# Bringing the City of Newark's Stormwater Management System into the 21st Century

**Master of Science in Sustainability Management Program Capstone Thesis**
**The Earth Institute at Columbia University in the City of New York**

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**May 2014**

**Version 4**

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# EXECUTIVE SUMMARY

Stormwater flooding and combined sewer overflows (CSOs) pose a number of serious challenges to the City of Newark. During average precipitation events, as well as periods of snow melt, the City's century-old combined sewer system (CSS), which is designed to convey both sewage and stormwater runoff to the wastewater treatment plant, can become overwhelmed. As a result, untreated sewage and stormwater is discharged from designated CSO locations into neighboring bodies of water. During extreme precipitation events - defined as at or above one, two, and four inches[1] - reports of localized flooding have been documented. According to an interview with the Newark sewer utility, such occurrences are caused by backup from the sewer system. Compounding these problems are the anticipated impacts of climate change, which threaten to increase average precipitation in the region by 5% by 2020, and 10% by 2050.[2] Under such a scenario, maintaining the status quo would incur the risk of more frequent localized flooding and more contaminated waterways around Newark, as well as negative impacts on the local economy and public health.[3]

Coupled with these environmental and social problems is the key issue of funding constraints. Addressing these problems will require significant investments in a mix of infrastructure and programmatic solutions, which will play out over the short-, medium-, and long-term. In its current financial state, Newark faces profound challenges in meeting these necessary, but costly, investments. These financial constraints can be traced to the larger economic problems facing the City, exemplified by the high proportion of low-income households, which was 22% according to the 2010 US Census.[4]

Traditional methods of addressing stormwater and CSO problems typically include the construction and renewal of "grey" infrastructure such as pipes, tanks, and large, energy-intensive treatment facilities.[5] To-date, the most comprehensive stormwater management plan, compiled by the engineering firm Hatch Mott MacDonald (HMM), is a ten-year water and sewer capital improvement plan focused on renewing key components of the existing sewer infrastructure. While the plan proposes valid and critically vital actions, such as drainage ditch repairs and pump replacements, it falls short of the Newark Water Group's ideal of an integrated sustainability plan for long-term management.

Specifically, the HMM plan does not address many of the low-cost, "green" solutions that are proposed in Newark's 2013 Sustainability Action Plan (NSAP). These green infrastructure (GI) solutions, such as rain gardens and swales, are designed to capture and divert stormwater before it enters the sewer. The New York City Department of Environmental Protection (DEP) Green Infrastructure Plan provides a valuable example of how GI can be strategically incorporated into a stormwater management plan to reduce flooding and CSO events in a cost-effective manner. Furthermore, this approach has cascading benefits to the social, environmental, and economic vitality of the City, which grey infrastructure alone does not.

This report evaluates a suite of stormwater and wastewater best management practices (BMPs), some of which have already been considered in the NSAP, and others that have been successfully carried out in

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[1] New York City Panel on Climate Change. *Climate Risk Information 2013: Observations, Climate Change Projections, and Maps*. The City of New York, June 2013. Web. 24 Apr. 2014. <Link>

[2] Ibid

[3] USA. EPA. EPA Region 2 Climate Change Work Group.*Epa.gov/region2/climate/*. By Irene Nielson and Joseph Siegel. N.p., 18 Sept. 2013. Web. 24 Apr. 2014. <Link>

[4] Selected Economic Characteristics from the 2006-2010 American Community Survey 5-Year Estimates for Newark city, Essex County, New Jersey, United States Census Bureau. Accessed April 24, 2014. <Link>

[5] "Blue, Green and Grey Infrastructure: What's the Difference – and Where Do They Overlap?" *Engineering Nature's Way*. Hydro International Stormwater, 2 Sept. 2011. Web. 24 Apr. 2014. <Link>

similar cities such as New York and Philadelphia. While green infrastructure is a major focus, a set of equally important policy and programmatic solutions were also evaluated and have been recommended in this report for Newark. Some of these are, in fact, essential for successful and long-term implementation of green infrastructure. The recommended BMPs include, but are not limited to, reducing stormwater in the sewer system using GI, measuring and monitoring CSO discharges, consumer water-use conservation, and new policies and programs that incentivize GI and conservation.

Many of these strategies focus on addressing the issues of flooding and CSOs at the source. They are meant to complement traditional grey infrastructure technologies such as stormwater storage and treatment. Grey infrastructure projects are known as end-of-pipe solutions because, rather than changing the process creating the problem, they only focus on the end result.

## Overview of Recommended Actions

The proposed recommendations for improving stormwater and CSO management, and which the Newark Water Group should support, can be divided into four key components.

### 1) Conduct a pilot study in the recommended area to control stormwater runoff using green infrastructure

As mentioned earlier, green infrastructure can be utilized in urban areas to mimic the natural processes of absorption and filtration, which are carried out by soil and vegetation in undeveloped land. By soaking up and storing water during precipitation events, these stormwater management systems reduce the amount of runoff that flows to the sewer system, thereby reducinfg stress on the treatment plant and lowering the risk of untreated discharges from CSOs.

In New York City, the DEP has proposed controlling stormwater runoff by capturing the first inch of rain from 10% of the impervious areas in combined sewer watersheds. Using complex stormwater modeling, the DEP was able to estimate that such a goal would reduce CSOs by approximately 1.5 billion gallons per year. [6] While such modeling was not feasible for this report, the basic principles of this approach are transferable to Newark given comparable hydrological patterns and land use. Similarly, the city of Philadelphia now requires that all new developments capture and store the first inch of rainfall that lands on their property, in order to reduce instances of sewage discharge during precipitation events.[7] It is recommended that Newark adopt a similar goal of capturing the first inch of rain from 10% of impervious surfaces using appropriate GI technologies. To achieve this in the most cost-effective manor, those neighborhoods located in CSS districts that exhibit the most flooding, and are also served by CSO locations highly prone to discharge occurrences, should be made the primary targets of GI intervention.

According to the Newark Sustainability Office, plans are currently underway to develop green infrastructure pilot projects in such target neighborhoods; however, no further information on the status of this work could be gained for this report. Based on this report's analysis of existing land use, topography, population, and CSO watersheds in Newark, a target region which includes the Jackson, Ferry, and Adams sewer districts, circled in Figure 1 below, was selected for use in a green infrastructure and residential water conservation pilot program. A more detailed explanation of this pilot study determination can be found in the Recommendations section of this report.

[6] *New York City Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways*. Rep. New York City Department of Environmental Protection, 2010. Web. <Link>
[7] *Philadelphia Code: Chapter 6*. N.d. 600.5 Post-Construction Stormwater Management Criteria. Philadelphia, PA. <Link>


Using the land-use data available for this area, the strategies and technologies outlined in Table 1 below, are recommended for implementation in that region. As shown, successful adoption of these strategies in the pilot area has the potential for diverting nearly 80 million gallons of water from entering the CSS each year, which this report surmises could potentially reduce the occurrence of harmful CSO discharges from the connected outfalls.

FIGURE 1: PROPOSED GREEN INFRASTRUCTURE PILOT REGION

| Land Use / Land Cover Type | | Total CSS Watershed | CSS Pilot Region | Potential Strategies and Technologies | Thousand Gals. Diverted / Year | | % of Goal | |
|---|---|---|---|---|---|---|---|---|
| Open or Green Space | Trees & Grass | 28.6% | 13.1% | Double the Tree Canopy | 10,434 | | 13.3% | |
| | Bare Earth | 1.3% | 3.3% | Rain Gardens and Swales | 3,492 | 34,856 | 4.4% | 44.4% |
| Developed Space | Roads | 18.4% | 16.1% | Permeable Pavement and Swales along sides | 1,675 | - | 2.1% | 0.0% |
| | Barren Land | 0.3% | 0.5% | Rain Gardens and Swales | - | 23,888 | 0.0% | 30.4% |
| | Commercial / Industrial | 25.5% | 33.7% | Cisterns and Reduce Consumer Demand | 56 | - | 0.1% | 0.0% |
| | Mixed or Other Urban | 2.9% | 5.8% | Reduce Consumer Demand & Rain Barrels | - | 28 | 0.0% | 0.0% |
| | Residential | 22.0% | 27.1% | Reduce Consumer Demand | 1,800 | | 2.3% | |
| | Transport./ Commer./Utilily | 1.0% | 0.3% | Swales along the sides | 3,375 | | 4.3% | |
| TOTAL | | 100.0% | 100.0% | | 79,603 | | 101.4% | |

TABLE 1: RECOMMENDED GI AND CONSERVATION FOR PILOT STUDY

The chart in Figure 2 below illustrates the breakdown of technologies based on their expected effectiveness in the pilot region. Due to their cost effectiveness, swales have the most potential for stormwater management in the selected pilot region, however, other measures such as tree canopy and rain gardens are also recommended due to the added qualitative benefits they exhibit through neighborhood beautification and ability to reduce the heat island effect.

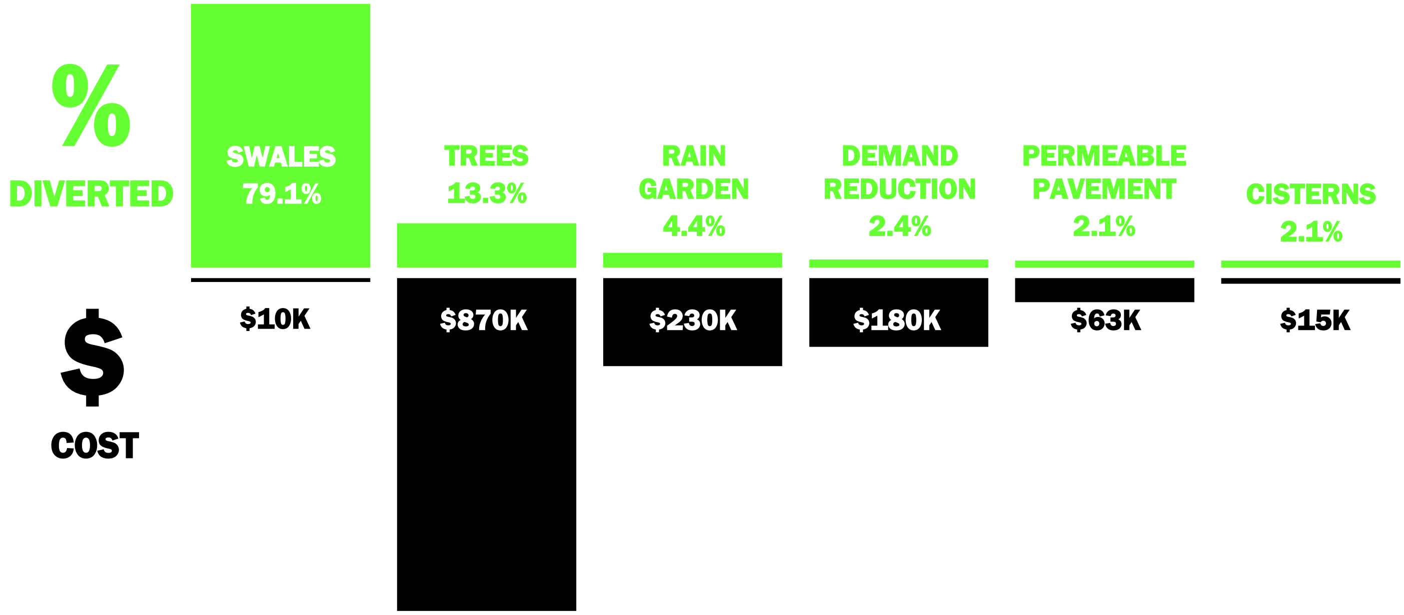


FIGURE 2: BREAKDOWN OF RECOMMENDED TECHNOLOGY FOR PILOT AREA

## 2) Establish a municipal CSO and water quality monitoring program and complete the scheduled control upgrades at remaining CSO outfalls

Ultimately, to determine the impact of any GI strategy on CSO events, precise monitoring of the CSOs must be performed before, during, and after the intervention. Unfortunately, current methods of this, which utilize water quality testing around the Passaic River, provide insufficient data for determining when and where overflow events occur. To address this, a more robust and targeted water quality-monitoring program should be developed. This program should be designed to track bacteria levels, a key indicator of sewage overflow, around each CSO outfall point in Newark.

Ideally, a methodical water sampling program can be used to match precipitation events with degraded water quality to better determine the sensitivity of each CSO watershed in Newark to stormwater runoff. Based on the results of this analysis, the total square area of any sewer district, together with the percentage of surface that is impervious, can help determine the approximate volume of stormwater that flows into the CSS during a precipitation event. Targets for gallons of water to be retained during such an event in order to avoid a CSO event can then be established, similar to the analysis undertaken to develop the NYC DEP Green Infrastructure Plan

To finance such a program, an opportunity for corporate sponsorship exists with HSBC through the FreshWater Watch program. Through this, industry could be contracted to train Newark community volunteers and participants on how to perform coordinated water quality monitoring tests as part of a community outreach program.[8] In addition to aiding with CSO event analysis, this program would also raise public awareness of the issues and engage the community in working to find solutions.

Some grey infrastructure projects, already in the planning phase, are also necessary to improve outflow control in Newark. Specifically, management of floatable waste, the visible solid waste often present in CSO discharges, is an important aspect of the US Environmental Protection Agency's (EPA) CSO Control Policy. Common measures for controlling floatables include baffles, screens and trash racks, and netting.[9]

[8] "Freshwater Watch & the HSBC Water Programme." Earthwatch Institute, 2014. Web. 26 Apr. 2014. <Link>
[9] United States. Environmental Protection Agency. Office of Water. *Combined Sewer Overflow Technology Fact Sheet*. F99 ed. Vol. 832. Washington DC: EPA, 1999. Print. Ser. 008.

Of the 17 CSO outfall locations in Newark, 12 have already been outfitted with screening and netting measures. These projects are mandated under an Administrative consent order from the NJDEP. The remaining four locations are currently scheduled to be outfitted with floatable control measures. According to the Sewer Utility's 2014 capital improvement plan, detailed later in this report, one, the Freeman Street CSO, is budgeted for this work. The three others were funded under previous authorization from the New Jersey Environmental Infrastructure Trust (NJEIT), but have yet to be completed.[10] It is recommended that the City complete these necessary CSO floatable control measures to comply with state and federal regulations, and that the NWG support this effort.

## 3) Promote water use monitoring and conservation programs to reduce overall amount of sewage flow from water and sewerage customers

Since the load on a combined sewer system is largely dependent on wastewater from consumer use, buildings within the CSS watershed should be targeted for water efficiency and conservation programs. This would directly alleviate a portion of the water load sent to the waste treatment plant for processing. Furthermore, it would reduce the risk of CSO discharges during hydrological events.
In the short term, a pilot study involving all city-owned buildings should be conducted to determine the costs and effectiveness of various conservation measures, including, but not limited to, those suggested later in this report. Much like the energy use program described in the Newark Sustainability action plan, the water conservation pilot should begin with benchmarking of the water use of each building. From there, water audits can be implemented on those buildings which show to be high relative users and conservation targets based on the audit results can be established. Conservation measures should be implemented as determined by the audits and post-implementation data should be gathered after one year to gauge the effectiveness of the program in terms of water use reductions. The benchmarking and audit steps of this pilot study require minimal funding to initiate, and could be carried out by staff in the Newark Sustainability Department. Results of the water audits will determine the eventual costs of the recommended conservation measures to be implemented in step three, but these measures do not typically have high costs as shown in the Cost Benefit Analysis of Efficient Technologies tables located in the Appendix. Upon successful demonstration of the pilot, a city-wide program can be rolled out for all properties over 10,000 square feet, in an effort to target the city's largest water consumers.

Because regular residential accounts make up roughly 84% of the total number of water customers and account for nearly 27% of the utility's cost of services, additional conservation efforts should target these customers. A Water Conservation Assistance Program, which would provide free water audits and basic conservation measures for low income households, should be established in the recommended pilot area, with the long-term goal of expanding to a city-wide program upon successful pilot demonstration. As Table 2, below, indicates, nearly 70% of the households in the pilot region are between 1 and 4 units, which is indicative of smaller systems and more limited and inexpensive conservation solutions; i.e. showers and faucets rather than cooling towers and central heating plants.

| Number of Units in Building | Percent of Population | | Percent of Homes | |
|---|---|---|---|---|
| | Newark | Pilot Region | Newark | Pilot Region |
| Single Family Homes | 26.1% | 13.7% | 20.0% | 10.9% |
| 2 - 4 Units | 47.6% | 59.6% | 45.2% | 58.6% |
| 5 + Units | 26.3% | 26.7% | 34.7% | 30.4% |
| Other (Mobile Homes, RVs, etc.) | 0.1% | 0.0% | 0.1% | 0.1% |

TABLE 2: RESIDENTIAL MAKEUP OF NEWARK AND PILOT AREA

[10] Water and Sewer Capital Projects SFY 2014 NJEIT Funding. Newark: City of Newark, 2013. Print.

Due to the high proportion of low-income residents in Newark, this program could be eligible for financing with federal grants from the Department of Housing and Urban Development (HUD). The HUD Community Development Grant program, detailed later in this report, provides block grants for cities with populations of at least 50,000 to improve housing and living conditions for low- and medium-income residents while expanding economic activity through job creation. Among the numerous qualifying activities are housing rehabilitation and energy conservation, both of which would be addressed by a water conservation assistance program. Furthermore, the program would be a source of job creation and economic stimulus by employing water auditors, plumbers, and light construction workers to implement the conservation measures. The HUD grant requires that 70% of the funding be used for improving low- and medium-income households, which could easily be met given the current Newark demographics.[11]

## 4) Conduct feasibility studies to determine the economic impact of stormwater surcharge and water-consumption inclining block rates

At present, widespread adoption of stormwater infrastructure is hindered in New Jersey due to specific statutory and regulatory barriers, which do not authorize municipal and regional entities to charge property owners fees for stormwater they contribute to the system.[12] As a result, property owners have little incentive to employ green infrastructure BMPs into their buildings and developments. Compounding this lack of incentives is the underlying inequity of the current sewer rate structure, which charges customers based on their water consumption levels. Because of this, properties such as commercial parking lots, whose large, impermeable footprints contribute significant amounts of stormwater runoff to the sewer annually, do not pay proportionally for the load they contribute to the system. Treatment for this stormwater is subsidized by other rate payers who may have smaller properties with less impermeable surfaces.

To correct this, the NWG should advocate for legislation that authorizes utilities to charge property owners for sewer usage based on stormwater load contribution, as suggested in Newark's Master Plan.[13] Such a bill has recently been introduced in the New Jersey State Assembly. Assembly Bill 1583, introduced by Assemblywoman L. Grace Spencer of District 29 in Newark, would effectively authorize any municipality holding a combined sewer system general permit to establish a designated stormwater utility for the purpose of creating a stormwater management system. The bill further authorizes this entity to finance operations through the imposition of user fees, i.e. stormwater charges.[14] A similar bill passed the State Senate in 2011, but was subsequently vetoed by Governor Christie. It is recommended that the NWG fully support this important bill, which represents a crucial first step towards establishing the economic and regulatory conditions necessary for green infrastructure proliferation throughout the City.

Through such a charge, properties could incur a fee proportional to the amount of impervious surface covering the lot footprint. This separate fee would stimulate private investment in green infrastructure by improving the financial payback through the potential for lower charges, while also reducing stormwater runoff and CSO events in the City.[15] Additionally, it will improve equity of the sewer financing system and

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[11] "Community Development Block Grant Entitlement Communities Grants/U.S. Department of Housing and Urban Development (HUD)." *Community Development Block Grant Entitlement Communities Grants/U.S. Department of Housing and Urban Development (HUD)*. Web. 29 Apr. 2014.

[12] Worstell, Carolyn. *Green Infrastructure in the State of New Jersey: Statutory and Regulatory Barriers to Green Infrastructure Implementation*. Rep. N.p.: New Jersey Future, 2013. Print. <Link>

[13] "Newark's Master Plan." *City of Newark, NJ* - Web. 24 Apr. 2014. <Link>

[14] "*A1583, Authorizing creation of stormwater utilities for certain local government entities.*" Assembly, No. 1583 State Of New Jersey 216TH Legislature. <Link>

[15] Worstell, Carolyn. *Green Infrastructure in the State of New Jersey: Statutory and Regulatory Barriers to Green Infrastructure Implementation*. Rep. N.p.: New Jersey Future, 2013. Print. <Link>

could even offset the need for potentially hurtful across the board rate increases, described later in the report.

Finally, in order to incentivize water conservation, NWG should support a feasibility study to determine the economic and financial effects of switching the volumetric water rate schedule to an inclining block structure. Currently, volumetric water rates decrease as customers increase their usage. The nature of such a structure targets only high-volume consumers, and would therefore minimally impact the 84% of customers whose “Regular” rate distinction indicates lower usage.

## TIMELINE OF RECOMMENDATIONS

The tables below specify how the recommendations should be broken out. The timelines are designed over 3 time scales: short-term 1 year, medium-term 4 years, long-term over 4 years. It was determined that the recommendations listed in the short term will help kick start this program and help bring about meaningful change to the way Newark handles its wastewater. Additionally the stormwater fund, passage of NJ Bill A1583, feasibility study for a stormwater charge will be pivotal to provide sustained funding for these projects.

| **Short Term** |
|---|
| Support the passage of NJ State Assembly Bill A1583 |
| Create a Stormwater Fund |
| Request cost and capacity totals for new wastewater capacity projects |
| City buildings benchmarking Water Use |
| Create a Program mimicking Philly's CAP for water efficiency |
| Feasibility study for stormwater charge |
| Uniform water quality testing |
| Feasibility Study for Water rate structure change |
| Develop guidelines for GI incorporation |
| Incorporate GI in pilot area |
| **Medium Term** |
| Flow data Gathered from sensors |
| Mandatory Benchmarking for Commercial and Industrial Users |
| Roll out of Stormwater Charge |
| Roll out of a  Water Inclining Rate Structure |
| Incorporate policies and guidelines for GI into design guidelines |
| Incorporate GI in Pilot Area |
| Analyze Results of Pilot Projects |
| **Long Term** |
| Mandatory Benchmarking for High-density residential |
| Mandatory Benchmarking for Mixed Use |
| City-wide Water Audits |
| Develop and Execute Plans for Resiliency Projects |
| Expand Successful Pilot Projects to other parts of Newark |

# CHAPTER 1: INTRODUCTION

## 1.1 CLIENT BACKGROUND

The Newark Water Group (NWG) is a non-partisan, citizen-led organization founded in 2008. The group's self-described mission is to maintain public control Newark's water systems. To this end, the group led a successful opposition to the Newark Watershed Conservation and Development Corp's (NWCDC) attempt to create a Municipal Utility Authority (MUA) through which it would have effectively controlled the City's water and sewage systems. According to NWG, this move would have led to higher water rates with less oversight of an aging system in need of significant repairs. [16] In 2013, after an investigation from the State Comptroller's Office revealed widespread corruption within the NWCDC, the organization was dissolved, leaving the City of Newark in charge of managing the water supply for 500,000 customers.[17]

## 1.2 EXISTING STORMWATER SYSTEM REPORTS

### 1.2.1 Hatch Mott MacDonald Study

In 2011, the engineering firm Hatch Mott MacDonald provided the City with a comprehensive study of the City's existing sewer system. This included a risk analysis of the major system components, a list of 22 recommended capital improvement projects, an estimated timeframe for implementation, and a financial viability analysis detailing predicted debt obligations and resulting rate adjustments.

Of the 22 recommended projects, all but five are categorized as either "Renewal/Replacement" projects (8) or "Flood Control" projects (9). Table 3, below, shows a breakdown of the HMM projects by type, including estimated costs. The first group, "Renewal/Replacement, are defined as, "those intended to rehabilitate, replace, or upgrade aging infrastructure that is nearing the end of its useful life."[18] These projects include items such as: emergency sewer repair contracts, sewer brick rehabilitation and monitoring, non-brick sewer rehabilitation, South Side Interceptor rehabilitation, and CSO control facilities and outfall rehabilitation.

The second group, "Flood Control," represent projects focused on improving stormwater drainage and alleviating flooding. The majority of these projects are restorative in nature as well. These include projects such as pump station upgrades and drainage ditch restoration. Combined with the flood control projects, these account for 80% of the proposed recommendation budget. The remaining projects, grouped in "Regulatory Compliance" and "Operational Efficiency," include measures such as implementing CSO floatables control programs, discussed previously, and direct flow metering at the Passaic Valley Wastewater Treatment Plant (PVSC), where 94% of Newark's combined sewer and stormwater is treated.[19]

While a detailed analysis of the individual HMM project recommendations is beyond the scope of this report, the key takeaway is the Plan's focus on end-of-pipe solutions, i.e. those which effect the end of process stream, which in this case is contaminated water that has already entered the sewer system. While this approach is certainly necessary, as evidenced by the utility's own adopted 2014 capital improvement plan, which includes many of these projects, it is by no means exhaustive. To complete the

[16] "Newark Water Group - Welcome to Newark Group." *Newark Water Group - Welcome to Newark Group*. Web. 02 Apr. 2014. <Link>
[17] Giambusso, David. "Report: Newark Needs to Raise Water Rates to Fix Infrastructure."*NJ.com*. Web. 21 Feb. 2014. <Link>
[18] Schneider, Eric, PE, comp. *City of Newark Sewer System Master Plan*. Tech. 2011. Print.
[19] Ibid.

picture, equal attention should be given to solutions that target the sources of flooding and CSOs, thereby reducing the aggregate water entering the sewer system before problems arise.

| Category | Description | No. of Projects | Estimated Project Costs (2010 $ million) 10-Year Total |
|---|---|---|---|
| **Renewal/ Replacement** | Projects intended to rehabilitate, replace, or upgrade aging infrastructure that is nearing the end of its useful life. | 8 | $116.6 |
| **Regulatory Compliance** | Projects required or that may be required by NJPDES permits or consent orders. | 3 | $25.7 |
| **Flood Control** | Projects primarily intended to improve the stormwater drainage system and mitigate storm related flooding. | 9 | $114.3 |
| **Operational Efficiency** | Projects intended to improve the ability to operate and maintain the sewer system efficiently. | 2 | $30.9 |
| | TOTAL | **22** | **$287.5** |

TABLE 3: BREAKDOWN OF HMM PROJECTS BY TYPE. SOURCE: CITY OF NEWARK SEWER SYSTEM MASTER PLAN

## 1.2.2 Newark Sustainability Action Plan

In contrast to the HMM proposal, the Newark Sustainability Action Plan, adopted in 2013, approaches the issue of stormwater management from a system input perspective. Central to the plan's vision is an emphasis on the repurposing of land to, "absorb stormwater before it gets into the sewer system."[20] The plan identifies six action items, all of which effectively utilize green infrastructure to reduce flooding and prevent overwhelming the sewer system by capturing and detaining stormwater as it falls during precipitation events.

The actions described in the plan include doubling the tree canopy of Newark, adopting common green infrastructure ordinances, developing green infrastructure standards, implementing pilot green infrastructure projects, creating a stormwater infrastructure bank to fund projects, and supporting neighborhood rain capture projects.

While thorough in its analysis of the green infrastructure capabilities, the plan falls short in two important areas. Firstly, the Sustainability Plan does not incorporate conservation into its strategy for improving the overall system performance. Newark typically receives about 46 inches of precipitation each year and is therefore is not prone to water shortages.[21] Given this amount, it is normal to discount the importance of conservation when addressing the stormwater issues. However, conservation plays an integral role, particularly with respect to the problem of CSOs. This is because the inherent design of a combined sewer system of a fundamental rule relating water and sewer utilities, which is: what goes in must come out. Many municipalities, including Newark, determine sewerage charges for their customers based on this principal. While input scarcity is not currently a pressing issue in Newark, the ability to responsibly treat outflow is indeed a limiting factor. In this regard, water consumption must be adjusted to match the City's capacity to process the outputs under various hydrological conditions. By omitting this, the Plan ultimately presents a one-sided approach to confronting a two-sided problem with regard to CSOs. Because

[20] *The City of Newark Sustainability Action Plan*. Rep. Newark: 2013. *The City of Newark Sustainability Action Plan*. The City of Newark Office of Sustainability, 2013. Web. 2 Mar. 2014.
[21] "NowData - NOAA Online Weather Data". National Oceanic and Atmospheric Administration. Retrieved 2014-4-22. <Link>

combined sewer systems convey both sewage and stormwater, in order to enhance the effect of the green infrastructure on the system as a whole, conservation on the consumer input side should be taken into consideration.

Secondly, while the plan does identify a goal of establishing green infrastructure pilot projects, it does not clearly articulate target areas for implementation of these pilots. A specific set of criteria should be used to determine the areas most impacted by stormwater flooding and CSOs in order to most effectively implement these projects. Additionally, a method of determining the effectiveness of such projects should also be developed in order to quantify the results to assist with future project planning.

According to the Director of Sustainability, a study is currently underway, led by the engineering firm CDM Smith, to assist with this geographic targeting. Seven neighborhoods have been analyzed remotely, and three have been targeted for further evaluation. Sites on city-owned land with high potential for green infrastructure intervention have been selected and are currently being reviewed according to CDM Smith's site analysis process. According to the Sustainability office, it is intended that the evaluation process being developed by CDM Smith be transferred to Newark's Planning and Sustainability offices to be used for future project implementation.[22] Because this process is still being developed, specific information was not available during the research period for this report. Consequently, one of the aims of this report is to provide useful information to assist with the efforts currently underway to strategically target areas for green infrastructure intervention based on existing conditions and highest expected impact.

## 1.3 Methodology for Analysis

### 1.3.1 Background Research of Existing Conditions

In order to effectively address the problem of stormwater flooding and CSOs, existing conditions in Newark were analyzed. Variables which both affect and indicate these problems, such as precipitation data, land use, topography, population, and water quality, were examined in order to best match solutions to specific problems and areas.

Quantitative and qualitative data from local weather stations, the Newark Water and Sewer Utility, the Passaic Valley Sewerage Commission, and the Federal Emergency Management Agency (FEMA) was collected and analyzed. This data was analyzed according to its significance in impacting stormwater management and CSO events in Newark. The primary goal of this analysis was to determine what specific variables contribute to these problems and where, geographically, the issues are most pronounced. The existing Sewer Utility budget and underlying rate schedules were also studied and compared to financial indicators of nearby cities in order to develop a comparative understanding of the existing capital structure as well as the projected impacts of planned grey infrastructure projects on future water and sewer rates.

### 1.3.2 Research Existing Proposals and Best Management Practices

As noted, Newark has already given much attention to addressing stormwater and CSO related problems as demonstrated by the HHM and NSAP plans. In addition to these two plans, a water and sewer rate study by Red Oak Consulting was analyzed, to determine what management practices have already been considered. Additionally, the plans were compared to the 2013 adopted capital improvement plan to determine which recommendations were in the process of being undertaken.
Acknowledging that much work has already been done to address stormwater issues in other cities, research was conducted of best management practices (BMPs) which have been successfully

[22] "Interview with Stephanie Greenwood, Sustainability Director, City of Newark." E-mail interview. 12 Apr. 2014.

implemented in other cities and where the success has been documented in specific case studies. These BMPs were broadly divided into two categories: those that targeted stormwater runoff from precipitation, and those that affected consumer water use. In examining each case study, the capstone team sought to identify the following, in order to determine the applicability of the BMP to Newark:

- The source of the water (stormwater or sewage);
- The applicable building or land use type;
- The upfront and long-term costs;
- The environmental, social, and economic benefits;
- The cost effectiveness of capturing stormwater or reducing sewage; and
- The approximate timeline for implementation.

In addition, each BMP was also evaluated based on its incorporation in the existing HHM and NSAP proposals.

### 1.3.3 Sources of Information

To collect the data used in this analysis, analysis was conducted of sustainability plans from other cities, technical reports, and municipal budgets. To provide geospatial analysis of the existing conditions and to help target BMPs, census data was collected an interpreted in the form of graphical information systems (GIS) maps. These maps help show where Newark flooding and CSOs are a problem, how land use and surface material relate to the problems, and where potential solution space exists. Finally, a series of interviews with key stakeholders in government, business, community organizations, and academia were conducted. The following is a breakdown of various resources used to compile data for this report:

| Case Studies Reviewed | Interviews Conducted | Map Layers Analyzed/Created |
|---|---|---|
| 46 | 12 | 29 |

# CHAPTER 2: STORMWATER AND FLOODING

**NOTE:** Throughout the report, the term "flooding" is used to describe bulk water accumulation caused specifically by precipitation. In order to narrow the scope of the research and eventual recommendations, storm surge flooding and risks of sea level rise were not addressed. Such flooding requires a different form of analysis and includes solutions which were deemed financially out of the scope for this report.

## 2.1 STORMWATER BACKGROUND INFORMATION

### 2.1.1 Historic Precipitation

To address solutions to stormwater flooding, it is important to understand and describe the current and expected precipitation trends affecting Newark. Historic precipitation and temperature data from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center was analyzed. The monitoring station used in this analysis is located at the Newark-Liberty International Airport (EWR), and the earliest reliable data available for that station starts in 1936.

Figures 3 and 4, below, depict graphs of historic annual rainfall and temperatures for Newark and NYC since 1936. The graph shows a distinct long-term trend of rising annual precipitation amounts and average annual temperature in Newark over the past 80 years. According to a June 2013 report by the New York City Panel on Climate Change (NYCPCC), the region may experience up to a 6.5°F increase in temperature and up to a 15% increase in precipitation by 2050 compared to a 1971-2000 baseline.[23]

A more in-depth analysis of the historic rain data was undertaken to describe the characteristics of an average precipitation event in Newark, as well as the frequencies of both an average and extreme event. The histograms below, in Figures 5 and 6, depict the relative frequency of rain and snowfall events by size, as measured in inches of precipitation. As illustrated, the vast majority of Newark rain events, 58.5%, were less than 0.25 inches; however, the average rain event is approximately 0.39 inches, indicating that stronger rainstorms occur at statistically significant intervals. This analysis was critical to formulating strategies outlined in this report, which are meant to reduce the impact of average precipitation events on flooding and CSOs.

According to the 2013 NYC Panel on Climate Change Report, the frequency, intensity, and duration of extreme precipitation events is expected to increase over this timeframe.[24] The chart in Figure 7, below, shows that the number of extreme precipitation events has trended upward. A rise in precipitation may be attributable to larger climatic changes, notably rising temperatures.[25] If these trends continue, they will result in further overburdening and deteriorating the existing stormwater infrastructure.[26] Specifically, it will lead to more frequent flooding and CSO events.

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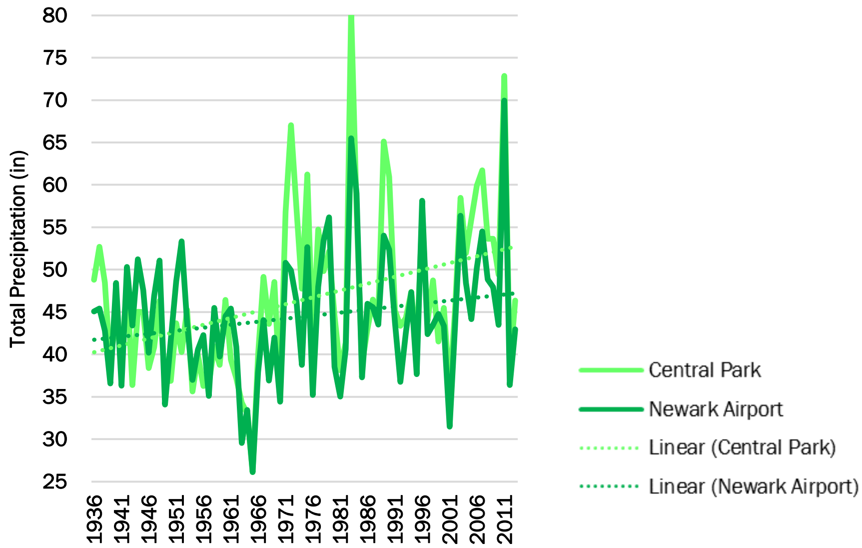
[23] "Climate Risk Information 2013: Observations, Climate Change Projections, and Maps." New York City Panel on Climate Change, June 2013. Report. P. 5. <Link>
[24] Ibid. P 20.
[25] "Climate Change Indicators in the United States." US EPA, 13 Sep 2013. <Link>
[26] Moritz, Heidi, and Hans Moritz. "Evaluating Extreme Storm Power and Potential Implications to Coastal Infrastructure Damage." US Army Corps of Engineers. Article. <Link>



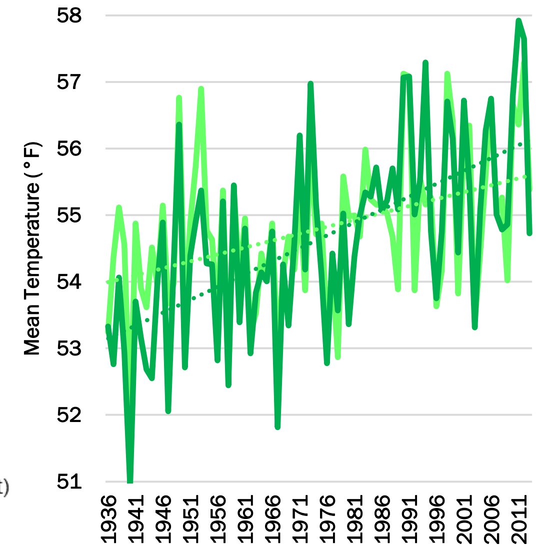
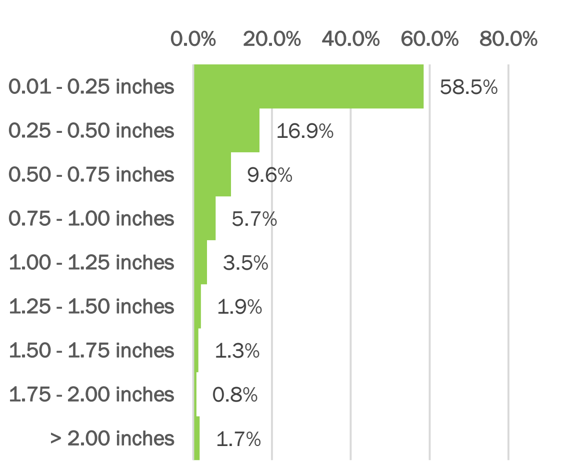




FIGURE 3: HISTORIC ANNUAL TOTAL PRECIPITATION IN NEWARK AND NYC

FIGURE 4: HISTORIC ANNUAL MEAN TEMPERATURE IN NEWARK AND NYC



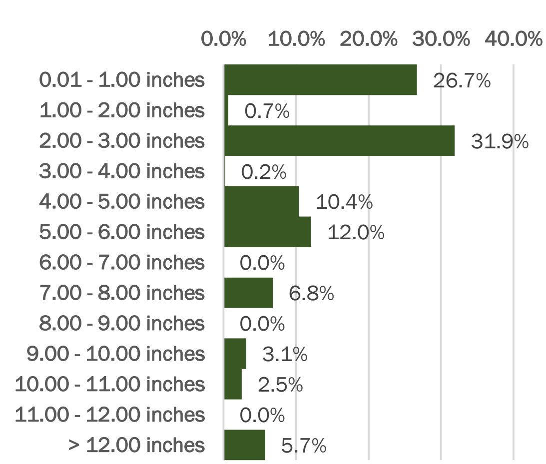




FIGURE 5: NEWARK'S HISTORICAL RAINSTORMS BY SIZE 1936-2013

FIGURE 6: NEWARK'S HISTORICAL SNOWSTORMS BY SIZE 1936-2013

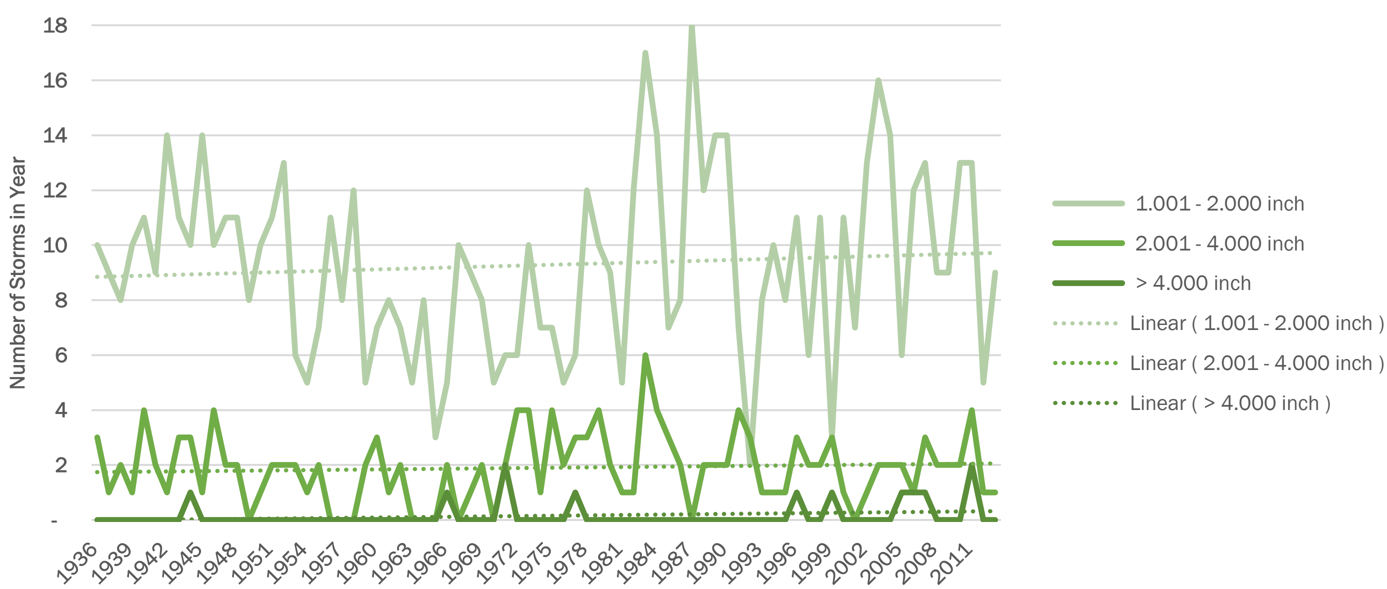



FIGURE 7: ANNUAL FREQUENCY OF EXTREME PRECIPITATION EVENTS IN NEWARK

## 2.1.2 Newark Topography, Land Use, and Elevation

In addition to precipitation analysis, it is equally important to examine Newark's elevation, topography, and land use. These variables directly impact the way in which precipitation events interact with the City's sewer system by dictating the path of stormwater runoff resulting from precipitation events or snowmelt. Impervious surfaces, for example, prevent water from naturally infiltrating the ground. Barring infiltration, stormwater runoff will flow downhill and can pool in areas of lower elevation if the storm drains are clogged by debris. This runoff can collect debris and various pollutants on its way to the sewer, burdening the treatment plant and contaminating nearby bodies of water.[27]

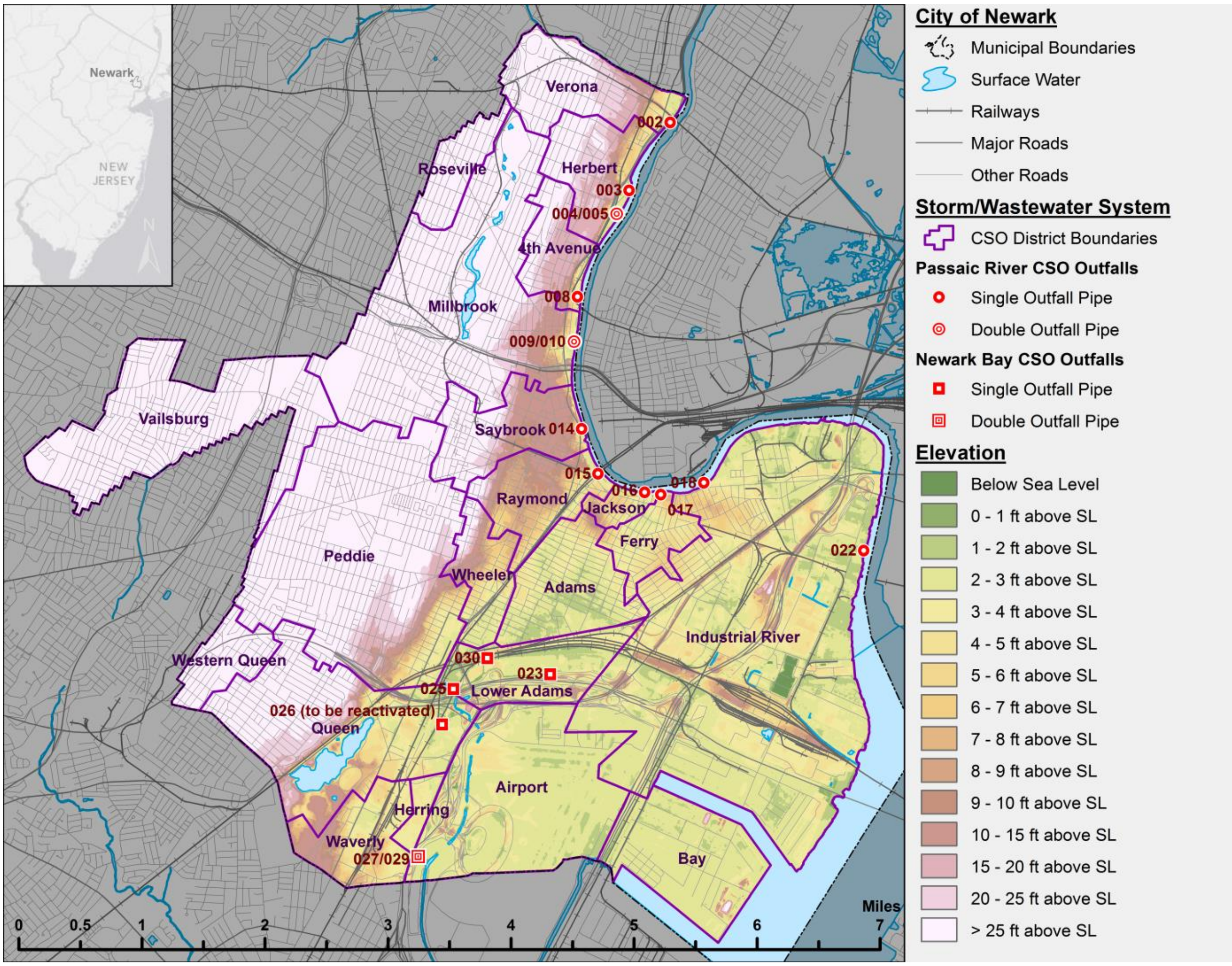


FIGURE 8: GRADIENT MAP OF NEWARK ELEVATION

Elevation data taken from the U.S. Geological Survey's National Elevation Dataset website was used to map low-lying areas in the city. As the maps in Figures 8 and 9 below indicate, 47% of the city is less than six feet above sea level, and 28% of the city is less than three feet above sea level. These areas of lower elevation are primarily in the eastern half of the city, east of Route 21. As the maps show, the city slopes downward from West to East toward the Passaic River and Newark Bay. Within this eastern section of the city, there are subtle variations in elevation from street to street. Southern sections of the Ironbound District, for example, are lower than neighboring North Ironbound and Springfield/Belmont indicating that

27 ""After the Storm"" *EPA.gov*. US EPA, Web. 11 Apr. 2014. <Link>

stormwater runoff from those neighborhoods may flow down to those areas in the South Ironbound, serviced by the Adams Sewer District shown in the maps below.

Land use in Newark is primarily divided into high-density residential and commercial/industrial use, with a very small proportion of land dedicated to undeveloped, open space. The map in Figure 10 below shows the various land uses in Newark, highlighting the high proportion of high-density residential, commercial, and industrial land comprising the City. The mixed land-uses will each require distinct strategies to address flooding and combined sewer overflow events. Parks and other green space provide vegetated cover where rain can infiltrate the ground, but rooftops, sidewalks, and parking lots represent large swaths of land where rain is directed towards the sewer system as stormwater runoff.

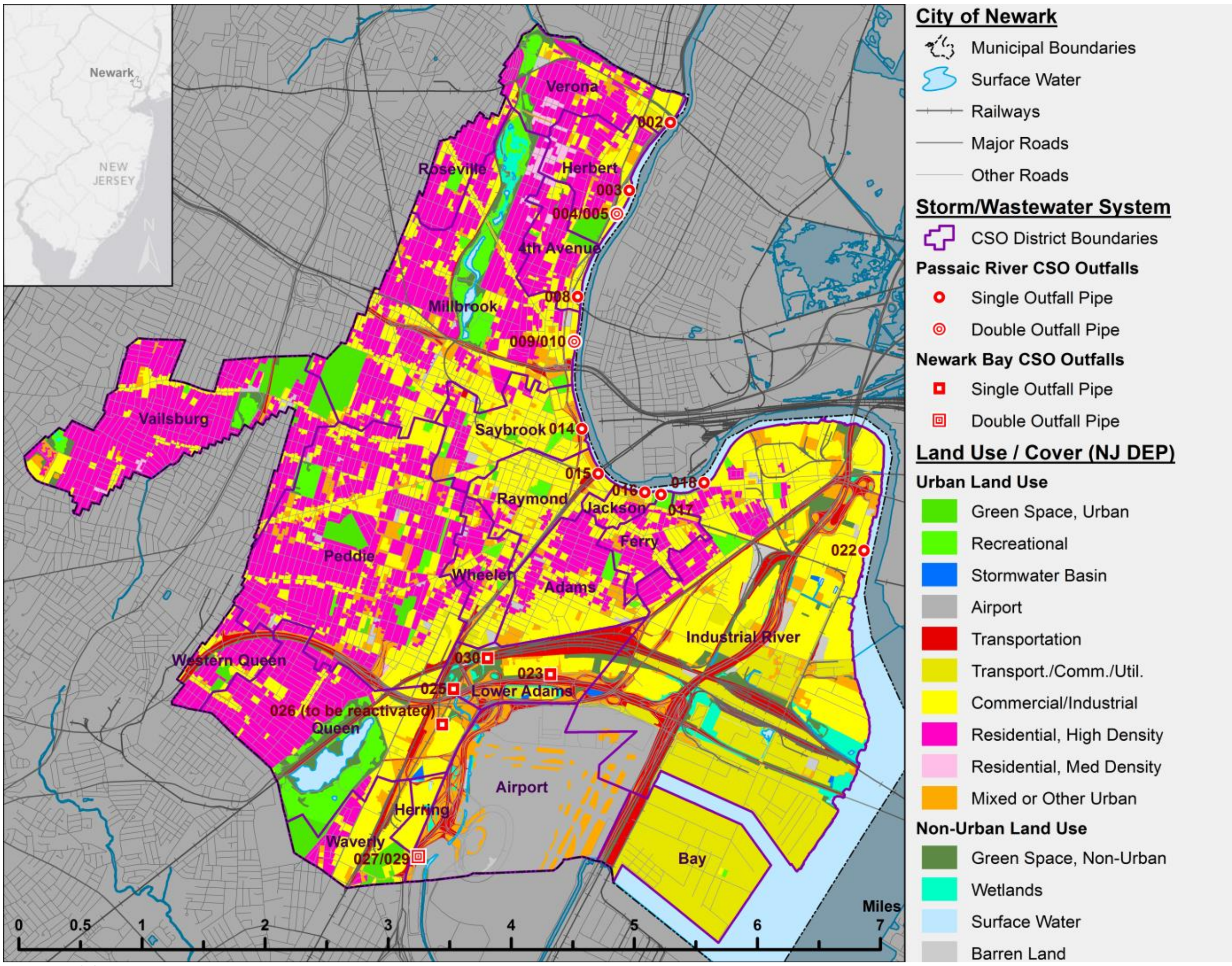


FIGURE 10: LAND USE IN NEWARK

As a result of this land use, the topography is primarily composed of impervious surface materials. According to the U.S. Geological Survey's National Land Cover Database (NLCD), more than half of Newark is covered by surfaces that are characterized as 70-100% impervious, as illustrated in the map in Figure 11 below. When compared to the previous elevation map, one can see that the areas of highest concentrated impervious surfaces are also areas of lower elevation.

Based on analysis of Newark's sewer districts, approximately 7,254 acres of Newark is serviced by a combined sewer system. The average percentage of imperviousness of this area is 68%, meaning that for every gallon of water that falls as precipitation, 32% is infiltrated into the ground and 68% is converted to runoff. Using Newark's average rainfall data, it is estimated that the City produces approximately 5.9 billion gallons of stormwater runoff annually, which, by design, is conveyed to the wastewater treatment plant for processing.

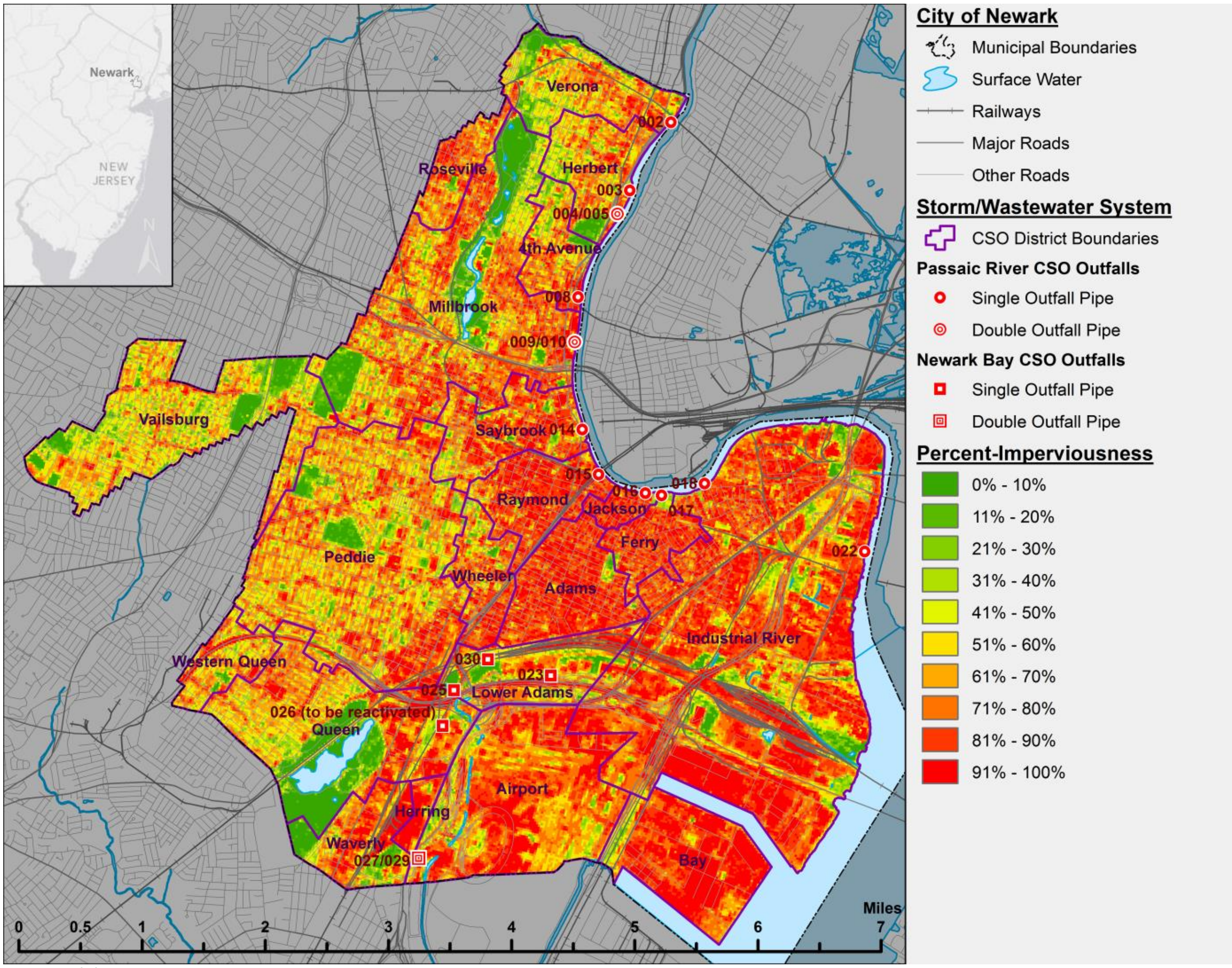


FIGURE 11: PERCENT-IMPERVIOUSNESS OF NEWARK LAND

## 2.2 ENVIRONMENTAL IMPACTS OF STORMWATER

Stormwater runoff can contribute to numerous water quality problems through conveyance of pollutants into nearby waterways, as well as increasing health risks, degrading ecosystems, and damaging tourist economies.[28] The pollution levels from urban stormwater runoff have been shown to be higher than secondary domestic sewage, and are considered to be second in total annual volume only to agricultural stormwater runoff, making the need for addressing this problem a primary environmental and health concern for the City.[29] Table 2 shows a list of common pollutants found in stormwater as determined by the New Jersey DEP.

Pollution levels from urban stormwater runoff have been shown to be higher than secondary domestic sewage, and are considered to be second in total annual volume only to agricultural stormwater runoff,

[28] "Rooftops to Rivers II." *Stormwater Runoff, Controlling Water Pollution*. Web. 26 Apr. 2014. <Link>

[29] Deletic, A. and Maksimovic, C. (1998). "Evaluation of Water Quality Factors in Storm Runoff from Paved Areas." *J. Environ. Eng.*,124(9), 869–879.

making the need for addressing this problem a primary environmental and health concern for the City. Table 4 shows a list of common pollutants found in stormwater as determined by the New Jersey DEP.

PHOTO 1: RUNOFF POLLUTION.
PHOTO CREDIT: JORDAN BONOMO, COLUMBIA UNIVERSITY

| Pollutant | Typical Concentration |
|---|---|
| Total suspended solids [a] | 80 mg/l |
| Total phosphorus [b] | 0.30 mg/l |
| Total nitrogen [a] | 2.0 mg/l |
| Total organic carbon [d] | 12.7 mg/l |
| Fecal coliform bacteria [c] | 3600 MPN/100ml |
| E. Coli bacteria [c] | 1450 MPN/100ml |
| Petroleum hydrocarbons [d] | 3.5 mg/l |
| Cadmium [e] | 2 ug/l |
| Copper [a] | 10 ug/l |
| Lead [a] | 18 ug/l |
| Zinc [e] | 140 ug/l |
| Chlorides [f] (winter only) | 230 mg/l |
| Insecticides [g] | 0.1 to 2.0 ug/l |
| Herbicides [g] | to 5.0 ug/l |

Notes

1. Data sources: a Schueler (1987), b Schueler (1995), c Schueler (1997), d Rabanal and Grizzard (1996), e USEPA (1983), f Oberts (1995), g Schueler (1996).
2. Concentrations represent mean or median storm concentrations measured at typical sites and may be greater during individual storms. Mean or median runoff concentrations from stormwater hotspots are higher than those shown.
3. Units: mg/l = milligrams/liter ug/l = micrograms/liter MPN = Most Probable Number

TABLE 4: TYPICAL STORMWATER POLLUTANTS[30]

## 2.3 IMPACTS OF STORMWATER ON FLOODING

Stormwater runoff collected on impervious surfaces (streets, sidewalks, parking lots, roofs) is conveyed to drains and basins to be treated at a wastewater treatment plant for discharge into nearby water bodies.[31] Major rainfall events can cause flooding when drainage systems do not have the necessary capacity to cope with sudden increased flow rates. When sewer systems become inundated, or storm drains blocked with debris, backup can occur. Runoff can enter the sewage system in one place and resurfaces elsewhere. Such flooding is common in Europe, as experienced by the floods that affected parts of England in the summer of 2007. Increased urbanization, rising populations, and high demands for land lead to obstruction of the natural flow path of water, which can cause flooding.[32]

Newark is already experiencing problems of flooding as depicted in Figure 12 which shows areas of commonly-flooded streets and intersections in Newark, based on a list circulated by the City, and published on NewarkPulse.com, in 2011.[33] According to an interview with the City of Newark's Water and Sewer Utility, inland flooding in Newark generally occurs due to back-up of the stormwater drainage system and a lack of pervious surfaces. The elevation of these flood prone regions varies, and the contours of the land can also affect flooding locations as discussed previously.

30 *New Jersey Stormwater Best Practices Manual*. Rep. New Jersey DEP, Feb. 2004. Web. <Link>
31 Field, Richard, Hugh Masters, and Melvin Singer. *Status of Porous Pavement Research*. Tech. Edison, NJ: United States EPA, 1981. Print.
32 Cities and Flooding, A Guide to Integrated Urban Flood Risk Management for the 21st Century, Abhas K Jha, Robin Bloch and Jessica Lamond, 2012 International Bank for Reconstruction and Development/ International Development Association P 57-58. <Link>
33 "Hurricane Flooding Zones and Info - Newark, NJ." *Hurricane Flooding Zones and Info - Newark, NJ*. Web. 28 Mar. 2014. <Link>

The State of New Jersey was declared a Major Disaster Area due to severe storms and flooding once in the 1980s, three times in the 1990s, and six times between 2000 and 2009.[34] New York State underwent a similar increase between those decades, with five disaster declarations in the 1980s, five in the 1990s, and twelve between 2000 and 2009. In 2011, Hurricane Irene precipitated nearly nine inches of rain in Newark, displacing thousands of New Jersey residents and resulting in nearly $38 million in reparatory federal loans and grants for Essex County.[35] [36] According to FEMA, between 20%-25% of all flooding-related economic losses occur because of poor urban drainage in non-floodplain areas, which are non-coastal land normally not prone to flooding from storm surge.[37] If climate predictions discussed earlier are realized, it is likely that flood risk, and associated monetary damages from flooding, will also increase going forward.[38] Recent studies indicate that monetary damages from flooding will increase in 14 of the 18 Water Resource Regions in the contiguous United States—including the one for Newark, NJ. These are regions that depict the boundaries of the river drainage-basin units in the United States.[39]

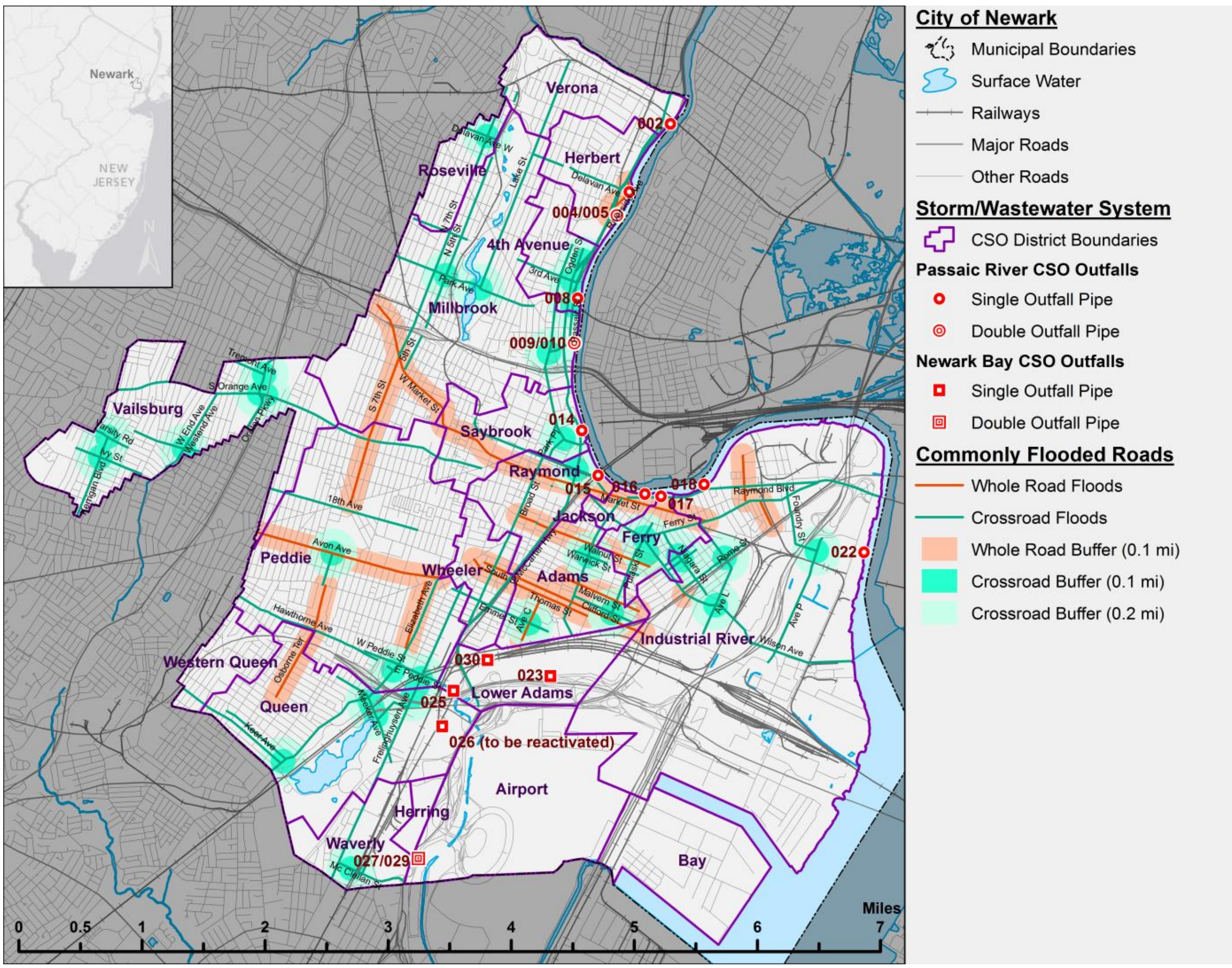



FIGURE 12: COMMONLY FLOODED STREETS AND INTERSECTIONS IN NEWARK

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[34] *Disaster Declarations*. Federal Emergency Management Agency, Web. 02 Mar. 2014. <Link>
[35] "Summary of Flooding in New Jersey Caused by Hurricane Irene, August 27–30, 2011." New Jersey USGS. <Link>
[36] Stirling, Stephen. "A year after Irene, experts say N.J. must strengthen infrastructure before it's too late." NJ.com. 25 Aug 2012. <Link>
[37] "Chapter 2: Types of Floods and Floodplains." FEMA Training Manual <Link>
[38] Wobus, Cameron, et al. "Estimating monetary damages from flooding in the United States under a changing climate." *Journal of Flood Risk Management* (2013).
[39] Ibid.

# Chapter 3: Flooding Solution Space

## 3.1 Reducing Stormwater with Green Infrastructure

Green infrastructure is characterized by low impact development (LID), which is an approach to development that manages stormwater at the source by preserving or recreating natural landscape features and processes. Examples of GI technologies include cisterns, rain gardens, green roofs, and permeable pavements. These help make up a set of stormwater best management practices that reduce the impact of built areas on a watershed.[40]

Green infrastructure can be categorized into three groups – detention, retention, and filtration – which describe the level to which they mimic the natural process of absorption, infiltration, and filtration of stormwater during and after precipitation events. Table 5 lists the benefits of each classification of these GI technologies, many of which overlap. Detention technologies delay stormwater from entering the system thereby reducing flooding, sewer backups, and overall strain on sewer systems. Retention technologies can both delay and minimize runoff by allowing more water to infiltrate and recharge groundwater. Additionally, retention technologies can also reduce potable water consumption by allowing captured stormwater to be repurposed for other uses.

| Benefits and Limitations | Filtration / | Retention / | Detention |
|---|---|---|---|
| Reduces CSOs | F | R | D |
| Reduces treatment costs | F | R | |
| Reduces potable water consumption | | R | |
| Reduces flooding | F | R | D |
| Reduces sewer backups | F | R | D |
| Reduces separate/direct discharges | F | R | |
| Reduces strain on sewers | F | R | D |
| Provides a community asset | F | | |
| Improves air quality | F | | |
| Reduces urban heat effect | F | | |
| Limited by high groundwater and bedrock | F | | |
| Higher capital expense than standard construction | F | R | D |
| Higher maintenance expense than standard construction | F | R | D |

Table 5: Benefits of different green infrastructure types[41]

Filtration techniques produce similar benefits those of retention while also reducing pollutants in the stormwater by mimicking the natural filtration provided by vegetation and soil. The inclusion of vegetation provides additional environmental and social benefits such as improved air quality and reduced urban heat island effect. Filtration technologies also provide certain economic benefits related to the costs of wastewater treatment. Currently, the sewer fee, collected through the PVSC user charge, consists of three components: volume load, biological oxygen demand load (BOD), and total suspended solids (TSS) load.

[40] "Low Impact Development (LID)." *Home*. US EPA, Web. 29 Apr. 2014.

[41] USA. The Mayor's Office of Long Term Planning and Sustainability. *Sustainable Stormwater Management Plan 2008*. Mayor Michael Bloomberg, 2008. Web. 12 Feb. 2014. P 50. <Link>.

The last two of these components are indicators of contaminant levels in the wastewater. Adoption of sufficient levels of filtration technologies could reduce these contaminant levels thereby reducing treatment costs at PVSC.[42] As PlaNYC has demonstrated, effective integration of these stormwater BMPs can lessen the costs of traditional grey infrastructure upgrades by reducing the necessary capacity of those systems.[43] Preserving and recreating natural landscape features can also create functional and appealing site drainage that treats stormwater as a resource rather than a waste product. The following sections contain examples of each type of green infrastructure technology along with case studies exemplifying successful implementation in other cities across the country.

## 3.1.1 Detention

### Rain Barrels and Cisterns

Rain barrels are placed beneath roof downspouts to collect runoff for reuse in lawn and garden watering. Barrels defer runoff, preventing stormwater from reaching CSOs all at once, and reduce overall runoff volume. Typically, rain barrels have capacity for between 50 and 100 gallons and multiple barrels can be connected in parallel to increase the amount of capture. This intervention strategy works best when the collected water is repurposed for landscaped areas of residential, commercial, or industrial buildings. Rain barrels are only useful outside of winter months, at which time they must be disconnected from downspouts to prevent freezing. If properly maintained, a plastic rain barrel can last for 20 years or more.[44] Designing and installing a rain barrel system is relatively simple, and can typically be performed a worker with little previous training. Because of this, the cost of a rain barrel system is relatively inexpensive, costing, on average, $3.65 per gallon, or $182.50 to $365 per barrel. Ultimately, the specific size for a residential unit depends on the square footage of the roof to which it is being applied.[45]

PHOTO 2: RAIN BARREL. PHOTO CREDIT: FROZEN GARDNER

PHOTO 3: RAIN CISTERN. PHOTO CREDIT: DIG COOPERATIVE

Cisterns are manufactured tanks, or underground holding areas, which store large volumes of non-potable stormwater, which can be applied to residential, commercial or industrial buildings. Captured water is can be lightly treated and used for fountains, pools, grey water, air conditioning, and other purposes. Cisterns are typically sized between 300 and 1,000 gallons, though some are as large as 10,000 gallons. With proper maintenance, these systems can last for more than 20 years, with an associated cost of approximately $7.40 per gallon of storage, or $2,220 to $7,400, depending on the roof size.[46] System design may require engineering and typically requires longer construction timelines than rain barrels, due to more intensive plumbing requirements. Unlike rain barrels, cisterns can remain in service year-round.

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[42] Schneider, Eric, PE, comp. *City of Newark Sewer System Master Plan*. Tech. Hatch Mott MacDonald, 2011. Print.
[43] USA. *PLANYC2030*. The City of New York, Apr. 2011. Web. 15 Mar. 2014. P 69.<Link>.
[44] Gannon, Mike. President, The Pond Hunter/Ful Service Aquatics 27 October 2012.
[45] USA. The Mayor's Office of Long Term Planning and Sustainability. *Sustainable Stormwater Management Plan 2008*. Mayor Michael Bloomberg, 2008. Web. 12 Feb. 2014. P 50 <Link>.
[46] Ibid.

Furthermore, the cost per gallon is low and could be offset with financial savings if collected water is repurposed for non-potable uses.

**Case Study: New York City**

Both rain barrels and cisterns have been implemented in NYC with notable success. The DEP conducted a pilot program in Jamaica Bay, Queens. The city distributed 250 rain barrels and installation equipment and provided installation guidance in a low-density, residential neighborhood. Residents installed the barrels themselves, though the DEP provided free training sessions to aid in the process. While surveys are still being analyzed, early responses are overwhelmingly positive. The Council on the Environment for New York City (CENYC) has helped to create rain-harvesting systems at 39 community gardens. Using their online design guidelines "How to Make a Rainwater Harvesting System," they have saved over 500,000 gallons of water since the installation of these 39 cisterns.

While rain barrels and cisterns are not explicitly recommended in the Newark Sustainability Plan, they are discussed as potential small-scale strategies that can be incentivized through the development of a city-wide green infrastructure policy.[47] The calculations below assume a 75% rain capture rate for a 75 gallon barrel on a 400 square foot roof, which increases the cost effectiveness, $/gallon diverted, relative to the NYC Stormwater Management Plan rate of $3.65/gal. To provide an example of the cost-effectiveness of this technology, a model was developed based on a typical installation. The other set of calculations below assume a 700-gallon cistern for a commercial or multi-family building with a 1,000 square foot roof and a capture rate of 100%, based on the assumption of a larger capacity and water re-use rate.

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Rain Barrel** | Single Family Residential | Reduces peak stormwater runoff; reduces consumer demand | Community engagement; job creation | Customer water bill savings; Utility sewer savings | $273.75 | $0.0226 |
| **Conclusions:** Barrels will be most useful in areas that have landscape to maintain or some other use for this non-potable water. Otherwise it is only a way to delay the timing of stormwater into the wastewater system. Need to be disconnected in winter months to avoid freezing | | | | | | |
| **Cisterns** | Industrial, Commercial, and Public | Reduces peak stormwater runoff; reduces consumer demand | Community engagement; job creation | Customer water bill savings; Utility sewer savings | $5,180.00 | $0.1707 |
| **Conclusions:** Cisterns have longer lead times and may require more upfront and maintenance costs compared to rain barrels but captured water is more likely be used for non-potable uses than a rain barrel, enhancing overall benefits. | | | | | | |

## 3.1.2 Retention

### Permeable Pavements

Traditional pavements used in developed areas are highly impermeable, reducing infiltration, and quickly channeling runoff downhill to sewer drains. Permeable pavement, which costs approximately 10-20% more to install than traditional pavement, is particularly useful in areas that repeatedly experience heavy flooding.[48] The United States EPA states that the lifespan of permeable pavement is longer than that of

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[47] USA. The City of Newark Sustainability Action Plan." Web. 18 Feb. 2014. P 72. <Link>.
[48] Ibid

impervious pavement due to a reduction of freeze-thaw periods.[49] This can be more than 30 years compared to a 15-year lifespan of traditional pavement.[50] While permeable pavement requires special rubber snowplow blades to protect from damages, it actually can reduce overall costs associated with snow removal by absorbing snowfall and reducing shoveling time requirements. It also eliminates the need for road sand and reduces costs associated with salting in the winter. Additionally, permeable pavement is rougher than traditional pavements, providing better traction to pedestrians and vehicles.[51]

Porous pavement is not recommended for use in high traffic areas, streets commonly used by heavy trucks, areas with high levels of bedrock, high water tables, commercial nurseries, auto recycling facilities, vehicle maintenance areas, fueling stations, industrial parking lots, hazardous material generators, outdoor loading facilities, or public works storage areas. Also, areas with soil containing high clay content have significantly lower permeability, which minimizes the benefits of this technology.[52]

There are also some additional maintenance costs, which include regular street-sweeping and bi-annual vacuuming to remove accumulated sediment and dirt, allowing full permeability of the pavement. These annual maintenance costs are approximated to be about $285 per acre.[53] Additionally, there are added costs for sand and stone substrate materials where the stone costs $40 while the sand is $25 per cubic yard. These costs come from a project at Stewart Airport, which uses an 18” stone and 12” sand substrate.[54] When comparing traditional concrete to permeable concrete, the lifespan of the concrete and differences in maintenance costs must also be considered. Based on a typical lifespan of 15 years and costs of $1 per square foot with zero maintenance, traditional concrete costs approximately $0.067/sf/yr. By comparison, permeable concrete lasts 30 years and costs $4.49/sf over its lifetime. This results in costs of $0.15/sf/yr. Over a 30 year period, traditional pavement costs are $0/07/sf. However, these cost do not include the reduced costs of stormwater runoff or snow removal and treatment associated with permeable pavement; further adding to the economic benefits of the technology.

To illustrate the applicability, benefits, and economics of this technology, a hypothetical model was developed based on figures from existing case studies. The chart below provides a summary of the benefits of permeable pavement with an assumed lifecycle cost of $4.49 per square foot. The estimated infiltration rate used was 100%, based on examples found in other case studies. Permeable pavement will be a technology utilized in the pilot area and discussed within that section.

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Permeable Pavement** | Parking Lots, Sidewalks, low traffic streets | Reduce peak stormwater runoff; Increase groundwater recharging; reduce pollutants | Visual representation of city progress on water issues | Increased pavement life; reduced snow related costs | $4,494.68 | $0.1481 |

**Conclusions:**

Can be used in many concrete areas and can be coupled with other GI technologies. While capital and maintenance costs are higher than traditional pavement they should be mitigated by the increased life and reduced snow related costs

49 “National Pollutant Discharge Elimination System (NPDES).” 3 November 2012. <Link>.

50 Gunderson, J., Pervious Pavements: New Findings About Their Functionality and Performance in Cold Climates, *Stormwater*, Sep. 2008. <Link>

51 “National Pollutant Discharge Elimination System (NPDES).” 3 November 2012. <Link>.

52 "Pervious Pavement." *EPA - Stormwater Menu of BMPs*. 10 Sept. 2009. Web. 2 Apr. 2014. <Link>.

53 "Stormwater Management - Pervious Pavement." *Lake Superior Streams*. Web. 31 Mar. 2014. <Link>.

54 Cremin, Phillip "Stewart Airport Pervious Pavement Project." Telephone interview. 2 May 2014.

## Case Study: Lebanon Valley PA

Porous pavement was installed in the Lebanon Valley Agricultural Center parking lot in Pennsylvania to provide additional parking space in July of 2003. The completed lot has a center drive lane composed of conventional asphalt and 58 new spaces, 40 of which are porous.

PHOTO 4: POROUS ASPHALT PARKING LOT IN LEBANON COUNTY

The overflow design is comprised of four 4-inch pipes located at the top of a 24" infiltration bed, which discharge to a well-vegetated area. Two 6-inch pipes discharge to an existing vegetated swale on the site, providing additional overflow.[55] Upon completion, several high intensity storms demonstrated the success of the technology, as there was little to no discharge observed from the connected overflow pipes. Observed costs for this stormwater management BMP have been approximately $2,000-$2,500 per parking space.[56]

## 3.1.3 Filtration

### Rain Gardens

Rain Gardens are engineered natural stormwater treatment systems consisting of landscaped, planted areas. They are constructed with a special soil mixture, an aggregate base, an under drain, and utilize site-appropriate, preferably native, plants. The rain garden is graded to intercept runoff from paved areas, grass swales, or roofs. The garden is moderately depressed with a bottom layer of stone to help retain stormwater. They can be connected to sewer systems through an overflow structure; however, they are typically sized to infiltrate the collected runoff within 72 hours of a precipitation event.

Rain gardens are easy to incorporate into landscaped areas, and are compatible with many types and sizes of developments and retrofits.[57] Typical rain gardens are designed to manage 0.5 inches of rain per hour, though specific systems can be designed to handle different capacities depending on the conditions. With proper drainage from the soil, the garden can be sized at 20% of the total square footage of the impervious surface it is servicing.[58] For example, a 0.25 acre rain garden could provide sufficient capacity to infiltrate runoff from a 54,450 square foot impervious surface.

In 2009, the Greater Newark Conservancy partnered with Rutgers University to develop six rain gardens. Through the City's Adopt-a-Lot program, more of these gardens can be constructed on city-owned vacant land for a $1/year lease. In addition to the environmental benefits, rain garden development can provide social benefits through community engagement.[59]

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[55] USA. Pennsylvania DEP. *Pennsylvania Stormwater Best Management Practices Manual*. Jan. 2005. Web. 18 Mar. 2014. P.24 <Link>.
[56] USA. Pennsylvania DEP. *Pennsylvania Stormwater Best Management Practices Manual*. Jan. 2005. Web.18 Mar. 2014. P. P.25. <Link>.
[57] "Green Stormwater Infrastructure Tools." *Green Stormwater Infrastructure Tools*. Philadelphia Water Department, 2014. Web. 15 Mar. 2014. <Link>.
[58] Hinman, Curtis. *Rain Garden Handbook for Western Washington Homeowners*. Washington State University Pierce County Extension, June 2007. Web. 14 Apr. 2014. <Link>.
[59] USA. The City of Newark Sustainability Action Plan." Web. 18 Feb. 2014 P 78. <Link>.

Economic benefits can be realized due to the relatively low costs of implementation. These can be as low as $3-$4 plus excavation for residential and smaller gardens and as high as $10 - $40 per square foot for commercial gardens, which could include under drains or other control structures.[60] [61] The useful life of a typical rain garden is 30 years. Based on information from the Rutgers University project, yearly maintenance costs amount to approximately $0.252 per square foot.[62] Properly located, rain gardens can provide numerous public benefits for low upfront and maintenance costs.

PHOTO 5: RAIN GARDEN AT HOLMELTWP, PUBLIC SCHOOL DISTRICT. PHOTO CREDIT: ASLA

To illustrate the cost effectiveness of this BMP, the table below depicts a hypothetical rain garden situated on a 0.25 acre vacant lot. Land costs were estimated at $1/year based on the existing Adopt-a-Lot program, and construction costs were conservatively set at $10/sq-ft with yearly maintenance costs of $0.252/sq-ft, based on the results of the Rutgers University project.

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Rain Garden** | Any area that is downhill of impervious surfaces. Vacant lots work well | Reduce peak stormwater runoff; reduce pollutants; | Can be a visual representation of city progress and can engage community to help with construction of garden | Utility sewer savings; possible property value increases of surrounding area | $191,258.40 | $0.1158 |

**Conclusions:**
Rain gardens are an extremely visual representation of progress in the city on water issues and can beautify the landscape while removing vacant lots from the city. Gardens can be designed to handle various hourly precipitation rates according to the specific needs of the site.

## Swales

Swales are densely vegetated depressions that retain and filter the first rush of runoff from impervious surfaces such as parking lots or streets. Typically, swales are sized at 1% of the total surface area draining into them.[63] Swales can be defined as dry or wet in nature. Dry swales are optimal for treating highway and residential runoff due to their linear structure. They are best utilized in low- to moderate-density developments. Wet swales function as a wetland and can be constructed in relatively impervious soils or in areas with higher water tables. Both types reduce peak runoff and promote infiltration while improving water quality and reducing erosion. In general, they are less expensive, and easier to maintain, than traditional curb and gutter systems. Due to their filtration benefits, swales also act as an effective pretreatment of stormwater runoff before it is released to a treatment facility. Because a wet swale will constantly contain some level of standing water, they can risk harboring mosquitoes, which limits their applicability to areas located further away from residential and commercial districts.

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60 Flynn, Kevin Martin. *Evaluation of Green Infrastructure Practices using Life Cycle Analysis.* Thesis. College of Engineering, Villanova University. Villanova: Kevin Martin Flynn, 2011. <Link>
61 Guillette, Anne. "Low Impact Development Technologies." WBDG, 18 Oct. 2010. Web. 15 Mar. 2014. <Link>.
62 Flahive DiNardo, Madeline. *Rain Garden Maintenance*. Rutgers University Cooperative Extension, 2009. Web. 20 Mar. 2014. <Link>.
63 USA. EPA. Office of Water. *Stormwater Tech Fact Sheet Vegetated Swales*. N.p., Sept. 1999. Web. 1 Apr. 2014. <Link>.

To be effective, swales must be constructed downhill from a runoff source and are generally at the edge of these paved or impervious areas. As grassed swales are typically linear in construction, they can be fashioned even on the smallest parcels of land, and are often incorporated alongside highways and railroad infrastructure. Design strategies vary based on the desired effects, with some designs meant only to slow the release of runoff during peak storm events, while other designs can incorporate more elaborate filtration methods to remove pollutants.

PHOTO 6: ROADSIDE WET SWALE. PHOTO CREDIT: NATIVE PLANTS AND WILDLIFE GARDENS

This technology is easily retrofitted and customizable to many types of land use, size, shape, and depth. This infrastructure should not be used in ultra-urban locations unless coupled with other technologies or additional swales, as they could become inundated with runoff. Furthermore, these swales should not be located downhill of areas that have high levels of contaminants such as gas stations.[64] According to a study conducted by the US DOT in Charlottesville, Virginia, a dry swale remediated approximately 40% of the pollutants from runoff in a system designed to detain stormwater for 90 minutes.[65] Costs of these projects range from roughly $0.25 - $0.50 per sf depending on design costs.[66] Regular maintenance is required to ensure a dense vegetated cover, which includes mowing, weeding, reseeding barren areas, and removing built up sediment. The charts below illustrate the cost effectiveness, as well as social, environmental, and economic benefits of a hypothetical dry and wet swale installation. The figures shown assume a swale size of 1,000 square feet, with capacity to detain two acres worth of runoff.

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Dry Grassed Swale** | Residential; alongside highways and rail; Low to Moderate density development | Reduce peak stormwater runoff; reduce pollutants; limited ground water recharge | Can be a visual representation of city progress | Cheaper than concrete ditches or sewers | $2,900.00 | $0.0010 |
| **Conclusions:** While this GI cannot be used in downhill of high contaminated areas they can be established in many land use types due to their adaptable, linear, design. They will delay peak stormwater runoff | | | | | | |
| **Wet Grassed Swale** | Alongside highways and rail; Areas of high water tables or relatively impervious soil | Reduce peak stormwater runoff; reduce pollutants | Can be a visual representation of city progress | Cheaper than concrete ditches or sewers | $2,900.00 | $0.0010 |
| **Conclusions:** While this GI can't be used in downhill of high contaminated areas they can be established in many land use types due to their adaptable, linear, design. This GI acts as a natural wetland and will delay the peak stormwater runoff. Maintenance is very low and construction is relatively inexpensive. Not to be used in residential or commercial areas due to threat of mosquitoes breeding from standing water | | | | | | |

64 "Stormwater Management - Grassed Swales." Web. 20 Mar. 2014. <Link>.
65 "Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring." US Department of Transportation, 1994. Web. 20 Mar. 2014. <Link>.
66 Guillette, Anne. "Low Impact Development Technologies." WBDG, 18 Oct. 2010. Web. 15 Mar. 2014. <Link>.

## Urban Tree Canopy

Trees provide a number of additional environmental benefits by improving air quality, reducing urban heat island effect, sequestering carbon dioxide from the atmosphere, and absorbing stormwater runoff through natural transpiration. Trees also provide social benefits through neighborhood beautification and economic benefits through increased property values, often resulting in higher community support for this stormwater management intervention.[67]

As described previously, vegetated space makes up a small portion of Newark's land use, particularly in the eastern half of the City, as illustrated in the map in Figure 13, below. This can be attributed to the high proportion of impervious surfaces that make up this region. Furthermore, these are areas of particularly high population density, represented in the Adams and Ferry sewer districts below. Urban tree canopies, as well as previously discussed rain gardens, provide a solution which combines effective stormwater management with the added benefit of neighborhood beautification.

A tree can store about 50 to 100 gallons of water throughout the parts above ground, meaning the ultimate volume of runoff is reduced and the time of peak flow is delayed.[68] This difference in volume retention is determined by characteristics in the trunk, stem, and surface areas, textures, area of gaps, period when leaves are present, and dimensions. Trees with coarse surfaces can retain more rainfall than those with smooth surfaces. An urban forest, or a collection of vegetation across an urban area, can mitigate stormwater runoff by between two and seven percent.

Based on extensive inclusion in the Newark Sustainability Action Plan, the City already recognizes the important role urban forestry can play in improving stormwater management. The NSAP proposes to double the City's urban forest and capitalize on the environmental services and social benefits which they provide. To achieve this goal, the Plan identifies six recommendations needed to expand and maintain the urban forest. The recommendations, listed below, are detailed sufficiently to achieve the goal of doubling the urban tree canopy:

1. Develop a baseline analysis of existing tree canopy coverage
2. Increase the City's capacity to plant and maintain street trees
3. Create a self-sustaining funding source for the project
4. Public promotion
5. Link to carbon offset programs
6. Build community engagement

Planting costs are estimated to be between $300 and $400 per tree.[69] Inclusive of all site preparation and initial maintenance costs, the total cost is estimated to be approximately $435 per tree pit.[70] The average annual maintenance costs per tree are roughly $20-$40, depending on the size of the tree. On average, trees typically have a 40 year life with a 66% survival rate during that time. Public trees produce higher benefits over the life of the tree due to lower maintenance costs compared to private trees. The NSAP study suggests that net benefits over the life of the measure, ranging by size, are $364 for a small public tree to $4,531 for a larger public tree.[71]

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[67] USA. Department of Agriculture. Forest Service. *Northeast Community Tree Guide Benefits, Costs, and Strategic Planting*. By Gregory E. McPherson., Aug. 2007. Web. 21 Mar. 2014. <Link>.

[68] USA. Department of Agriculture. Forest Service. *Northeast Community Tree Guide Benefits, Costs, and Strategic Planting*. By Gregory E. McPherson. P 15. Aug. 2007. Web. 21 Mar. 2014. <Link>.

[69] USA. Department of Agriculture. Forest Service. *Northeast Community Tree Guide Benefits, Costs, and Strategic Planting*. By Gregory E. McPherson. P 49. Aug. 2007. Web. 21 Mar. 2014. <Link>.

[70] Greenwood, Stephanie. "Sustainability Department." E-mail interview. 8 Apr. 2014.

[71] USA. Department of Agriculture. Forest Service. *Northeast Community Tree Guide Benefits, Costs, and Strategic Planting*. By Gregory E. McPherson. P 8., Aug. 2007. Web. 21 Mar. 2014. <Link>.

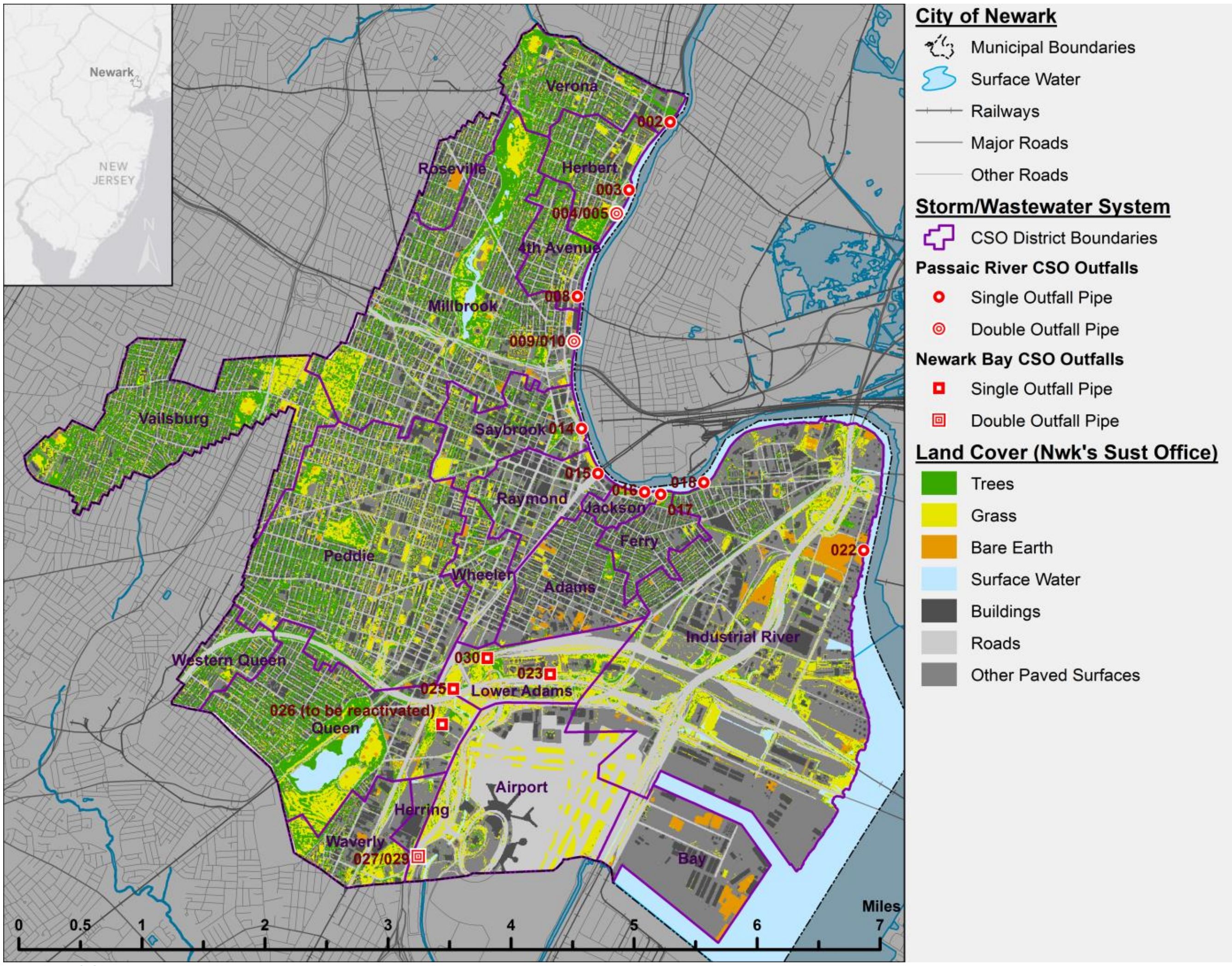


FIGURE 13: LAND COVER IN NEWARK

The table below illustrates the numerous social, environmental, and economic benefits of tree canopy BMPs. A hypothetical tree project was modeled assuming a single, medium-sized public street tree with an installed cost of $435 and an annual maintenance cost of $30 per year over a 30-year life. Water retention was estimated at 5,217 gallons stormwater runoff retained over that period based on similar estimates provided in the following PlaNYC case study.

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Street Tree** | Nearly everywhere | Reduce peak stormwater runoff; reduce pollutants; | Beautify neighborhoods; improve air quality | Reduce wind in winter and provide shade in summer reducing heating and cooling needs; increase property values; utility sewer savings | $1,335.00 | $0.2559 |

**Conclusions:**

The new tree pits constructed in Newark will aid the city in absorbing more stormwater runoff and has an added benefit of removing impervious surface, as they are being used to replace sidewalk concrete.

**Case Study: PlaNYC**

Photo 7: Brooklyn Treebox filter. Photo Credit: PlaNYC

Tree box filters are an effective method of incorporating trees into the urban environment. These 'boxed' bio-retention cells are placed at the curb adjacent to storm drain inlets. The tree pits beautify streetscapes with trees, shrubs, or perennials, while also providing habitat for local ecology. NYC has installed five pilot projects utilizing these tree pits and are currently analyzing the costs and benefits of the strategy. The tree boxes receive the first rush of stormwater along the curb and filter the runoff through layers of vegetation and soil before it enters a sub-surface catch basin. The catch basin mitigates the risk associated with tree roots growing into water or sewer lines which can occur particularly with older, and fractured, water infrastructure. Using tree box filters also eliminates problems associated with traditional street trees, such as stunted growth and damaged sidewalks. They also help maintain healthier trees increase the overall stormwater retention rate.[72] Enhanced tree pits, while larger than the newly revised code for city tree pits, can be easily incorporated into the design phase of new sidewalks, planned since 2012 with the funding received from the Urban Enterprise Zone.

### 3.1.4 Stormwater Management Legislation

To facilitate the adoption of green infrastructure, an effort must be made to promote a favorable regulatory environment for stormwater management. A number of bills have been adopted recently by the New Jersey State Legislature which focus on addressing stormwater problems. The most immediately relevant of these, as discussed in Recommendation #4 of this report, is Assembly Bill 1583, which authorizes municipalities to regulate combined sewer overflow events, create a stormwater management system to address runoff and, most importantly, finance the operations through the imposition of new user fees.[73] As previously explained, such user fees can include the adoption of a separate stormwater surcharge, which would essentially tax large properties based on impervious surface area contributing to runoff.

Additional NJ State bills — A2303, 2304, 2305, and 2307 of 2014 — seek to establish incentives for green and blue roof construction.[74] Similarly, Senate Bill 575, incentivizes the use of green infrastructure design by establishing a $5 million "Solutions Fund" and a tax exemption "from the property tax levy cap for capital expenditures and debt service of combined sewer overflow abatement and prevention measures."[75] The "Municipal Stormwater Management and Combined Sewer Overflow Abatement Assistance Fund" allows relevant projects to be State-funded by up to 90%.[76] Examples of ways in which various incentives have been utilized to promote green infrastructure can be found in Appendix B of this report.

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72 USA. *PLANYC2030*. The City of New York, P 68. Apr. 2011. Web. 15 Mar. 2014. <Link>.

73 "*A1583, Authorizing creation of stormwater utilities for certain local government entities.*" Assembly, No. 1583 State Of New Jersey 216TH Legislature. <Link>

74 "A2303, Requiring certain State departments, divisions, commissions, and authorities to consider use of green or blue roof in construction of certain new State buildings, facilities, and structures." Assembly, No. 2303 State Of New Jersey 216TH Legislature. <Link>

75 "S575, Concerning combined sewer overflows; exempts improvements thereto from 2% property tax cap; requires certain permit holders address such overflows in capital improvement plans; and appropriates $5 million." Senate, No. 575 State Of New Jersey 216th Legislature. <Link>

76 "*58:25-29. Abatement assistance fund.*" New Jersey Permanent Statutes Database. <Link>

# Chapter 4: Combined Sewer Overflows

## 4.1 Background Conditions

### 4.1.1 Existing Combined Sewer System

Separate Sewer Systems (SSS) are comprised of two independent networks of piping that carry different types of wastewater. One is dedicated for the transmittance of sanitary sewage, consisting of domestic, commercial, and industrial wastewater, to a treatment facility. The other completely separate piping system carries stormwater runoff out to nearby rivers and bays.

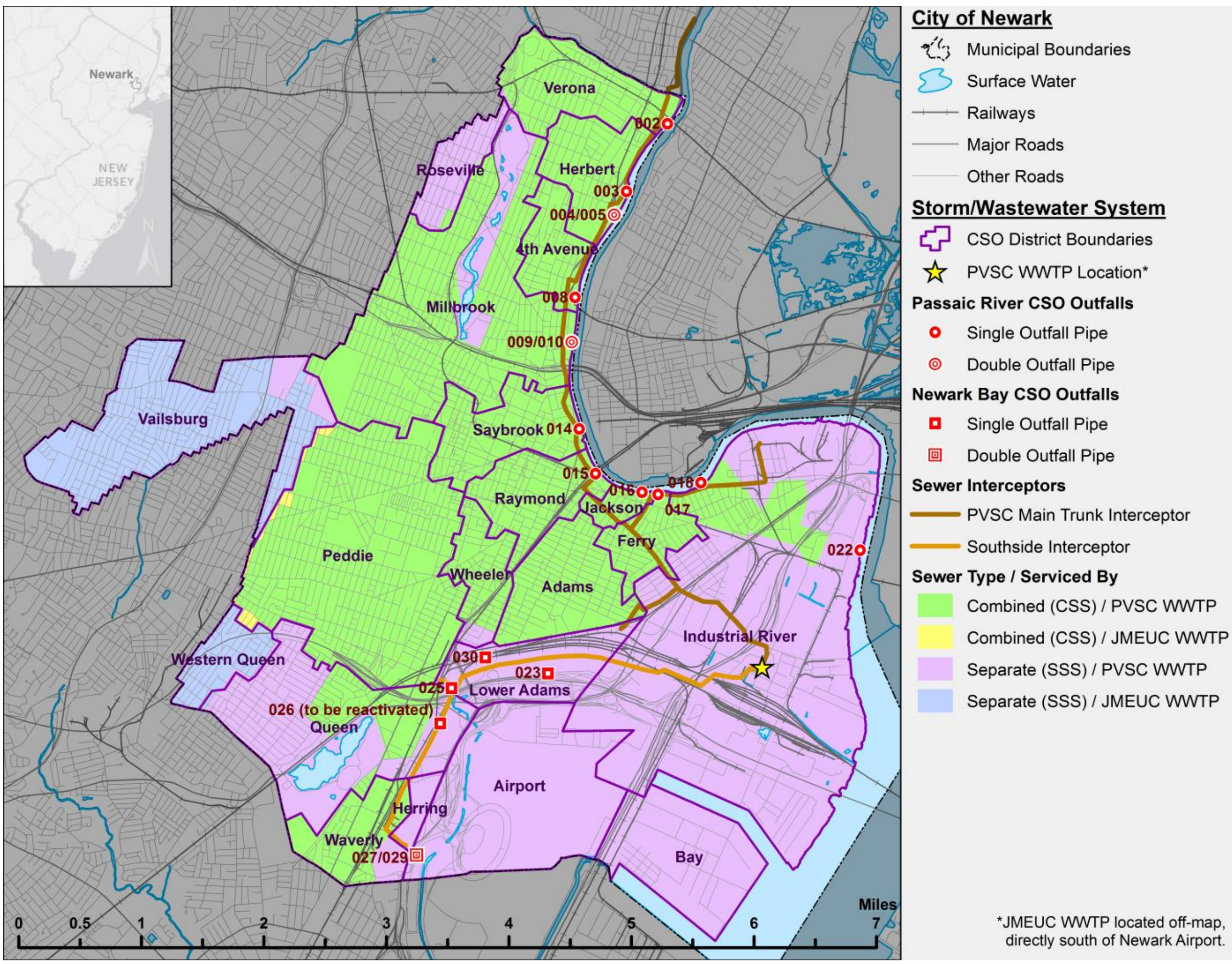


Figure 14: Map of SSS and CSS service areas with CSO locations and WWTP designations

In contrast, a Combined Sewer System (CSS) is a single-pipe design that carries both sanitary sewage and stormwater to a treatment facility. CSSs were a popular solution installed in many cities decades ago, but are no longer permitted in new communities in New Jersey. Under typical dry conditions, Newark's CSS can manage the conveyance of combined wastewater to the Passaic Valley Sewerage Commission's sewage treatment plant, where approximately 93% of Newark's wastewater is treated.[77] There, it is treated and released into the Passaic River or Newark Bay. The Joint Meeting Essex & Union wastewater treatment plant, located south of the Airport, serves the remaining 7% of Newark, namely a small area in the far western end of the city.

## 4.1.2 Combined Sewer Overflows

During periods of large variation in flow between dry and wet weather, such as large storms or snowmelt, total wastewater in the single-pipe can exceed the capacity of the CSS and/or the treatment facility. To combat this problem, a relief structure in the design allows some of the combined stormwater and sewage to be diverted, untreated, directly into the rivers and bays, via outfalls. Such an event is called a Combined Sewage Overflow (CSO).

The City of Newark maintains and operates 17 CSOs along the Passaic River and the Peripheral Ditch, which runs along the perimeter of Newark International Airport. There are 12 permitted CSO outfalls along the Passaic River, and five on the Peripheral Ditch. From these points, excess sewer water is discharged into nearby water ways to relive the system during periods of intense precipitation. Figure 14 shows a map of the locations of each of these outfalls, and the connected interceptor. The map also outlines the geographical borders of the different districts that are serviced by each CSO.

## 4.1.3 Pollutants in CSO Outflows

Because CSOs contain untreated stormwater run-off they can be a significant source of pollution to nearby waterways particularly in densely developed areas where the natural filtration process is drastically limited due to the abundance of impervious surfaces, as previously explained.[78]

| Outfall Designator | Water Quality Impairments |
|---|---|
| 002A, 003A, 004A, 005A, 008A, 009A, 010A, 014A, 015A, 016A | Benzo(a)pyrene (PAHs), PCBs in Fish Tissue, Arsenic, DDD, Dieldrin, DDT, DDE, Heptachlor epoxide, Ammonia (Un-ionized), Chlordane, Mercury in Fish Tissue, Dioxin (including 2, 3, 7, 8-TCDD) |
| 017A, 018A, 022A | Heptachlor epoxide, Dioxin (including 2, 3, 7, 8-TCDD), Dieldrin, DDT, DDE, DDD, Chlordane, Ammonia (Un-ionized), Arsenic, Mercury in Fish Tissue, Oxygen, Dissolved, PCBs, Benzo(a)pyrene (PAHs) |
| 023A, 025A, 026A | DDE, PCBs, Phosphorus (Total), Mercury in Fish Tissue, Dioxin (including 2, 3, 7, 8-TCDD), Benzo(a)pyrene (PAHs), DDT, DDD, Chlordane, Dieldrin |
| 027A, 030A | DDE, Polychlorinated biphenyls, Phosphorus (Total), Mercury in Fish Tissue, Dioxin (including 2, 3, 7, 8-TCDD), Benzo(a)pyrene (PAHs), DDT, DDD, Chlordane, Dieldrin |

TABLE 6: WATER QUALITY IMPAIRMENTS OF VARIOUS NEWARK CSO OUTFALL LOCATIONS

Additionally, as CSO outflows combine stormwater with greywater from the sewer system, they also contain untreated human and industrial waste.[79] Such contaminants can include, but are not limited to: pathogens, oxygen-demanding pollutants, suspended solids, nutrients, toxics, and floatable matter. Due to the volume of CSO flows and their contaminants, CSOs can have a variety of adverse impacts on rivers and bays, impairing vital aquatic habitats, and threatening the safety and health of those who use these waterways

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[77] Schneider, Eric, PE, comp. *City of Newark Sewer System Master Plan*. Tech. 2011. Print. <Link>
[78] *New Jersey Stormwater Best Practices Manual*. Rep. New Jersey DEP, Feb. 2004. Web. <Link>
[79] *The City of Newark Sustainability Action Plan*. Rep. Newark: 2013. *The City of Newark Sustainability Action Plan*. The City of Newark Office of Sustainability, 2013. Web. 2 Mar. 2014. <Link>

for boating, fishing or swimming.[80] Table 6 shows examples of these water quality impairments, including dissolved PCBs and Arsenic, for various Newark CSO outfall locations.

## 4.1.4 Health Effects of CSOs

Pollution from CSOs can have adverse impacts on human health via the microbial pathogens and toxins which can be present in effluent. Nearby residents can become exposed to CSO pollutants through several pathways. The most common means include recreating in the local rivers or bays receiving CSO discharges, ingesting water contaminated by CSO discharges, and consuming or handling fish or shellfish that have been contaminated by CSO discharges. Other pathways include direct contact with discharges, occupational exposure, and secondary transmission.[81]

A study by The New York-New Jersey Harbor Estuary Program identified six sources of Polychlorinated Biphenyl (PCBs) inputs to the harbor. The study found that discharges to the lower estuary from municipal point sources and CSOs are significant in causing PCB levels in striped bass to exceed the FDA standard for fish consumption. PCBs were used as dielectric and coolant fluids for transformers, capacitors, and electric motors until they were banned by the Federal Government in 1979. Their effect of PCBs on humans range from skin rash to more serious illnesses including anemia, nervous system and blood problems, liver and kidney problems, reproductive difficulties, and increased risk of cancer. Current data indicate that PCB contamination to the harbor can be attributed to stormwater flows at 15% and CSOs at 10% based on an estimated total daily load of 3.6kg. Overflow discharges may also contribute significantly to Polycycli Aromatic Hydrocarbons (PAHs) in the harbor.[82] Figure 15 shows a breakdown of the various sources of synthetic organic chemicals deposition in Newark Harbor.[83]

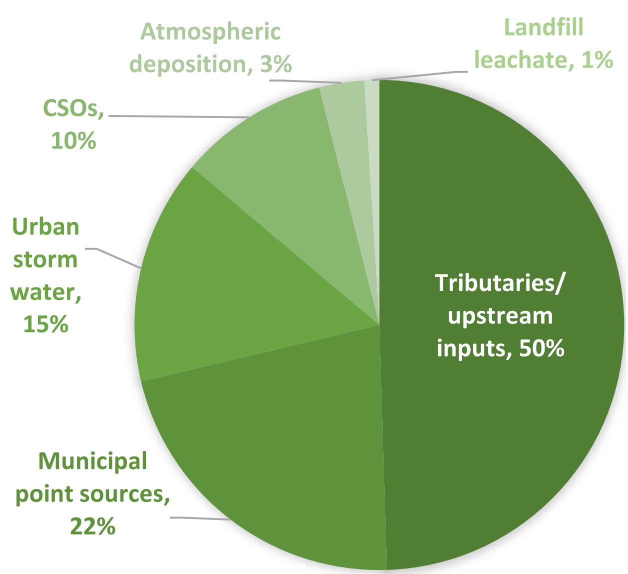


FIGURE 15: SOURCES OF SYNTHETIC ORGANIC CHEMICALS DEPOSITION INTO THE NY/NJ HARBOR.

## 4.1.5 CSO Impacts on Local Economy

Excessive pollution in public waterways can have significant impacts on a local economy. The EPA estimates there are at least 5,576 illnesses each year due to water-borne illnesses from recreational exposure, resulting in medical costs and lost productivity.[84] A report from 2000 on the 'Estimated Annual Economic Impacts from Harmful Algal Blooms (HABs) in the United States' estimates the average public health impact due to shellfish poisoning from HABs was approximately $1 million per year (caused by paralytic, neurotoxic, and amnesic shellfish poisoning, or PSP, NSP, and ASP, respectively).[85] The negative health and economic impacts of CSOs demonstrate the urgency with which these issues must be addressed by municipalities operating combined sewer systems.

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80 "2005 Stormwater and Combined Sewer Overflow (CSO) Pollution Prevention Plan." City of Newark, 2005. Web. 25 Mar. 2014. <LInk>.

81 "Report to Congress: Impacts and Control of CSOs and SSOs." *National Pollutant Discharge Elimination System (NPDES)*. U.S. EPA, 26 Aug. 2004. Web. 28 Mar. 2014. <Link>.

82 *New York-New Jersey Harbor Estuary Program: Management of Toxic Contamination*. Rep. *Management of Toxic Contamination*. New York-New Jersey Harbor Estuary Program, Mar. 1996. Web. 23 Feb. 2014. <Link>.

83 "Report to Congress: Impacts and Control of CSOs and SSOs." *National Pollutant Discharge Elimination System (NPDES)*. U.S. EPA, 26 Aug. 2004. Web. 28 Mar. 2014. <Link>.

84 EPA. "Report to Congress Impacts and Control of CSOs and SSOs." August 2004. Washington, D.C. 1-633. <Link>

85 Anderson, Donald M., et al. *Estimated annual economic impacts from harmful algal blooms (HABs) in the United States*. No. WHOI-2000-11. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION NORMAN OK NATIONAL SEVERE STORMS LAB, 2000.

# Chapter 5: CSO Solution Space

Under the Clean Water Act (CWA), municipalities are required to tightly manage their CSOs. A common solution is the construction of underground storage tanks to hold stormwater until it can be treated and safely released into the environment. These end-of-pipe, grey infrastructure solutions are often necessary but offer only limited benefits. These solutions are typically expensive and can be difficult to implement in densely populated urban areas. The green infrastructure solutions discussed previously as BMPs for stormwater control can be utilized, through targeted implementation, to reduce CSO events by addressing stormwater as a cause of CSOs. The practices discussed in the following section are meant to be complimentary to these infrastructure projects. The aim of these practices is to reduce CSO occurrences and limit their negative environmental, social, and economic effects.

## 5.1 CSO Monitoring and Control Measures

Installing netting and screening technologies at CSO outfalls is a common approach to addressing the problem of floatable discharges. These large filtering and netting equipment are important because they reduce the amount of solids and floatables, which, if not filtered out before discharge with such equipment, are the most visible pollutants in Newark's waterways. Photo 8 shows a floatable containment system at Newark CSO Outfall 025 near Peddie Street.

Photo 8: Floatable containment system at CSO outfall 025 near Peddie Street. Photo Credit: US EPA

Of the 17 CSO locations in Newark, 12 have been outfitted with these floatable control measures already, 4 are currently under construction, and 1 will continue to operate with existing netting. Table 6, below, lists all Newark CSO locations along with the status of their solids/floatables control measures.[86] Outfalls labeled in green have already been outfitted with the new netting systems. Outfalls in yellow are not yet complete, and outfalls in red are not scheduled upgrades. Solid and floatable materials include: sediment, debris, trash, and other floating, suspended, or sinkable solids.

According to Timothy Groninger, a Professional Engineer at environmental engineering firm Hazen and Sawyer, CSO outfall points are often designed with the crown of their opening located at the mean water height of the waterway into which they are discharging. During periods of low tide, they can be completely exposed. At high tide, while they can be submerged, they are still perfectly capable of discharging effluent. The CSO outfall pipes are sloped downward and long enough to allow for some waterway backflow.[87] Figure 16, below, illustrates this design system.[88]

86 Water and Sewer Capital Projects SFY 2014 NJEIT Funding. Newark: City of Newark, 2013. Print.

87 Groninger, Timothy. "The Physics of CSO Outfalls." Personal interview. 8 Apr. 2014.

88 U.S. Environmental Protection Agency, Washington, D.C. "Report to Congress: Impacts and Control of CSOs and SSOs." Document No. EPA 833-R-04-001 <Link>.

| Outfall Number | Outfall Name | Solids/Floatables Control Measures Status | Outfall Number | Outfall Name | Solids/Floatables Control Measures Status |
|---|---|---|---|---|---|
| 002A | Verona Avenue | Completed-January 2010-Screening Facility | 016A | Jackson Street | Completed-February 24, 2013, and operation of Netting Facility began March 1, 2013 |
| 003A | Delavan Avenue | Not Completed – delay due to property acquisition difficulties. | 017A | Polk Street | Completed-Netting Facility |
| 004A | Herbert Place | Completed-October 2009-Screening Facility | 018A | Freeman Street | Not Completed- delay due to property acquisition difficulties. |
| 005A | Herbert Place | Completed-October 2009-Screening Facility | 022A | Roanoke Avenue | Not Completed- delay due to property acquisition difficulties. |
| 008A | Fourth Avenue | Not Completed- delay due to property acquisition difficulties. | 023A | Adams Street | Completed-April 2005-Netting Facility |
| 009A | Clay Street | Completed-February 2014 | 025A | Peddie Street | No New Construction, Existing Netting Facility to Remain |
| 010A | Clay Street | Completed-February 2014 | 026A (to be reactivated) | Queen Ditch | Construction of a box culvert and a netting facility to begin after permit issuance |
| 014A | Saybrook Place | Completed-September 2006-Screening Facility | 027A/029A | Waverly | Completed-April 2005-Netting Facility |
| 015A | City Dock | Completed-December 2007-Netting Facility | 030A | Avenue A | Completed-April 2005-Netting Facility |

TABLE 7: STATUS OF SOLIDS/FLOATABLES CONTROL MEASURES OF NEWARK CSOS[89]

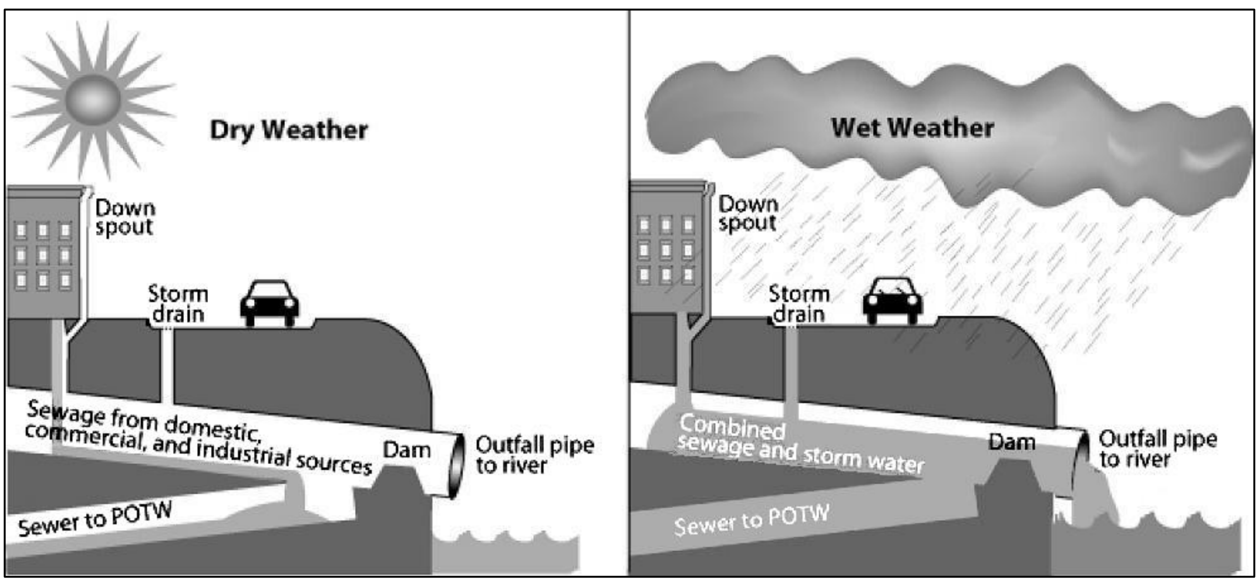


FIGURE 16: CSO OUTLET DESIGN. SOURCE: U.S. ENVIRONMENTAL PROTECTION AGENCY

If clean water from the waterway is permitted to flow into the CSO outfall point and into the sewer, it will flow to the wastewater treatment plant (WWTP), adding to the plant's normal load.[90] Furthermore, if the water way contains seawater, or brackish water, the salt content can potentially damage the WWTP equipment. This is referred to as 'seawater intrusion,' and is a serious concern for plant operators.

To prevent this from occurring, CSO pipes are sloped downwards, forcing surplus backflow to travel upwards to the sewer. Tidal gates, or flap gates, are also installed to prevent backflow to the system.

[89] "Draft Surface Water Renewal Permit Action." Letter to Luis A. Quintana, Mayor of City of Newark. 17 Jan. 2014. Web. <Link>
[90] *Stormwater / Wastewater Collection*. Tideflex Technologies, 2014. Web. 10 Apr. 2014. <Link>.

Located close to the netting and screening apparatus, these gates act as one-way valves, limiting the flow to one direction.

According to Joseph Beckmeyer, Engineering Consultant in the City of Newark's Department of Water and Sewer Utilities, all of the CSO outflows operated by the PVSC have tidal gates installed, as do some of those run by the City. The remaining CSO outflows without tidal gates are scheduled to receive them at the time of installation of the netting and screen equipment mentioned previously.[91]

## 5.1.1 CSO Monitoring

Despite the adverse role CSOs have on the quality of public waterways, and the potential impact they can have on human health and the local economy, they are not as closely monitored as would be expected. Until recently, little evidence has been found of US cities directly monitoring the CSO event flows. According to Mr. Beckmeyer, one installation in North Philadelphia attempted to measure CSO flow from the outfall but it was complex and required a new chamber to be constructed. In most situations, there is insufficient room between the overflow point and the tidal gate. Any attempts to monitor flow downstream of the tide gate would experience the problem of waterway backflow mixing with CSO outflow, dependent on the tide level and outfall flow rate. Jersey City Municipal Utilities Authority installed sensors to determine when overflow was occurring, but their efforts did not include measurements of the actual flow rates. In addition to the technical complexities associated with CSO flow rate monitoring, these monitoring systems are also cost-prohibitive.[92]

A more common approach to monitoring CSO events, though less direct, is through periodic water quality testing. According to Dr. Wade McGillis, Doherty Scientist in Geochemistry at Lamont Doherty Earth Observatory, and Associate Professor of Earth and Environmental Engineering at Columbia University, fecal coliform counts above 100 colony-forming units (CFU) per 100mL found in a sample of water from a river like the Passaic indicate the likely occurrence of a nearby CSO event. Multiple organizations, from State entities to citizen groups, perform regular monitoring of the water in the Passaic River around Newark to test for an assortment of water characteristics, from temperature and salinity to dissolved oxygen and bacteria, i.e. Fecal Coliforms and Enterococcus.

## 5.1.2 Current Water Monitoring in Newark

To analyze the current impact of stormwater on CSOs, water quality sample data were obtained from the New Jersey Department of Environmental Protection's (DEP) Water Quality Data Exchange (WQDE) site,[93] as well as the Interstate Environmental Commission (IEC).[94] This data contained fecal coliform counts for water samples taken during 2010 and 2011 at various locations along the Passaic River and Newark Bay. The map in Figure 17, below, shows the location of the sampling sites. It is important to note that these sampling locations are not necessarily aligned with existing CSO outfall locations.

Sample locations 10, 11, and 12 are most closely aligned with existing Newark CSOs; hence, these three sample locations were chosen for closer analysis. The map in Figure 18 shows the approximate relationship between these sample locations and the existing CSO outfall locations.

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91 Beckmeyer, Joseph. "CSO Control and Monitoring Measures." Personal interview. 9 Apr. 2014.
92 Ibid.
93 "DEP Data Miner - Ambient Water Quality." *NJ Open Public Records Act*. NJDEP, 12 June 2012. Web. 11 Apr. 2014. <Link>.
94 "Historical Reports and Other Documents Issued by the IEC." *Reports and Publications*. Interstate Environmental Commission, 2013. Web. 11 Apr. 2014. <Link>.


FIGURE 17: MAP OF WATER SAMPLING LOCATIONS FROM 2010-2011

The fecal coliform count from these locations was overlaid with the precipitation data of the sampling time period to attempt to show the relationship between rain events and elevated bacteria counts, as shown in the graph in Figure 19. As indicated, spikes in fecal coliform counts were often preceded by precipitation events of as little as a tenth of an inch of rainfall.

Table 8, below, shows the average fecal coliform counts as measured along with the average 5-day cumulative precipitation preceding the sample measurement date.

A more thorough analysis, however, shows that the measured fecal coliform levels and the preceding precipitation amounts bear little correlation to each other as illustrated by the regression line in Figure 20 below. This indicates that the current method water quality monitoring, using samples taken at locations unrelated to CSO outfalls and at irregular intervals, is insufficient for the purpose of precisely analyzing CSO events.

| Testing Location | # Samples Over 2-Year Period | Avg. Fecal Coliform (cfu/100mL) | Avg. Previous 5-Day Precip. (inches) |
|---|---|---|---|
| **10** | 56 | 501 | 0.73 |
| **11** | 57 | 519 | 0.73 |
| **12** | 45 | 382 | 0.77 |

TABLE 8: AVG FECAL COLIFORM LEVEL WITH PRECEDING 5-DAY PRECIPITATION AVG

Ideally, one could use accurate water quality sample data to determine the correlation between the amounts of precipitation (e.g. 0.25 inches, 0.5 inches) and the variability of fecal coliform levels at each CSO outfall, and derive the sensitivity of each CSS drainage district to an average precipitation event in Newark. Such a method would enable the City to determine which outfall points are most problematic and target those connected CSS watersheds for green infrastructure projects. Unfortunately, as illustrated in the above graph, the current approach to water quality sampling does not produce an accurate enough depiction of this relationship. It is possible that the sampling points used by the DEP and IEC were not taken close enough to each Newark CSO outfall point to ensure that samples collected were isolated from interference from other outfall locations, those servicing Newark, or across the river servicing neighboring NJ towns east of the Passaic - Harrison, East Newark, and Kearny. Furthermore, other variables, beyond the scope of this report, may be affecting the samples and reducing accuracy.

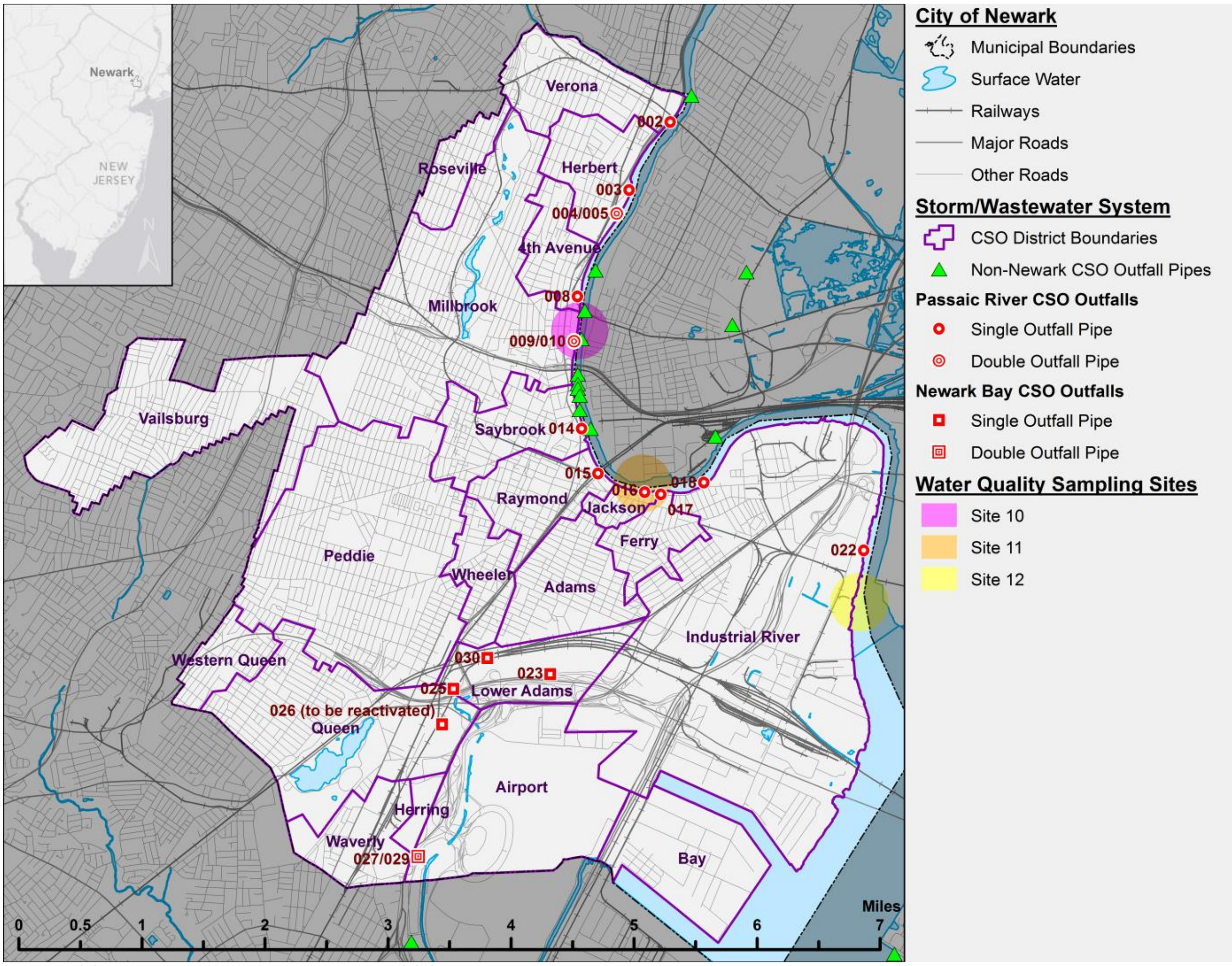


FIGURE 18: WATER SAMPLE LOCATIONS AND CSO OUTFALL LOCATIONS

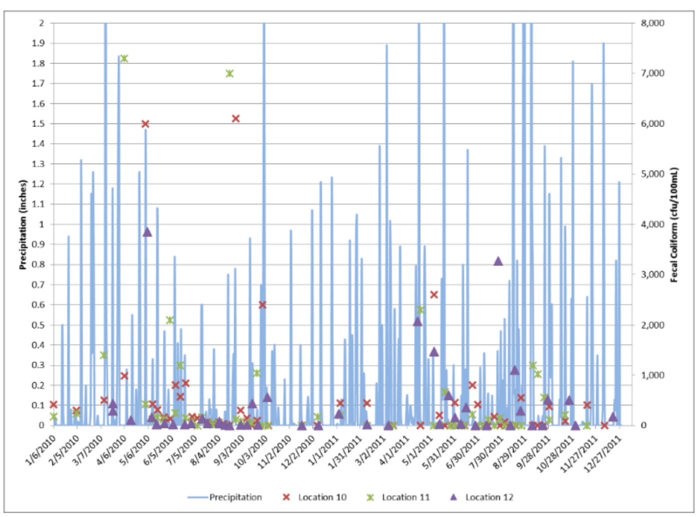


FIGURE 19: FECAL COLIFORM LEVELS IN THE PASSAIC RIVER RELATIVE TO NEWARK PRECIPITATION EVENTS

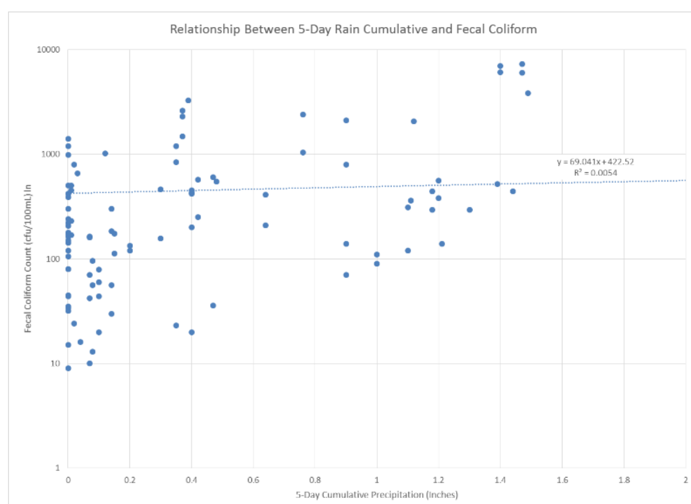


FIGURE 20: REGRESSION ANALYSIS OF PRECIPITATION AND FECAL COLIFORM LEVELS IN THE PASSAIC RIVER

## 5.1.3 Water Monitoring Conclusions

As explained previously, no sampling site was close enough to any given Newark CSO outfall point so as to declare it completely isolated from the outflows of other CSO locations and other potential sources of contamination. Sites 10, 11, and 12, however, provided the best examples for the ideal scenario as they were relatively more aligned with existing CSO locations than the other sites. The sewer districts serviced by these CSO outfall points also exhibit land-use mixes that are primarily high-density residential and commercial, and which are highly impervious in surface composition. This selection and justification process yielded three CSO outfall points and corresponding Newark CSO districts to be used as pilot studies for green infrastructure programs as discussed later on.

A sound monitoring policy can have profound implications for public health and safety, as demonstrated by NYC's recent water quality public awareness system. Through this system, the City incorporated CSO events into its list alerts that it sends out to residents. This system, named Notify NYC, is available for any resident who signs up to receive email, text message, phone message, or twitter alerts. Among other things, this system updates the public to when and where a CSO event has happened as well as when they predict the alert will be lifted.[95]

## 5.1.4 CSO Regulation

The City of Newark is currently authorized to discharge CSOs pursuant to a Master General Permit (General Permit) issued by the New Jersey Department of Environmental Protection (NJDEP). On January 17, 2014, NJDEP served notice on Mayor Luis A. Quintana advising that it proposes to terminate authorization under the General Permit based on a NJDEP determination that it is more appropriate to regulate all CSO discharges under individual permits in order to address the site-specific conditions of each outfall.[96] This change highlights the importance of a better monitoring program as described previously.

Currently, CSO events are treated as point-source pollution and regulated under a separate federal permit administered by the NJDEP. The CSO permit must be consistent with the national EPA 'Combined Sewer Overflow Control Policy,' which has three objectives:

1. Ensure that CSOs occur only as a result of wet weather;
2. Bring all wet-weather CSO discharge points into compliance with the technology- and water quality-based requirements of the Clean Water Act (CWA); and
3. Minimize the impacts of CSOs on water quality. [97]

The EPA has begun to crack down on lax enforcement of the permit requirements in recent years. Other CSS communities have looked to green infrastructure as a cost effective way to limit CSO events, and in turn avoid future fines. When considering the cost of implementing green infrastructure technologies and practices, Newark should include the benefits associated with cost avoidance of these fines that will result. According to PlaNYC, using a combined approach of adopting both green and grey infrastructure allows the city to meet its wastewater demand in the most cost effective way possible.[98] The graph below clearly shows utilizing green infrastructure can mitigate additional capacity necessary to meet the City's demand. The amount of money saved in real dollars is about $1.3 billion, representing approximately 22% cost reduction, see Figure 21. These same benefits can be transferred to Newark if the costs of green

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[95] "DEP, OEM Announce Notify NYC Will Provide Advisories During and After Rain Events." NYC DEP, 5 Oct. 2012. Web. 14 Apr. 2014. <Link>.
[96] "Draft Surface Water Renewal Permit Action." Letter to Luis A. Quintana, Mayor of City of Newark. 17 Jan. 2014. Web. <Link>.
[97] Worstell, Carolyn. "Green Infrastructure in the State of New Jersey - Statutory and Regulatory Barriers to Green Infrastructure Implementation." New Jersey Future, Jan. 2013. Web. <Link>.
[98] USA. *PLANYC2030*. The City of New York, P 69. Apr. 2011. Web. 15 Mar. 2014. <Link>.

infrastructure could be compared to costs of new capacity. Unfortunately, neither the HMM or Newark Capital Improvement Plan break out new capacity from total construction costs of the six potential projects that state capacity upgrades would take place.

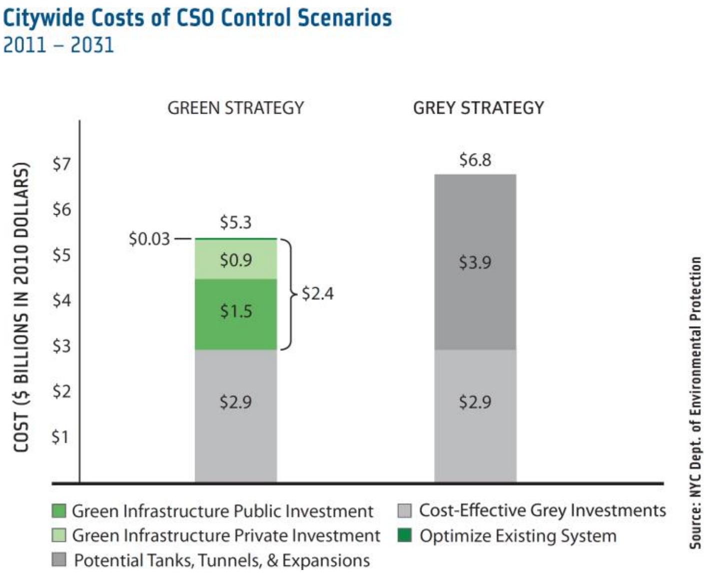


FIGURE 21: ESTIMATED COST SAVINGS OF NYC GI PROGRAM

## 5.2 MANAGING WATER DEMAND

The Passaic Valley Sewage Treatment Plant currently processes about 80 million gallons of gray water per day (MGD). This figure represents a decrease from about 87 MGD in 2007, a result of industrial loss over that period.[99] Reducing overall water consumption should be an important element in improving Newark's water and wastewater systems. Demand reductions will alleviate the stress on the existing filtration and treatment facilities and can reduce CSO discharge during minor precipitation events. Conservation will also save money for consumers, create jobs, and raise public awareness of these issues.

Benchmarking the city's existing water demand and processing amounts is a critical first step for implementing any conservation program. Annual benchmarking of water consumption should be required for all buildings over a certain size. This will ensure that large customers will view their consumption patterns on a regular basis and presumably be incentivized to reduce their water use.

### 5.2.1 Reduce Existing Building Water Consumption

Managing consumer water demand has played an important role in many cities' sustainability plans. Cities with combined sewer systems realize the important role demand reduction plays in effective CSO management. In New York, the DEP adopted a Water Demand Management Plan partly to reduce expenses related to sewage treatment. Demand management strategies include higher water efficiency standards for new developments, annual water use benchmarking for existing buildings, and conservation programs to help buildings implement water saving strategies. By reducing the overall throughput of consumer wastewater, environmental and social benefits can be realized through a reduction of contaminants entering the CSS and nearby waterways from CSO discharges. Conservation also provides economic benefits through reduced energy needed to pump and treat wastewater at treatment plants, as well as lower water bills for property owners.[100]

Newark's current Sustainability Action Plan establishes goals for reducing energy consumption in municipal buildings by 20 percent over the next five years; however, it does not extend a similar conservation target for water demand.[101] Reducing water demand is equally important since doing so reduces the overall amount of water entering the CSS, thereby reducing the risk of CSO discharges during rainstorms.[102] A water conservation strategy for municipal buildings proved successful for New York City, as shown in the accompanying case study. Starting with municipal buildings as a conservation pilot

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[99] Schneider, Eric, PE, comp. *City of Newark Sewer System Master Plan*. Tech., 2011. Print. <Link>.
[100] "*Water Demand Management Plan*". NYC Environmental Protection. NYC.gov. Web. 1 Apr. 2014. Web. 1 Apr 2014. <Link>
[101] *The City of Newark Sustainability Action Plan*. Rep. The City of Newark, 2013. Web. 25 Mar 2014. P. 30<Link>
[102] *PlaNYC: Water Supply*. Rep. New York City Office of Long-Term Planning and Sustainability, Web. 23 Feb. 2014.

program will allow the city to test and benchmark conservation BMPs most appropriate for Newark. [103] Together with the stormwater green infrastructure projects, the City can reduce the total amount of water flowing through the CSS to the treatment plant from both precipitation and consumer use.

Currently, Newark owns and manages more than 100 buildings, with 76 actively in use for municipal purposes.[104] According to a United States Conference of Mayors report published in April 2013, local municipal spending for public water (supply and wastewater management) reached an all-time annual high of $111.4 billion in 2010.[105] Like the energy reduction plan, it is important that Newark develop a strategy to reduce municipal water consumption. A good target would be 20 percent below an established baseline as measured through an initial benchmarking process. A comprehensive approach will include benchmarking current water use, facilities auditing, conservation retrofits, and reviews of building operations and maintenance. These strategies will reduce water consumption and effluent, and aid in reducing CSOs, while achieving economic savings and creating jobs in the water conversation industry sector.

In Newark's energy reduction program, 17 buildings were identified through benchmarking as the highest energy consumers and chosen for the pilot program. Similarly, buildings identified as the highest consumers of water should be targeted for the water conservation pilot program. A baseline for water consumption will help track, measure, and verify the impact of water conservation efforts. Building data such as size, use, occupancy, and water consumption history are important for determining performance and setting goals. Newark's Energy Taskforce successfully used the EPA's Portfolio Manager Tool to identify the most economic and strategic energy retrofit projects, and this same tool can be used to determine the highest priority targets for a water conservation program.[106]

| Water Consumption | Total Water Sales CCF / Year |
|---|---|
| **Inside City** | |
| Residential (Regular/Senior) | 7,224,694 |
| Commercial | 5,565,475 |
| Industrial | 2,459,916 |
| TOTAL | **15,250,085** |

TABLE 9: NEWARK'S WATER CONSUMPTION FY2013[1]

Table 9 shows a breakdown of water use by customer type. Water consumption data specific for municipal buildings was not available. Water consumption is measured in cubic feet, and a unit or CCF stands for 100 cubic feet. For reference, 1 cubic foot of water equals 7.48 gallons; and 1 CCF or 1 unit equals 748 gallons of water.[107] Therefore, Newark's total water consumption in fiscal year 2013 was over 114 billion.

An examination of the cost of service for each customer type, from the Red Oak rate study, shows that residential customers account for the highest percentage of total costs of service for the City, as shown in Table 10. Conservation programs targeting this group of customers would be highly cost effective for both the City and property owners given the low cost of many of the associated efficiency measures, e.g. efficient water fixtures and leak repairs. A conservation program with the goal of reducing residential water consumption by 20% could save the city $2.6 million annually based on the 2013 cost of service numbers. Since roughly 76% of the city's residents are renters, the costs of the upgrades could be passed on to the property owners, who would then recoup those costs through water bill savings. Appendix C details a list of common residential and commercial water conservation technologies.

[103] "*Water Demand Management Plan*". NYC Environmental Protection. NYC.gov. Web. 1 Apr. 2014. Web. 1 Apr 2014. <Link>.

[104] *The City of Newark Sustainability Action Plan*. Rep. Newark: 2013. *The City of Newark Sustainability Action Plan*. The City of Newark Office of Sustainability, 2013. Web. 2 Mar. 2014. <Link>.

[105] The United States Conference of Mayors. *Growth in Local Government Spending on Public Water and Wasterwater-But How Much Progress Can American Households Afford?* April 2013. Washington DC. Web. 1 Apr 2014. <Link>

[106] *The City of Newark Sustainability Action Plan*. Rep. The City of Newark, 2013. Web. P. 30. 25 Mar 2014. <Link>

[107] EPA.org. Web. 2 Apr. 2014 <Link>.

| Customer Type | # of customers | Total Required Base + Extra Capacity (CCF/Year) | Total Cost of Service | % of Total | $/CCF |
|---|---|---|---|---|---|
| Residential (Regular) | 31,260 | 7,198,284 | $ 13,025,503 | 26.6% | $ 1.81 |
| Commercial | 4,429 | 5,125,357 | $ 9,419,413 | 19.2% | $ 1.84 |
| Industrial | 872 | 2,282,333 | $ 3,511,064 | 7.2% | $ 1.54 |
| Direct PVSC | 56 | 1,718,910 | $ 12,276,368 | 25.0% | $ 7.14 |
| Senior Citizens | 535 | 34,221 | $ 94,961 | 0.2% | $ 2.77 |
| Wholesale (Outside City) | 6 | 7,896,945 | $ 10,317,340 | 21.0% | $ 1.31 |
| Fire Protection (Public) | | 1,404 | $ 386,304 | 0.8% | $275.15 |
| TOTAL | **37,158** | **24,257,454** | **$ 49,030,953** | **100.0%** | |

Table 10: Cost of Service Comparison[108]

## Case Study: New York City

Pursuant to Local Law 86, the NYC DEP created the Demand Management Unit in 2011 to develop a citywide strategy for water demand management projects through 2021. The unit identified key strategies for managing water demand and specific initiatives for implementation over the next eight years in order to achieve targeted demand reductions. Building on the existing water conservation program at DEP, the unit created programmatic, policy and funding mechanisms to support conservation initiatives. Programs include metering, leak detection, residential audits, and retrofit kits to reduce consumer water demand. By replacing old fixtures with more water efficient models in existing buildings and new developments, the city's demand is at its lowest point in the last fifty years despite population growth.[109]

The DEP's near-term goal is to reduce demand by 50 million gallons per day through the Municipal Water Efficiency Program, Residential Water Efficiency Program, and Non-Residential Water Efficiency Program. The Municipal Water Efficiency Program provides funding for water conservation and water efficiency projects in city-owned facilities. DEP has identified water savings opportunities in 2,000 city properties, with estimated savings of 9 million gallons of water per day by completion. It has also established inter-agency partnerships with the School Construction Authority, Department of Education, Department of Parks and Recreation, Fire Department and Housing Authority to implement water efficiency projects in schools, parks playgrounds, recreation centers, firehouses, and public housing developments.

DEP has also identified apartment buildings and homes with opportunities for water conservation. Home water audits indicate that the largest percentage of water consumption in single and multi-family dwellings comes from toilets, laundry, and showering, as illustrated in Figure 22. As a result, DEP is launching a Toilet Replacement Program this year as a first step in reducing residential water consumption. The program will provide discounts for residential buildings owners who replace old toilets with high-efficiency models.[110]

The Non-Residential Water Efficiency Program promotes conversation in commercial and non-residential buildings through partnerships with the private sector. In 2013, the Mayor's Office launched the Mayor's Challenge, a year-long, voluntary challenge to the private sector to match the reduction in consumption in municipal use. Participants must calculate baseline water consumption, track water usage, develop a water conservation plan, and provide updates to the Mayor's Office. Participants receive formal recognition from the Mayor and are included in various public relations communications.

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108 Redoak Consulting - Water and Sewer Rate Study, City of Newark, NJ September 25, 2013.
109 USA. New York City Environmental Protection Agency. Office of the Mayor.*Water Demand Management Plan*, 2011. Web. <Link>.
110 USA. New York City Environmental Protection Agency. Office of the Mayor.*Water Demand Management Plan*. 2011. Web. <Link>.

## Case Study: New York City (cont.)

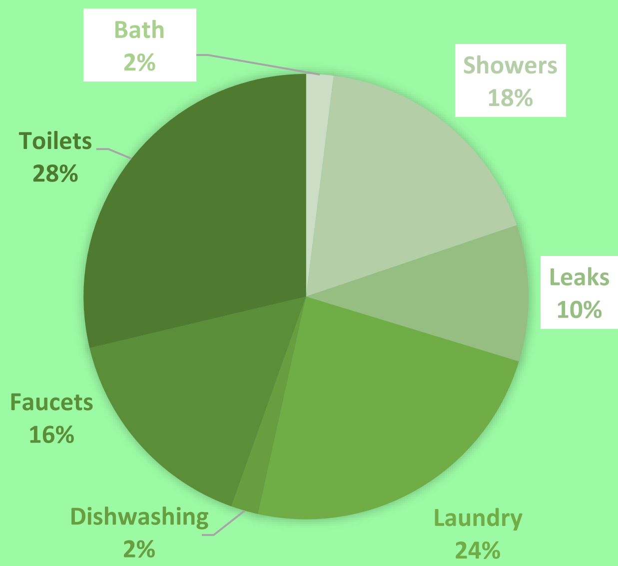


FIGURE 22: INDOOR WATER USE IN AVG. SINGLE FAMILY HOMES

The NYC DEP is currently evaluating criteria for initiating a cost-sharing program by 2015. The program will include water-cooled refrigeration in food related businesses, hotels or health care facilities; water reuse in laundry and car wash facilities; steam condensate use for toilet or urinal flushing, cooling tower makeup water or other non-potable uses; increased cycles of concentration in cooling towers; changes to water-related industrial processes; climate based smart irrigation controls; and water reuse for non-potable applications, such as toilet flushing and irrigation.[111] In Newark, where commercial water use accounts for nearly 20% of all service costs, but accounts for only 12% of the total users, there is opportunity for meaningful savings to the city through a targeted commercial conservation program such as implemented in NYC.

## Case Study: Philadelphia

The Philadelphia Water Department (PWD) has managed the Conservation Assistance Program (CAP) since 1986. CAP is a direct-installation effort designed to assist low-income and "payment-troubled" customers better manage their water consumption through education, water consumption efficiency and to lower future water usage and cost. The program has resulted in an average household water savings of 25%. The CAP program installs water efficiency technologies such as low-flow showerheads and faucet aerators, toilet retrofit devices, and repairs toilet, pipe, and faucet leaks. Water conversation methods offered through the program have varied little over the years due to external factors. For example, Philadelphia has a strong plumbers union which has made toilet replacements cost prohibitive. The measure was therefore dropped for eligibility in the program.[112]

As a snapshot of the program's effectiveness, CAP saved 5.1 million cubic feet of water in 1992 (~ 38 million gallons) and 5.5 million cubic feet in 1993 (~ 41 million gallons). The program has resulted in average annual water savings assessed for 1992 of almost 4,000 cubic feet per participant, with an average 25% water savings per household. Of the total water savings realized through this program, 90% were achieved by 10% of its participants. These were primarily residences with a noticeably high level of consumption to begin with. High water use was usually attributed to the presence of major leaks and was not a function of a participant's water use habits. This indicates the importance of benchmarking and auditing in the conservation process. While these large water users experienced an average 37.2% reduction in water consumption, more typical residences saved on the order of 8.5%. The administrative costs of CAP remained constant in nominal dollars at $33,200 per year, and overall total program costs increased by $3,640 from $247,030 in 1992 to $250,670 in 1993.[113]

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111 All data taken from "*Water Demand Management Plan*". NYC Environmental Protection. NYC.gov. Web.1 Apr. 2014. Web. 1 Apr 2014. <Link>.
112 Philadelphia Water Department Conservation Assistance Program Profile #109. Philadelphia Water Department 1994 Statistics. <Link>.
113 All data taken from Ibid.

# CHAPTER 6: EXISTING FINANCING MECHANISMS

The City of Newark currently has a 4-year capital improvement plan for sewer system upgrades, the Sewer System Capital Improvement Plan (SSCIP). The plan includes approximately $130 million worth of grey infrastructure upgrades. These projects will add significant costs to the annual utility budget through increased debt service. The following section provides a brief analysis of the current budget, the proposed and scheduled projects, and the anticipated impacts of these projects on future operating costs and user rates. The goal is to provide an understanding of the costs of grey infrastructure while noting that many of the green infrastructure and conservation projects described previously can reduce these costs through proper implementation. Additionally, alternative methods of financing the SSCIP, which could both mitigate expected rate increases and incentivize the GI and conservation recommendations previously discussed, do exist and should be further studied for potential adoption by the City.

## 6.1 SEWER FINANCIAL PLAN FY2013 THROUGH FY2022

Due to a combination of ageing sewer infrastructure, anticipated new regulations from NJPDES, and to better manage stormwater and storm-related flooding, it is clear that the City of Newark will be compelled to undertake a number of projects to improve their existing gray infrastructure. Many such projects, including one similar to those proposed in the Hatch Mott MacDonald plan, are already included in the Utility's 4-year SSCIP. Based on discussions with the City's Water and Sewer Utility, Table 11 below shows the proposed 4-year SSCIP for the City of Newark, as well as the expected costs. For comparison, table also shows the recommendations made in the HMM Sewer System Master Plan.[114] As the proposed plan indicates, approximately $130 million will be spent on renewal of existing grey infrastructure over the next four years.

In 2013, Newark commissioned Red Oak Consulting to undertake a detailed Water and Sewer Rate Study. According to estimates in the Red Oak report new debt will be the primary source of financing for the projects, 88.5%, with the remaining portion funded through pay as you go. The goal of the study was to determine what the implications of such additional debt would be on the utility's future operating budgets, as well as how best to finance this new debt over the long-term. To support this new debt, the report estimates that utility revenues will need to rise 57% between 2013 and 2022, from approximately $55.8M to $87.7M. Table 12 shows the expected increase in new debt service over a ten-year period.[115]

[114] Hatch Mott MacDonald City of Newark Sewer System Master Plan, January 2011 Table 5.2 Summary of Capital Improvements Projects
[115] Redoak Consulting - Water and Sewer Rate Study, City of Newark, NJ September 25, 2013.

| City of Newark - Sewer System Capital Projects | | |
|---|---|---|
| $000's | Sewer System CIP FY 2014- FY2018 | HMM First 5 Years Total |
| Project | | |
| CSO Solids/Floatables Control (Freeman St) | 1,750 | |
| CSO Solids/Floatables Control Program Phase III- Netting and Screening | | 25,700 |
| CSO Control Facilities and Outfall Rehabilitation Program | | 900 |
| Meadowlands Pump Station Upgrade Construction | 5,700 | 3,700 |
| Meadowlands Drainage Channel Investigation | | 500 |
| McClellan St. Stromwater Pump Station Upgrade | | 300 |
| Emergency Repairs | 7,500 | 15,000 |
| Non-Brick Sewer Condition Assessment | 1,500 | |
| Non-Brick Wastewater Collection System Renewal Program | | 38,000 |
| Consolidate and Update GIS | 700 | |
| Non-Brick Sewer Design | 600 | |
| Non-Brick Sewer Construction | 12,000 | |
| Pierson's Creek drainage Improvement Design | 1,000 | 1,000 |
| Pierson's Creek Drainage Improvement Construction | 6,300 | 6,300 |
| Queen Ditch Restoration | 8,000 | 8,000 |
| Strom Water Rehabilitation | 14,000 | 28,000 |
| Vailsburg Ditch Study and Preliminary Design | 1,000 | 1,500 |
| Brick Sewer Rehabilitation Condition Monitoring | 6,250 | 14,500 |
| Brick Sewer Rehabilitation Condition Phase IV | 13,700 | 13,700 |
| Frontage Rd, Wheeler/Adams drainage Design | 1,200 | 1,200 |
| Frontage Rd, Wheeler/Adams drainage Construction | 6,900 | 6,900 |
| CSO Long Term Control Plan Development | 400 | 400 |
| Meters For PVSC Flows Design | 2,500 | |
| Meter Installation for PVSC Flows | | 25,000 |
| South Side Interceptor & Regulator Rehab. Design | 1,250 | 300 |
| South Side Interceptor & Regulator Rehab. Construction | 5,200 | 6,200 |
| Areas Drainage improvements Design Phase 1 | 2,106 | |
| Adams, South & Wheeler Drainage Construction Phase 1 | 29,500 | |
| Adams, South & Wheeler Drainage Design Phase 2 | 1,900 | |
| Jasper Creek Restoration and Improvements Project | | 12,600 |
| Peripheral Ditch restoration and Improvements Projects | | 72,300 |
| Sewer Cleaning and CCTV inspection Equipment | | 5,900 |
| | 130,956 | 287,900 |

Note: The HMM estimates CSO Long Term Plan Implementation to Program to be between $300 to $500M.
This is not presented in the above table.

**Footnotes**

1. Redoak Consulting - Water and Sewer Rate Study, City of Newark, NJ, 9-25-2-13 page 4-3
2. Hatch Mott MacDonald City of Newark Sewer System Master Plan, January 2011 Table 5.2

TABLE 11: LIST OF PROPOSED SEWER SYSTEM CAPITAL IMPROVEMENTS FOR NEWARK

$ in Millions

| Fiscal Year | Operating Expenses | Existing Debt Service Cost | New Debt Service Cost | TOTAL |
|---|---|---|---|---|
| 2013 | $ 49.0 | $ 6.8 | $ - | $55.8 |
| 2014 | $ 50.2 | $ 6.6 | $ 1.4 | $58.2 |
| 2015 | $ 51.3 | $ 6.6 | $ 2.8 | $60.7 |
| 2016 | $ 52.8 | $ 5.5 | $ 4.1 | $62.4 |
| 2017 | $ 54.3 | $ 5.4 | $ 5.9 | $65.6 |
| 2018 | $ 55.6 | $ 5.4 | $ 9.2 | $70.2 |
| 2019 | $ 57.0 | $ 5.4 | $ 11.3 | $73.7 |
| 2020 | $ 58.4 | $ 5.4 | $ 13.5 | $77.3 |
| 2021 | $ 59.9 | $ 5.4 | $ 15.8 | $81.1 |
| 2022 | $ 60.9 | $ 5.4 | $ 18.6 | $84.9 |

TABLE 12: 10-YEAR DEBT SERVICE TREND.
SOURCE: REDOAK WATER AND SEWER RATE STUDY

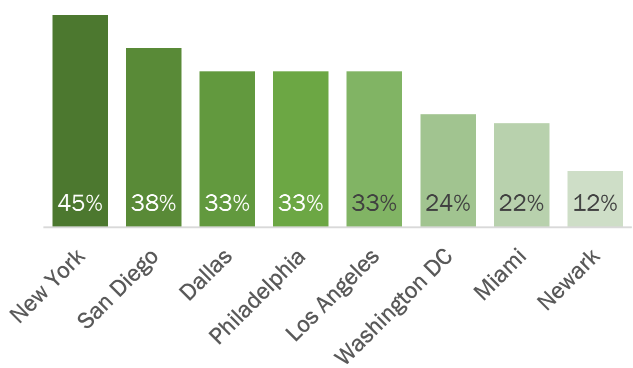


FIGURE 23: DEBT AS A % OF OPERATING BUDGET

| Consumption | Rate/1000CUFT | |
|---|---|---|
| | Regular Customer | Senior Citizen |
| First 300 CUFT | $8.03 | $6.93 |
| Next 33,000 CUFT | $24.08 | $20.80 |
| Next 133,000 CUFT | $21.50 | |
| Next 166,000 CUFT | $19.29 | |

TABLE 13: CURRENT NEWARK WATER RATE SCHEDULE

Based on this SSCIP, the Sewer Utility operating budget is forecast to increase from $49.0M in 2013 to $60.9 in FY2022 an increase of 24%. This rise is mainly attributed to an increase in debt service over the 10-year period which is expected to grow by $82.6M as a result of new projects. As a result of this new debt the amount of debt service as a percentage of revenue is expected to increase from 12% in 2013 to 27% by 2022. This is generally in line with that of other cities in as shown in Figure 23, below.[116]

## 6.2 RATE STRUCTURE

To cover this added debt, it is estimated that current water and sewer rates will have to rise proportionally. According to a report by Malcolm Pirnie Arcadis, Newark's current water rates are low relative to surrounding communities. On average, Newark households pay just $25 per month for water compared to $50 average costs in nearby South Orange and Bloomfield. The average monthly sewer bill for a Newark household is $35.[117] Newark employs a declining block rate, meaning that as a customer's usage increases, the price per unit decreases. Over the last ten years this form of rate structure has been replaced in many cities with an inclining block rate, which incentivizes conservation by increasing rates as consumption increases. [118]

For consumption costs, Newark subdivides customers into two categories: Regular Customers and Senior Citizens, with the latter paying 14% less for consumption, see Table 13. This rate amounts to approximately $0.0036 per gallon of water consumed for a Regular customer – 84% of Newark water customers. This is slightly below the NYC supply rate of $0.0045 per gallon.

For sewer rates, Newark recognizes three customer types: Regular, Senior Citizens, and Direct PVSC customers. This last group represents industrial customers who receive an additional sewer bill from the Passaic Valley Sewer Commission each quarter. As is common with most sewer utilities, rates are based on water usage (potable water being supplied to a facility) as well as a fixed minimum charge. As stated earlier, it is assumed that what comes in must go out. Each customer type pays a monthly sewer rate plus a monthly PVSC rate. The total combined water/sewer rate for Newark is summarized in Table 14 below.

[116] *NYC DEP Water and Sewer Rate Study*. Rep. New York City: NYC Department of Environmental Protection, 2010. Print. P 32 <Link>.
[117] Giambusso, David. "Report: Newark Needs to Raise Water Rates to Fix Infrastructure."*NJ.com*. Web. 21 Feb. 2014. <Link>.
[118] *NYC DEP Water and Sewer Rate Study*. Rep. New York City: NYC Department of Environmental Protection, 2010. Print. <Link>.

| Customer Type | Rate/1000CUFT | | |
|---|---|---|---|
| | Water | Sewer | TOTAL |
| Regular | $24.08 | $31.06 | $55.14 |
| Direct P.V.S.C. | $24.08 | $19.83 | $43.91 |
| Senior Citizen | $20.80 | $29.53 | $50.33 |

TABLE 14: CURRENT NEWARK SEWER RATES

| Comparison of Newark and NYC Water & Sewer Charges per 1000 CUFT | | |
|---|---|---|
| Customer Type | Newark | NYC |
| Regular | $ 55.14 | $87.80 |
| Senior Citizen | $ 50.33 | $87.80 |
| Industrial | $ 43.91 | $87.80 |

TABLE 15: NEWARK AND NEW YORK RATE COMPARISON

Newark's total rates are 37% lower than those of nearby NYC, as shown in Table 15 above. Additionally, NYC does not offer reduced rates to senior citizens or industrial customers.

## 6.3 CURRENTLY PRESCRIBED RATE ADJUSTMENTS

According to the Red Oak Sewer Rate Study, Newark has recently raised sewer rates in line with cost of living (2012 3.5% and 2013 2.0%).[119] Further rate increases are expected to be required to accommodate the cost of living adjustment to the operating budget, and to projects slated in the adopted capital improvement plan. Given Newark's relatively low rates, a rate increase would put the city in line with its neighbors.

As noted in this same study, in 2003 a rate design workshop was held in which several pricing objectives were considered. These included Customer Class Equity, Fixed and Low income Affordability, Revenue Stability and Predictability, Administrative Ease and Simplicity, Minimized Bill Impacts from Rate Structure Changes, Encouragement of Economic Development; and Conservation. As a result of this meeting and other discussions the Red Oak Rate Study put forth two alternate rate structures to improve revenue in an equitable way.

The first alternative simply increases the volumetric rate by 6% annually, through 2018. The second alternative proposes adding a "Fixed Service Charge" based on the size of the customer's existing meter as well as adjusting sewer rates for customers that are directly billed by the PVSC for sewer treatment. In theory, this would charge larger customers a higher fee, thereby making the system more equitable.[120]

Both maintain the declining block rate schedule. While charging higher fees for larger users does provide a measure of fairness, because the fee is fixed there is no incentive to reduce overall consumption[121]. Additionally, as we have already discussed in the previous section, 84% of the customers are Regular Residential customers, most of whom are renters. Any rate increase will likely be passed on to them. Given the existing economic conditions of Newark, it is unlikely that residents would be able to comfortably absorb even a modest rate increase.

Finally, the study did not address the issue of stormwater as it relates to charges incurred by the City through the existing treatment process. As previously mentioned, alternative options exist for addressing both of these aspects, consumption reduction and stormwater costs, while minimizing the impact on income-sensitive customers.

[119] Redoak Consulting - Water and Sewer Rate Study, City of Newark, NJ September 25, 2013. P 4-1
[120] Ibid.
[121] Ibid.

# CHAPTER 7: FINANCING SOLUTION SPACE

The following mechanisms are water rate structures and policies which incentivize conservation and more equitably charging properties for their stormwater runoff contributions to the CSS. These include inclining block rates, and stormwater fees.

## 7.1 INCLINING BLOCK RATE

As explained previously, Newark's existing rate schedule utilizes a declining block volumetric rate structure for water and sewer fees, whereby customers pay less per unit of water as they increase their usage. Alternatively, inclining block rates have unit price increases as the volume of water consumed raises above static thresholds. The chart in Figure 24 illustrates this rate structure.

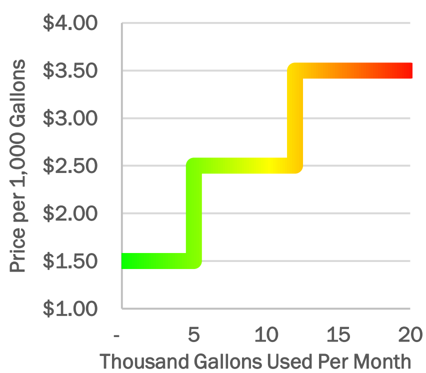


FIGURE 24: INCLINING BLOCK RATE STRUCTURE EXAMPLE.

Switching to an inclining block rate would promote conservation, particularly among high-usage customers. In addition to this, Newark could increase the amount of gradations in their rate schedule to capture more revenue from customers on the upper bounds of each usage bin. Because this structure penalizes high usage customers, it is one way in which revenue can be raised without impacting the 84% of the customers who are low-usage residential customers. A feasibility study, similar to the one performed by Red Oak, should be conducted to determine if this structure is appropriate for the City.

## 7.2 SEPARATE STORMWATER CHARGES

As discussed previously, under traditional sewerage billing, a large surface parking lot may pay no sewer fees at all despite its contribution to stormwater runoff to the sewer system. Stormwater costs are, in essence, passed on to water consumers, such as single family residences, whose properties often contribute much less runoff to the system. To adjust for this, some municipalities charge separate stormwater fees based the amount of runoff it generates and conveys to the sewer system. This is sometimes called an impervious area charge, and is a more equitable way to distribute the costs of maintaining storm sewers and protecting area waterways. [122] Because the charge will disproportionately affect large commercial and industrial properties, due to their extensive impermeable surface areas, a stormwater charge can be thought of as a progressive tax on impermeability.

Because property types vary widely, municipalities often breakdown property stock into four classes based on predicted impervious area of each property type: parking lots and commercial buildings, multi-family residential, single-family homes, and vacant land/open space. For ease of collection, the storm water fee is often added to water, sewer, or utility bills.[123]

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122 *The City of Newark Sustainability Action Plan*. Rep. The City of Newark, 2013. Web. <Link>.

123 EPA, Office of Wetlands, Oceans and Watersheds. "Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure." P. 27. Aug. 2010. Web. 23 Feb. 2014. <Link>.

Unfortunately, current New Jersey Law does not authorize municipalities to charge landowners a fee based on the quantity of stormwater generated. This can be changed by authorizing the establishment of a stormwater utility, or by authorizing the wastewater utility to impose separate fees for stormwater treatment. Legislation to this extent was proposed for Ocean County, but was eventually vetoed by the Governor in 2011.[124] Assembly Bill A.1583, introduced in 2014, would grant municipalities holding CSS general permits this authority if adopted.[125]

### 7.2.1 Case Study: Stormwater Charges and Incentives in Minneapolis

In March 2005, the City of Minneapolis adopted a separate stormwater charge for all properties. The charge is calculated based on the amount of impervious surface area covering the property. Coupled with the new fee, the city established an incentive program through which property owners could qualify for a full, or partial, abatement by establishing onsite water-quality and/or -quantity treatment systems, such as rain gardens and green roofs. This two-pronged approach allowed the city council to more equitably charge property owners for the demand their properties placed on the wastewater system. Additionally, it encouraged property owners to manage stormwater onsite, reducing the overall demand and strain on the existing treatment facilities. Minneapolis' new system – Minnesota Statute section 444.075/Minneapolis Code of Ordinances, chapter 510 – is designed to collect 100 percent of the funds needed for the city's stormwater management operations. As designed, the new stormwater charge is "revenue-neutral" for the utility. The increase in stormwater fees are offset by a reduction in the sanitary sewer charge. Stormwater charges are based on the size of the property and the land use, which serves as a proxy for imperviousness. The degree to which a property was covered by impervious surfaces was estimated based on a statistical sampling of similar land uses nationwide. For example, sports or recreational facilities and parks and playgrounds were estimated to be 20 percent impervious, while office properties were estimated to be 91 percent impervious. By charging stormwater fees by area rather than water consumption, the city added 6- 8,000 parcels to its roll of fee-paying properties. Property classes such as parking lots, which previously had not paid water or sewage charges, represented a significant portion of the increase.[126]

## 7.3 Alternative Sources of Funding

In addition to adjustments to revenue collection, there are several opportunities for external funding which Newark should consider pursuing. Such options often provide technical and financial assistance including public financing programs and public-private partnerships. Newark appears to be eligible for many government programs that are funded by both the federal government and by the State of New Jersey through New Jersey Department of Environmental Protection (NJDEP). In addition, certain limited public-private partnerships could offer creative funding opportunities.

### 7.3.1 Government Funding

There are several federal and state government programs which distribute millions of dollars in grants and loans for water and wastewater infrastructure projects. The following programs appear to be potential sources of financial assistance to Newark, some of which are referenced in the HMM report.

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124 Worstell, Carolyn. *Green Infrastructure in the State of New Jersey: Statutory and Regulatory Barriers to Green Infrastructure Implementation*. Rep. New Jersey Future, 2013. Print. <Link>.

125 "*A1583, Authorizing creation of stormwater utilities for certain local government entities.*" Assembly, No. 1583 State Of New Jersey 216TH Legislature. <Link>.

126 Krause, Michael. "Minneapolis Earns Stars and Scars by Charging for Hardscape." *Water Laws*. Fifth Annual Greening Rooftops for Sustainable Development, Conference Proceedings, Minneapolis, April 29-May 1, 2007, 1 May 2007. <Link>.

## State Revolving Fund Loan Program

The most significant source of public funding available for wastewater infrastructure improvements is the Clean Water State Revolving Fund (SRF). This program is funded by the U.S. Environmental Protection Agency (EPA) to provide independent state loan programs with financial aid. The main purpose of SRF is to assist with meeting the standards for performance levels of municipal sewage treatment plants, established under the Clean Water Act (CWA), to prevent the release of harmful waste into surface waters. The SRF is co-funded by the federal government (80%) and the state government (20%) providing loan assistance in furtherance of CWA compliance.

SRF programs provide assistance with making loans; buying or refinancing existing local debt obligations; guaranteeing or purchasing insurance for local debt obligations; guaranteeing SRF debt obligations; providing loan guarantees for sub-state revolving funds; earning interest on fund accounts; and supporting reasonable costs of administering the SRF. States cannot use SRFs as a source of grants. Loans are provided at or below market interest rates, including possible zero interest loans. The exact interest rates are negotiated by the applicant and state SRF.

The projects or activities that are eligible for SRF loans are those needed for constructing or upgrading publicly owned municipal wastewater treatment plants, such as the PVSC, and implementing nonpoint pollution management programs, exemplified by the recommendations in this report. Devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage are eligible. These include construction or upgrading of secondary or advanced treatment plants; construction of new collector sewers, interceptor sewers or storm sewers; and projects to correct existing problem of sewer system rehabilitation, infiltration/inflow of sewer lines, and combined sewer overflows.[127]

A portion of SRF grants must be dedicated to a Green Project Reserve (GPR) that addresses green infrastructure, water efficiency, energy efficiency, or other environmentally innovative activities. GPR was established on February 17, 2009 with the America Recovery Act of 2009 which appropriated $4 billion to SRF.[128] Accordingly, projects that include innovative environmental activities involve innovative approaches to managing water resources such as decentralized wastewater treatment solutions, projects that facilitate adaptation of clean water facilities to climate change, and projects that identify and quantify the benefits of using integrated water resources management approaches.[129]

The SRF in New Jersey is administered by NJDEP in conjunction with the New Jersey Environmental Infrastructure Financing Program (NJEIFP), and in accordance with the New Jersey Sewage Infrastructure Improvement Act (SIIA) which establishes comprehensive requirements for municipalities to address CSOs and stormwater management. NJEIFP offers loans to municipalities for projects that protect, maintain, and improve drinking water and wastewater infrastructure. This program provides New Jersey municipalities with financial assistance for CSO and stormwater management, and the planning, design and construction of wastewater infrastructure projects, and includes green infrastructure funded from GPR. Financing includes zero percent interest rate loans to local government units for up to half the allowable project costs, and a market rate loan from NJEIFP for the remaining allowable costs.[130] In January 2014, NJDEP published a list of 208 projects with an estimated value of $1.683 billion identified for financing under NJEIFP. According to the report, approximately $46 million will be applied to brownfield redevelopment

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[127] "Accessibility Information." *66.458*. Web. 23 Mar. 2014. <Link>.
[128] *EPA*. Environmental Protection Agency, Web. 08 Apr. 2014. <Link>.
[129] "Green Project Reserve." *Home*. Web. 08 Apr. 2014. <Link>.
[130] "NJDEP-Division of Water Quality, Municipal Finance and Construction Element." *NJDEP-Division of Water Quality, Municipal Finance and Construction Element*. Web. 23 Mar. 2014. <Link>.

projects and green infrastructure.[131] Newark has participated in NJEIFP. For example, NJDEP reported that in November 2008, Newark received $4,894,140 for cleaning and lining Pequannock Aqueducts.[132]

**Case Study: Camden, NJ**

Camden is located in Camden County New Jersey with a population of 508,932 with a CSS that lacks adequate stormwater management. During rain events, raw sewage causes public health and environmental issues. As such, NJDEP has designated Camden County MUA first on the 2015 NJEIFP funding priority list for a $6,614,815 Green Infrastructure/CSO Project. The project specifies green infrastructure including rain gardens as well as grey infrastructure including improvements to sewer lines, to increase conveyance capacity.[133]

## U.S Army Corps of Engineers Civil Works and Environmental Infrastructure Programs

The U.S. Army Corps of Engineers (Corps) also provides assistance to communities with the design and construction of wastewater infrastructure and surface water protection and development projects. Most environmental infrastructure projects are financed 75% federally and 25% locally. Congress provides the Corps the portion from the federal government. The Corps also provides for local protection from flooding under the Snagging and Clearing for Flood Control Program. Under this plan, the local government is responsible for a minimum of 35 percent to a maximum of 50 percent of the total project costs and the federal government covers the balance up to a maximum of $500,000 for each project. [134]

## HUD Community Development Grants

The Department of Housing and Urban Development (HUD) provides community grants through the Community Development Block Grants (CDBG) program for activities creating decent housing in suitable living environments. Water and waste disposal needs are considered part of that environment and are eligible for funding, but must compete with many other needs for funding. Program policy requires that at least 70% of funding benefit low and moderate-income residents. Grant allocations are issued annually with advance notice on amount of federal funds approved. Local and state authorities distribute the grants based on local priorities and must specify how they will measure performance. Acceptable activities include a wide range of projects such as public facilities and improvements, housing rehabilitation, energy conservation, public services, economic development, job creation, and brownfields redevelopment. Each activity must meet one of the three national objectives which include benefitting low- and moderate-income persons, aiding in the prevention or eliminations of slums or blight, or assisting other community development needs that present a serious and immediate threat to the health or welfare of the community.[135]

## EDA Public Works and Economic Development Programs

Support for water and sewer projects is also available from the Economic Development Administration (EDA) through the Public Works and Economic Development Program. The purpose of the program is to promote long-term economic development. Accordingly, the EDA assists in the construction of public works

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131 "New Jersey Environmental Infrastructure Trust." Jan. 2014. Web. <Link>.
132 New Jersey Department of Environmental Protection Drinking Water State Revolving Fund." Aug. 2012. Web. <Link>.
133 "New Jersey Environmental Infrastructure Trust." Jan. 2014. Web. <Link>.
134 "HEADQUARTERS." Headquarters U.S. Army Corps of Engineers Missions Military Missions Interagency & International Support. Web. 23 Mar. 2014. <Link>.
135 "Community Development Block Grant Entitlement Communities Grants/U.S. Department of Housing and Urban Development (HUD)." *Community Development Block Grant Entitlement Communities Grants/U.S. Department of Housing and Urban Development (HUD)*. N.p., n.d. Web. 29 Apr. 2014.

and development facilities that are needed to support the creation or retention of permanent jobs in the private sector in areas experiencing substantial economic distress. In general, EDA assistance average, and may not exceed, 50% of the cost of the program. Projects may receive additional funding, not to exceed 30%, based on the relative needs of the region in which the project will be located as determined by EDA. Qualified projects must fill a pressing need of the area and: (1) be intended to improve opportunities for the creation of businesses, (2) create long-term employment, and (3) benefit long-term unemployed or underemployed persons and low-income families. Projects must also fulfill a pressing need and be consistent with the comprehensive economic development plan of the area. Furthermore, eligible projects must be located in areas with low per-capita income, unemployment above the national average, or an actual or anticipated abrupt rise in unemployment.[136]

## 7.3.2 Public-Private Partnerships

A second financing option that Newark should consider is public-private partnerships (PPP). A 2013 report by the New York State Comptroller's Office found that most successful public-private infrastructure partnerships were undertaken to provide roads, bridges, buildings, and water and wastewater facilities.[137] These projects are generally revenue producing and able to recuperate the expenditures through tolls, energy-savings, taxation, and other mechanisms. PPP contracts are formed when cities take an inventory of revenue-producing public assets, like their water supply and wastewater system, to "lease or divest with help from private partners willing to invest capital in improving them."[138] Newark should consider pursuing PPPs as an alternative financing mechanism for future green infrastructure projects, such as green roofs and permeable pavement, when public funding cannot fully support the initiatives. PPPs need not, however, involve an outright sale of the city's assets, and the transaction recommended here allows Newark to retain ownership of the system while also seeking funding from the private sector. Public-private partnerships are becoming "integral to the overall capital investment and infrastructure strategy of the nation."[139] Newark should explore corporate sponsorship and private funding of the green infrastructure projects outlined in this report. In other cities, tax incentives have been offered as well to the private funders in similar partnerships, but caution should be applied when choosing the term-length of these exemptions. PPPs should not be explored as a method of short-term budget relief or to avoid budgetary controls, but instead when they are socially beneficial, as are the green projects in this report.[140]

### Case Study: RE:invest Initiative

The RE:invest Initiative is a two-year collaboration of public-private partnerships established in 2013 that includes eight cities and funding by the Rockefeller Foundation to help develop sustainable stormwater and sewer systems. The stated goal of the partnerships is to "ease the burden on government by bringing together technical experts from inside and outside government, and mobilize resources to protect communities by aligning public resources with private investment."[141] As such, The Rockefeller Foundation is providing seed money to leverage private financing for green infrastructure projects in San Francisco, CA; Miami Beach, FL; New Orleans, LA; Hoboken, NJ; Honolulu, HI; El Paso, TX; Milwaukee, WI; and Norfolk, VA.[142]

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136 "Accessibility Information." *14.218*., Web. 23 Mar. 2014. <Link>.
137 DiNapoli, Thomas. "Private Financing of Public Infrastructure: Risks and Options for New York State." New York State Comptroller's Office, June 2013. P 4. <Link>.
138 Rowey, Kent. "Public-Private Partnerships Could Be a Lifeline for Cities." New York Times, 15 July 2013.
139 Puentes, Robert. "Strengthen Federalism: Establish a National PPP Unit to Support Bottom-Up Infrastructure Investment." Brookings Institution, November 2012. <Link>.
140 Engel, Eduardo, Ronald Fischer, and Alexander Galetovic. "The Hamilton Project: Public-Private Partnerships to Revamp U.S. Infrastructure." Brookings Institution, February 2011. <Link>.
141 "Goals." *RE.invest Initiative*. N.p., n.d. Web. 24 Apr. 2014. <Link>.
142 "News & Media." RE.invest Initiative Announces Partnership with Eight Cities to Build More Resilient Stormwater Systems : News : The Rockefeller Foundation. Web. 24 Apr. 2014. <Link>.

# CHAPTER 8: FACTORS USED TO EVALUATE BMPS

To arrive at the final list of recommended actions, certain criteria were looked for in each BMP analyzed. Stormwater and CSO BMPs were first screened based on their applicability to Newark given the existing land use, demographics, financial feasibility, and political conditions of the City and State. Once BMPs were deemed feasible for implementation in Newark, factors such as applicable land use, implementation costs, and cost effectiveness for addressing stormwater and CSOs were examined.

Additional benefits related to environmental, social, and economic factors were considered when evaluating measures for recommendation. Finally, the timeframe for which each BMP could successfully be implemented was studied and factors considered prerequisites for certain long-term strategies were targeted as short- and medium-term recommendations.

For example, while a long-term goal for stormwater management using green infrastructure is recommended, existing conditions, which impede this goal, e.g. a lack of stormwater management incentives, must be overcome through policy changes in the short-term. Below is a summary of the factors used throughout the analysis and evaluation process.

## 8.1 FEASIBILITY

Before proceeding with detailed analysis on each measure, we performed a preliminary feasibility screening to determine if the BMP could be practically implemented within the political, economic, and geographic boundaries of Newark as they exist today.

## 8.2 APPLICABLE LAND USE

For those green infrastructure BMPs analyzed, we examined where each could most effectively be implemented based on land type. For example, certain measures are best implemented in residential spaces, such as rain barrels. Other measures, such as permeable pavement, are ones best suited for commercial and public spaces.

## 8.3 ENVIRONMENTAL BENEFITS

Environmental benefits encompass those such as water savings and filtration, air purification, cooling/shading, energy savings, and emissions reductions.

## 8.4 SOCIAL BENEFITS

In our analysis, social benefits are those which strengthen the local Newark community. They include community engagement and activism, job creation, Health impacts, neighborhood beautification, noise reduction, and education.

## 8.5 Economic Benefits

We defined economic benefits as monetary gains, savings, and avoided costs which accrue to both the consumers as well as to the City of Newark Water and Sewer Utility.

## 8.6 Life Cycle Costs

Many of the recommendations require both upfront capital costs as well as ongoing maintenance expenses. Capital Costs are measured as the upfront costs associated with implementing each BMP. These costs were derived from those found in similar projects in other cities as well as the proposals set forth in the HMM report. Ongoing expenses are defined as those which are incurred periodically over the life of the BMP measure and were similarly taken from analysis of relevant case studies.

## 8.7 Stormwater Reduction

Stormwater reduction is measured as the amount of precipitation captured, detained, or diverted from the CSS by each BMP targeting stormwater. This was standardized as annual gallons/sf (or annual gallons/$ cost).

## 8.8 Consumer Demand Reduction

Demand reduction is a measure of the effectiveness of each BMP at reducing demand-side water usage. As is common practice, it is assumed that a consumer water usage (inflow) is equal to the amount sent out as wastewater (outflow). This metric was standardized as annual gallons saved/$ cost.

## 8.9 Implementation Timeframe

Thanks to the efforts of the NWG, in 2013, control of the water and sewer system was officially transferred from the NWCDC to the City of Newark. This transfer of power coincides with a change in political leadership in Newark, as former Mayor Cory Booker moves to the US Senate and a new mayor is set to assume office in the summer of 2014. These changes made it necessary for our client to have a carefully prepared set of water management strategies ready to act as a roadmap for the incoming decision makers.

A key component of this roadmap is a timeframe for which each BMP analyzed can be implemented. This will allow the new administration to more effectively allocate resources and budget based on a predetermined expected timeframe for each measure. In our analysis, we divided this timeframe into three distinct periods: short-, medium-, and long-term, which we defined as one, four, and ten years respectively. Implementation timeframes were derived from case studies of similar projects initiated in other cities. Specifically, the timeframe measures the amount of time between a measure’s primary steps to when benefits are first realized.

# CHAPTER 9: RECOMMENDED ACTIONS

## 9.1 CONDUCT A PILOT STUDY IN THE RECOMMENDED AREA TO CONTROL STORMWATER RUNOFF USING GREEN INFRASTRUCTURE

### 9.1.1 Pilot Area Selection

As expressed in Newark's own Sustainability Action Plan, the purpose for developing pilot programs is to vet the costs and benefits of recommended GI stormwater management practices.[143] Due to high capital costs, it is necessary that green infrastructure be implemented in a targeted fashion, in order to produce the most cost effective results. As mentioned earlier, efforts by the Sustainability Office are currently underway to analyze and identify neighborhoods for stormwater management intervention for this purpose. While this information was not readily available at this time, this report attempts to make use of existing information relating to combined sewer districts, land use, topography, population distribution, and observed flooding and sewer overflows in order to exemplify the process of strategic geographic targeting.

To begin the process of narrowing down an area for the pilot study the City was analyzed in terms of sewer districts. Using the NYC DEP Green Infrastructure Plan as a guide, only those areas serviced by the combined sewer system were examined, as these are the areas that most directly impact the CSO problem in Newark, indicated in black in the Figure 25 map.

Using the CSS region as a starting point, land topography data was analyzed to determine areas composed of high percentages of impermeable surfaces. The map in Figure 26 depicts areas of highly impermeable surfaces, black, based on land use. These indicated areas represent those where the average surface impermeability is greater than 70%, indicating high volumes of stormwater runoff during precipitation events.

Because the causes and effects of CSOs are more severe in heavily populated areas, due to high volumes of wastewater as discussed previously, population density was considered to be a key factor for in the evaluation process. As a result, areas with high population density were deemed a priority for stormwater management intervention. The map in Figure 27 illustrates Newark in terms of population density.

Finally, as stormwater flooding was a central issue to be addressed by this report, information from reports of localized flooding during Hurricane Irene was compiled and mapped to provide geographic representation of areas most prone to flooding. The City collects and publicizes this information via a public hotline, whereby residents are urged to report incidents of local flash floods.

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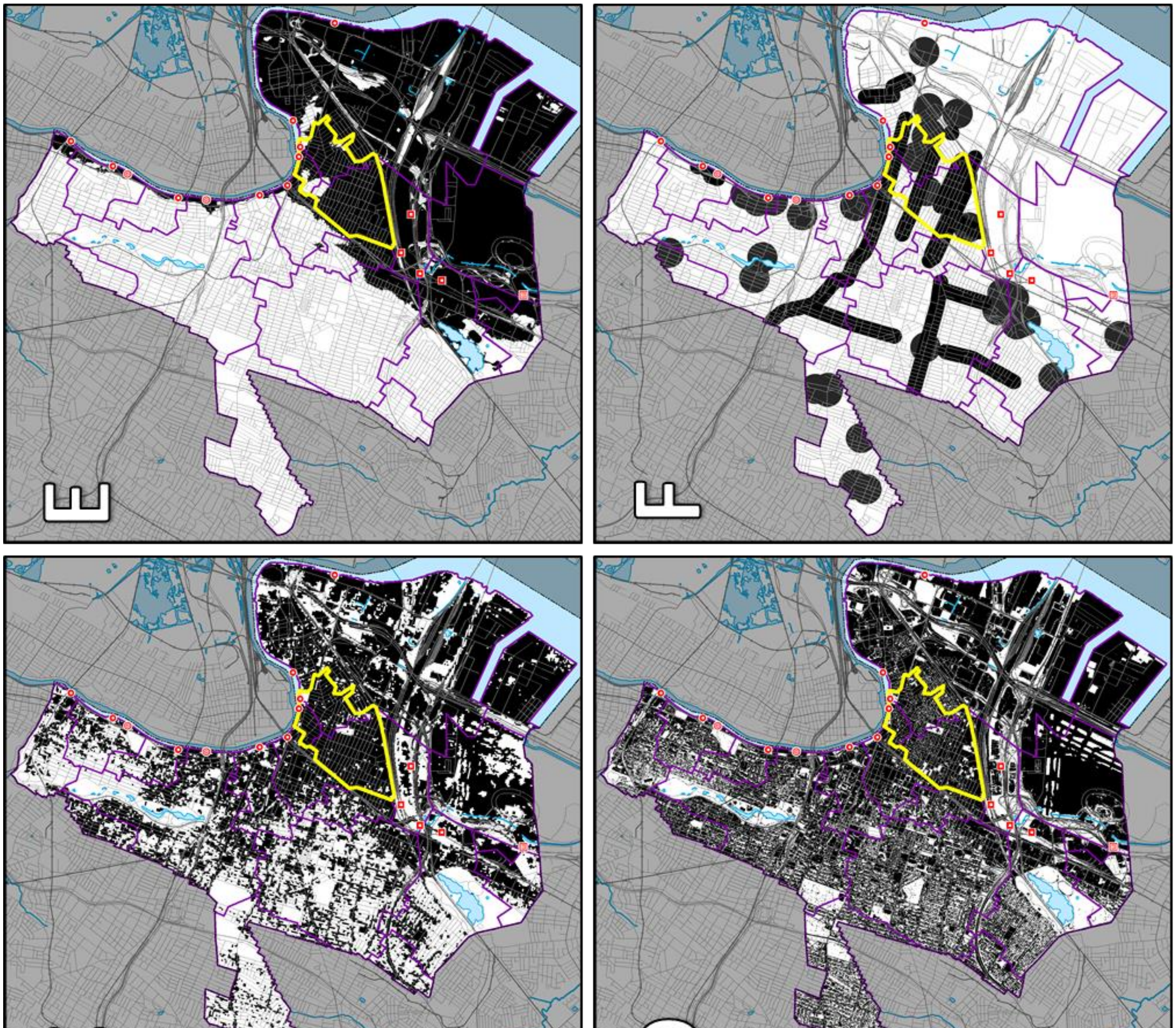
[143] *The City of Newark Sustainability Action Plan*. Rep. Newark: n.p., 2013. *The City of Newark Sustainability Action Plan*. The City of Newark Office of Sustainability, 2013. Web. 2 Mar. 2014. <Link>.




**Map A:** High Population Density (≥ 8 people per 1000 sq-ft)
**Map B:** Combined Sewer System
**Map C:** High Imperviousness (≥ 70% impermeable)
**Map D:** Not Tree/Grass Cover
**Map E:** Low Elevation (≤ 6 ft above sea level)
**Map F:** Commonly-Flooded Roads

FIGURES 25-27 : PILOT REGION SELECTION CRITERIA

Combined, analysis of these mapped factors – CSS districts, impermeability, population, elevation, tree cover, and high-risk flood areas – aligned to indicate that the sewer districts of Jackson, Ferry, and Adams should be the target for green infrastructure intervention. These districts all exhibited characteristics related to relatively high levels of stormwater runoff and wastewater production, thereby demonstrating higher risks for flooding and CSO events.

These sewer districts service the iconic North Ironbound and Ironbound neighborhoods. Together, this is one of the most well-known areas in the city and is considered by many to be an example of Newark's economic vitality. The area is one of the most densely populated regions of the city, with 10.39 people per 1,000 square feet.[144] It is also a highly developed area, with a high proportion of impervious surfaces, and a low percentage of tree canopy relative to the rest of the city - at just 9%.[145] Based on five-year average precipitation data, as well as the square footage of impervious surface area, these three CSS districts were estimated to contribute approximately 785 million gallons of stormwater runoff annually, which, combined with its high population density, makes it a good candidate for GI pilot projects.

In addition to the analysis of relevant stormwater and demographic factors this area exhibits, its iconic status enhances its qualifications for pilot intervention. As one of the goals of the pilot study is to raise awareness of sustainable stormwater management across the City, implementing green infrastructure in a highly visible region such as this is the best way to promote future adoption of these strategies over the long-term. It should be a goal of this pilot to become representative Newark's commitment to sustainability.

## 9.1.2 Selection of Green Infrastructure Technology

As discussed previously, the different land uses that make up Newark will each require specifically tailored GI strategies to maximize the effect of each. To accommodate this, each distinct land use type in the pilot region was analyzed to determine the GI intervention strategy best suited for the area. Costs for many of the technologies, as well as stormwater detention capacities for each, are based on those provided in New York City's PlaNYC green infrastructure analysis, detailed in Table 16 below.

| SOURCE CONTROL | INCREMENTAL CAPITAL COST (PER SQ. FT. OR UNIT) | NET PRESENT VALUE (PER SQ. FT. OR UNIT) | LIFESPAN (YEARS) | COST PER YEAR | GALLONS* (PER SQ. FT. OR UNIT) | COST TO CAPTURE GALLON | ANNUAL COST PER GALLON |
|---|---|---|---|---|---|---|---|
| Blue Roof (2-inch detention) | $4.00 | $4.00 | 20 | $0.20 | 1.25 | $3.21 | $0.16 |
| Rain Barrel (55-gallon tank) | $200 | $200 | 20 | $10.00 | 55 | $3.64 | $0.18 |
| Sidewalk Biofiltration | $36.81 | $39.68 | 20 | $1.98 | 8.60 | $4.61 | $0.23 |
| Porous Asphalt Parking Lane | $8.13 | $10.33 | 20 | $0.52 | 2.18 | $4.74 | $0.24 |
| Porous Concrete Sidewalk | $6.83 | $8.67 | 20 | $0.43 | 1.82 | $4.77 | $0.24 |
| Swale | $18.73 | $22.50 | 40 | $0.56 | 1.82 | $12.39 | $0.31 |
| Blue Roof (1-inch detention) | $4.00 | $4.00 | 20 | $0.20 | 0.62 | $6.42 | $0.32 |
| Cistern (500-gallon tank) | $3,700.00 | $3,700.00 | 20 | $185.00 | 500 | $7.40 | $0.37 |
| Greenstreet | $42.67 | $82.79 | 30 | $2.07 | 5.24 | $15.81 | $0.53 |
| Sidewalk Reservoir | $98.48 | $110.41 | 20 | $5.52 | 3.74 | $29.52 | $1.48 |
| Green Roof | $24.45 | $62.39 | 40 | $1.56 | 0.47 | $133.37 | $3.33 |
| **REFERENCE CASES** | **INCREMENTAL CAPITAL COST (PER SQ. FT. OR UNIT)** | **NET PRESENT VALUE (PER SQ. FT. OR UNIT)** | **LIFESPAN** | **COST PER YEAR** | **CSO GALLONS (PER SQ. FT. OR UNIT)** | **COST TO CAPTURE GALLON** | **ANNUAL COST PER GALLON** |
| Newtown Creek Tunnel | $1,299,000,000 | $1,300,000,000 | 50 | $26,000,000 | 40,000,000 | $32.50 | $0.65 |
| Flushing Bay Tunnel | $1,038,000,000 | $1,039,000,000 | 50 | $20,800,000 | 25,000,000 | $41.56 | $0.83 |

* "Gallons" in the source control fields refers to gallons of stormwater runoff that can be retained or detained in those source controls. The exact relationship between those quantities and the corresponding reduction in CSOs is not yet established. See Appendix D.

TABLE 16: COSTS AND CAPACITIES OF GI TECHNOLOGIES, PLANYC STORMWATER MANAGEMENT PLAN 2008

144 U.S. Census Bureau. 5-Year American Community Survey 2008-2012. 2012. Raw data. N.p.
145 Sustainability Office. Land Cover Map. 2012. Raw data. Newark, NJ.

## Paved Areas – Permeable Pavement and Tree Canopy

Newark is comprised of nearly 70% impervious surfaces, which contributes to the high volume of annual runoff. In the proposed pilot area there are nearly 12 million square feet of non-road paved surfaces.[146] Since the Newark Sustainability Action Plan already includes permeable pavement as a potential GI strategy, it is recommended that NWG support the implementation of this technology in the pilot area. Since permeable pavement has been calculated to cost $0.14 per gallon of stormwater diverted, it is a cost effective solution for Newark. It is recommended for the pilot region that Newark install 55,200 square feet, or roughly 10.5 miles of permeable pavement; about 1% of Newark's road surface. Sidewalks and city owned parking spaces should be the considered options for utilizing this pavement. Based on previously stated costs of $4.49 per square foot, installed costs of this project would be $247,849 with annual maintenance of $522, to maintain full performance. Upon completion, it is estimated that stormwater runoff will be reduced by approximately 1.68 million gallons annually, and over 50.2 million gallons over the life of the pavement. This equates to approximately 2.1% of the total goal reduction for the pilot region.

Newark also has been making tremendous strides to achieve its goal of doubling its tree canopy and expects to install 2,000 more trees in 2014.[147] These new 2,000 can expect to mitigate 10.4 million gallons of stormwater annually and over 313 million gallons over an assumed 30 year life. If 2,000 trees were planted in the pilot region, it would equate to 13.3% of the of the total goal reduction. The total costs of these tree plantings are $870,000,[148] 56% of the total projected costs to reduce 10% of the pilot regions stormwater. At $0.26 per gallon diverted, street trees are a good option and it appears that great progress is being made, so it is this papers recommendation that NWG support the current tree planting progression. Lastly, when permeable pavement construction is done, spaces should be left for tree pit development, eliminating the need to cut concrete, to make the tree pits more economical.

## Transportation and Barren or Bare Lands - Swales

It is recommended that swales be situated alongside as many major highways, railways, along the edges of parking lots, or barren lands as possible. Swales have been analyzed to cost $0.001 per gallon diverted and should be implemented over the short term. Based on the analysis of this paper, swales are the most cost effective strategy to reduce capacity constraints on CSS pipes during peak precipitation events. As both NJ rail systems and the NJ turnpike are on the borders of this papers recommended target area, these swales could help to mitigate runoff from these large impervious surfaces in addition to other runoff. NWG should work with NJ transit and the NJ Turnpike authority to enable the development of swales on this land. Concurrently NWG should encourage swales to be developed on all other suitable lands within the pilot region as well. The rule of thumb for swale design is total surface area of the swale should be 1% of the area draining into the swale.[149] The analysis of this paper concludes that, Newark should install 20,471 square feet of swales, which is possible due to the extreme flexibility and linear design of swales. These installations would require just over $10,000 in capital costs and $1,230 in annual maintenance costs. This would enable Newark to mitigate over 62 million gallons of stormwater annually and nearly 2.5 billion gallons of stormwater over the lifetime of the swales installed. Swales equate to 79.1% of the target water reduction.

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146 Sustainability Office. Land Cover Map. 2012. Raw data. Newark, NJ.
147 Greenwood, Stephanie. "Sustainability Department." E-mail interview. 8 Apr. 2014.
148 Ibid.
149 USA. EPA. Office of Water. *Stormwater Tech Fact Sheet Vegetated Swales*. N.p., Sept. 1999. Web. 1 Apr. 2014. <Link>.

### Vacant Lots – Rain Gardens

There are numerous vacant lots across the city and Newark is currently taking advantage of this by leasing out lots for $1 per year to develop rain gardens. As the analysis of this paper puts rain garden costs at $0.13 per gallon diverted focusing efforts to areas that are prone to flooding would be the best course of action. Rain gardens are a very visual representation of city progress and can generate community support and activism. If the soil in the rain garden is a type that drains well, the garden will need to only be 20% of the square footage of the impervious surface it is serving. If 55,200 square feet of rain gardens were installed it would cost approximately $63,480 in capital costs and around $417,000 in maintenance and land leasing costs over a 30-year period. Using average yearly precipitation data for Newark this equates to just under 8.4 million gallons of per year and over 251 million gallons over the lifespan of stormwater, retained by the rain garden. This equates to 4.4% of the target goal reduction.

### Residential – Rain Barrels

For residential homes rain barrels have been deemed a very compatible technology. It has been analyzed that 10% of the homes within the pilot region are single-family. It is not recommended to deploy these in rented units as the owner generally is the only financial beneficiary and the tenant would generally have to perform the maintenance. Narrowing down this focus leaves 836 single-family residential homes within the target region. It is recommended to deploy rain barrels to 100 of these single family owned homes who have a garden for which the captured rain water could be easily used, or other residential who have permeable surfaces, to maximize the barrels benefits. Deployment of 100 barrels would reduce over 900,000 gallons of stormwater annually and about 1.1% of the reduction goal for a cost of $27,375. These estimates are based on costs for a 400 square foot roof with a 75-gallon rain barrel.

The build out of previously stated green infrastructure projects should be continued over the medium term as well. Funding for these projects should be gathered from HUD grants, the stormwater fund, and stormwater fixed charges. Once the 10% water reduction has been achieved, Newark should reassess and determine what impact this has had on CSO events within the pilot region and determine if the program needs to achieve more within that area.

Over the long-term if this pilot proves successful it should be expanded to other areas of Newark. Also continued progress in increasing the penetration of street trees, permeable pavement, rain gardens, bio swales, and water conservation program should occur citywide. Once the results of the pilot are analyzed, NWG should encourage the city to expand the projects that appear to be the most fruitful at a faster rate than projects that appear less successful to increase performance with minimal capital outlay. Finally, all high-density residential and mixed-use buildings should have benchmarking phased in over the long term.

## 9.2 Establish a municipal CSO and water quality monitoring program and complete the scheduled control upgrades at remaining CSO outfalls

More accurate and precise CSO monitoring programs are necessary for future prioritizing of CSS districts for stormwater management interventions. As explained previously, current methods of CSO monitoring are insufficient for determining when and where overflow events occur. To address this, a more robust and targeted water quality-monitoring program should be developed. This program should be designed to track bacteria levels, a key indicator of sewage overflow, around each CSO outfall point in Newark.

Ideally, a methodical water sampling program can be used to match precipitation events with degraded water quality to better determine the sensitivity of each CSO watershed in Newark to stormwater runoff. Based on the results of this analysis, the total square area of any sewer district, together with the percentage of surface that is impervious, can help determine the approximate volume of stormwater that flows into the CSS during a precipitation event. Targets for gallons of water to be retained during such an event in order to avoid a CSO event can then be established, similar to the analysis undertaken to develop the NYC DEP Green Infrastructure Plan

To finance such a program, an opportunity for corporate sponsorship exists with HSBC through the FreshWater Watch program. Through this, industry could be contracted to train Newark community volunteers and participants on how to perform coordinated water quality monitoring tests as part of a community outreach program.[150] In addition to aiding with CSO event analysis, this program would also raise public awareness of the issues and engage the community in working to find solutions.

Some grey infrastructure projects, already in the planning phase, are also necessary to improve outflow control in Newark. Specifically, management of floatable waste, the visible solid waste often present in CSO discharges, is an important aspect of the US Environmental Protection Agency's (EPA) CSO Control Policy. Common measures for controlling floatables include baffles, screens and trash racks, and netting.[151] Of the 17 CSO outfall locations in Newark, 12 have already been outfitted with screening and netting measures. These projects are mandated under an Administrative consent order from the NJDEP. The remaining four locations are currently scheduled to be outfitted with floatable control measures. According to the Sewer Utility's 2014 capital improvement plan, the Freeman Street CSO, is budgeted for this work. The three others were funded under previous authorization from the New Jersey Environmental Infrastructure Trust (NJEIT), but have yet to be completed.[152] It is recommended that the City complete these necessary CSO floatable control measures to comply with state and federal regulations, and that the NWG support this effort.

## 9.3 Promote water use monitoring and conservation programs to reduce overall amount of sewage flow from water and sewerage customers

Since the load on a combined sewer system is largely dependent on wastewater from consumer use, buildings within the CSS watershed should be targeted for water efficiency and conservation programs. This would directly alleviate a portion of the water load sent to the waste treatment plant for processing. Furthermore, it would reduce the risk of CSO discharges during hydrological events.

In the short term, a pilot study involving all city-owned buildings should be conducted to determine the costs and effectiveness of various conservation measures. Much like the energy use program described in the Newark Sustainability action plan, the water conservation pilot should begin with benchmarking of the water use of each building. From there, water audits can be implemented on those buildings which show to be high relative users and conservation targets based on the audit results can be established. Conservation measures should be implemented as determined by the audits and post-implementation data should be gathered after one year to gauge the effectiveness of the program in terms of water use reductions. The benchmarking and audit steps of this pilot study require minimal funding to initiate, and could be carried out by staff in the Newark Sustainability Department. Results of the water audits will

[150] "Freshwater Watch & the HSBC Water Programme." Earthwatch Institute, 2014. Web. 26 Apr. 2014. <Link>.
[151] United States. Environmental Protection Agency. Office of Water. *Combined Sewer Overflow Technology Fact Sheet*. F99 ed. Vol. 832. Washington DC: EPA, 1999. Print. Ser. 008.
[152] Water and Sewer Capital Projects SFY 2014 NJEIT Funding. Newark: City of Newark, 2013. Print.

determine the eventual costs of the recommended conservation measures to be implemented in step three, but these measures do not typically have high costs as shown in the Cost Benefit Analysis of Efficient Technologies tables located in the Appendix. Upon successful demonstration of the pilot, a city-wide program can be rolled out for all properties over 10,000 square feet, in an effort to target the city's largest water consumers.

Because regular residential accounts make up roughly 84% of the total number of water customers and account for nearly 27% of the utility's cost of services, additional conservation efforts should target these customers. A Water Conservation Assistance Program, which would provide free water audits and basic conservation measures for low income households, should be established in the recommended pilot area, with the long-term goal of expanding to a city-wide program upon successful pilot demonstration. As Table 2, below, indicates, nearly 70% of the households in the pilot region are between 1 and 4 units, which is indicative of smaller systems and more limited and inexpensive conservation solutions; i.e. showers and faucets rather than cooling towers and central heating plants.

| Number of Units in Building | Percent of Population | | Percent of Homes | |
|---|---|---|---|---|
| | Newark | Pilot Region | Newark | Pilot Region |
| Single Family Homes | 26.1% | 13.7% | 20.0% | 10.9% |
| 2 - 4 Units | 47.6% | 59.6% | 45.2% | 58.6% |
| 5 + Units | 26.3% | 26.7% | 34.7% | 30.4% |
| Other (Mobile Homes, RVs, etc.) | 0.1% | 0.0% | 0.1% | 0.1% |

TABLE 17: RESIDENTIAL MAKEUP OF NEWARK AND PILOT AREA

Due to the high proportion of low-income residents in Newark, this program could be eligible for financing with federal grants from the Department of Housing and Urban Development (HUD). The HUD Community Development Grant program, provides block grants for cities with populations of at least 50,000 to improve housing and living conditions for low- and medium-income residents while expanding economic activity through job creation. Among the numerous qualifying activities are housing rehabilitation and energy conservation, both of which would be addressed by a water conservation assistance program. Furthermore, the program would be a source of job creation and economic stimulus by employing water auditors, plumbers, and light construction workers to implement the conservation measures. The HUD grant requires that 70% of the funding be used for improving low- and medium- income households, which could easily be met given the current Newark demographics.[153]

This grant could create a water efficiency program, similar to Philadelphia's CAP in Newark. To meet the requirements of the starting first with government owned buildings, especially public housing. The budget in Philadelphia is around $250,000 per year with $33,200 being administration costs. In the first year NWG should encourage a focus on customers that meet the following requirements: they benchmark their water use, are current on their water bills, have an AMR, and live in an area serviced by Jackson, Ferry, or Adams CSS. Currently the pilot region there is nearly 9 million square feet of high-density residential space and based on BMPs stated previously, the most cost effective technologies to be deployed are aerators, high efficiency toilets and showerheads.

Assuming a single toilet and shower, for approximately $600 per residence, the city could save around 6,000 gallons of water per year, or 180,000 gallons over the lifetime of the equipment.[154] If 75% of this grant money were used for improving 300 residences, focusing also on those in public housing, this would equate to around 1.8 million gallons diverted annually from residential users or 2.3% of the reduction

[153] "Community Development Block Grant Entitlement Communities Grants/U.S. Department of Housing and Urban Development (HUD)." *Community Development Block Grant Entitlement Communities Grants/U.S. Department of Housing and Urban Development (HUD)*.. Web. 29 Apr. 2014.

[154] Philadelphia Water Department Conservation Assistance Program Profile #109. Philadelphia Water Department 1994 Statistics. <Link>.

target. Over the 30 year expected lifetime of the technologies mentioned, an investment of $180,000 eliminates roughly 54 million gallons of water from the wastewater stream.

Before consumer demand is reduced at the commercial and industrial level, the city should mandate annual water use benchmarking for all buildings over a predetermined size; NYC uses 10,000 square feet as the benchmark for this mandate. Currently in the proposed pilot region there are nearly 16 million square feet of commercial and industrial space. Water efficiency is very important for these users as well, with a focus on high efficiency toilets, urinals, and commercial prerinse spray valves. Utilizing one of each of these would cost around $900 and save around 8,000 gallons per year or over 240,000 gallons over the life of this equipment.

If $62,000 went to this group of water consumers, Newark could expect to save over 640,000 gallons from this investment annually, and around 19 million gallons over the lifetime of the technologies installed. Cisterns can be installed on-site of existing commercial and industrial building sites. 2, 700-gallon cisterns should be installed, which would cost $10,360. This would result in a diversion of about 56,000 gallons of stormwater annually and over 1.12 million gallons over the life of the cisterns. This equates to only a small fraction of a percent of the goal reduction. If these buildings utilized the captured water for non-potable uses it would improve the economics of the cisterns by reducing the supply of water needed to meet the buildings demand.

The recommendations for mixed land use types mimic those presented in the high density residential and commercial and industrial sections. This paper's pilot area has nearly 1.5 million square feet of mixed-use land and these buildings should also be included in the water efficiency program. One cistern should be installed in building to analyze the results. Capital costs would be $5,180 for a 700-gallon cistern and it could mitigate 28,000 gallons of stormwater each year.

## 9.4 Establish a stormwater fund and conduct feasibility studies to determine the impact of a stormwater surcharge and inclining block rates on water-consumption

It is recommended that NWG pursue the action stated within the NSAP for the development of a stormwater fund. NSAP recommended that this fund receive revenue from major redevelopments and new construction sites that do not capture 100% of rainfall on-site.

At present, widespread adoption of stormwater infrastructure is hindered in New Jersey due to specific statutory and regulatory barriers, which do not authorize municipal and regional entities to charge property owners fees for stormwater they contribute to the system.[155] As a result, property owners have little incentive to employ green infrastructure BMPs into their buildings and developments. Compounding this lack of incentives is the underlying inequity of the current sewer rate structure, which charges customers based on their water consumption levels. Because of this, properties such as commercial parking lots, whose large, impermeable footprints contribute significant amounts of stormwater runoff to the sewer annually; do not pay proportionally for the load they contribute to the system. Other ratepayers who may have smaller properties with less impermeable surfaces subsidize treatment for this stormwater.

To correct this, NWG should advocate for legislation that authorizes utilities to charge property owners for sewer usage based on stormwater load contribution, as suggested in Newark's Master Plan.[156] Such a bill

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[155] Worstell, Carolyn. *Green Infrastructure in the State of New Jersey: Statutory and Regulatory Barriers to Green Infrastructure Implementation*. Rep. N.p.: New Jersey Future, 2013. Print. <Link>.

[156] "Newark's Master Plan." *City of Newark, NJ* -. N.p., n.d. Web. 24 Apr. 2014. <<Link>.>.

has recently been introduced in the New Jersey State Assembly. Assembly Bill 1583, introduced by Assemblywoman L. Grace Spencer of District 29 in Newark, would effectively authorize any municipality holding a combined sewer system general permit to establish a designated stormwater utility for the purpose of creating a stormwater management system. The bill further authorizes this entity to finance operations through the imposition of user fees, i.e. stormwater charges.[157] A similar bill passed the State Senate in 2011, but was subsequently vetoed by Governor Christie. It is recommended that the NWG fully support this important bill, which represents a crucial first step towards establishing the economic and regulatory conditions necessary for green infrastructure proliferation throughout the City.

Through such a charge, properties could incur a fee proportional to the amount of impervious surface covering the lot footprint. This separate fee would stimulate private investment in green infrastructure by improving the financial payback through the potential for lower charges, while also reducing stormwater runoff and CSO events in the City.[158] Additionally, it will improve equity of the sewer financing system and could even offset the need for potentially hurtful across the board rate increases. These charges should be established within the second year, if the law is passed, since the fees will be crucial to help finance the GI build-out over the medium and long term. As a reference, the average impermeability across various land types of Newark has been analyzed.

| Land Use Type (NJDEP)[159] | Million Sq-Ft in Newark | Average %-Impermeability |
|---|---|---|
| **Airport** | 43.44 | 80.0% |
| **Barren Land** | 6.23 | 75.6% |
| **Commercial/Industrial** | 184.54 | 78.4% |
| **Green Space, Non-Urban** | 21.27 | 30.5% |
| **Green Space, Urban** | 16.51 | 20.9% |
| **Mixed or Other Urban** | 44.50 | 61.7% |
| **Recreational** | 24.41 | 27.3% |
| **Residential, High Density** | 195.39 | 63.5% |
| **Residential, Med Density** | 3.17 | 42.8% |
| **Stormwater Basin** | 0.67 | 62.8% |
| **Surface Water** | 6.08 | 16.1% |
| **Transport./Commer./Utility** | 64.55 | 84.2% |
| **Transportation** | 57.45 | 73.5% |
| **Wetlands** | 7.80 | 27.4% |

Finally, in order to incentivize water conservation, NWG should support a feasibility study to determine the economic and financial effects of switching the volumetric water rate schedule to an inclining block structure. Currently, volumetric water rates decrease as customers increase their usage. The nature of such a structure targets only high-volume consumers, and would therefore minimally impact the 84% of customers whose "Regular" rate distinction indicates lower usage.

## 9.5 Timeline for Implementation

The tables below specify how the recommendations should be broken out. The timelines are designed over 3 time scales: short-term 1 year, medium-term 4 years, long-term over 4 years. It was determined that the recommendations listed in the short term will help kick start this program and help bring about meaningful change to the way Newark handles its wastewater. The passage of NJ Bill A1583 will be the most pivotal

[157] *"A1583, Authorizing creation of stormwater utilities for certain local government entities."* Assembly, No. 1583 State Of New Jersey 216TH Legislature. <Link>.

[158] Worstell, Carolyn. *Green Infrastructure in the State of New Jersey: Statutory and Regulatory Barriers to Green Infrastructure Implementation*. Rep. N.p.: New Jersey Future, 2013. Print. <Link>.

[159] Land Use Source. 2007. Raw data. NJ Department of Environmental Protection.

action item in the short term to help Newark finance all future projects. The utmost priority should be given to the passage of this bill, as it will enable Newark to create a stormwater charge. In terms of other financing mechanisms, the creation of a stormwater fund should also be established as another source of revenue. After the pilot program is complete careful analysis should be done to determine which projects prove the most successful in the City of Newark. When the stormwater charge and stormwater fund become a stable source of revenue, build out of the wastewater reduction program and green infrastructure programs can expand throughout the entire city, focusing first on CSS districts.

| **Short Term** |
| --- |
| Support the passage of NJ State Assembly Bill A1583 |
| Create a Stormwater Fund |
| Request cost and capacity totals for new wastewater capacity projects |
| City buildings benchmarking Water Use |
| Create a Program mimicking Philly's CAP for water efficiency |
| Feasibility study for stormwater charge |
| Uniform water quality testing |
| Feasibility Study for Water rate structure change |
| Develop guidelines for GI incorporation |
| Incorporate GI in pilot area |
| **Medium Term** |
| Flow data Gathered from sensors |
| Mandatory Benchmarking for Commercial and Industrial Users |
| Roll out of Stormwater Charge |
| Roll out of a  Water Inclining Rate Structure |
| Incorporate policies and guidelines for GI into design guidelines |
| Incorporate GI in Pilot Area |
| Analyze Results of Pilot Projects |
| **Long Term** |
| Mandatory Benchmarking for High-density residential |
| Mandatory Benchmarking for Mixed Use |
| City-wide Water Audits |
| Develop and Execute Plans for Resiliency Projects |
| Expand Successful Pilot Projects to other parts of Newark |

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Township of Cranford, N.J., Ord. No. 2005-46; §106-1 et seq.

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# APPENDIX A: ADDITIONAL GREEN INFRASTRUCTURE TECHNOLOGIES

## BLUE ROOFS

Blue roofs restrict the flow of runoff to a downspout. If the water depth exceeds the established threshold, water will flow over the restriction cover into the roof drain. A flow restrictor, pictured below, can reduce runoff from entering the stormwater system by 85% relative to a conventional roof.[160] Specific conditions related to building construction must be met to implement a blue roof, and they are most economical when placed on new builds or major renovations. Because of this, this technology is not included in the pilot recommendation for Newark, though it should be considered in a long-term strategy once more comprehensive stormwater management policies, which incentivized green infrastructure BMPs citywide, are in place.

PHOTO 9: BLUE ROOF FLOW RESTRICTOR. PHOTO CREDIT: PLANYC

The roof must be flat and able to handle the additional weight of ponded water atop the roof. Unless a parapet surrounds the roof, small walls would need to be constructed to contain the captured water. This technology is best suited to be incorporated into the design of newly built large commercial, multi-family residential, industrial, and institutional buildings. The costs of a blue roof are approximately $22 per square foot for new construction, or $4 per square foot more than a conventional roof.[161] This is primarily due to additional labor, flow restriction collars, and having to add a second waterproofing membrane. This second membrane however as an added benefit of increasing the life of a roof to 20 years compared to a conventional roof of 10-15 years.[162]

FIGURE 28: CLOSE UP OF BLUE ROOF SECTION. PHOTO CREDIT: PLANYC

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160 USA. The Mayor's Office of Long Term Planning and Sustainability. *Sustainable Stormwater Management Plan 2008*. Mayor Michael Bloomberg, 2008. Web. 12 Feb. 2014. <Link>. P 42

161 USA. The Mayor's Office of Long Term Planning and Sustainability. *Sustainable Stormwater Management Plan 2008*. Mayor Michael Bloomberg, 2008. Web. 12 Feb. 2014. <Link>. P 55

162 USA. The Mayor's Office of Long Term Planning and Sustainability. *Sustainable Stormwater Management Plan 2008*. Mayor Michael Bloomberg, 2008. Web. 12 Feb. 2014. <Link>. P 54

Since blue roofs enable the building owner to delay roof replacement by at least 5 years, the technology will ultimately pay for itself over time. A conventional roof with a useful life of 15 years costs $18 per square foot installation therefore the building owner is paying $1.20 per square foot per year over the life of the roof. A blue roof building owner assumes a 20-year roof life at $22 per square foot costs and therefore is paying $1.10 per square foot per year for their roof over the life of that roof. To normalize these amounts over a 20 year time horizon a conventional roof would cost $24 per square foot while a blue roof would only cost $22 per square foot.

The ordinance already in place requiring 100% of stormwater capture from new or major renovation projects is a great place to build on for fostering growth of water efficiency and green and blue roof technologies. New codes should be developed and incorporated into the city design guidelines to promote the deployment of blue roofs. Blue roof technology, should be considered for new builds, major renovation projects, or buildings that need to replace an aging roof. This papers analysis determined the cost to delay stormwater is $0.14/gallon. However, since a blue roof increases the life of a roof by at least 5 years the building owner would save $2 per square foot, compared to a conventional roof, based on normalized costs.

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Blue Roofs** | Multi-family Residential, Industrial, Commercial | Reduces peak stormwater runoff; reduced roofing material waste | | Increased roof lifespan of 5 - 10 years | $4,000.00 | $0.1318 |

**Conclusions:**

While a blue roof does not divert the water it can significantly alter the time of peak precipitation runoff, determined by the flow restrictor. While it costs $4 more per square foot those costs are made up through an increased roof life, delaying construction costs of new roof installation.

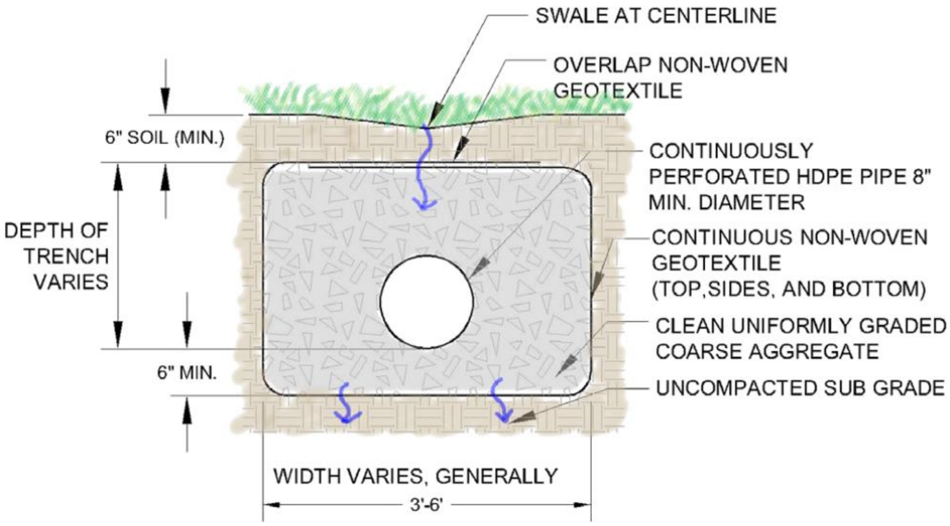
## INFILTRATION TRENCHES

Infiltration trenches are well-suited for dense urban areas where there are space constraints. These subsurface stormwater retention facilities are typically installed beneath permeable or impervious parking lots, roadways, and paved areas associated with commercial, industrial, and residential developments Trenches are used to retain and filter stormwater, infiltrate and recharge ground water, and alter runoff volume and timing. Modular systems allow this technology to be installed quickly and because they are durable have a 50-year or more life.

Because the ground temperatures remain fairly constant year-round, these systems are naturally insulated from freezing. While a good strategy for extremely urban areas this technology is very capital intensive and has high maintenance costs associated with it. This helps productivity in colder months and also avoids pooled surface water, which could attract mosquitoes and eliminating the chance of a public safety issue, see Figure 8. Furthermore, they are aesthetically pleasing in the sense that they are out of sight and out of mind for the residents of Newark.

The costs of infiltration trenches are highly variable. The primary cost drivers are the quality of the materials utilized, storage capacity, construction and labor costs, site location and physical conditions, and excavation and fill amounts. This range is generally $3 - $10 per cubic foot of water storage.[163]

[163] "Stormwater Management - Underground Storage." *Lake Superior Streams*. N.p., n.d. Web. 18 Mar. 2014. <Link>.




If improperly maintained these trenches can have high failure rates. Maintenance costs range between 5 – 20% of construction costs but are most realistically towards 20% to ensure longevity.[164] These costs can be better than surface stormwater treatment in areas where land is expensive or in short supply to acquire.

FIGURE 29: CROSS SECTION OF AN INFILTRATION TRENCH. PHOTO CREDIT: PENNSYLVANIA STORMWATER BEST MANAGEMENT PRACTICES MANUAL

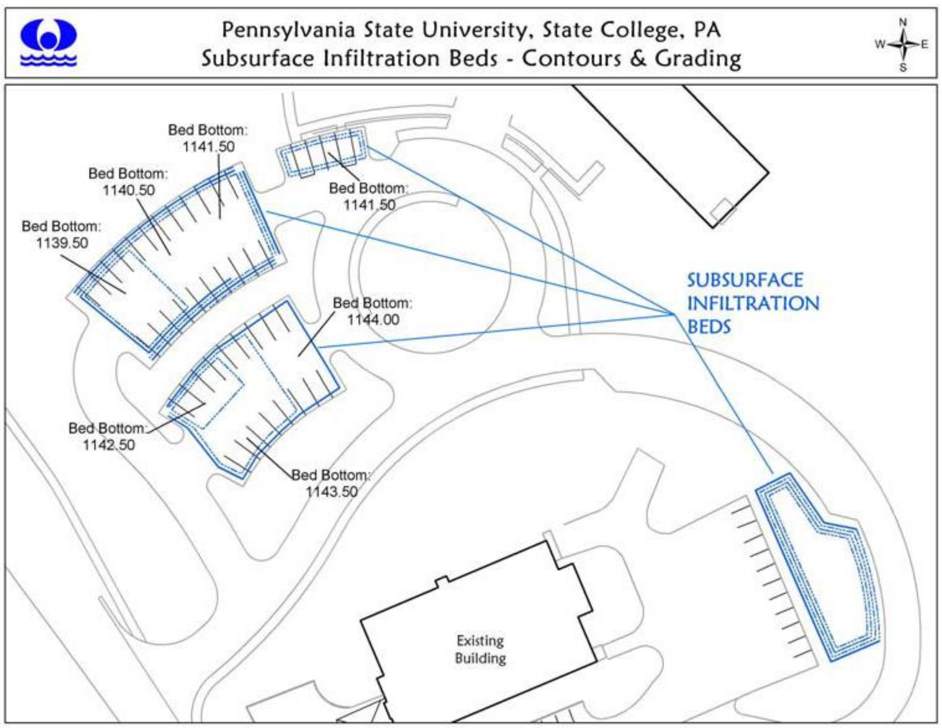



FIGURE 30: SUBSURFACE CONTOURS AND GRADING FOR THE INFILTRATION

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Infiltration Trench** | Underground areas that are several feet above water table | Reduce peak stormwater runoff; Increase groundwater recharging | Out of sight and out of mind | Where land is scare or high priced can make more financial sense than alternative solutions | $398,753.84 | $13.1414 |

**Conclusions:**

Very useful in ultra urban areas especially when used in conjunction with other GI technologies. Trenches are very versatile in terms of the size and drainage rate and can be located in unusable land areas and even used linearly.

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[164] "EPA - Stormwater Menu of BMPs." N.p., n.d. Web. 15 Mar. 2014. <Link>.

# GREEN ROOFS

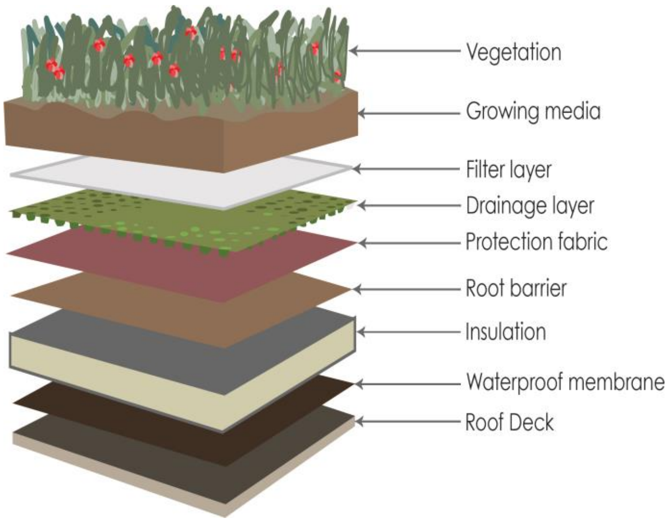


FIGURE 31: COMPONENTS OF A GREEN ROOF.
PHOTO CREDIT: DC GREEN WORKS

Green roofs are vegetated rooftops that can be installed on residential, commercial, or government buildings. Ideally buildings should have a flat roof but can also be utilized on certain pitched roofs as well. There are two types of common green roofs: Extensive, 6" soil or less, and Intensive, more than 6" of soil. Green roofs utilize a distinct lightweight soil mixture and can use a variety of plants to store, detain, and filter precipitation. While green roofs provide extensive social, economic, and environmental benefits, they lose much of the economic incentive when additional structural support is required, which is generally the case for older buildings. Unless an energy service company is used to finance them, Newark should not place a large focus on green roofs.

With the help of Emory Knoll Farms, green roof experts, it was determined that between four and six different species are ideal to maintain biodiversity.[165] As Steven Cantor, a leading green roof expert, noted, depth of soil and the reservoir layer are more important to stormwater retention than plant selection.[166] On rainy days, saturated soil allows excess water to flow down through the filter paper to the drainage layer and eventually into the building's drainage system, but at a much slower rate than would happen on a conventional roof. On sunny days, water not taken up by the soil simply evaporates in the sun via evapotranspiration.

There is some mention of roof-based stormwater capturing systems in the NSAP; however, most of the building stock in the city is older making feasibility a challenge. Because of this reality, the NSAP does not make implementation of green roofs a major focal point of its plan. Steven Cantor suggests that roof support is not always uniform across the entire roof and if architectural plans are not available, costs to perform an engineering judgment increase significantly.[167] If an engineering judgment determines structural support needs to be added it is usually not economically feasible to install a green roof. The existing policy of new construction and major renovations capturing 100% of all stormwater or paying into a fund will help incentivize developers to consider this option.

Capital and maintenance costs for green roofs vary significantly depending on whether it is an extensive or intensive roof system. Capital costs for an extensive roof can range from $5-$35 per square foot. Intensive roof systems can range from $15 - $70 per square foot. Maintenance costs for extensive roofs are low, with only a few visits conducted in the first two years; intensive roofs require significantly more maintenance. Some or all of a green roof's costs could be mitigated through the use of an Energy Service Company that would install and maintain these gardens with their own private capital and collect some of the financial benefits, usually energy savings, associated with them.

In addition to the benefits of stormwater retention, multiple studies have found that green roofs significantly increase the life of a roof. Conventional roofs generally last 10-15 years and green roofs last

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165 Carey Rowsom Emory Knoll Farms "Email Conversation" Dec 6 2013.
166 Cantor, Steven. "Green Roofs." Personal interview. 12 Mar. 2014.
167 Cantor, Steven. "Green Roofs." Personal interview. 12 Mar. 2014.

on average between 40-60 years.[168] [169] Their inclusion in the design phase of a new development can reduce the costs of building materials needed for the roof and add aesthetic improvements to building. Lastly, incorporation of green roofs into new constructions may allow for a reduction in the size of the building's heating and cooling equipment. This is due to the added insulation green roofs supply. While heating and cooling savings are difficult to predict for any given building, the avoided costs of roof replacement are not. Conservatively assuming a high-end estimation of an extensive green roof at $35 per square foot and low-end average life of 40 years, the cost would be $0.875 per square foot per year over the roof's lifetime. Comparatively, a conventional roof, which costs $18 per square foot, and last 15 years, will cost $1.20 per square foot per year. These numbers normalized over a 40-year period show green roofs to cost $35 per square foot while a conventional roof would cost $48 per square foot.

According to a study performed by Columbia University on a Con Edison green roof, about 30% of the annual rainfall and snowfall water will never enter the municipal stormwater runoff system or wastewater treatment facilities.[170] Another study, conducted by the US EPA, concluded that a simple, four-inch deep green roof system will retain, on average, 50% of the annual rainfall that it intercepts[171] Based on average rainfall by month for the City of Newark and using a benefits transfer from that EPA study, we have estimated that annual rainfall capture of a green roof in Newark to be approximately 4.56 gallons per square foot of green roof using a 4" soil medium. This equates to approximately 61% of the city's annual precipitation retained per square foot.

Green roofs should be installed on all new flat roofed construction and where feasible on renovated buildings especially on government owned buildings. Furthermore, NWG should support new policies, guidelines, and incentives that support build out of green roofs throughout the city. The analysis of this paper shows green roofs to cost approximately $0.58/ gallon of stormwater diverted. However, since a green roof will increase the ultimate life of the roof, the building owner will save $13 per square foot, compared to a conventional roof, based on normalized costs. These savings also do not include energy savings, which vary widely from building to building. There are also other secondary benefits green roofs have, like removing CO2 and reducing the urban heat island affect, which could help in a small way to mitigate some of the impacts of climate change.

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Green Roof** | New construction of flat roofed multi-family residential, industrial, commercial, and public buildings | Reduce peak stormwater runoff; reduce pollutants; | Can be a visual representation of city progress on sustainability issues if in sight line | Significant increase of roof life; reduced heating and cooling costs; utility sewer savings | $16,000.00 | $0.5273 |

**Conclusions:**

61% of annual stormwater can be retained on a green roof with the remaining water delayed from entering the wastewater system.

Significant long term benefits will outweigh the initial upfront costs, especially when integrated into planning of a new building

168 Lee, A. "Life Cycle Cost Analysis - Green from an Investment Perspective." Proc. of Greening Rooftops for Sustainable Communities, Portland. N.p.: n.p., 2004. N. pag. Print.

169 Wong, N.H., S.F. Tay, R. Wong, C.I. Ong, A. Sia. "Life cycle cost analysis of rooftop gardens in Singapore." *Building and Environment,* 203 P. 38, 499-509.

170 Gaffin, S. R., Rosenzweig, C., Eichenbaum-Pikser, J., Khanbilvardi, R. and Susca, T., 2010. "A Temperature and Seasonal Energy Analysis of Green, White, and Black Roofs" Columbia University, Center for Climate Systems Research. New York.

171 U.S. Environmental Protection Agency. Office of Research and Development. Green Roofs for Stormwater Runoff Control. By Robert D. Berghage, David Beattie, Albert R. Jarrett, Christine Thuring, and Farzaneh Razaei. The Pennsylvania State University, Feb. 2009. Web.

# Downspout Disconnection

Downspouts normally direct stormwater toward streets and storm drains. They can be disconnected and re-directed to grass swales, rain gardens or rain barrels to reduce runoff, promote soil infiltration, and lengthen runoff timing, reducing peak stormwater-loads during precipitation events.

## Case Study: Portland, Oregon

Between 1993 and 2011, Portland's Downspout Disconnection Program disconnected over 56,000 downspouts from the city's combined sewer system in the target areas shown on the map below. As a result Portland has removed over 1.3 billion gallons of stormwater annually from its combined sewer system.[172] For any resident who was in a targeted area, the city provided an option of receiving either a $53 incentive to disconnect or to have the town come and do it for free. While the program no longer offers free work or incentives for disconnecting downspouts, oversight of the process is offered to ensure that property owners are satisfied with any work done by the Program.

While Newark is made up of mostly high density residential there are some areas, like University Heights, that fit into the medium-density residential category and serviced by CSS. In total this area makes up less than 3 million square feet of Newark. A downspout disconnection program could prove successful in these areas especially if they are coupled with other GI technologies. This type of intervention is extremely simple and can even be done by homeowners themselves. If this intervention is not coupled with other technologies it should only be done in areas of Newark that are the most permeable as to reduce further runoff. This intervention would cost just $0.01 per gallon diverted in the first year, assuming a 30% capture rate, but this would continue diverting stormwater until the downspout was reconnected. The table below models a typical downspout disconnection for a hypothetical 400 square foot roof. Similar to the Portland case, it does not include additional GI technologies that can be combined with a downspout disconnect system. Since Newark has few permeable surfaces to which water can drain the effectiveness of this program may not be as effective as Portland. To address this, we assume a conservative 30% capture rate for the system, which is also roughly the percentage of permeability for the entire city.

| Technology/ Policy | Applicable Land Use | Environmental Benefits | Social Benefits | Economic Benefits | Life Cycle Costs | $/Gal Diverted |
|---|---|---|---|---|---|---|
| **Downspout Disconnection** | Residential and some commercial | Reduce peak stormwater runoff; promote groundwater recharge | A way to promote community activism | One time, low cost fee | $53.00 | $0.0146 |

**Conclusions:**
This is a very simple and cost effective change that can bring about large stormwater reductions especially when focused in flood prone areas. Generally coupled with other GI technologies to enhance the benefits of this intervention.

[172] "The City of Portland, Oregon." *Downspout Disconnection Program RSS*. N.p., July 2006. Web. 20 Mar. 2014. <Link>.

# Appendix B: Examples of Common GI Incentives

A number of incentives can be used to encourage adoption of these green infrastructure practices. These include stormwater fee discounts, developmental zoning upgrades, tax credits and marketing opportunities with awards and recognition, as Table 6 shows.[173]

| Types of Local Incentives for Green Infrastructure |
| --- |
| **Fee Discount:** Requires a stormwater fee that is based on impervious surface area. If property owners can reduce need for service by reducing impervious area, the municipality reduces the fee. |
| **Development Incentives:** Offered to developers during the process of applying for development permits. Includes zoning upgrades, expedited permitting, reduced stormwater requirements, etc. |
| **Rebates & Installation Financing:** Gives funding, tax credits or reimbursements to property owners who install specific practices. Often focused on practices needed in certain areas or neighborhoods. |
| **Awards & Recognition Programs:** Provides marketing opportunities and public outreach for exemplary projects. May include monetary awards. |

Table 18: Types of local incentives for green infrastructure used in the United States

## Fee Discount

Portland, OR, offers an incentive program that provides property owners with rate discounts for treating stormwater runoff on site. The Clean River Rewards Incentive and Discount (CRID) program encourages property owners to adopt practices that control flow rate, pollution, and disposal. Property owners are offered discounts on their monthly utility bills based on the extent and effectiveness of stormwater management. The program applies to both residential and commercial properties. [174]

## Rebates & Installation Financing

Stormwater charges, discussed in further detail later on in the report, are another mechanism for encouraging GI adoption. In 2005, the City of Minneapolis adopted a separate stormwater charge for all properties. The charge is calculated based on the amount of impervious surface area covering the property. Coupled with the new fee, the city established an incentive program through which property owners could qualify for a full, or partial, abatement by establishing onsite water-quality and/or -quantity treatment systems, such as rain gardens and green roofs. This two-pronged approach allowed the city council to more equitably charge property owners for the demand their properties placed on the wastewater system. Additionally, it encouraged property owners to manage stormwater onsite, reducing the overall demand and strain on the existing treatment facilities.

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173 "Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure." *Epa.gov*. EPA Office of Wetlands, Oceans and Watersheds, Aug. 2010. Web. 10 May 2013.

174 "Using Incentive Programs to Promote Stormwater BMPs." Water Environment Research Foundation, 2009. Web. 02 Mar. 2014. <http://www.werf.org/liveablecommunities/toolbox/incentives.htm>.

## Development Incentives

In Chicago, developers are offered a premium on the floor to area ratio (FAR) for installing green roofs. This allows the developer to increase the amount of square footage it can develop on a parcel while mitigating negative impacts of heat island effect and stormwater runoff. Likewise, developers in other municipalities are offered incentives for seeking certification pursuant to the U.S. Green Building Council LEED rating system which could include green roofs and stormwater management practices. Seattle, for example, offers density bonuses to developers for projects that earn LEED Silver or greater to allow construction of buildings that are higher and/or have more floor area than is normally permitted.[175]

In New Jersey many municipalities have enacted local ordinances encouraging LEED certification to reduce stormwater, among other things, by offering financial incentives and density bonuses. For example, the Township of Cranford grants permission to developers to construct larger buildings than would normally be allowed in return for achieving LEED certification. The entire size of the development is dependent on the level of LEED certification sought and the nature of the project.[176] Similarly, the Town of Kearny offers density bonuses to developers for LEED certified new buildings and additions within a formally designated redevelopment area.[177] The size of the increase is dependent on the level of LEED certification achieved. The bonuses offered are as follows:

- LEED Platinum – additional 0.3 FAR or 3 additional dwelling units/acre
- LEED Gold – additional 0.25 FAR or 2 additional dwelling units/acre
- LEED Silver – additional 0.20 FAR or 1 additional dwelling units/acre
- LEED Certified – additional 0.15 FAR or .5 additional dwelling units/acre

In Jersey City, a refund of building permit and land development application fees are available to developers with proof of LEED certification.[178] The amount of the refund is also based on the level of certification achieved. As such, the ordinance provides for refunds as follows:

- LEED Platinum – 25%
- LEED Gold – 20%
- LEED Silver – 15%
- LEED Certified – 10%

These types of municipal ordinances and incentive programs motivate green building practices that can reduce stormwater runoff.

## Awards & Recognition Programs

Award and recognition programs reward innovation and increase awareness of green infrastructure projects. The Lake Champlain International (LCI) Blue Certification is a good example. LCI offers homeowners lawn signs indicating that their property is “Blue Certified” for meeting certain green infrastructure standards. LCI green infrastructure practices include runoff prevention features such as redirecting downspouts, rain gardens, and rain barrels.[179]

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175 "Using Incentive Programs to Promote Stormwater BMPs." Water Environment Research Foundation, 2009. Web. 02 Mar. 2014. <http://www.werf.org/liveablecommunities/toolbox/incentives.htm>.
176 Township of Cranford, N.J., Ord. No. 2005-46; §106-1 et seq.
177 Town of Kearny, N.J., Ord. No. 2007(o)-42 §27-1 et seq.
178 Jersey City, N.J., Ord. No. 09-002 (2009).
179 http://stormwater.wef.org/2013/01/five-types-of-green-infrastructure-incentive-programs/

# Appendix C: Efficient Water Technologies

WaterSense, a national water efficiency program managed by the EPA, sets certification criteria for efficient water-using products[180]. Tables 10 and 11 list some common and intensive water-efficient technologies from the LEED 2009 for New Construction and Major Renovations guidelines.

| | CURRENT BASELINE | HIGH EFFICIENCY |
|---|---|---|
| **COMMERCIAL FIXTURES** | | |
| Toilets | 1.6 gallons per flush | Less than or equal to 1.3 gallons per flush |
| Urinals | 1.0 gallons per flush | Less than or equal to 0.5 gallons per flush |
| Lavatory Faucets | 2.2 gallons per minute | Less than 2.0 gallons per minute |
| Commercial Prerinse Spray Valves | Flow rate less than or equal to 1.6 gallons per minute | Flow rate less than or equal to 1.3 gallons per minute |
| **RESIDENTIAL FIXTURES** | | |
| Toilets | 1.6 gallons per flush | Less than or equal to 1.3 gallons per flush |
| Lavatory Faucets | 2.2 gallons per minute | Less than 2.0 gallons per minute |
| Kitchen Faucets | 2.2 gallons per minute | Less than 2.0 gallons per minute |
| Showerheads | 2.5 gallons per minute | Less than 2.0 gallons per minute |

Table 19: Common efficient water fixtures

| EFFICIENT TECHNOLOGY | BENEFIT |
|---|---|
| Waterless Urinals | Use gravity rather than water to drain. |
| Duel Flush Water Closets | Manage solid and liquid waste differently, allowing the user a choice between heavy or light flush. Water outputs are 0.8 gallons (light) or 1.6 gallons (heavy). |
| Graywater and Condensate Recovery Systems | Repurposes wastewater for reuse in irrigation and water closets. |

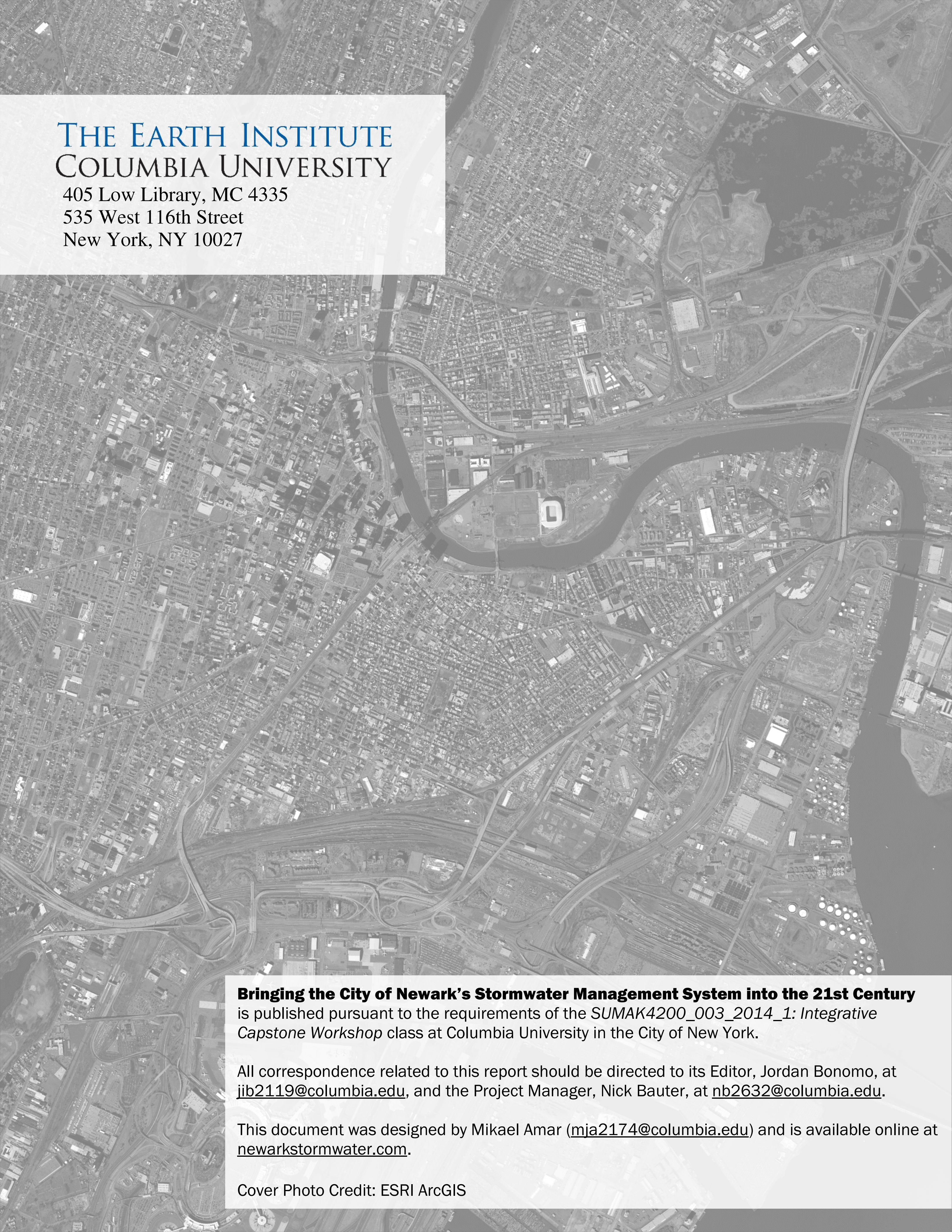
Table 20: Intensive water saving technologies

[180] *Water Matters, A Design Manual for Water Conservation in Buildings*. New York Department of Design and Construction. June 2010. P. 18

Cost Benefit Analysis of Efficient Technologies

| | | Benefits | | | | |
|---|---|---|---|---|---|---|
| **Technology/Policy** | **Applicable Land Use** | **Environmental** | **Social** | **Economic** | **Life Cycle Costs** | **$/gallon diverted** |
| High Efficiency Toilets | Municipal, Non-residential | Reduces water consumption, reduces effluence, reduces energy usage at treatment facilities | Conservation sector job creation, health improvement | Reduces costs at treatment facilities | $300 | $0.0046 |
| High Efficiency Urinals | Municipal, Non-residential | Reduces water consumption, reduces effluence, reduces energy usage at treatment facilities | Conservation sector job creation, health improvement | Reduces costs at treatment facilities | $300 | $0.0027 |
| High Efficiency Lavatory Faucets | Municipal, Non-residential | Reduces water consumption, reduces effluence, reduces energy usage at treatment facilities | Conservation sector job creation, health improvement | Reduces costs at treatment facilities | $300 | $0.0068 |
| High Efficiency Commercial Prerinse Spray Valves | Municipal, Non-residential | Reduces water consumption, reduces effluence, reduces energy usage at treatment facilities | Conservation sector job creation, health improvement | Reduces costs at treatment facilities | $300 | $0.0046 |
| Conclusions: | | | | | | |
| These high efficiency products are a one time upfront fee with no maintenance fees associated. Out of all the BMPs discussed, efficiency is the most cost effective to free up capacity on CSS pipes. | | | | | | |
| High Efficiency Toilets | Residential | Reduces water consumption, reduces effluence, reduces energy usage at treatment facilities | Conservation sector job creation, health improvement | Reduces costs at treatment facilities | $300 | $0.0046 |
| High Efficiency Lavatory Faucets | Residential | Reduces water consumption, reduces effluence, reduces energy usage at treatment facilities | Conservation sector job creation, health improvement | Reduces costs at treatment facilities | $300 | $0.0068 |
| High Efficiency Kitchen Faucets | Residential | Reduces water consumption, reduces effluence, reduces energy usage at treatment facilities | Conservation sector job creation, health improvement | Reduces costs at treatment facilities | $300 | $0.0068 |
| High Efficiency Showerheads | Residential | Reduces water consumption, reduces effluence, reduces energy usage at treatment facilities | Conservation sector job creation, health improvement | Reduces costs at treatment facilities | $300 | $0.0027 |
| Conclusions: | | | | | | |
| These high efficiency products are a one time upfront fee with no maintenance fees associated. Out of all the BMPs discussed, efficiency is the most cost effective to free up capacity on CSS pipes. | | | | | | |

Data from RS Means Building Construction Cost Data 2013



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405 Low Library, MC 4335
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New York, NY 10027

**Bringing the City of Newark's Stormwater Management System into the 21st Century** is published pursuant to the requirements of the *SUMAK4200_003_2014_1: Integrative Capstone Workshop* class at Columbia University in the City of New York.

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