
	Subcontractors		$ 2,421							
			$ 3,628							
				$ 6,049						
	for 23 ft Ø:	Div H = 12,424 lf		$ 487						
		per ft Ø:		$ 0.92	$0.90/ftØ²/lf					
	50% of this is hauling, and 50% is dump fee					$0.45/ftØ²/lf	$0.45/ftØ²/lf	5	$ 4,459	$ 4,459
6	Tunnel Indirect Costs									
			$ 46							
			$ 401							
			$ 65							
		per month		$ 512						
	12,424 in 15 months =	830 ft/mo		$ 616.87	$620/lf of tunnel					
				$ 379.61		$380/lf of tunnel				
							$620/lf of tunnel	6	$ 3,458	$ 5,642
7	Overhead and Profit									
			$ 173,961							
	plus tunnel indirects		$ 7,664							
	total cost			$ 181,625						
	S/T indirects		$ 80,448							
	less tunnel indirects		$ (7,664)							
	total indirects			$ 72,784						
		Percent total		40.1%	40% of total cost	40% of total cost	40% of total cost	7	$ 45,567	$ 51,198
8	Escalation									
	These numbers are based on 2012 work									
				Use:	3%/year	3%/year	3%/year	8		
9	Contingency									
	concept design (no design or geotech)				40%	40%	40%	9		
	30% design				30%	30%	30%			
	60% design				25%	25%	25%			
	90% design				20%	20%	20%			
	Bid-level				15%	15%	15%			
10	total							10 Total	$ 159,483	$ 179,193
								$/lf	17525.63741	

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TABLE 4- POTOMAC TUNNEL LF COSTS

Cost Model for Rock Tunnels by TBM
Modified from Div H 100% Estimate per notes
Assumes systematic lining during excavation is not req'd.

No.	Item	(000)		Soil	Completent Rock	Not-so-good rock
1	Fixed Costs for tunnel					
	Erect Plant	$ 624				
	Assemble TBM	$ 445				
	Dis-assemble/Remove	$ 520				
	Break-in/out facilities	$ 717				
			$ 2,306	$2.3 million	$1.6 million	$1.6 million
2	Fixed costs for certain finish diameter					
	TBM & equip	$ 7,870				
	TBM & equip	$ 10,507				
			$ 18,377			
		23 ft diameter	$ 799	$800,000/ftØ	$800,000/ftØ	$800,000/ftØ
	For tunnel range: 10 ft to 30 ft finish diameter					
	For 2nd tunnel using same equipment, use only $150,000/ftØ					
3	Variable costs by tunnel length (diameter not a factor)					
	Labor	$ 4,302				
		$ 5,962				
	Equipment	$ 9,866				
		$ (7,870)				
		$ 13,173				
		$ (10,507)				
	Remove utilities/cleanu	$ 1,387				
	Instrumentation	$ 4,115				
			$ 20,428			
		Div H = 12,424 lf	$ 1,644.24			
			$ 1,017			
		temp support	$ 200			
				$ 1,217	$1220/lf of tunnel	
			$ 1,479			
		temp support	$ 400			
				$ 1,879		$1880/lf of tunnel
4	Variable costs by tunnel diameter and length					
	Material	$ 10,695				
		$ 15,963				
			$ 26,658			
	for 23 ft Ø:	Div H = 12,424 lf	$ 2,146			
		per ft Ø:	$ 93.29	$93/ftØ/lf		
	concrete line 22 ft @ 12" @$1,200/cy =		$3,150/lf	for tunnel Ø from 15 ft to 25 ft: use $140/ftØ		
	concrete line 34 ft @18" @ $1200/cy		$7,350/lf	for tunnel Ø from 25 ft to 35 ft: use $215/ftØ		
5	Variable costs by square of diameter and length:					
	Subcontractors	$ 2,421				
		$ 3,628				
			$ 6,049			
	for 23 ft Ø:	Div H = 12,424 lf	$ 487			
		per ft Ø:	$ 0.92	$0.90/ftØ²/lf		
	50% of this is hauling, and 50% is dump fee				$0.45/ftØ²/lf	$0.45/ftØ²/lf
6	Tunnel Indirect Costs					
		$ 46				
		$ 401				
		$ 65				
		per month	$ 512			
	12,424 in 15 months =	830 ft/mo	$ 616.87	$620/lf of tunnel		
			$ 379.61		$380/lf of tunnel	
						$620/lf of tunnel
7	Overhead and Profit					
		$ 173,961				
	plus tunnel indirects	$ 7,664				
	total cost		$ 181,625			
	S/T indirects	$ 80,448				
	less tunnel indirects	$ (7,664)				
	total indirects		$ 72,784			
		Percent total	40.1%	40% of total cost	40% of total cost	40% of total cost
8	Escalation					
	These numbers are based on 2012 work					
			Use:	3%/year	3%/year	3%/year
9	Contingency					
	concept design (no design or geotech)			40%	40%	40%
	30% design			30%	30%	30%
	60% design			25%	25%	25%
	90% design			20%	20%	20%
	Bid-level			15%	15%	15%
10	total					

Line -2			Line -3		
9.1 ,000 ft Length			9.1 ,000 ft Length		
30 ft Diameter			19 ft Diameter		
	Rock Type			Rock Type	
Cost item	Competent $,000	Not so good $,000	Cost item	Competent $,000	Not so good $,000
1	$ 1,600	$ 1,600	1	$ 1,600	$ 1,600
2	$ 23,970	$ 23,970	2	$ 15,181	$ 15,181
3	$ 11,071	$ 17,096	3	$ 11,071	$ 17,096
4	$ 58,695	$ 58,695	4	$ 37,174	$ 37,174
5	$ 3,686	$ 3,686	5	$ 1,478	$ 1,478
6	$ 3,458	$ 5,642	6	$ 3,458	$ 5,642
7	$ 40,992	$ 44,275	7	$ 27,985	$ 31,268
8			8		
9			9		
10 Total	$ 143,471	$ 154,963	10 Total	$ 97,946	$ 109,438
$/lf	15766.02895		$/lf	10763.30511	

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SCENARIO 1- COST ESTIMATES AND RESULTS
TABLE 5- POTOMAC TUNNEL LF COSTS

Cost Model for Rock Tunnels by TBM
Modified from Div H 100% Estimate per notes
Assumes systematic lining during excavation is not req'd.

No.	Item		(000)		Soil	Completent Rock	Not-so-good rock
1	Fixed Costs for tunnel						
	Erect Plant	$	624				
	Assemble TBM	$	445				
	Dis-assemble/Remove	$	520				
	Break-in/out facilities	$	717				
				$ 2,306	$2.3 million	$1.6 million	$1.6 million
2	Fixed costs for certain finish diameter						
	TBM & equip	$	7,870				
	TBM & equip	$	10,507				
				$ 18,377			
		23 ft diameter		$ 799	$800,000/ftØ	$800,000/ftØ	$800,000/ftØ
	For tunnel range: 10 ft to 30 ft finish diameter						
	For 2nd tunnel using same equipment, use only $150,000/ftØ						
3	Variable costs by tunnel length (diameter not a factor)						
	Labor	$	4,302				
		$	5,962				
	Equipment	$	9,866				
		$	(7,870)				
		$	13,173				
		$	(10,507)				
	Remove utilities/cleanu	$	1,387				
	Instrumentation	$	4,115				
				$ 20,428			
		Div H = 12,424 lf		$ 1,644.24			
				$ 1,017			
		temp support		$ 200			
					$ 1,217	$1220/lf of tunnel	
				$ 1,479			
		temp support		$ 400			
					$ 1,879		$1880/lf of tunnel
4	Variable costs by tunnel diameter and length						
	Material	$	10,695				
		$	15,963				
				$ 26,658			
	for 23 ft Ø:	Div H = 12,424 lf		$ 2,146			
		per ft Ø:		$ 93.29	$93/ftØ/lf		
	concrete line 22 ft @ 12" @$1,200/cy =			$3,150/lf	for tunnel Ø from 15 ft to 25 ft: use $140/ftØ		
	concrete line 34 ft @18" @ $1200/cy			$7,350/lf	for tunnel Ø from 25 ft to 35 ft: use $215/ftØ		
5	Variable costs by square of diameter and length:						
	Subcontractors	$	2,421				
		$	3,628				
				$ 6,049			
	for 23 ft Ø:	Div H = 12,424 lf		$ 487			
		per ft Ø:		$ 0.92	$0.90/ftØ^2/lf		
	50% of this is hauling, and 50% is dump fee					$0.45/ftØ^2/lf	$0.45/ftØ^2/lf
6	Tunnel Indirect Costs						
		$	46				
		$	401				
		$	65				
		per month		$ 512			
	12,424 in 15 months =	830 ft/mo		$ 616.87	$620/lf of tunnel		
				$ 379.61		$380/lf of tunnel	
							$620/lf of tunnel
7	Overhead and Profit						
		$	173,961				
	plus tunnel indirects	$	7,664				
	total cost			$ 181,625			
	S/T indirects	$	80,448				
	less tunnel indirects	$	(7,664)				
	total indirects			$ 72,784			
		Percent total		40.1%	40% of total cost	40% of total cost	40% of total cost
8	Escalation						
	These numbers are based on 2012 work						
				Use:	3%/year	3%/year	3%/year
9	Contingency						
	concept design (no design or geotech)				40%	40%	40%
	30% design				30%	30%	30%
	60% design				25%	25%	25%
	90% design				20%	20%	20%
	Bid-level				15%	15%	15%
10	total						

Line -4
9.1 ,000 ft Length
26 ft Diameter

Cost item	Rock Type: Competent $,000	Not so good $,000
1	$ 1,600	$ 1,600
2	$ 20,774	$ 20,774
3	$ 11,071	$ 17,096
4	$ 50,869	$ 50,869
5	$ 2,768	$ 2,768
6	$ 3,458	$ 5,642
7	$ 36,216	$ 39,500
8		
9		
10 Total	$ 126,756	$ 138,248
$/lf	13929.21664	

Line -5
9.1 ,000 ft Length
18 ft Diameter

Cost item	Rock Type: Competent $,000	Not so good $,000
1	$ 1,600	$ 1,600
2	$ 14,382	$ 14,382
3	$ 11,071	$ 17,096
4	$ 35,217	$ 35,217
5	$ 1,327	$ 1,327
6	$ 3,458	$ 5,642
7	$ 26,822	$ 30,105
8		
9		
10 Total	$ 93,876	$ 105,369
$/lf	10316.07203	

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TABLE 6- POTOMAC TUNNEL VALUES VS. SIZE

Values to Use for Potomac Tunnel Costing

Parameter	Basis	Tunnel ID (ft)				
		33	30	19	26	18
Pump Station Shaft ID	3 x Tunnel ID	99	90	57	78	54
Screening Shaft ID	1.5 x Tunnel ID	49.5	45	28.5	39	27
Retrieval Shaft ID at CSO 029	2 x Tunnel ID	66	60	38	52	36
Shaft Dia (Ft) V's Flow Rate		12	12	10	10	10
Pump Station Firm Capacity						
Tunnel Volume (mg)	@ 9100' long	58	48	19	36	17
Dewatering Time (hrs)		49	51	49	48	48
Pump Station Avg Capacity (mgd)		29	23	9	18	9
Peaking Factor to fill Valleys in Potomac Diurnal Flows		1.5	1.5	1.5	1.5	1.5
Pump Station Firm Capacity mgd)		43	34	14	27	13
Force Main Dia (ft)	@ 6 ft/sec	3.7	3.3	2.2	3.0	2.1
		48.0	48.0	36.0	36.0	36.0
Overflow Structure Length (ft)	Based on Consolid	275'	275'	275'	275'	275'

	Design Diversion Rate (mgd)				
	# Overflows/avg yr				
CSO	4	4	12	4	12
CSO 020	126	107	50	88	41
CSO 021	490	416	322	343	265
CSO 022	250	213	85	175	70
CSO 023/024	269	229	229	188	188
CSO 025	52	44	44	36	36
CSO 026	12	10	10	8	8
CSO 027	357	303	303	250	250
CSO 028	70	60	60	49	49
CSO 029	42	36	15	29	12

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SCENARIO 1- COST ESTIMATES AND RESULTS
TABLE 7- CSO FLOW RATES

	CSO 020				CSO 021				CSO 022				CSO 029			
	Easby Point				Slash Run				I St. - 22nd St. NW				College Pond			
Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	OF mgd rank
It162	11.05	257.35	1	**It22**	42.85	481.63	4	**It162**	12.96	386.92	1	**It162**	3.66	90.35	1	1
It84	8.04	223.28	1	**It162**	33.28	462.87	1	**It76**	16.88	335.19	2	**It102**	2.95	80.28	1	2
It22	5.38	201.65	3	**It76**	81.96	458.10	2	**It102**	8.87	330.89	1	**It76**	5.87	66.68	2	3
It102	7.43	197.05	1	**It102**	36.29	450.28	1	**It150**	10.03	267.36	2	**It84**	2.33	64.96	3	4
It150	10.33	191.90	2	**It150**	52.40	446.82	2	**It85**	3.83	146.57	2	**It85**	3.16	58.49	2	5
It90	5.04	158.45	1	**It85**	49.04	426.22	2	**It97**	3.32	134.62	1	**It150**	3.99	56.67	2	6
It94	6.33	158.25	2	**It97**	27.62	418.46	1	**It96**	3.99	114.69	1	**It90**	1.75	45.26	3	7
It76	10.59	132.74	2	**It75**	21.93	416.59	2	**It75**	2.34	108.78	3	**It22**	2.22	42.95	4	8
It169	4.26	127.81	1	**It96**	43.11	415.58	1	**It30**	2.61	90.10	2	**It97**	1.81	40.56	1	9
It85	6.40	127.33	2	**It30**	42.22	410.91	2	**It126**	2.05	87.36	1	**It147**	3.03	38.77	4	10
It91	1.55	107.23	1	**It126**	31.46	408.99	1	**It88**	2.43	86.08	1	**It96**	2.41	37.14	1	11
It95	4.85	105.06	2	**It84**	38.46	408.06	3	**It84**	1.89	76.55	3	**It169**	1.07	34.87	3	12
It80	3.91	102.71	1	**It88**	33.14	407.00	1	**It80**	1.51	73.37	1	**It132**	1.26	34.24	1	13
It131	2.96	100.15	1	**It80**	23.83	406.36	1	**It147**	2.46	72.68	3	**It126**	1.56	32.80	1	14
It152	2.95	99.73	1	**It151**	53.78	404.96	1	**It151**	1.94	67.71	1	**It83**	1.59	32.11	3	15
It97	4.83	95.88	1	**It147**	63.93	404.58	3	**It169**	1.29	65.54	1	**It36**	1.05	30.95	1	16
It147	2.99	91.58	2	**It169**	20.06	403.79	1	**It22**	0.94	19.63	3	**It151**	2.27	29.94	1	17
It96	5.46	88.97	1	**It106**	26.80	379.36	1	**It106**	0.51	12.38	1	**It75**	1.20	29.32	2	18
It75	2.76	85.03	2	**It83**	35.36	376.64	3	**It90**	0.50	12.06	2	**It80**	1.47	29.24	1	19
It83	4.30	84.45	2	**It132**	18.20	372.21	1	**It132**	0.39	9.68	1	**It88**	1.60	29.05	1	20
It30	3.73	81.74	2	**It131**	13.03	362.71	1	**It36**	0.32	8.82	1	**It94**	1.23	28.28	2	21
It29	4.82	78.34	2	**It49**	21.64	352.01	1	**It94**	0.43	8.57	2	**It131**	0.78	27.47	1	22
It132	3.00	77.21	1	**It82**	39.49	350.31	2	**It83**	0.58	8.10	3	**It23**	0.59	25.03	1	23
It126	3.00	76.22	1	**It94**	18.10	349.48	2	**It131**	0.24	7.82	1	**It120**	0.81	23.98	1	24
It120	1.19	72.11	1	**It36**	15.48	348.62	1	**It95**	0.37	6.79	2	**It95**	1.31	21.91	6	25
It25	0.89	70.41	1	**It90**	20.34	347.03	2	**It120**	0.26	6.55	1	**It49**	1.10	21.09	1	26
It153	1.58	68.54	1	**It51**	29.38	343.30	1	**It49**	0.34	6.50	1	**It145**	0.46	19.84	1	27
It49	3.08	65.67	1	**It4**	22.77	340.78	1	**It23**	0.15	6.47	1	**It30**	1.33	18.73	2	28
It140	5.80	64.87	1	**It29**	28.45	340.10	3	**It164**	0.61	6.28	1	**It163**	2.20	18.12	1	29
It64	1.59	62.87	1	**It74**	16.71	337.69	1	**It163**	0.71	5.81	1	**It64**	0.77	18.06	2	30
It88	3.63	62.51	1	**It23**	9.38	333.97	1	**It4**	0.32	5.74	1	**It82**	1.87	17.94	3	31
It23	1.22	60.88	1	**It79**	11.04	330.80	1	**It51**	0.36	5.58	1	**It164**	1.48	17.10	1	32
It36	1.75	57.50	1	**It164**	30.30	330.19	1	**It64**	0.26	5.41	1	**It51**	1.20	15.74	1	33
It151	2.01	51.34	1	**It120**	25.18	320.37	1	**It145**	0.12	5.38	1	**It153**	0.41	15.54	1	34
It37	1.06	50.15	1	**It64**	14.49	318.38	1	**It82**	0.68	5.29	2	**It106**	1.01	15.37	1	35
It145	0.96	49.15	1	**It123**	7.98	315.22	1	**It140**	0.52	4.97	1	**It4**	0.86	14.70	1	36
It106	2.32	45.24	1	**It163**	42.99	314.57	1	**It29**	0.52	4.94	4	**It91**	0.20	13.77	1	37
It164	2.02	40.21	1	**It142**	9.30	286.17	1	**It153**	0.11	4.88	1	**It29**	1.66	13.72	4	38
It14	0.90	37.72	1	**It19**	6.35	277.25	1	**It91**	0.08	4.82	1	**It14**	0.65	11.83	1	39
It4	1.67	37.39	1	**It145**	7.58	272.78	1	**It14**	0.20	4.29	1	**It152**	0.33	11.59	1	40
It51	1.60	36.01	1	**It153**	6.98	261.12	1	**It152**	0.09	4.22	1	**It142**	0.31	11.21	1	41
It146	0.59	34.92	1	**It98**	26.19	248.83	3	**It33**	0.16	4.18	1	**It74**	0.43	10.71	1	42
It82	1.40	32.93	1	**It14**	10.43	248.04	1	**It98**	0.35	3.95	3	**It105**	0.81	10.56	1	43
It33	0.96	32.62	1	**It140**	21.78	221.80	1	**It37**	0.14	3.55	1	**It140**	1.26	10.40	1	44
It74	0.58	29.37	1	**It170**	19.94	219.37	1	**It105**	0.23	3.50	1	**It98**	1.31	10.37	3	45
It79	0.42	25.50	1	**It77**	7.98	219.17	1	**It74**	0.12	3.39	1	**It37**	0.42	10.17	1	46
It98	0.46	22.46	1	**It105**	18.82	217.83	1	**It139**	0.21	3.31	1	**It33**	0.43	9.73	1	47
It139	0.36	18.13	1	**It156**	12.99	212.14	1	**It123**	0.08	3.31	1	**It123**	0.35	8.13	2	48
It58	0.11	10.46	1	**It95**	10.54	197.57	2	**It142**	0.07	3.09	1	**It25**	0.09	6.90	2	49
It101	0.08	7.68	1	**It37**	6.63	189.46	1	**It79**	0.07	3.00	1	**It19**	0.22	6.78	2	50
It163	0.24	6.87	1	**It44**	3.74	184.33	1	**It19**	0.06	2.87	1	**It139**	0.69	6.44	2	51
It12	0.04	3.69	1	**It58**	8.63	174.60	1	**It170**	0.17	2.29	1	**It79**	0.23	6.16	2	52
It170	0.00	0.00	0	**It167**	5.89	163.18	1	**It25**	0.03	2.18	1	**It77**	0.22	5.05	1	53
It105	0.00	0.00	0	**It139**	14.21	161.89	2	**It77**	0.05	2.08	1	**It170**	0.50	4.67	1	54
It156	0.00	0.00	0	**It33**	6.37	155.15	1	**It12**	0.04	1.86	1	**It12**	0.21	4.19	2	55
It142	0.00	0.00	0	**It7**	7.48	122.08	1	**It167**	0.05	1.75	1	**It58**	0.27	4.15	1	56
It123	0.00	0.00	0	**It91**	1.44	112.83	1	**It101**	0.03	1.53	1	**It101**	0.20	3.84	1	57
It77	0.00	0.00	0	**It6**	1.92	97.42	1	**It69**	0.08	1.52	1	**It69**	0.38	3.53	1	58
It7	0.00	0.00	0	**It152**	1.13	90.29	1	**It58**	0.07	1.41	1	**It167**	0.21	3.52	1	59
It19	0.00	0.00	0	**It101**	2.66	84.51	1	**It70**	0.01	1.03	1	**It70**	0.11	3.37	2	60
It167	0.00	0.00	0	**It69**	4.51	84.40	1	**It156**	0.03	0.97	1	**It146**	0.10	3.13	1	61
It69	0.00	0.00	0	**It72**	2.60	82.52	1	**It44**	0.01	0.80	1	**It111**	0.20	2.98	1	62
It44	0.00	0.00	0	**It111**	3.64	82.27	1	**It111**	0.03	0.71	1	**It156**	0.21	2.85	2	63
It111	0.00	0.00	0	**It12**	1.74	63.05	1	**It15**	0.01	0.31	1	**It44**	0.18	2.61	1	64

	CSO 020				CSO 021				CSO 022				CSO 029			
	Easby Point				Slash Run				I St. - 22nd St. NW				College Pond			
Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	**Rain Event No.**	OF Vol. (mg)	Max OF Rate (mgd)	Freq	**Rain Event No.**	OF Vol. (mg)	Max OF Rate (mgd)	Freq	**Rain Event No.**	OF Vol. (mg)	Max OF Rate (mgd)	Freq	OF mgd rank
It72	0.00	0.00	0	**It70**	1.13	59.47	1	**It146**	0.00	0.25	1	**It41**	0.10	2.42	1	65
It6	0.00	0.00	0	**It41**	0.14	13.22	1	**It7**	0.00	0.24	1	**It48**	0.06	2.39	1	66
It70	0.00	0.00	0	**It15**	0.07	6.84	1	**It6**	0.00	0.10	1	**It53**	0.07	2.16	1	67
It130	0.00	0.00	0	**It130**	0.05	4.32	1	**It72**	0.00	0.00	0	**It72**	0.15	2.10	2	68
It20	0.00	0.00	0	**It25**	0.00	0.00	0	**It130**	0.00	0.00	0	**It6**	0.11	1.98	2	69
It15	0.00	0.00	0	**It20**	0.00	0.00	0	**It20**	0.00	0.00	0	**It7**	0.18	1.80	1	70
It138	0.00	0.00	0	**It146**	0.00	0.00	0	**It138**	0.00	0.00	0	**It20**	0.12	1.78	1	71
It66	0.00	0.00	0	**It138**	0.00	0.00	0	**It66**	0.00	0.00	0	**It138**	0.17	1.61	1	72
It168	0.00	0.00	0	**It66**	0.00	0.00	0	**It168**	0.00	0.00	0	**It15**	0.17	1.60	1	73
It87	0.00	0.00	0	**It168**	0.00	0.00	0	**It87**	0.00	0.00	0	**It26**	0.04	1.58	2	74
It50	0.00	0.00	0	**It87**	0.00	0.00	0	**It50**	0.00	0.00	0	**It87**	0.12	1.50	2	75
It41	0.00	0.00	0	**It50**	0.00	0.00	0	**It41**	0.00	0.00	0	**It50**	0.07	1.46	2	76
It53	0.00	0.00	0	**It53**	0.00	0.00	0	**It53**	0.00	0.00	0	**It168**	0.07	1.40	1	77
It56	0.00	0.00	0	**It56**	0.00	0.00	0	**It56**	0.00	0.00	0	**It32**	0.04	1.34	2	78
It112	0.00	0.00	0	**It112**	0.00	0.00	0	**It112**	0.00	0.00	0	**It130**	0.17	1.33	1	79
It154	0.00	0.00	0	**It154**	0.00	0.00	0	**It154**	0.00	0.00	0	**It35**	0.01	1.08	1	80
It45	0.00	0.00	0	**It45**	0.00	0.00	0	**It45**	0.00	0.00	0	**It171**	0.03	1.02	1	81
It73	0.00	0.00	0	**It73**	0.00	0.00	0	**It73**	0.00	0.00	0	**It154**	0.04	1.00	2	82
It63	0.00	0.00	0	**It63**	0.00	0.00	0	**It63**	0.00	0.00	0	**It118**	0.01	0.94	1	83
It124	0.00	0.00	0	**It124**	0.00	0.00	0	**It124**	0.00	0.00	0	**It63**	0.03	0.90	1	84
It68	0.00	0.00	0	**It68**	0.00	0.00	0	**It68**	0.00	0.00	0	**It117**	0.02	0.88	1	85
It48	0.00	0.00	0	**It48**	0.00	0.00	0	**It48**	0.00	0.00	0	**It112**	0.05	0.87	2	86
It122	0.00	0.00	0	**It122**	0.00	0.00	0	**It122**	0.00	0.00	0	**It122**	0.03	0.78	1	87
It107	0.00	0.00	0	**It107**	0.00	0.00	0	**It107**	0.00	0.00	0	**It21**	0.02	0.77	2	88
It61	0.00	0.00	0	**It61**	0.00	0.00	0	**It61**	0.00	0.00	0	**It148**	0.03	0.74	1	89
It55	0.00	0.00	0	**It55**	0.00	0.00	0	**It55**	0.00	0.00	0	**It68**	0.02	0.69	1	90
It32	0.00	0.00	0	**It32**	0.00	0.00	0	**It32**	0.00	0.00	0	**It28**	0.01	0.64	1	91
It114	0.00	0.00	0	**It114**	0.00	0.00	0	**It114**	0.00	0.00	0	**It56**	0.02	0.60	1	92
It57	0.00	0.00	0	**It57**	0.00	0.00	0	**It57**	0.00	0.00	0	**It61**	0.02	0.56	1	93
It26	0.00	0.00	0	**It26**	0.00	0.00	0	**It26**	0.00	0.00	0	**It114**	0.01	0.53	1	94
It171	0.00	0.00	0	**It171**	0.00	0.00	0	**It171**	0.00	0.00	0	**It66**	0.06	0.52	2	95
It148	0.00	0.00	0	**It148**	0.00	0.00	0	**It148**	0.00	0.00	0	**It124**	0.02	0.52	1	96
It143	0.00	0.00	0	**It143**	0.00	0.00	0	**It143**	0.00	0.00	0	**It109**	0.01	0.46	1	97
It21	0.00	0.00	0	**It21**	0.00	0.00	0	**It21**	0.00	0.00	0	**It159**	0.00	0.41	1	98
It1	0.00	0.00	0	**It1**	0.00	0.00	0	**It1**	0.00	0.00	0	**It107**	0.01	0.41	1	99
It117	0.00	0.00	0	**It117**	0.00	0.00	0	**It117**	0.00	0.00	0	**It113**	0.01	0.37	1	100
It9	0.00	0.00	0	**It9**	0.00	0.00	0	**It9**	0.00	0.00	0	**It1**	0.01	0.33	1	101
It103	0.00	0.00	0	**It103**	0.00	0.00	0	**It103**	0.00	0.00	0	**It99**	0.01	0.33	1	102
It46	0.00	0.00	0	**It46**	0.00	0.00	0	**It46**	0.00	0.00	0	**It81**	0.00	0.33	1	103
It5	0.00	0.00	0	**It5**	0.00	0.00	0	**It5**	0.00	0.00	0	**It54**	0.00	0.27	1	104
It28	0.00	0.00	0	**It28**	0.00	0.00	0	**It28**	0.00	0.00	0	**It55**	0.00	0.27	1	105
It8	0.00	0.00	0	**It8**	0.00	0.00	0	**It8**	0.00	0.00	0	**It86**	0.00	0.27	1	106
It99	0.00	0.00	0	**It99**	0.00	0.00	0	**It99**	0.00	0.00	0	**It57**	0.00	0.23	1	107
It115	0.00	0.00	0	**It115**	0.00	0.00	0	**It115**	0.00	0.00	0	**It45**	0.01	0.18	1	108
It109	0.00	0.00	0	**It109**	0.00	0.00	0	**It109**	0.00	0.00	0	**It73**	0.01	0.16	1	109
It81	0.00	0.00	0	**It81**	0.00	0.00	0	**It81**	0.00	0.00	0	**It46**	0.00	0.16	1	110
It113	0.00	0.00	0	**It113**	0.00	0.00	0	**It113**	0.00	0.00	0	**It31**	0.00	0.14	1	111
It133	0.00	0.00	0	**It133**	0.00	0.00	0	**It133**	0.00	0.00	0	**It8**	0.00	0.07	1	112
It35	0.00	0.00	0	**It35**	0.00	0.00	0	**It35**	0.00	0.00	0	**It125**	0.00	0.05	1	113
It2	0.00	0.00	0	**It2**	0.00	0.00	0	**It2**	0.00	0.00	0	**It143**	0.00	0.03	1	114
It118	0.00	0.00	0	**It118**	0.00	0.00	0	**It118**	0.00	0.00	0	**It103**	0.00	0.03	1	115
It157	0.00	0.00	0	**It157**	0.00	0.00	0	**It157**	0.00	0.00	0	**It9**	0.00	0.01	1	116
It42	0.00	0.00	0	**It42**	0.00	0.00	0	**It42**	0.00	0.00	0	**It115**	0.00	0.01	1	117
It86	0.00	0.00	0	**It86**	0.00	0.00	0	**It86**	0.00	0.00	0	**It5**	0.00	0.00	0	118
It121	0.00	0.00	0	**It121**	0.00	0.00	0	**It121**	0.00	0.00	0	**It133**	0.00	0.00	0	119
It128	0.00	0.00	0	**It128**	0.00	0.00	0	**It128**	0.00	0.00	0	**It2**	0.00	0.00	0	120
It159	0.00	0.00	0	**It159**	0.00	0.00	0	**It159**	0.00	0.00	0	**It157**	0.00	0.00	0	121
It71	0.00	0.00	0	**It71**	0.00	0.00	0	**It71**	0.00	0.00	0	**It42**	0.00	0.00	0	122
It52	0.00	0.00	0	**It52**	0.00	0.00	0	**It52**	0.00	0.00	0	**It121**	0.00	0.00	0	123
It54	0.00	0.00	0	**It54**	0.00	0.00	0	**It54**	0.00	0.00	0	**It128**	0.00	0.00	0	124
It92	0.00	0.00	0	**It92**	0.00	0.00	0	**It92**	0.00	0.00	0	**It71**	0.00	0.00	0	125
It31	0.00	0.00	0	**It31**	0.00	0.00	0	**It31**	0.00	0.00	0	**It52**	0.00	0.00	0	126
It65	0.00	0.00	0	**It65**	0.00	0.00	0	**It65**	0.00	0.00	0	**It92**	0.00	0.00	0	127
It119	0.00	0.00	0	**It119**	0.00	0.00	0	**It119**	0.00	0.00	0	**It65**	0.00	0.00	0	128
It78	0.00	0.00	0	**It78**	0.00	0.00	0	**It78**	0.00	0.00	0	**It119**	0.00	0.00	0	129
It27	0.00	0.00	0	**It27**	0.00	0.00	0	**It27**	0.00	0.00	0	**It78**	0.00	0.00	0	130
It166	0.00	0.00	0	**It166**	0.00	0.00	0	**It166**	0.00	0.00	0	**It27**	0.00	0.00	0	131
It141	0.00	0.00	0	**It141**	0.00	0.00	0	**It141**	0.00	0.00	0	**It166**	0.00	0.00	0	132
It155	0.00	0.00	0	**It155**	0.00	0.00	0	**It155**	0.00	0.00	0	**It141**	0.00	0.00	0	133
It165	0.00	0.00	0	**It165**	0.00	0.00	0	**It165**	0.00	0.00	0	**It155**	0.00	0.00	0	134
It125	0.00	0.00	0	**It125**	0.00	0.00	0	**It125**	0.00	0.00	0	**It165**	0.00	0.00	0	135
It16	0.00	0.00	0	**It16**	0.00	0.00	0	**It16**	0.00	0.00	0	**It16**	0.00	0.00	0	136
It34	0.00	0.00	0	**It34**	0.00	0.00	0	**It34**	0.00	0.00	0	**It34**	0.00	0.00	0	137
It104	0.00	0.00	0	**It104**	0.00	0.00	0	**It104**	0.00	0.00	0	**It104**	0.00	0.00	0	138
It161	0.00	0.00	0	**It161**	0.00	0.00	0	**It161**	0.00	0.00	0	**It161**	0.00	0.00	0	139
It134	0.00	0.00	0	**It134**	0.00	0.00	0	**It134**	0.00	0.00	0	**It134**	0.00	0.00	0	140
It60	0.00	0.00	0	**It60**	0.00	0.00	0	**It60**	0.00	0.00	0	**It60**	0.00	0.00	0	141
It62	0.00	0.00	0	**It62**	0.00	0.00	0	**It62**	0.00	0.00	0	**It62**	0.00	0.00	0	142

Rain Event No.	CSO 020 Easby Point OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	CSO 021 Slash Run OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	CSO 022 I St. - 22nd St. NW OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	CSO 029 College Pond OF Vol. (mg)	Max OF Rate (mgd)	Freq	OF mgd rank
lt93	0.00	0.00	0	**lt93**	0.00	0.00	0	**lt93**	0.00	0.00	0	**lt93**	0.00	0.00	0	143
lt24	0.00	0.00	0	**lt24**	0.00	0.00	0	**lt24**	0.00	0.00	0	**lt24**	0.00	0.00	0	144
lt108	0.00	0.00	0	**lt108**	0.00	0.00	0	**lt108**	0.00	0.00	0	**lt108**	0.00	0.00	0	145

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SCENARIO 1- COST ESTIMATES AND RESULTS
TABLE 8- POTOMAC COST SUMMARY

Line	Potomac CSO Capital Cost ($M)	Potomac CSO Capital Cost ($)
1	$ 594	594000000
2	$ 546	546000000
3	$ 447	447000000
4	$ 506	506000000
5	$ 442	442000000

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SCENARIO 1- COST ESTIMATES AND RESULTS
TABLE 9- POTOMAC LINE - 1

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	POTOMAC LTCP PROJECTS											
	Tunnel From Potomac P.S to CSO 029 in Rock	9,100	LF	$ 15,766	$ 143,470,863							
	Tunneling Work Shaft	165	VLF	$ 153,954	$ 25,402,342						99	
	Dewatering P.S. internals in Shaft	1	LS	$ 10,536,034	$ 10,536,034			43				
	Screening Work Shaft	140	VLF	$ 78,970	$ 11,055,859						49.5	
	Screening Shaft Internals	140	VLF	$ 31,718	$ 4,440,510						49.5	
	Force Main Connection to Potomac Force Mains	100	LF	$ 1,036	$ 103,580							48
	CSO 020											
	CSO 020 Diversion Structure	1	MGD	$ 1,049,370	$ 1,049,370			126				
	12' Dia Pipeline CSO 020 to Drop Shaft	1,200	LF	$ 4,040	$ 4,848,183							144
	CSO 020 Tangential Inlet	1	LS	$1,320,796	$ 1,320,796			126				
	CSO 021											
	CSO 021 Diversion Structure	1	MGD	$ 2,357,070	$ 2,357,070			490				
	CSO 021 Tangential Inlet	1	LS	$2,245,970	$ 2,245,970			490				
	CSO 021 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 021 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	CSO 022											
	CSO 022 Diversion Structure	1	LS	$ 1,514,242	$ 1,514,242			250				
	CSO 022 Tangential Inlet	1	LS	$1,636,125	$ 1,636,125			250				
	CSO 022 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 022 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	12' Dia Pipeline CSO 020 to Drop Shaft	400	LF	$ 4,040	$ 1,616,061							144
	Tunnel Overflow Structure at CSO 022	1	LS	$ 22,000,000	$ 22,000,000							
	CSO 024											
	CSO 024 Diversion Structure	1	LS	$ 1,583,763	$ 1,583,763			269				
	CSO 024 Tangential Inlet	1	LS	$1,684,471	$ 1,684,471			269				
	CSO 024 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 024 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	CSO 025											
	CSO 025 Diversion Structure	1	LS	$ 762,036	$ 762,036			52				
	Pipeline CSO 025 to CSO 023/024	600	LF	$ 612	$ 367,318							18
	CSO 026											
	CSO 026 Diversion Structure	1	LS	$ 603,932	$ 603,932			12				
	Pipeline CSO 026 to CSO 027	600	LF	$ 837	$ 502,396							36
	CSO 027											
	CSO 027 Diversion Structure	1	LS	$ 1,899,677	$ 1,899,677			357				
	CSO 027 Tangential Inlet	1	LS	$1,908,387	$ 1,908,387			357				
	CSO 024 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 024 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	CSO 028											
	CSO 028 Diversion Structure	1	LS	$ 832,509	$ 832,509			70				
	Pipeline CSO 028 to CSO 029	1,400	LF	$ 1,275	$ 1,784,563							60
	CSO 029											
	CSO 029 Diversion Structure	1	LS	$ 722,084	$ 722,084			42				
	CSO 029 Tangential Inlet	1	LS	$1,106,469	$ 1,106,469			42				
	CSO 029 Retrieval Shaft	140	VLF	$ 95,635	$ 13,388,831						66	
	CSO 029 Shaft Internals	140	VLF	$ 41,585	$ 5,821,917						66	
	POTOMAC TOTAL				$ 325,994,097	$ 423,792,326	$ 594,000,000					

DISTRICT OF COLUMBIA
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SCENARIO 1- COST ESTIMATES AND RESULTS
TABLE 10- POTOMAC LINE - 2

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	POTOMAC LTCP PROJECTS											
	Tunnel From Potomac P.S to CSO 029 in Rock	9,100	LF	$ 13,929	$ 126,755,871							
	Tunneling Work Shaft	165	VLF	$ 134,744	$ 22,232,727						90	
	Dewatering P.S. internals in Shaft	1	LS	$ 8,365,711	$ 8,365,711			34				
	Screening Work Shaft	140	VLF	$ 75,871	$ 10,622,000						45	
	Screening Shaft Internals	140	VLF	$ 29,386	$ 4,114,089						45	
	Force Main Connection to Potomac Force Mains	100	LF	$ 1,036	$ 103,580							48
	CSO 020											
	CSO 020 Diversion Structure	1	MGD	$ 976,687	$ 976,687			107				
	12' Dia Pipeline CSO 020 to Drop Shaft	1,200	LF	$ 4,040	$ 4,848,183							144
	CSO 020 Tangential Inlet	1	LS	$1,272,677	$ 1,272,677			107				
	CSO 021											
	CSO 021 Diversion Structure	1	MGD	$ 2,106,652	$ 2,106,652			416				
	CSO 021 Tangential Inlet	1	LS	$2,059,075	$ 2,059,075			416				
	CSO 021 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 021 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	CSO 022											
	CSO 022 Diversion Structure	1	LS	$ 1,375,662	$ 1,375,662			213				
	CSO 022 Tangential Inlet	1	LS	$1,540,706	$ 1,540,706			213				
	CSO 022 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 022 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	12' Dia Pipeline CSO 020 to Drop Shaft	400	LF	$ 4,040	$ 1,616,061							144
	Tunnel Overflow Structure at CSO 022	1	LS	$ 22,000,000	$ 22,000,000							
	CSO 024											
	CSO 024 Diversion Structure	1	LS	$ 1,435,566	$ 1,435,566			229				
	CSO 024 Tangential Inlet	1	LS	$1,581,800	$ 1,581,800			229				
	CSO 024 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 024 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	CSO 025											
	CSO 025 Diversion Structure	1	LS	$ 731,368	$ 731,368			44				
	Pipeline CSO 025 to CSO 023/024	600	LF	$ 612	$ 367,318							18
	CSO 026											
	CSO 026 Diversion Structure	1	LS	$ 596,769	$ 596,769			10				
	Pipeline CSO 026 to CSO 027	600	LF	$ 837	$ 502,396							36
	CSO 027											
	CSO 027 Diversion Structure	1	LS	$ 1,708,627	$ 1,708,627			303				
	CSO 027 Tangential Inlet	1	LS	$1,772,129	$ 1,772,129			303				
	CSO 024 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 024 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	CSO 028											
	CSO 028 Diversion Structure	1	LS	$ 791,451	$ 791,451			60				
	Pipeline CSO 028 to CSO 029	1,400	LF	$ 1,275	$ 1,784,563							60
	CSO 029											
	CSO 029 Diversion Structure	1	LS	$ 697,330	$ 697,330			36				
	CSO 029 Tangential Inlet	1	LS	$1,090,499	$ 1,090,499			36				
	CSO 029 Retrieval Shaft	140	VLF	$ 88,611	$ 12,405,540						60	
	CSO 029 Shaft Internals	140	VLF	$ 37,757	$ 5,286,036						60	
	POTOMAC TOTAL				$ 299,667,017	$ 389,567,122	$ 546,000,000					

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TABLE 11- POTOMAC LINE - 3

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	POTOMAC LTCP PROJECTS											
	Tunnel From Potomac P.S to CSO 029 in Rock	9,100	LF	$ 10,316	$ 93,876,255							
	Tunneling Work Shaft	165	VLF	$ 85,512	$ 14,109,533						57	
	Dewatering P.S. internals in Shaft	1	LS	$ 3,492,275	$ 3,492,275			14				
	Screening Work Shaft	140	VLF	$ 69,810	$ 9,773,337						28.5	
	Screening Shaft Internals	140	VLF	$ 22,155	$ 3,101,745						28.5	
	Force Main Connection to Potomac Force Mains	100	LS	$ 837	$ 83,692							36
	CSO 020											
	CSO 020 Diversion Structure	1	MGD	$ 754,706	$ 754,706			50				
	12' Dia Pipeline CSO 020 to Drop Shaft	1,200	LF	$ 4,040	$ 4,848,183							144
	CSO 020 Tangential Inlet	1	LS	$1,127,566	$ 1,127,566			50				
	CSO 021											
	CSO 021 Diversion Structure	1	MGD	$ 1,773,535	$ 1,773,535			322				
	CSO 021 Tangential Inlet	1	LS	$1,818,127	$ 1,818,127			322				
	CSO 021 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 021 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 022											
	CSO 022 Diversion Structure	1	LS	$ 890,917	$ 890,917			85				
	CSO 022 Tangential Inlet	1	LS	$1,216,283	$ 1,216,283			85				
	CSO 022 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 022 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	12' Dia Pipeline CSO 020 to Drop Shaft	400	LF	$ 4,040	$ 1,616,061							144
	Tunnel Overflow Structure at CSO 022	1	LS	$ 22,000,000	$ 22,000,000							
	CSO 024											
	CSO 024 Diversion Structure	1	LS	$ 1,435,566	$ 1,435,566			229				
	CSO 024 Tangential Inlet	1	LS	$1,581,800	$ 1,581,800			229				
	CSO 024 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 024 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 025											
	CSO 025 Diversion Structure	1	LS	$ 731,368	$ 731,368			44				
	Pipeline CSO 025 to CSO 023/024	600	LF	$ 612	$ 367,318							18
	CSO 026											
	CSO 026 Diversion Structure	1	LS	$ 596,769	$ 596,769			10				
	Pipeline CSO 026 to CSO 027	600	LF	$ 837	$ 502,396							36
	CSO 027											
	CSO 027 Diversion Structure	1	LS	$ 1,708,627	$ 1,708,627			303				
	CSO 027 Tangential Inlet	1	LS	$1,772,129	$ 1,772,129			303				
	CSO 024 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 024 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 028											
	CSO 028 Diversion Structure	1	LS	$ 791,451	$ 791,451			60				
	Pipeline CSO 028 to CSO 029	1,400	LF	$ 1,275	$ 1,784,563							60
	CSO 029											
	CSO 029 Diversion Structure	1	LS	$ 615,842	$ 615,842			15				
	CSO 029 Tangential Inlet	1	LS	$1,038,155	$ 1,038,155			15				
	CSO 029 Retrieval Shaft	140	VLF	$ 72,282	$ 10,119,527						38	
	CSO 029 Shaft Internals	140	VLF	$ 26,066	$ 3,649,195						38	
	POTOMAC TOTAL				$ 245,171,730	$ 318,723,250	$ 447,000,000					

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TABLE 12- POTOMAC LINE - 4

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	POTOMAC LTCP PROJECTS											
	Tunnel From Potomac P.S to CSO 029 in Rock	9,100	LF	$ 12,565	$ 114,340,020							
	Tunneling Work Shaft	165	VLF	$ 112,986	$ 18,642,706						78	
	Dewatering P.S. internals in Shaft	1	LS	$ 6,676,125	$ 6,676,125			27				
	Screening Work Shaft	140	VLF	$ 72,703	$ 10,178,458						39	
	Screening Shaft Internals	140	VLF	$ 26,517	$ 3,712,413						39	
	Force Main Connection to Potomac Force Mains	100	LF	$ 837	$ 83,692							36
	CSO 020											
	CSO 020 Diversion Structure	1	MGD	$ 903,542	$ 903,542			88				
	12' Dia Pipeline CSO 020 to Drop Shaft	1,200	LF	$ 4,040	$ 4,848,183							144
	CSO 020 Tangential Inlet	1	LS	$1,224,557	$ 1,224,557			88				
	CSO 021											
	CSO 021 Diversion Structure	1	MGD	$ 1,849,271	$ 1,849,271			343				
	CSO 021 Tangential Inlet	1	LS	$1,872,179	$ 1,872,179			343				
	CSO 021 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 021 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 022											
	CSO 022 Diversion Structure	1	LS	$ 1,235,268	$ 1,235,268			175				
	CSO 022 Tangential Inlet	1	LS	$1,445,288	$ 1,445,288			175				
	CSO 022 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 022 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	12' Dia Pipeline CSO 020 to Drop Shaft	400	LF	$ 4,040	$ 1,616,061							144
	Tunnel Overflow Structure at CSO 022	1	LS	$ 22,000,000	$ 22,000,000							
	CSO 024											
	CSO 024 Diversion Structure	1	LS	$ 1,285,269	$ 1,285,269			188				
	CSO 024 Tangential Inlet	1	LS	$1,479,129	$ 1,479,129			188				
	CSO 024 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 024 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 025											
	CSO 025 Diversion Structure	1	LS	$ 700,621	$ 700,621			36				
	Pipeline CSO 025 to CSO 023/024	600	LF	$ 612	$ 367,318							18
	CSO 026											
	CSO 026 Diversion Structure	1	LS	$ 589,601	$ 589,601			8				
	Pipeline CSO 026 to CSO 027	600	LF	$ 837	$ 502,396							36
	CSO 027											
	CSO 027 Diversion Structure	1	LS	$ 1,513,875	$ 1,513,875			250				
	CSO 027 Tangential Inlet	1	LS	$1,635,871	$ 1,635,871			250				
	CSO 024 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 024 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 028											
	CSO 028 Diversion Structure	1	LS	$ 750,250	$ 750,250			49				
	Pipeline CSO 028 to CSO 029	1,400	LF	$ 1,275	$ 1,784,563							60
	CSO 029											
	CSO 029 Diversion Structure	1	LS	$ 672,526	$ 672,526			29				
	CSO 029 Tangential Inlet	1	LS	$1,074,528	$ 1,074,528			29				
	CSO 029 Retrieval Shaft	140	VLF	$ 80,960	$ 11,334,374						52	
	CSO 029 Shaft Internals	140	VLF	$ 33,080	$ 4,631,174						52	
	POTOMAC TOTAL				$ 277,568,258	$ 360,838,735	$ 506,000,000					

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TABLE 13- POTOMAC LINE - 5

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	POTOMAC LTCP PROJECTS											
	Tunnel From Potomac P.S to CSO 029 in Rock	9,100	LF	$ 10,316	$ 93,876,255							
	Tunneling Work Shaft	165	VLF	$ 82,689	$ 13,643,689						54	
	Dewatering P.S. internals in Shaft	1	LS	$ 3,199,625	$ 3,199,625			13				
	Screening Work Shaft	140	VLF	$ 69,672	$ 9,754,016						27	
	Screening Shaft Internals	140	VLF	$ 21,601	$ 3,024,093						27	
	Force Main Connection to Potomac Force Mains	100	LF	$ 837	$ 83,692							36
	CSO 020											
	CSO 020 Diversion Structure	1	MGD	$ 719,894	$ 719,894			41				
	12' Dia Pipeline CSO 020 to Drop Shaft	1,200	LF	$ 4,040	$ 4,848,183							144
	CSO 020 Tangential Inlet	1	LS	$1,105,054	$ 1,105,054			41				
	CSO 021											
	CSO 021 Diversion Structure	1	MGD	$ 1,568,389	$ 1,568,389			265				
	CSO 021 Tangential Inlet	1	LS	$1,673,751	$ 1,673,751			265				
	CSO 021 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 021 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 022											
	CSO 022 Diversion Structure	1	LS	$ 832,509	$ 832,509			70				
	CSO 022 Tangential Inlet	1	LS	$1,178,115	$ 1,178,115			70				
	CSO 022 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 022 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	12' Dia Pipeline CSO 020 to Drop Shaft	400	LF	$ 4,040	$ 1,616,061							144
	Tunnel Overflow Structure at CSO 022	1	LS	$ 22,000,000	$ 22,000,000							
	CSO 024											
	CSO 024 Diversion Structure	1	LS	$ 1,285,269	$ 1,285,269			188				
	CSO 024 Tangential Inlet	1	LS	$1,479,129	$ 1,479,129			188				
	CSO 024 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 024 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 025											
	CSO 025 Diversion Structure	1	LS	$ 700,621	$ 700,621			36				
	Pipeline CSO 025 to CSO 023/024	600	LF	$ 612	$ 367,318							18
	CSO 026											
	CSO 026 Diversion Structure	1	LS	$ 589,601	$ 589,601			8				
	Pipeline CSO 026 to CSO 027	600	LF	$ 837	$ 502,396							36
	CSO 027											
	CSO 027 Diversion Structure	1	LS	$ 1,513,875	$ 1,513,875			250				
	CSO 027 Tangential Inlet	1	LS	$1,635,871	$ 1,635,871			250				
	CSO 024 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 024 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 028											
	CSO 028 Diversion Structure	1	LS	$ 750,250	$ 750,250			49				
	Pipeline CSO 028 to CSO 029	1,400	LF	$ 1,275	$ 1,784,563							60
	CSO 029											
	CSO 029 Diversion Structure	1	LS	$ 605,320	$ 605,320			12				
	CSO 029 Tangential Inlet	1	LS	$1,031,422	$ 1,031,422			12				
	CSO 029 Retrieval Shaft	140	VLF	$ 71,532	$ 10,014,517						36	
	CSO 029 Shaft Internals	140	VLF	$ 25,185	$ 3,525,954						36	
	POTOMAC TOTAL				$ 242,779,086	$ 315,612,812	$ 442,000,000					

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TABLE 14- PINEY BRANCH TUNNEL SIZE

Piney Branch

Line	Tunnel Capacity	Diameter	Length				
	Req'd Storage Gal	ft	ft	Prov Storage Cu Ft	Prov Storage Gal	Difference Req'd - Prov	# of CSO Overflows
6	8,000,000	22	2900	1101826	8241658	-241,658	4 per ave year

Piney Branch

Scenario	Tunnel Capacity	Diameter	Length				
15% implementation	Req'd Storage Gal	ft	ft	Prov Storage Cu Ft	Prov Storage Gal	Difference Req'd - Prov	# of CSO Overflows
7	5,500,000	18	2900	737586	5517143	-17,143	4 per ave year
8	800,000	7	2900	111548.5	834383	-34,383	8 per ave year

Piney Branch

Scenario	Tunnel Capacity	Diameter	Length				
30% implementation	Req'd Storage Gal	ft	ft	Prov Storage Cu Ft	Prov Storage Gal	Difference Req'd - Prov	# of CSO Overflows
9	4,500,000	17	2900	657908.5	4921156	-421,156	4 per ave year
10	500,000	6	2900	81954	613016	-113,016	8 per ave year

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TABLE 15 - PINEY BRANCH LF COSTS

	Cost Model for Rock Tunnels by TBM							Line - 6		
	Modified from Div H 100% Estimate per notes								2.9 ,000 ft Length	
	Assumes systematic lining during excavation is not req'd.								22 ft Diameter	
		(000)			Soil	Completent Rock	Not-so-good rock		Rock Type	
1	Fixed Costs for tunnel							Cost item	Competent	Not so good
	Erect Plant	$ 624							$,000	$,000
	Assemble TBM	$ 445								
	Dis-assemble/Remove	$ 520								
	Break-in/out facilities	$ 717								
			$ 2,306		$2.3 million	$1.6 million	$1.6 million	1	$ 1,600	$ 1,600
2	Fixed costs for certain finish diameter									
	TBM & equip	$ 7,870								
	TBM & equip	$ 10,507								
			$ 18,377							
		23 ft diameter	$ 799		$800,000/ftØ	$800,000/ftØ	$800,000/ftØ	2	$ 17,578	$ 17,578
	For tunnel range: 10 ft to 30 ft finish diameter									
	For 2nd tunnel using same equipment, use only $150,000/ftØ									
3	Variable costs by tunnel length (diameter not a factor)									
	Labor	$ 4,302								
		$ 5,962								
	Equipment	$ 9,866								
		$ (7,870)								
		$ 13,173								
		$ (10,507)								
	Remove utilities/cleanup	$ 1,387								
	Instrumentation	$ 4,115								
			$ 20,428							
		Div H = 12,424 lf	$ 1,644.24							
			$ 1,017							
		temp support	$ 200							
				$ 1,217		$1220/lf of tunnel		3	$ 3,528	$ 5,448
			$ 1,479							
		temp support	$ 400							
				$ 1,879			$1880/lf of tunnel			
4	Variable costs by tunnel diameter and length									
	Material	$ 10,695								
		$ 15,963								
			$ 26,658							
	for 23 ft Ø:	Div H = 12,424 lf	$ 2,146							
		per ft Ø:	$ 93.29		$93/ftØ/lf					
	concrete line 22 ft @ 12" @$1,200/cy =		$3,150/lf		for tunnel Ø from 15 ft to 25 ft: use $140/ft Ø					
	concrete line 34 ft @18" @ $1200/cy		$7,350/lf		for tunnel Ø from 25 ft to 35 ft: use $215/ft Ø			4	$ 13,717	$ 13,717
5	Variable costs by square of diameter and length:									
	Subcontractors	$ 2,421								
		$ 3,628								
			$ 6,049							
	for 23 ft Ø:	Div H = 12,424 lf	$ 487							
		per ft Ø:	$ 0.92		$0.90/ftØ²/lf					
	50% of this is hauling, and 50% is dump fee					$0.45/ftØ²/lf	$0.45/ftØ²/lf	5	$ 632	$ 632
6	Tunnel Indirect Costs									
		$ 46								
		$ 401								
		$ 65								
		per month	$ 512							
	12,424 in 15 months =	830 ft/mo	$ 616.87		$620/lf of tunnel					
			$ 379.61			$380/lf of tunnel				
							$620/lf of tunnel	6	$ 1,102	$ 1,798
7	Overhead and Profit									
		$ 173,961								
	plus tunnel indirects	$ 7,664								
	total cost		$ 181,625							
	S/T indirects	$ 80,448								
	less tunnel indirects	$ (7,664)								
	total indirects		$ 72,784							
		Percent total	40.1%		40% of total cost	40% of total cost	40% of total cost	7	$ 15,263	$ 16,309
8	Escalation									
	These numbers are based on 2012 work									
			Use:		3%/year	3%/year	3%/year	8		
9	Contingency									
	concept design (no design or geotech)				40%	40%	40%	9		
	30% design				30%	30%	30%			
	60% design				25%	25%	25%			
	90% design				20%	20%	20%			
	Bid-level				15%	15%	15%			
10	total							10 Total	$ 53,419	$ 57,082
								$/lf	18420.44763	

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TABLE 16- PINEY BRANCH LF COSTS

Cost Model for Rock Tunnels by TBM
Modified from Div H 100% Estimate per notes
Assumes systematic lining during excavation is not req'd.

		(000)		Soil	Completent Rock	Not-so-good rock
1	Fixed Costs for tunnel					
	Erect Plant	$ 624				
	Assemble TBM	$ 445				
	Dis-assemble/Remove	$ 520				
	Break-in/out facilities	$ 717				
			$ 2,306	$2.3 million	$1.6 million	$1.6 million
2	Fixed costs for certain finish diameter					
	TBM & equip	$ 7,870				
	TBM & equip	$ 10,507				
			$ 18,377			
		23 ft diameter	$ 799	$800,000/ftØ	$800,000/ftØ	$800,000/ftØ
	For tunnel range: 10 ft to 30 ft finish diameter					
	For 2nd tunnel using same equipment, use only $150,000/ftØ					
3	Variable costs by tunnel length (diameter not a factor)					
	Labor	$ 4,302				
		$ 5,962				
	Equipment	$ 9,866				
		$ (7,870)				
		$ 13,173				
		$ (10,507)				
	Remove utilities/cleanup	$ 1,387				
	Instrumentation	$ 4,115				
			$ 20,428			
		Div H = 12,424 lf	$ 1,644.24			
			$ 1,017			
		temp support	$ 200			
				$ 1,217	$1220/lf of tunnel	
			$ 1,479			
		temp support	$ 400			
				$ 1,879		$1880/lf of tunnel
4	Variable costs by tunnel diameter and length					
	Material	$ 10,695				
		$ 15,963				
			$ 26,658			
	for 23 ft Ø:	Div H = 12,424 lf	$ 2,146			
		per ft Ø:	$ 93.29	$93/ftØ/lf		
	concrete line 22 ft @ 12" @$1,200/cy =		$3,150/lf	for tunnel Ø from 15 ft to 25 ft: use $140/ftØ		
	concrete line 34 ft @18" @ $1200/cy		$7,350/lf	for tunnel Ø from 25 ft to 35 ft: use $215/ftØ		
5	Variable costs by square of diameter and length:					
	Subcontractors	$ 2,421				
		$ 3,628				
			$ 6,049			
	for 23 ft Ø:	Div H = 12,424 lf	$ 487			
		per ft Ø:	$ 0.92	$0.90/ftØ^2/lf		
	50% of this is hauling, and 50% is dump fee				$0.45/ftØ^2/lf	$0.45/ftØ^2/lf
6	Tunnel Indirect Costs					
		$ 46				
		$ 401				
		$ 65				
		per month	$ 512			
	12,424 in 15 months =	830 ft/mo	$ 616.87	$620/lf of tunnel		
			$ 379.61		$380/lf of tunnel	
						$620/lf of tunnel
7	Overhead and Profit					
		$ 173,961				
	plus tunnel indirects	$ 7,664				
	total cost		$ 181,625			
	S/T indirects	$ 80,448				
	less tunnel indirects	$ (7,664)				
	total indirects		$ 72,784			
		Percent total	40.1%	40% of total cost	40% of total cost	40% of total cost
8	Escalation					
	These numbers are based on 2012 work					
			Use:	3%/year	3%/year	3%/year
9	Contingency					
	concept design (no design or geotech)			40%	40%	40%
	30% design			30%	30%	30%
	60% design			25%	25%	25%
	90% design			20%	20%	20%
	Bid-level			15%	15%	15%
10	total					

Line - 7	2.9 ,000 ft Length / 18 ft Diameter		Line - 8	2.9 ,000 ft Length / 8 ft Diameter	
	Rock Type			Rock Type	
Cost item	Competent $,000	Not so good $,000	Cost item	Competent $,000	Not so good $,000
1	$ 1,600	$ 1,600	1	$ 1,600	$ 1,600
2	$ 14,382	$ 14,382	2	$ 6,392	$ 6,392
3	$ 3,528	$ 5,448	3	$ 3,528	$ 5,448
4	$ 11,223	$ 11,223	4	$ 4,988	$ 4,988
5	$ 423	$ 423	5	$ 84	$ 84
6	$ 1,102	$ 1,798	6	$ 1,102	$ 1,798
7	$ 12,903	$ 13,950	7	$ 7,077	$ 8,124
8			8		
9			9		
10 Total	$ 45,161	$ 48,823	10 Total	$ 24,771	$ 28,433
$/lf	15572.75107		$/lf	8541.709694	

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TABLE 17 - PINEY BRANCH LF COSTS

Cost Model for Rock Tunnels by TBM
Modified from Div H 100% Estimate per notes
Assumes systematic lining during excavation is not req'd.

No.	Item	(000)			Soil	Completent Rock	Not-so-good rock
1	Fixed Costs for tunnel						
	Erect Plant	$ 624					
	Assemble TBM	$ 445					
	Dis-assemble/Remove	$ 520					
	Break-in/out facilities	$ 717					
			$ 2,306		$2.3 million	$1.6 million	$1.6 million
2	Fixed costs for certain finish diameter						
	TBM & equip	$ 7,870					
	TBM & equip	$ 10,507					
			$ 18,377				
		23 ft diameter	$ 799		$800,000/ftØ	$800,000/ftØ	$800,000/ftØ
	For tunnel range: 10 ft to 30 ft finish diameter						
	For 2nd tunnel using same equipment, use only $150,000/ftØ						
3	Variable costs by tunnel length (diameter not a factor)						
	Labor	$ 4,302					
		$ 5,962					
	Equipment	$ 9,866					
		$ (7,870)					
		$ 13,173					
		$ (10,507)					
	Remove utilities/cleanu	$ 1,387					
	Instrumentation	$ 4,115					
			$ 20,428				
		Div H = 12,424 lf	$ 1,644.24				
			$ 1,017				
		temp support	$ 200				
				$ 1,217		$1220/lf of tunnel	
			$ 1,479				
		temp support	$ 400				
				$ 1,879			$1880/lf of tunnel
4	Variable costs by tunnel diameter and length						
	Material	$ 10,695					
		$ 15,963					
			$ 26,658				
	for 23 ft Ø:	Div H = 12,424 lf	$ 2,146				
		per ft Ø:	$ 93.29		$93/ftØ/lf		
	concrete line 22 ft @ 12" @$1,200/cy =		$3,150/lf		for tunnel Ø from 15 ft to 25 ft: use $140/ftØ		
	concrete line 34 ft @18" @ $1200/cy		$7,350/lf		for tunnel Ø from 25 ft to 35 ft: use $215/ftØ		
5	Variable costs by square of diameter and length:						
	Subcontractors	$ 2,421					
		$ 3,628					
			$ 6,049				
	for 23 ft Ø:	Div H = 12,424 lf	$ 487				
		per ft Ø:	$ 0.92		$0.90/ftØ²/lf		
	50% of this is hauling, and 50% is dump fee					$0.45/ftØ²/lf	$0.45/ftØ²/lf
6	Tunnel Indirect Costs						
		$ 46					
		$ 401					
		$ 65					
		per month	$ 512				
	12,424 in 15 months =	830 ft/mo	$ 616.87		$620/lf of tunnel		
			$ 379.61			$380/lf of tunnel	
							$620/lf of tunnel
7	Overhead and Profit						
		$ 173,961					
	plus tunnel indirects	$ 7,664					
	total cost		$ 181,625				
	S/T indirects	$ 80,448					
	less tunnel indirects	$ (7,664)					
	total indirects		$ 72,784				
		Percent total	40.1%		40% of total cost	40% of total cost	40% of total cost
8	Escalation						
	These numbers are based on 2012 work						
			Use:		3%/year	3%/year	3%/year
9	Contingency						
	concept design (no design or geotech)				40%	40%	40%
	30% design				30%	30%	30%
	60% design				25%	25%	25%
	90% design				20%	20%	20%
	Bid-level				15%	15%	15%
10	total						

Line - 9	2.9 ,000 ft Length, 17 ft Diameter		**Line - 10**	2.9 ,000 ft Length, 6 ft Diameter	
	Rock Type			Rock Type	
Cost item	Competent $,000	Not so good $,000	**Cost item**	Competent $,000	Not so good $,000
1	$ 1,600	$ 1,600	1	$ 1,600	$ 1,600
2	$ 13,583	$ 13,583	2	$ 4,794	$ 4,794
3	$ 3,528	$ 5,448	3	$ 3,528	$ 5,448
4	$ 10,600	$ 10,600	4	$ 3,741	$ 3,741
5	$ 377	$ 377	5	$ 47	$ 47
6	$ 1,102	$ 1,798	6	$ 1,102	$ 1,798
7	$ 12,316	$ 13,362	7	$ 5,925	$ 6,971
8			8		
9			9		
10 Total	$ 43,106	$ 46,768	10 Total	$ 20,737	$ 24,399
$/lf	14863.97694		$/lf	7150.621418	

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TABLE 18- PINEY BRANCH TUNNEL VALUES VS. SIZE

		Tunnel ID (ft)				
Parameter	Basis	22	18	7	17	6
Pump Station Shaft ID	3 x Tunnel ID	66	54	21	51	18
Retrieval Shaft ID	2 x Tunnel ID	44	36	14	34	12
Gravity sewer to East Rock Creek Diversion Sewer		24	24	24	24	24

CSO	1
PB flows MGD	294

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TABLE 19 PINEY BRANCH COST SUMMARY

Line	Piney Branch Capital Cost ($M)	Piney Brnch Capital Cost ($)
6	$ 120	120000000
7	$ 104	104000000
8	$ 63	63000000
9	$ 100	100000000
10	$ 56	56000000

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TABLE 20- PINEY BRANCH LINE - 6

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	PINEY BRANCH LTCP PROJECTS											
	Tunnel From Structure 70 to East Rock Creek Div Sewer in Rock	2,900	LF	$ 18,420	$ 53,419,298							
	Tunneling Work Shaft @ str 70	40	VLF	$ 75,267	$ 3,010,676						44	
	Str 70 Diversion Structure	1	LS	$ 1,674,527	$ 1,674,527			294				
	Str 70 Tangential Inlet	1	LS	$1,748,083	$ 1,748,083			294				
	Str 70 Shaft Internals	40	VLF	$ 28,889	$ 1,155,566						44	
	Retrieval Shaft	40	VLF	$ 75,267	$ 3,010,676						44	
	Pipeline East Rock Creek Div Swr	300	LF	$ 677	$ 203,232							24
	Junction Chamber East Rock Creek Div Swr	1	LS	$ 300,000	$ 300,000							
	Venting and Odor Control Chamber	1	LS	$ 300,000	$ 300,000							
	Landscaping	1	LS	$ 300,000	$ 300,000							
	PINEY BRANCH TOTAL				$ 65,768,003	$ 85,498,404	$ 120,000,000					

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TABLE 21- PINEY BRANCH LINE - 7

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	PINEY BRANCH LTCP PROJECTS											
	Tunnel From Structure 70 to East Rock Creek Div Sewer in Rock	2,900	LF	$ 15,573	$ 45,160,978							
	Tunneling Work Shaft @ str 70	40	VLF	$ 71,532	$ 2,861,291						36	
	Str 70 Diversion Structure	1	LS	$ 1,674,527	$ 1,674,527			294				
	Str 70 Tangential Inlet	1	LS	$1,748,083	$ 1,748,083			294				
	Str 70 Shaft Internals	40	VLF	$ 25,185	$ 1,007,415						36	
	Retrieval Shaft	40	VLF	$ 71,532	$ 2,861,291						36	
	Pipeline East Rock Creek Div Swr	300	LF	$ 677	$ 203,232							24
	Junction Chamber East Rock Creek Div Swr	1	LS	$ 300,000	$ 300,000							
	Venting and Odor Control Chamber	1	LS	$ 300,000	$ 300,000							
	Landscaping	1	LS	$ 300,000	$ 300,000							
	PINEY BRANCH TOTAL				$ 57,038,094	$ 74,149,522	$ 104,000,000					

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TABLE 22- PINEY BRANCH LINE - 8

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	PINEY BRANCH LTCP PROJECTS											
	Tunnel From Structure 70 to East Rock Creek Div Sewer in Rock	2,900	LF	$ 8,542	$ 24,770,958							
	Tunneling Work Shaft @ str 70	40	VLF	$ 71,359	$ 2,854,374						14	
	Str 70 Diversion Structure	1	LS	$ 635,718	$ 635,718			20				
	Str 70 Tangential Inlet	1	LS	$1,050,890	$ 1,050,890			20				
	Str 70 Shaft Internals	40	VLF	$ 17,511	$ 700,427						14	
	Retrieval Shaft	40	VLF	$ 71,359	$ 2,854,374						14	
	Pipeline East Rock Creek Div Swr	300	LF	$ 677	$ 203,232							24
	Junction Chamber East Rock Creek Div Swr	1	LS	$ 300,000	$ 300,000							
	Venting and Odor Control Chamber	1	LS	$ 300,000	$ 300,000							
	Landscaping	1	LS	$ 300,000	$ 300,000							
	PINEY BRANCH TOTAL				$ 34,477,721	$ 44,821,037	$ 63,000,000					

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TABLE 23- PINEY BRANCH LINE - 9

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	PINEY BRANCH LTCP PROJECTS											
	Tunnel From Structure 70 to East Rock Creek Div Sewer in Rock	2,900	LF	$ 14,864	$ 43,105,533							
	Tunneling Work Shaft @ str 70	40	VLF	$ 70,905	$ 2,836,183						34	
	Str 70 Diversion Structure	1	LS	$ 1,674,527	$ 1,674,527			294				
	Str 70 Tangential Inlet	1	LS	$1,748,083	$ 1,748,083			294				
	Str 70 Shaft Internals	40	VLF	$ 24,336	$ 973,421						34	
	Retrieval Shaft	40	VLF	$ 70,905	$ 2,836,183						34	
	Pipeline East Rock Creek Div Swr	300	LF	$ 677	$ 203,232							24
	Junction Chamber East Rock Creek Div Swr	1	LS	$ 300,000	$ 300,000							
	Venting and Odor Control Chamber	1	LS	$ 300,000	$ 300,000							
	Landscaping	1	LS	$ 300,000	$ 300,000							
	PINEY BRANCH TOTAL				$ 54,893,792	$ 71,361,929	$ 100,000,000					

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TABLE 1- RESULTS

	Green for CSO 027, 028 and 029																Gray							Total Cost		
Line	% GI Application of Imp Area at 1.2" (Public & Private)	CSO 027 Imp ac	CSO 027 %GI Applied	CSO 028 Imp ac	CSO 028 %GI Applied	CSO 029 Imp ac	CSO 029 %GI Applied	Total Acres	Imp Acres	Imp Ac Treated	Low Unit Cost ($/Imp Ac)	Avg Unit Cost ($/Imp Ac)	High Cost ($/Imp Ac)	Low Green Cost ($M)	Avg GI Cost ($M)	Hi Green Cost ($M)	# CSOs/ Avg Yr	CSO Overflow vol (mg/avg yr)	Tunnel Volume (mg)	Tunnel Dia (ft)	Low Cost (-20% cost)	Avg Grey Cost ($M)	High Cost (+30% cost range)	Low	Avg	High
Potomac Tunnel																										
1	0% (LTCP)							5,488	3,283								4	79	58	33	$ 475	$ 594	$ 772	$ 475	$ 594	$ 772
2	Varies	104	30%	13	30%	164	60%	515	281	134	$ 0.11	$ 0.22	$ 0.44	$ 15	$ 29	$ 59	4		21	28	$ 466	583	$ 758	$ 481	$ 612	$ 817
3	Varies	104	15%	13	15%	164	30%	515	281	67	$ 0.11	$ 0.22	$ 0.44	$ 7	$ 15	$ 29	12		9	18	$ 322	402	$ 523	$ 329	$ 417	$ 552

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FIGURE 1- POTOMAC COST RANGES

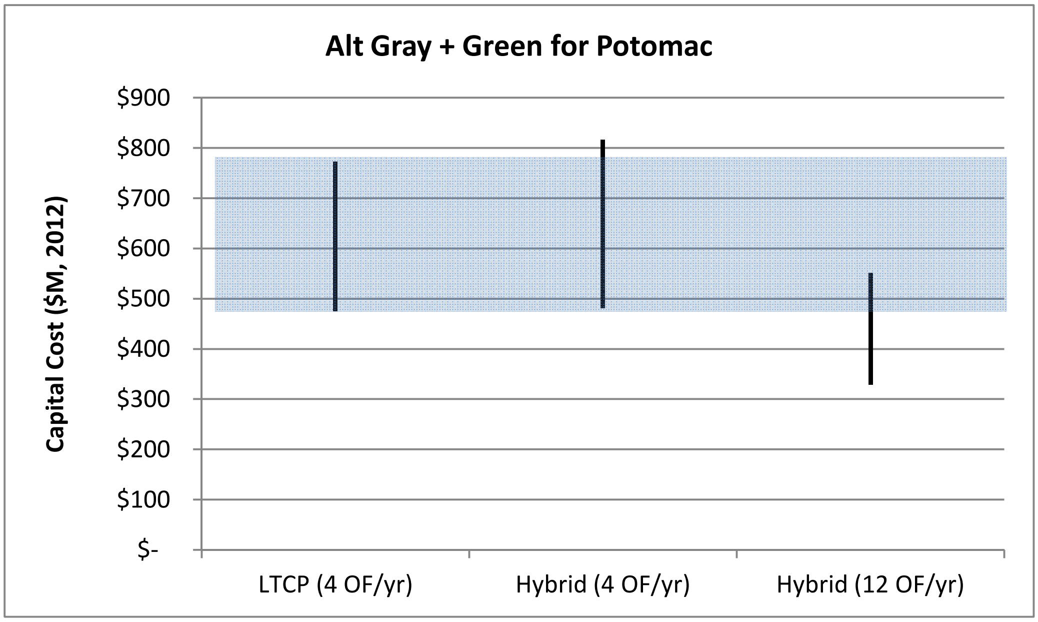

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TABLE 2- TUNNEL VOLUMES

Potomac

Line	Tunnel Capacity	Diameter	Length	
	Req'd Storage Gal	ft	ft	Tunnel Volume (mg)
2		28	4500	21
3		18	4500	9

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TABLE 3- POTOMIC TUNNEL LF COSTS

Cost Model for Rock Tunnels by TBM
Modified from Div H 100% Estimate per notes
Assumes systematic lining during excavation is not req'd.

#	Item		(000)		Soil	Completent Rock	Not-so-good rock
1	Fixed Costs for tunnel						
	Erect Plant		$ 624				
	Assemble TBM		$ 445				
	Dis-assemble/Remove		$ 520				
	Break-in/out facilities		$ 717				
				$ 2,306	$2.3 million	$1.6 million	$1.6 million
2	Fixed costs for certain finish diameter						
	TBM & equip		$ 7,870				
	TBM & equip		$ 10,507				
				$ 18,377			
		23 ft diameter		$ 799	$800,000/ftØ	$800,000/ftØ	$800,000/ftØ
	For tunnel range: 10 ft to 30 ft finish diameter						
	For 2nd tunnel using same equipment, use only $150,000/ftØ						
3	Variable costs by tunnel length (diameter not a factor)						
	Labor		$ 4,302				
			$ 5,962				
	Equipment		$ 9,866				
			$ (7,870)				
			$ 13,173				
			$ (10,507)				
	Remove utilities/cleanup		$ 1,387				
	Instrumentation		$ 4,115				
				$ 20,428			
		Div H = 12,424 lf		$ 1,644.24			
				$ 1,017			
		temp support		$ 200			
					$ 1,217	$1220/lf of tunnel	
				$ 1,479			
		temp support		$ 400			
					$ 1,879		$1880/lf of tunnel
4	Variable costs by tunnel diameter and length						
	Material		$ 10,695				
			$ 15,963				
				$ 26,658			
	for 23 ft Ø:	Div H = 12,424 lf		$ 2,146			
		per ft Ø:		$ 93.29	$93/ftØ/lf		
	concrete line 22 ft @ 12" @$1,200/cy =			$3,150/lf	for tunnel Ø from 15 ft to 25 ft: use $140/ftØ		
	concrete line 34 ft @18" @ $1200/cy			$7,350/lf	for tunnel Ø from 25 ft to 35 ft: use $215/ftØ		
5	Variable costs by square of diameter and length:						
	Subcontractors		$ 2,421				
			$ 3,628				
				$ 6,049			
	for 23 ft Ø:	Div H = 12,424 lf		$ 487			
		per ft Ø:		$ 0.92	$0.90/ftØ²/lf		
	50% of this is hauling, and 50% is dump fee					$0.45/ftØ²/lf	$0.45/ftØ²/lf
6	Tunnel Indirect Costs						
			$ 46				
			$ 401				
			$ 65				
		per month		$ 512			
	12,424 in 15 months =	830 ft/mo		$ 616.87	$620/lf of tunnel		
				$ 379.61		$380/lf of tunnel	
							$620/lf of tunnel
7	Overhead and Profit						
			$ 173,961				
	plus tunnel indirects		$ 7,664				
	total cost			$ 181,625			
	S/T indirects		$ 80,448				
	less tunnel indirects		$ (7,664)				
	total indirects			$ 72,784			
		Percent total		40.1%	40% of total cost	40% of total cost	40% of total cost
8	Escalation						
	These numbers are based on 2012 work						
				Use:	3%/year	3%/year	3%/year
9	Contingency						
	concept design (no design or geotech)				40%	40%	40%
	30% design				30%	30%	30%
	60% design				25%	25%	25%
	90% design				20%	20%	20%
	Bid-level				15%	15%	15%
10	total						

line-2
4.5 ,000 ft Length
28 ft Diameter

Cost item	Rock Type: Competent $,000	Rock Type: Not so good $,000
1	$ 1,600	$ 1,600
2	$ 26,367	$ 26,367
3	$ 5,475	$ 8,454
4	$ 27,090	$ 31,928
5	$ 1,588	$ 1,588
6	$ 1,710	$ 2,790
7	$ 25,532	$ 29,090
8		
9		
10 Total	$ 89,361	$ 101,816
$/lf	$ 19,858	

line -3
4.5 ,000 ft Length
18 ft Diameter

Cost item	Rock Type: Competent $,000	Rock Type: Not so good $,000
1	$ 1,600	$ 1,600
2	$ 14,382	$ 14,382
3	$ 5,475	$ 8,454
4	$ 17,415	$ 17,415
5	$ 656	$ 656
6	$ 1,710	$ 2,790
7	$ 16,495	$ 18,119
8		
9		
10 Total	$ 57,733	$ 63,416
$/lf	$ 12,829	

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TABLE 4- POTOMAC TUNNEL VALUES VS. SIZEG

Values to Use for Potomac Tunnel Costing

Parameter	Basis	Tunnel ID (ft)			
		33	28	20	0
Pump Station Shaft ID	3 x Tunnel ID	99	84	60	0
Screening Shaft ID	1.5 x Tunnel ID	49.5	42	30	0
Retrieval Shaft ID at CSO 029	2 x Tunnel ID	66	56	40	0
Shaft Dia (Ft) V's Flow Rate		12	12	10	10
Pump Station Firm Capacity					
Pump Station Firm Capacity mgd)		250	250	250	250
Force Main Dia (ft)	@ 6 ft/sec	9.1	9.1	9.1	9.1
		120.0	120.0	120.0	120.0
Overflow Structure Length (ft)	Based on Consolid	275'	275'	275'	275'

CSO	Design Diversion Rate (mgd) # Overflows/avg yr			
	2	4	8	12
CSO 020	268	126	91	59
CSO 021	555	490	419	378
CSO 022	402	250	150	100
CSO 023/024	269	269	269	269
CSO 025	52	52	52	52
CSO 026	12	12	12	12
CSO 027	357	357	357	357
CSO 028	70	70	70	70
CSO 029	96	42	29	18

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TABLE 5- CSO FLOW RATES

	CSO 020				CSO 021				CSO 022				CSO 029			
	Easby Point				Slash Run				I St. - 22nd St. NW				College Pond			
Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	OF mgd rank
It162	11.05	257.35	1	**It22**	42.85	481.63	4	**It162**	12.96	386.92	1	**It162**	3.66	90.35	1	1
It84	8.04	223.28	1	**It162**	33.28	462.87	1	**It76**	16.88	335.19	2	**It102**	2.95	80.28	1	2
It22	5.38	201.65	3	**It76**	81.96	458.10	2	**It102**	8.87	330.89	1	**It76**	5.87	66.68	2	3
It102	7.43	197.05	1	**It102**	36.29	450.28	1	**It150**	10.03	267.36	2	**It84**	2.33	64.96	3	4
It150	10.33	191.90	2	**It150**	52.40	446.82	2	**It85**	3.83	146.57	2	**It85**	3.16	58.49	2	5
It90	5.04	158.45	1	**It85**	49.04	426.22	2	**It97**	3.32	134.62	1	**It150**	3.99	56.67	2	6
It94	6.33	158.25	2	**It97**	27.62	418.46	1	**It96**	3.99	114.69	1	**It90**	1.75	45.26	3	7
It76	10.59	132.74	2	**It75**	21.93	416.59	2	**It75**	2.34	108.78	3	**It22**	2.22	42.95	4	8
It169	4.26	127.81	1	**It96**	43.11	415.58	1	**It30**	2.61	90.10	2	**It97**	1.81	40.56	1	9
It85	6.40	127.33	2	**It30**	42.22	410.91	2	**It126**	2.05	87.36	1	**It147**	3.03	38.77	4	10
It91	1.55	107.23	1	**It126**	31.46	408.99	1	**It88**	2.43	86.08	1	**It96**	2.41	37.14	1	11
It95	4.85	105.06	2	**It84**	38.46	408.06	3	**It84**	1.89	76.55	3	**It169**	1.07	34.87	3	12
It80	3.91	102.71	1	**It88**	33.14	407.00	1	**It80**	1.51	73.37	1	**It132**	1.26	34.24	1	13
It131	2.96	100.15	1	**It80**	23.83	406.36	1	**It147**	2.46	72.68	3	**It126**	1.56	32.80	1	14
It152	2.95	99.73	1	**It151**	53.78	404.96	1	**It151**	1.94	67.71	1	**It83**	1.59	32.11	3	15
It97	4.83	95.88	1	**It147**	63.93	404.58	3	**It169**	1.29	65.54	1	**It36**	1.05	30.95	1	16
It147	2.99	91.58	2	**It169**	20.06	403.79	1	**It22**	0.94	19.63	3	**It151**	2.27	29.94	1	17
It96	5.46	88.97	1	**It106**	26.80	379.36	1	**It106**	0.51	12.38	1	**It75**	1.20	29.32	2	18
It75	2.76	85.03	2	**It83**	35.36	376.64	3	**It90**	0.50	12.06	2	**It80**	1.47	29.24	1	19
It83	4.30	84.45	2	**It132**	18.20	372.21	1	**It132**	0.39	9.68	1	**It88**	1.60	29.05	1	20
It30	3.73	81.74	2	**It131**	13.03	362.71	1	**It36**	0.32	8.82	1	**It94**	1.23	28.28	2	21
It29	4.82	78.34	2	**It49**	21.64	352.01	1	**It94**	0.43	8.57	2	**It131**	0.78	27.47	1	22
It132	3.00	77.21	1	**It82**	39.49	350.31	2	**It83**	0.58	8.10	3	**It23**	0.59	25.03	1	23
It126	3.00	76.22	1	**It94**	18.10	349.48	2	**It131**	0.24	7.82	1	**It120**	0.81	23.98	1	24
It120	1.19	72.11	1	**It36**	15.48	348.62	1	**It95**	0.37	6.79	2	**It95**	1.31	21.91	6	25
It25	0.89	70.41	1	**It90**	20.34	347.03	2	**It120**	0.26	6.55	1	**It49**	1.10	21.09	1	26
It153	1.58	68.54	1	**It51**	29.38	343.30	1	**It49**	0.34	6.50	1	**It145**	0.46	19.84	1	27
It49	3.08	65.67	1	**It4**	22.77	340.78	1	**It23**	0.15	6.47	1	**It30**	1.33	18.73	2	28
It140	5.80	64.87	1	**It29**	28.45	340.10	3	**It164**	0.61	6.28	1	**It163**	2.20	18.12	1	29
It64	1.59	62.87	1	**It74**	16.71	337.69	1	**It163**	0.71	5.81	1	**It64**	0.77	18.06	2	30
It88	3.63	62.51	1	**It23**	9.38	333.97	1	**It4**	0.32	5.74	1	**It82**	1.87	17.94	3	31
It23	1.22	60.88	1	**It79**	11.04	330.80	1	**It51**	0.36	5.58	1	**It164**	1.48	17.10	1	32
It36	1.75	57.50	1	**It164**	30.30	330.19	1	**It64**	0.26	5.41	1	**It51**	1.20	15.74	1	33
It151	2.01	51.34	1	**It120**	25.18	320.37	1	**It145**	0.12	5.38	1	**It153**	0.41	15.54	1	34
It37	1.06	50.15	1	**It64**	14.49	318.38	1	**It82**	0.68	5.29	2	**It106**	1.01	15.37	1	35
It145	0.96	49.15	1	**It123**	7.98	315.22	1	**It140**	0.52	4.97	1	**It4**	0.86	14.70	1	36
It106	2.32	45.24	1	**It163**	42.99	314.57	1	**It29**	0.52	4.94	4	**It91**	0.20	13.77	1	37
It164	2.02	40.21	1	**It142**	9.30	286.17	1	**It153**	0.11	4.88	1	**It29**	1.66	13.72	4	38
It14	0.90	37.72	1	**It19**	6.35	277.25	1	**It91**	0.08	4.82	1	**It14**	0.65	11.83	1	39
It4	1.67	37.39	1	**It145**	7.58	272.78	1	**It14**	0.20	4.29	1	**It152**	0.33	11.59	1	40
It51	1.60	36.01	1	**It153**	6.98	261.12	1	**It152**	0.09	4.22	1	**It142**	0.31	11.21	1	41
It146	0.59	34.92	1	**It98**	26.19	248.83	3	**It33**	0.16	4.18	1	**It74**	0.43	10.71	1	42
It82	1.40	32.93	1	**It14**	10.43	248.04	1	**It98**	0.35	3.95	3	**It105**	0.81	10.56	1	43
It33	0.96	32.62	1	**It140**	21.78	221.80	1	**It37**	0.14	3.55	1	**It140**	1.26	10.40	1	44
It74	0.58	29.37	1	**It170**	19.94	219.37	1	**It105**	0.23	3.50	1	**It98**	1.31	10.37	3	45
It79	0.42	25.50	1	**It77**	7.98	219.17	1	**It74**	0.12	3.39	1	**It37**	0.42	10.17	1	46
It98	0.46	22.46	1	**It105**	18.82	217.83	1	**It139**	0.21	3.31	1	**It33**	0.43	9.73	1	47
It139	0.36	18.13	1	**It156**	12.99	212.14	1	**It123**	0.08	3.31	1	**It123**	0.35	8.13	2	48
It58	0.11	10.46	1	**It95**	10.54	197.57	2	**It142**	0.07	3.09	1	**It25**	0.09	6.90	2	49
It101	0.08	7.68	1	**It37**	6.63	189.46	1	**It79**	0.07	3.00	1	**It19**	0.22	6.78	2	50
It163	0.24	6.87	1	**It44**	3.74	184.33	1	**It19**	0.06	2.87	1	**It139**	0.69	6.44	2	51
It12	0.04	3.69	1	**It58**	8.63	174.60	1	**It170**	0.17	2.29	1	**It79**	0.23	6.16	2	52
It170	0.00	0.00	0	**It167**	5.89	163.18	1	**It25**	0.03	2.18	1	**It77**	0.22	5.05	1	53
It105	0.00	0.00	0	**It139**	14.21	161.89	2	**It77**	0.05	2.08	1	**It170**	0.50	4.67	1	54
It156	0.00	0.00	0	**It33**	6.37	155.15	1	**It12**	0.04	1.86	1	**It12**	0.21	4.19	2	55
It142	0.00	0.00	0	**It7**	7.48	122.08	1	**It167**	0.05	1.75	1	**It58**	0.27	4.15	1	56
It123	0.00	0.00	0	**It91**	1.44	112.83	1	**It101**	0.03	1.53	1	**It101**	0.20	3.84	1	57
It77	0.00	0.00	0	**It6**	1.92	97.42	1	**It69**	0.08	1.52	1	**It69**	0.38	3.53	1	58
It7	0.00	0.00	0	**It152**	1.13	90.29	1	**It58**	0.07	1.41	1	**It167**	0.21	3.52	1	59
It19	0.00	0.00	0	**It101**	2.66	84.51	1	**It70**	0.01	1.03	1	**It70**	0.11	3.37	2	60
It167	0.00	0.00	0	**It69**	4.51	84.40	1	**It156**	0.03	0.97	1	**It146**	0.10	3.13	1	61
It69	0.00	0.00	0	**It72**	2.60	82.52	1	**It44**	0.01	0.80	1	**It111**	0.20	2.98	1	62
It44	0.00	0.00	0	**It111**	3.64	82.27	1	**It111**	0.03	0.71	1	**It156**	0.21	2.85	2	63
It111	0.00	0.00	0	**It12**	1.74	63.05	1	**It15**	0.01	0.31	1	**It44**	0.18	2.61	1	64

	CSO 020				CSO 021				CSO 022				CSO 029			
	Easby Point				Slash Run				I St. - 22nd St. NW				College Pond			
Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	Rain Event No.	OF Vol. (mg)	Max OF Rate (mgd)	Freq	OF mgd rank
It72	0.00	0.00	0	**It70**	1.13	59.47	1	**It146**	0.00	0.25	1	**It41**	0.10	2.42	1	65
It6	0.00	0.00	0	**It41**	0.14	13.22	1	**It7**	0.00	0.24	1	**It48**	0.06	2.39	1	66
It70	0.00	0.00	0	**It15**	0.07	6.84	1	**It6**	0.00	0.10	1	**It53**	0.07	2.16	1	67
It130	0.00	0.00	0	**It130**	0.05	4.32	1	**It72**	0.00	0.00	0	**It72**	0.15	2.10	2	68
It20	0.00	0.00	0	**It25**	0.00	0.00	0	**It130**	0.00	0.00	0	**It6**	0.11	1.98	2	69
It15	0.00	0.00	0	**It20**	0.00	0.00	0	**It20**	0.00	0.00	0	**It7**	0.18	1.80	1	70
It138	0.00	0.00	0	**It146**	0.00	0.00	0	**It138**	0.00	0.00	0	**It20**	0.12	1.78	1	71
It66	0.00	0.00	0	**It138**	0.00	0.00	0	**It66**	0.00	0.00	0	**It138**	0.17	1.61	1	72
It168	0.00	0.00	0	**It66**	0.00	0.00	0	**It168**	0.00	0.00	0	**It15**	0.17	1.60	1	73
It87	0.00	0.00	0	**It168**	0.00	0.00	0	**It87**	0.00	0.00	0	**It26**	0.04	1.58	2	74
It50	0.00	0.00	0	**It87**	0.00	0.00	0	**It50**	0.00	0.00	0	**It87**	0.12	1.50	2	75
It41	0.00	0.00	0	**It50**	0.00	0.00	0	**It41**	0.00	0.00	0	**It50**	0.07	1.46	2	76
It53	0.00	0.00	0	**It53**	0.00	0.00	0	**It53**	0.00	0.00	0	**It168**	0.07	1.40	1	77
It56	0.00	0.00	0	**It56**	0.00	0.00	0	**It56**	0.00	0.00	0	**It32**	0.04	1.34	2	78
It112	0.00	0.00	0	**It112**	0.00	0.00	0	**It112**	0.00	0.00	0	**It130**	0.17	1.33	1	79
It154	0.00	0.00	0	**It154**	0.00	0.00	0	**It154**	0.00	0.00	0	**It35**	0.01	1.08	1	80
It45	0.00	0.00	0	**It45**	0.00	0.00	0	**It45**	0.00	0.00	0	**It171**	0.03	1.02	1	81
It73	0.00	0.00	0	**It73**	0.00	0.00	0	**It73**	0.00	0.00	0	**It154**	0.04	1.00	2	82
It63	0.00	0.00	0	**It63**	0.00	0.00	0	**It63**	0.00	0.00	0	**It118**	0.01	0.94	1	83
It124	0.00	0.00	0	**It124**	0.00	0.00	0	**It124**	0.00	0.00	0	**It63**	0.03	0.90	1	84
It68	0.00	0.00	0	**It68**	0.00	0.00	0	**It68**	0.00	0.00	0	**It117**	0.02	0.88	1	85
It48	0.00	0.00	0	**It48**	0.00	0.00	0	**It48**	0.00	0.00	0	**It112**	0.05	0.87	2	86
It122	0.00	0.00	0	**It122**	0.00	0.00	0	**It122**	0.00	0.00	0	**It122**	0.03	0.78	1	87
It107	0.00	0.00	0	**It107**	0.00	0.00	0	**It107**	0.00	0.00	0	**It21**	0.02	0.77	2	88
It61	0.00	0.00	0	**It61**	0.00	0.00	0	**It61**	0.00	0.00	0	**It148**	0.03	0.74	1	89
It55	0.00	0.00	0	**It55**	0.00	0.00	0	**It55**	0.00	0.00	0	**It68**	0.02	0.69	1	90
It32	0.00	0.00	0	**It32**	0.00	0.00	0	**It32**	0.00	0.00	0	**It28**	0.01	0.64	1	91
It114	0.00	0.00	0	**It114**	0.00	0.00	0	**It114**	0.00	0.00	0	**It56**	0.02	0.60	1	92
It57	0.00	0.00	0	**It57**	0.00	0.00	0	**It57**	0.00	0.00	0	**It61**	0.02	0.56	1	93
It26	0.00	0.00	0	**It26**	0.00	0.00	0	**It26**	0.00	0.00	0	**It114**	0.01	0.53	1	94
It171	0.00	0.00	0	**It171**	0.00	0.00	0	**It171**	0.00	0.00	0	**It66**	0.06	0.52	2	95
It148	0.00	0.00	0	**It148**	0.00	0.00	0	**It148**	0.00	0.00	0	**It124**	0.02	0.52	1	96
It143	0.00	0.00	0	**It143**	0.00	0.00	0	**It143**	0.00	0.00	0	**It109**	0.01	0.46	1	97
It21	0.00	0.00	0	**It21**	0.00	0.00	0	**It21**	0.00	0.00	0	**It159**	0.00	0.41	1	98
It1	0.00	0.00	0	**It1**	0.00	0.00	0	**It1**	0.00	0.00	0	**It107**	0.01	0.41	1	99
It117	0.00	0.00	0	**It117**	0.00	0.00	0	**It117**	0.00	0.00	0	**It113**	0.01	0.37	1	100
It9	0.00	0.00	0	**It9**	0.00	0.00	0	**It9**	0.00	0.00	0	**It1**	0.01	0.33	1	101
It103	0.00	0.00	0	**It103**	0.00	0.00	0	**It103**	0.00	0.00	0	**It99**	0.01	0.33	1	102
It46	0.00	0.00	0	**It46**	0.00	0.00	0	**It46**	0.00	0.00	0	**It81**	0.00	0.33	1	103
It5	0.00	0.00	0	**It5**	0.00	0.00	0	**It5**	0.00	0.00	0	**It54**	0.00	0.27	1	104
It28	0.00	0.00	0	**It28**	0.00	0.00	0	**It28**	0.00	0.00	0	**It55**	0.00	0.27	1	105
It8	0.00	0.00	0	**It8**	0.00	0.00	0	**It8**	0.00	0.00	0	**It86**	0.00	0.27	1	106
It99	0.00	0.00	0	**It99**	0.00	0.00	0	**It99**	0.00	0.00	0	**It57**	0.00	0.23	1	107
It115	0.00	0.00	0	**It115**	0.00	0.00	0	**It115**	0.00	0.00	0	**It45**	0.01	0.18	1	108
It109	0.00	0.00	0	**It109**	0.00	0.00	0	**It109**	0.00	0.00	0	**It73**	0.01	0.16	1	109
It81	0.00	0.00	0	**It81**	0.00	0.00	0	**It81**	0.00	0.00	0	**It46**	0.00	0.16	1	110
It113	0.00	0.00	0	**It113**	0.00	0.00	0	**It113**	0.00	0.00	0	**It31**	0.00	0.14	1	111
It133	0.00	0.00	0	**It133**	0.00	0.00	0	**It133**	0.00	0.00	0	**It8**	0.00	0.07	1	112
It35	0.00	0.00	0	**It35**	0.00	0.00	0	**It35**	0.00	0.00	0	**It125**	0.00	0.05	1	113
It2	0.00	0.00	0	**It2**	0.00	0.00	0	**It2**	0.00	0.00	0	**It143**	0.00	0.03	1	114
It118	0.00	0.00	0	**It118**	0.00	0.00	0	**It118**	0.00	0.00	0	**It103**	0.00	0.03	1	115
It157	0.00	0.00	0	**It157**	0.00	0.00	0	**It157**	0.00	0.00	0	**It9**	0.00	0.01	1	116
It42	0.00	0.00	0	**It42**	0.00	0.00	0	**It42**	0.00	0.00	0	**It115**	0.00	0.01	1	117
It86	0.00	0.00	0	**It86**	0.00	0.00	0	**It86**	0.00	0.00	0	**It5**	0.00	0.00	0	118
It121	0.00	0.00	0	**It121**	0.00	0.00	0	**It121**	0.00	0.00	0	**It133**	0.00	0.00	0	119
It128	0.00	0.00	0	**It128**	0.00	0.00	0	**It128**	0.00	0.00	0	**It2**	0.00	0.00	0	120
It159	0.00	0.00	0	**It159**	0.00	0.00	0	**It159**	0.00	0.00	0	**It157**	0.00	0.00	0	121
It71	0.00	0.00	0	**It71**	0.00	0.00	0	**It71**	0.00	0.00	0	**It42**	0.00	0.00	0	122
It52	0.00	0.00	0	**It52**	0.00	0.00	0	**It52**	0.00	0.00	0	**It121**	0.00	0.00	0	123
It54	0.00	0.00	0	**It54**	0.00	0.00	0	**It54**	0.00	0.00	0	**It128**	0.00	0.00	0	124
It92	0.00	0.00	0	**It92**	0.00	0.00	0	**It92**	0.00	0.00	0	**It71**	0.00	0.00	0	125
It31	0.00	0.00	0	**It31**	0.00	0.00	0	**It31**	0.00	0.00	0	**It52**	0.00	0.00	0	126
It65	0.00	0.00	0	**It65**	0.00	0.00	0	**It65**	0.00	0.00	0	**It92**	0.00	0.00	0	127
It119	0.00	0.00	0	**It119**	0.00	0.00	0	**It119**	0.00	0.00	0	**It65**	0.00	0.00	0	128
It78	0.00	0.00	0	**It78**	0.00	0.00	0	**It78**	0.00	0.00	0	**It119**	0.00	0.00	0	129
It27	0.00	0.00	0	**It27**	0.00	0.00	0	**It27**	0.00	0.00	0	**It78**	0.00	0.00	0	130
It166	0.00	0.00	0	**It166**	0.00	0.00	0	**It166**	0.00	0.00	0	**It27**	0.00	0.00	0	131
It141	0.00	0.00	0	**It141**	0.00	0.00	0	**It141**	0.00	0.00	0	**It166**	0.00	0.00	0	132
It155	0.00	0.00	0	**It155**	0.00	0.00	0	**It155**	0.00	0.00	0	**It141**	0.00	0.00	0	133
It165	0.00	0.00	0	**It165**	0.00	0.00	0	**It165**	0.00	0.00	0	**It155**	0.00	0.00	0	134
It125	0.00	0.00	0	**It125**	0.00	0.00	0	**It125**	0.00	0.00	0	**It165**	0.00	0.00	0	135
It16	0.00	0.00	0	**It16**	0.00	0.00	0	**It16**	0.00	0.00	0	**It16**	0.00	0.00	0	136
It34	0.00	0.00	0	**It34**	0.00	0.00	0	**It34**	0.00	0.00	0	**It34**	0.00	0.00	0	137
It104	0.00	0.00	0	**It104**	0.00	0.00	0	**It104**	0.00	0.00	0	**It104**	0.00	0.00	0	138
It161	0.00	0.00	0	**It161**	0.00	0.00	0	**It161**	0.00	0.00	0	**It161**	0.00	0.00	0	139
It134	0.00	0.00	0	**It134**	0.00	0.00	0	**It134**	0.00	0.00	0	**It134**	0.00	0.00	0	140
It60	0.00	0.00	0	**It60**	0.00	0.00	0	**It60**	0.00	0.00	0	**It60**	0.00	0.00	0	141
It62	0.00	0.00	0	**It62**	0.00	0.00	0	**It62**	0.00	0.00	0	**It62**	0.00	0.00	0	142
It93	0.00	0.00	0	**It93**	0.00	0.00	0	**It93**	0.00	0.00	0	**It93**	0.00	0.00	0	143
It24	0.00	0.00	0	**It24**	0.00	0.00	0	**It24**	0.00	0.00	0	**It24**	0.00	0.00	0	144
It108	0.00	0.00	0	**It108**	0.00	0.00	0	**It108**	0.00	0.00	0	**It108**	0.00	0.00	0	145

DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY

DC Clean Rivers Project
Technical Memorandum No. 7
SCENARIO 2A- COST ESTIMATES AND RESULTS
TABLE 6- POTOMAC LINE 2

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	POTOMAC LTCP PROJECTS											
	Tunnel From Potomac P.S to CSO 029 in Rock	4,500	LF	$ 19,858	$ 89,360,763							
	Tunneling Work Shaft	165	VLF	$ 82,689	$ 13,643,689						54	
	Dewatering P.S. internals in Shaft	1	LS	$ 61,662,125	$ 61,662,125			250				
	Screening Work Shaft	140	VLF	$ 69,672	$ 9,754,016						27	
	Screening Shaft Internals	140	VLF	$ 21,601	$ 3,024,093						27	
	Force Main Connection to Potomac Force Mains	100	LF	$ 3,052	$ 305,166							120
	CSO 020											
	CSO 020 Diversion Structure	1	MGD	$ 556,098	$ 556,098							
	12' Dia Pipeline CSO 020 to Drop Shaft	1,200	LF	$ 4,040	$ 4,848,183							144
	CSO 020 Tangential Inlet	1	LS	$1,000,000	$ 1,000,000							
	CSO 021											
	CSO 021 Diversion Structure	1	MGD	$ 556,098	$ 556,098							
	CSO 021 Tangential Inlet	1	LS	$1,000,000	$ 1,000,000							
	CSO 021 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 021 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	CSO 022											
	CSO 022 Diversion Structure	1	LS	$ 816,884	$ 816,884			66				
	CSO 022 Tangential Inlet	1	LS	$1,139,948	$ 1,139,948			55				
	CSO 022 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 022 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	12' Dia Pipeline CSO 020 to Drop Shaft	400	LF	$ 4,040	$ 1,616,061							144
	Tunnel Overflow Structure at CSO 022	1	LS	$ 10,000,000	$ 10,000,000							
	CSO 024											
	CSO 024 Diversion Structure	1	LS	$ 1,583,763	$ 1,583,763			269				
	CSO 024 Tangential Inlet	1	LS	$1,684,471	$ 1,684,471			269				
	CSO 024 Work Shaft	140	VLF	$ 72,078	$ 10,090,917						12	
	CSO 024 Shaft Internals	140	VLF	$ 16,996	$ 2,379,381						12	
	CSO 025											
	Sewer Separation	10	ac	$ 200,000	$ 1,978,000							
	CSO 026											
	Sewer Separation	14	ac	$ 200,000	$ 2,776,000							
	CSO 028											
	New Diversion to UPIRS and Pipeline	1	LS	$10,000,000	$ 10,000,000							
	Blue Plains											
	Add 75 mgd Pump to BPTDPS	1	LS	$ 7,000,000	$ 7,000,000							
	Add 75 mgd ECF Capacity	75	MGD	$ 620,000	$ 46,500,000							
	POTOMAC TOTAL				$ 320,296,177	$ 416,385,030	$ 583,000,000					

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SCENARIO 2A- COST ESTIMATES AND RESULTS
TABLE 7- POTOMAC LINE 3

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	POTOMAC LTCP PROJECTS											
	Tunnel From Potomac P.S to CSO 029 in Rock	4,500	LF	$ 12,829	$ 57,732,663							
	Tunneling Work Shaft	165	VLF	$ 91,985	$ 15,177,535						63	
	Dewatering P.S. internals in Shaft	1	LS	$ 4,266,238	$ 4,266,238			17				
	Screening Work Shaft	140	VLF	$ 70,292	$ 9,840,894						31.5	
	Screening Shaft Internals	140	VLF	$ 23,316	$ 3,264,239						31.5	
	Force Main Connection to Potomac Force Mains	100	LF	$ 837	$ 83,692							36
	CSO 020											
	CSO 020 Diversion Structure	1	MGD	$ 789,418	$ 789,418			59				
	12' Dia Pipeline CSO 020 to Drop Shaft	1,200	LF	$ 4,040	$ 4,848,183							144
	CSO 020 Tangential Inlet	1	LS	$1,150,078	$ 1,150,078			59				
	CSO 021											
	CSO 021 Diversion Structure	1	MGD	$ 1,974,527	$ 1,974,527			378				
	CSO 021 Tangential Inlet	1	LS	$1,962,502	$ 1,962,502			378				
	CSO 021 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 021 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 022											
	CSO 022 Diversion Structure	1	LS	$ 949,035	$ 949,035			100				
	CSO 022 Tangential Inlet	1	LS	$1,254,450	$ 1,254,450			100				
	CSO 022 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 022 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	12' Dia Pipeline CSO 020 to Drop Shaft	400	LF	$ 4,040	$ 1,616,061							144
	Tunnel Overflow Structure at CSO 022	1	LS	$ 10,000,000	$ 10,000,000							
	CSO 024											
	CSO 024 Diversion Structure	1	LS	$ 1,583,763	$ 1,583,763			269				
	CSO 024 Tangential Inlet	1	LS	$1,684,471	$ 1,684,471			269				
	CSO 024 Work Shaft	140	VLF	$ 72,919	$ 10,208,660						10	
	CSO 024 Shaft Internals	140	VLF	$ 16,511	$ 2,311,526						10	
	CSO 025											
	Sewer Separation	10	ac	$ 200,000	$ 1,978,000							
	CSO 026											
	Sewer Separation	14	ac	$ 200,000	$ 2,776,000							
	CSO 028											
	New Diversion to UPIRS and Pipeline	1	LS	$7,000,000	$ 7,000,000							
	Blue Plains											
	Add 75 mgd Pump to BPTDPS	1	LS	$ 7,000,000	$ 7,000,000							
	Add 75 mgd ECF Capacity	75	MGD	$ 500,000	$ 37,500,000							
	POTOMAC TOTAL				$ 220,506,807	$ 286,658,850	$ 402,000,000					

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SCENARIO 2A- COST ESTIMATES AND RESULTS
ECF COST

Item	Cost	Remark
Capital Cost of ECF	$ 195,000,000	ECF Budget cost
Cacpity (mgd)	225	
$/mgd	$ 866,667	
Contruction Cost with	$ 619,048	
Use	$0.62 M/mgd	

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DC Clean Rivers Project
Technical Memorandum No. 7
SCENARIO 2B- COST ESTIMATES AND RESULTS
TABLE 1- RESULTS

Line	Green										Gray							Total Cost		
	% GI Application of Imp Area at 1.2" (Public & Private)	Total Acres	Imp Acres	Imp Ac Treated	Low Unit Cost ($/Imp Ac)	Avg Unit Cost ($/Imp Ac)	High Cost ($/Imp Ac)	Low Green Cost ($M)	Avg GI Cost ($M)	Hi Green Cost ($M)	# CSOs/ Avg Yr	CSO Overflow vol (mg/avg yr)	Storage Volume (mg)	Tunnel Dia (ft)	Low Cost (-20% cost)	Avg Grey Cost ($M)	High Cost (+30% cost range)	Low	Avg	High
Piney Branch Tunnel																				
1	0% (LTCP)	2,329	1,215								1	0.9	8.0	22.0	$ 114	134	$ 174	$ 114	$ 134	$ 174
2	30%	2,329	1,215	365	$ 0.12	$ 0.25	$ 0.50	$ 45	$ 91	$ 182	1	1.0	2.5	N/A	$ 44	52	$ 68	$ 90	$ 143	$ 250
3	30%	2,329	1,215	365	$ 0.12	$ 0.25	$ 0.50	$ 46	$ 91	$ 182	12	13.0	0.5	N/A	$ 13	15	$ 20	$ 58	$ 106	$ 202

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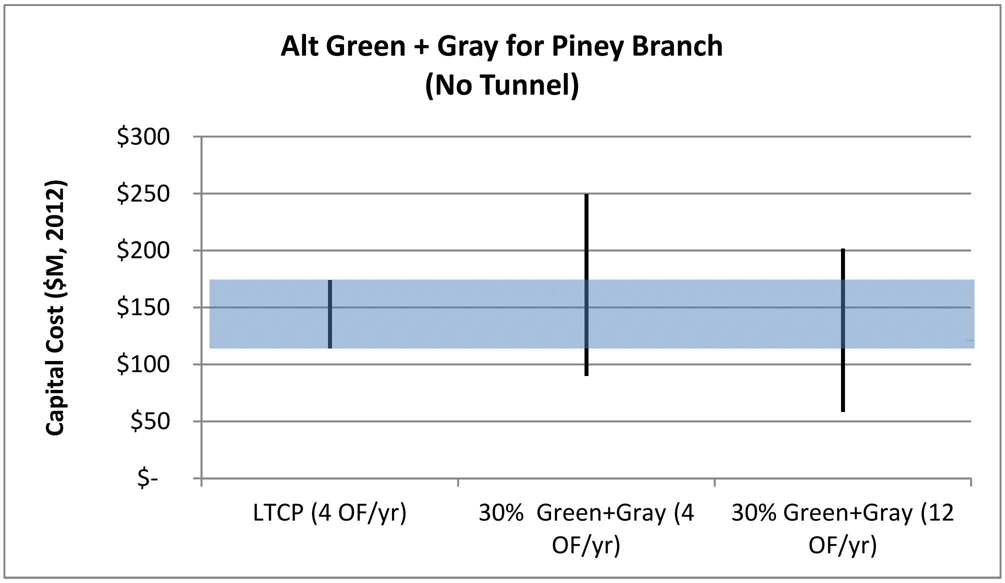
DC Clean Rivers Project
Technical Memorandum No. 7
SCENARIO 2B- COST ESTIMATES AND RESULTS
FIGURE 1-PINEY COST RANGES



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DC Clean Rivers Project
Technical Memorandum No. 7
SCENARIO 2B- COST ESTIMATES AND RESULTS
TABLE 2- CAPITAL COST OPINION, LINE 2

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	PINEY BRANCH LTCP PROJECTS											
	Str 70 Diversion Structure	1	LS	$ 1,949,015	$ 1,949,015			371				
	Storage Basin	2,500,000	Gal	$10	$ 25,000,000			371				
	Pipeline East Rock Creek Div Swr	300	LF	$ 677	$ 203,232							24
	Junction Chamber East Rock Creek Div Swr	1	LS	$ 300,000	$ 300,000							
	Venting and Odor Control Chamber	1	LS	$ 300,000	$ 300,000							
	Landscaping	1	LS	$ 300,000	$ 300,000							
	PINEY BRANCH TOTAL				$ 28,052,247	$ 36,467,922	$ 52,000,000					

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DC Clean Rivers Project
Technical Memorandum No. 7
SCENARIO 2B- COST ESTIMATES AND RESULTS
TABLE 3- CAPITAL COST OPINION, LINE 3

No.	Item	Quantity	Unit	Unit Cost	Base Const Cost (no Contingency)	Const Cost (1.3 * Base)	Capital Cost (Rounded to Nearest Million)	Design Flow Rate (mgd)	Tun Dia (ft)	Stor Vol (mg)	Shaft Dia (ft)	Pipe Dia (in)
	PINEY BRANCH LTCP PROJECTS											
	Str 70 Diversion Structure	1	LS	$ 1,949,015	$ 1,949,015			371				
	Storage Basin	500,000	Gal	$10	$ 5,000,000			371				
	Pipeline East Rock Creek Div Swr	300	LF	$ 677	$ 203,232							24
	Junction Chamber East Rock Creek Div Swr	1	LS	$ 300,000	$ 300,000							
	Venting and Odor Control Chamber	1	LS	$ 300,000	$ 300,000							
	Landscaping	1	LS	$ 300,000	$ 300,000							
	PINEY BRANCH TOTAL				$ 8,052,247	$ 10,467,922	$ 15,000,000					

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DC Clean Rivers Project
Technical Memorandum No. 7
SCENARIO 3- COST ESTIMATES AND RESULTS
TABLE 1- TURNER COSTS RESULTS

	Green										Gray							Total Cost		
Line	% GI Application of Imp Area at 1.2" (Public & Private)	Total Acres	Imp Acres	Imp Ac Treated	Avg Unit Cost ($M/imp AC)	Avg GI Cost ($M)	Low Unit Cost $M/imp Ac(-15% cost)	Low Green Cost ($M)	Hi Unit Cost $M/imp Ac (+30% cost range)	Hi Green Cost ($M)	# CSOs/ Avg Yr	CSO Overflow vol (mg/avg yr)	Tunnel Volume (mg)	Tunnel Dia (ft)	Grey Cost ($M)	Low Cost (-15% cost)	High Cost (+30% cost range)	Avg	Low	High
1-(Turner Proposal) **Potomac**	15%	1,525	985	148	976,322.8	144,225,528	$ 829,874	$ 122,591,699	$ 1,269,220	$ 187,493,187								$ 144,225,528	$ 122,591,699	$ 187,493,187
2 -(Turner Proposal) **Piney Br**	15%	2,329	1,215	182	976,322.8	177,976,257	$ 829,874	$ 151,279,818	$ 1,269,220	$ 231,369,134										

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SCENARIO 3- COST ESTIMATES AND RESULTS
TABLE 2- STORAGE SYSTEM PROPOSAL EVALUATION

No	Item	Cost ($M)	Cost for Pervious Pavement	Notes
1	Conceptual planning and sampling	$ 0.9	$ 0.9	
2	Pilot programs	$ 20.0	$ 10.0	50% of cost for pervious pavement
3	Dredge operations	$ 200.0	$ -	
4	Plant construction	$ 25.0	$ 12.5	50% of cost for pervious pavement
5	Capping operations in river	$ 20.8	$ -	
6	Six site cleanup, imporvement etc.	$ 194.0	$ -	
7	Pervious roadways, alleys and parking	$ 910.0	$ 910.0	
8	Subtotal	$ 1,370.7	$ 933.4	
9	Contingencies, escalation, agencies	$ 298.2	$ 202.78	68% for pervious pavement = proportionate to subtotal
10	Overhead, insurance, bond, fees	$ 165.2	$ 112.34	68% for pervious pavement = proportionate to subtotal
11	Subtotal	$ 463.4	$ 315.1	
12	Grant Total	$ 1,834.10	$ 1,248.51	

Reported Storage Volume (mg)		250	
Cost per gallon stored ($/gal)		$ 4.99	
Assumed thickness of gravel layer (in)		12	
Assumed porosity		0.6	
Gallons/sf stored		**4.49**	
SF requird for 250 mg		55,704,100	
Acres required for 250 mg		1,279	
Acres req'd per mg		5.12	
Cost per ac		$ 976,323	
Cost per sf		$ 22.41	

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SCENARIO 3- COST ESTIMATES AND RESULTS
TABLE 3- SEWERSHED CHARACTERSTICS

			Area (acres)		
CSO Sewershed	***Total Acres***	***Impervious Acres***	Alleys	Primary Road	Secondary Road
Potomac					
CSO 020	595	450	11.44	108.17	66.55
CSO 021	24	19	0.00	0.09	2.04
CSO 022	199	158	4.48	30.35	36.86
CSO 023	0	0			
CSO 024	175	62	0.98	4.14	25.16
CSO 025	15	12	0.16	0.00	4.27
CSO 026	3	3	0.14	0.24	1.72
CSO 027	164	104	3.11	12.52	18.21
CSO 028	21	13	0.00	2.07	3.81
CSO 029	330	164	8.39	14.49	44.97
Subtotal	1,525	985	28.69	172.08	203.60
Rock Creek					
CSO 031					
CSO 032	13	10	0.44	1.66	1.58
CSO 033	16	12	0.83	0.01	2.85
CSO 034	393	338	17.24	55.46	52.75
CSO 035	551	399	19.17	55.79	88.24
CSO 036	75	45	0.84	3.21	16.43
CSO 037					
CSO 038	6	3	0.11		1.64
CSO 039	39	26	0.75	1.20	9.12
CSO 040	18	13	0.82	1.53	2.79
CSO 041	25	15	0.75	0.94	4.85
CSO 042	38	24	0.84	2.51	4.93
CSO 043	73	49	2.92	6.02	10.82
CSO 044	19	11	1.27	1.03	1.45
CSO 045	16	10	1.03	1.10	1.46
CSO 046	20	11	0.98	2.02	2.03
CSO 047					
CSO 048	33	17	0.38	0.30	6.52
CSO 049	2,329	1,215	103.10	132.79	341.20
CSO 050	38	27	0.53	3.71	5.48
CSO 051	12	8	0.00	0.28	2.20
CSO 052	104	58	1.90	7.37	12.02
CSO 053	5	4	0.01	0.70	0.86
CSO 054	0	0			
CSO 055	0	0			
CSO 056	0	0			
CSO 057					
CSO 058	7	5	0.08	2.81	0.41
Subtotal	3,831	2,298	153.96	280.44	569.66

Appendix - K

Responses to Public Comments

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1. INTRODUCTION

This Appendix presents responses to comments received on the Draft Long Term Control Plan Modification for Green Infrastructure that was released in January 2014. A large number of comments were received and a significant degree of overlap and common themes are identified between them. As a result, comments were grouped by type and subject matter and addressed together in a commentary type response which is both readable and comprehensive. The comments were grouped in the following categories:

- Nature of Commitment
- Degree of Control
- Rates/ Financial
- Implementability
- Schedule
- Maintenance
- Implementation Strategies
- Miscellaneous
- General Opposition
- General Support

In the following text, each category of comments is described and a response is provided. The number listed after each comment refers to the "Comment No." that is assigned for each comment. The overall list of comments received is summarized in Table 1 of this Appendix and the original comments are included in a separately bound report. For correlation purposes, each commenter is also assigned a "Commenter No." and this number is indicated in both Table 1 and in the separately bound report containing the raw comments received.

2. COMMENTS ON NATURE OF COMMITMENT

2.1 Comments applicable to the performance criteria of Green Infrastructure

2.1.1 Three commenters indicated that DC Water should include site specific performance criteria and water quality-based performance standards equivalent to a tunnel based approach, to measure the effectiveness of GI projects. (20, 23, 28)

2.1.2 A commenter indicated that a financial commitment is not an acceptable substitute for enforceable, clearly defined performance metrics, which are necessary to comply with EPA guidance. (23)

2.1.3 Two commenters indicated that the proposal lacks specific reductions from Green Infrastructure controls, water quality-based performance standards or performance criteria to ensure DC Water will achieve equivalent or greater CSO reductions in lieu of tunnel capacity. (27, 467)

2.1.4 A commenter requested that DC Water develop an actionable plan with performance criteria, hard targets, for CSO reductions that can be measured and assessed on a regular two year milestone schedule leading up to the 2025 LTCP deadline. (377)

2.1.5 A commenter indicated that replacing the current performance-based controls with a GI spending cap would weaken the requirement to effectively operate and maintain the CSO controls and would be a clear violation of the Clean Water Act (25). A commenter indicated that the proposal to substitute tunnel capacity with a Green Infrastructure spending cap is contrary to D.C. Water's NPDES permit, and may constitute backsliding. (469)

2.1.6 A commenter indicated that instead of avoiding the commitment to performance targets, consider categorizing the uncertainties in widespread applications of GI in urban environment into engineering performance, planning, and cost and then resolve those uncertainties by laying out specific strategies. (360)

2.1.7 A commenter questioned if DC Water was guaranteeing $60 M or similar performance to the LTCP. (422).

2.1.8 A commenter requested performance requirements for GI and questioned if DC Water has a dollar value for Green Infrastructure and an associated volume/acreage. (425)

2.1.9 A commenter indicated that it is not acceptable to commit to a fixed dollar value due to the hesitancy on GI performance. Commenter suggested that a modest up-front outlay of planning funds will provide greater degree of confidence for DC Water, regulators, and ratepayers in what can be achieved and how much will be spent (and/or saved) to achieve it. (361)

2.1.10 A commenter questioned what has been done to date by DC Water to evaluate GI and indicated his skepticism on DC Water's financial commitments without concrete measurable milestones and objectives. (451)

2.1.11 A commenter indicated that the Proposed Draft LTCP Modification conveyed unwarranted hesitancy in using GI for CSO control. Commenter expressed that hesitancy on GI could not be the reason for not setting up the performance criteria. Commenter suggested proceeding with wholehearted commitment as there is substantial evidence on GI (329).

Response:

The analyses that DC Water has performed indicate that the following controls will provide a degree of control equivalent to the gray controls in the LTCP:

Rock Creek	Potomac River
• For Piney Branch (CSO 049), construct GI and targeted sewer separation to manage the volume of runoff produced by a 1.2" of rain falling on 365 impervious acres	• Construct GI and targeted sewer separation to control CSOs 027, 028, and 029 by managing to manage the volume of runoff produced by a 1.2" of rain falling on 133 impervious acres. • For CSOs 025 and 026, separate these sewersheds, thereby eliminating these outfalls as combined sewer overflows • For CSOs 020, 021, 022 and 024, construct a 30 million gallon storage/conveyance tunnel that is connected by gravity to the Blue Plains, thereby providing an interconnected tunnel system for the Anacostia and Potomac River CSOs.

The Proposed Draft LTCP Modification for GI identified a financial commitment of $60M for Rock Creek and $30M for Potomac CSO 027, 028 and 029. This was proposed in order to better manage the financial and performance risks associated with GI.

Based on the comments received, the recommended Final LTCP Modification for GI proposes a commitment expressed in terms of constructing sufficient GI and targeted seer separation to manage the volume of runoff produced by a 1.2" of rain falling on 365 impervious acres in Piney Branch CSO 049 and 133 impervious acres in the Potomac CSOs 027, 028 and 029. This is a commitment to construct a specified volume of GI and will ensure that the necessary amount of GI is in place in order to provide the degree of CSO control required.

Given that there is some uncertainty associated with the ability to implement GI in the District at the large scale by the deadlines identified, DC Water has revised the LTCP modification to provide for constructing the first GI project in each sewershed and then evaluate GI in terms of constructability, operability, efficacy, public acceptability and cost effectiveness. If, based on that evaluation, it is determined that it is not practicable to complete the specified GI projects by the specified deadlines,, then DC Water would be required to construct the gray controls as specified in the LTCP Modification. Should this occur, the gray controls would be constructed within the same timeframe allowed for GI so there is no delay or extension of the time allowed for implementation. If GI is determined to be practicable after the first project, then DC Water will continue to implement the remaining GI projects until they are completed on schedule.

2.2 Comments applicable to the budget assigned for Green Infrastructure

2.2.1 A commenter indicated that DC Water estimates $91 million for GI will achieve the same or better performance of a $42 million tunnel (2002 estimate), by realization of only 30% of the GI potential in the sewershed. If that's the case, the commenter wanted to know the rationale behind the $60 million allocation on GI via five contracts. (429)

Response:
DC Water performed modeling and analyses to determine the degree of GI needed in Piney Branch (CSO 049) necessary to provide the same degree of control equivalent to the LTCP. The analyses indicated that treatment of 30% of the impervious acreage in the sewershed or 365 acres at the equivalent of 1.2" would provide control equivalent to the LTCP. The $60M budget cost was estimated based on a review of costs and technologies for GI implementation which determined that $165,000 per impervious acres was a reasonably conservative cost for implementation of GI.

The $42M was the 2001 cost estimate for the Piney Branch Tunnel.

2.2.2 A commenter indicated that $100M is a small percentage of the total committed for solving this problem (424). Two commenters suggested if we could put more into it. (319, 424)

Response:
The mix of gray and Green CSO controls were selected to deliver the most cost effective benefits to ratepayers while achieving an equivalent level of control to the all gray controls. Green controls were selected for sewersheds and locations where they are most likely to be effective for CSO control. Similarly, the gray controls were selected to control the largest CSOs in the more dense areas of the city. Given that ratepayer affordability is limited, the degree of Green and gray CSO controls was selected to achieve the CSO reduction performance goals of the LTCP.

2.2.3 A commenter questioned if the $60 M commitment is capital cost or does it include O and M as well. (423)

Response:
The financial commitment in the Proposed Draft LTCP Modification represents capital costs only. Operations and maintenance costs will become part of DC Water's operating budget as GI projects are completed. DC Water is no longer proposing a financial limitation for GI. See the response to comment 2.1.

2.2.4 A commenter indicated that DC Water must incorporate lessons learned through pilot and other Green Infrastructure programs to add sufficient details to each specific project. Commenter added that this will help writing contracts with enforceable accountability and DC Water will be able to accurately predict the costs that will be incurred. (381)

Response:
DC Water has already invested more than $14 million in planning, analysis, design and construction of GI in the District. In addition, we have researched and summarized GI experience in the District and at other locations across the country. DC Water will continue to avail itself of actual GI experience as it implements the GI program.

2.3 Comments applicable to the modification of LTCP

2.3.1 One commenter questioned if DC Water is taking all corrective actions required by the CD dated 3/2005 or if it is avoiding responsibilities by seeking modification to the CD. (426)

Response:
DC Water has met all Consent Decree milestones to date. DC Water is seeking to modify the LTCP because it believes that a green/gray hybrid CSO control plan offer more benefits to District residents and the environment than an all gray CSO plan. The hybrid green/gray approach to CSO control is predicted to have an equivalent degree of CSO reduction to the all gray controls in the LTCP.

2.3.2 One commenter is concerned that failure to comply with the law would require DC residents to bear the penalties on top of the maintenance costs. (427).

Response:
While the existing Long Term Control Plan Consent Decree has stipulated financial penalties for not meeting specified deadlines, DC Water has met all Consent Decree milestones to date. If the decree is modified to include GI, it is likely the decree will impose similar penalties for failure to meet deadlines. DC Water has identified a project schedule that is achievable and reduces the potential for penalties from missed deadlines. The potential for penalties is no greater with the green/gray hybrid plan than it is for the all gray plan.

2.4 Comments applicable to the selection of Green Infrastructure approach for Rock Creek

2.4.1 One commenter questioned if DC Water intends to address CSOs in the area north of Rock Creek Parkway or not. (427)

2.4.2 A commenter asked what exactly is proposed for Ward 4, what is the health risk, do they have to wait twenty more years, what is the socio/economic and demographic impact if Rock Creek is not addressed. (428)

Response:
The Final LTCP specifies the controls that DC Water must implement in order to meet water quality standards. They are summarized as follows:

Controls	Status
Separate Luzon Valley (CSO 059)	Completed
Separate CSO 031, 037, 053 and 058	Completed
Monitoring and diversion structure improvements at CSO 033, 036, 047 and 057	Completed
Construct 9.5 million gallon Rock Creek Tunnel to control Piney Branch CSO 049	DC Water is proposing to modify this requirement and replace the Rock Creek Tunnel with GI.

As shown in the table above, DC Water has completed all CSO projects in Rock Creek except the Rock Creek tunnel to control Piney Branch CSO 049. DC Water is proposing to control the Piney Branch CSO Outfall 049 with GI. DC Water's analyses indicate that GI in Piney Branch can provide a degree of CSO control equivalent to that provided by the gray controls in the LTCP.

The water quality standards have been established to protect human health and the environment. The District Department of the Environment and the U.S. Environmental Protection Agency have determined that DC Water's CSO Plan will comply with water quality standards, subject to post construction monitoring after implementation. As a result, the implementation of the CSO control plan will improve conditions in Rock Creek and the watershed as a whole and is expected to eliminate health risk due to CSOs.

2.4.3 A commenter indicated that the performance standards for GI should mesh with GI characteristics if they are to be efficient and cost-effective. (31)

Response:
Expected performance of the GI-based CSO controls is based on the expectation that the GI will retain 1.2" of rainfall. This is consistent with the characteristics of GI strategies identified under the GI Plan and with the District's stormwater requirements for design of GI.

3. COMMENTS ON DEGREE OF CSO CONTROL

3.1 A commenter requested "Predicted CSO Volume" graph to include all outfalls discharging to Potomac and not just CSO 025-029. (1). A commentator mentioned that Section 3, Figure 3-6 deals with the entire Potomac control but Figure 3-7 deals with the small CSOs only. A commenter quoted that the true impact of the delay on the Potomac River is not presented clearly and that Figure 3-7 should show CSO volumes of all nine outfalls.(6)

Response:
In the Final LTCP Modification for GI, DC Water has updated the CSO reduction versus time graphs in Section 3 to include the entire Potomac CSO plan.

3.2 A commenter requested an increase in CSO reduction (2). A commenter questioned if more GI could get overflows down to 0% in Rock Creek. (10)

Response:
DC Water developed it's LTCP between 1998 and 2002. The purpose of the LTCP was to determine the degree of CSO control necessary to meet water quality standards and the measures to be implemented to achieve that degree of control. The process involved extensive data collection, analysis and an extensive and extended opportunity for public participation and feedback on the plan. The process also included an extensive analysis of the cost to ratepayers and associated impacts on water quality of various degrees of CSO control. The result of that process was the Final LTCP, issued in 2002, which provided for a 96% reduction in overflow volume system-wide and a 98% reduction in overflow volume on the Anacostia River in an average year. The District Department of the Environment and the U.S. Environmental Protection Agency have determined that DC Water's CSO Plan will comply with water quality standards, subject to post construction monitoring after implementation.

As part of the LTCP, an evaluation was made of the feasibility, cost and benefits of complete separation to eliminate CSOs. This analysis determined that separation would result in poorer water quality than would be achieved with a high degree of CSO control, that separation was cost prohibitive and that construction impacts of separation were severe. .

3.3 A commenter noted that CSO impacts on the Potomac and Rock Creek are overpowered by storm sewer runoff from DC and the jurisdictions upstream. The commenter was concerned that the improvements from CSO reductions are going to be masked by other sources of wet weather pollution and by glaring issues like TMDL allocation and the Chesapeake Bay Syndrome.(4)

Response:
There are other pollution loads from other states in the water shed which impact water quality in the Potomac and Rock Creek. The goal of the CSO project is to address one of

the major sources of pollution *in the District* which is combined sewer overflows. Other sources of pollution must also be controlled in order to attain water quality standards in the receiving waters. There are other regulatory-driven programs in place that must be implemented to address these other sources of pollution. The control of sources of pollution other than CSOs is beyond the scope of the LTCP.

3.4 <u>A commenter indicated that the Executive Summary has no clear statement of how many million gallons per year of CSO will exist beyond 2025 if the proposed GI plan is accepted. (5)</u>

Response:
DC Water projects that the hybrid Green and gray controls described in this modification will achieve an equivalent degree of CSO reduction compared to the gray controls in the LTCP. Tables 3-2 and 3-5 of the Report present the predicted number of million gallons per average year of CSO remaining if the GI plan is implemented.

3.5 <u>A commenter questioned why the Anacostia with only ten outfalls been given a higher priority over Rock Creek. The commenter expressed concern that the City is trying to modify its responsibilities under the consent decree in a material way which could be adverse to those who live on the east side of Rock Creek. (7)</u>

Response:
The 10 outfalls discharging to the Anacostia River are predicted to produce approximately 70% of the total CSOs volume discharged to all three rivers. The Anacostia River does not have the large dilution capacity like the Potomac River, is not fast flowing like Rock Creek and is not well aerated. During the development of the LTCP, the Anacostia River was identified as the river most severely impacted by CSOs. Also, there were many comments from the public and regulatory agencies during development of the LTCP indicating that the Anacostia River should be given priority. As a result, the Consent Decree schedule requires construction of many of the Anacostia projects first.

3.6 <u>A commenter questioned what sewer separation projects have already completed. (8)</u>

Response:
As required by the LTCP Consent Decree, CSO 006 on the Anacostia and CSO 031, 037, 053 and 058 on Rock Creek have been separated. Previously, CSO 59 in Luzon Valley had been separated.

3.7 Two commenters indicated support for GI, but were concerned that the proposed small scale GI projects by DC Water will not have sufficient impact on the Rock Creek watershed's impervious surface to make much difference on CSOs. (12, 16).

Response:
DC Water has performed modeling and analysis to predict the effect of implementation of GI on CSO overflow volume and frequency. As indicated in Table 3.2 of the Report, the proposed projects that include GI and the Potomac Tunnel are projected to achieve equivalent CSO reductions to the gray controls in the LTCP.

3.8 Comments applicable to the effectiveness of Green Infrastructure

3.8.1 Several commenters expressed concern over the lack of concrete evidence on the effectiveness of Green Infrastructure for the abatement of volume and incidences of overflows at a level better or equivalent to a tunnel. (3, 9, 11, 14, 29, 37, 330). Two commenters indicated support for Green Infrastructure on assurance of achieving same or greater reductions in the volume and incidence of CSOs compared to a tunnel. (13, 18).

3.8.2 A commenter indicated disapproval on shortening Piney Branch Tunnel without clear evidence that GI will achieve same results on the same timeframe (21). A comment indicated disapproval of shortening Potomac Tunnel at expense of reduced performance or extended schedule (22).

3.8.3 A commenter expressed concern on DC Water's lack of experience with GI on this scale and on uncertainties involved in using Green Infrastructure to curb sewage discharges. Commenter indicated support if same or greater reductions in volume and CSO occurrence could be assured by GI. (13, 321)

3.8.4 Two commenters demanded that DC Water demonstrate same or greater reductions in the volume and incidence of CSOs compared to a tunnel. (24, 466)

3.8.5 A commenter indicated that the new plan avoids taking steps needed to cure the problem and quotes, as noted in an Appendix, that DC admits that it cannot meet EPA mandated pollution limits for the Potomac and Chesapeake. Green Infrastructure will not provide anywhere near the control provided by gray Infrastructure. (29)

Response:
GI technology has made progress over the years, as indicated by widespread use of it throughout the country. DC Water predicts that the hybrid Green and gray controls identified in this modification will achieve an equivalent degree of CSO reduction compared to the gray controls in the LTCP. Tables 3-2 and 3-5 of the Report present the predicted number of million gallons per average year of CSO remaining if the GI plan is implemented. These findings are based on:

- A review of the performance, cost and benefits of GI in the District, the United States and abroad
- An extensive and detailed analysis using a state of the art, calibrated collection system model (Danish Hydraulic Institute MikeUrban Model). This is the same model used to develop the LTCP. The model was used to predict the performance of both gray and GI controls to reduce CSOs
- DC Water's experience having invested more than $14 million in planning, analysis, design, and construction of GI in the District. These projects have included tree planting, bioretention at Irving Street and Green roofs at DC Water facilities. These projects have allowed DC Water to gain practical experience in constructing GI in the District.

Based on the foregoing, DC Water has performed the analysis and due diligence to be able to make the predictions that the hybrid Green and gray controls identified in this modification will achieve an equivalent degree of CSO reduction compared to the gray controls in the LTCP.

In response to public comments, DC Water has revised its LTCP modification to include an interim step after the first GI project in each receiving water. After the first project in each receiving water, DC Water will evaluate the effectiveness and practicality of GI. If GI is determined to be impracticable, DC Water will construct the gray controls in the LTCP Modification; otherwise DC Water will complete the construction of GI. As required by its NPDES Permit, DC Water will perform post-construction monitoring after implementation to determine whether the controls are performing as expected.

3.9 A commenter requested an estimate of the overflows into Potomac from the three pipes that will not be separated due to the GI proposal. (17)

Response:
The predicted overflows for these outfalls after implementation of the GI controls in these sewersheds are shown in the following table.

Outfall	Predicted Overflow Volume After LTCP (implementation of GI), mg/average year)
027	0.5
028	0.4
029	0.8

3.10 A commenter requested that DC Water provide the effectiveness of gray Infrastructure alone for CSOs, in billions of gallons, and its cost as compared to Green Infrastructure.(30)

Response:
The consent decree requires DC Water to construct gray controls for the Potomac River and Rock Creek. DC Water projects that the hybrid Green and gray controls identified in this modification will achieve an equivalent degree of CSO reduction compared to the gray controls in the LTCP. In terms of cost, DC Water anticipates that the hybrid Green and gray controls identified in this modification are approximately equal in cost to the gray controls in the LTCP.

3.11 A commenter requested the average number of overflows into the Anacostia River and questioned where to find the real-time information online regarding CSO overflows, if possible. (407)

Response:
The CSO overflow volume and number of events per average year to the Anacostia River after replacement of the inflatable dams and rehabilitation of the pumping stations is as follows:

Parameter	Anacostia River
CSO Overflow Volume (million gallons/average year)	1,282
# of Overflow Events (per average year)	73

The magnitude, frequency and duration of overflows to all three receiving waters during each, month, quarter and year is predicted based on actual rainfall data using a sophisticated model developed by DC Water. This data is posted on DC Water's website every quarter. (See the following website:
http://www.dcwater.com/wastewater_collection/css/when_do_csos_occur.cfm)
Currently there is no real time or measurement of actual overflows occurring.

3.12 A commenter indicated that any modified LTCP should include options for eliminating foreseeable overflows under average and wet design-years. (468)

Response:
The purpose of the LTCP modification was not to re-evaluate the appropriate degree of CSO control. This was established when the LTCP was finalized.

In accordance with the CSO Policy, DC Water used an average hydrologic year as a basis for assessing CSO control. Except sewer separation, no CSO control strategy could completely eliminate CSOs. Complete separation would actually have a negative impact on water quality since the separated system would convey storm water runoff to the nearest water body in comparison to the combined system which conveys storm flows to

Blue Plains Advanced Wastewater Treatment Plant most of the time. Every CSO LTCP balances cost with degree of CSO control or capture and DC Water's LTCP reduces CSO discharge volume by 96% overall and 98% to the Anacostia which represents one of the highest capture rates of any big City in the nation.

4. COMMENTS ON RATES/ FINANCIAL

4.1 Comments applicable to the ratepayers affordability for Green Infrastructure

4.1.1 Several commenters expressed concern about affordability for ratepayers. (41, 356, 431, 437, 440). A commenter urged DC Water to redouble its effort to find ways of funding the LTCP that are equitable and affordable for financially vulnerable households, and at the same time does not sacrifice water quality and public health risks. (440).

4.1.2 A commenter expressed concern that DC Water has yet to develop a plan to equitably and affordably finance needed improvements or to mitigate and spread out potential water rate increases. (41).

4.1.3 A commenter suggested evaluating financing mechanisms to avoid a seven year delay. (378)

Response:
DC Water is acutely aware of the heavy financial burden bourne by District rate payers to implement the DC Clean Rivers project and has taken steps to both mitigate and spread out water rate increases. Unfortunately this is not discretionary spending by DC Water but is mandated to comply with the Clean Water Act. To mitigate the impact of this project on DC residents, DC Water has actively sought assistance from the Federal Government and has received over $196 Million in funding to date for the Clean Rivers Project. Even though the cost of the project is borne mostly by District rate payers, the funding mechanism has been the issuance of 30 year bonds which spreads out the financing significantly longer than the duration of the project.

DC Water has also taken measures to ensure that the financial burden is equitable. The funding for the DC Clean Rivers project is shown separately on the customer's monthly bill and is based on an impervious area charge (IAC). The IAC is based on the amount of impervious area associated with each customer's property. In that way, the customer contributes to the DC Clean Rivers in proportion to the amount of impervious area on their property and not in proportion to their water consumption.

It is important to note that the public has the right to let the regulatory agencies know their concerns regarding affordability.

4.1.4 A commenter questioned if rates will decrease when LTCP modification goes through (435). A commenter requested that public should be made aware if there is an anticipated requirement to increase the residential sewer and impervious area charges for GI. (438)

Response:
The LTCP modification for GI will allow slowing the rate of increase of rates for the Clean Rivers Project when compared to the consent decree. However, rates will continue to increase in order to fund both the Green and gray controls.

DC Water holds public meetings and a public hearing to explain proposed changes to rates each year. This information is available on DC Water's web site at: http://www.dcwater.com/customercare/rates.cfm.

4.1.5 A commenter indicated that EPA has reset DC Water's priorities over and over again since 2002, crowding out the most vital interests of people who live here in favor of other Clean Water Act interests. Commenter urged DC Water and DC Government to ask EPA, U.S. Department of Justice and District Court to take a fresh, hard look at the LTCP in the interests of environmental justice and sound public policy in our democracy. (437)

Response:
Regulatory driven programs associated with the Clean Water Act such as the Clean Rivers Project and the Total Nitrogen/Wet Weather Plan impose a significant cost burden on ratepayers. The costs associated with these programs reduce the amount of investment that DC Water can make in other areas such as water and sewer rehabilitation.

The Recommended LTCP Modification for GI will slow the rate of rise of rates by spreading costs over a longer period. This will allow somewhat more investment in other priorities. However, the regulatory driven projects still impose a significant burden on rate-payers and reduce DC Water's discretion in deciding where funds should be invested. We have conveyed this comment to our regulatory agencies and urge them to act reasonably when implementing regulations.

Public is encouraged to convey these concerns to regulatory agencies as well as elected representatives.

4.1.6 A commenter requested a revised financial analysis incorporating benefits of alternative practices and water reuse. (439)

Response:
The mix of GI practices and locations are conceptual at this stage. The exact mix and configuration of practices will be determined during preliminary

design and will depend on many factors such as cost performance and site constraints. We expect that this evaluation will include evaluation of water reuse, rain water harvesting and other practices. It is unlikely that these alternative practices will impact the cost of GI to such a degree that financial predictions are affected.

4.1.7 Two commenters requested information on how DC Water is helping to mitigate costs on bills for renters who can't control the impervious areas that their landlords install. (435, 442)

Response:
DC Water has programs such as the Clean Rivers Impervious Area Charge Incentive Program which offer reductions in the impervious area charge for storm water management BMPs and reductions in impervious area on property. However, these programs are geared toward the owner of water account. DC Water encourages renters to discuss these incentives with the property owner and to urge them to implement measures to reduce storm water runoff.

4.2 A commenter questioned why they should pay for Anacostia tunnel, when they are doing Green Infrastructure in their neighborhood. (436)

Response:
The purpose of the Clean Rivers Project is to control CSOs and improve the water quality in the receiving waters. The improvement in water quality is a common good, that all benefit from regardless of whether a person resides in the CSO area or not or the particular technology used to achieve CSO reduction. As a result, all DC rate-payers pay for the Clean Rivers Project through the Impervious Area Charge (IAC) which apportions the cost of the project in proportion to the impervious area specific to a property.

4.3 A commenter suggested granting at least $30 million funding for GI projects in Wards 7 and 8 along the Anacostia River, under DDOE's administration, to address the inequity of charging all DC Water ratepayers for the ancillary benefits enjoyed by only NW portion of the city due to Green Infrastructure. Commenter added that funding for this could be raised by alternative financing mechanisms and by consistent with the Sustainable DC Plan timeline and/ or by offering on-bill financing rebates and reductions to ratepayers, in the SE portion of the city, to encourage the installation of GI on their residential properties and promote substantial enrollment. (379)

Response:
Since the Anacostia River is significantly impaired, projects to control CSOs to the Anacostia River are early in the schedule and also are the largest projects currently underway. The residents along the Anacostia will enjoy benefits to water quality much earlier than residents in other areas. Because the Potomac and Rock Creek projects are

later in the schedule there was an opportunity to explore the potential of reducing the scale of the grey Infrastructure projects that are required and implement Green Infrastructure instead. That analysis resulted in LTCP Modification for GI. Because the massive project that is underway along the Anacostia will achieve an average CSO reduction of 98% which is one the highest in the nation, it is not possible to spend additional funds on CSO control in the Anacostia watershed without added burden on ratepayers that are already significantly affected by utility costs.

4.4 A commenter requested a present worth analysis comparison for the current vs. proposed plan. (430). A commentator questioned if present worth analysis was performed based on the statement in Appendix D- "This analysis uses an EIA approach rather than a benefit-cost analysis (BCA)". (432) A commenter requested an operating plan for the tunnels, in regards to water storage in tunnel versus GI, detailing operating costs with regard to pumping water from the tunnels to the WTP and the energy requirement for treatment of water per unit. Commenter indicated to base the costs on average annual capture per tunnel. (434)

Response:
Based on the level of project definition and accuracy currently available, DC Water estimates that the cost of Green versus gray are approximately equivalent. More information will be available after facility planning is conducted and after the first GI projects in each receiving water are constructed.

4.5 Comments applicable to the financing alternatives for Green Infrastructure

4.5.1 A commenter expressed his concern that ratepayers of Washington DC should not be alone in paying for the solution. Commenter requested the use of innovative techniques to engage Federal Government, Maryland, and Virginia as well as the District Department of Transportation. (370)

Response:
DC Water has an active governmental relations program which reaches out to the federal government regularly and has been successful in procuring more than $196M in federal grants for the DC Clean Rivers project. The Virginia and Maryland suburban users are part of the Inter-municipal Agreement (IMA) between DC Water and the suburban users whereby the wholesale customers are contributing 7.1% to the DC Clean Rivers Project. The percentage is based an analysis of the impact of suburban flows on CSOs in the District.

The DC Department of Transportation (DDOT) controls a large proportion of the impervious area of the District. Therefore, DC Water and DDOT will continue to coordinate closely on GI projects in the District. DC Water will look for opportunities to construct GI as part of District projects in order to realize economies of scale associated with other projects in the transportation right of way.

4.5.2 A commenter suggested identifying new revenue sources to pay for GI by revisiting 1) PILOT payments to the DC CFO 2) exemption of suburban customers from any part of such PILOT payments 3) exemption of impervious surfaces in the transportation Right of Way from any Clean Rivers IAC charges and 4) a DC retail rate structure which sets non-residential (i.e., commercial and federal government) unit rates at no higher level than residential and multi-family rates. Commenter indicated that exploring different revenue sources, instead of an arbitrary cap like $60 million for Piney Branch, will relieve low-income households some of the growing burdens. (384)

Response:
For item No. 1 and 2, the payment in lieu of taxes (PILOT) is a charge imposed by the District. This charge is paid by ratepayers. Reducing the PILOT would make DC Water's rates more affordable, but would require the District to increase taxes or fees on ratepayers to make up for the loss of the PILOT charge. The PILOT is therefore not a new funding source, but is a transfer of funds from the ratepayers to the same ratepayers.

Regarding item 3, the IAC charge is not assessed against the transportation right of way.

In the past, DC Water has introduced initiatives to ease the burden on DC Water rate payers and make them more equitable. These include the Customer Assistance Programs (CAP) and the introduction of the IAC which apportions more of the cost to customers with larger impervious areas. DC Water is currently exploring other rate structures to make water and sewer rated more affordable and equitable.

4.5.3 A commenter suggested (a) securing additional funding from the Virginia and Maryland suburbs that send sewage to Blue Plains (b) securing more federal funding (c) expanding the Customer Assistance Program to identify tenants of multi-family buildings that do not receive bills from DC Water but may be directly impacted by rising bills and (d) adopting revised rate structures that allocate costs more efficiently and equitably among various customer sectors. (440)

Response:
(a) Lengthy negotiations with the suburban users resulted in an Inter-municipal Agreement (IMA) whereby the suburban users agreed to pay 7.1% of the cost of the DC Clean Rivers Project. (b) Efforts to secure additional

federal funds will continue. So far more than $196M has been appropriated. (c) DC Water's customer is the account holder (d) Introduction of the impervious area charge is intended for this purpose. It apportions a higher percentage of the cost to customer with more impervious area because run off from impervious area contributes by far the most storm water to the combined sewer system which causes CSOs to occur.

5. COMMENTS ON IMPLEMENTABILITY

5.1 A commenter requested that DC Water expand on negative impacts of the proposed plan in the Executive Summary. (320)

Response:
All projects have temporary construction impacts such as noise, dust and traffic impacts. Because they are smaller projects, the GI project impacts are anticipated to be less impact and of a shorter duration than the gray CSO controls. Potential implementation challenges of GI are summarized on page ES-8 which addresses why additional time is needed to implement the recommended plan.

5.2 A commenter indicated that the runoff reduction can only be achieved if the building permit office could discourage home owners from adding impervious areas to their properties.(322)

Response:
DC Water is supportive of regulatory measures that reduce impervious area. The Impervious Area Rate Charge (IAC) charges customers based on the impervious area. This provides a motivation to reduce impervious area. Lastly, the District's Municipal Separate Storm Sewer System (MS4) regulations require the control of storm water runoff for land disturbing activities above a certain threshold. These regulations are enforced as part of building and land disturbance permit applications and will assist in runoff reductions since they apply to both the combined and separate storm water areas.

5.3 A commenter mentioned that Georgetown residents have experienced many months of disruption due to a recent reconstruction of O and P streets at a cost of $ 12 million dollars. Commenter warned that willingness of residents west of Georgetown will depend on demonstration of pervious pavement effectiveness. (323)

Response:
DC Water has already invested more than $14 million in planning, analysis, design, and construction of GI in the District, which includes pervious paving. Multiple GI strategies could be implemented in Georgetown. DC Water will work with residents, ANCs and the District and the Old Georgetown Board to identify strategies that fit within the historic fabric of Georgetown and minimize disruption to the degree possible.

5.4 A commenter expressed his concern about the combined sewers between Georgetown University and Wisconsin Ave being too old. (324). Two commenters indicated that there is a risk of tearing up newly installed Green Infrastructure to replace the failing combined sewers in a few short years. (324, 344)

Response:
In most cases, aging sewers are rehabilitated through trenchless methods that minimize the use of open-cut excavations that disturb streets and sidewalks. Where opportunities are present to perform sewer rehabilitation work in coordination with GI and other streetscape construction, DC Water will work to execute projects in a way that avoids the need to revisit areas multiple times for water, sewer and GI work to the degree this is feasible. We will try to minimize the length of construction time and reduce disruption of the neighborhood to the extent practicable.

5.5 Comments applicable to the implementability of Green Infrastructure in Georgetown

5.5.1 A commenter indicated that siting a rain barrel in front of building, or a side yard, could be disapproved by Old Georgetown Board, and Commission of Fine Arts due to the historical character of Georgetown.(325)

5.5.2 A commenter expressed uncertainty on using a brick as a pervious surface based on its permeability. Commenter indicated that all Georgetown sidewalks are brick and replacement of brick sidewalks in residential areas with another type of pavement could be disapproved by the Old Georgetown Board and the U. S. Commission on Fine Arts due to the historical character of Georgetown.(326)

5.5.3 A commenter indicated that the use of pervious pavement will require DDOT to identify steps to avoid dangerous conditions on Georgetown streets and sidewalks during winters. Commenter expressed that the proposed plan should include the directions from DC Attorney General on the property owner's liability for leaving a sidewalk covered with ice or snow due to prohibitions on using melting agents and abrasives.(327)

5.5.4 A commenter indicated that proposal must include a more rigorous and detailed planning analysis to provide greater confidence about expected outcomes. Commenter suggested developing more comprehensive plans for its installation, maintenance and for monitoring the impacts. (395)

5.5.5 A commenter questioned the proposed GI system for replacing impervious parking and sidewalk surfaces. (342)

5.5.6 A commenter questioned if more rain barrels could be used and disconnect downspouts. (345)

5.5.7 A commenter indicated the need for underdrains due to the presence of impervious clay as the prevalent subsoil in Georgetown.(350)

5.5.8 Commenter questioned how flexible porous paving compares with porous paving and requested the reason for its omittence in addition to porous rubber (such as Flexi®-Pave used by DDOT and federal government) from GI technologies. (352)

5.5.9 A commenter suggested that slowing traffic and using porous cobblestone as pervious pavement material, will not only help absorbing water but also improve livability on the historic places around drainage areas CSO 025 and 026.(357)

Response:
Multiple GI strategies could be implemented in Georgetown, and the selected strategies must respect the historic aesthetic in order to be permitted through the Old Georgetown Board and Commission of Fine Arts. DC Water will work with neighborhood groups and the approval agencies to implement techniques and practices that are complementary and integrated with the historic fabric of the neighborhood. As part of development of each project, DC Water will consult with neighborhood groups, the community and interested parties to develop designs that are appropriate for each neighborhood.

In response to public comments, DC Water has revised its LTCP modification to include an interim step after the first GI project in each receiving water. After the first project in each receiving water, DC Water will evaluate the effectiveness and practicality of GI. If GI is determined to be impracticable, DC Water will construct the gray controls in the LTCP Modification; otherwise DC Water will complete the construction of GI. As required by its NPDES Permit, DC Water will perform post-construction monitoring after implementation to determine whether the controls are performing as expected.

5.6 A commenter expressed concern that improper modification of LTCP could cause permanent severe damage to Georgetown Waterfront Park and the area around K and Water Streets NW. (328)

Response:
The Potomac Tunnel, as described in the original Long Term Control Plan, would require large sites for the construction of near-surface facilities in the vicinity of Georgetown Waterfront Park. If the LTCP Consent Decree is not modified and the tunnel project were to be constructed through Georgetown as originally described, DC Water would prepare an extensive public outreach effort as part of the Environmental Impact Statement process in order to fully define and mitigate project impacts. Under the GI Plan, the Potomac Tunnel would be terminated at the eastern edge of Georgetown and would not have a significant impact on Georgetown Waterfront Park.

5.7 Multiple commenters expressed concern about potential disruption caused by tunneling, particularly in the Georgetown and National Park areas. (157, 236, 278)

Response: The Proposed Draft LTCP Modification included a 21 mg, approximately 4500 foot long Potomac Tunnel to capture CSO 020-024, a new pumping station to empty the tunnel and the addition of 75 mgd of capacity at the Tunnel Dewatering Pumping Station (TDPS) and Enhanced Clarification Facility (ECF) at Blue Plains. As part of the response to comments, DC Water has evaluated an approximately 23,000 foot long gravity Potomac Tunnel that would run from the Potomac River CSOs to connect to the Blue Plains Tunnel at Joint Base Anacostia-Bolling (Bolling Air Force Base). This would eliminate the need for tunnel dewatering pumping station for the Potomac Tunnel. This is advantageous because of the complexity of the station, the difficulty in siting such a facility in the vicinity of the National Mall area, the need for a permanent building associated with the pumping station. Because of the elimination of the pumping station, the gravity tunnel provides substantially less disruption both during and after construction.

The gravity Potomac Tunnel also allows interconnecting the storage volumes of the Potomac and Anacostia tunnels into one tunnel system, allowing any CSO on either water body access to the entire storage volume of both tunnels. DC Water's analyses have demonstrated that a 30 million gallon gravity Potomac Tunnel for CSO 020-024 connected to the Blue Plains Tunnel provides a degree of CSO control equal to the LTCP without the need to expand the Blue Plains TDPS and ECF. Because the gravity tunnel offers greater reliability and avoids a new pumping station, the gravity tunnel is preferred and has been added to the LTCP modification.

6. COMMENTS ON SCHEDULE

6.1 A commenter requested monitoring data of fecal coliform and Escherichia coli values in Potomac River to be able to assess the potential effect on public health from either an acceleration or delay in abating overflows. (15).

Response:
DC Water undertook extensive characterization of the receiving waters and sewer system in developing the CSO Long Term Control Plan which is the basis of the controls in the original Consent Decree. This characterization included conducting a monitoring and modeling program using the data collected. The biological monitoring parameters studied included E. Coli and fecal coliform levels. Further modeling has been conducted to investigate the effectiveness of the modified consent decree controls in the current proposal. This investigation determined that the results will be equivalent. In addition once the Consent Decree work is completed it will be followed by a period of post construction monitoring which includes an extensive amount of sampling and testing both at outfalls and in the receiving waters at regular intervals and during storms to assess the effectiveness of the controls. Appendix C of the Long Term Control Plan has the predicted bacteria concentrations before implementation of the LTCP and the predicted concentration after implementation of the plan. See the link below.

https://www.dcwater.com/workzones/projects/pdfs/ltcp/Complete%20LTCP%20For%20CD.pdf

6.2 A commenter suggested investigating raising weir level earlier.(443)

Response:
Modification of the diversion structures for CSO 027, 028 and 029 cannot be performed until the Potomac Tunnel is in service. This is because the tunnel will lower the water surface elevation in the existing Upper Potomac Interceptor Relief Sewer to allow diversion of more flow to the interceptor. If the diversion structures were modified prior to placing the tunnel in service, the capacity of the existing Upper Potomac Interceptor Relief Sewer would be exceeded, potentially causing flooding.

The weir structure at Piney Branch can be raised earlier. This will reduce overflows to Piney Branch but will increase overflows to the Potomac River until the Potomac Tunnel is in service. Given that the Potomac River has much more assimilative capacity than Piney Branch or Rock Creek, this is a reasonable trade-off to make. As a result, DC Water has revised the LTCP modification to raise the weir height of the CSO 049 control structure in Piney Branch by 2020.

6.3 Comments applicable to the proposed schedule extension for Green Infrastructure

6.3.1 Several commenters indicated their disapproval on the schedule extension. (447, 453, 454, 458, 459, 464, 471).

6.3.2 A commenter indicated support for GI, but concerned that the current situation in the District may require some portions of the previously approved tunnel/storage system in order to resolve the storm water/sewage management concern expeditiously. (445)

6.3.3 One commenter indicated that the timeline is too extended and requested to shorten by at least 10 years as climate change, citizen health, and economic benefits demand accelerated action. Commenter indicated that Rock Creek tunnel should be completed by 2022 and the Potomac tunnel by 2025. (450)

6.3.4 A commenter questioned if the basis for schedule extension is the community acceptance of large scale GI. Commenter suggested overcoming this issue with public education and outreach. (455)

6.3.5 A commenter indicated that it is not the appropriate strategy to address affordability issues relating to all of D.C. Water’s programs. (471)

6.3.6 A commenter indicated that no clear reason was provided on why the good GI plan has to be combined with bad extension and expressed eagerness to see the end of sewage polluting the rivers. (458)

6.3.7 A commenter indicated their lack of confidence in supporting the schedule revision. (465)

6.3.8 A commenter indicated the existing LTCP schedule can be hit with proper planning and alternative financing can alleviate the financial burden on ratepayers. (464)

6.3.9 Two commenters indicated that current proposal does not adequately justify the requested delay in compliance deadlines and that DC Water seeks the extension on affordability reasons without actually analyzing the affordability options. (462, 471). A commenter recommended exploring options for addressing rate increase first and indicated that seven additional years of pollution should be considered a last resort for schedule extension. (462)

Response:
Extra time in the schedule is needed compared to the original plan due to a new requirement to complete an Environmental Impact Statement for the Potomac Tunnel, in view of the increased development in recent years along the Potomac River waterfront, and to mitigate the financial impacts on rate payers. Additional time also affords an adaptive management approach to GI implementation to ensure the performance of GI projects is optimized. Adaptive management means early GI projects will be monitored and assessed so that later projects are more practical and effective. In response to comments, DC Water has evaluated the engineering, fiscal and practical issues and has modified the schedule to complete GI projects by 2030 (two years earlier than originally proposed).

Extending the schedule is not intended as a standalone strategy to address affordability issues, however, affordability is a benefit of the recommended GI Plan.

6.4 A commenter suggested sticking to the tunnel and completing it by 2025, as it may cost more to re-activate the current plan due to the failure of Green initiatives. Commenter suggested continuing promoting Green education, and incentivizing residents and businesses to make the City healthy (449). A commenter recommended that sooner the GI gets implemented, better it is to know if it will achieve the desired results or not. (451)

Response:
DC Water's analyses indicate that the green/gray hybrid controls will provide equivalent performance to the gray controls in the LTCP. In addition, the Green control offer other ancillary benefits to the District. In response to public comments, DC Water has revised its LTCP modification to include an interim step after the first GI project in each receiving water. After the first project in each receiving water, DC Water will evaluate the effectiveness and practicality of GI. If GI is determined to be impracticable, DC Water will construct the gray controls in the LTCP Modification; otherwise DC Water will complete the construction of GI.

6.5 A commenter questioned when DC Water expects to reach a decision on GI. (446)

Response:
The public comment period on DC Water's Proposed Draft LTCP Modification closed on April 14, 2014. Revisions to the plan that incorporate public comments will be presented to EPA after responding to comments. EPA must approve the selected approach and the consent decree must be modified prior to implementing GI. The schedule for determining whether or not to proceed with GI depends on many factors beyond DC Water's control and is difficult to predict. However, we are hopeful to have the matter resolved in late 2014 or early 2015.

6.6 A commenter suggested prioritizing near term projects to protect public health and the environment, particularly around areas of known public contact such as the boat houses, along the Potomac River and Georgetown Waterfront. Commenter indicated deadlines must only be extended if site specific performance criteria are instituted to ensure reductions are gained. (457) A commenter suggested investigating separating CSO 025/026 earlier. (444) A commenter recommended separating Georgetown CSOs concurrent with tunnel construction and not at the end of the process. (460)

Response:
Projects are prioritized in the GI Plan to deliver CSO reductions as soon as possible and in consideration of permitting requirements and financial impacts to rate payers. In response to comments, the schedule for the separation of sewers in CSOs 025 and 026 has been moved up to completion in 2023 (9 years earlier than originally proposed).

6.7 A commenter demanded that DC Water must pause to assess and quantify all potential human health risks associated with the proposed seven-year delay before advancing this proposal (463). A commenter requested to quantify and disclose the health risk associated with the proposed delay. (471) A commenter indicated that the proposed plan lacks analysis of public health effects due to the delayed CSO reductions on D.C.'s most heavily used aquatic recreation areas. Commenter added that lack of DDOE's active role in preparing this plan to tackle the City's major source of water pollution, will put the health of District residents at risk. (41)

Response:
DDOE was extensively consulted as part of development of this modification and the District supports the modification of the LTCP to include GI.

Primary contact recreation in District waters is prohibited because the waters do not meet water quality standards under some conditions. CSOs are one of the causes of the waters not meeting standards. However, stormwater and upstream pollution sources from Maryland, Virginia and other states in the Potomac watersheds also contribute significant pollution sources. DC Water is not aware of illnesses or deleterious public health effects that are a direct result of CSO discharges. That said, DC Water agrees that CSO is one of the pollution sources that must be controlled and that is why the LTCP is aggressively being implemented.

While the LTCP Modification for GI does propose to extend the schedule for CSO control, it offers the advantages of achieving CSO as GI is brought on line. This will achieve CSO reduction much earlier than all-gray CSO controls which only provide a benefit when all facilities are completed and on-line.

6.8 A commenter indicated that the time needed to optimize Green Infrastructure performance has been offered as one of the reasons for schedule extension. Commenter questioned what does "optimizing performance" mean and how would it be accomplished. Commenter questioned if optimizing performance means perfecting the design of individual facilities based on lessons learnt and suggested that even from one's own experience, there is nothing to suggest that the lessons will be so profound as- to rewrite the findings of the last several decades, or to alter the specification now embodied in national and regional design manuals available from all over the country, or to require multiple additional years to digest. (456)

Response:
Optimizing GI performance is one of the important outcomes of an adaptive management approach which primarily relates to the process of monitoring the performance of GI practices after construction to ensure that they are delivering the intended runoff reductions. DC Water believes that important lessons from post-construction monitoring will influence both the design and construction of subsequent projects and significantly improve cost and performance efficiency of this very large-scale GI implementation. A more significant challenge relating to schedule could be the need to identify and select GI technologies suitable for urbanized and historic neighborhoods, address the unique planning issues, develop third-party agreements related to construction and maintenance, and to perform the necessary public outreach to support successful implementation.

In response to comments, DC Water's recommended plan includes completing GI projects by 2030 (two years earlier than originally proposed).

6.9 A commenter indicated that the end dates are so far down the line that costs will be doubled or tripled by then and the budget will be inadequate. (452)

Response:
Financial model assumptions include the project cost factors related to time such as escalation due to inflation, interest rates on debt and cost of living adjustment. These financial model assumptions are used in the affordability assessment of DC Water's Capital Improvement Plan. This information is included in Appendix E of the Report. Extending the schedule for GI Plan actually reduces the financial burden on ratepayers compared to the original LTCP. However, some change in the projected costs is not ruled out because of the inherent uncertainty in any predictions.

7. COMMENTS ON MAINTENANCE

7.1 A commenter wanted to know the long term funding for GI (389). A commenter requested more explanation on the costs associated with operations and maintenance of the tunnel. (419).

Response:
The design and construction of the GI projects will be funded from the DC Clean Rivers budget which is allocated for CSO control. This funding comes mostly from DC rate payers via the impervious are rate charge and some funding from Federal Appropriations ($196 M so far). The operation and maintenance of the GI projects would be funded through DC Water's operating budget funded by rate payers.

7.2 Comments applicable to the life cycle costs for operation and maintenance of Green Infrastructure

7.2.1 Two commenters asked who will perform O & M (41, 388). A commenter wanted to know if the proposed plan includes 10 year life cycle costs for O and M (387).A commenter expressed concern over the life cycle costs of GI. (3)

Response:
DC Water will perform O&M or will arrange for others to perform it. DC Water will be ultimately responsible that the O&M is performed adequately. Project cost information described in the GI Plan represents capital costs only. Operations and maintenance costs will become part of DC Water's operating budget as GI projects are completed.

7.2.2 A commenter questioned the rationale behind using a 10 year life cycle for O & M in Appendix D. Commenter questioned the basis for quoting O&M costs of GI to be only half of the tunnel in the new plan, while original LTCP evaluated GI to be cost prohibitive due to high O&M even though the capital costs were lower than the tunnel. (433)

Response:
Appendix D of the LTCP Modification for Green Infrastructure is an economic impact analysis to evaluate the relative impact of alternative CSO control strategies on the local economy. This is primarily an analysis of potential job creation, and does not attempt to estimate project costs. A 10-year spending period was used to evaluate the relative impact on jobs that include both construction jobs and maintenance jobs.

7.3 A commenter indicated his past experiences were that rain catcher systems will either break after a season or are just too much trouble to use. The commenter requested analyses comparing and contrasting the pros and cons of both the current plan and the proposal from the perspective of maintenance.(390)

Response:
Maintenance requirements for GI practices are discussed in Appendix I of the LTCP Modification for Green Infrastructure. Maintenance costs of both tunnels and GI practices are discussed in Appendix D.

7.4 Comments applicable to the long term maintenance and incentives for Green Infrastructure

7.4.1 Three commenters requested that DC Water provide a commitment for long term maintenance. (26, 386, 389). A commenter indicated that any modified consent decree must include a detailed plan for providing operation and maintenance on a continuous basis for all Green Infrastructure installations. (470)

7.4.2 Two commenters requested that DC Water's document its commitment to protecting GI long term in both public and private space. (333, 334). A commenter questioned how much GI will need to be implemented on public vs. private property. (339)

7.4.3 Two commenters questioned if GI will require covenants and when does DC Water plan on starting them. (335, 336)

7.4.4 A commenter supported adding incentives for private property in targeted areas. (337)

7.4.5 Two commenters supported providing stronger incentives for reducing impervious area. (338, 339)

7.4.6 A commenter suggested to coordinate with DC government on ways to support (through training and incentives) private clients for supportive actions such as Green roofs and rain gardens on private property.(348)

7.4.7 A commenter requested to know the lands where the GI will be added to and if it requires buy in from land owners. (358)

Response:
DC Water will perform O&M or will arrange for others to perform it. DC Water will be ultimately responsible that the O&M is performed adequately.

The GI Plan includes GI practices constructed in both public and privately-owned spaces. DC Water will consider incentives for work in private space, as well as the need for regulatory measures to reduce impervious area.

Opportunities to strengthen long term maintenance commitments for private property through the creation of covenants and other regulatory tools will be explored. Maintenance agreements with District agencies will be considered to define DC Water's responsibility to maintain GI projects constructed in the public space.

Additionally, DC Water is actively exploring partnerships with non-profits and District agencies to develop and implement training programs for Green jobs.

7.4.8 A commenter asserted the need for a continuous maintenance plan as changes in property ownership may lead to non-maintenance of Green roofs, or rain gardens and put the environment back in jeopardy.(391)

Response:
Changes in property ownership present a unique maintenance concern which will have to be addressed in the individual agreements created to govern the relationship with property owners for GI projects that are constructed on private property. Opportunities to strengthen long term maintenance commitments for private property through the creation of covenants and other regulatory tools will be explored.

7.4.9 A commenter indicated the need for regular dewatering and occasional maintenance of rain gardens. He quoted that the water level measurements taken by MWCOG indicated that rain barrels remained 60% full, on an average, which greatly reduced their overall effectiveness. (392) Three comments indicated that rain barrels could become breeding sites for mosquitoes which could lead to threat of serious disease. (382, 393, 394). Two comments expressed that the community willingness to install rain barrels will depend on DC Department of Health's risk assessment and identification of practical actions to eliminate them. Comments suggested that disconnection of rain barrels from downspouts in winter will lead to sending roof runoff into the combined sewer again or onto the sidewalk where it may potentially ice over. (393, 394)

Response:
If a rain barrel program is implemented as part of the GI Plan, the available capacity and functionality would need to be downgraded when projecting effectiveness to account for available storage capacity and maintenance issues. Any rain barrel or downspout disconnection program will need to consider where water flows when the rain barrel is full to avoid flooding neighbor's properties or creating nuisance or safety conditions.

7.5 A commenter expressed concerns on operations and maintenance of the tunnel resulting additional discharges that may continue for months or years due to lack of a backup system for the tunnels. (419)

Response:

It is anticipated that the tunnel will require infrequent inspection and maintenance. To the degree possible, this will be scheduled for dry weather conditions where feasible. If the tunnel is out of service for maintenance when it rains, combined sewer overflow will be discharged from the existing CSO outfalls to prevent flooding or sewage backups. It is not practical or affordable to construct a complete backup tunnel system since the tunnel is not anticipated to be out of service for extended periods for inspection or maintenance and because much of this activity can be scheduled for dry weather conditions.

8. COMMENTS ON IMPLEMENTATION STRATEGIES

8.1 Comments applicable to recommending tunnels supported by Green Infrastructure

8.1.1 Two commenters indicated that Green Infrastructure should supplement and not substitute the tunnels. (29, 330)

Response:
DC Ratepayers cannot afford to construct both GI and the tunnels identified in the LTCP to address the same CSO outfalls. As part of the original LTCP, DC Water evaluated downsizing the tunnels using GI. Because of economies of scale, the reduction in tunnel cost provided by GI was not adequate to justify constructing both GI and tunnels for the same CSO sewersheds. As a result, DC Water's plan is to apply both Green and gray technologies in areas where each technology will be successful. This will result in a CSO plan that provides the degree of CSO control required, maximizes community benefits and manages cost for ratepayers.

8.1.2 A commenter quoted that paragraph 43 of NPDES permit states "Such LID projects shall constitute additional work which WASA agrees to perform in addition to the injunctive relief set forth in Section VI". (426)

Response:
The NPDES Permit does not address requirements to construct LID. Section IX of the Long Term Control Plan Consent Decree (including paragraph 43) requires DC Water to invest $3M of LID at DC Water facilities. This work has been completed. The modification of the Consent Decree would replace the Rock Creek Tunnel to control Piney Branch CSO 049 in Rock Creek with GI and change the Potomac Tunnel by constructing GI for CSO 027, 028 and 029 in the Potomac sewershed.

8.2 A commenter requested investigating options to attenuate flow at CSO apron. (332)

Response:
This refers to reducing flows or the flow velocity at the Piney Branch CSO outfall prior to discharge into Piney Branch stream. DC Water's modification of the LTCP provides for treating 365 impervious acres in the Piney Branch sewershed with GI. This will

reduce CSO overflows and will also reduce peak flow rates discharged to Piney Branch for rain events that exceed the capacity of the CSO controls. Stream improvements beyond control of CSOs are beyond the scope of the LTCP.

8.3 A commenter indicated the need for a better approach to charge for sewerage services since the costs include treatment for the rainwater runoff which is larger proportion of waste water. Commenter suggested the possibility of basing the charges on impermeable area to incentivize property owners for conversion of roofs, driveways etc. to Green roofs, permeable paving and/or rainwater harvesting for uses such as flushing toilets and garden irrigation. (340)

Response:
In 2013, DC Water implemented changes to the impervious area charge (IAC) that incorporates incentives for GI. The IAC is based on the amount of impervious area associated with each customer's property. In that way, the customer contributes to the DC Clean Rivers in proportion to the amount of impervious area on their property and not in proportion to their water consumption. DC Water will continue to examine opportunities for improving the effectiveness of the IAC.

8.4 Commenter suggested considering techniques like shallow reconstruction of roads above utilities; lining the excavation with an impermeable membrane protected by geotextile forming a detention tank; using porous asphalt or permeable paving on a high void aggregate base to capture rainwater falling on the road, collect it by perforated pipe and discharged slowly through an attenuator (341)

Response:
Multiple GI strategies will be implemented in the public space, including bio retention, pervious paving, and other forms of localized detention. The selected strategies will be tailored to meet the unique characteristics of each site.

8.5 A commenter asked what specific things need to be done by the owners on their property to aid the Green Infrastructure effort and what is DC water's strategy to obtain their cooperation and support. (359)

Response:
The specific types of GI practices to be implemented on private property have not been defined at this time, but could include the disconnection of downspouts, rain barrels, rain gardens, and Green roofs. GI implementation on private property may include incentives or rebates.

8.6 Comments applicable to the agency coordination for better implementation of Green Infrastructure

8.6.1 A commenter advocated expansion of agency coordination with PEPCO, Washington Gas, etc.(339)

Response:
DC Water typically engages utility companies during the planning and conceptual design phases of engineering projects to identify opportunities to mitigate utility conflicts and opportunities to collaborate on work in shared utility corridors. The design of GI projects would follow a similar process.

8.6.2 A commenter indicated that highway department has a significant role as they make up a high proportion of impermeable area discharging to the combined sewers (341). A commenter indicated that DC Water should be aware of DDOT's experience in implementing each of the GI technologies described in the Modification. (352)

8.6.3 A commenter suggested better coordination efforts with DDOE (319). A commenter questioned if DC Water and DDOE could collaborate better to cover both MS4 and CSO issues. (346)

8.6.4 A commenter indicated that most Green opportunities will be in public space and DDOT will have to install GI measures complying with DC Storm Water regulations while rebuilding streets, roads, sidewalks, and alleys. Commenter questioned if DC Water has coordinated with DDOT and DDOE for runoff reduction and requested to share that information with the public.(355)

8.6.5 A commenter suggested improving the proposal using the lessons learned from experiences with Green Infrastructure in the District and throughout the capital region. (375)

8.6.6 A commenter indicated that DC Water should request written and enforceable commitments from DC government to delineate its agencies responsibilities for ownership, operations, and maintenance of any GI projects on public space with supporting funding. (380)

Response:
DC Water recognizes that extensive coordination and cooperation between the District and DC Water will be required in order for GI to be successful. This coordination is already underway. DC Water has collaborated extensively with DDOT on GI projects over the last decade, and especially through the recent initiatives in Bloomingdale and the Riversmart Washington demonstration project. DC Water has also collaborated extensively with DDOE on MS4 and CSO policy issues over the last decade, and especially through the recent joint initiatives for rain barrel programs.

In addition, DC Water and the District have begun coordination on the first GI project that would be constructed if the LTCP Modification for GI is approved. This early coordination will allow adequate time to address issues that arise during planning and design of the first GI projects.

8.6.7 A commenter suggested coordinating with DDOT on the proposed street car line construction due to the construction and alignment of the relief interceptor sewer. (351)

Response:
Any construction in the public right-of-way would be coordinated extensively with DDOT, as is the case with other DC Water tunneling projects. Under the GI Plan, there would not be a diversion sewer, relief sewer, or tunnel constructed in Georgetown. The original LTCP included the construction of a tunnel and multiple diversion structures in Georgetown to intercept flows from existing trunk sewers.

8.6.8 A commenter suggested that DC Water should work to relieve capacity in the Potomac Interceptor and Potomac Pumping Station, institute aggressive water conservation projects throughout the region tributary to the interceptor, provide support for DDOT and DDOE to implement the stormwater regulations and reduce runoff, and renegotiate the IMA and the charges for the Potomac Interceptor to more fairly allocate the costs of CSO controls to the entire region that will benefit by a cleaner Potomac. (368)

Response:
The allowable flows handled by the Upper Potomac Interceptor Relief Sewer (Potomac Interceptor) are specified in the Inter-municipal Agreement (IMA). These are in essence contract limits between DC Water and the suburbs. DC Water is responsible for monitoring the performance of the Upper Potomac Interceptor Relief Sewer to assure there is adequate capacity in the system.

DC Water supports flow reduction efforts in the service area. However, these efforts will not have a significant impact on CSO control since the majority of flow causing CSOs is generated by storm water runoff in the combined sewer area in the District.

The Proposed Draft LTCP Modification identified a 21 mg, approximately 4500 foot long Potomac Tunnel to capture CSO 020-024, a new pumping station to empty the tunnel and the addition of 75 mgd of capacity at the Tunnel Dewatering Pumping Station (TDPS) and Enhanced Clarification Facility (ECF) at Blue Plains. As part of the response to comments, DC Water has evaluated an approximately 22,000 foot long gravity Potomac Tunnel that would run from the Potomac River CSOs to connect to the Blue Plains Tunnel at Joint Base Anacostia-Bolling (Bolling Air Force Base). This would eliminate the need for tunnel dewatering pumping station for the Potomac Tunnel. In the event Potomac Pumping Station or Potomac Force Mains are out of service or fails, the gravity tunnel can be used to convey flow to Blue Plains for treatment. This substantially improves the reliability of the system

Regarding suburban funding of the LTCP, the District and the suburbs have completed negotiations regarding the suburban cost share for the LTCP. The suburbs are contributing 7.1% to joint use LTCP facilities. This agreement was codified in the updated IMA. Renegotiating the IMA is not a viable path forward and would have an uncertain outcome.

8.6.9 A commenter requested continued involvement in this project especially for the proposed GI initiatives in Glover Park- Cathedral Heights area. Commenter suggested working with district agencies like DDOT, MPD and DGS to ensure that pedestrian and vehicular safety is enforced and surrounding environment is protected. (369) A commenter suggested that DC Water should continue to strive for maximum cooperation and coordination with other agencies (e.g., DDOE, DDOT, DCRA, OP, OZ) and internally.(385) A commenter suggested closer coordination between stakeholders and agencies such as DC Water, DDOE, DDOT, GSA, Interior, DOD, Virginia and Maryland. (295)

Response:
DC Water will engage the public and District agencies during design development. DC Water will work with the full range of District agencies during planning and design to ensure the GI measures are integrated into the fabric of the District. This includes the bicycle and pedestrian safety departments at DDOT.

8.7 A commenter questioned if pumping system could be expanded later for greater capacity. (343)

Response:
The capacity of Potomac Pumping Station cannot be feasible expanded because the station must discharge into force mains that convey flow to Blue Plains. In order to increase station capacity, additional force mains would be required since the existing station maximizes the capacity of the existing force mains. Adding addition conveyance to Blue Plains was evaluated in the LTCP and was determined to not be cost effective or practical.

8.8 A commenter questioned if composting toilets could be installed in every home and business. (347)

Response:
It is unlikely that such a system would be accepted by the populace due to the difficulties involved in the operation and maintenance required by each and every property.

8.9 A commenter requested that DC Water further explore the implications of new proposal on constructing parallel sewer lines between C&O Canal and K Street NW. (349)

Response:
If the modification of the LTCP for GI is approved, DC Water will perform more detailed engineering to define the sewer separation for CSO 025 and 026, including the location of new sewer lines, service connections and other details. This type of engineering is typically called facility planning and will provide more definition regarding the separation work.

8.10 A commenter indicated that the Mayor should take responsibility for GI facilities and DC Water should take responsibility for building and managing storage tunnels and other "grey" facilities for effective coordination and full benefits. (353)

Response:
DC Water is the permittee under the NPDES Permit and has signed the Long Term Control Plan Consent Decree. This makes DC Water responsible for controlling CSOs. DC Water and the District will coordinate activities to minimize the cost of GI and to maximize its effectiveness. Any change to the current arrangement will have to be made by the city's political leadership.

8.11 A commenter indicated that if legislation is passed to disconnect downspouts (total 361 impervious acres of the total 1,125 – well over 30% and 11 million gallons) and convey drainage from the roofs to rain barrels, it will yield more control than the original LTCP (9.5 million gallon tunnel) and the proposed GI (30% of the 1,125-acre impervious area-11 million gallons). Commenter complained that DC Water proposed only 40% disconnection by means of a $20 million contract program.(354)

Response:
Water disconnected from the combined sewer system in the form of downspout disconnects or other methods do not directly translate to CSO reduction on a gallon per gallon basis. This is because the combined sewer system captures much of the runoff in the system and the system only overflows during times of high intensity rainfall. DC Water's analyses regarding the degree of GI and gray controls required were developed using a computer model of the sewer collection system to analyze and make predictions regarding performance.

DC Water will employ multiple GI strategies in the project area, including downspout disconnection, and the selected strategies will be tailored to meet the unique characteristics of each site.

8.12 A commenter indicated that GI benefits outlined in the Modification far exceed CWA benefits and questioned why they should pay for these benefits that are already unaffordable. Commenter added that other District revenue sources generally have ability-to-pay features built into them (unlike Clean Rivers impervious area charges) and much contamination into Rock Creek originates outside the District and still those agencies and jurisdictions bear no costs of Rock Creek remediation – Green or grey. Commenter indicated that most of the DC run off comes from the transportation ROW and still DDOT budgets have not contributed to controlling that run off. (356)

Response:
The LTCP was prepared between 1998 and 2002 and a key aspect of the study was to determine the appropriate degree of CSO control to meet water quality standards. The final LTCP was determined by DDOE and EPA to meet water quality standards in the District, subject to post-construction monitoring. The LTCP modification for GI is not intended to revisit the analysis in the LTCP to determine the appropriate degree of CSO control. Instead, the LTCP modification for GI proposes different CSO controls to achieve a degree of control equivalent to the gray controls in the LTCP. The GI controls are recommended because they offer other benefits to the District in addition to CSO control.

The Clean Rivers project is funded by the Impervious Area Rate Charge (IAC) which allocates cost based on impervious area. This was selected because the primary generator of combined sewer overflow is runoff from impervious areas. Like other utilities, charges are based on use of the service, not ability to pay. When the IAC was implemented, a policy decision was made to not include the transportation right of way in the fee charges. This was done because the public right of way is a public good used by all and because whatever charges assessed under the IAC would be paid by District tax payers, who are essentially the same users who pay water and sewer bills.

8.13 A commenter indicated that DC Water's GI unit costs are too high and suggested using a more comprehensive and sophisticated treatment of costs like considering cost reductions as a result of GI. (362)

Response:
Unit costs presented in the LTCP Modification for GI are used primarily to determine the relative cost among various GI practices and to determine a practical program level budget. Project level costs will be evaluated as individual projects are developed, and cost information from early projects will be used to inform programming for subsequent projects.

8.14 A commenter indicated that community acceptance is probably the biggest unknown facing the implementation of this plan and suggested investing significant resources in public education and community outreach. (363)

Response:
DC Water will engage the public and District agencies during design development.

8.15 A commenter indicated that DC Water didn't propose real adaptive management as the process didn't involve generating hypotheses and designing monitoring experiments. Commenter added that proposed approach will generate almost no new information that isn't already known. (364)

Response:
Originally DC Water did propose a Pilot Project to test various available LIDs and investigate effectiveness of these when implemented in the District. Regulatory agencies did not agree to the proposal since it would have delayed full implementation.

A great deal of new information specific to large-scale GI implementation in the District of Columbia remains to be learned. This includes targeting the location of GI practices in the sewer sheds to optimize detention time and CSO reductions, public outreach strategies, the challenges of implementing GI in historic neighborhoods, and coordinating the aesthetic and technical parameters of GI with District and Regional agencies that hold jurisdiction over public and private spaces. The GI Program includes adaptive management because subsequent projects will be modified based on the results of prior projects.

8.16 A commenter requested that DC Water disseminate more information on GI so that residents can implement and pursue GI on their own (365)

Response:
DC Water has begun the process of reaching out and educating the public on the many positive attributes of GI however this process is only beginning and will continue to be a large part of the implementation process throughout the life of the program.

8.17 A commenter suggested that DC Water should take action to protect ratepayers by reducing capital costs, extending the deadlines, canceling the Piney Branch Tunnel, and building the shortened Potomac Tunnel. Commenter added that DC Water should investigate new funding sources such as creating new rate classes and increasing charges for the use of Potomac Interceptor. (366)

Response:
It is agreed that extending the deadlines would have spread out the financial burden, however, we are limited by regulatory requirements. This proposal will spread the costs over a longer period thereby reducing the rate of increase for rate payers. It will eliminate the Rock Creek Tunnel and construct a revised Potomac tunnel. DC Water has introduced the Impervious Area Charge (IAC) to apportion the cost of the project more equitably. With the IAC in place, customers with larger areas of impervious area will absorb a proportionally higher share of the cost.

8.18 A commenter suggested using Blue Plains for treated water supply, to increase flow to Anacostia, for irrigation in watershed and groundwater recharge. (371)

Response:
The purpose of the LTCP Modification for GI is to address the CSO controls in the Potomac and Rock Creek. The Anacostia CSO controls consist primarily of the tunnels in the LTCP Consent Decree and these are being implemented. Alternative control plans for the Anacostia River are not being considered.

8.19 A commenter suggested considering one regional water authority to include DC Water, WSSC, Arlington, Alexandria, and Fairfax for water, wastewater, and polluted runoff. (372)

Response:
Creation of a regional water authority is a broader issue that is beyond the scope of the LTCP Modification for GI.

8.20 A commenter indicated that DC Water should evaluate smart technologies for managing and reducing wet weather flow and considerations to be given in water conservation and reuse of stormwater flows. (373)

Response:
Smart technologies such as local storm water storage will be one of the many technologies considered for implementation when projects are implemented. However, the long term reliability and need for maintenance will be a factor when considering what technologies to implement.

8.21 A commenter suggested that DC Water should commit to supplemental Green Infrastructure installation in the Anacostia watershed. This would help to achieve additional CSO reductions, advance environmental justice goals, and save DC Water money on operating costs for the Anacostia tunnel (374). A commenter suggested to use GI in the Anacostia and complained that DC Water is only spending GI money in wealthier sections of District. (294) A commenter suggested to consider unused pavement at RFK's North lot for Greening.(331)

Response:
DC Water's GI Plan proposes GI implementation in the Potomac River and Rock Creek watersheds, and does not include GI projects in the Anacostia River watershed. The Anacostia River projects are currently being implemented in accordance with the LTCP Consent Decree, which involves constructing tunnels for control of CSOs. These tunnels are projected to achieve a 98% reduction in CSO in an average year on the Anacostia. Further, DDOE and EPA have determined that these controls will meet water quality standards, subject to post construction monitoring. DC Water is supportive of GI implementation in the Anacostia River watershed, including the reduction of impervious areas.

8.22 A commenter argued that proposed CD modification schedule change should also include 1) moratorium on new post-2025 construction by sub-watershed until systems are fully operational 2) memorialize the 2022 accelerated date for the Anacostia tunnels to become operational; 3) Freeze other jurisdictions allocations at current levels until Consent Decree is completed; 4) Update plumbing codes to promote reuse of “grey water” in all jurisdictions; 5) set specific water conservation targets and milestones; 6) Requirement for other jurisdictions to store or reduce wet weather flow; 7) Assess rainwater diversion to Dalacarlia water treatment plant;8) A robust effort to eliminate illicit discharges and a plan for inspection and repair by 2025;9) NO DECREASE in percentage of captured storms should be proposed; 10) Funds to be provided for 3rd party evaluation by Plaintiffs. (295)

Response:
1) The LTCP controls were designed assuming build-out of the service area with Blue Plains annual average dry weather flows at 370 mgd. Actual flows to Blue Plains have been approximately 280 mgd. Imposing a moratorium on new connections would be a severe economic hardship on the service area. Given that actual flows are only about 75% of design flows, a moratorium is not in the interest of rate payers.

2) The 2022 deadline for the Anacostia River Tunnels has been set as a goal to deliver flood relief to at-risk neighborhoods. However, commitment to this earlier schedule in the Consent Decree would not be practical due to the extensive inter-agency agreements, easements, and property acquisitions that need to be completed in order to meet the deadline. DC Water is working diligently with the District to meet the aggressive 2022 deadline.

3). The Inter-municipal Agreement specifies contract flows that the District has agreed to treat for the suburbs at Blue Plains. Changing this contract is not a straightforward or timely alternative to reduce CSOs. Further, actual flows to Blue Plains have been approximately 280 mgd, or about 75% of design flows.

4) and 5). DC Water has a water conservation program in place. In addition, DC Water has seen a steady reduction in potable water use even with increasing population in the District. This is attributed to the increased use of low flow fixtures as part of redevelopment in the District.

6). The Inter-municipal Agreement specifies contract wet weather flows that the District has agreed to treat for the suburbs at Blue Plains. Wet weather limits for these flows are in place in the IMA.

7) Dalecarlia is a potable water treatment plant providing drinking water to the District with the Potomac River as source water. Diverting polluted runoff directly to the treatment plant would be very difficult and expensive and is not conducive to producing high quality drinking water.

8). In the combined sewer system, storm water discharges from homes and streets are designed to be diverted to combined sewers. In the separate sanitary area, DC Water has a sewer facility plan which provides for ongoing inspection and rehabilitation of the sanitary sewer system. Removing illicit connections, if present, is part of this program.

9) DC Water's analyses indicate that the green/gray hybrid controls identified in the LTCP Modification will provide an equivalent degree of control to the gray controls in the LTCP.

8.23 A commenter indicated that the proposal has insufficient information to secure stakeholder confidence in the implementation strategy.(376)

Response:
Once the LTCP modification for GI is approved, DC Water will perform the next level of planning to take the project to the next level of project definition. The next level of planning is called the GI Program Plan. It is similar to a facility plan and will identify GI project areas, anticipated technologies, estimated costs and other details. This will be followed by detailed design and then construction.

8.24 A commenter suggested that Potomac EIS should consider options for eliminating the Potomac tunnel and not just shortening it or at least keep the tunnel away from National Park Service lands. (383)

Response:
The revised Potomac Tunnel is recommended as part of DC Water's GI Plan, which would mitigate many of the impacts to NPS lands. DC Water's analyses indicate that the Potomac Tunnel cannot be eliminated altogether due to the large CSO volumes in the southern portion of the Potomac River CSO area. The Potomac Tunnel EIS process will identify opportunities to reduce the impacts of the project on NPS lands, as well as other public and private properties in the project vicinity.

9. COMMENTS ON MISCELLANEOUS TOPICS

9.1 Comments applicable to the overall aspects of the LTCP

9.1.1 A commenter questioned if the First Street Tunnel is being constructed due to the new development. (396)

Response:
The First Street tunnel was originally part of the Northeast Boundary Tunnel (NEBT) system which was to be in operation by 2025 predominantly to address flooding in the Florida Avenue/Rhode Island area. Due to a major recurrence of flooding in the Summer of 2012, the NEBT was brought forward in the schedule to be completed by 2022 and the First Street tunnel was broken out, expanded and accelerated to be complete by 2016. First

Street Tunnel is to mitigate flooding in the Bloomingdale and Le Droit neighborhoods until the NEBT is completed. The NEBT will be the permanent solution to this century old problem. The tunnel is not being constructed to facilitate new development.

9.1.2 A commenter questioned if stormwater flows will be stored in the sand filters at McMillan. (397)

Response:
One of the McMillan sand filters has been modified for temporary storage of storm water from North Capitol Street as the first line of defense against a recurrence of the flooding that took place in the Bloomingdale and LeDroit Park neighborhoods in the summer of 2012. This is not related to the GI proposal for the Potomac and Rock Creek watersheds.

9.1.3 A commenter questioned if First Street will be widened. (398)

Response:
No. It will remain the same width at the end of the First Street Tunnel Project.

9.1.4 A commenter questioned how the shafts would look at the end of the project. (399)

Response:
Final details of how the Potomac Tunnel shafts will look will not be finalized until detailed design. However, tunnel shafts are typically buried below grade with access covers and manholes projecting to grade. These access covers and manholes will be located at ground level and will be traffic rated if located in road ways.

9.1.5 Two commenters questioned on what happens to the tunnel if there is an earthquake? (405, 421)

Response:
The tunnels are designed to withstand the type and magnitude of forces anticipated, including seismic loads.

9.2 A commenter questioned how DC Water envisions quantifying the Triple Bottom Line Benefits for GI. (400)

Response:
Triple bottom line benefits will be assessed based on post construction monitoring. Some benefits such as heat island effects may be possible to quantify, while other benefits such

as aesthetic improvements may be more difficult to quantify. A plan for assessing triple bottom line benefits will be developed as project definition increases. If necessary, experts in undertaking such analyses will be engaged.

9.3 A commenter offered to volunteer as a stakeholder for GI projects and requested more information on current Long Term Control Plan, proposed Long Term Control Plan, description of Green Infrastructure with phases from 2015 to 2032, description of the Potomac Tunnel and description of options for building GI. (401)

Response:
The current Long Term Control Plan is posted on DC Water's website. The Proposed Draft LTCP Modification for GI has been available to the public review since January 2014 which contains detailed description of the proposed GI project and it's phasing. Both these documents contain the best and latest information that is available on the Potomac tunnel. Appendix I of the Recommended Final LTCP Modification for GI contains extensive information on the GI technologies available.

9.4 A commenter questioned how old are the combined sewers. (402)

Response:
Most of the combined sewers were constructed in the late 1800's and the first decade of the 20th century.

9.5 A commenter questioned if the CD modification is not approved will DC Water build Green Infrastructure anyway. (404)

Response:
No. If the Consent Decree modification is not approved DC Water will implement the original tunnel solution.

9.6 Two commenters requested additional time to review the GI proposal before indicating the support (408, 411). A commenter requested DC Water to extend the public comment period by 30 days.(408)

Response:
The public comment period began on January 12, 2014. The comment period was originally scheduled to end on March 14, 2014, and was extended to April 14, 2014.

9.7 Comments applicable to the job growth due to Green Infrastructure

9.7.1 A commenter suggested promoting education programs in schools to foster training and job growth. (78)

9.7.2 A commenter expressed his concern about DC Water's commitment on development of local talent on GI employment (409)

9.7.3 A commenter requested to know how many jobs are anticipated by GI. (410)

Response:
DC Water has put significant emphasis to date in promoting local participation in the Clean Rivers project and has had considerable success even on large tunnel projects. One of the advantages of GI is that it is a good generator of local Green jobs both for construction and maintenance.

If the LTCP modification for GI is approved, DC Water will work to promote Green jobs with a living wage for local residents. Activities may include establishing a certification program for GI jobs, partnering with organization to provide training that ultimately leads to certification, conducting outreach in the District and partnering with local organization.

Appendix D of the Recommended Final LTCP Modification for GI explores the economic impacts and benefits of alternative CSO control strategies on job creation. Table 9 of Appendix D shows that the hybrid approach will generate more jobs than the tunnel under original LTCP.

9.8 A commenter asked why the three combined sewers in east Georgetown have minimal overflows into Rock Creek in contrast with very large overflows from west Georgetown into the Potomac River. (412)

Response:
CSO 020, 021, 022 and 024 on the east side of Georgetown are the largest CSOs on the Potomac. These outfalls are the termination point for large interceptor sewers designed to convey CSO flows out of Rock Creek because of the low assimilative capacity of the creek. The interceptor sewers were designed to discharge flow to the Potomac River during CSO events. The CSOs are large because they drain the combined area on both sides of Rock Creek from the Potomac River to the Maryland Boundary. CSO 025 and 026 in east Georgetown are the smallest CSOs to the Potomac River. These CSOs are small because the contributing drainage area is very small, on the order of 10 to 15 acres. CSO 027, 028 and 029 on the west side of Georgetown are medium-size CSOs because the contributing area is larger than that of CSO 026 and 026, but much smaller than CSO 020, 021, 022 and 024.

9.9 A commenter requested a characterization of the extent of any infiltration/inflow in the areas between Georgetown University and Wisconsin Avenue and requested description on its impact on DC Water's abatement strategies for overflows from CSO 027 and 028. (413)

Response:
Data on infiltration in these sewersheds is not currently available. Data may become available when flow monitoring is performed as part of pre and post construction monitoring for these sewersheds.

9.10 A commenter indicated that proposed LTCP should address the changes since 2002 which outmoded LTCP. (414)

9.11 A commenter questioned the rationale for selecting Green Infrastructure for Rock Creek and tunnel for Anacostia for CSO control (403). A commenter questioned if Anacostia tunnel could be replaced with Green Infrastructure. (406)

9.12 A commenter questioned why can't GI be done in Bloomingdale and indicated that it is intentional, and not coincidental, to eliminate the tunnel in most expensive neighborhood of the city and as always east of the park. (44) Another commenter indicated that GI is great for Rock Creek Park but could just be a dig festival to consider these measures in Bloomingdale. (43)

Response:
Back in 2005 when Consent Decree has prioritized the Anacostia River projects, tunnels were the only CSO control strategy which could achieve the required CSO reduction. The source control strategies including GI have gained far more acceptance as a solution to CSO issues in the recent decade. It is effective in reducing CSO while at the same time providing multiple other economic, social and environmental benefits. This is the reason for proposing this alternative plan.

The Consent Decree has prioritized the Anacostia River projects, over Potomac and Rock Creek, due to its poor flow characteristics- much lower flow rate, very long residence time and slow moving. In addition, approximately two thirds of the CSO volume in the District discharges into the Anacostia River. Hence the bulk of the Anacostia system has to be in operation by 2018 a full 7 years earlier than the Potomac and Rock Creek projects.

9.13 A commenter indicated that Figure A-4 in Appendix A of Appendix J- Technical Memorandum No. 7 actually shows a portion of the sewershed for CSO 024 and labeled as CSO 025.(415)

Response:
The figure has been corrected.

9.14 A commenter requested that DC Water provide the experiences learned from Philadelphia and the monitoring results of those few projects initiated in the District. (416). A commenter requested the results of the GI pilot projects installed at DC Water facilities as part of investigating how GI might reduce runoff. (19)

Response:
DC Water's LID project at its own facilities has been completed and one year post construction monitoring period is about to commence. The results will be made available once monitoring period is complete.

Philadelphia's CSO program is also in its early stages. DC Water is eager to learn from and share experiences learnt elsewhere as we continue to implement our program.

9.15 A commenter expressed concern to know that the water models used in project are based of decades old data without taking climate change impacts in to consideration. (417). A commenter requested to update analysis to reflect climate change, outdated flow and population projections. (418)

Response:
The LTCP controls were designed assuming build-out of the service area with Blue Plains annual average dry weather flows at 370 mgd. Actual flows to Blue Plains have been approximately 280 mgd. Future build-out has therefore been considered when sizing the LTCP.

Further, the CSO controls being constructed are 20% larger than modeling indicates is required to provide the degree of control necessary. This margin provides a safety factor for a variety of factors including climate change.

9.16 A commenter indicated that adaptive management must account for timely enhancements to the GI Plan and that post-construction monitoring alone is insufficient. (420)

Response:
Agreed. The adaptive management approach takes in to account of the lessons learned from each implementation phase and applies them to the next thereby, improving the efficiency of successive projects. One element of this would apply to the overflow reduction efficiency of the practice which would be determined by post construction monitoring. DC Water would also apply lessons from many other aspects of the implementation such as dealing with stakeholders, permitting, contract delivery, product selection, private incentives, utility conflicts etc.

10. COMMENTS IN GENERAL OPPOSITION

10.1 A commenter indicated that DC Water should construct both grey and Green and if it is not possible then do a full Potomac tunnel. Commenter indicated that the risk is too high to gamble with experiments. (32)

Response:
Constructing both Green and gray controls is not affordable for ratepayers and is not necessary to provide the degree of control necessary to meet water quality standards. EPA, the District and DC Water have concluded that GI is a proven practice. DC Water's plan applies gray technology where it is most suitable in areas with the largest CSOs and in the densest downtown areas. Similarly, Green controls are proposed in areas where it is most suited and will provide the most benefits to the District.

10.2 A commenter complained that the description of plan is so abstract and unintelligible and requested DC Water to avoid secrecy and opacity (33)

Response:
All relevant information is available to the public under the freedom of Information requirements. All the work that DC Water has done to date to support the Consent Decree modification has been made available and explained in numerous public meetings throughout this public comment period. See our website at www.dcwater/Green for summaries of what is being recommended, including a short video. Lastly, DC Water reports on the status of the implementation of the Consent Decree on our web site as follows: http://www.dcwater.com/wastewater_collection/css/css_reports.cfm.

10.3 Comments applicable to the support of original consent decree

10.3.1 Several commenters urged DC Water to construct the temporary holding tunnel under the Piney Branch Tributary. Comments indicated that it's time to solve the decade old Rock Creek's water pollution problems once and for all, as quickly as possible. Commenters requested that DC Water should follow the orders given by EPA. (34, 35, 36, 38).

10.3.2 A commenter indicated opposition to DC Water's proposal to modify the Consent Decree to lessen its duties pertaining to the construction of Ward 4's Rock Creek and Piney Branch Tunnel. (36)

10.3.3 A commenter indicated support to the original plan and feels that there is no reason why the metropolitan area cannot afford the investment envisioned by the original plan. (39)

Response:
Proceeding without modifying the Consent Decree and implementing the controls listed under the existing Consent Decree is a viable alternative but DC Water strongly believes that the LTCP Modification incorporating GI is superior to the original plan. Similar to the original plan it will greatly reduce the volume and frequency of CSOs to the Potomac and Rock Creek rivers and in addition will provide multiple environmental, social and economic benefits. These benefits include a reduction in heat island effects, better carbon foot print, improved energy conservation, enhanced ground water benefits, Greener more pleasant environment, enhanced property values, more natural habitat and enhanced wetlands. In addition, it will represent a permanent above ground visible record of the valuable investment of District ratepayers in their environment.

The costs of both plans are equivalent and are a heavy financial burden on District rate payers. The overall financial impact of the modified plan with the new schedule is less due to spreading out the construction over a longer period.

10.4 A commenter expressed his concern that storms are getting stronger and heavier and DC water is trying to implement the technologies that suit steady low rain absorption which won't work in major storms. Commenter indicated permeable surfaces only work on flat terrain not the hilly DC landscape and they need constant maintenance. (37)

Response:
Irrespective of the technology that DC Water implements there is the potential for very large storms to occur which will overwhelm the CSO control Infrastructure. Based on the analysis conducted as part of the original long term control plan, the projects were sized to limit over flows to no more than 4 to the Potomac and 1 to Piney Branch during an average hydrological year. The controls described in the recommended LTCP Modification are sized to provide an equivalent degree of control to the LTCP.

Controls employing permeable surfaces work better on flat terrain than on steep slopes. Other practices such as rain barrels and tree canopy are not as sensitive to the degree of slope. It will be a function of the design process to select practices to accommodate all the known site specific constraints including slopes and select the optimum practice to base on the specific conditions present.

10.5 A commenter indicated that DC Water's "desktop" GI screening analysis lacks sufficient detail needed to justify a modification of the consent decree. (40)

Response:
The GI screening analysis was conducted to explore alternatives in the Potomac and Rock Creek to assess whether there were alternatives that included GI that provided an equivalent degree of CSO control to the gray controls in the LTCP while taking advantage of additional environmental, social and economic benefits while at the same time not placing any additional financial burden on hard pressed District rate payers. Our screening analysis examined multiple alternatives and concluded that there are viable alternatives that achieve these goals. In the less dense neighborhood of Piney Branch in Rock Creek, it is feasible to eliminate the tunnel completely and substitute a full GI project and achieve these objectives. Along the more challenging Potomac Riverfront, our screening analysis yielded a hybrid project with a substantial Green component. All the information leading to these conclusions has been made available for review as part of this public outreach process.

11. COMMENTS IN GENERAL SUPPORT

11.1 About 60% of comments expressed support for the LTCP Modification for GI. (42- 293, 296-318, 448, 461)

Response:
Comments noted and DC Water appreciates the support received.

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District of Columbia Water and Sewer Authority

Table 1- Summary of Comments on "Long Term Control Plan Modification for Green Infrastructure"

First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Abbey	Ammerman	1	270	Washington Interfaith Network	5302 Baltimore Ave		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Abeba	Mebratu	2	254	Washington Interfaith Network	1301 Vermont Ave NW #804		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Alan	Johnson	3	121	Washington Interfaith Network	1721 Kilbourne Pl NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Albert	Sabir	4	164	Washington Interfaith Network	615 14th St NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Alexis	Olive	5	308		5414 1ST PLACE NW		4/14/2014	survey monkey	Support GI. That way people can see environmentally friendly green solutions in actions and not just in theory. Also it should make people more cognizant of their actions in genera and how it will impact the environment	General Support	11.1
Alison	Sargent	6	73				2/27/2014	comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment; I love the idea of green infrastructure to create jobs, but also the ability to use our land and natural resources for our benefi of the environment & the people	General Support	11.1
Allison	Reese	7	156	Washington Interfaith Network	3149 Hawthorne Dr. NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Althea	Sellars	8	268	Washington Interfaith Network	4501 Connecticut Ave NW #610		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Amanda	Lindamood	9	277	Washington Interfaith Network	1236 Harvard St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Amy	Vruno	10	150	Washington Interfaith Network	1126 Montello Ave NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Amy	Tarce	11	339	National Capital Planning Commission			1/22/2014	meeting	How much GI will need to be implemented on public vs. private property? Is DC Water looking into incentives for private property owners such as reduction in Impervious Area Charge? Advocates expansion of agency coordination with PEPCO, Washington Gas, etc.	Maintenance & Implementation Strategies	7.4.2, 7.4.5, 8.6.1
Andrea	Barbery	12	52		327 13th st SE		2/8/2014	survey monkey	Support green infrastructure!	General Support	11.1
Andrew	Parker	13	298	Tetra Tech			4/14/2014	letter	We believe DC water and other stakeholders should move forward quickly with a plan that incorporates GI and encourage DC Water to help increase the implementation of more sustainable stormwater techniques.	General Support	11.1
Andria	Hayes-Birchler	14	16				3/13/2014	survey monkey	While I generally support green infrastructure projects, the Rock Creek watershed has so much impervious surface that dozens of small-scale green infrastructure projects will not make much of a difference on CSOs.	Degree of Control	3.7
Andria	Hayes-Birchler	14	38				3/13/2014	survey monkey	As a concerned citizen, I urge DC Water to construct the temporary holding tunnel under the Piney Branch Tributary as in consent decree. Rock Creek's water pollution problems caused by combined sewer overflows (CSO) is decades old, and its time to solve this problem once and for all, as quickly as possible.	General Opposition	10.3.1
Angelica	Alston	15	186	Washington Interfaith Network	4477 B Street SE #203		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Angelica	Alston	15	187	Washington Interfaith Network	4477 B Street SE #203		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Ann	Michel	16	148	Washington Interfaith Network	1724 Q Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Anne	Ford	17	124	Washington Interfaith Network	4477 B Street SE #203		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Anne	Womeldorf	18	177	Washington Interfaith Network	905 East Capitol St SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Anthony	Conto	19	223	Washington Interfaith Network	6114 42nd Place		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

District of Columbia Water and Sewer Authority
Table 1- Summary of Comments on "Long Term Control Plan Modification for Green Infrastructure"

First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Armele	Vilceus	20	217	Washington Interfaith Network	807 Houston Ave #3		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Ashley	Becker	21	234	Washington Interfaith Network	619 N Jordan St #202		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Ashley	Foughty	22	238	Washington Interfaith Network	2032 Belmont Rd NW #105		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Ashley	Goff	23	198	Washington Interfaith Network	2033 S. Nelson St		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Astau	Fanta	24	86				3/13/2014	comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment; Maintenance and green job opportunities and DDOE involvement	General Support	11.1
Barbara	Arbiter	25	106				4/6/2014	comment form	Support GI, schedule and financial commitment.	General Support	11.1
Barbara	Craft	26	309		2947 Upton St., NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Barbara	Tate	27	157	Washington Interfaith Network	4215 Chesapeake St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Becky Jim	Hammer Foster	28	23	Natural Resources Defense Council/ Anacostia Water Shed			4/14/2014	letter	Proposal must incorporate water quality-based performance standards equivalent to what would be achieved by the current tunnel-based approach. A financial commitment is not an acceptable substitute for enforceable, clearly defined performance metrics and does not comply with EPA guidance.	Nature of Commitment	2.1.1, 2.1.2
Becky Jim	Hammer Foster	28	374	Natural Resources Defense Council/ Anacostia Water Shed			4/14/2014	letter	DC Water should commit to supplemental green infrastructure installation in the Anacostia watershed. This would help to achieve additional CSO reductions, advance environmental justice goals, and save DC Water money on operating costs for the Anacostia tunnel.	Implementation Strategies	8.21
Becky Jim	Hammer Foster	28	375	Natural Resources Defense Council/ Anacostia Water Shed			4/14/2014	letter	DC Water should take heed of lessons learned from experiences with green infrastructure in the District and throughout the capital region, and use those lessons to improve its proposal.	Implementation Strategies	8.6.5
Becky Jim	Hammer Foster	28	395	Natural Resources Defense Council/ Anacostia Water Shed			4/14/2014	letter	Proposal must include a more rigorous and detailed planning analysis to provide greater confidence about expected outcomes. Specifically, DC Water should develop more comprehensive plans for its installation and maintenance, and for monitoring of the impacts its use of green infrastructure will achieve.	Implementability	5.5.4

District of Columbia Water and Sewer Authority
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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Becky Jim	Hammer Foster	28	462	Natural Resources Defense Council/ Anacostia Water Shed			4/14/2014	letter	Current proposal does not adequately justify the requested delay in compliance deadlines. To the extent that DC Water seeks the extension for affordability reasons, it must explore other options for addressing rate increases first; seven additional years of pollution should be considered a last resort.	Schedule	6.3.9
Ben	Roberts	29	145	Washington Interfaith Network	615 H Street SW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Bendita	Malakia	30	304		5306 7th St NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Bernard	Williams	31	208	Washington Interfaith Network	1420 Harvard St NW #206		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Bernie	Davis	32	193	Washington Interfaith Network	729 46th Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Betty	Rudolph	33	183	Washington Interfaith Network	5029 V Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Bianca	Vazquez	34	252	Washington Interfaith Network	10406 Mountain Qvail Rd		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Bill	Brower	35	50	DC Water	614 Sheridan St, NW		2/4/2014	survey monkey	Support GI. This is a great opportunity for the District. The knock-on benefits will curry favor with residents, and get people thinking about water flows and connections with the natural environment.	General Support	11.1
Bonny	Henderson	36	167	Washington Interfaith Network	2212 Tunlaw Rd NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Brenda	Richardson	37	410				3/5/2014	comment form	How many jobs does this generate? Support GI, schedule and financial commitment	Miscellaneous	9.7.3
Brian	Cohen	38	369	ANC 3B	P O Box 32312		4/13/2014	letter	We seek continued involvement in this project especially for the proposed GI initiatives in Glover Park - Cathedral Heights area. We ask that DC Water work with district agencies like DDOT, MPD, DGS to ensure that pedestrian and vehicular safety is enforced and surrounding environment is protected	Implementation Strategies	8.6.9

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Brian	Cohen	38	417	ANC 3B	P O Box 32312		4/13/2014	letter	Support green infrastructure but concerned to know that the water models used in the project are based on decades old data and do not take the impacts of climate change. This could imperil the long term success of the project	Miscellaneous	9.15
Brian	Cohen	38	438	ANC 3B	P O Box 32312		4/13/2014	letter	Public be made aware if there is an anticipated requirement to increase the residential sewer and impervious area charges for GI	Rates/ Finance	4.1.4
Brian	Cohen	38	458	ANC 3B	P O Box 32312		4/13/2014	letter	Disappointed with DC Water's proposed extension in completing Clean Rivers project. Our rivers have been polluted by sewage for decades and we are eager to see it end. No clear reason was provided why the good GI plan has to be combined with bad extension.	Schedule	6.3.1, 6.3.6
Brian	Cox	39	194	Washington Interfaith Network	726 46th Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Brian	Eriksen	40	390		2822 Rittenhouse Street NW		3/8/2014	email	Comment on the long term costs and complexities with maintaining the GI investment, as opposed to the more centralized maintenance and control of maintaining the currently planned tunnel system. It would seem that GI components would all need maintenance (just as the tunnel system would). But the difference is in how the GI investments would be more unprotected, being out above ground. At least with a tunnel system, access to it is much more limited, and maintenance should be much more centralized and predictable. I've seen so many rain catcher systems that neighbors and friends have used for, say, a season and then they break, or just are too much trouble to use. Provide analysis comparing and contrasting the pros and cons of both the current plan and the proposal from the perspective of ongoing maintenance of the resulting systems that would be in place by the end of implementation.	Maintenance	7.3
Brian	Lutenegger	41	101		1845 Summit Place NW #704	Washington, DC	3/30/2014	survey monkey	Support GI	General Support	11.1
Brian	Schimming	42	311		616 E St NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Brittany	Koteler	43	261	Washington Interfaith Network	4528 4th St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Brown	Sherry	44	312		325 18th Place NE		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Bryan	Szalwinski	45	70		118 Quincy Pl NE		2/21/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Bryan	Vestergen	46	111		2804 Martin Luther King Jr. Ave SE		4/9/2014	survey monkey	My support for DC Water's LTCP, though enthusiastic, is contingent upon the creation and continued support of employment opportunities for DC residents to build, sustain, and manage this green infrastructure.	General Support	11.1
Buena	Guizman	47	256	Washington Interfaith Network	3121 Mount Pleasant St NW #31		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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Buffie Hans	Brownstein Moennig	48	407	Ward/ANC 3			2/22/2014	email	Clarify regarding the magnitude of the CSO overflow problem. In the February 16 Washington Post article which focused on Lady Bird and the tunneling effort underway, the claim was made that there were hundreds of releases of sewage via CSO's on an annual basis. The briefing slides indicated that there were only 74 overflows annually, on average, to the Potomac and 25, on average, into Rock Creek. If the Post article is correct then there must be substantially more overflows into the Anacostia River. What is the average number of overflows into the Anacostia? Also is real-time information available online regarding CSO overflows? If so, where would we find it?	Degree of Control	3.11
C	Brinkley	49	266	Washington Interfaith Network	1629 Columbia Rd NW #530		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
C	Daven	50	391				3/10/2014	survey monkey	The Green initiatives mentioned in the mailing insert can all be lost if a continual maintenance plan is not in place, and/or if ownership of a property changes. Non-maintenance of green roofs, or rain gardens would then put the environment in jeopardy again.	Maintenance	7.4.8
C	Daven	50	449				3/10/2014	survey monkey	With cost escalations overtime, if it proves out that the current plan must be re-activated due to the failure of green initiatives, the cost will be much higher. Lets just bite the bullet, get it done by 2025 AND still as a City continue to push the green education, and incentivize residents and businesses to make the City healthy.	Schedule	6.4
Cara	Huang	51	448		709 Harvard St NW		3/6/2014	survey monkey	The proposed modification to the LTCP to include green infrastructure is a better solution than tunnels alone. Early implementation of green infrastructure will result in sooner water quality improvements, lower cost to rate payers, opportunities for urban renewal, and green jobs associated with long term green infrastructure maintenance. I strongly support the proposed modification.	General Support	11.1
Carl	Proper	52	253	Washington Interfaith Network	6721 Fairfax Rd		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Carla	Fenwick	53	189	Washington Interfaith Network	102 54th Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Carol	Aten	54	99	Ward 3			3/25/2014	email	I would like to support the proposed strategy. It seems to make good sense in terms of long term control and fiscal responsibility.	General Support	11.1
Carol	Aten	54	359	Ward 3			3/25/2014	email	I am unclear exactly what implementing green infrastructure means in the green areas identified. There is a great deal of development in those areas; does this mean that property owners will need to do some specific things on their property to aid the green infrastructure effort? If so, is there a strategy to obtain their cooperation and support?	Implementation Strategies	8.5

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Carol	Blythe	55	284	Washington Interfaith Network	302 Waterford Rd		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Carol	Huls	56	168	Washington Interfaith Network	3620 Connecticut Ave NW #33		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Carol	Porter	57	233	Washington Interfaith Network	8708 First Avenue #409		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Caroline	Henne	58	137	Washington Interfaith Network	313 E Monroe Ave		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Carolyn	Hull	59	184	Washington Interfaith Network	417 11th Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Carrol	Akanegbu	60	122	Washington Interfaith Network	1836 Potomac Ave SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Cathy	Starr	61	140	Washington Interfaith Network	1500 Harvard St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Cecil	Fruman	62	315		2310 King Place NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Chalves	Shields	63	120	Washington Interfaith Network	3728 Military Road NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Chancee	Lundy	64	107	NSPI			4/8/2014	letter	Support GI, schedule and financial commitmen	General Support	11.1
Chase	Courd	65	55	Ecospaces			2/19/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment - Stress all the educational opportunities with G	General Support	11.1

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Chistiana	Lundholm	66	125	Washington Interfaith Network	5057 1 Street NW #303		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Chris	Brown	67	97				3/22/2014	email	I am extremely enthusiastic about DC Water's Green Infrastructure plan. As someone who can remember the condition of the Potomac in the '50's and '60's and now paddles or swims in it at least 50 times a year, I am very pleased that DC Water is stepping up to continue the last 40 years of water quality improvement with these next steps.	General Support	11.1
Chris	Schwortz	68	119	Washington Interfaith Network	2480 16th St NW #528		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Chris	Weiss	69	408				3/4/2014	letter	Support GI, but still reviewing the proposal and extensive technical appendices, and consulting with green infrastructure practitioners. We request that DC Water announce a 30-day extension of the public comment period.	Miscellaneous	9.6
Christina	Porche	70	135	Washington Interfaith Network	1410 N Carolina Ave NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Christine	Pearl	71	300		1340 Kennedy St, NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Colleen	Haw Kinson	72	59		1207 Emerson St NW		2/19/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Cortney	Donnalley	73	127	Washington Interfaith Network	H St, SW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Courtney	Spearman	74	165	Washington Interfaith Network	441 S Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Craig	Wyatt	75	259	Washington Interfaith Network	1420 N Street NW #508		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Cynthia	Durham	76	264	Washington Interfaith Network	1624 Trinidad Ave NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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D	Pratt	77	110				4/9/2014	survey monkey	Great idea on all levels	General Support	11.1
Dale	McDaniel	78	138	Washington Interfaith Network	547 5th Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Dale	Ostrander	79	282	Washington Interfaith Network	631 Maryland Ave NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Dan	Maceda	80	416		475 K St NW		3/16/2014	survey monkey	Philadelphia began ahead of DC what is their experience. Is monitoring of the few projects initiated in the District occurring and if not why not? What are the results?	Miscellaneous	9.14
Dan	Maceda	80	451		475 K St NW		3/16/2014	survey monkey	I think it is necessary to begin the GI immediately. I question what has been done to date to provide green infrastructure and what evaluation is / has occurred. I am skeptical of financial commitments without concrete measurable milestones and objectives. Either green infrastructure will achieve the desired results or it won't , the sooner we know the better.	Nature of Commitment & Schedule	2.1.10, 6.4
Dan	Smith	81	389				3/5/2014	comment form	What is long term maintenance plan and funding for GI?	Maintenance	7.4.1
Dan	Smith	81	447				3/5/2014	comment form	Support GI with modifications, do not support schedule, support financial commitment.	Schedule	6.3.1
Dan	Thompson	82	219	Washington Interfaith Network	2801 Elnora St		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Daniel	Herrema	83	77	LimnoTech			3/5/2014	letter	Support GI, schedule and financial commitment. The investment is likely to create construction and maintenance jobs available to a wider range of local residents- a real plus for the city.	General Support	11.1
Danielle	Jefferson	84	176	Washington Interfaith Network	4405 E Street SE #4		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Dara	Scaife	85	249	Washington Interfaith Network	6716 Eldridge St		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Darlene	Thomas	86	108			718 E St NE	4/8/2014	letter	Support GI, schedule and financial commitmen	General Support	11.1
Dave	Wilson	87	84	ANC 4A07 Commissioner			3/11/2014	email	During ANC 4A's March 4, 2014 community meeting, it voted to oppose the Long Term Modification and send the Resolution to DC Water. In contrast, I dissented from that vote because the Long Term Modification that embodies the Green Approach is in the best interest of DC, its citizens, both financially and most important, environmentally.	General Support	11.1

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David	Bardin	88	31				4/14/2014	email	Performance standards for GI should mesh with GI characteristics (not necessarily tunnel designs) if they are to be efficient and cost-effective.	Nature of Commitment	2.4.3
David	Bardin	88	352				3/14/2014	letter	DC Water should recognize that DDOT has hands-on experience in implementing each of the GI technologies of bio retention, pervious pavement, soil system detention, and vegetated swales described in the Modification. Why does DC Water omit flexible porous paving, including porous rubber (such as Flexi®-Pave used by DDOT and federal government) from GI technologies? How does flexible porous paving compare with porous?	Implementability & Implementation Strategies	5.5.8, 8.6.2
David	Bardin	88	353				3/14/2014	letter	Mayor should take responsibility on GI facilities and DC Water should be responsible for building and managing storage tunnels and other "grey" facilities for effective coordination and full benefits. LTCPs elsewhere commit city governments to GI and are presumably enforceable.	Implementation Strategies	8.10
David	Bardin	88	354				3/14/2014	letter	DC Water aims for controlling run off from about 30% of the 1,125-acre impervious area which is 11 million gallons with GI – much more than the 9.5 million gallon capacity of the storage tunnel in 2002 LTCP. Roofs connected by downspouts to the combined sewer system total 361 impervious acres of the total 1,125 – well over 30%. If legislation required downspout disconnection and drainage from these roofs to rain barrels that alone might yield more control than the LTCP tunnel. But DC Water has not asked for such legislation. Instead it proposes to achieve 40% disconnection by means of a $20 million contract program.	Implementation Strategies	8.11
David	Bardin	88	355				3/14/2014	letter	Most opportunities DC Water identifies are in public space. Eventually, when DDOT rebuilds streets, roads, sidewalks, and alleys it will have to install GI measures to comply with DC Storm Water Regulation requirements. In regards to runoff reduction, DC Water should coordinate with DDOE and DDOT and share that information with the public	Implementation Strategies	8.6.4
David	Bardin	88	356				3/14/2014	letter	GI benefits outlined in the Modification far exceed CWA benefits. Why should sewer rates, which are unaffordable to almost half the public, pay for these benefits? Other District revenue sources generally have ability-to-pay features built into them (unlike Clean Rivers impervious area charges). Much contamination into Rock Creek originates outside the District. Yet Maryland agencies and jurisdictions bear no costs of Rock Creek remediation – green or grey. Most of the DC run off comes from the transportation ROW. Yet DDOT budgets have not contributed to controlling that run off.	Rates/ Finance & Implementation Strategies	4.1.1, 8.12
David	Bardin	88	383				4/14/2014	email	DC Water also proposes to cut the size of the Potomac tunnel, but not eliminate it. The Potomac EIS should consider options for eliminating the Potomac tunnel as well -- or at least keeping it away from National Park Service lands.	Implementation Strategies	8.24
David	Bardin	88	384				4/14/2014	email	DC Water should identify new revenue sources to pay fully for GI features (instead of an arbitrary cap, e.g., $60 million for Piney Branch) and to relieve low-income households of some of the growing burdens. Such sources possibly include revisiting some or all of the following: 1) PILOT payments to the DC CFO 2) exemption of suburban customers from any part of such PILOT payments 3) exemption of impervious surfaces in the transportation Right of Way from any Clean Rivers IAC charges, and 4) a DC retail rate structure which sets non-residential (i.e., commercial and federal government) unit rates at no higher level than residential and multi-family rates.	Rates/ Finance	4.5.2

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David	Bardin	88	385				4/14/2014	email	DC Water should continue to strive for maximum cooperation and coordination with other agencies (e.g., DDOE, DDOT, DCRA, OP, OZ) and internally	Implementation Strategies	8.6.9
David	Bardin	88	414				3/14/2014	letter	Support GI but proposed LTCP does not address changes since 2002 which render that LTCP outmodec	Miscellaneous	9.10
David	Bardin	88	429				3/14/2014	letter	A 90% reduction in annual overflows (from 49 to 5 million gallons a year) by a 9.5 million gallon Piney Branch storage tunnel in original LTCP is being replaced by GI to achieve the same or better performance. DC Water proposes realization of only 30% of the GI potential in this sewershed at an estimated cost of up to $91 million for GI instead of $42 million (2002 estimate) on the tunnel. Yet DC Water proposes to spend $60 million on GI via five contracts without explaining selection of that amount or why five contracts	Nature of Commitment	2.2.1
David	Bardin	88	437				3/14/2014	letter	DC's rapidly rising sewer rates are not affordable for two out of five customer households, as the Modification explains. EPA has reset DC Water's priorities over and over again since 2002, crowding out the most vital interests of people who live here in favor of other Clean Water Act interests. DC Water, DC Government must ask EPA and U.S. Department of Justice and District Court to take a fresh, hard look at the LTCP in the interests of environmental justice and sound public policy in our democracy	Rates/ Finance	4.1.1, 4.1.5
David	Bardin	88	441				4/14/2014	email	Asserted generosity of DC Water's Customer Assistance Program for 6000 of the low income households does not excuse inattention to the rest of the 100,000.	Rates/ Finance	4.1.4
David	Gilbrith	89	214	Washington Interfaith Network	3244 Q Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
David	Gottfried	90	302		1322 Longfellow Street NW		4/14/2014	survey monkey	There is a great deal of runoff into Rock Creek Park from the Kennedy Street NW area. There are a number of small parks that could be upgraded to reduce this runoff	General Support	11.1
Deborah	Demuren	91	246	Washington Interfaith Network	2503 Someiton Court		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Diane	Dale	92	400	AECOM			1/22/2014	meeting	How does DC Water envision quantifying the Triple Bottom Line Benefits for GI?	Miscellaneous	9.2
Don	Looney	93	293		1327 Webster St NE		4/13/2014	email	Support GI alternative to the Piney Branch tunnel. Green technology not only makes our city more livable but also provides long-term jobs. The cost to rate payers for the other two tunnels is enough of a burden without the additional cost of a third when a less expensive alternative is available.	General Support	11.1
Doris	Marlin	94	216	Washington Interfaith Network	2445 Lyttonsville Rd #905		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Doris	Warrell	95	159	Washington Interfaith Network	743 Hamilton St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Drew	Bongiovanni	96	146	Washington Interfaith Network	2231 1st St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Dwane	Jones	97	103	DC Center for Sustainable Development			4/2/2014	letter	Support GI, schedule and financial commitment. We understand that feedback from EPA and Stakeholders is incorporated in revised plan to include an upfront commitment for GI.	General Support	11.1
Earl	Biglow	98	299		414 Marietta Pl NW		4/14/2014	survey monkey	I support the implementation of Green Infrastructure along Kennedy Street and Petworth/Brightwood neighborhoods. it will enhance the neighborhoods	General Support	11.1
Ed	Cronin	99	75	Greeley & Hansen			3/4/2014	letter	Support GI, schedule and financial commitmen	General Support	11.1
Eddy	Ameen	100	170	Washington Interfaith Network	3930 1/2 New Hampshire Ave NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Edward	White	101	281	Washington Interfaith Network	5908 Nevada Ave NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Edwina	Dorcat	102	241	Washington Interfaith Network	3448 Joan Court		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Elizabeth	Topping	103	382		Longfellow st nw		4/14/2014	survey monkey	I'm glad you've selected Kennedy St for the pilot program. We're a neighborhood that's usually ignored. I like the idea of green infrastructure I can see better than a tunnel I'd never see. I'd much rather have improved little green parks and rain water areas and green roofs than a tunnel. Am happy to have a green roof at my home if you're looking for residential participants. My only concern is I wouldn't want any rain water barrels to be open anywhere so that they could become breeding grounds for Mosquitos. Please make sure they're designed so people can't leave them to Mosquitos	Maintenance	7.4.9
Elizabeth	Young	104	313		1701 Irving St NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Emily	Rice	105	305		5606 Kansas Ave NW		4/14/2014	survey monkey	I enthusiastically support the green infrastructure proposed for the triangle along Kansas Ave, especially the one located at Kansas and Longfellow. I live across the street. I also support the GI planned for Kennedy Street	General Support	11.1

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Emily	Swartz	106	160	Washington Interfaith Network	5328 28th St NW #0		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Emma	Miniscalco	107	93		658 Acker Street NE		3/18/2014	survey monkey	I am thrilled by DC Water's progressive and forward-looking vision for green infrastructure. The benefits of this investment are excellent, from beautifying our city to harnessing natural filtration systems and educating residents about water cycles along the way. You have my full support and confidence behind this proposal.	General Support	11.1
Erika	Landberg	108	132	Washington Interfaith Network	2842 28th St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Erin	Hamilton	109	11		905 16th St., NW		3/10/2014	survey monkey	Some concern about whether or not GI as proposed would mitigate the same level of stormwater as the third tunnel	Degree of Control	3.8.1
Felicia	Miller	110	191	Washington Interfaith Network	730 46th Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Fernando	Pasquel	111	114	ARCADIS	3101 Wilson Blvd		4/11/2014	letter	Support GI, schedule and financial commitment. Given that green infrastructure is being successfully implemented and a strong body of knowledge and research exists throughout the nation, it is imperative that DC Water take a lead in implementing innovative green infrastructure technologies tha improve water quality and enhance the environment while also providing social and economic benefits.	General Support	11.1
Frederick	Tipson	112	116	Washington Interfaith Network	1882 Columbia Road NW Apt. 303		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Fritz and Ruth	von Fleckenstein	113	53		3109 14th St. NE	Washington DC 20017	2/15/2014	email	I am in favor of this new approach to the correction of the water disposal problem of DC Water. Please let me know if there is a way in which I can weigh in with EPA on allowing an even larger allocation to this part of the program.	General Support	11.1
Gale	Barron Black	114	7	ANC Commissioner 4A08			2/20/2014	letter	City is trying to modify its responsibilities under the consent decree in a material way, which could be very adverse to those who live on east side of Rock Creek. Out of total 53 outfalls, Rock Creek and Piney Branch account for 29 outfalls, then why is Anacostia with only ten outfalls being given a higher priority?	Degree of Control	3.5
Gale	Barron Black	114	426	ANC Commissioner 4A08			2/20/2014	letter	NPDES permit, paragraph 43 says "Such LID projects shall constitute additional work which WASA agrees to perform in addition to the injunctive relief set forth in Section VI". Plan is clear that LID retrofits are not in lieu of other measures. Is DC Water taking all of the corrective actions required by the CD dated 3/2005? or is the City hoping to quietly avoid their responsibilities by seeking modification to the CD?	Nature of Commitment & Implementation Strategies	2.3.1, 8.1.2

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Gale	Barron Black	114	427	ANC Commissioner 4A08			2/20/2014	letter	We recognize long overdue maintenance is expensive. Now, we may also have to bear the added costs of WASA's failure to comply with the law and consent decree, if penalties are added. Does DC Water intend to address CSOs in the area north of Rock Creek Parkway?	Nature of Commitment	2.3.2, 2.4.1
Gale	Barron Black	114	428	ANC Commissioner 4A08			2/20/2014	letter	What exactly is proposed for Ward 4, what is the health risk, will we have to wait twenty more years? What is the socio/economic and demographic impact if RC is not addressed?	Nature of Commitment	2.4.2
Gary	Penn	115	265	Washington Interfaith Network	1421 Buchanan St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
George	Hofmann	116	74		4545 Connecticut Ave. NW	apt. 619	2/28/2014	survey monkey	This seems like a very desirable approach.	General Support	11.1
Gerald	Schwinn	117	365				4/7/2014	comment form	Spread more info on GI that residents can implement and pursue	Implementation Strategies	8.16
Gerry	Hendershot	118	222	Washington Interfaith Network	4437 Wells Parkway		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Ginny	Callanen	119	117	Washington Interfaith Network	4930 47th Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Glenn	Williamson	120	113	Amber Real Estate, LLC	4407 3th St		4/11/2014	letter	Supports GI, schedule and financial commitment	General Support	11.1
Glenn	Williamson	120	337	Amber Real Estate, LLC			1/22/2014	meeting	We support adding incentives for private property in targeted areas.	Maintenance	7.4.4
Grace	Park	121	139	Washington Interfaith Network	1021 17th SE Apt. 4		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Hannah	Massey	122	242	Washington Interfaith Network	5308 Willard Ave		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Hannah	McMahan	123	128	Washington Interfaith Network	56 U Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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Hannah	Webster	124	239	Washington Interfaith Network	1211 7th Street NW #302		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Heather	Renwick	125	143	Washington Interfaith Network	11320 Belmont St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Hypolite	Padameli	126	64	ITT Tech			2/21/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment	General Support	11.1
Irv	Sheffey	127	78	Ward 7B			3/5/2014	comment form	Support GI, schedule and financial commitment. Use more traditional methods of outreach to the community like flyers at metro, twitter, radio etc. Would like to see shorter tunnel. Promote education programs on LTCP in schools to foster training and job growth	Miscellaneous & General Support	9.7.1, 11.1
J Kristin	Hedges	128	95		614 East Capitol St NE, Apt #1		3/20/2014	survey monkey	From the beginning it was my opinion that a "tunnel" solution was faulty for not including waste water treatment solutions which were more "green". I am therefore gratified to find that there are these new "green" solutions. Not only will DC be contributing directly to green technology, but our example will help spur other municipalities to adopt more "green" solutions in handling their waste water.	General Support	11.1
Jack	Reiffer	129	126	Washington Interfaith Network	1500 Massachusetts Ave NW #514		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jade	Huang	130	60	Ward/ANC 1			2/20/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment - More green space, shade, green jobs, beauty, seems like a no-brainer.	General Support	11.1
James	Collier	131	3				1/23/2014	email	Based on past experiences, concerned over the life cycle costs and effectiveness of GI	Degree of Control & Maintenance	3.8.1, 7.2.1
James	Collier	131	4				1/23/2014	email	The Potomac and Rock Creek CSO projects primarily impact the human population's recreational use of the water bodies and CSO impacts are overpowered by storm sewer runoff from DC and the jurisdictions upstream. Thus the improvements from CSO reductions are going to be masked by other sources of wet weather pollution. The most glaring issues are the TMDL allocation and the Chesapeake Bay Syndrome	Degree of Control	3.3
James	Collier	131	5				1/23/2014	email	In Executive Summary, no clear statement of how many million gallons per year of CSO will exist beyond 2025 if the proposed GI plan is accepted.	Degree of Control	3.4
James	Collier	131	6				1/23/2014	email	In Section 3, Figure 3-6 deals with the entire Potomac control but Figure 3-7 deals with the small CSOs only. The true impact of the delay on the Potomac River is not presented clearly. Figure 3-7 should show all nine of the outfall volumes	Degree of Control	3.1
James	Collier	131	320				1/23/2014	email	In Executive Summary, the minimal description of the negative impacts of the proposed plan should have been expanded.	Implementability	5.1

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James	Collier	131	432				1/23/2014	email	In Appendix D, based on the following statement, It is unclear if there was a present worth analysis performed as was done in the LTCP. *"This analysis uses an EIA approach rather than a benefit-cost analysis (BCA)"*	Rates/ Finance	4.4
James	Collier	131	433				1/23/2014	email	Based on the following italicized statement in Appendix D, and at the 1-21-2014 meeting, it was not answered why a 10 year life cycle was used for O & M analysis. The LTCP evaluated GI and found it to be cost prohibitive due to high O&M even though the capital costs were much lower than the tunnel alternative. The current report uses an O&M that is only half of the O&M costs of the tunnel alternative. The source of the O&M cost of GI is referenced to another report but is unclear if even that report would contain the basis. *"Table 2 shows the amount of spending (in 2012 USD) for grey and green infrastructure installations for each year of implementation of the hybrid alternative. For this alternative, O&M activities associated with grey infrastructure are assumed to begin immediately following construction, and will amount to about $1.77 million per year (2012 USD). O&M activities associated with GI will be initiated upon completion of the first GI project and will incrementally increase until all GI projects are fully implemented. In addition to the capital costs reflected in Table 2, at full implementation, GI O&M activities will cost an estimated $915,000" per year (2012 USD).1 For the EIA, Stratus Consulting analyzed spending associated with 10 years of O&M activities."*	Maintenance	7.2.2
James	Foster	132	21	Anacostia Watershed Society			4/14/2014	letter	Does not support eliminating Piney Branch Tunnel without clear evidence it will achieve same results on the same timeframe	Degree of Control	3.8.2
James	Foster	132	22	Anacostia Watershed Society			4/14/2014	letter	Does not support size reduction of Potomac Tunnel at expense of reduced performance or extended schedule	Degree of Control	3.8.2
James	Foster	132	294	Anacostia Watershed Society			4/14/2014	letter	Use GI in the Anacostia. You are only spending GI money in wealthier sections of District. (Environmental Justice)	Implementation Strategies	8.21
James	Foster	132	295	Anacostia Watershed Society			4/14/2014	letter	If CD is modified to change the schedule, then argue to Include 1) moratorium on new post-2025 construction by sub-watershed until systems are fully operational 2) memorialize the 2022 accelerated date for the Anacostia tunnels to become operational; 3) Freeze other jurisdictions allocations at current levels until Consent Decree is completed; 4) Update plumbing codes to promote reuse of "grey water" in all jurisdictions; 5) set specific water conservation targets and milestones; 6) Requirement for other jurisdictions to store or reduce wet weather flow; 7) Assess rainwater diversion to Dalacarlia water treatment plant;8) A robust effort to eliminate illicit discharges and a plan for inspection and repair by 2025;9) NO DECREASE in percentage of captured storms should be proposed; 10) Funds to be provided for 3rd party evaluation by Plaintiffs; and 110 Much closer coordination on water between stakeholders and agencies such as DC Water, DDOE, DDOT, GSA, Interior, DOD, Virginia and Maryland.	Implementation Strategies	8.6.9, 8.22
James	Foster	132	370	Anacostia Watershed Society			4/14/2014	letter	The ratepayers of Washington DC should not be alone in having to pay for the solution. Use innovative techniques to engage Federal Government, Maryland, and Virginia as well as the District Department of Transportation	Rates/ Finance	4.5.1
James	Foster	132	371	Anacostia Watershed Society			4/14/2014	letter	Consider using Blue Plains for potable water supply, to increase flow to Anacostia, for irrigation in watershed and groundwater recharge	Implementation Strategies	8.18

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James	Foster	132	372	Anacostia Watershed Society			4/14/2014	letter	Consider one regional water authority to include DC Water, WSSC, Arlington, Alexandria, and Fairfax should be made for water, wastewater, and polluted runoff	Implementation Strategies	8.19
James	Foster	132	373	Anacostia Watershed Society			4/14/2014	letter	Look at flow reduction and smart technologies for reducing wastewater/stormwater flows	Implementation Strategies	8.20
James	Foster	132	418	Anacostia Watershed Society			4/14/2014	letter	Update analysis to reflect outdated flow and population projections, including climate change	Miscellaneous	9.15
James	Foster	132	419	Anacostia Watershed Society			4/14/2014	letter	Provide explanation of the tunnel system's redundancy in the event of catastrophic failure. Costs associated with operations and maintenance (O&M) need to be more fully explained. AWS has concerns that the operations and maintenance of the tunnel may result in additional discharges and lack of a backup system for the tunnels could result in large discharges that would continue for months or years. Long-term O&M costs may be substantially affected and what would render them unsustainable?	Maintenance	7.1, 7.5
James	Foster	132	439	Anacostia Watershed Society			4/14/2014	letter	Revise financial analysis incorporating benefits of alternative practices and water reuse	Rates/ Finance	4.1.6
James	Foster	132	459	Anacostia Watershed Society			4/14/2014	letter	AWS is opposed to extending the agreed-to schedule	Schedule	6.3.1
James	Foster	132	460	Anacostia Watershed Society			4/14/2014	letter	Separate Georgetown CSOs concurrent with tunnel construction, not at the end of the process	Schedule	6.6
James	Ploeser	133	236	Washington Interfaith Network	1435 Perry Pl NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jamie	Genevie	134	54	DC Water website			2/18/2014	comment form	In support of Green Infrastructure, schedule revision and DC Water's financial commitment. Would like to make sure GI is invested throughout the city too in addition to these two areas	General Support	11.1
Janet	Smith	135	152	Washington Interfaith Network	4740 Connecticut Ave NW #1017		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jean	Udo	136	231	Washington Interfaith Network	12308 Justice Place		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jeanne	Mayer	137	151	Washington Interfaith Network	3901 Cathedral Ave NW #116		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jeanne	Mayer	137	275	Washington Interfaith Network	3901 Cathedral Ave NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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Jeff	Pittman	138	243	Washington Interfaith Network	1613 Ballard Street		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jeffrey	Catts	139	87	Washington Parks & People			3/14/2014	email	Supports the proposal and revised schedule to use extensive green infrastructure	General Support	11.1
Jeffrey	Francisco	140	181	Washington Interfaith Network	4134 New Hampshire Ave NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jeffrey	Lenn	141	199	Washington Interfaith Network	211 Wilkes St		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jeffrey	Ruch	142	24	PEER			4/14/2014	letter	In order to justify changing the tunnel capacity requirements in the consent decree, D.C. Water must demonstrate that the modified plan will achieve equivalent or better performance at reducing the incidence and volume of CSOs as compared to the required minimum tunnel capacity.	Degree of Control	3.8.4
Jeffrey	Ruch	142	25	PEER			4/14/2014	letter	The GI spending cap approach is a proposal to avoid water quality-based performance criteria. This approach does not meet the terms for modification of the consent decree, and flouts EPA guidance. Replacing the current performance-based controls with a GI spending cap would substantially weaken the requirement to effectively operate and maintain the CSO controls and would be a clear violation of the Clean Water Act.	Nature of Commitment	2.1.5
Jeffrey	Ruch	142	26	PEER			4/14/2014	letter	A detailed plan for providing operation and maintenance on a continuous basis for all GI installations is missing. This would leave every one un accountable for the maintenance and operational needs of GI projects and facilities.	Maintenance	7.4.1
Jeffrey	Ruch	142	40	PEER			4/14/2014	letter	D.C. Water's "desktop" GI screening analysis merely claims that some type of GI plan could be deployed somewhere in the relevant sewersheds to reduce stormwater burdens. This GI screening analysis lacks sufficient detail needed to justify a modification of the consent decree.	General Opposition	10.5
Jeffrey	Ruch	142	440	PEER			4/14/2014	letter	we urge D.C. Water to redouble its effort to find ways of funding the LTCP that are equitable and affordable for financially vulnerable households, and at the same time, does not sacrifice water quality and public health risks. The efforts may include (a) securing additional funding from the Virginia and Maryland suburbs that send sewage to Blue Plains, (b) securing more federal funding, (c) expanding the Customer Assistance Program to identify tenants of multi-family buildings that do not receive bills from D.C. Water but may be directly impacted by rising bills, and (d) adopting revised rate structures that allocate costs more efficiently and equitably among various customer sectors.	Rates/ Finance	4.1.1, 4.5.3
Jeffrey	Ruch	142	463	PEER			4/14/2014	letter	Before advancing this proposal, D.C. Water must pause to assess and quantify all potential human health risks associated with the proposed seven-year delay for implementing the full LTCP for the Potomac River.	Schedule	6.7

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Jenkins	Rufaro	143	276	Washington Interfaith Network	1445 Shippen Ln SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jennifer	Chavez	144	466	American Canoe, AWS, DC Env Network, Friends of Earth, Kingman Park Civic Assoc, Potomac Riverkeeper, Sierra Club			4/14/2014	letter	D.C. Water must demonstrate that the modified plan will achieve equivalent or better performance at reducing the incidence and volume of CSOs as compared to the current requirement to provide minimum specified tunnel capacity	Degree of Control	3.8.4
Jennifer	Chavez	144	467	American Canoe, AWS, DC Env Network, Friends of Earth, Kingman Park Civic Assoc, Potomac Riverkeeper, Sierra Club			4/14/2014	letter	The proposal lacks specific green infrastructure controls and performance criteria to ensure D.C. Water will achieve equivalent or greater CSO reductions in lieu of tunnel capacity.	Nature of Commitment	2.1.3
Jennifer	Chavez	144	468	American Canoe, AWS, DC Env Network, Friends of Earth, Kingman Park Civic Assoc, Potomac Riverkeeper, Sierra Club			4/14/2014	letter	Any modified LTCP should include options for eliminating foreseeable overflows under average and wet design-years.	Degree of Control	3.12
Jennifer	Chavez	144	469	American Canoe, AWS, DC Env Network, Friends of Earth, Kingman Park Civic Assoc, Potomac Riverkeeper, Sierra Club			4/14/2014	letter	The proposal to substitute tunnel capacity with a green infrastructure spending cap is contrary to D.C. Water's NPDES permit, and may constitute backsliding.	Nature of Commitment	2.1.5
Jennifer	Chavez	144	470	American Canoe, AWS, DC Env Network, Friends of Earth, Kingman Park Civic Assoc, Potomac Riverkeeper, Sierra Club			4/14/2014	letter	Any modified consent decree must include a detailed plan for providing operation and maintenance on a continuous basis for all green infrastructure installations.	Maintenance	7.4.1
Jennifer	Chavez	144	471	American Canoe, AWS, DC Env Network, Friends of Earth, Kingman Park Civic Assoc, Potomac Riverkeeper, Sierra Club			4/14/2014	letter	The Proposal to Delay the Entire Long Term Control Plan Schedule Is Not Justified, and Lacks Needed Analysis of Other Affordability Options. Health risk associated with the proposed delay should be quantified and publicly disclosed. Delaying the entire LTCP schedule is not an appropriate strategy to address affordability issues relating to all of D.C. Water's programs.	Schedule	6.3.1, 6.3.5, 6.3.9, 6.7
Jennifer Becky	Chavez Hammer	145	329	Earth Justice/ Natural Resources Defense Council			4/3/2014	letter	The modified LTCP indicated unwarranted hesitancy in using GI for CSO control. This hesitancy on GI is unnecessarily blocking more tangible commitments to meaningful criteria against which the performance of proposed CSO control alternatives should be judged. There is substantial evidence that a wholehearted commitment to a GI approach (a level of commitment that is not yet evident in the Modified LTCP) could wind up with the best of both worlds: better net environmental outcomes at a lower net cost.	Nature of Commitment	2.1.11

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Jennifer Becky	Chavez Hammer	145	360	Earth Justice/ Natural Resources Defense Council			4/3/2014	letter	I believe it is valuable to break down the uncertainties in widespread application of GI in an urban environment into three distinct categories: engineering performance, planning, and cost. A credible plan would, first, resolve those uncertainties on GI to the greatest extent possible. For those uncertainties that remain, the plan should lay out specific strategies to address each in turn, rather than use them to simply avoid committing to concrete performance targets.	Nature of Commitment	2.1.6
Jennifer Becky	Chavez Hammer	145	361	Earth Justice/ Natural Resources Defense Council			4/3/2014	letter	Based on the current, relatively low level of analysis, the hesitancy to commit to anything beyond a fixed dollar outlay is understandable but unacceptable. A modestly greater upfront outlay of planning funds, trivial in the context of future capital costs, will provide DC Water, regulators, and ratepayers alike with a far greater degree of confidence in what can be achieved and how much will be spent (and/or saved) to achieve it.	Nature of Commitment	2.1.9
Jennifer Becky	Chavez Hammer	145	362	Earth Justice/ Natural Resources Defense Council			4/3/2014	letter	DC Water's GI unit costs are too high. DC Water should us a more comprehensive and sophisticated treatment of costs rater than using unit costs – like considering cost reductions as a result of GI.	Implementation Strategies	8.13
Jennifer Becky	Chavez Hammer	145	363	Earth Justice/ Natural Resources Defense Council			4/3/2014	letter	Community acceptance is probably the biggest unknown facing the implementation of this plan. Investing significant resources in public education and community outreach, and there is an existing record amongst multiple jurisdictions about the necessary magnitude and resulting outcomes of such efforts	Implementation Strategies	8.14
Jennifer Becky	Chavez Hammer	145	364	Earth Justice/ Natural Resources Defense Council			4/3/2014	letter	DC Water is not proposing real adaptive management because you are not generating hypotheses and designing monitoring experiments. DC Water's proposed approach will generate almost no new information that isn't already known.	Implementation Strategies	8.15
Jennifer Becky	Chavez Hammer	145	455	Earth Justice/ Natural Resources Defense Council			4/3/2014	letter	There's no basis for a schedule extension other than community acceptance of large scale GI. This can be overcome with public education and outreact	Schedule	6.3.4
Jennifer Becky	Chavez Hammer	145	456	Earth Justice/ Natural Resources Defense Council			4/3/2014	letter	Time needed to optimize green infrastructure performance has been offered as one of the reasons for schedule extension. What does "optimizing performance" really mean and how would it be accomplished? If it is to perfect the design of individual facilities based on lessons learnt, even from one's own experience, there is nothing to suggest that the lessons will be so profound as- to rewrite the findings of the last several decades, or to alter the specification now embodied in national and regional design manuals available from all over the country, or to require multiple additional years to digest.	Schedule	6.8
Jerimiah	Sanders	146	330		2021 Rosedale Street NE		1/21/2014	email	Green infrastructure should support conventional infrastructure and not necessarily act as a pure replacement. Until the District can get more concrete evidence, the tunnels should be built as originally intended and should be supported by green infrastructure.	Degree of Control & Implementation Strategies	3.8.1, 8.1.1
Jerimiah	Sanders	146	331		2021 Rosedale Street NE		1/21/2014	email	If the District is serious about greening the watershed, any major green infrastructure endeavor would consider eliminating RFK's North lot. The amount of unused pavement has an extremely negative impact on the watershed.	Implementation Strategies	8.21
Jesse P	Achtenberg	147	358		627 Quebec Pl NW	Washington, DC 20010	3/22/2014	survey monkey	I strongly support any commitment to green infrastructure that will reduce runoff and strain on the DC sewer systems. However, it's not at all clear from the information here and that was mailed to customers, how this will be achieved. What lands will this GI be added to? Does it require buy-in from landowners? How can DC WASA guarantee that improvements can actually be made? And will the GI have the same statistical effect as the originally-proposed tunnel?	Maintenance	7.4.7

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Jessica	Kirschner	148	290	Washington Interfaith Network	1235 S St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jimar	Abererbre	149	85				3/13/2014	comment form	In support of Green Infrastructure	General Support	11.1
Joanna	London	150	158	Washington Interfaith Network	3940 Langley Ct. NW #E635		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Joe	Takacs	151	80		437 Manor Place NW Apt 2		3/7/2014	survey monkey	I think it is a strong move to include GI in this plan as it would not only help lower the cost but also help improve both the environment visually but physically as well	General Support	11.1
John	Amanda	152	27	Potomac Conservancy			4/14/2014	letter	The proposal must incorporate water quality-based performance standards and metrics by which to evaluate reductions equivalent to what would be achieved by the current tunnel-based approach.	Nature of Commitment	2.1.3
John	Amanda	152	376	Potomac Conservancy			4/14/2014	letter	Yes, Potomac Conservancy supports DC Water's financial investment in Green Infrastructure but feels there is insufficient information to secure stakeholder confidence in the implementation strategy.	Implementation Strategies	8.23
John	Amanda	152	377	Potomac Conservancy			4/14/2014	letter	Potomac Conservancy calls on DC Water to develop an actionable plan with performance criteria, hard targets, for CSO reductions that can be measured and assessed on a regular two year milestone schedule leading up to the 2025 LTCP deadline.	Nature of Commitment	2.1.4
John	Amanda	152	378	Potomac Conservancy			4/14/2014	letter	Alternative financing mechanisms must be employed to avoid a seven year delay in the completion of the long term control plan	Rates/ Finance	4.1.3
John	Amanda	152	379	Potomac Conservancy			4/14/2014	letter	Address the issue of inequity when it comes to charging all DC Water ratepayers, residents and businesses, for the ancillary benefits associated with green infrastructure only in the NW portion of the city. Grant at least $30 million of dedicated funding to be administered by the District Department of Environment for Green Infrastructure projects in wards 7 and 8 along the Anacostia River in order to balance the inequity of ancillary benefits under the proposed LTCP for Northwest communities. This can be raised through alternative financing mechanisms and by consistent with the Sustainable DC Plan timeline. AND/OR 2) Offer on-bill financing opportunities to ratepayers in the SE portion of the city to offer rebates and reductions that can be dedicated to and encourage the installation of green infrastructure on their residential properties and promote substantial enrollment.	Rates/ Finance	4.3
John	Amanda	152	420	Potomac Conservancy			4/14/2014	letter	Adaptive management must account for timely enhancements to the GI Plan, not just post-construction monitoring at the end of LTCP implementation	Miscellaneous	9.16
John	Amanda	152	464	Potomac Conservancy			4/14/2014	letter	No, Potomac Conservancy does not support the proposed seven year deadline extension but commends DC Water on its accelerated CSO reductions ahead of the existing LTCP schedule. This deadline can be hit with proper planning and a financial burden on ratepayers can be alleviated through alternative financing.	Schedule	6.3.1, 6.3.8
John	Craig	153	317	Paradigm Environmental	3301 Saddlestone Court		4/15/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1

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John	Ferris	154	56	Endpoint Solutions Corp.	12065 W Janesville Rd		2/19/2014	email	Support modification of LTCP to include GI. Back in October 2013, we demonstrated through Design Challenge submittal that GI would cost approximately 1/10th the cost of the construction of tunnel. Further, in January 2013 we submitted the results of pilot study on the Bloomingdale Neighborhood that demonstrated that our GI system of permeable pavement and stormwater trees/planters could relieve the frequent flooding in the Bloomingdale Neighborhood	General Support	11.1
John	Ferris	154	57	Endpoint Solutions Corp.	12065 W Janesville Rd		2/19/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
John	Murphy	155	105				4/6/2014	comment form	Support GI, schedule and financial commitment.	General Support	11.1
Jonah	Blank	156	255	Washington Interfaith Network	2235 Q Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Jonathan	Jarvis	157	79	Director, US Department of Interior Park Service			3/6/2014	letter	Writing to express strong support for DC Water's proposed LTCP Modification for Green Infrastructure. NPS recognizes that some of proposed GI projects may require either temporary or permanent use of NPS lands and we look forward to collaborate with DC Water. It is our hope that EPA supports this proposal.	General Support	11.1
Jose	Sanchez	158	118	Washington Interfaith Network	1822 Harvard Street, NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Sanchez	Jose	158	278	Washington Interfaith Network	1822 Harvard St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Judith	Brace	159	452				3/17/2014	email	I think the Green Infrastructure plan is the obvious way to meet increased service demands in the coming years. I'm concerned that the "end dates" are so far down the line, that costs will have possibly doubled or tripled by then, and the budget will be inadequate. Moving the "completion" date forward might avoid this problem, while creating more jobs.	Schedule	6.9
Julia	Doherty	160	263	Washington Interfaith Network	1346 Leegate NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Julia	Hustwit	161	209	Washington Interfaith Network	1620 Fuller Street NW #503		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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Kamika	Barnes	162	123	Washington Interfaith Network	5351 C Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Kara	Koehrn	163	102	US EPA	6141 Veemac Ave	Washington, DC 20009	3/31/2014	survey monkey	I heard about this at the environmental film festival. Thanks so much for the opportunity to comment!	General Support	11.1
Karen	Garrett	164	180	Washington Interfaith Network	3900 Watson Place NW #2E		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Karen	Laney	165	453		1238 Duncan Pl Ne		3/17/2014	survey monkey	I support the green infrastructure initiative but encourage an implementation plan that is more aggressive than the 2032 date. Thank you.	Schedule	6.3.1
Karrye	Braxton	166	36	ANC 4A Chair			3/13/2014	letter	ANC 4A Resolution in Opposition to WASA's Proposal to Modify the Consent Decree to lessen its duties pertaining to the construction of Ward 4's Rock Creek and Piney Branch Tunnel. ANC 4A voted five in favor with one opposed to 1) oppose the Long Term Control Plan Modification Request; 2) support the testimony provided by Commissioner Black (ANC 4A08) on February 20, 2014 public meeting; and 3) advise DC, the Dept. of Justice, EPA and the DC Attorney General that it believes it is in the public interest to abide by the terms set forth in the current consent decree, without modification.	General Opposition	10.3.1, 10.3.2
Katherine	Touzinsky	167	62				2/20/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment - "Green" by nature is resilient system so I am supportive	General Support	11.1
Kathy	Bovello	168	291	Washington Interfaith Network	4515 Willard Ave		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Kathy	Keler	169	153	Washington Interfaith Network	3530 39th Street NW #B		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Keitha	Cole	170	30				4/14/2014	email	I love what you're doing. I'm doing a project for my Probability and Statistics class, and need to know what gray infrastructure alone would save CSOs in billions of gallons, and how much more or less it would cost more than green infrastructure.	Degree of Control	3.10
Kenisha	Scott	171	206	Washington Interfaith Network	1433 T Street NW #103		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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Kenithia	Alston	172	250	Washington Interfaith Network	2507 Southern Ave #301		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Kevin	Oakley	173	244	Washington Interfaith Network	6114 42nd Place		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Kiara	Ford	174	188	Washington Interfaith Network	2601 Douglas Rd SE #102		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Kristen	Kane-Osorto	175	130	Washington Interfaith Network	28 Seaton Pl NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Kristin	Einberger	176	35		11 Black Duck Ct.		3/11/2014	survey monkey	As a concerned visitor to Rock Creek Park on many occasions, I urge DC Water to construct the temporary holding tunnel under the Piney Branch Tributary. I see this green infrastructure plan as a stalling tactic by your organization. The underground storage tunnels have been proposed for decades, and now that the EPA has told DC Water to implement them, its time for DC Water to follow orders."	General Opposition	10.3.1
Kyle	Lefler	177	171	Washington Interfaith Network	1236 Harvard St NW #1		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
LaLinda	Street	178	197	Washington Interfaith Network	8807 Worsley Court		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Larry	Martin	179	434				1/26/2014	email	Provide an operating plan for the tunnels that details operating costs with regard to pumping water from the tunnels to the WTP and the energy requirement for treatment of water per unit? It would be satisfactory to base costs on average annual capture per tunnel.	Rates/ Finance	4.4
Larry	Slagle	180	149	Washington Interfaith Network	208 6th St SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Lauren	Tarves	181	307		5505 7th Street NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1

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Lauren	Hovis	182	144	Washington Interfaith Network	3460 14th St NW #157		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Laurna	Strikwerda	183	169	Washington Interfaith Network	1390 Kenyon St NW #80		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Letty	Limbach	184	94		5226 Chevy Chase Pkwy NW		3/20/2014	survey monkey	I have not seen arguments against the Green Infrastructure Plan but based on what I have so far seen, I believe the Green plan is worthy of supporting	General Support	11.1
Liliana	Maldonado	185	297	CH2MHILL			4/14/2014	letter	The DC Clean Rivers Project holds great promise for our region's future as an example of environmental stewardship and responsible infrastructure management – values we enthusiastically endorse	General Support	11.1
Linda	Guild	186	205	Washington Interfaith Network	1600 Maryland Ave NE #265		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Linda	Lader	187	310		1313 New York Ave NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Linda	Silversmith	188	172	Washington Interfaith Network	7750 16th Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Lindsay	Lucke	189	71		5861 Nebraska Ave. 20015		2/24/2014	email	I want to express my support for the proposed changes to the stormwater management plan.	General Support	11.1
Lindsay	Lucke	189	424		5861 Nebraska Ave		2/11/2014	survey monkey	Indefinitely favor substituting low-tech, high-labor solutions for high-capital ones. I'm not sure about the timing, so didn't respond to question 3. $100M is a small percentage of the total committed for solving this problem. Can't we put more into it?	Nature of Commitment	2.2.2
Lisa	Friedman	190	88		4441 Harrison St NW		3/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Lisa	Maria	191	91	DC Building Industry			3/18/2014	survey monkey	Support GI. It is our hope that DC Water will work with DC Council and Mayor to develop incentives for the development community to make the GI a reality	General Support	11.1
Lisa	Schamess	192	348		1349 Newton Street NW		2/28/2014	survey monkey	I am especially enthusiastic about the direction DCWASA is taking. This is leadership, and I endorse it. I hope that DCWASA will work with the DC government on ways to support (through training and incentives) private clients for supportive actions such as green roofs and rain gardens on private property.	Maintenance	7.4.6
Lorita	Miller	193	224	Washington Interfaith Network	122 Big Chimney Branch		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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Lorraine	Miller	194	190	Washington Interfaith Network	75 54th Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Madhusudan	Joshi	195	42		13722 Engleman Drive		1/17/2014	survey monkey	This is good alternate plan using green infrastructure as an added benefit and in combination with gray plan	General Support	11.1
Majeed	Warees	196	409	7-DO4			3/5/2014	comment form	Support GI, schedule and financial commitment. Concerned about commitment on development of local talent on GI employment	Miscellaneous	9.7.2
Malcolm	Kelly	197	17		1245 33rd St NW	Washington, DC 20007	3/24/2014	survey monkey	The GI proposal means that sewage will continue to overflow into the Potomac from at least 3 pipes that will not have storm water and sewage separated. Can you please let me have an estimate for the flows from the three pipes that would not be separated under the current Green Infrastructure proposal?	Degree of Control	3.9
Marcia	Finn	198	303		1202 Kennedy St, NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Marcus	Loute	199	210	Washington Interfaith Network	1620 Fuller Street NW #503		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Marean	Duarte	200	235	Washington Interfaith Network	1380 Monroe St #537		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Margaret	Missiaen	201	322		647 S Carolina Ave		2/21/2014	survey monkey	Support GI. It is difficult to see runoff reduction unless home owners discouraged from adding impervious areas to their properties. This would have to be done through building permit office	Implementability	5.2
Margaret	Myers	202	314		1701 Irving St NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Margaret	Schroeder	203	92		4705 Quebec St NW		3/18/2014	survey monkey	Support proposed plan over existing	General Support	11.1
Marianne	Anderson	204	196	Washington Interfaith Network	1224 Michigan Court		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Marsha	Lyons	205	142	Washington Interfaith Network	1333 New Hampshire Ave NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Martin	Dickinson	206	274	Washington Interfaith Network	2209 Hall Pl NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Mary	Boylen	207	289	Washington Interfaith Network	60 Underwood Pl NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Mary	Cheh	208	321	DC Council	1350 Pennsylvania Ave NW	Washington DC	2/18/2014	letter	While the proposal may bring about some incremental reductions sooner, the overall schedule extension would mear that major sewage discharges will occur well beyond 2025. Delay is not our only concern. DC Water's lack of experience with GI on this scale, and given the uncertainties involved in using green infrastructure to curb sewage discharges, it is crucial that the proposal be given a full and independent review.	Implementability	3.8.3
Mary	Holcomb	209	163	Washington Interfaith Network	745 Hilltop Ter SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Mary	Pate	210	141	Washington Interfaith Network	3119 38th St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Mary	Rollefson	211	100	Encore Garden Design	4515 Q ST NW	Washington, DC 20007	3/26/2014	survey monkey	I'm thrilled that Dc Water is taking this approach. There is so much to learn about the effectiveness of GI and I look forward to learning about it as this project goes forward. Yeah George Hawkins!!!!	General Support	11.1
Maryam	Clark	212	286	Washington Interfaith Network	2855 Bladensburg Rd NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Matt	Fleischer	213	28	Rock Creek Conservancy			4/14/2014	letter	DC Water must present clearly defined and enforceable performance criteria, on a site specific basis, which will yield equal or more substantial benefits	Nature of Commitment	2.1.1
Matt	Fleischer	213	380	Rock Creek Conservancy			4/14/2014	letter	DC Water must have written and enforceable commitments from DC government that its agencies' responsibilities for ownership, operations, and maintenance of any projects on public space are clearly delineated and that supporting funding will be appropriated.	Implementation Strategies	8.6.6
Matt	Fleischer	213	381	Rock Creek Conservancy			4/14/2014	letter	DC Water must incorporate lessons learned through pilot and other green infrastructure programs to add sufficient details to each specific project. This will help writing contracts with enforceable accountability and DC Water will be able to accurately predict the costs that will be incurred	Nature of Commitment	2.2.4

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Mayor Vincent	Gray	214	49	DC Mayor			1/31/2014	letter	Support DC Water's proposed modification and strongly support the commitment to green infrastructure improvements. We understand that the feedback from EPA and stakeholders and the experiences on the previously explored pilot program to test the GI practices was the basis behind this revised plan to include an upfront commitment of $100 million on GI and sewer separation. If the CSO controls are not performing adequately during post construction monitoring, DC water will have to evaluate the effectiveness of CSO controls and develop a plan to meet water quality standards.	General Support	11.1
Meghan	Stevenson	215	247	Washington Interfaith Network	9905 Campus Way South		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Melinda	St. Louis	216	260	Washington Interfaith Network	1340 Fairmont St NW #22		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Melissa	Rosenblart	217	221	Washington Interfaith Network	1613 Ballard Street		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Merchant	Wentworth	218	19	Wentworth Green Strategies	903 Hamlin St		4/11/2014	letter	Original LTCP included $3 million for GI pilot projects at DC Water facilities to investigate how such projects might reduce runoff. We eagerly await the results of those projects.	Miscellaneous	9.14
Merchant	Wentworth	218	20	Wentworth Green Strategies	903 Hamlin St		4/11/2014	letter	DC Water must include site specific performance criteria to better measure the effectiveness of GI projects and to ensure that DC Water meets LTCP water quality goals and water quality standards	Degree of Control	2.1.1
Michael	Anderson	218	129	Washington Interfaith Network	705 7th Street NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Michael	Wilker	218	285	Washington Interfaith Network	226 E Capitol St NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Merchant	Wentworth	218	366	Wentworth Green Strategies	903 Hamlin St		4/11/2014	letter	DC Water should take action to protect ratepayers by reducing capital costs, extending the deadlines, canceling the Piney Branch Tunnel, and building the shortened Potomac Tunnel. In addition, DC Water should investigate new funding sources such as creating new rate classes and increasing charges for the use of Potomac Interceptor.	Implementation Strategies	8.17

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Merchant	Wentworth	218	367	Wentworth Green Strategies	903 Hamlin St		4/11/2014	letter	DC Water should resolve questions of ownership and long term maintenance and operation by working with DC Council to craft enabling legislation to delineate roles and responsibilities coupled with milestones and goals between DC Water, DDOT and DDOE.	Implementation Strategies	8.6.6
Merchant	Wentworth	218	368	Wentworth Green Strategies	903 Hamlin St		4/11/2014	letter	Over the long term, DC Water should work to relieve capacity in the Potomac Interceptor, institute aggressive water conservation projects throughout the region tributary to the interceptor, provide support for DDOT and DDOE to implement the stormwater regulations and reduce runoff, and renegotiate the IMA and the charges for the Potomac Interceptor to more fairly allocate the costs of CSO controls to the entire region that will benefit by a cleaner Potomac.	Implementation Strategies	8.6.8
Merchant	Wentworth	218	457	Wentworth Green Strategies	903 Hamlin St		4/11/2014	letter	DC Water should prioritize near term projects to protect public health and the environment particularly around areas of known public contact such as the boat houses along the Potomac River and Georgetown Waterfront. Deadlines must only be extended if site specific performance criteria are instituted to ensure reductions are gained.	Schedule	6.6
Michele	Jacobson	221	357				3/17/2014	email	Slowing traffic and using porous cobblestone as pervious pavement material, will not only help absorbing water but also improve livability on the historic places around drainage areas CSO 025 and 026.	Implementability	5.5.9
Michelle	Stepney	222	185	Washington Interfaith Network	2601 Douglas Rd SE #102		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Mike	Henriques	223	32				2/19/2014	email	Do both grey and green. If you can't do both, do what is proven which I believe is full potomac tunnel. The risk is too high to gamble with experiments. We need clean, swimmable rivers around our capital city	General Opposition	10.1
Mike	Marsjanik	224	461	Hazen Sawyer			4/14/2014	letter	The $ 2.6 billion Clean Rivers project is a once in a generation investment that has already placed a large financial obligation on DC Water ratepayers. A relatively short extension of the schedule for portions of the project will help alleviate some of the financial burden on rate payers by reducing the scale of future rate increases.	General Support	11.1
Mitchell	F	225	182	Washington Interfaith Network	18 6th Stree SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Monica	Krause	226	267	Washington Interfaith Network	5130 Connecticut Ave #507		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Myles	Smith	227	292	Kennedy Street Development Assoc			4/13/2014	email	Pleased to inform KSDA has endorsed DC Water's Green Infrastructure plan, and believe that the added benefits of GI far outweigh any costs associated with the change in strategy and the longer timeframe. We would like to emphasize that our support from this project stems from the likely improvements to the business climate that would result from GI installations along Kennedy Street that would improve the environmental, aesthetic, and uniqueness of the street.	General Support	11.1

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Nancy	Daugherty	228	178	Washington Interfaith Network	3100 Connecticut Ave NW #145		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Nathan	Andrews	229	112	NACWA General Counsel	1816 Jefferson Place NW		4/10/2014	letter	Supports GI, schedule and financial commitment. At the outset, NACWA notes that DC Water's proposed approach to incorporating GI into its LTCP and consent decree is supported by EPA's recently issued GI guidance	General Support	11.1
Neal	Sofge	230	215	Washington Interfaith Network	1900 Lyttonsville Rd #416		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Nicola	Whiteman	231	338	Apartment & Office Building Association			1/22/2014	meeting	Would like stronger incentives for reducing Impervious Area Charge. Consider construction impacts and coordinate work accordingly.	Maintenance	7.4.5
Norman	Kelley	232	133	Washington Interfaith Network	PO Box 33983		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Ola	Barnes	232	136	Washington Interfaith Network	5351 C Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
P	Fletcher	234	67	ITT Tech			2/21/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment	General Support	11.1
Pamela	Coukos	235	245	Washington Interfaith Network	7403 Baltimore Ave		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Pamela	Moore	236	14	Citizens Association of Georgetown			3/13/2014	letter	There is uncertainty over whether abatement of overflows from CSO outfalls 027 and 028 will be achieved through Green Infrastructure, or by capital projects, i.e., a 'gray' solution.	Degree of Control	3.8.1
Pamela	Moore	236	15	Citizens Association of Georgetown			3/13/2014	letter	Unless monitoring data is presented for fecal coliform and Escherichia coli values for overflows from the six Georgetown CSO outfalls into the Potomac River, we are unable to assess the potential effect on public health from either an acceleratior or delay in abating discharges from these overflows.	Schedule	6.1
Pamela	Moore	236	323	Citizens Association of Georgetown			3/13/2014	letter	Georgetown residents on O and P streets (within the catchment area of CSO 027) recently experienced many months of disruption as these two historic streets were excavated and totally reconstructed at a cost of $12 million dollars. The willingness of residents of west Georgetown to endure disruption of an even greater scale would depend on DC Water's demonstrating of effectiveness on pervious pavement	Implementability	5.3

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Pamela	Moore	236	324	Citizens Association of Georgetown			3/13/2014	letter	The two combined sewers between Georgetown University and Wisconsin Ave are likely among the oldest in the city, probably between 110 and 130 years old. Their condition is surely fragile and failing. A large-scale construction project to install pervious pavement followed by another large-scale construction to replace failing combined sewers beneath the pervious pavement will not reflect good government, or good engineering.	Implementability	5.4
Pamela	Moore	236	325	Citizens Association of Georgetown			3/13/2014	letter	Installation of rain barrels infront of building, or a sideyard, could be disapproved by Old Georgetown Board, and Commission of Fine Arts due to the historical character of Georgetown	Implementability	5.5.1
Pamela	Moore	236	326	Citizens Association of Georgetown			3/13/2014	letter	Unsure of using brick as a pervious surface and provided no information on its permeability. Nearly all Georgetown sidewalks are brick. The proposed replacement of brick sidewalks in residential areas with another type of pavement could be disapproved by the Old Georgetown Board and the U. S. Commission on Fine Arts due to the historical character of Georgetown	Implementability	5.5.2
Pamela	Moore	236	327	Citizens Association of Georgetown			3/13/2014	letter	If pervious pavement was installed, DDOT may need to identify steps to avoid having Georgetown streets and sidewalks become inherently more dangerous or impassable during future winters. Reference is lacking to DC Water contacting the DC Attorney General on a property owner's liability for leaving a sidewalk ice or snow covered because melting agents and abrasives are prohibited	Implementability	5.5.3
Pamela	Moore	236	350	Citizens Association of Georgetown			3/13/2014	letter	As impervious clay is the prevalent subsoil in our area, underdrains are likely to be essential in Georgetowı	Implementability	5.5.7
Pamela	Moore	236	351	Citizens Association of Georgetown			3/13/2014	letter	The construction and alignment of the relief interceptor sewer is noted to have little or no impact on the Georgetown Waterfront Park. However, construction could affect plans to establish a streetcar line down this corridor, and should be coordinated with DDOT.	Implementation Strategies	8.6.7
Pamela	Moore	236	392	Citizens Association of Georgetown			3/13/2014	letter	Rain barrels require regular dewatering and occasional maintenance. Water level measurements taken by MWCOG staff indicated that, on average, rain barrels remained 60% full, greatly reducing their overall effectiveness.	Maintenance	7.4.9
Pamela	Moore	236	393	Citizens Association of Georgetown			3/13/2014	letter	Rain barrels can become breeding sites for mosquitoes which could lead to threat of serious disease. We believe community acceptance as well as willingness to install, rain barrels would be aided by DC Department of Health assessment of the degree of risk, and an identification of practical actions available for eliminating it. In winter, rain barrels may be recommended to be disconnected from downspouts when freezing temperatures occur. Disconnection will either have the roof runoff sent into the combined sewer will flow onto the sidewalk, where it may potentially ice over.	Maintenance	7.4.9
Pamela	Moore	236	394	Citizens Association of Georgetown			3/13/2014	letter	In winter, rain barrels may be recommended to be disconnected from downspouts when freezing temperatures occur. Disconnection will either have the roof runoff sent into the combined sewer will flow onto the sidewalk, where it may potentially ice over.	Maintenance	7.4.9
Pamela	Moore	236	412	Citizens Association of Georgetown			3/13/2014	letter	The draft Modification plan does not categorize the age, current condition, mode of construction, or future service life of the combined sewers with outfalls 027, 028, and 029. An explanation for why these three combined sewers in east Georgetown have minimal overflows into Rock Creek, when contrasted to the very large overflows from west Georgetown into the Potomac River, would help our understanding of the need for major investment to correct overflow problems in our community.	Miscellaneous	9.8

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Pamela	Moore	236	413	Citizens Association of Georgetown			3/13/2014	letter	Characterize the extent of any infiltration/inflow in the areas between Georgetown University and Wisconsin Ave. and describe its impact on DC Water's choice of abatement strategies and methods for overflows from CSO 027 and 028.	Miscellaneous	9.9
Pamela	Sparr	237	220	Washington Interfaith Network	1308 Elson Place		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Patricia	Absher	238	109			4119 Military Rd NW	4/8/2014	email	We support the Green Infrastructure and the schedule for implementing it in 2014. This seems like a good plan to reduce the storm runoffs and pollution of our rivers	General Support	11.1
Patricia	Cummings	239	98		4431 Harrison St NW	Washington, DC	3/23/2014	survey monkey	Support GI, schedule and financial commitment.	General Support	11.1
Patricia	Johnson	240	154	Washington Interfaith Network	3318 Fessenden St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Patricia	Withers	241	306		5505 7th St. NW		4/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Paul	N	242	63	ITT Tech			2/21/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment	General Support	11.1
Paul	Williams	243	454	ShootFirst Pictures	7417 14TH Street NW	Washington, DC 20012	3/24/2014	survey monkey	Right On! Do not support schedule	Schedule	6.3.1
Paula	Arroyo	244	69				2/21/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment	General Support	11.1
Paula	Lancastler	245	225	Washington Interfaith Network	4809 Briercrest Ct		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Paulett	McIntosh	246	248	Washington Interfaith Network	9720 Country Meadows Lane #1D		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Peter	Bishop	247	61	Washington Interfaith Network			2/20/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment - reducing financial impact is important, also more local jobs is very good	General Support	11.1
Peter	Dowty	248	212	Washington Interfaith Network	4500 Mass Ave NW #98		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Peter	Ensign	249	96	DC GreenWorks			3/21/2014	letter	This letter is to voice support for DC Water's proposed modification to the Clean Rivers Project, which was published for public comment on January 12, 2014. We strongly support DC Water making a financial commitment to green infrastructure. We support allowing DC Water additional time to implement the plan to include a significant investment in Green Infrastructure.	General Support	11.1
Peter	Ensign	249	431	DC GreenWorks			1/22/2014	meeting	Concerned about affordability for ratepayers.	Rates/ Finance	4.1.1

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Phil	Menderson	250	13	DC Council			3/12/2014	letter	Declare support for DC Water's proposal to incorporate green infrastructure, provided that there is assurance of the same or greater reductions in the volume and incidence of CSOs in to waterways as provided in existing LTCP	Degree of Control	3.8.1, 3.8.3
Phil	Mendelson	250	18	MWCOG			4/10/2014	letter	COG endorses inclusion of green infrastructure in DC Water's long-term control plan provided that there is assurance of it to achieve same or greater CSO reduction	Degree of Control	3.8.1
Rachel	Johnson	251	271	Washington Interfaith Network	809 Juniper St #301		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Ralph	Cyrus Jr.	252	228	Washington Interfaith Network	10004 Tranverse Way		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Ramos	Nadine	253	288	Washington Interfaith Network	1206 N Livingston St		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Rebecca	Gibbons	254	280	Washington Interfaith Network	475 K St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Rebecca	Lenn	255	201	Washington Interfaith Network	2727 S Quincy St #1010		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Reeve	Tyndall	256	257	Washington Interfaith Network	1301 15th St. NW # 217		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Reggie	Govan	257	39		3311 Ross Place, NW	Washington, DC 20008	4/4/2014	survey monkey	Simply put, I support the original plan. There is a lot more wealth in the metropolitan area than ever before and, thus, there is no reasonable reason why the metropolitan area cannot afford the investment envisioned by the original plan. Thank you.	General Opposition	10.3.3
Renata	Lana	258	81		3605 13th St. NW		3/9/2014	survey monkey	Green infrastructure is an excellent investment for cleaner water and should be supported	General Support	11.1
Rene	Rodriguez	259	66	ITT Tech			2/21/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment	General Support	11.1

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Rita	Miller	260	192	Washington Interfaith Network	730 46th Street SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Rizwan	Siddiqui	261	90	EBA			3/17/2014	survey monkey	Support GI, schedule and financial commitment.	General Support	11.1
Robert	Boursighoty	262	204	Washington Interfaith Network	1455 B North Van Dorn Street		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Robert	Carr	263	33		5426 39th St. NW		3/10/2014	survey monkey	Description of plan seems to consist only of the word GREEN, and dollars and dates. All descriptions of the actual project seem abstract and unintelligible. I suspect it's all a sham, otherwise why such secrecy and opacity?	General Opposition	10.2
Robert	Eigen	264	51	Friends of Georgetown Waterfront			2/4/2014	letter	Strongly endorses DC Water's proposal to reduce the size of the planned underground tunnel along the Potomac River and install green infrastructure to capture slow and clean storm water. FOGWP supports the extension of the schedule and proposal to finance by DC Water. FOGWP believes the investment by DC Water in green infrastructure is in the public interest.	General Support	11.1
Robert	Eigen	264	328	Friends of Georgetown Waterfront			4/2/2014	letter	Support GI. Our concern springs from points recently made by Citizens Association of Georgetown. CAG's letter cautions the impact of existing consent decree approach if not properly modified "would be localized in the area of K and Water Streets NW, and potentially result in permanent, severe damage to Georgetown Waterfront Park." Please meet with us at your earliest convenience so that we may discuss our concerns	Implementability	5.6
Robert	Jayes	265	115	Washington Interfaith Network	4930 47th Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Robert	Johnsen	266	134	Washington Interfaith Network	4716 Ellicott St, NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Robert	McClinton	267	207	Washington Interfaith Network	91 New York Ave NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Robert	Nelb	268	240	Washington Interfaith Network	1211 7th Street NW #302		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

Table 1- Summary of Comments on "Long Term Control Plan Modification for Green Infrastructure"

First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Robert	Rutkowski	269	29		2527 Faxon Cort	Topeka, Kansas	4/14/2014	email	The new plan for preventing CSOs into the Potomac avoids taking steps needed to cure the problem. Green infrastructure, such as permeable sidewalks, rain gardens and green roofs, is laudable but will provide nowhere near the pollution relief of the tunnels. Buried in a plan appendix, D.C. admits that it cannot meet EPA mandated pollution limits for the Potomac and Chesapeake. "Green infrastructure should supplement not substitute for the tunnels."	Degree of Control & Implementation Strategies	3.8.1, 3.8.5, 8.1.1
Robert	Rutkowski	269	41		2527 Faxon Cort	Topeka, Kansas	4/14/2014	email	As PEER points out, the proposed plan 1) lacks any analysis of the public health effects associated with deferring additiona tunnels even though the delayed reductions affect some of D.C.'s most heavily used aquatic recreation areas; 2) does not even specify who will maintain the green infrastructure, from what source of funds or how its effectiveness will be measured; 3) has yet to develop a plan to equitably and affordably finance needed improvements or to mitigate and spread out potential water rate increases, especially for more vulnerable residents. District's own environmental agency had no role in preparing this plan purporting to tackle the City's major source of water pollution.. This plan represents a form of public corruption that puts the health of District residents at risk.	Rates / Financial, Schedule, Maintenance, General Opposition	4.1.1, 4.1.2, 6.7, 7.2.1, 10.6
Robert	Sullivan	270	131	Washington Interfaith Network	3621 Newark St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Robert	Thompson	271	47		1519 C Street SE		1/26/2014	survey monkey	Support GI. Applaud DC Water's effort in providing a variety of multimedia resources to keep the general public well educated and updated on the Green Infrastructure (GI) proposal.	General Support	11.1
Roberta	Carroll	272	37		3514 Yuma St NW		3/13/2014	survey monkey	I do not believe the EPA has supported this plan for dealing with the sewer pipe reconstruction that should be taking place You are trying to control heavy rain water into the system and the roof gardens and permeable surface solutions are for steady low rain absorption. The only thing to stop flooding are new pipes and these other so called solutions do not work in major storms. Storms are getting stronger and heavier not lighter. Permeable surfaces only work on flat terrain not the hilly DC landscape and they need constant maintenance. Roof gardens would be heavy and can only absorb a limited amount of water.	Degree of Control & General Opposition	3.8.1, 10.4
Robin	Bvek	273	218	Washington Interfaith Network	28 Lee Avenue #100A		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Robin	Morey	274	316	Georgetown University			4/14/2014	email	Support GI, schedule and financial commitment. Look forward to collaborating with DC Water and District of Columbia to help achieve our shared sustainability goals	General Support	11.1
Roger	Lovett	275	147	Washington Interfaith Network	1645 Fort Davis Pl SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Roland	Gilmore	276	46				1/25/2014	email	Your city is on the right track and that the attitude of groups calling themselves environmental or amenity campaigners will change if they educate themselves and get up to speed with modern technology and the low risk methodologies inherent with green solutions (compared to high risk tunneling) together with acknowledging and costing the benefits properly.	General Support	11.1
Rolland	Smith	276	269	Washington Interfaith Network	111 Lee Ave #209		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Roland	Gilmore	276	340				1/25/2014	email	The big question with this approach is who pays. It requires a fundamental shift in charges for sewerage services to a more equitable system based upon the established legal principal that "the polluter pays". Washington DC has higher precipitation which leads to rainwater run off to be larger proportion of "waste" water. The environmental and monetary cost of treating that rainwater must also be considered. It may be possible to base charges on impermeable area. This will incentivise property owners to reduce charges through conversion of roofs, driveways etc. to green roofs, permeable paving and/or rainwater harvesting for uses such as flushing toilets and garden irrigation.	Implementation Strategies	8.3
Roland	Gilmore	276	341				1/25/2014	email	The Highways Department to play a significant role since highways make up a high proportion of impermeable area discharging to the combined sewers. Dependent on geology, rainwater run off can be infiltrated to ground, diverted into rain gardens and vegetated bump outs, street trees or other vegetated installations. Another technique is shallow reconstruction of roads (above utilities). Lining the excavation with an impermeable membrane protected by geotextile forms a detention tank. Use of porous asphalt or permeable paving on a high void aggregate base allows rainwater falling on the road to be captured, collected by perforated pipe and discharged slowly through an attenuator, designed so as not to overload the sewers.	Implementation Strategies	8.4, 8.6.2
Ron	Lewis	278	76	ANC Commissioner 2E			3/5/2014	letter	ANC 2E support the concept of viable alternatives to construction and disruption in Georgetown waterfront area caused by the original plan for a storage tunnel.	General Support	11.1
Ron	Lewis	278	349	ANC Commissioner 2E			3/5/2014	letter	DC Water should explore further the implications of new proposal to construct parallel sewer lines between C&O Canal and K Street NW.	Implementation Strategies	8.9
Rose	Berger	279	450	Homeowner	1131 Fairmont Street NW		3/16/2014	survey monkey	I am fully in support of adopting the Green Infrastructure initiatives. I am very pleased at the extensive involvement of DC Water, EPA, and civil society groups in creating this initiative. However, the timeline is too extended. It needs to be shaved off by at least 10 years. Rock Creek tunnel should be completed by 2022 and the Potomac tunnel by 2025. These must be accelerated projects. Climate change, citizen health, and economic benefits demand accelerated action.	Schedule	6.3.3
Ryan	Gibbons	280	287	Washington Interfaith Network	475 K St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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First Name	Last Name	Commenter No.	Comment No.	Affiliation	Address 1	Address 2	Date	Forum	Comment	Category	Response No.
Sadie	Lansdale	281	195	Washington Interfaith Network	5017 Scarsdale Rd		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Salima	Appiah-Duffell	282	272	Washington Interfaith Network	223 N Adams St		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Sally	Stephenson	283	162	Washington Interfaith Network	2911 Tilden St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Sara	Stewart	284	161	Washington Interfaith Network	1915 Kalorama Rd NW #612		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Sarah	Heidema	285	58		936 S ST, NW		2/19/2014	survey monkey	I am excited to see a utility acting in a thoughtful and long term fashion. The GI not only looks like it will help reduce waste water, but it adds an attractive and green design element to the city. Thanks DC Water!	General Support	11.1
Scott	Einberger	286	12		6313 8th Street NW		3/10/2014	survey monkey	While I support green infrastructure in general, I do not believe that DC Water's proposed small-scale projects will have any large effect on the Rock Creek watershed's impervious surface.	Degree of Control	3.7
Scott	Einberger	286	34		6313 8th Street NW		3/10/2014	survey monkey	As a concerned citizen, I strongly urge DC Water to follow EPA orders by constructing the temporary storage tunnel under Piney Branch Parkway. The CSO problem in Rock Creek is decades old at this point, and it's time to fix it once and for all, as quickly as possible. Create the tunnel without delay and then let these tunnels serve as an example for other municipalities.	General Opposition	10.3.1
Scott	Schulke	287	83		4201 Cathedral Ave., NW #318W		3/10/2014	survey monkey	Keep up the good work, DC Water is doing exactly what it should be doing, including the work with CaseyTree, and the DC Department of Environment. Thank you very much	General Support	11.1
Sean	Murphy	288	166	Washington Interfaith Network	230 Rhode Island Ave NE #401		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Sean	Walsh	289	48		3902 14th St NW # 515		1/26/2014	survey monkey	Support GI	General Support	11.1
Shaun	Pharr	290	296	Apartment & Office Building Association			4/14/2014	letter	Support GI, schedule and financial commitment	General Support	11.1
Shelagh	Bocoum	291	72		755 Faraday Pl NE		2/26/2014	survey monkey	I understand that the changes will result in a lower cost solution to our stormwater problems, a solution that will begin to take effect sooner, and one that will provide more jobs for DC residents.	General Support	11.1
Shelly	Parker	292	43				1/23/2014	email	Great for Rock Creek park but no one may consider the measures in Bloomingdale. Could just be a dig festiva	Miscellaneous & General Support	9.12, 11.1

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Shelly	parker	292	44		2228 1st st nw		1/23/2014	survey monkey	Support GI. Why can't the same be done in Bloomingdale? I don't think it is a coincidence that this elimination of this tunne is occurring in one of the most expensive neighborhoods in the city and as always east of the park	Miscellaneous & General Support	9.12, 11.1
Stan	Lou	293	200	Washington Interfaith Network	2016 N. Adams St #603		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Stephanie	Sierra	294	68	School			2/21/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment	General Support	11.1
Stephen	Szibler	295	82		411 Richardson Pl., NW		3/10/2014	survey monkey	Yes! I support both the GI schedule and financial commitment. Focusing on a green infrastructure instead of eschewing it for what is essentially not much different than the Army Corps of Civil Engineers project (building retaining walls) in the Anacostia over 100 years ago, makes little sense. If only sewer technology is used, by the time it is built i will be time to build another sewer project in order to keep up with the runoff and other effects of modern unsustainable society, and at a much greater cost to the taxpayers and those living in the area. Thank you!	General Support	11.1
Steve	Monee	296	65	ITT Tech			2/21/2014	Comment form	In support of Green Infrastructure; In support of schedule revision; In support of DC Water's financial commitment	General Support	11.1
Steven	Coxe	297	273	Washington Interfaith Network	1013 16th St S		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Stiles	Sarah	298	279	Washington Interfaith Network	1026 16th St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Stover	Voght	299	202	Washington Interfaith Network	1307 E Abingdon Drive #3		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Sudie	Johnson	300	283	Washington Interfaith Network	1133 46th St SE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Sunmee	Jo	301	179	Washington Interfaith Network	1630 Hobart St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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Susan	D	302	45		748 Rock Creek Church Rd. NW	A	1/24/2014	survey monkey	Wonderful! Whole-hearted support of the green infrastructure project. It may take a little longer, but will be of a much greater benefit in the long run both financially and environmentally.	General Support	11.1
Tatiana	Howard	303	232	Washington Interfaith Network	10117 Palamar Drive		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Terri	Weifenbach	304	301		614 Ingraham st NW		4/14/2014	survey monkey	Kennedy St. NW is a perfect place to start as it is now ready for redevelopment. It would be fantastic to see small parks and green areas for the residents and children of the area	General Support	11.1
Theresa	Leon	305	262	Washington Interfaith Network	2732 Ordway St NW #1		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Tim	Hampton	306	104				4/6/2014	comment form	Support GI, schedule and financial commitment. This is the best sustainable decision for our City	General Support	11.1
Timothy	Ledlie	307	89		1317 Shepherd St NW		3/14/2014	survey monkey	Support GI, schedule and financial commitment	General Support	11.1
Timothy	Tilghman	308	226	Washington Interfaith Network	12502 Ivory Pass		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Tiyonna	Hill	309	229	Washington Interfaith Network	8240 Imperial Drive		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Tom	Knoll	310	155	Washington Interfaith Network	309 E St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Tony	Thompson	311	445	Vulcan Materials Company	6860 Commercial Drive		1/28/2014	survey monkey	Support GI. A properly researched, planned and constructed Green Infrastructure plan for handling storm water is certainly the appropriate solution for the District as well as other local municipalities. Green infrastructure should be a standard practice for all new development and redevelopment, but the current situation in the District must be addressed without delay and may still require some portions of the previously approved tunnel/storage system in order to resolve the storm water/sewage management concern expeditiously.	Schedule	6.3.2
Tracey	Kirkbrider	312	411	ANC 4C10			3/13/2014	comment form	Support schedule and financial commitment but need to read more about GI before I support	Miscellaneous	9.6

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Trerese	Roberts	313	251	Washington Interfaith Network	10901 New Salem Avenue		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Troy	Hill	314	230	Washington Interfaith Network	8240 Imperial Drive		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
V	Wilber	315	211	Washington Interfaith Network	1900 S Street NW #103		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Vickie	Lindsey	316	258	Washington Interfaith Network	2456 20th St NW #307		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Walter	Groszyk	317	415				3/14/2014	email	The map in Figure A-4, Sewershed characteristics for CSO 025, at p.4 of the GI Screening Analysis, Appendix A, Sewershed Characterization, of Technical Memorandum No. 7 is in error. The map actually shows a portion of the sewershed for CSO 024.	Miscellaneous	9.13
Wanda	Ross	318	227	Washington Interfaith Network	1107 Drum Avenue		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Whitney	Cooper	319	237	Washington Interfaith Network	4040 8th Street NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
William	Botelar	320	175	Washington Interfaith Network	811 Houston Ave #2		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
William	Hoffman	321	173	Washington Interfaith Network	3253 Worthington St NW		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1

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William	Tucker	322	203	Washington Interfaith Network	1948 Marthas		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Yolanda	Appiah-Kubi	323	174	Washington Interfaith Network	1836 Barrington Ct		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
Zach	Wilks	324	213	Washington Interfaith Network	525 3rd Street NE		4/11/2014	WIN letter	Support green jobs, want transparent measures and ongoing accountability from DC Water to make sure that pollution in our waterways is reduced. For affordability of DC residents, urge DC water to make reasonable enhancements in local and federal government budget allocations to reduce pollution, protect our environment, and create living wage careers for DC residents.	General Support	11.1
	Not Identified	325	401				2/14/2014	survey monkey	Please provide more information on the following: 1) The current Long Term Control Plan. 2) The proposed Long Term Control Plan. 3) Description of Green Infrastructure - and the phases from 2015 to 2032. 4) Description of the Potomac Tunnel. 5) Description of options for building GI. I volunteer as a stakeholder for these projects.	Miscellaneous	9.3
	Not Identified	326	421	Following news articles online				online	if there's an earthquake what happens to the tunnel?	Miscellaneous	9.1.5
	Not Identified	326	435				2/20/2014	online	Will rates decrease when LTCP modification goes through? How is DC Water helping to mitigate costs on bills where we can't control impervious areas our landlords install?	Rates/ Finance	4.1.4, 4.1.7
	Not Identified	327	1				1/21/2014	meeting	Request for "Predicted CSO Volume" graph for all of Potomac (not just CSO 025-029).	Degree of Control	3.1
	Not Identified	328	2				1/21/2014	meeting	DC Water should reduce more CSOs.	Degree of Control	3.2
	Not Identified	329	8				2/20/2014	Petworth Public Meeting	What sewer separation has already occurred?	Degree of Control	3.6
	Not Identified	330	9				2/20/2014	Petworth Public Meeting	Can we get comparable results with Green Infrastructure?	Degree of Control	3.8.1
	Not Identified	331	10				2/20/2014	Petworth Public Meeting	Can we use additional GI to get overflows down to 0% in Rock Creek	Degree of Control	3.2
	Not Identified	332	318	Following news articles online				online	In support of Green Infrastructure; In support of DC Water's financial commitment	General Support	11.1
	Not Identified	333	319	Following news articles online				online	More $ to GI and work better with DDOE	Nature of Commitment & Implementation Strategies	2.2.2, 8.6.3
	Not Identified	334	332				1/21/2014	meeting	Investigate options to attenuate flow at CSO apron.	Implementation Strategies	8.2
	Not Identified	335	333				1/21/2014	meeting	Document DC Water's commitment to protecting GI long term in both public and private space (Investigate options through DC Council to protect GI).	Maintenance	7.4.2
	Not Identified	336	334				1/21/2014	meeting	Document DC Water's commitment to protecting GI long term in both public and private space (Discussion about increasing DC Water legal staff).	Maintenance	7.4.2
	Not Identified	337	335				1/21/2014	meeting	Will GI have covenants?	Maintenance	7.4.3
	Not Identified	338	336				1/21/2014	meeting	Has DC Water started planning for covenants?	Maintenance	7.4.3
	Not Identified	339	342				2/18/2014	Georgetown Public Meeting	What do you plan to replace (impervious) parking and sidewalk surfaces with?	Implementability	5.5.5

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	Not Identified	340	343				2/18/2014	Georgetown Public Meeting	Can your pumping system be expanded later for greater capacity?	Implementation Strategies	8.7
	Not Identified	341	344				2/18/2014	Georgetown Public Meeting	The combined sewers are 120 yrs old, what is the remaining life expectancy of the combined sewers? Would you have to tear up newly installed Green Infrastructure to replace the old pipes in a few short years?	Implementability	5.4
	Not Identified	342	345				2/20/2014	Petworth Public Meeting	Why don't we use more rain barrels and disconnect downspouts?	Implementability	5.5.6
	Not Identified	343	346				2/20/2014	Petworth Public Meeting	I've heard that relations between DC Water and DDOE are not the best. Can we have follow-up methods to cover both MS4 and CSO issues?	Implementation Strategies	8.6.3
	Not Identified	344	347				2/20/2014	Petworth Public Meeting	Can we change the business models to get people of the sanitary sewer grid? Can we install composting toilets in every home and business?	Implementation Strategies	8.8
	Not Identified	345	386				1/21/2014	meeting	Document DC Water's commitment for GI long-term maintenance	Maintenance	7.4.1
	Not Identified	346	387				1/21/2014	meeting	Is there a 10 year life cycle costs for O and M in the public comment documents?	Maintenance	7.2.1
	Not Identified	347	388				1/21/2014	meeting	Is DC Water performing O and M?	Maintenance	7.2.1
	Not Identified	348	396				1/21/2014	meeting	Is the First Street Tunnel being constructed due to development?	Miscellaneous	9.1.1
	Not Identified	349	397				1/21/2014	meeting	Will stormwater flow be stored in the sand filters at McMillan?	Miscellaneous	9.1.2
	Not Identified	350	398				1/21/2014	meeting	Will First Street be widened?	Miscellaneous	9.1.3
	Not Identified	351	399				1/21/2014	meeting	What will shafts look like at the end of the project?	Miscellaneous	9.1.4
	Not Identified	352	402				2/18/2014	Georgetown Public Meeting	How old are the combined sewers?	Miscellaneous	9.4
	Not Identified	353	403				2/18/2014	Georgetown Public Meeting	You are proposing Green Infrastructure in Rock Creek, what about the Anacostia, why no Green Infrastructure for CSO control in Anacostia?	Miscellaneous	9.11
	Not Identified	354	404				2/18/2014	Georgetown Public Meeting	If the CD modification is not approved will you build Green Infrastructure anyway?	Miscellaneous	9.5
	Not Identified	355	405				2/20/2014	Comment form	Support of Green Infrastructure; unsure of schedule revisions, support financial commitment. What happens to tunnel during earth quake?	Miscellaneous	9.1.5
	Not Identified	356	406				2/20/2014	Petworth Public Meeting	Do we have to do the Anacostia tunnel? Why can't we do more Green Infrastructure in Anacostia?	Miscellaneous	9.11
	Not Identified	357	422				1/21/2014	meeting	Is DC Water guaranteeing $60 M or similar performance?	Nature of Commitment	2.1.7
	Not Identified	358	423				1/21/2014	meeting	Is the $60 M commitment capital cost or does that include O and M as well?	Nature of Commitment	2.2.3
	Not Identified	359	425				2/18/2014	Georgetown Public Meeting	You have listed a dollar value for Green Infrastructure, what about the associated volume/acreage. Do you have performance requirements for these aspects?	Nature of Commitment	2.1.8
	Not Identified	360	430				1/21/2014	meeting	Request for Present Worth Analysis Comparison for Current vs. Proposed plan.	Rates/ Finance	4.4
	Not Identified	361	436				2/20/2014	Petworth Public Meeting	We're already doing Green Infrastructure in our neighborhood. Why are we paying for a tunnel in Anacostia?	Rates/ Finance	4.2
	Not Identified	362	442	Following news articles online				online	How is DC Water helping to mitigate costs on bills for renters?	Rates/ Finance	4.1.7
	Not Identified	363	443				1/21/2014	meeting	Investigate raising weir level earlier.	Schedule	6.2
	Not Identified	364	444				1/21/2014	meeting	Investigate separating CSO 025/026 earlier.	Schedule	6.6
	Not Identified	365	446				2/18/2014	Georgetown Public Meeting	When do you expect to reach a decision?	Schedule	6.5
	Not Identified	366	465	Following news articles online				online	Unsure support of schedule revision	Schedule	6.3.7