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Green Infrastructure

City of New Rochelle

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Contents

Executive Summary

The City of New Rochelle (City) has commissioned this report for identifying and assessing Green Infrastructure (GI) opportunities into both capital municipal projects where feasible and land use development regulations. The City received a planning grant to fund the report from the National Fish and Wildlife Foundation, Long Island Sound Futures Fund, which seeks to advance activities to reduce urban runoff currently impacting water quality in the Long Island Sound. The overall goals of this planning grant, which are woven throughout the report, are to promote clean waters and healthy watersheds, promote thriving habitats and abundant wildlife, and promote education to engage sustainable and resilient communities.

GI practices maintain or restore stormwater's natural flow patterns by allowing the water to slowly permeate into the ground and be used by plants. GI is beneficial as it provides environmental benefits by way of stormwater control and mitigation, social benefits by way of providing more green and open spaces, and economic benefits by providing an attractive setting that draws in business and home owners. In addition to managing stormwater, GI can recharge groundwater, provide wildlife habitat, beautify neighborhoods, cool urbanized areas, improve air quality and reduce stress on storm sewer systems.

This plan identifies GI opportunities with regard to the general physical overview of the City, existing land use regulations, locating and accessing the feasibility of GI, New York standard guidelines, maintenance, City capabilities, cost benefit, financing, and local employment. The ultimate goal is to understand the process for GI implementation, from start to finish, that ensures consistent and effective results.

GI implementation is recommended through a careful and thorough planning process that involves identifying GI parameters used to evaluate the potential for GI practices, identify sites meeting GI practice criteria, hydrologic and hydraulic modeling, and applying a site scoring system incorporating community considerations.

Land use regulations geared toward managing stormwater, landscaping, reducing impervious coverage, and stormwater quality are areas where the City can focus on encouraging GI improvements. Engaging the community and developing partnerships is important to ensure broad support for GI installation and thus the long-term success of the GI program.

A significant benefit of GI is that it can effectively reduce stormwater flow thereby increasing the overall capacity of an existing storm sewer system to improve resiliency to storm events. A key component to the longevity and success of GI is a thorough a comprehensive maintenance program. A maintenance plan for GI includes specific maintenance tasks and schedules, cost estimates, and identifies the entities responsible for the maintenance. The cost-benefit analysis of GI, including maintenance needs such as costs and personnel, is broken down in detail in the chapters of this report.

The following recommendations have been made to Implement a Green Infrastructure Initiative Program:

RECOMMENDATIONS FOR CITY CODE CHANGES

- Incorporate GI practices into projects that result in an increase in impervious surfaces as a means of managing stormwater runoff.
- Modify City landscaping codes to incorporate the use of GI practices into planting requirements.

- Regulate water quality improvements and storm sewer connections through GI practices.
- Develop requirements for performance criteria monitoring of GI infrastructure, including adaptive management.
- Incorporate GI practices when on-site detention improvements are required
- Create a checklist for projects designed internally by the City engineers and planners to ensure that GI is used to the maximum extent possible in development plans. Incorporate design strategies for new and retrofitted stormwater management projects
- Require enforceable maintenance plans to accompany all privately-owned GI improvements.
- Adopt New York State guidance documents on green infrastructure into the City's Land Use Ordinances:
  - Green Infrastructure Practices – New York State Stormwater Management Design Manual
  - Green Infrastructure Practices – New York State Department of Transportation

RECOMMENDATIONS FOR COMMUNITY ENGAGEMENT AND PUBLIC EDUCATION

- Implement a Public Education, Outreach, and Engagement Program that focuses on activities to education the public on Green Infrastructure including:
  - Maintain a stormwater related page on the municipal website or on a municipal social media site.
  - Post signs at municipally-owned green infrastructure sites that describe the function and importance of the infrastructure, contact phone number, municipal identification number, and/or website for more information.
  - Present a green infrastructure related display or materials at any municipal event (e.g., Earth Day, town picnic), at the municipal building or other similar public venue.
  - Distribute an item or items with a green infrastructure related message (e.g., refrigerator magnets, temporary tattoos, key chains, bookmarks, coloring books, and pens or pencils).
  - Distribute an educational brochure on green infrastructure via a mailing to every resident and business in the City.
  - Distribute a letter or e-mail from the mayor or municipal official to every resident and business in the municipality highlighting the requirements and environmental benefits of green infrastructure (if adopted into the city code requirements). Provide a link to the municipal website where subject ordinances are posted.
  - Organize an educational contest with a local school district or a local community organization serving youth to design a poster, magnet, rain stick, rain barrel or other craft/art object. Contest themes shall have an appropriate green infrastructure message. Winning entries are to be displayed at publicly accessible locations within the municipality such as at the town hall, library, post office, or school. The winning design should be shown on the municipality's website or social media site, if practical.
  - Provide green infrastructure related educational presentation(s) and/or activities to local preschool, elementary, middle, and/or high school classes using municipal staff. Topics could include examples of green infrastructure and benefits of green infrastructure.
  - Organize or participate in a rain barrel, rain garden or other green infrastructure workshop.

RECOMMENDATIONS FOR CITY CAPITAL IMPROVEMENT PROJECTS

- Conduct a benefit analysis as described in this report to verify both the tangible and intangible project benefits. This should be incorporated into the decision-making process for whether or not to proceed with the incorporation of GI practices into a specific project. Other decision factors include:
  - Detrimental environmental and social impacts that outweigh the need for the GI improvements.
  - Cost of accommodations is accessibly disproportionate to the cost of the overall project.
  - The safety or timing of the project is compromised by the inclusion of GI infrastructure.
- Promote GI infrastructure on existing City properties, examples include:
  - A program to include new tree plantings on municipal properties following GI practices.
  - A native planting program to promote the installation of native plants and trees in place of turf grass for open space areas not used for specific recreational purposes.
  - Incorporating GI designs when stormwater mitigation is required.

FUNDING RECOMMENDATIONS

- Continue to pursue local, state, and federal grant opportunities for GI implementation, studying, and planning.
- Although less desirable, the Stormwater Tax option is comprehensive, dedicated, steady, and reliable. The amount of the “tax” can be raised or lowered depending on the municipalities needs for funding as the program grows and expands. To incentivize privately owned GI infrastructure, consideration should be given to providing a discounted “tax” rate if a property owner installed rain barrels, rain gardens, or other methods of GI and fulfills the requirements of their maintenance agreement.
- Incorporate GI into local budget and capital bonding where appropriate and feasible.

DEPARTMENT CAPABILITIES RECOMMENDATIONS

- It is recommended that one department take the lead to integrate GI practices for stormwater maintenance within their current duties. This can be expanded on a yearly basis to include more departments and revised as needed with the understanding that if the department’s staff are fully utilized, this may result in the need for additional man power through new hires or contracting the maintenance responsibilities to a contractor. Department capabilities may be contingent upon funding being made available.
- Administer and enforce code changes by municipal officials including but not limited to the zoning official, construction code official, city planner, and city engineer.
- Engineering Department to lead in the incorporation of the evaluation into City projects. This task may be assigned to consultants retained for larger projects.

MAINTENANCE RECOMMENDATIONS

- Following the installation of GI, a maintenance plan should be adopted that highlights the following key points to serve as a guidance and supporting documenting for initiating any GI funding mechanism described in Chapter 9 of this report
  - Maintenance requirements for GI
  - Maintenance equipment requirements for GI
  - Maintenance material requirements for GI

  - Maintenance labor requirements for GI
- Establish a maintenance tracking system for new GI using GIS or another similar database.
- Maintenance on City projects should be budgeted and the responsibility assigned to the appropriate department with the understanding that if the department's staff are fully utilized, this may result in the need for additional man power through new hires or contracting the maintenance responsibilities to a contractor.
- Monitoring maintenance on private property would be undertaken by code enforcement.

1 Introduction and Overview

Introduction and Overview

The intent of this document is to provide guidance to the City of New Rochelle (City) for identifying and assessing GI opportunities into both capital municipal projects where feasible and land use development regulations as appropriate. GI has many benefits with a primary focus on reducing stormwater runoff quantity and nonpoint source pollutant loading to improve water quality in surface water bodies.

The City received a planning grant from the National Fish and Wildlife Foundation, Long Island Sound Futures Fund to consider GI opportunities. Mott MacDonald has been retained by the City to undertake this report in accordance with the grant requirements. The grant supports projects in local communities that aim to protect and restore the Long Island Sound.

This document is divided into ten (10) chapters that include the following:

- Chapter 1- Introduction & Overview
- Chapter 2 – Physical Setting
- Chapter 3 - Land Use Regulations
- Chapter 4 - Locating and Assessing the Feasibility of Green Infrastructure
- Chapter 5 - New York State Standard Guidelines
- Chapter 6 – Maintenance Considerations
- Chapter 7 – Department Capabilities
- Chapter 8 – Cost Benefit Overview
- Chapter 9 - Financing Green Infrastructure
- Chapter 10 - Local Employment Opportunities

1.1 What is Green Infrastructure?

GI is a broad term that generally refers to engineered systems that manage runoff close to where it is generated by incorporating natural features into the design of the system. The stormwater volume reduction and/or water quality benefits achieved using GI offers environmental, economic and social benefits. GI allows stormwater to infiltrate into the ground, to be treated by vegetation or soils, to be stored for reuse, or to be detained and slowly released into the receiving waterbody.

According to the New York State, Department of Environmental Conservation, GI practices maintain or restore stormwater’ s natural flow pattern by allowing the water to slowly permeate into the ground and be used by plants. These practices include rain gardens, vegetated swales, green roofs and porous pavements. GI also includes preserving or restoring natural areas, such as forests, stream buffers and wetlands, and reducing the size of paved surfaces. GI generally includes "better site design" or "low impact development" stormwater projects.

In addition to managing stormwater, GI can recharge groundwater, provide wildlife habitat, beautify neighborhoods, cool urbanized areas, improve air quality and reduce stress on existing storm sewer systems.

Furthermore, GI uses natural processes to improve water quality and manage water quantity by restoring the hydrologic function of the urban landscape and managing stormwater at its source.

These practices are designed to restore the hydrologic function of the urban landscape, managing stormwater at its source and alleviating pressure on gray infrastructure systems. An important objective of GI is to reduce stormwater volume, which improves water quality by reducing pollutant loads, stream bank erosion, and sedimentation. GI practices can be integrated into existing features of the built environment, including streets, parking lots, and landscaped areas.

1.2 Purpose of Green Infrastructure

In urban areas, space for stormwater management is often a limiting factor; however, GI is generally designed to manage small, frequent storm events and may be appropriate for these space-limited areas. GI may be designed to manage several rain events from less than an inch to, in some circumstances, significantly larger events. GI is often designed to capture and treat the full Water Quality Volume (WQV). GI practices are also commonly designed to provide 80% removal of Total Suspended Solids (TSS) and 40% removal of total phosphates.

Because of the flexibility of GI in design performance, GI can serve to reduce and mitigate localized flooding. An integrated plan that addresses water quality, water quantity, and flooding can often be more cost-effective than addressing these issues separately. The use of GI throughout the community can be considered to build resilience to large storm events and used to promote sound stormwater management practices.

In June of 2012, the US EPA issued an Integrated Municipal Stormwater and Wastewater Planning Approach Framework (https://www3.epa.gov/npdes/pubs/integrated_planning_framework.pdf) which highlighted the use of innovative technologies for States and local governments to develop effective integrated plans under the Clean Water Act (CWA). This framework includes GI as one of the four overarching principles which specifically states: “Innovative technologies, including GI, are important tools that can generate many benefits, and may be fundamental aspects of municipalities’ plans for integrated solutions.”

Strategic implementation of GI involves utilizing an integrated watershed management approach that is based on sustainable principles and manages stormwater as a resource instead of a nuisance. In the above referenced framework, EPA has committed to working closely with State and local governments to incorporate GI. The EPA released “Community Solutions for Stormwater Management: A Guide for Voluntary Long-Term Planning,” for guidance to states and local governments in preparing long-term stormwater plans.

1.3 Benefits of Green Infrastructure in New Rochelle

Benefits that result from the implementation of GI can include environmental, economic, and social benefits.

Environmental Benefits - GI can be an integrated part of stormwater control and help to mitigate other urban environmental issues such as urban heat island effect. GI can also offset air quality pollution, wildlife habitat loss and degradation, and effects from climate change.

Social Benefits - GI is viewed as an opportunity to beautify the City. GI can be viewed as an opportunity to provide green space for recreation, attract businesses and visitors to the area, and improve traffic dynamics, particularly in the case of traffic islands and stormwater curb extensions.

> **Economic Benefits** - GI provides economic benefits such as improved property value, reduced need for traditional gray infrastructure, reduced risk and costs from environmental damage due to surface flooding, and the creation of green jobs.

Selection of GI types may depend on aesthetics, habitat potential, recreational needs, community acceptance, public visibility, and education/demonstration potential. Often GI programs must be consistent with and can help to catalyze other programs in the community which may include:

- Sustainability Plans
- Neighborhood Plans
- Street Revitalization
- Comprehensive Plans
- Natural Resources Inventories
- Recreational Parks and Green Acres

GI can be built into existing programs to promote similar planning goals. Supplementing other programs allows the implementation of GI in a holistic manner that can serve as a cooperative effort to meet community goals.

Metrics to measure the benefits of GI may include, but not be limited to, the following:

- Acres of impervious area managed at the end of 5, 10, 15 and 25 years
- Gallons of stormwater captured at the end of 5, 10, 15 and 25 years
- Pollutant loading removal in lbs./acres

Adaptive Management of milestones and adaptations for GI is discussed in Chapter 3, Section 3.3.

1.4 Green Infrastructure

Several different methodologies for evaluating GI have been examined across the country. A high-level planning approach is described below. The suggested approach is an iterative process and some steps may need to be re-evaluated as additional information is gathered. While a suggested order is included below, these steps do not necessarily need to be conducted in this order. Additional detail on each step is provided throughout the document.

Step 1: Establish goals and milestones for GI implementation and evaluate land uses, drainage areas and other community specific drivers and benefits.

- Complex methods will utilize various layers to identify strategic locations. Develop multiple scenarios integrating GI with gray infrastructure and optimal use of existing infrastructure.
- Identify potential locations for GI in various categories including the right-of-way, public property, private property and vacant parcels.
- Prioritize locations based on amount of stormwater managed and other community specific environmental, social and economic criteria.

Step 2: Identify program needs for GI implementation. This may include development of:

- Changes to local ordinances to require or encourage GI
- A community vision or coordinated GI plan with existing community plans

- Stakeholder and community outreach and education including development of materials, presentations, and a webpage.
- GI advisory committee
- Planning, design and construction standards
- Maintenance needs/equipment
- A project tracking system to assist with maintenance and asset management
- Skilled workforce
- Pre and post installation monitoring program requirements

Step 3: Evaluate the expected performance of GI.

- Select GI practices and the appropriate design criteria based on appropriate suitability. Incorporate GI in future stormwater modeling and determine the amount(s) of impervious area needed to meet the goals and milestones.
- Quantify potential stormwater capture and flooding reduction from GI as compared to the selected goals.

Step 4: Determine lifecycle costs associated with the selected scenarios and relate to the water quality benefits and local community benefits achieved to identify the optimal scenario.

Step 5: Identify opportunities/strategies for funding and/or means to incentivize GI development.

- Evaluation of opportunities for GI projects to align with community redevelopment or renewal plans or other infrastructure projects
- Modification of stormwater management regulations and ordinances for private development and redevelopment. This can include innovative approaches including public-private partnerships and credit trading.
- Establishment of a capital program for GI
- Identification of Federal or state funding programs/grant and loan programs

1.5 Green Infrastructure Goals & Objectives

1.5.1 New Rochelle Comprehensive Plan

The New Rochelle Comprehensive Plan targets several recommendations to incorporate resiliency planning into New Rochelle's Utility Systems. These recommendations can be targeted goals GI projects.

A comprehensive plan, as defined by New York State statute, is "materials, written and/or graphic, including but not limited to maps, charts, studies, resolutions, reports, and other descriptive material that identify the goals, objectives, principles, guidelines, policies, standards, devices, and instruments for the immediate and long-range protection, enhancement, growth and development of the locality." The following are recommendations from the New Rochelle Comprehensive Plan to incorporate resiliency planning into New Rochelle's utility systems:

1. Encourage Implementation of Stormwater Best Management Practices

   The quality and quantity of stormwater can be improved through the introduction of Stormwater Best Management Practices (BMP's). Some of these practices include the development of a GI program that encourages implementation of bioswales/tree pits, rain gardens, green roofs and permeable pavements and pavers.

Trees can contribute to stormwater management. Increase the number of trees within New Rochelle through preservation requirements and incentives, enhanced maintenance, and an expanded planting program.

Work with the County and other municipalities to complete the formation of a regional storm water district. Continue to explore the concept of an inter-municipal assessment district for the improvement of the Hutchinson River.

Continue to promote the City's Inflow & Infiltration (I & I) program to mitigate stormwater infiltration.

2. Establish Raingardens Community-Wide

   Establish at least 5 acres of rain gardens community-wide, including at several locations on appropriate municipal property, such as parks, and roadway right-of-way including traffic islands and medians. Seek opportunities on larger tracks of land including golf courses to GI and environmentally sound stormwater management systems. Create an implementation plan for a municipal rain garden demonstration project and engage an expert to identify the most appropriate location.

3. Reduce Impervious Surfaces

   Reduce the incidence and severity of local flooding by controlling stormwater run-off, expanding permeable surface coverage, repairing existing infrastructure, and utilizing new GI models. Examine the local building and zoning codes with the goal of removing potential impediments to and creating incentives and/or requirements for the use of permeable surfaces, such as permeable pavers and pavements. Establish and enforce lot coverage maximums and impose fees for non-compliance. These fees and/or alternate payments may be used to endow the City's Open Space Fund or a city-wide tree planning program.

1.5.2 New Rochelle Sustainability Plan:

The following are recommendations from the GreeNR: The New Rochelle Sustainability Plan 2010-2030 that are related to GI:

Ecology, Biodiversity, and Public Health Indicatives:

Initiative 3.16: Sound, Lake, & Stream Water Quality – Undertake comprehensive capital improvements and encourage best practices to improve the Long Island Sound ecosystem and restore the health, beauty, retention capacity, and recreational value of local inland water bodies.

Initiative 3.17: Habitat & open Space Preservation – Utilize diverse land use tools to protect and preserve New Rochelle's remaining natural habitats and to reclaim contaminated properties for public use and benefit.

Initiative 3.18: Urban Forestry – Increase the number of trees within New Rochelle through preservation requirements and incentives, enhanced maintenance, and an expanding planting program.

Initiative 3.19: Flood Control & Mitigation – Reduce the incidence and severity of local flooding by controlling storm water run-off, expanding permeable surface coverage, repairing existing infrastructure, and utilizing new GI models.

Initiative 3.20: Rain Gardens – Establish at least 5 acres of rain gardens community-wide, including at least 50 locations on appropriate municipal property including parks, traffic islands, and medians.

Initiative 3.21: Green Lawn & Garden Care – Encourage sustainable garden and lawn care through enhanced education about low-water and no-chemical options, and through possible amendments of codes that impede sustainable landscaping.

Initiative 3.22: Idling prevention – Discourage motor vehicle idling through better public education, stricter enforcement, and a promulgation of municipal work rules.

Initiative 3.23: GreeNR Walking Guides – Create walking guides featuring maps, suggested routes, distances, challenge ratings, health benefits, and notes on natural, architectural, historic, and cultural points of interest.

Initiative 3.24: Local Agriculture & Fresh Foods – Improve access to fresh and nutritious produce through expansion of community gardening programs, expansion of the New Rochelle Farmer's Market, and possible introduction of rooftop gardens.

Public Participation and Awareness Initiatives:

Initiative 6.37: GreeNR Awareness Campaign – Conduct a broad-based and ongoing public awareness campaign to share information about sustainable action and enlist community participation in achieving GreeNR's objectives.

Initiative 6.38: Informed Social Competition – Provide residents with comparative statistics on utility use to facilitate self-evaluation and foster friendly social competition toward reduced resource consumption.

Initiative 6.39: Civic Communication – Better utilize electronic and traditional communication methods to improve the flow of information between municipal government and the larger community.

Initiative 6.40: Sustainability Education Center Study – Consider adapting an under-utilized municipal building to serve as a Sustainability Education Center, providing ongoing outreach, instruction, programming and demonstration.

Initiative 6.41: Outdoor Classrooms – Promote understanding and appreciation of regional ecology by facilitating school-sponsored instruction within wooded parks and by introducing maps and interpretive signage.

Initiative 6.42: GreeNR Tote Bags – Create and distribute reusable GreeNR tote bags, while also adopting disincentives for the use of non-biodegradable plastic shopping bags.

Initiative 6.43: English Language Proficiency – Ensure that English Language instruction is available, accessible, and affordable to all non-English speakers in New Rochelle.

The following are goals from the New Rochelle Sustainability Plan that are related to GI:

Ecology, Biodiversity, and Public Health Goals by 2030:

- Preserve or expand the amount of land in a substantially natural state.
- Achieve a new increase of 10,000 trees on public property and right-of-way

- Reduce run-off from a one-inch rain event by 25 million gallons
- Provide universal access to healthful nutritious options
- Restore the water quality and retention capacity of all City-owned lakes and streams
- Reduce by 75% the number of annual beach closures at Hudson Park
- Restore 104 acres of brown fields to environmental health
- Increase community-wide permeable surface by 50 acres
- Establish a regional storm water management district
- Create at least 5 acres of rain gardens, including 50 on public property
- Encourage at least 50% of single and two-family homeowners to employ sustainable lawn and garden care practices
- Site at least one designated walking route within or close to all neighborhoods
- Increase the number of community gardening plots to 200

Public Participation and Awareness Goals by 2030:

- Subscribe at least half of all households to the official City website
- Achieve near-universal English-language proficiency
- Achieve near-universal awareness of the GreeNR logo and its meaning
- Restore distribution of semi-annual City newsletter
- Reduce by 7.2 million the number of non-biodegradable plastic shopping bags used annually in New Rochelle

1.5.3 County of Westchester, Long Island Sound Watershed:

The following are recommendations from the Stormwater Reconnaissance Plan for the Coastal Long Island Sound Watershed prepared for the County of Westchester, New York that are related to GI:

Recommendation #1: Review NFIP Requirements, Maps and Studies

The first thing a municipality should do is review the Flood Insurance maps (FIRM) for the community as well as the Flood Insurance Study (FIS). This is to determine the likelihood of a flooding event as well as checking if FEMA's maps are accurate because there are often discrepancies that could have financial impact to property owners. As well as just these, it is important to review additional mapping and other information that FEMA may have for the area. Local municipalities should also examine these additional pieces of information for items that may not be accurate, especially since these additional pieces of information aren't usually open for public comment. The municipality must also comply with the requirements of the National Flood Insurance Program. Participation in the program requires the municipality to perform several tasks including ensuring that new and substantially damaged structures comply with the standards required by FEMA and that documents are recorded and made available to the public. Consider participation in the Community Rating System (CRS), which lowers insurance premiums for property owners.

Recommendation #2: Protect Floodplains, Streams, and Wetlands

One of the most effective means to reduce risk is to redirect development away from flood hazard areas. Identify flooding as an issue of concern on plans and identify all known flood-prone areas within the municipality. Include strategies to redirect development away from these areas while limiting effects on the community's needs. The placement of fill impairs the functions that floodplains have, such as, flood storage, natural habitat, and water quality. They should be avoided to the greatest extent possible. If development cannot be redirected from within the floodplains, standards for the development of floodplains must include a restriction on the loss of floodplain storage. Municipalities may consider applying the no-net rise standard now commonly used for development within floodways to the entire floodplain (area known as the 1% annual chance flood or 100-year floodplain) for additional restriction of floodplain impacts. Compensation needs to be met for each storm even over the entire elevation range of the site’s floodplain, including 1-year, 2-year, 5-year, 10-year, 25-year, 50-year and 100-year storms. In addition, riparian buffers, a minimum of 50 feet in width (100 feet is preferred) must be provided along the edge of the stream or floodway, whichever is further from the center of the stream, for flood damage prevention, resource protection, floodwater storage, water quality, pollutant/sediment removal, and natural stream function. All wetlands should be protected from alteration, regardless of size, and a minimum buffer of 50 feet must be required (100 feet is preferred). Most Westchester municipalities have adopted a model ordinance that prohibits the alteration of wetlands, in part as a recognition of the ability of natural wetlands to detain stormwater runoff and mitigate flooding. However, the definition of wetlands and wetlands buffers varies widely. Similarly, streams should also be protected from alteration unless it can be demonstrated, using acceptable engineering studies, that the proposed alteration will not: (a) create or exacerbate any flooding conditions on properties upstream or downstream from the project area, (b) create an unstable condition within the stream channel, or (c) substantially impact aquatic habitats and organisms within the stream and its buffer. Riparian buffers must also be required to protect streams and their banks.

Recommendation #3: Increase Development Standards

Subdivision regulations and site plan review standards must ensure that development plans are carefully evaluated so that any increases in risk or costs to the community are eliminated or minimized (e.g., a development that creates an inaccessible building or neighborhood during a flood even must not be approved). Language must be included in applicable regulations (at a minimum, subdivision regulations) to ensure that building sites are located on a portion of the property above the base flood elevation and with adequate access during a 100-year flood event. Municipal development standards and regulations must reference technical state stormwater management guidance documents. The principal goal of these documents is to provide guidance on the design, implementation and maintenance of “best stormwater management practices” aimed at improving water quality. Carefully review the model flood damage prevention ordinance and consider whether increased standards are appropriate. Amend the flood damage prevention ordinance or other applicable ordinances to require that critical facilities be elevated to a minimum of two feet above the base flood elevation for the 0.2% annual chance flood (500-year flood interval) and that access routes must be elevated to at least the base flood elevation for the 0.2% annual chance flood. Critical facilities are those critical to the community’s public health and safety; essential to the orderly functioning of a community; store or produce highly volatile, toxic or water-reactive materials; or house occupants that may be insufficiently mobile to avoid loss of life or injury. Examples of critical development include jails, operation centers, police facilities, nursing homes, wastewater treatment facilities, water plants, gas/oil/propane storage facilities, hazardous waste handling and storage facilities and other public equipment storage facilities. Municipalities can expand the applicability of regulations like the flood damage prevention ordinance by modifying definitions of applicable development. Adopt a Hazard Mitigation Plan, meeting the requirements of the Federal Emergency Management Agency (FEMA).

Recommendation #4: Reduce Impervious Surfaces

Review and amend subdivision regulations, road standards, site plan review standards, special permit standards and/or other applicable regulations to require clustering within special flood hazard areas and minimization of impervious surfaces within all other areas of the municipality. Impervious surfaces are the single issue most responsible for increased flooding.

Recommendation #5: Require On-Site Detention

Requiring on-site detention and, to the extent practical, infiltration, is an appropriate method to reduce the amount of stormwater entering the streams during or shortly after the storm even to prevent increased flood flows and limit increased runoff from a proposed development to pre-development conditions. This is important because the impacts to streams from stormwater runoff can be destructive. The municipality must demonstrate adoption of sample local law for stormwater management and erosion and sediment control prepared by the New York State Department of Environmental Conservation, or equal, modified to apply to all development activity involving 5,000 square land disturbances as small as 500 square feet.

Recommendation #6: Review Engineering Data and Methodology

Technical Release 55 (TR-55), Urban Hydrology for Small Watersheds, was first issued by the Soil Conservation Service (now the Natural Resource Conservation Service) in January 1975. It is a set of simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for small watersheds.

Recommendation #7: Implement Recommendations from Watershed Plans

Municipalities should be familiar with the plans and continue implementing as many recommendations as practical.

Recommendation #8: Increase Public Awareness

Municipalities can adopt local laws requiring property owners to disclose historic flooding as a condition of property transfer. Property owners must be notified by documenting such conditions on subdivision plats, deed restrictions or other means. Working with local boards of realtors on flooding issues and the requirements of local regulations can also be effective. Many residents may not be aware of ordinances requiring property owners to maintain local streams and drainage ways. Using community websites to share information on flooding and how to prepare in advance for a flood is recommended. Using the county website as well is useful because it contains much information and resources on flood issues for a variety of audiences.

Recommendation #9: Maintain and Improve Infrastructure

Undertake efforts to maintain and improve infrastructure capacity. This may include one or more of the following: enforcing regulations to prevent obstructions to stream channels or modifications of floodplains, clearing snags and obstructions from stream channels, maintaining culverts and storm sewer systems, regular catch basin cleaning and street sweeping to reduce sediment buildup.

Recommendation #10: Work Together

Demonstrate a willingness and commitment to work with other watershed municipalities as well as the County. This is important because flooding impacts everyone and municipalities must work together to address this problem.

Recommendation #11: Reduce Costs

Community flood insurance premium rates are discounted to reflect the reduced flood risk resulting from the community actions meeting the three goals of the CRS:

Reduce flood damage to insurable property; Strengthen and support the insurance aspects of the NFIP and Encourage a comprehensive approach to floodplain management.

There is a guidance document available from FEMA for local municipal officials that describes the program and its benefits.

Recommendation #12: Acquire Flood-Prone Land

For land that lie in flood prone areas, a municipality should try and acquire and hold these pieces of land as public open space. Doing this will allow them to achieve a flood mitigation purpose. For vacant or derelict properties in flood prone areas, acquisition and clearance should be considered in a municipal flood action program.

1.5.4 Long Island Sound Futures Fund Grant:

Goals Specific to New Rochelle:

- Advance activities to reduce urban runoff currently impacting water quality in the Long Island Sound
- Overall Grant goals:
  - Clean waters and healthy watersheds: Improving water quality by delivering projects that reduce stormwater runoff and nonpoint source nutrient loading into the Long Island Sound.
  - Thriving Habitats and Abundant Wildlife: Restoring coastal habitats to maintain resiliency and function, and foster diverse, balanced and abundant populations of fish, birds and wildlife.
  - Educating to Engage Sustainable and Resilient Communities: Increasing knowledge and engagement of the public in the protection and restoration of Long Island Sound.

2 Physical Setting

Overview

New Rochelle is located in southern Westchester County, New York and consists of a land area of 6,639 Acres, or 10.37 Square Miles. New Rochelle is bordered to the South by the Long Island Sound, the west by Town of Pelham, Village of Pelham Manor, and Town of Eastchester, the north and east by the Village of Scarsdale, and the Town of Mamaroneck and the Village of Larchmont to the East.

New Rochelle includes numerous water bodies, streams, and rivers including Huguenot Lake, Beechmont Lake, Pine Brook, Paine Lake, Glenwood Lake, New Rochelle Harbor, Sheldrake Lake, Sheldrake River, Carpenter Pond, Hutchinson River, Lake Innisfree (Reservoir No. 1), Reservoir No. 2 and Reservoir No. 3. (Note: Huguenot Lake, Beechmont Lake and Sheldrake Lake are manmade retention basins.)

Transportation through New Rochelle is provided through a large network of paved roadways owned by the Municipality, the County, and the State of New York. There are approximately 176 miles of paved roadways within New Rochelle.

2.1 Water Quality

Most of the stormwater captured in New Rochelle is discharged into the Long Island Sound. Stormwater can collect chemical contaminates, silt and other impairments that ultimately end up in the receiving water bodies. The Long Island Sounds main impairment is due to nitrogen loading. The source of Nitrogen is typically from residential turf fertilizer applications and on-site wastewater treatment systems (septic systems). The secondary impairment of the Long Island Sound is due to pathogens (bacteria). Overall improving the water quality in the Long Island Sound by reducing stormwater runoff and nonpoint source nutrient loading is a key goal of New Rochelle.

2.2 Soils

New Rochelle soils are important for understanding the soil infiltration potential, or hydrologic soil groups within the community to locate, and design GI practices. Soils with the greatest infiltration potential, namely hydrologic soil groups A and B, are ideal opportunities for GI practices. Soils with lesser infiltration potential, namely hydrologic soil groups C and D are not ideal opportunities for GI practices. Much of soils within New Rochelle are hydrologic soil group D. There is however a large band of A and B soils that runs through New Rochelle near the Wykagyl Country Club.

Most of the soils within hydrologic soil group D are Urban Land Soils (UpB, UpC, UpD, UrB, UrC, UrC, etc.), with varying slopes. Typically, the Urban land consists of areas covered by buildings, streets, parking lots, and other structures. The natural soil layers have been altered or mixed with manufactured materials, such as bricks, broken concrete, or cinders. This soil group is used mainly for urban development. The open areas are lawns, gardens, or vacant and wooded land between structures.

The predominant soils within hydrologic soil group A are Charlton loam. This soil is gently sloping, very deep, and well drained. It is on hilltops and parts of hillsides. It is formed in glacial till derived from granite, schist, and gneiss. Charlton loams used for community development or for recreation. Other areas are wooded, are covered by brush, or are used for farming. No major limitations affect the use of this soil as a site for dwellings with basements, for septic tank absorption fields, or for local roads and streets.

The predominant soils within hydrologic soil group B are largely Charlton-Chatfield complex and Chatfield -Hollis-Rock outcrop complex. Charlton-Chatfield complex consists of the very deep and moderately deep, well drained and somewhat excessively drained Chatfield soil and the well-drained Charlton soil. It is on the tops and sides of hills that are underlain by highly folded bedrock. In Westchester County, many areas are used for community development. Other areas are wooded or are used for pasture. The major limitation on sites for dwellings with basements is the irregular topography. The moderate depth to bedrock in the Chatfield soil and the areas of rock outcrop also are limitations. Chatfield-Hollis-Rock outcrop complex consists of the rolling, moderately deep, well drained and somewhat excessively drained Chatfield soil, the shallow, well drained and somewhat excessively drained Hollis soil, and areas of Rock outcrop, dominantly granite, gneiss, and schist. Most areas are wooded or covered by brush. A few areas are used for pasture. Some scattered areas are used for community development. The main limitation on sites for dwellings with basements are the shallow depth to bedrock and the irregular topography.

Hydrologic soil group information for New Rochelle can be found in Appendix A. This information can also be found at www.websoilsurvey.nrcs.usda.gov.

Locating and assessing the feasibility of Green Infrastructure is described in detail in Section 4 of this report, however it should be noted that soil types and therefore soil infiltration potential is a very significant factor in determining the feasibility of placing GI infrastructure.

2.3 Flood Plains

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) for New Rochelle outline floodplains and the potential risk of flooding to the various sections of New Rochelle by through riverine and coastal sources. The Special Flood Hazard Area is subject to inundation by the 1% annual chance flood and is regulated by the National Flood Insurance Program (NFIP) requiring homeowners within this area to purchase flood insurance. The FEMA FIRM maps for New Rochelle can be found in the Appendix B of this report.

The most recent updates for Westchester County FEMA FIRM maps occurred in 2007. Revised panels, including updated coastal analysis, were released on December 9, 2014 however. These preliminary maps are currently still undergoing revisions and pending adoption. As such, FEMA is recommending that municipalities use the most conservative estimate – from either the currently adopted maps, or the maps pending adoption, to reduce flood risk.

The Hutchinson River is a freshwater stream located in Southern Westchester County. The river flows through New Rochelle and Scarsdale where it forms the municipal boundary between each (New Rochelle on the east and Scarsdale on the west). South of Scarsdale, the river flows through the boundary of New Rochelle and Eastchester. There are various culverts or small bridges that cross the river. While flowing through New Rochelle, the river experiences periodic flooding that adversely affect residents of the community.

The Sheldrake River flows through New Rochelle near the Northeast municipal border with Scarsdale. The Sheldrake River enters Sheldrake Lake between crossing into Mamaroneck. While flowing through New Rochelle, the river experiences some flooding that impacts a small portion of residents.

Huguenot Lake and the Stephenson Brook located in the western part of New Rochelle experiences some flooding as well. A portion of New Rochelle High School is located within the Special Flood Hazard Area adjacent to Huguenot Lake. Many of the High School's recreational fields also lie within the Special Flood Hazard Area.

Coastal Flooding is present along the waterfront of the Long Island Sound, as well as the various Islands within the Long Island Sound.

Locating and assessing the feasibility of Green Infrastructure is described in detail in Section 4 of this report, however it should be noted that flood plains/flood prone areas are not ideal for the construction of GI infrastructure.

2.4 Land Use & Zoning

Per the New Rochelle Comprehensive Plan, adopted November 15, 2016, the land use area breakdown of the City is as follows:

Land Use Area Type	Parcels	Acres	% of Total
Single Family	9,765	2,609	47.6%
Two-Three Family	2,166	327	6.0%
Multi-Family	415	271	4.9%
Vacant Undeveloped	910	326	5.9%
Commercial and Retail	494	213	3.9%
Manufacturing, Industrial, and Warehouses	160	77	1.4%
Office Building	38	20	0.4%
Mixed Use	175	30	0.6%
Institutional and Public Assembly	165	376	6.9%
Transportation, Communication, and Utilities	50	87	1.6%
Public Open Space and Recreation	97	689	12.6%
Private Open Space and Recreation	51	359	6.6%
Rights of Way	32	99	1.8%
Total:	14,518	5,482	

As demonstrated above, residential uses amount to 58.5% of the City's total land area. This results in a character of the City has predominantly residential neighborhoods with suburban traits. The next largest land use area within New Rochelle is Open Space (public and private) which makes up 19.2% of the City's total land area. This includes numerous parks, playgrounds, and wooded areas.

Per the New Rochelle Sustainability Plan, 2010-2030, impermeable surfaces cover 3,744 acres or 56.4% of the land cover of New Rochelle. Developed permeable surfaces, such as lawns and recreation field, cover 24.8% of the land cover and undeveloped permeable surfaces, such as woods and water bodies, cover 18.8% of the land cover of New Rochelle. New Rochelle has 72,500 linear feet of Shoreline including on the mainland, Glen Island, David's Island and vacant/private islands. The New Rochelle Sustainability Plan, 2010-2030, estimates the total number of trees in the City to be 400,000, with 29,000 (7.25%) of those trees owned by the City.

Zoning regulates permitted development in certain land use areas within New Rochelle. New Rochelle has 39 zoning districts and 6 overlay zones as outlined on the next page.

Zoning Districts

Zone	Designation	Zone	Designation
AR DMU	Air Rights Downtown Mixed Use	R1-10	One Family Residence
C-1M	General Commercial Modified	R1-10A	One Family Residence
CR-1	College Related	R1-15	One Family Residence
DB	Downtown Business	R1-20	One Family Residence
DMU	Downtown Mixed Use	R1-7.5	One Family Residence
DMUR	Downtown Mixed Use Urban Renewal	R1-C	One Family Cluster Residence
H	Hospital	R1-HIS	One Family Historic Residence
I	Industrial	R1-WF 10	One Family Waterfront Residence
LI	Light Industry	R2-7.0	Two Family Residence
LSR	Large Scale Retail	RAILROAD	Railroad
MUFE	Mixed Used Family Entertainment	RMF-0.4	Multi-Family Residence
NA	North Avenue	RMF-0.7	Multi-Family Residence
NB	Neighborhood Business	RMF-1.0	Multi-Family Residence
PUD-AH	Planned Unit Development Affordable Housing Floating Zone	RMF-1.3	Multi-Family Residence
PWD-3	Planned Waterfront Development	RMF-2.0	Multi-Family Residence
PWD-5	Planned Waterfront Development	RMF- SC 4.0	Multi-Family Senior Citizen Residence
PWD-8	Planned Unit Development	RMSC-4	Multi-Family Residence
PWDE-5	Planned Waterfront Development Extension Floating Zone	ROS	Recreation open Space
R-URTH	Urban Renewal Townhouse Residence	WR	Water Related
Overlay Zones			
CAB	Cabaret Overlay	FA	Fifth Ave Overlay Zone
CPA	Central Parking Area Overlay Zone	SFSC	Single Family Senior Citizen Overlay
DOZ	Downtown Overlay Zone	WV	Water View Overlay Zone

The most recent zoning change came in 2015 when New Rochelle approved a new zoning plan for the City's downtown. This new zoning included the Downtown Overlay Zone (DOZ) with the intent to spark development and redevelopment within the downtown area.

2.5 Utilities

2.5.1 Storm Sewers

Stormwater management is provided by New Rochelle in the form of inlets, pipes, culverts as well as ponds, rivers, streams, and swales. New Rochelle has approximately 87 miles of storm drains and approximately 5,471 catch basins. Most of the stormwater captured in New Rochelle is discharged into the Long Island Sound. A stormwater management program was created in February 2009, revised in January 2013, and is continually reviewed under New Rochelle's annual stormwater report. Although a formal study has not been undertaken, it is understood that the system capacity is undersized for large storm events. As part of complying with the City's MS4 permitting, an annual Stormwater Report is posted on the City's website where it can be downloaded and viewed. (https://www.newrochelleny.com/DocumentCenter/View/3628/2016-stormwater-draft-report?bidId=)

2.5.2 Sanitary Sewers

Sanitary Sewer service are provided by Westchester County and New Rochelle. The sanitary sewer system consists of 232 total miles of pipe lines of which 186 are City owned and maintained. The remaining 6 miles of sewer are County owned and maintained. New Rochelle's waste flow to three Westchester County Sewer Districts, which each have their own treatment plant. New Rochelle owns and maintains the sewer collection system, while the County of Westchester operates and owns the major sewer trunk lines, major pump stations and the wastewater treatment plants. The New Rochelle Sanitary Sewer District covers over 80% of New Rochelle. Several privately-owned sites in lower density residential areas are not connected to sanitary sewers. There are no combined sewer systems within New Rochelle.

2.6 Public Lands

New Rochelle has numerous public facilities to serve the community. These facilities include:

- New Rochelle City Hall, 515 North Avenue
- New Rochelle Public Library, 1 Library Plaza
- New Rochelle Police Department (NRPD), 475 North Avenue (adjacent to City Hall)
- New Rochelle Fire Department (NRFD), 90 Beaufort Place
  - Station 1 – 45 Harrison Street
  - Station 2 – 170 Webster Avenue
  - Station 3 – 756 North Avenue
  - Station 4 – 155 Drake Avenue
  - Station 5 – 456 Stratton Road
- Department of Public Works (DPW) City Yard, 235 East Main Street
- High A. Doyle Senior Center, 94 Davis Avenue
- Municipal Marina, 22 Pelham Road

In addition to public buildings, the City maintains 35 parks and playgrounds. The major parks and playgrounds include:

- Davenport Park (22 Acres)
- D'Onofrio Park (22 Acres)
- Eddie Foy Park (0.5 Acres)
- Feeney Park (4.08 Acres)
- Five Islands Park (20 Acres)
- Flowers (City) park (22 Acres)
- Hudson Park (10 Acres)
- Leif Erickson Park (0.46 Acres)
- Lemke Park (0.74 Acres)
- Ruby Dee Park @ Library Green (1.09 Acres)
- Lincoln Park (4 Acres)
- Maplewood Park (4.1 Acres)
- Neptune Park (8.6 Acres)
- Pinebrook Park (4.43 Acres)
- Roosevelt Park (4 Acres)

- Seacord Park (1 Acre)
- Stephenson Park (4.63 Acres)
- Sycamore Park (2.38 Acres)
- VFW Tot Lot (0.26 Acres)
- Ward Acres Park
- Glen Island Park (130 Acres)

Locating and assessing the feasibility of Green Infrastructure is described in detail in Section 4 of this report. Emphasis should be put on the availability and suitability of publicly owned lands, such are those mentioned above, for the implementation of GI infrastructure.

3 Land Use Regulations

Introduction and Overview

Land use regulations, including ordinances, resolutions, and city codes, is a mechanism for implementing and enforcing stormwater management on private properties. Land Use Regulations can also serve as barriers and obstacles to GI implementation. They can be they are silent on, ambiguous towards, or in direct conflict with GI implementation. New Rochelle's Land Use Regulations are silent on GI implementation.

Evaluation of Land Use Regulations should identify opportunities for reducing impervious cover, integrating low impact development (LID), and removing barriers to green stormwater infrastructure practices.

3.1 Managing Stormwater

Pursuant to Section 402 of the Clean Water Act (CWA), stormwater discharges from certain construction activities are unlawful unless they are authorized by a National Pollutant Discharge Elimination System (NPDES) permit or by a state permit program. New York's State Pollutant Discharge Elimination System SPDES) is a NPDES-approved program with permits issued in accordance with the Environmental Conservation Law (ECL).

There are three SPDES general permits required for activities associated stormwater discharges.

- The Multi- Sector General Permit for Stormwater Discharges Associated with Industrial Activities (MSGP) addresses stormwater runoff from certain industrial activities. This permit requires facilities to develop Stormwater Pollution Prevention Plans (SWPPPs) and report the results of industry-specific monitoring to the New York State Department of Environmental Conservation (NYSDEC) on an annual basis.
- A federal regulation, commonly known as Stormwater Phase II, requires permits for stormwater discharges from Municipal Separate Storm Sewer Systems (MS4s) in urbanized areas. Permittees are required to develop Stormwater Management Program (SWMP) and submit annual reports to the Department. New Rochelle is an MS4.
- Construction activities disturbing one or more acres of soil must be authorized under the General Permit for Stormwater Discharges from Construction Activities. Permittees are required to develop a SWPPP to prevent discharges of construction-related pollutants to surface waters. New Rochelle requires SWPPP's for projects developing an acre or more of land.

The New York State Stormwater Management Design Manual provides designers with a general overview on how to size, design, select, and locate stormwater management practices at a development site to comply with State stormwater performance standards. This manual is a key component of the Phase II State Pollution Discharge Elimination System (SPDES) general permit for stormwater runoff from construction activities from all sizes of disturbance.

Reducing Impervious Cover

New Rochelle's 2010 Sustainability Plan, GreeNR, states that "approximately 3,474 acres, or 56.4% of New Rochelle's surface is estimated to be impermeable".

New Rochelle defines the following relevant terms in their Code:

- Impervious Surface: Any surface or material through which water will not flow under ordinary hydrostatic pressure and including structures, parking areas, driveways, sidewalks, terraces and paved areas.
- Building Coverage: The percentage of lot area covered by the combined building area of all buildings on a lot, excluding those located underground.
- Lot Coverage, Total: That percentage of lot area covered by the ground floor area of all buildings sited thereon, together with all other structures, including pavement and other impervious surfaces.

The Following table includes the Schedule of Dimensional Regulations for Building and Impervious Surface coverage in the zones in New Rochelle:

District Use	Maximum Dimensional Requirements	
	Building Coverage	Impervious Surface Coverage
R1-20: One-Family Residence	20%	35%
R1-15: One-Family Residence	25%	45%
R1-10: One-Family Residence	25%	45%
R1-10A: One-Family Residence	30%	50%
R1-HIST: One-Family Historic		
R1-CH: One-Family Cluster Residence	25%	45%
R1-7.5: One-Family Residence	25%	45%
R2-7.0: Two-Family Residence	30%	50%
R1-URTH: Urban Renewal Townhouse District	30%	60%
RMF-0.4: Multifamily Residence	35%	70%
RMF-0.5: Multifamily Residence	30%	60%
RMF-0.7: Multifamily Residence	30%	60%
RMF-1.0: Multifamily Residence	35%	60%
RMF-1.3: Multifamily Residence	35%	65%
RMF-2.0: Multifamily Residence	40%	65%
RMF-SC-4.0: Multifamily Senior Citizen	50%	65%
C-1M: General Commercial Modified	100%	100%
DB: Downtown Business	90%	100%
DMU: Downtown Mixed Use	100%	100%
DMUR: Downtown Mixed Use Urban Renewal	100%	100%
H: Hospital	70%	95%
I: Industry	70%	100%
LI: Light Industry	60%	90%
LSR: Large Scale Retail	70%	100%
LSR - 1: Large Scale Retail	95%	100%

District Use	Maximum Dimensional Requirements	
	Building Coverage	Impervious Surface Coverage
MUFE: Mixed Use Family Entertainment	100%	100%
NA: North Avenue	70%	90%
NB: Neighborhood Business	50%	95%
PWD – 3: Planned Waterfront Development	40%	80%
PWD – 5: Planned Waterfront Development	40%	80%
PDW – 8: Planned Unit Development	40%	40%
Railroad: Railroad		
ROS: Recreation Open Space	5%	10%

Reducing impervious cover can achieve the following benefits:

- reduce the incidence and severity of local flooding by controlling stormwater run-off
- reduce erosion
- contribute to the replenishment of groundwater
- provide for the removal of pollutants contained in surface waters
- reduce the need for the public construction of stormwater infrastructure
- provide a medium for the planting and maintenance of groundcover and trees
- reduce heat and the need for air conditioning
- absorb air pollution
- add to the aesthetic quality of the community.

Impervious cover is regulated by the local building and zoning codes. As described above, New Rochelle regulates impervious surfaces through the Schedule of Dimensional Regulations which sets a maximum dimensional requirement on the allowable impervious surface coverage per lot. New Rochelle also regulates impervious surfaces through Chapter 178 of the City code. The code requires any increase in impervious coverage on a property of greater than 200 square feet to obtain a building permit from the municipality. This code requires the creation or expansion of impervious surfaces, to be mitigated with the planting of new trees with a minimum diameter at base height (DBH) of two inches. The code states that for every 200 square feet of impervious surface created or expanded or part thereof in excess of the first 200 square feet, the property owner shall plant one tree with a minimum DBH of two inches. The code does not set a limit on the maximum increase or expansion of impervious surfaces for which tree planting is an acceptable mitigation. The opportunity to encourage the use of GI exists in that it could be an alternative to tree planting and/or used to conjunction with tree planting when the increase in coverage is significant.

The use of permeable surfaces is not specifically outlined in the New Rochelle Code. Revising the zoning code with the goal of creating incentives and/or requirements for the use of permeable surfaces (such as permeable pavers and pavements) may promote the use of this GI technique to reduce impervious cover.

Landscaping

The City of New Rochelle regulates required landscaping for new development and redeveloped through the local building and zoning codes. The following sections are applicable:

- Chapter 301: Trees and Shrubs, Article III
  - § 301-19 through 301-33, Trees and Shrubs on Private Property
- Chapter 301: Trees and Shrubs, Article III
  - § 301-3 through 301-18, Trees and Shrubs on City Property
- Chapter 331: Zoning, Article IX Dimensional and Other Requirements
  - § 331-62 DMU Downtown Mixed-Use District
  - 331-64 ROS Recreation Open Space District
  - § 331-66 PWD-3 Planned Waterfront Development – 3-Story District
  - § 331-67 PWD-5 Planned Waterfront Development – 5-Story District
  - § 331-70 C-1M General Commercial Modified District
- Chapter 331: Zoning, Article XIII Site Plan Approval
  - § 331-119.1 Landscaping Requirements for multifamily, nonresidential & mixed-use zones
- Chapter 331: Zoning, Article XIV Off-Street Parking and Loading
  - § 331-130 Landscaping and Screening

The various codes where landscaping requirements are described do not include any reference to or requirement for GI techniques. This presents a void where there can be modifications to the code to specifically call for targeted GI techniques to meet the goals of landscaping.

Stormwater Water Quality

The City of New Rochelle regulates stormwater water quality for industrial and commercial sites through the local building and zoning codes. The following sections are applicable:

§ 215-12 Use of Best Management Practices to Prevent, Control, and Reduce Stormwater Pollutants.

"The owner or operator of a commercial or industrial establishment shall provide, at its own expense, reasonable protection from accidental discharge of prohibited materials or other wastes into the municipal storm drain system or watercourses using these structural and nonstructural BMPs. Further, any person responsible for a property or premises, which is, or may be, the source of an Illegal Discharge, may be required to implement, at said person's expense, additional structural and nonstructural BMPs to prevent the further discharge of pollutants to the municipal separate storm sewer system. Compliance with all terms and conditions of a valid NPDES permit authorizing the discharge of stormwater associated with industrial activity, to the extent practicable, shall be deemed compliance with the provisions of this section. These BMPs shall be part of a Stormwater Pollution Prevention Plan (SWPPP) as necessary for compliance with requirements of the NPDES permit."

The code references "these" structural and non-structural BMPs without further mention of what these techniques are. This code could be modified to incorporate GI practices as a method of managing stormwater from commercial and industrial sites.

§ 281-45 Connections to sanitary sewers and stormwater drains.

A. Service lines.

(1) The installation and repair of sewer and drainage service lines within the limits of any public street, highway, easement or other public property, and the connection of such service lines to the sanitary sewers and stormwater drains of the City shall be done in accordance with the provisions of the rules and regulations of the Department of Public Works and shall also conform to such specifications as may be promulgated by the Commissioner.

(2) A sewer service line, between its connection point at the sanitary sewer and building, shall be a heavy cast-iron pipe with lead joints or such other approved types of joints as may be allowed by the Plumbing Code of the City of New Rochelle[2] and shall be laid by a licensed plumber.

[2] Editor's Note: See Ch. 242, Plumbing and Drainage.

(3) A drainage service line between its connection point at the stormwater drain and the property line shall be of heavy cast-iron pipe with lead or other approved joints, reinforced concrete or other pipe approved by the Commissioner.

(4) Such service lines shall be laid on a straight alignment and uniform gradient of not less than 1/4 inch per foot unless otherwise specifically authorized by the Director and having all changes in direction made with approved fittings.

B. Restriction as to type or amount of discharge.

(1) No domestic sewage nor industrial wastes and no injurious waste substance shall be discharged into a stormwater drain, watercourse or body of water through any connection thereto.

(2) No industrial wastes nor any injurious waste substance shall be discharged into a sanitary sewer unless the method and degree of treatment, prior to discharge, have been approved by the Commissioner of Public Works of Westchester County and unless such method and degree of treatment continue at all times to meet with such approval.

(3) Subject to the prior approval of the Commissioner, waste lines from a swimming pool shall be connected into a sanitary sewer, and discharge of wastewater from a swimming pool into the sanitary sewer shall be restricted to the period between 12:00 midnight and 6:00 a.m. The size of the discharge line at the point of connection shall not, in general, exceed four inches, and may be further reduced by the Commissioner at the latter's discretion.

C. Connections.

(1) Except as otherwise provided hereinbelow, connections to sanitary sewers and stormwater drains shall be made by means of forty-five-degree or ninety-degree M-D Cut-In Connections of approved size as manufactured by Joseph G. Rollard Co., Inc., or an approved equal.

(2) The use of an existing Y-branch, or other existing fitting, for the purpose of connecting a service line thereto shall be allowed only when such branch or fitting is already available and in place as a part of a sanitary sewer or stormwater drain, is in satisfactory condition and at an acceptable location and is of adequate size to receive said service line

(3) Whenever the proposed service line is greater than four inches when the sanitary sewer or stormwater drain is six inches or less; or greater than five inches, when the sanitary sewer or stormwater drain is eight inches or less; or greater than six inches when the sanitary sewer or stormwater drain is 10 inches or less, a manhole shall be built over said sanitary sewer or stormwater drain at the point of connection unless otherwise specifically authorized by the Commissioner. The above sizes refer to the internal diameter of the pipe or conduit.

(4) M-D Cut-In Connections and other approved types of connections shall be installed in such a manner that the invert of said connection shall be higher than the invert of the sanitary sewer or stormwater drain by an amount not less than 1/2 the vertical diameter of said sanitary sewer or not less than 3/4 of the vertical diameter of said stormwater drain, unless otherwise authorized by the Commissioner.

(5) Connections to an existing cast-iron pipe sanitary sewer or stormwater drain shall be made by burning an opening in said pipe in an approved manner or by such other means as may be authorized by the Commissioner.

(6) When a connection is made into an existing manhole or when a manhole is required to be built at the point of connection, as specified hereinabove, the invert of the service line at the point of connection shall be higher than the invert of the sanitary sewer or stormwater drain by an amount not less than the vertical diameter of said sanitary sewer or stormwater drain, unless otherwise authorized by the Commissioner.

(7) When the difference in invert elevation in the manhole at the point of connection exceeds three feet, a drop connection shall be installed in said manhole.

(8) Adequate provision shall be made so that the discharge from a service line within a manhole shall be conducted smoothly into and in the direction of flow of the main channel of the sanitary sewer or stormwater drain by means of a built-up channel or by extending said service line partly into the manhole, as may be necessary and in such manner as may be approved by the Commissioner.

(9) Construction of new manholes, drop connections and any other necessary structures, and connections to existing structures, shall conform to such specifications as may be promulgated by the Commissioner; in general, the current standard specifications and construction details of the Department of Public Works shall be followed subject to the prior approval of the Commissioner.

(10) In the event that the sewer or drain connection is not installed under the supervision and the approval of the Commissioner's authorized personnel, the permittee shall forfeit the deposit, and the Commissioner shall have the authority to deny said permittee of any future permit.

D. Drainage from business, commercial, industrial and other buildings.

(1) Roof and other drainage from properties on which buildings are hereinafter constructed to be used in whole or in part for business, commercial, industrial or other public purposes shall be discharged through drainage service lines

directly into a stormwater drain through an approved connection thereto when such a stormwater drain is available and unless such connection, in the opinion of the Commissioner, is deemed impracticable.

(2) Discharge of such drainage through sidewalk or curb drains and discharge of roof or other drainage from any privately owned buildings or properties into a catch basin will not be allowed except with the prior approval of the Commissioner, and provided that the owner of said property has filed with the Commissioner a signed statement by said owner that the City of New Rochelle is to be saved harmless from any loss, injury or damage arising out of the approval of the Commissioner of the discharge of drainage into a catch basin or through sidewalk or curb drains.

E. Sidewalk and curb drains.

(1) Unless otherwise authorized in writing by the Commissioner, drainage outlets laid under or across the sidewalk area between the property line and the curbline and discharging into the gutter or into a catch basin or curb inlet, shall be approved cast-iron or steel construction.

(2) When holes are cut through curbs for the purpose of providing drainage outlets, care shall be taken not to damage the curb, and any damage or injury to said curb shall be repaired by the permittee at the latter's own expense and to the satisfaction of the Commissioner.

[1] Editor's Note: Amended at time of adoption of Code (see Ch. 1, General Provisions, Art. II).

The code provides guidance for connections to stormwater drains. It contains many positive attributes such as restrictions as to type and amount of discharge to the stormwater system. This code has the potential to be revised to include the use of GI rather than storm sewer connections, particularly for low-flow residential connections.

3.2 Performance Criteria

A performance criteria should be identified to adequately evaluate GI practices, select design parameters, guide initial design efforts, and determine its effectiveness. Performance criteria includes: impervious areas managed; storm size managed; infiltration rates; storage volume; detention slow release; detention overflow control; loading ratio; ponding depth; depth to groundwater and bedrock; material standards; and vegetation.

A description of each of these suggested performance criteria is as follows:

3.2.1 Impervious Area Managed

The first step when designing a GI implementation plan is to understand the amount of stormwater that needs to be managed. To determine this, the contributing drainage area and the impervious portion of the drainage area should be determined. In general, GI practices will be placed at topographic low points to the contributing impervious area; however, it is also possible to hydraulically connect impervious areas to a GI site with pipes and catch basins.

3.2.2 Storm Size Managed

Establishing a target design storm that will be managed by GI is important for identifying minimum design standards required to properly size a GI practice. An estimate of the total volume the GI practice should be able to store can be determined using the design storm rainfall depth. Peak rainfall intensities can be used to determine the size of the conveyance requirements of the system. For example, inlets, catch basins, and pipes that may lead into the GI practice should all be sized to convey these peak flows without causing backups or bypass of the GI practice.

The target precipitation managed will be dependent on local precipitation patterns and characteristics of the storm sewer system.

3.2.3 Infiltration Rates

Infiltration of stormwater within a GI practice is an effective approach to reducing stormwater entering the storm sewer system since flow is discharged to the groundwater instead of the storm sewer system, thereby reducing both the volume and, potentially, the number of overflows. The following recommendations can be used to determine the ability of the site to infiltrate:

- The minimum required field infiltration rate is 0.5 in/hr (per the New York State Stormwater Management Design Manual, Appendix D)
- A safety factor of two (2) is recommended to be applied to the lowest measured permeability rate when determining a design infiltration rate.
- The maximum recommended design infiltration rate is 10 in/hr, even if testing produced higher rates.

Additionally, the potential effects of groundwater mounding should be considered, as a groundwater mound can cause reduced infiltration rates as it approaches the bottom of a GI practice.

In cases where native soils between the bottom of the GI practice and the groundwater do not meet the minimum infiltration rates, soil replacement can be considered. If soil replacement is proposed, the soil layer not meeting the minimum infiltration rate should be entirely excavated and replaced with more permeable soil. Where infiltration is not possible, the GI practice can be designed for subsurface storage and detainment. GI practices for detainment are designed with underdrain systems that slowly release the water back into the storm sewer system. If infiltration rates are determined to be excessively high (greater than 20 in/hr), further investigation should be considered to ensure the infiltrated water is not draining into an underground structure such as an adjacent building or back into the storm sewer system.

3.2.4 Storage Volume

The storage of the system is the volume of water the practice can hold. This is a combination of the ponding area volume plus the effective porosity of the subsurface storage (stone, media, etc.) and soils.

$$\begin{aligned} \mathit{Total\ Storage}\ (cf) &= \mathit{Ponding\ Volume}\ (cf) + \mathit{Soil\ Depth}\ (ft) * \mathit{Soil\ Footprint}\ (sf) \\ &* \mathit{Soil\ Void\ Ratio}\ (\%) + \mathit{Storage\ Depth}\ (ft) * \mathit{Storage\ Footprint}\ (sf) \\ &* \mathit{Storage\ Void\ Ratio}\ (\%) + \mathit{Sand\ Depth}\ (ft) * \mathit{Sand\ Footprint}\ (sf) \\ &* \mathit{Sand\ Void\ Ratio}\ (\%) \end{aligned}$$

3.2.5 Detention Slow Release

Water detained within a GI practice should be designed to draw down using a slow release system within 48 to 72 hours to avoid public health concerns. The release rate should also consider a minimum duration for detention to reduce the peak flows entering the storm sewer system and potentially reduce overflows. A slow release orifice can be used to achieve the desired draw down time.

Determining the optimal release rate for the system depends on the flow conditions of the storm sewer system receiving the released flow. Hydraulic and hydrologic modeling of the storm sewer system can help determine acceptable release rates for a particular detention system.

3.2.6 Detention Overflow Control

During larger rain events, the GI practices can overflow so it is important to consider how the system will respond. In many cases, a GI practice will overflow back into the storm sewer system. The main design concern is to ensure the practice does not restrict flow, resulting in flooding of the practice or nearby streets. The GI practice should be designed to allow flows from larger storm events to bypass the practice and flow into the storm sewer system. This can be done using control measures such as overflow structures or spillways that allow the system to function for stormwater control during smaller rain events while not restricting flows during larger events. Careful attention should be taken during construction to ensure that overflows are installed at the correct elevation. An overflow installed lower than designed can result in design storms bypassing the system, thereby reducing performance.

3.2.7 Loading Ratio

The hydraulic loading ratio of an infiltration-based GI practice is an important factor to consider ensuring consistent infiltration over the practice's lifetime. In general, the loading ratio relates the size of the infiltration area in the practice to the runoff area of the drainage area it receives. Total infiltration will be higher when spread out over a larger surface area. Additionally, having a larger infiltration area reduces the risk of clogging the pores of the native soil which can reduce the infiltration rates of the system over time. Refer to the section on loading ratios in Chapter 2 for more information on typical loading ratios for GI practices.

$$Loading\ Ratio = \frac{Catchment\ Area\ (sf)}{Infiltration\ Area\ (sf)}$$

3.2.8 Ponding Depth

The ponding depth provides an opportunity to store stormwater, however, excessive depths can create hazards to pedestrians. Typically, GI practices that are located where pedestrians are present should have ponding depths in the range of approximately 2-inches to 6-inches. When a practice has a ponding zone in a pedestrian area, a guard or fence should be installed around the perimeter of the practice for fall protection. Practices that are located in remote locations where there is no hazard to the public can be deeper. Embankment slopes in the GI practice should not exceed a 3:1 slope.

3.2.9 Depth to Groundwater and Bedrock

Infiltration based GI will not function well if groundwater levels are high. GI practices that are designed to infiltrate into the subsoil should have a 2-foot minimum separation from the seasonal high-water table. Practices designed with an underdrain should have a 1-foot minimum separation. Additionally, bedrock in close proximity to the base of GI practices can often result in poor infiltration rates. Soil exploration should be performed at each potential GI site to assess these factors.

3.2.10 Material Standards

It is important to ensure that materials used in construction of a GI practice meet all the hydrologic and hydraulic design specifications. Consideration of criteria such as the conductivity of various sands, soils, and stone is important to ensure that the design storage and infiltration rates are maintained.

3.2.11 Vegetation

Vegetation chosen for GI should be native to the State of New York and specifically Westchester County. Planting non-native species can result in one type of vegetation taking over the practice. Heartier vegetation such as shrubs, grasses, and trees can provide more resilience to the potentially adverse growing conditions that may exist in GI practices located in urban environments.

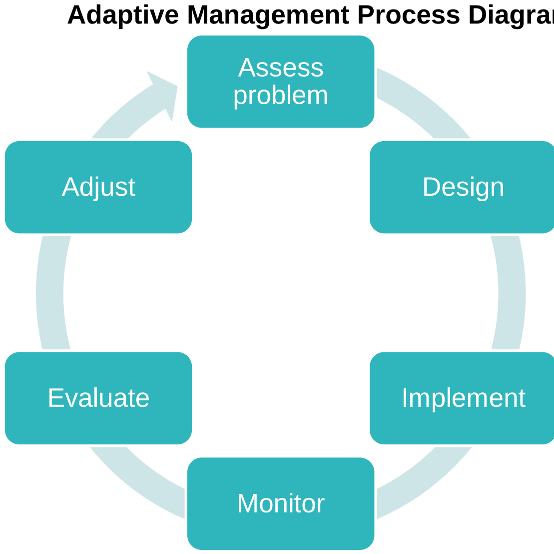
3.2.12 NYC DEP GreenHUB

As described above, to quantify the benefits of GI, GI practice monitoring is required. The monitoring techniques discussed in the previous section can be employed to evaluate the performance of the practices. The NYC DEP however, in 2017, began utilizing a GI project tracking tool called GreenHUB. This tool can track GI at both the project level and individual asset level. GreenHUB tracks all related asset attributes such as geographic location, cubic feet of stormwater managed, soil classification, permeability data, and year constructed. Through GreenHUB, the NYC DEP can analyze, query, map, and report on GI assets. Utilization of this system, or a smaller scale version, by the City would be a beneficial practice monitoring program for GI infrastructure.

3.3 Adaptive Management

Adaptive management is a useful approach to maximize the effectiveness of a GI implementation plan, as the intent is to learn as you build in a sequential implementation of GI practices. As projects are built, monitoring techniques can be employed to evaluate the performance of the practices. This information can provide insight for improving the GI implementation plan and effectively locating, designing and constructing future GI practices.

Adaptive Management Process Diagram



Source: U.S. Department of the Interior (DOI), 2009

GI performance can be difficult to predict since many factors (e.g. temperature, rainfall patterns, pollutant loads, native soil infiltration, etc.) can vary between different sites. Monitoring performance of GI practices as they are installed can provide valuable "lessons learned." With these "lessons learned," proper modifications can be made to the plan to ensure desired performance goals are being met. Continuously adapting the plan will help mitigate uncertainties and risks that may arise with GI implementation.

The components for an adaptive management approach include, but are not limited to:

- Identify uncertainties (e.g. survival of vegetation, drain down of practices, volume reductions, pollutant removal, ancillary benefits, etc.)
- Involve stakeholders
- Prepare a comprehensive monitoring plan to evaluate expected outcomes, include site specific and watershed scale monitoring
- Prepare interim goals and evaluate performance (e.g. stormwater volume reductions, pollutant removal performance, triple bottom line benefits, etc.)

3.4 Community Engagement & Education

The visibility of GI can spur a desire in the community to become educated about the importance of clean water and how to maintain water as a valuable resource. Pilot projects are a valuable opportunity to promote community engagement and education. GI is a relatively new approach for many municipalities and typically unfamiliar to most of the public. Because GI practices are usually visible and require a footprint area, public outreach and education is critical to the success of a pilot program. Partnerships within the community can assist not only with education and outreach but can also provide a public forum for feedback on aspects of a program. There may be grant opportunities that are not available to public entities but could be secured by a partner. These partners could consist of watershed associations, environmental groups, neighborhood associations, local business alliances, community gardens, in addition to many others. Hosting public presentations or workshops and developing educational materials is recommended but it is also necessary to provide opportunities to gather input from the public. Successful programs create unity within a community by fostering a collaborative environment that conveys the benefits of GI, which can be accomplished by holding design workshops for specific projects to engage stakeholders.

Successful GI programs often rely on volunteer resources to maintain the landscaping in GI. A permittee or municipality could partner with stewardship groups such as local tree tenders or horticultural societies. It is also essential that a GI program aligns with other local initiatives and municipal or state requirements or codes. Therefore, GI programs need to be well coordinated with the appropriate officials from departments of transportation (DOTs), public works and parks. Finally, it is important to manage public perception and expectations of a GI program. Several initiatives that can be used for an outreach program are listed below with examples of successful use in existing GI programs.

> ***Presentations and Workshops***: Holding presentations and workshops enables staff to meet individual members of the community and better understand and meet community needs. For example, New York City's Department of Environmental Protection makes presentations to community boards and other civic and environmental organizations, in addition to elected officials and their staff about the city's GI Program.

> ***Media Campaigns:*** Kansas City engaged in an extensive media campaign involving interviews on television and the radio, as well as advertisements and articles in local newspapers. These media campaigns reached an estimated three million people in 2007.

In 2013, New York City's Department of Environmental Protection created an educational video on the GI Program which described some of the environmental challenges caused by stormwater as well as some GI solutions such as green roofs, rain gardens, and permeable interlocking paver units. In the state of Maryland, the Clean Water, Healthy Families coalition created a radio ad with a catchy song to combat opponents who had labeled stormwater fees as a "rain tax."

Websites: In 2013, New York City's Department of Environmental Protection launched a new website that provides information on the City's GI Program, including the most common types of GI practices as well as a map of priority areas for GI installation. Community members can use the site to see if their neighborhood will receive GI installations and to better understand the practices. Kansas City's 10,000 Rain Gardens initiative created a website offering residents and other audiences a clearinghouse of information pertaining to the program and to stormwater management more generally and received more than 100,000 visits per year even after the main media campaign had ended.

Written Materials: Written materials such as brochures and surveys can be effective means of engaging the public and partner agencies about stormwater management practices and the permittee's use of GI. For example, New York City's Department of Environmental Protection developed a brochure that explains the siting and construction process for projects in the right-of-way, answers frequently asked questions, and describes the co-benefits of GI. Similarly, Seattle Public Utilities (SPU) used parking surveys to better understand and meet the needs of the community for its Street Edge Alternatives Program. The surveys revealed community concerns about reductions in parking from reduced street width as a result of GI projects. SPU responded to this concern by installing occasional angled parking clustered along the street.

***Inter-Agency Partnerships*:** Creating partnerships between agencies can help to efficiently and effectively implement GI practices. By pooling the resources, expertise, and knowledge of different agencies, inter-agency partnerships are formed that can be crucial to successful pilot programs. These partnerships can exist to aid in any stage of the process, including planning, installation, maintenance, and monitoring. For example, in New York City, the Departments of Environmental Protection and Parks and Recreation have worked together to develop the GI Maintenance Program to allocate appropriate resources for the long-term maintenance of DEP's GI projects.

Engaging the community and developing partnerships is important to ensure broad support for GI installation and thus the long-term success of the GI program. This engagement will allow the program to address the community's concerns with the GI program, which may include both perceived and real negative impacts. Since GI practices will be installed in public and private domains, it is important to ensure the public is aware of projects, can participate in the planning process, and has their concerns adequately addressed. Perceived negative impacts can include things like mosquito breeding. While the public may perceive that these types of issues would arise from GI, they generally do not from properly functioning GI systems, and these concerns can, generally, be alleviated through education. If these concerns persist even after educating the public, designs can be revised to alleviate the concern, such as reducing the time water will be ponded in the system. While a 72 hour drain time is sufficient to prevent mosquito breeding, the drain time could be reduced to 36 hours to alleviate concerns. Real negative impacts can include issues such as loss of parking spaces in a neighborhood. Since a GI installation may result in the loss of parking spaces, this concern cannot be fully resolved through education. However, education, such as explaining why the GI is needed and the benefits it will provide, can still be an important tool in overcoming concerns with real negative impacts. Involving the public and any entities partnering in a green endeavor early in the planning process can mitigate friction during design and, especially, construction. A GI partnership that is the lead on engaging with the public and any outreach or education can be useful. A partnership that operates in this capacity can prove to be an asset for all types of stormwater infrastructure design and implementation throughout a community as it can be a way to connect various types of GI projects and the local residents. These projects could include road improvements, commercial and residential development, or other infrastructure improvements. The partnership can allow the community to be educated on stormwater related manners as well as allow them the opportunity to discuss how different types of projects within their communities can assist with dealing with stormwater related issues. Another valuable aspect of this type of partnership is that the partnership can educate residents on how they can change their daily activities to have a positive impact in their community.

An example of such an alliance is the Camden New Jersey SMART (Stormwater Management and Resource Training) Initiative. The partnership involves many key entities such as government agencies, universities, the Camden County Municipal Utilities Authority (CCMUA), and non-profit organizations providing a dynamic approach to community involvement in green efforts throughout the City of Camden.

Partnerships can also provide financial benefits. A few examples are provided below:

- Milwaukee, WI works with other local organizations to implement green projects that include education and outreach, cost-share or matching funding partnerships. "Greenseams" is a notable partnership with The Conservation Fund to purchase easements on land along waterways and wetlands. Greenseams has effectively sustained 3,383 acres of flood-prone areas which comprise 28 communities and 1.1 million people. In addition, these partnerships resulted in the planting of 102,862 trees over 500 acres to capture more stormwater; ultimately reducing stormwater flow to the City. By increasing the surrounding areas' ability to slow peak flows to the City, through conservation and restoration, Milwaukee will avoid incurring millions of dollars in flood damage. These projects also provide ancillary benefits in the form of increased greenspace for residents to enjoy.
- New York City, NY implements a Public-Private cost-share/partnership. These partnerships have resulted in contributions of $1.6B and $900M from public and private investments, respectively with an estimated $139M - $418M in benefits through reduced energy bills, increased property values, improved health and mitigation of CO2 emissions.
- In Philadelphia, PA the Green Stormwater Infrastructure Partners (GSI Partners), an initiative by Sustainable Business Network (SBN), is a network of engineering firms, landscape architects, maintenance firms, contractors and suppliers that work together to move GI forward in the Greater Philadelphia Area.
- Onondaga County, NY partnered with Courts4Kids Foundation to install new porous asphalt basketball courts. Courts4Kids provided funding for all non-green aspects of the basketball courts.

A partnering plan should be developed early on. Some examples of initiatives that can help are listed below:

- Develop and manage a list of key partners and volunteers.
- Develop partnerships and volunteer efforts to implement an urban tree canopy project.
- Develop a GI page on partners' websites.
- Develop a homeowner's guide to GI.

- Provide GI fact sheets and education materials.
- Develop a public outreach plan, and timeline for execution of the outreach plan.
- Leverage community education and outreach by utilizing local and state stakeholders.

3.5 Land Use and Planning Recommendations

The following recommendations related to land use and planning techniques should be considered by the City as part of a Green Infrastructure Initiative Program:

- Incorporate GI practices into projects that result in an increase in impervious surfaces as a means of managing stormwater runoff.
- Modify City landscaping codes to incorporate the use of GI practices into planting requirements.
- Regulate water quality improvements and storm sewer connections through GI practices.
- Develop requirements for performance criteria monitoring of GI infrastructure, including adaptive management.
- Incorporate GI practices when on-site detention improvements are required
- Create a checklist for projects designed internally by the City engineers and planners to ensure that GI is used to the maximum extent possible in development plans. Incorporate design strategies for new and retrofitted stormwater management projects
- Require enforceable maintenance plans to accompany all privately-owned GI improvements.
- Adopt New York State guidance documents on green infrastructure into the City's Land Use Ordinances:
    - Green Infrastructure Practices – New York State Stormwater Management Design Manual
    - Green Infrastructure Practices – New York State Department of Transportation

3.6 Community Engagement and Public Education Recommendations

- Implement a Public Education, Outreach, and Engagement Program that focuses on activities to education the public on Green Infrastructure including:
  - Maintain a stormwater related page on the municipal website or on a municipal social media site.
  - Post signs at municipally-owned green infrastructure sites that describe the function and importance of the infrastructure, contact phone number, municipal identification number, and/or website for more information.
  - Present a green infrastructure related display or materials at any municipal event (e.g., Earth Day, town picnic), at the municipal building or other similar public venue.
  - Distribute an item or items with a green infrastructure related message (e.g., refrigerator magnets, temporary tattoos, key chains, bookmarks, coloring books, and pens or pencils).
  - Distribute an educational brochure on green infrastructure via a mailing to every resident and business in the City.
  - Distribute a letter or e-mail from the mayor or municipal official to every resident and business in the municipality highlighting the requirements and environmental benefits of green infrastructure (if adopted into the city code requirements). Provide a link to the municipal website where subject ordinances are posted.

- Organize an educational contest with a local school district or a local community organization serving youth to design a poster, magnet, rain stick, rain barrel or other craft/art object. Contest themes shall have an appropriate green infrastructure message. Winning entries are to be displayed at publicly accessible locations within the municipality such as at the town hall, library, post office, or school. The winning design should be shown on the municipality's website or social media site, if practical.
- Provide green infrastructure related educational presentation(s) and/or activities to local preschool, elementary, middle, and/or high school classes using municipal staff. Topics could include examples of green infrastructure and benefits of green infrastructure.
- Organize or participate in a rain barrel, rain garden or other green infrastructure workshop.

4 Locating and Assessing the Feasibility of Green Infrastructure

This chapter discusses the wide range of topics involved in assessing the overall feasibility of GI and how to locate potential GI sites. An example stepwise process is provided and discussed throughout this chapter, with several supporting case studies from across the United States.

4.1 Work Flow Process

A sample work flow process for locating and assessing the feasibility of GI projects is outlined below.

Step 1: Compile a GIS Database

- Topography
- Impervious surface coverage
- Depth to groundwater and bedrock
- Sewer Infrastructure (Piping, manholes, inlet locations, etc.)
- Sewershed boundaries
- Utilities
- Parcel data
- Soil infiltration potential
- Flood prone areas
- Existing stormwater BMP locations
- Building Footprint via LiDAR
- Road Slope
- Location of municipally owned facilities, parks and right-of-way
- Location of vacant parcels
- Locations of contaminated properties
- Planned municipal upgrade

Step 2: Identify Sites Meeting GI Practice Criteria

- Determine sites that meet the GI practice criteria
- Desktop analysis used to estimate drainage areas and the size of the BMP using load ratios
- Field Reconnaissance to verify desktop analysis
- Post-field processing to organizxe informaton for input in the hydraulic and hydrologic model

Step 3: Hydrologic & Hydraulic Modeling

- Calculate the effects of the proposed GI practices individually

Step 4: Apply a Site Scoring System that Incorporates Community Considerations

- Cost per runoff volume managed
- Feedback from public outreach and coordination
- Flood alleviation
- Public visability
- Public Amenity value
- Environmental justice considerations

Step 1: Compile a GIS Database for GIS Parameters

GIS analysis can be used to determine where multiple parameters align and identify optimal GI site locations. Using GIS technology, permittees can assess the feasibility of GI installation, and target the most advantageous locations. The following are common GIS parameters used to evaluate the potential for GI practices.

Topography

Topography, along with surface features and sewer infrastructure, dictates the direction of stormwater runoff. Analysis can be specific to GI practices or at a much larger scale to understand the movement of runoff within the entire community.

Impervious surface coverage

When locating potential GI sites, a crucial parameter is the community's impervious surface coverage. Targeting large areas of impervious surface coverage often allows for the greatest pollutant removal and stormwater volume reduction potential. Combining this analysis with topography assists in identifying prime locations for GI implementation. For example, areas with large amounts of connected impervious surface coverage and ground slope that allows for runoff to drain towards one location, provide excellent opportunities to capture and manage stormwater.

Depth to Groundwater and Bedrock

Understanding the depth of soils to restrictive features is crucial in determining the feasibility of GI practices within a community. The soil type will determine the depth to groundwater and bedrock. Depth to groundwater and bedrock for each soil type found in New Rochelle can be found in Appendix A. This information can also be found at www.websoilsurvey.nrcs.usda.gov.

Storm Sewer Infrastructure

Existing storm sewer infrastructure along with surface features and topography dictate the direction of stormwater runoff. Knowledge of the existing storm sewer infrastructure is key to locating GI practices and for designing for safe conveyance of GI overflows. Additionally, the storm sewer infrastructure is vital to the hydraulic and hydrologic modeling discussed in Step 4.

Cautionary Note:
In urban communities, it may be necessary to have GI practices installed near existing buildings and structures (e.g. a tree trench in front of a building). Water that is infiltrated by a GI practice can make its way into nearby building basements and foundations without careful planning and design. To avoid this, permittees should perform groundwater mounding analysis for proposed locations. The United States Geological Survey (USGS) provides a model using the Hantush equation for groundwater mounding. As an alternative, the GI practices can be designed with liners to prevent the infiltration of stormwater that could seep into basements.

Watershed Boundaries

Watershed boundaries are crucial to understanding the flow of water within the community, determining target areas of GI implementation, and performing hydraulic and hydrologic modeling.

Utilities

Understanding the location of utilities (e.g., water mains, gas lines) will greatly assist in determining ideal locations for GI implementation during the desktop analysis that is further described in Step 3.

Parcel Data

GIS parcel information can assist in determining the location of GI practices by providing a visual representation of property boundaries.

Soil Infiltration Potential

Understanding the soil infiltration potential, or hydrologic soil groups, within the community is important for locating, and designing GI practices. Soils with the greatest infiltration potential, namely hydrologic soil groups A and B, are ideal opportunities for GI practices. Requiring infiltration testing prior to the installation of GI systems is highly recommendation and consideration should be given to making it a requirement for all proposed GI systems. Hydrologic soil group information for New Rochelle can be found in Appendix A. This information can also be found at www.websoilsurvey.nrcs.usda.gov.

Existing Stormwater BMP Locations

Existing stormwater BMPs are important to include in a GIS analysis. Depending upon the type of BMP, they may have the potential for cost effective retrofits to increase BMP performance. Alternatively, they may be identified as sites to avoid, since they are already high-functioning BMPs. Either way, existing BMPs should be documented and included in the hydrologic and hydraulic modeling described in Step 4.

Cautionary Note:
Identifying the infiltration rates of soil in proposed GI locations is crucial to avoiding failed systems. Foregoing soil investigation can result in systems that have standing water longer than desired (this can lead to mosquito and human health concerns). If GI practices are installed in an area with less than ideal infiltration rates, they should be designed with an underdrain system to ensure that water can leave the system.

Municipal Facilities, Parks, and Rights-of-Way

Municipally owned properties, including facilities, parks, and right-of-way's, can provide excellent opportunities for retrofitting with GI practices as property transfer, easements, and maintenance agreements can be much simpler. Parks in particular have high public visibility which can help increase public awareness.

Vacant Parcels

Vacant properties and underutilized parcels can be prime locations for GI. However, soil reconditioning may be required for optimal GI performance, and must be considered in the design and implementation of GI on the site. The EPA guidance document entitled, "Evaluation of Urban Soils: Suitability for GI or Urban Agriculture" (EPA Publication Number 905R1103) discusses soil evaluation and reconditioning strategies. The document also discusses the potential need for communities to develop and implement contract/bid specifications for demolition work that leave these sites amenable to GI.

Contaminated Properties

GI practices that rely on infiltration may still be considered during the remediation and redevelopment of contaminated properties; however, it is important to have stormwater and remediation goals align. Careful site analysis and planning is necessary before implementing GI on contaminated properties.

If it is determined that infiltration is not feasible at a particular site, practices that promote retention, filtration, evapotranspiration, or harvesting may be more appropriate. Examples include bioretention systems with an impermeable liner and an underdrain, green roofs, and cisterns.

For additional information, please see the EPA guidance document, “Implementing Stormwater Infiltration Practices at Vacant Parcels and Brownfield Sites” (EPA Publication Number 905F13001).

Locations of Planned Municipal Upgrades

Integrating GI practices into planned municipal projects such as Americans with Disabilities Act (ADA) improvements, streetscape improvements, or infrastructure upgrades (e.g. road and utility work) may be much more cost effective than building stand-alone GI projects.

Step 2: Identify Sites Meeting Green Infrastructure Practice Criteria

Using the GIS database compiled from Step 2, the next step is to identify sites that meet specific GI practice criteria. In order to do so, it is necessary to understand the uses of, and parameters governing, the array of GI tools.

GI Toolbox

The following is the list of typical GI practices:

- Bioretention Systems
  - Bioretention Basins
  - Bioswales
- Small Scale Bioretention
  - Rain Gardens
  - Downspout Planter Boxes
  - Stormwater Planters
  - Curb bump outs
  - Enhanced and Continuous Tree Pits
- Pervious Paving Systems
  - Porous Asphalt
  - Pervious Concrete
  - Permeable Interlocking Paver Units
- Reduction of impervious cover
  - Roadway reduction
  - Sidewalk reduction
  - Driveway reduction
  - Cul-de-sac reduction

  - Building footprint reduction
  - Parking lot reduction
- Vegetated Filter Strips
- Green Roofs
- Cisterns
- Tree Plantings
- Grass Swales
- Infiltration Basins
- Sand Filters designed to infiltrate into the subsoil
- Dry Wells
- Preservation of Undisturbed Areas

While all of these GI practices will have benefits in terms of both water quantity and quality, their characteristics and suitability for particular environments vary greatly. For example, infiltration practices can provide excellent runoff reduction, but can only be utilized in certain soil types. Whereas filtering practices do not require well-draining soils and provide less volume reduction benefit, they do retain and slowly release runoff which can still be of benefit to the system.

Site Specific Work

Site specific investigation is required to determine which GI practice is appropriate for a particular site. Site specific work is performed using a focused desktop analysis, including an assessment of loading ratios, coupled with field reconnaissance and post field processing. Desktop analysis can be used to estimate issues such as the GI practices drainage area, and to size the practice using loading ratios. Field reconnaissance is used to verify items observed during desktop analysis and determine if any potential conflicts exist that could only be ascertained once in the field (e.g. utilities, undocumented stormwater structures, and possible sources of contamination).

Loading Ratios

The GI practice loading ratio is the directly connected impervious area that drains to the practice, divided by the footprint of the practice. The optimal function of infiltration or retention practices occurs when the runoff is dispersed as evenly as possible, and at as shallow a depth as possible, within the practice. As a common cause of GI practice failure is overloading runoff volume and pollutants (particularly sediment) into a small footprint, maximum loading ratios are utilized to determine the appropriate practice size. Loading ratios are crucial to the successful design, performance, maintenance, and safe operation of GI practices.

Field Reconnaissance

Field reconnaissance may follow desktop analysis to verify key issues that influence GI implementation and design. The level of detail involved in field reconnaissance will be dependent on the area being evaluated and the extent of potential GI proposed. It is recommended that a thorough field evaluation be completed for initial pilot projects and in cases where it is feasible to review several sites as part of the planning process. However, it may not be feasible to complete detailed field evaluation in early stages of planning for all sites; in this case, evaluation can be completed in the planning process.

The following are a few key recommendations to assist in the preliminary field reconnaissance process:

- Use or develop standardized forms for field staff to consolidate information into one format and ensure that all necessary data is collected at each site.
- Determine that location allows for capture of stormwater based on visual inspection of topography.
- Identify potential utility locations in the field via visual inspection.
- Identify all other constraints that could affect the feasibility of the GI practice, including land uses, permitting requirements, community impacts, etc.

The following are recommendations to assist in the field reconnaissance process once basic field information has been gathered and potential sites have been identified:

- Determine the best location for each proposed practice and verify the drainage area obtained from desktop analysis. Document the location and drainage area of each practice once field work is complete.
- Take photographs of each potential GI location.
- Ensure that there is sufficient depth for practices that require an underdrain.
- Perform borings and infiltration testing of native soils.

For further information to assist in the field reconnaissance and site evaluation process see the Center for Watershed Protection's "Urban Stormwater Retrofit Practices" Chapter 4: The Search for Storage – Finding Retrofit Opportunities at the Subwatershed Level. https://owl.cwp.org/?mdocs-file=5456

Post-Field Processing

With the information obtained from the desktop analysis, the GI practice size as estimated from the appropriate loading ratio, and the crucial information field verified, the next step is to consolidate and process this information. The potential GI practices can be included in the GIS database and the key parameters governing its function should be formatted for efficient input into the hydrologic and hydraulic model used in Step 4. The parameters may vary depending upon the model used.

Step 3: Hydrologic and Hydraulic Modeling

With the inclusion of the proposed GI practices in the GIS database, and the field verified GI practice parameters organized in a concise format, the next step is to perform hydrologic and hydraulic modeling. The purpose of the modeling effort is to calculate the individual effects of the proposed GI practices in terms of volume reduction and retention.

Step 4: Apply a Site Scoring System that Incorporates Community Considerations

Once potential GI practices have been determined from Steps 2 and 3 and modeled for volume/pollutant reduction in Step 4, the final step is to develop and apply a project scoring system. The scoring system can assist communities by prioritizing projects according to community-specific needs and values. While each scoring system may be different based on local values, the following are examples of common factors considered in a scoring system:

- Cost per runoff volume managed,
- Feedback from public outreach and coordination,
- Flood/sewer back-up alleviation,
- Public visibility,
- Public amenity value (e.g. extending greenways with public trail systems),

- Environmental justice considerations raised during the public participation process,
- Catchment properties (tributary catchment slope, depth to groundwater and bedrock),
- Available open space or vacant land that can be used for GI construction,
- Localized underlying soils data for identifying high potential infiltration locations,
- Consistency with local planning,
- Ease of implementation,
- Available funding opportunities,
- Proximity to other planned infrastructure and utility projects (e.g., road reconstruction) and cost sharing,
- Partnership opportunities with private entities, and
- Potential for local triple bottom line benefits (e.g. localized social and economic uplift).

The project ranking system may be basic or complex, qualitative and/or quantitative. If multiple factors are considered, the ranking system may employ a "weighting system" that seeks to prioritize certain factors above others and be informed through the public participation process. The weighting system is an opportunity for the community to prioritize issues of importance as they choose. For example, a community may be most concerned about the cost per runoff volume managed, but also seek to actively add public amenity value for all the projects considered. Therefore, the community may provide the highest multiplier in the weighted equation to cost per runoff volume managed and provide the second highest to projects that add public amenity value.

5 New York State Standard Guidelines

Overview

This chapter outlines the New York State Design Guidelines for GI as per the New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices as well as from the New York State Department of Transportation, Highway Design Manual, Chapter 8: Highway Drainage, Appendix B NYSDOT Design Requirements and Guidance for State Pollutant Discharge Elimination System (SPDES) General Permit For Construction Activity.

5.1 Green Infrastructure Practices – New York State Stormwater Management Design Manual

The New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices. New York State classifies GI into three categories:

1. Planning Practices for Preservation of Natural Features and Conservation
2. Planning Practices for Reduction of Impervious Cover
3. GI Techniques for Runoff Reduction

Planning Practices for Preservation of Natural Features and Conservation

The preservation of Natural Features and Conservation of land seeks to manage stormwater through GI by minimizing land disturbance or avoiding it completely. The techniques outlined in the New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices are summarized in the table below.

Table 5.1: Planning Practices for Preservation of Natural Features and Conservation

Practice	Description
Preservation of Undisturbed Areas	Delineate and place into permanent conservation undisturbed forests, native vegetated areas, riparian corridors, wetlands, and natural terrain.
Preservation of Buffers	Define, delineate and preserve naturally vegetated buffers along perennial streams, rivers, shorelines, and wetlands.
Reduction of Clearing and Grading	Limit clearing and grading to the minimum amount needed for roads, driveways, foundations, utilities and stormwater management facilities.
Locating Development in Less Sensitive Areas	Avoid sensitive resource areas such as floodplains, steep slopes, erodible soils, wetlands, mature forests and critical habitats by locating development to fit the terrain in areas that will create the least impact.
Open Space Design	Use clustering, conservation design or open space design to reduce
Soil Restoration	Restore the original properties and porosity of the soil by deep till and amendment with compost to reduce the generation of runoff and enhance the runoff reduction performance of post construction practices.

Source: New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices, Section 5.1: Planning for Green Infrastructure: Preservation of Natural Features and Conservation Design.

Planning Practices for Reduction of Impervious Cover

The reduction of impervious cover planning technique for GI seeks to reduce impervious areas to minimize the impact of land development. The techniques outlined in the New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices are summarized in the table below.

Table 5.4: Planning Practices for Reduction of Impervious Cover

Practice	Description
Roadway Reduction	Minimize roadway widths and lengths to reduce site impervious area
Sidewalk Reduction	Minimize sidewalk lengths and widths to reduce site impervious area
Driveway Reduction	Minimize driveway lengths and widths to reduce site impervious area
Cul-de-sac Reduction	Minimize the number of cul-de-sacs and incorporate landscaped areas to reduce their impervious cover.
Building Footprint Reduction	Reduce the impervious footprint of residences and commercial buildings by using alternate or taller buildings while maintaining the same floor to area ratio.
Parking Reduction	Reduce imperviousness on parking lots by eliminating unneeded spaces, providing compact car spaces and efficient parking lanes, minimizing stall dimensions, using porous pavement surfaces in overflow parking areas, and using multi-storied parking decks where appropriate.

Source: New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices

GI Techniques for Runoff Reduction

The reduction of runoff technique for GI seeks to reduce stormwater runoff to manage runoff more effectively, promote groundwater recharge, increase loses through evapotranspiration and emulate the preconstruction hydrology, resulting in redacted water-quality treatment volumes. The techniques outlined in the New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices are summarized in the table below.

Table 5.7: Green Infrastructure Techniques for Runoff Reduction

Practice	Description
Conservation of Natural Areas	Retain the pre-development hydrologic and water quality characteristics of undisturbed natural areas, stream and wetland buffers by restoring and/or permanently conserving these areas on a site.
Sheetflow to Riparian Buffers or Filter Strips	Undisturbed natural areas such as forested conservation areas and stream buffers or vegetated filter strips and riparian buffers can be used to treat and control stormwater runoff from some areas of a development project.
Vegetated Swale	The natural drainage paths, or properly designed vegetated channels, can be used instead of constructing underground storm sewers or concrete open channels to increase time of concentration, reduce the peak discharge, and provide infiltration.
Tree Planting / Tree Pit	Plant or conserve trees to reduce stormwater runoff, increase nutrient uptake, and provide bank stabilization. Trees can be used for applications such as landscaping, stormwater management practice areas, conservation areas and erosion and sediment control.
Disconnection of Rooftop Runoff	Direct runoff from residential rooftop areas and upland overland runoff flow to designated pervious areas to reduce runoff volumes and rates.
Stream Daylighting	Stream Daylight previously-culverted/piped streams to restore natural habitats, better attenuate runoff by increasing the storage size, promoting infiltration, and help reduce pollutant loads.
Rain Gardens	Manage and treat small volumes of stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression.
Green Roofs	Capture runoff by a layer of vegetation and soil installed on top of a conventional flat or sloped roof. The rooftop vegetation allows evaporation and

Practice	Description
	evapotranspiration processes to reduce volume and discharge rate of runoff entering conveyance system.
Stormwater Planters	Small landscaped stormwater treatment devices that can be designed as infiltration or filtering practices. Stormwater planters use soil infiltration and biogeochemical processes to decrease stormwater quantity and improve water quality.
Rain Barrels and/Cisterns	Capture and store stormwater runoff to be used for irrigation systems or filtered and reused for non-contact activities.
Porous Pavement	Pervious types of pavements that provide an alternative to conventional paved surfaces, designed to infiltrate rainfall through the surface, thereby reducing stormwater runoff from a site and providing some pollutant uptake in the underlying soils. When designed in accordance with the design elements in section 5.3.11, the WQv for the contributing drainage area is applied towards the runoff reduction

Source: New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices

For the complete New York State Stormwater Management Design Manual, Chapter 5: Green Infrastructure Practices, please see https://www.dec.ny.gov/chemical/29072.html.

5.2 Green Infrastructure Practices – New York State Department of Transportation

The New York State Department of Transportation, Highway Design Manual, Chapter 8: Highway Drainage, Appendix B NYSDOT Design Requirements and Guidance for State Pollutant Discharge Elimination System (SPDES) General Permit For Construction Activity provides design requirements and guidance for stormwater management incorporating green infrastructure on highway projects.

5.2.1 Applicability

The New York State Department of Transportation, Highway Design Manual requires permanent stormwater management practices for any project that requires coverage under the SPDES General Permit for Construction Activity. The Water Quality Volume (WQv) required to be treated as a result of the proposed project will determinate the sizes, locations, and number of stormwater management facilities required.

The SPDES General Permit for Construction activity requires designing facilities that detain the one-year, 24 hour storm event, and attenuate the peak flows for the ten-year, 24 hour and hundred-year, 24 hour storm events and establishing water quality treatment.

5.2.2 Use of Green Infrastructure

The New York State Stormwater Management Design Manual requires that green infrastructure principles are incorporated into the project planning and design process. The goal is that the designed stormwater management will preserve preconstruction hydrology and water quality through small-scale, distributed structural and non-structural practices. Per the NYSDOT, Green Infrastructure (GI) can include practices to manage and treat stormwater, maintain natural hydrology and ecological function by infiltration, evapotranspiration, capture and reuse of stormwater, and establishment of natural vegetative features. GI can achieve stormwater control through the creation of a hydrologically functional landscape that replicates a natural hydrologic regime. This can be achieved by:

Minimizing stormwater impacts by reducing imperviousness, conserving natural resources, maintaining natural drainage courses, reducing the use of pipes and minimizing clearing and grading.

Providing runoff storage measures dispersed uniformly through a site with the use of a variety of retention, detention, and runoff practices.

Maintaining predevelopment time of concentration by strategically routing flows to maintain travel time and control the discharge.

Per the NYSDOT, the objective is to replicate pre-development hydrology by maintaining preconstruction infiltration, peak runoff flow, discharge volume, as well as minimizing concentrated flow by using runoff control techniques to provide treatment in a distributed manner before runoff reaches the collection system.

5.2.3 Stormwater Management Site Planning and Design Using Green Infrastructure – A 5 Step Process (Source: The New York State Department of Transportation, Highway Design Manual, Chapter 8: Highway Drainage, Appendix B)

This process is intended to guide the designer through steps that maintain pre-construction hydrologic conditions of the site by application of environmentally-sound development principles, such as Green Infrastructure, as well as treatment and control of runoff discharges from the site.

Stormwater management using green infrastructure is summarized in the five-step process summarized below.

The five steps include:

1. Site Planning to Minimize Disturbed Areas and Impervious Areas,
2. Calculation of the Water Quality Volume for the Site,
3. Runoff Reduction by Applying Green Infrastructure Techniques and Standard Stormwater Management Practices with Runoff Reduction (RRv) Capacity,
4. Apply Standard or Alternative Stormwater Management Practices to Address Remaining Water Quality Volume, and
5. Apply Volume and Peak Rate Control Practices.

Step 1: Site Planning to Minimize Disturbed Areas and Impervious Areas

Here, the designer must use practices listed below to protect natural resources and utilize the hydrology of the project site when designing the project. The Preservation of Natural Resources Practices includes these planning strategies:

1. Preservation of Undisturbed Areas
2. Preservation of Buffers
3. Reduction of Clearing and Grading
4. Locating Development in Less Sensitive Areas
5. Locating development to fit the terrain in areas that will create the least impact.
6. Soil Restoration

The designer must consider practices to reduce impervious cover when designing the project. The Reduction of Impervious Cover Practices include:

1. Roadway Reduction
2. Sidewalk Reduction
3. Driveway Reduction
4. Cul-de-sac Reduction

5. Building Footprint Reduction
6. Parking Reduction

The SWPPP must include an evaluation of all the green infrastructure planning measures as they apply to the project site. This evaluation process requires the following information:

1. Develop a map that identifies natural resource areas and drainage patterns; including but not limited to the following (that will routinely be included in a SWPPP):
2. Develop strategies for protection and enhancement of natural resources
3. Reduce the impacts of development by reducing impervious surfaces
4. Demonstrate that all reasonable opportunities for preserving natural conditions of the site are employed to minimize the runoff and maintain the pre-construction hydrology

Step 2: Calculation of the Water Quality Volume for the Site

The Water Quality Volume is the volume of stormwater generated by the project that should be captured and treated within the project limits. This is intended to derive a Water Quality Volume prior to the application of Green Infrastructure design techniques to reduce water quality volumes. Treatment of the Water Quality Volume (WQv) is intended to capture and treat 90% of the average annual stormwater runoff volume. The designer should first determine the WQv required to be treated for the project in its entirety.

Once the preliminary site design is known, impervious areas are defined, and drainage areas are delineated, the designer should calculate the water quality volume. This shall be termed the Initial Water Quality Volume ($WQv_{(Initial)}$). This calculation of WQv will have to be revised after green infrastructure techniques are applied.

The Water Quality Volume should be calculated by taking a weighted average of the New Development and Redevelopment areas. The goal is to treat 100% of the WQv for the New Development areas and 25% of the WQv for the Redevelopment areas.

For projects in Phosphorus Restricted Watersheds (New York City EOH watershed, Greenwood Lake watershed, and Onondaga Lake watershed), the Water Quality Volume equals the estimated runoff volume (acre-feet) resulting from the 1-year, 24-hour design storm.

Step 3: Runoff Reduction by Applying Green Infrastructure Techniques and Standard Stormwater Management Practices with Runoff Reduction (RRv) Capacity

Green infrastructure techniques and certain standard SMPs are to be used to address stormwater runoff to avoid, reduce and manage the impacts of stormwater runoff by using natural features and runoff reduction practices to slow down the runoff, promote infiltration and evapotranspiration, and consequently minimizing the need for larger structural practices.

The reduction of the total Water Quality Volume by application of green infrastructure techniques and SMPs to replicate pre-development hydrology is called the Runoff Reduction Volume (RRv) and is best achieved through the reduction of the impervious surface area and minimization of disturbed area. This is particularly beneficial when pre-development soils possess significant infiltration capacity and are used to reduce runoff volume.

The strategies for runoff reduction fall under two general methods. The first group of practices includes site design techniques that a designer could factor in by subtracting areas from the total site area, resulting in reduced WQv and Channel Protection Volume (CPv), and includes (some of these practices are not appropriate for highway projects, but are included here for informational purposes):

1. Conservation of natural areas
2. Sheetflow to riparian buffers or filter strips.
3. Tree planting /tree pit
4. Disconnection of rooftop runoff
5. Stream daylighting for redevelopment activities

The second group of green infrastructure practices provides runoff reduction by storage of runoff volume, thereby reducing the WQv and Cpv, and includes (some of these practices are not appropriate for highway projects, but are included here for informational purposes):

a. Vegetated open
b. Rain garden
c. Green roof
d. Stormwater planter
e. Rain tank/Cistern
f. Porous Pavement

The following basic principles must be applied to all green infrastructure design applications:

- Each green infrastructure technique must be appropriately sized for its contributing drainage area.
- Contributing drainage areas, depending on final grading, flow path, impervious cover disconnection, and varying levels of management of the flow, may require sub-catchment delineation.
- For all green infrastructure techniques that involve infiltration, soil infiltration testing is required. Testing must be performed at the proposed practice site and follow the requirements in Appendix D of the Stormwater Management Design Manual.
- For all green infrastructure techniques that involve infiltration, adequate separation distance from ground water table (typically three feet, or four feet above sole source aquifers) and a reasonable drawdown time (typically 0.5 inch/hour minimum) must be met.
- Green infrastructure techniques with storage capacity (i.e., volume reduction practices) that are sited downstream from the developed areas must be sized for contributing areas (pervious and impervious covers), or sized for rainfall by run on.
- Green infrastructure techniques without storage capacity (i.e., area reduction practices) that are sited downstream from the developed areas must be sized for receiving runoff from a maximum contributing area (pervious and impervious covers).
- Areas of green infrastructure techniques that do not receive runoff from developed areas (i.e., Preservation of Natural Resources Practices) can be subtracted from the contributing area of the downstream SMP for WQv calculation. The Rv of the SMP is calculated based on the pervious and impervious cover of the remaining contributing areas.
- If any other calculation methods are utilized (e.g. TR-55), all the contributing areas and related practices must be modeled according to the requirements of the selected method.
- All green infrastructure practices must be designed for overflow and safe passage of storms greater than the design capacity of the system and conveyed to SMPs designed for quantity controls.
- A drainage layer shall be incorporated in most practices to enhance structural integrity, storage, drainage, and infiltration and may not be neglected.

There are SMPs that are considered "standard" as per the Stormwater Management Design Manual and promote infiltration to reduce runoff volumes, and therefore, can be used to meet the Runoff Reduction Volume requirement. These practices are called "standard SMPs with RRv capacity", and include:

- Infiltration Practices
- Bioretention Practice
- Dry Swale

Step 4: Apply Standard or Alternative Stormwater Management Practices to Address Remaining Water Quality Volume

In this step, use standard or alternative practices to meet the remaining water quality volume requirements that cannot be addressed by applying the green infrastructure techniques or the standard SMPs with RRv capacity discussed in the previous step.

If the WQv requirements in this section are not met, the technical standard is not met, and NYSDEC will not process the NOI.

Apply Standard Stormwater Management Practices to Address Remaining Water Quality Volume

The Stormwater Management Design Manual provides details for the five groups of standard SMPs to meet water quality treatment goals. The five groups are:

1. Ponds
2. Stormwater wetlands
3. Infiltration practices
4. Filtering systems
5. Open channel systems

The details in the Stormwater Management Design Manual include descriptors identifying individual features of each SMP.

Apply Alternative Stormwater Management Practices to Address Remaining Water Quality Volume (from Areas of Redevelopment)

Stormwater Management Practices that are considered "Alternative Practices" are listed on the NYSDEC website at http://www.dec.ny.gov/chemical/29089.html, and are not acceptable for treatment of stormwater runoff from areas of new development, but can be used to meet pretreatment requirements for standard practices, or as primary treatment for areas undergoing redevelopment.

Apply a Combination of Standard and Alternative Stormwater Management Practices with Impervious Cover Reduction to Address Remaining Water Quality Volume (from Areas of Redevelopment)

The remaining water quality volume requirements can be met by using a combination of impervious cover (IC) reduction of the existing impervious areas and the use of standard and/or alternative practices to treat the runoff from the replaced impervious areas, using the following equation:

Step 5: Apply Volume and Peak Rate Control Practices

The SPDES General Permit for Construction Activity requires the extended detention of the volume associated with the one-year, 24-hour storm event (Channel Protection Volume), and post-construction attenuation of the 10-year, 24-hour (Overbank Flood Control) and 100-year, 24-hour (Extreme Flood Control) storm events to the pre-construction site conditions. Designers are required to analyze both the pre- and post-construction site conditions to address the water quantity requirements, when practicable, using downstream analysis, detention, retention, infiltration practices, or green infrastructure strategies.

Stream Channel Protection Volume (Cpv)

The Stormwater Management Design Manual requires that the Channel Protection Volume (Cpv) within each drainage area be detained for a 24-hour period (or 12-hour detention if water discharges to a classified trout stream). The 24-hour extended detention period is a period of detention of stormwater intended to reduce the potential for streambank erosion downstream from stormwater discharge points.

Overbank Flood Control (Qp)

If the project requires coverage under the SPDES General Permit for Construction Activity, the Overbank Flood Control, Qp, (from the 10-year, 24-hour storm event) must be attenuated within each drainage area to the pre-construction discharge rates.

Extreme Flood Control (Qf)

If the project requires coverage under the SPDES General Permit for Construction Activity, the Extreme Flood Control, Qf, (from the 100-year, 24-hour storm event) must be attenuated within each drainage area to the pre-construction discharge rates.

Downstream Analysis

A downstream analysis should be conducted for each discharge point if there is an increase in post construction peak flow rates over the pre-construction rates for the 10 (Qp) and 100 (Qf) year flood events.

5.3 Recommendations

The following recommendations related to New York State Standard Guidelines should be considered by the City as part of a Green Infrastructure Initiative Program:

- Adopt New York State guidance documents on green infrastructure into the City's Land Use Ordinances:
    - Green Infrastructure Practices – New York State Stormwater Management Design Manual
    - Green Infrastructure Practices – New York State Department of Transportation

6 Maintenance Program

Overview

A key component to the longevity and success of GI is a thorough maintenance program. When gray infrastructure is poorly maintained, sediment buildup reduces the storage capacity resulting in a decrease in performance; similarly, when GI is poorly maintained, its ability to reduce runoff is also decreased. GI provides volume reduction primarily through uptake by vegetation, infiltration into the subsoil or retention in soil pores; as such it is critical that GI is properly maintained to ensure plant establishment and survival and the preservation of soil permeability. Additionally, routine maintenance can extend the life of the GI system and prevent costly repairs.

A maintenance plan for GI includes specific maintenance tasks and schedules, cost estimates, and identifies the entities responsible for the maintenance. This chapter describes components necessary for an effective GI maintenance plan.

6.1 Maintenance Considerations

Maintenance considerations vary for each type of GI practice and a specific maintenance program should be tailored for each installation. Maintenance responsibilities, inspection frequency, and costs should be evaluated during the design phase of each GI practice. Because of the different types of maintenance needs for each GI practice, annual maintenance costs and replacement costs should be included in any evaluation of the feasibility of GI. To ensure the proper performance of the GI practice, maintenance plans should identify responsible parties over the lifetime of the GI practice and put in place, as necessary, to ensure proper and regular maintenance of GI.

Throughout the lifetime of the GI practice, different types of maintenance are expected based on the current performance of the GI practice, age of the assets, environmental factors and other possible unexpected circumstances. The different types of maintenance can be categorized into reactive, predictive and proactive maintenance. Reactive maintenance occurs as a response to an unexpected circumstance. These incidents could be the result of an environmental impact such as a large storm or snowfall, a complaint, or an emergency or unexpected decrease in performance of the system. Although a specific expense and/or time allocation may be difficult to predict, a standard cost should be integrated into the maintenance plan for reactive maintenance situations. Predictive maintenance is the periodic maintenance that is expected over the lifetime of a GI program. This type of maintenance is driven by inspections and performance indicators included in the maintenance plan. These activities can be seasonal or scheduled. Lastly, proactive maintenance are measures that are adapted based on the performance and familiarity to the GI program. This type of maintenance is adapted over the lifetime of the GI program and should be continuously updated in the maintenance plan. Proactive maintenance can help to decrease the instances of reactive and predictive maintenance by identifying potential problem areas of the system and the need for additional predictive maintenance. High priority should be given to proactive maintenance to understand the function of the system, the predictive maintenance required and possible avoidance of certain types of reactive maintenance. Each type of maintenance should be included and addressed in the GI maintenance plans.

6.2 Development of a Maintenance Plan

The development of a maintenance plan is essential to the successful implementation of GI over time. The maintenance plan should identify the considerations mentioned in the above sections specifically, the organizations or individuals responsible for maintenance activities, specific agreements between owners and agencies, the design and intent of the GI, the training required to be able to successfully implement a maintenance plan and estimated costs. In addition to these considerations, the maintenance plan should identify the following items based on the type of GI being utilized:

- Identification of responsible party for maintenance
- Type of maintenance to be performed
- Cost of replacement components/parts (i.e. vegetation, porous pavement, sand) and where to procure replacement components.
- Inspection & maintenance schedule (Including frequency)
- Training required
- Personnel and equipment needed
- Additional considerations such as overall design, location and land use

Additional details are outlined in the next section for various types of maintenance needs required for each type of system. The typical maintenance discussed in this document are general, detailed maintenance needs should be found in the maintenance manual for each GI Project.

The frequency of maintenance can be significantly reduced by adding components to the design to address issues that are likely to occur based on the location of the GI practice or the nature of the inflow. For example, for those practices that collect runoff from roadways and sidewalks, such as rain garden bump outs or bioretention islands, the addition of filter bags at the upstream end can significantly reduce the amount of trash, debris or excess sediment that enters the system. For those GI practices that are expected to receive flow either from large drainage areas or areas with significant slopes, the inclusion of a rip rap apron at the entrance of a system that reduces runoff velocity can significantly reduce erosion and washouts of the GI practices.

Specific maintenance plans should be developed based on the intended use and expected performance of each system. Outlined below are typical maintenance procedures for various types of GI assets. Inspections and maintenance specification should not be limited to these recommendations. General, routine, protocols for all types of GI are as follows:

- All components of a system used to collect/trap sediment and debris should be inspected for clogging after every storm event exceeding one inch of rain or at least quarterly.
- Debris removed from these systems should be properly disposed of per local, state and federal guidelines.
- The inspection of all structural components, such as inlets, outlets, curb cuts, manholes etc., at least annually for cracking, spalling, erosion and deterioration.
- GI practices should not be used for stockpiling of snow or ice, compost or any other material.

More frequent maintenance and inspection may be prudent in the first year after installation to gain a greater understanding of site specific maintenance needs.

6.3 Example Protocols for Different Types of GI

6.3.1 Bioretention Systems

Bioretention systems include GI practices such as bioretention basins, rain gardens, downspout planter boxes, stormwater planters, bioswales and enhanced and continuous tree pits. General maintenance for a bioretention system includes:

- Inspection of underdrains should be completed after every storm event exceeding one inch of rain or at least quarterly.
- Excess sediment removal should occur when the system is dry.
- Additional inspections should be made to the structural components such as catch basins, inlets, sediment traps, observation wells, clean-outs and domed risers for potential clogging.
- Access points for maintenance are required for all inaccessible portions of a bioretention system. Additional details regarding the access points and any specific equipment or training, such as confined space entry, should be outlined in the maintenance plan.
- Any clogged underdrains should be cleaned out using jetting or vacuuming through cleanouts and/or inlets. Vacuum trucks may be required to remove debris through long runs of pipe or extremely clogged systems. Access for vacuum trucks to the system should be considered during the design of the system.
- During planting or restoring vegetation, bi-weekly inspections are required.
- Inspection of the vegetation should occur bi-annually to ensure the health of the existing vegetation and identification of any invasive species.
- Mowing and trimming of vegetation should be performed regularly based on the design of the system.
- The percentage of vegetative cover should be evaluated regularly, and additional plantings should be scheduled during any decreasing percentages that are noted.
- Care should be taken when utilizing fertilizers and pesticides to not diminish the function of the system.
- The infiltration rate of the system should be inspected bi-annually, preferably during the growing season and non-growing season. An estimated time for the system to drain as specified as part of the design of the system and in the maintenance plan for proper assurance. If there are indications of ponding or the system does not fully drain within 72 hours, corrective action should be taken.

6.3.2 Pervious Pavement

- The surface course of pervious pavement should be evaluated for cracking, subsidence, spalling, deterioration, erosion and growth of unwanted vegetation at least annually.
- Care should be taken to not damage the pavement when removing snow from the surface.
- If sediment is noticed on the surface of the system, care should be taken to remove the sediment when dry.
- The surface course of any porous pavement system should be vacuum swept at least four times a year. Each vacuum should be followed by a high-pressure hosing.

6.3.3 Vegetated filter strip

- Excess sediment removal should occur when the system is dry.
- The filter strip should be inspected for any areas of excess ponding after large storm events. Corrective action should be taken if ponding is noted.

- Bi-weekly inspections are required during planting and restoring vegetation.
- Inspection of the vegetation should occur bi-annually to ensure the health of the existing vegetation and identification of any invasive species.
- Mowing and trimming of vegetation should be performed regularly based on the design of the system.
- The percentage of vegetative cover should be evaluated regularly, and additional plantings should be scheduled during any decreasing percentages that are noted.
- Care should be taken when utilizing fertilizers and pesticides to not diminish the function of the system.
- The infiltration rate of the system should be inspected bi-annually, preferably during the growing season and non-growing season. An estimated time for the system to drain as specified as part of the design of the system and in the maintenance plan for proper assurance. If there are indications of ponding or the system does not fully drain within 72 hours, corrective action should be taken.

6.3.4 Green roofs

- The percentage of vegetative cover should be evaluated regularly, and additional plantings should be scheduled during any decreasing percentages that are noted.
- Care should be taken when utilizing fertilizers and pesticides to not diminish the function of the system.
- The drainage system of the roof should be inspected regularly to identify any clogging that might cause ponding across the system.

6.3.5 Cisterns

- Access points for maintenance are required for cisterns. Additional details regarding the access points and any specific equipment or training, such as confined space entry, should be outlined in the maintenance plan.
- Access points, inlets, outlets and storage areas should be inspected for trash and sediment accumulation monthly for the first year and at least annually for the remaining life of the system.
- The inside surfaces should be brushed and disinfected at least annually.
- Prior to freezing weather, the system should be winterized per manufacturer recommendations.

6.3.6 Tree plantings

- New plantings should be watered until the root system spreads. Watering should occur daily for at least two weeks following installation. Watering should occur once a week following the first two weeks until the tree is established.
- Replace surrounding mulch as needed based on annual inspections
- Care should be taken when utilizing fertilizers and pesticides to not diminish the function of the system.

6.3.7 Grass swales

- Excess sediment removal should occur when the system is dry.
- Bi-weekly inspections are required during planting and restoring vegetation.

- Inspection of the vegetation should occur bi-annually to ensure the health of the existing vegetation and identification of any invasive species.
- Mowing and trimming of vegetation should be performed regularly based on the design of the system.
- Grasses should be mowed with care to sustain the required grass height range of 3 to 6 inches.
- Grass clippings should be kept to a minimum or removed to avoid possible damage to the system and prevent mosquito breeding.
- The percentage of vegetative cover should be evaluated regularly, and additional plantings should be scheduled during any decreasing percentages that are noted.
- Care should be taken when utilizing fertilizers and pesticides to not diminish the function of the system.
- If there are indications of ponding 72 hours after a storm event, corrective action should be taken to reestablish the appropriate slope and/or permeability rate of the soil bed as per the original design.

6.3.8 Infiltration Basins

- Excess sediment removal should occur when the system is dry.
- Access points should be established during the design of the infiltration basin. These access points should be clearly noted on all maintenance plans. These access points should be inspected at least once annually.
- Any clogged underdrains should be cleaned out using jetting or vacuuming through cleanouts and/or inlets. Vacuum trucks may be required to remove debris through long runs of pipe or extremely clogged systems. Access for vacuum trucks to the system should be considered during the design of the system. The infiltration rate of the system should be evaluated bi-annually to determine if the permeability of the system has decreased. An estimated time for the system to drain should be noted in the design of the system and in the maintenance plan for proper assurance. If there are indications of ponding or the system does not fully drain within 72 hours, corrective action should be taken.

6.3.9 Sand Filters

- Excess sediment removal should take place when the sand bed is dry.
- For vegetative areas, bi-weekly inspections are required during planting.
- Inspection of the vegetation should occur bi-annually to ensure the health of the existing vegetation and identification of any invasive species.
- Mowing and trimming of vegetation should be performed regularly based on the design of the system.
- The percentage of vegetative cover should be evaluated regularly, and additional plantings should be scheduled during any decreasing percentages that are noted.
- Care should be taken when utilizing fertilizers and pesticides to not diminish the function of the system.
- The infiltration rate of the system should be inspected bi-annually, preferably during the growing season and non-growing season. An estimated time for the system to drain as specified in the design of the system should be included and in the maintenance plan for proper assurance. If there are indications of ponding or the system does not fully drain within 72 hours, corrective action should be taken.

6.3.10 Dry Wells

- Access points should be established during the design of the dry well. These access points should be clearly noted on all maintenance plans. These access points should be inspected at least once annually.
- The infiltration rate of the system should be evaluated bi-annually. An estimated time for the system to drain as specified in the design of the system should be included and in the maintenance plan for proper assurance. If there are indications of ponding or the system does not fully drain within 72 hours, corrective action should be taken.

6.4 Maintenance Agreements

Municipal ordinances should include the assignment of maintenance responsibilities as part of the approval process. The storm water management maintenance agreement should be signed and included with the record plan and included with the development of any property deeds. Maintenance responsibilities would be transferrable with the sale of the property.

An essential aspect of the success of a GI maintenance program is identifying the owner or agency responsible for maintaining the system. Usually the maintenance responsibility falls to the owner of the system, though other agencies can also take that responsibility. If a different agency other than the owner is identified as responsible for the maintenance of the system, an agreement needs to be established between the owner and responsible party. In these circumstances, the person responsible and any revisions made throughout the life of the program must be recorded in the deed of record for each property on which the maintenance occurs. During the initial phase of the program, consideration should be made to the responsible party's understanding and capabilities of performing the maintenance required for the system along with the possibility of ownership transfer over the lifetime of the program. There should also be an identification of the funding source for the required maintenance.

6.4.1 Types of Maintenance Agreements

- Ownership Maintenance Agreements – Public

  Ownership maintenance agreements are often for public agencies. Public ownership usually includes ownership by a governmental entity (e.g., municipality) or public authority (e.g., sewerage authority). These groups are often directly responsible for the installation of the system and have a general knowledge of the system's goals and function. This firsthand knowledge can provide for a successful maintenance program to be implemented throughout the lifetime of the project.

- Ownership Maintenance Agreements – Private

  Ownership maintenance agreements can also be for private entities. Examples of private ownership can include commercial developers, homeowner associations, or private individuals. An evaluation of the capabilities of private owners should be established early in the program and appropriate training should be provided when needed. Specific consideration should be made to determine if the owner understands the expected performance and design goals of the system, maintenance needs and costs required over time.

- Non-ownership Maintenance Agreements

  Instances can occur where the maintenance of the program differs from the owner such as a municipality maintaining the GI within its boundaries that are owned by the County. In these circumstances a maintenance agreement is essential. The maintenance agreement should include details on the types of maintenance to be performed and by whom, define access requirements, and identify details on the organization or individual responsible for the maintenance costs and eventual cost of replacement.

6.4.2 Enforcement of Maintenance Agreements

The enforcement of maintenance agreements should be the responsibility of the government agency approving the design and implementation of the GI plan. Additionally, the person responsible for maintenance of a system shall make available, upon request by any public entity with administrative health, environmental or safety authority over the site, the maintenance plan, applicable agreements and documentation such as inspection logs. These government agencies described in the section above retain the right to access the property with which the GI practice is installed to verify that proper maintenance and upkeep is met. In instances where maintenance needs have not been met over time, the government agency is permitted to intervene and ensure the problems are corrected.

6.5 Recommendations

The following recommendations related maintenance should be considered by the New Rochelle as part of the GI Implementation Program:

- Following the installation of GI, a maintenance plan should be adopted that highlights the following key points to serve as a guidance and supporting documenting for initiating any GI funding mechanism described in Chapter 9 of this report
    - Maintenance requirements for GI
    - Maintenance equipment requirements for GI
    - Maintenance material requirements for GI
    - Maintenance labor requirements for GI
- Establish a maintenance tracking system for new GI using GIS or another similar database.
- Maintenance on City projects should be budgeted and the responsibility assigned to the appropriate department with the understanding that if the department’s staff are fully utilized, this may result in the need for additional man power through new hires or contracting the maintenance responsibilities to a contractor.
- Monitoring maintenance on private property would be undertaken by code enforcement.

7 Local Department Capabilities

Overview

New Rochelle has several existing departments that can utilize GI practices for stormwater management. This section provides a summary of those GI practices as well as suggestions for potential improvements to strengthen those programs. In addition, recommendations for new programs are provided to help the City further integrate the GI practices and to meet the Town's goals and objectives.

7.1 Department of Public Works

The Department of Public Works (DPW) is the main department that are involved with operations and maintenance (O&M) of City's infrastructure. The DPW has several different divisions including:

- Bureau of Sewers & Drains
- Bureau of Engineering
- Bureau of Forestry
- Bureau of Sanitation
- Bureau of Streets & Highways
- Traffic Services Division

Bureau of Sewers & Drains Programs

The Bureau of Sewers & Drains is responsible for maintenance, cleaning, and repair of sewer and drain lines, pump stations, catch basins, brooks and facilities. Maintenance responsibilities include:

- 192 miles of sewer pipe
- 87 miles of drainage pipe
- Over 5500 catch basins
- Over 5700 sewer and drainage manholes

The City of New Rochelle constantly works on improving the performance of the City-owned stormwater system and monitors privately-owned facilities including parking lots. Conditions of some 30 outflows discharging runoff waters to the Long Island Sound are checked, sporadically controlled, and some debris is intercepted to prevent pollution of receiving waters.

Bureau of Engineering Programs

The Bureau of Engineering performs all necessary engineering services regarding Public Works projects, capital improvements, and related projects. The Bureau of Engineering reviews plans submitted to the Planning and Zoning Boards, as well as reviews permit applications for construction within the right-of-way, including on curbs, sidewalks, sewers, or drain lines.

Bureau of Forestry Programs

The Bureau of Forestry is responsible for trees located with the public right of way, tree removal on private property, and tree planting within the right of way.

Bureau of Sanitation Programs

The Bureau of Sanitation is responsible for the collection of garbage, bulk trash and other refuse from:

- Private Residences
- Commercial establishments on a restricted basis
- City litter cans and baskets located in business areas
- Apartment buildings

Over 36,000 tons of garbage are collected each year and over 20,000 tons of material is recycled each year. Staff and equipment from this Bureau are also used to plow streets during snowfall

Bureau of Highways & Streets Programs

The Bureau of Highways & Streets is responsible for mechanical sweeping of streets, maintenance and repair of roads, construction and maintenance of parking lots and traffic dividers, collection of leaves, collection of residential yard waste, control of snow and ice, removal of dead animals, roadside maintenance, structural work, painting, etc.

Traffic Services Division Programs

The Traffic Services Division is responsible for the replacement or repair any road sign (STOP, Curve, etc.) and road name signs that are located along City streets.

7.2 Municipal Maintenance Capabilities

To successfully implement a GI program, the City of New Rochelle must be able to maintain those GI improvements that they are responsible for the maintenance of. As previously mentioned, public ownership is ownership by a governmental entity (e.g., municipality), in this case the City of New Rochelle.

All maintenance personnel shall possess the appropriate training and experience to undertake the specific maintenance tasks required. Personnel operating equipment must be licensed and/or certified to operate said equipment. Personnel should be trained in the following:

- Basis description of purpose and function of GI infrastructure
- Major components of GI infrastructure
- Safety equipment and procedures
- Specialized training for inspection and maintenance tasks, on a case by case basis for certain GI measures, as required.

The manpower/labor, equipment, and resources required to maintenance GI is specific to the types of GI installed, and the quantity of GI infrastructure. Additionally, the list of maintenance equipment required is tied to the specific list of GI utilized. The following is a list of the most common equipment required for the municipality to maintain GI infrastructure:

- Jetting or vacuuming equipment
- Vacuum trucks
- Mechanical Sweeper
- Mowing Equipment
- Trimming Equipment

- Vacuum sweeping equipment
- High pressure hosing equipment
- Winterization of Cisterns
- Small Backhoe/Mini-excavator
- Leaf Blower
- Wood Chipper
- Hoses
- Tools –Chainsaw, Hammer, Crowbar, Pliers, Rakes, Shovels, etc.

The following is a list of the most common materials required for the municipality to maintain GI infrastructure:

- Clean Stone
- Sand
- Engineered Soil
- Replacement Vegetation
- Mulch
- Fertilizers and Pesticides
- Plastic Contractor Bags
- Cleaners

Resources, and lack thereof, for maintenance of GI systems must be considered. The City can undertake short term GI maintenance, due to the limited GI infrastructure currently in place which would require few work hours and personnel to complete. However, as GI infrastructure is constructed, more staff, time (work hours) and resources will need to be devoted toward GI maintenance. Overtime, dedicated funding staff will be needed to ensure that resources for GI maintenance are available and are not diverted to other municipal functions and departments. Potential funding mechanisms for a dedicated funding staff for GI maintenance is described in section 9.4.

One such way to off-set the GI maintenance needs, as they grow in the long-term, is to enlist the help of volunteer organizations within the City. Additional methods for funding GI maintenance are described in section 9.4.

When utilizing City staff for GI maintenance, consideration should be given to the type of GI, its location and maintenance needs when assigning staff. For example, parks staff might be more experienced in vegetation management whereas the public works department are more experiences in sediment removal, and have the equipment needed to complete the work.

7.3 Recommendations

The following recommendations related to land use and planning techniques should be considered by the City of New Rochelle as part of the Green Infrastructure Program:

- It is recommended that one department take the lead to integrate GI practices for stormwater maintenance within their current duties. This can be expanded on a yearly basis to include more departments and revised as needed with the understanding that if the department’s staff are fully utilized, this may result in the need for additional man power through new hires or contracting the maintenance responsibilities to a contractor. Department capabilities may be contingent upon funding being made available.

- Administer and enforce code changes by municipal officials including but not limited to the zoning official, construction code official, city planner, and city engineer.
- Engineering Department to lead in the incorporation of the evaluation into City projects. This task may be assigned to consultants retained for larger projects.

8 Cost Benefit Overview

Cost Benefit Overview

A key benefit of GI is that it can effectively increase the overall capacity of an existing storm sewer system to improve resiliency during significant storm events. However, assessing benefits with a dollar amount does not represent a complete picture. To address this gap, a benefit analysis should consider some of the additional benefits that are unique to GI. Benefits that are most valuable to the community should be considered. For example, this may include:

- Improve air quality
- Reduce carbon emissions
- Reduce heat island effect
- Property value uplift
- Economic water quality
- Energy savings
- Recreational improvements
- Reduce surface flooding

The benefits with GI are extensive. However, it is not possible to place a monetary value on all of them. These intangible benefits should be identified and be incorporated into decision making processes.

The project cost of GI requires an assessment of capital, operation and maintenance, and replacement costs, often referred to as life-cycle costs. While initial construction costs are a starting point, they are just a small piece of the big picture. Operation and maintenance of a GI plan is a vital component for success and overall effectiveness, thus the associated costs must be considered. Planning, design, and construction services costs for GI must also be incorporated when determining total capital costs. While efforts should be made during planning, design, and construction to maximize the useful life of GI practices, eventual replacement will be necessary, therefore, costs for replacements must also be added to the analysis.

To determine GI life-cycle costs a time-frame must be selected to perform the analysis, typically ranging from 20 to 50 years. Capital costs are a one-time investment, while operation and maintenance and replacement costs are reoccurring items throughout the time-frame of the analysis. These costs should then be compared to the additional environmental, economic, and social benefits provided by GI when making decisions.

8.1 Capital Costs

Capital costs are defined as the fixed, one-time expenses to bring a project to completion which include the cost of the land, construction, and design. Capital costs also typically include an appropriate contingency based on the planning or design level of the project. There is not a single way to represent capital costs for GI. Depending on the approach, one or a combination of the representations can be utilized throughout the cost benefit analysis. The following are common ways to represent capital costs for GI practices that have been used by others:

- Unit Cost per Square Footage of GI Practice ($/SF GI Footprint)

- Unit Cost per Square Footage of Drainage Area Managed ($/Acre Managed)
- Unit Cost per gallon of Stormwater Volume Captured ($/Gal Captured)
- Unit Cost per gallon of Overflow reduced ($/Gal OF Reduced)

The representations can be used for a comparison to gray infrastructure and other alternatives or to compare amongst different types of GI practices.

The unit costs of GI practices can vary based on location, site characteristics, amount of stormwater managed, and design limitations. For example, a bioretention system in front of a municipal building or in the center of town may need a more aesthetically pleasing appearance as compared to one that is hidden from public viewing even though they are designed to manage the same volume of stormwater. A more aesthetically pleasing system may require more design time to incorporate a visually appealing vegetative cover. Another example is a pervious paving system installed in an area with soils that drain poorly, which would require additional design features such as underdrains, compared to a pervious paving system installed in well drained soils. These factors should be considered while locating and assessing feasibility of GI and should be carried over into cost estimating.

Approximate Construction Costs for GI Practices

GI Practice	Low Range Cost ($[1]/Acre Managed)	High Range Cost ($[1]/Acre Managed)
Bioretention	$299,000	$449,000
Permeable Paving Systems	$232,000	$348,000
Enhanced Tree Pits	$305,000	$458,000
Green Roofs	$792,000	$1,200,000
Infiltration Systems	$132,000	$198,000
Combination of GI Practices	$248,000	$371,000

Source: PWD Green Projects, Philadelphia, PA (Construction Costs)

[1] *In 2017 dollars*

Refer to the following references for more detail regarding unit cost ranges for GI:

- The University of New Hampshire Stormwater Center
- San Francisco's LTCP Technical Memorandum No. 807
- The Center for Technology's Green Values National Stormwater Management Calculator

Diminishing returns for GI refers to a point at which the amount of rainfall captured becomes less cost-effective. Designing GI to capture large storm events is often less cost effective since there will be unused storage for most storm events. GI sized for the 2-year storm, for example, will utilize its full storage approximately once every two years on average. GI sized for even larger storms will utilize their full storage even less frequently. Usually, sizing GI for a larger design storm will increase the cost of the GI practice. Considering that most GI programs will not have unlimited funds and that additional storage for higher storm events will be utilized less frequently, it may be less cost effective than spending that same money on additional GI installations that are sized for smaller, more frequent storm events. A GI practice sized for 1.0" of rainfall would be sized to manage about 80% of the rain events in an average year, which may represent a good starting point for determining the point of diminishing returns.

8.2 Operation and Maintenance Costs

As with all constructed infrastructure, operation and maintenance is necessary for installed GI practices to perform as designed. One approach will require a determination of total footprint of each GI practice being employed throughout the plan. As the footprint of each GI practice increases as more implementation occurs each year, the annual O&M costs of the entire GI program will increase accordingly. This must be accounted for to provide an accurate analysis for the desired time-frame.

Typical Annual O&M Costs per GI Practices

GI Practice Type	Typical Annual O&M Cost (Cost/acres/yr.)	Typical Annual O&M Costs as a Percentage of Capital Cost (%)
Bioretention Systems[1]	$2,250	8
Pervious Pavement, specifically Porous Asphalt[1]	$1,250	4
Vegetative Filter Strip[2]	$1,250	60
Green Roof, specifically Extensive Green Roof[3]	$5,250	1
Cisterns	Based on manufacturer recommendations	N/A
Grass Swales, specifically Vegetated Swale[1]	$1,000	6
Infiltration Basin[2]	$600	20
Sand Filter[1]	$3,000	19

Sources:
[1]Houle et al, "Comparison of Maintenance Cost, Labor Demands, and System Performance for LID and Conventional Stormwater Management," *Journal of Environmental Engineering* July 2013: 932-938.
[2]State of Delaware and DNREC, "Appoquinimink River Watershed Plan" February 2011 http://www.dnrec.delaware.gov/swc/wa/Documents/AppoPCSdocs/Appendix%20E%20-%20Cost%20Calculations.pdf
[3]A Report of the United States General Services Administration "The Benefits and Challenges of Green Roofs on Public and Commercial Buildings" May 2011 https://www.gsa.gov/portal/mediaId/158783/fileName/The_Benefits_and_Challenges_of_Green_Roofs_on_Public_and_Commercial_Buildings

Since there are variations in GI design and local conditions that affect operation and maintenance, a bottom-up cost estimate for annual operation and maintenance should be performed. This approach should evaluate the operation and maintenance procedures, length and frequency for each procedure as well as local material, equipment, and labor costs.

8.3 Replacement Costs

Once a GI practice reaches the end of its useful life, many of the components will need to be rehabilitated or replaced. The lifetime expectancies can vary based on design and location.

Typical Life Expectancy Ranges for GI Practices

GI Practice Type	Life Expectancy (years)
Bioretention[4]	30
Pervious Pavement [4]	30
Vegetative Filter Strip[4]	30
Green Roof[4]	30

GI Practice Type	Life Expectancy (years)
Cistern[5]	20-50 depending on material type
Tree Plantings[4]	40
Grass Swales[4]	30
Infiltration Basins[4]	30
Sand Filters[6]	Filter media needs to be replaced about every 5 years
Dry Wells	15

Sources:
[4] *"Save the Rain Program, GI Maintenance Manual" Onondaga County, NY April 2013.*
[5] *Environmental Services City of Portland "Cisterns" July 2006 https://www.portlandoregon.gov/bes/article/127468.*
[6] *Urbonas, Ben R. "Stormwater Sand Filter Sizing and Design a Unit Approach" http://uwtrshd.com/assets/sand-flt-paper.pdf*
[7] *Maine Department of Environmental Protection "Maine Stormwater Management Design Manual, Technical Design Manual Volume III" May 2016 http://www.maine.gov/dep/land/stormwater/stormwaterbmps/vol3/chapter6.pdf*

8.4 Marginal Costs of Green Infrastructure

The difference in cost with replacing a conventional component of a project with GI (e.g. permeable asphalt instead of conventional) is known as the marginal cost. Since the marginal cost is lower than the cost to perform a standalone project, incorporating GI as part of other construction projects can provide a cost-effective approach to implementation. In determining the cost effectiveness, it is important to include the benefits associated with the GI component of the project. Thus, one would compare the marginal cost of the GI component to the benefits achieved from the GI component of the project. In such a comparison, the benefits achieved compared to those costs will likely be significantly higher than the benefits achieved compared to the cost of a separate standalone GI project. In fact, the monetary value of the benefits may exceed the marginal cost of the GI project when it is incorporated into another construction project.

The following are examples of how GI can be incorporated as part of other construction projects and required capital improvements:

- Paving a parking lot with permeable asphalt rather than conventional asphalt
- Replacing antiquated pedestrian walkways with a pervious paving system (pervious concrete or interlocking pavers) rather than conventional concrete
- Integration of GI within sidewalks/roadways when streets are replaced during water main and sewer replacement projects
- Integration of GI into state department of transportation plans for new/replacement pedestrian areas and roadways
- Upgrading a street with integrated GI such as tree pits, bioretention, and permeable paving systems rather than a conventional street replacement
- Utilizing bioretention curb bump-outs as a traffic calming strategy
- Constructing a bioretention basin rather than a conventional detention basin
- Incorporating small-scale bioretention features into park improvements
- Utilizing native landscaping and soil amendments for a proposed open space
- Replacing an antiquated roof with a green roof rather than traditional roof replacement
- Enhancing an existing tree pit to capture more stormwater

The Milwaukee Metropolitan Sewer District (MMSD) Regional GI Plan compared the costs of installing GI practices in lieu of conventional replacements to installing as stand-alone projects. For green roofs, the marginal cost was estimated to be 43% of the stand-alone cost. For bioretention and porous pavement, marginal cost was estimated to be 70% of the stand-alone cost.

The Case Study for the City of Lancaster, Pennsylvania concluded that the marginal cost for including GI in a 25-year implementation plan is estimated to be $77 million compared to the stand-alone estimation of $141 million. In other words, incorporating GI into other construction projects could reduce the cost of implementing the plan by 45%.

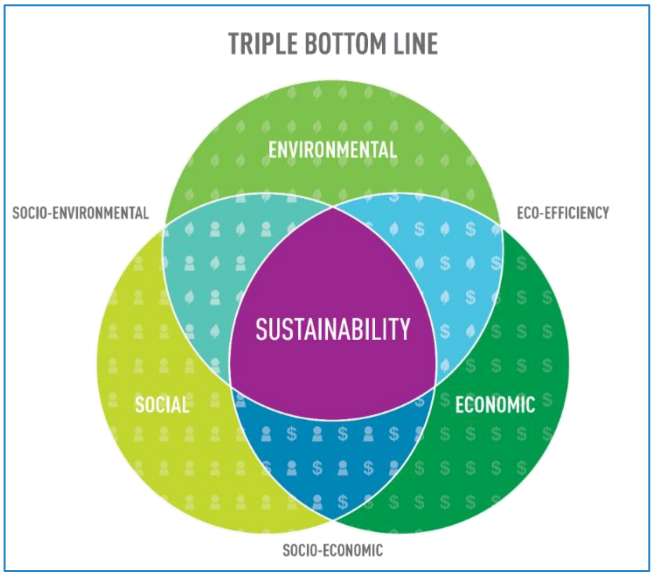
Economies of Scale

Economies of scale is a concept where cost savings can be achieved as the scope of construction increases. In construction, some examples are the ability to purchase materials in bulk, reducing number of mobilizations, and improving efficiency of labor. As savings can be achieved through incorporating GI into other capital improvements, savings can also be gained as GI practices are implemented on a larger scale. A single GI practice will have a small effect on storm water volume reduction, however, many practices installed throughout a storm sewer system can have a cumulative effect, resulting in a significant impact on volume reduction. Thus, GI installed as part of a long-term control for stormwater volume reduction will likely see the benefits of economies of scale due to the need for large scale implementation. Additionally, GI is a relatively new endeavor and may be unfamiliar to contractors. As familiarity rises amongst contractors, construction costs of GI may potentially decline.

8.5 Benefits of Green Infrastructure

The benefits associated with GI can either be economic, social, or environmental. Simply comparing the capital costs of green vs. gray infrastructure does not provide the complete picture for decision makers, the public, and ratepayers. The numerous added benefits of GI are expansive; however, many can be difficult to assign a dollar value. The collection of these benefits is known as the triple bottom line (TBL).

Triple Bottom Line Analysis



A TBL analysis is a crucial component in making an informed decision. The TBL benefits will benefit the overall community and the ratepayers. It is important that the TBL benefits be examined in the decision-making process for GI. Below is a list of benefits expected with GI implementation. This list is not intended to be exhaustive, and local communities may identify additional TBL benefits that they may want to quantify:

Economic

- Reduces energy usage for heating and cooling
- Increases property values
- Increases rent or lease prices
- Increases retail sales
- Creates "green" jobs
- Optimizes scale of gray or traditional infrastructure

Social

- Improves aesthetics and quality of life
- Increases recreational opportunities
- Reduces noise pollution
- Promotes public cohesion and education
- Increases urban green spaces
- Reduces stress
- Reduces urban heat island effect

Environmental

- Improves water quality by reducing pollutant loadings
- Improves air quality
- Reduces carbon emissions

- Increases groundwater recharge
- Reduces surface and basement sewage flooding
- Reduces salt use (permeable paving systems impeded frost layers forming)
- Provides wildlife habitat

There are several benefit calculation methods, as well as, different calculation software commercially available to help quantify TBL benefits. It is encouraged to become familiar with the available software and calculation methods. One example, is the Envision™ framework which is becoming an increasingly used and industry-wide approach to evaluating TBL benefits. Utilizing this defined rating system allows users to evaluate a project according to a common sustainability framework. Then TBL companion software to Envision™, such as AutoCase or other examples, may be used to quantify the associated TBL benefits. In some cases, custom calculations may need to be used specific to the local community. Representing these benefits as a monetary value can vary in complexity and may first require a general approach:

Step 1: Quantify the Benefit

- Calculate the quantity of the benefit, typically on an annual basis. For example:
  - Volume of stormwater reduced each year
  - Number of GI related jobs created each year
  - Number of acres of impervious area managed by GI
  - Number of acres of GI practices to be implemented
  - Acres of increased urban green spaces

Step 2: Determine Procedure to Monetize the Benefit

- Determine the procedures for calculating the monetary value of the benefit. For example:
  - The economic value of increased jobs
  - Reduction in air pollution and carbon emissions costs
  - Reduction in cost damages from reduced surface and basement sewage flooding
  - The social value of increased green spaces

Step 3: Calulate the Monetary Value of the Benefit

- Using the information determined in steps 1 and 2, a monetary value can be estimated. As discussed, commercial software is available to calculate monetary values of the TBL benefits or manual calculations can be performed.
- A summary of the overall TBL benefits, both monetized and non-monetized, where applicable, should then be provided.

A variety of benefits should be evaluated to accurately depict the monetary benefits that can be seen with the implementation of GI. While addressing computation methods for all the benefits listed is beyond the scope of this guidance document, assessment of the following benefits is suggested and is discussed below.

8.5.1 Air Quality Improvement and Carbon Emissions

GI, most notably vegetated practices, can sequester carbon and remove air pollutants from the air. This removal of air pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), and fine particulate matter with diameters 2.5 micrometers of less ($PM_{2.5}$) provides environmental and social benefits. Additionally, GI can provide reductions in energy usage by reducing surrounding air temperatures or providing insulation, thus resulting in avoided electricity, natural gas, propane, and diesel; which also contribute to reductions in carbon and air pollutant emissions and improvement in air quality.

8.5.2 Heat Island Mortality Reduction

GI can reduce temperatures in urban environments by replacing impervious covers with vegetation. The reduction in heat can be estimated as well as the avoided deaths over the length of the project from the heat reductions. Utilizing the EPA's Value of Statistical Life (VSL) Method which assigns value to lives saved, a financial benefit can be determined.

8.5.3 Recreational Use Benefit

GI projects that provide additional green space for recreational use provide an added social benefit to the community. By estimating the increased total user days after implementation and multiplying this value with the Willingness to Pay (WTP) of users, a benefit can be calculated. Upon implementation, these numbers can be improved with actual survey data or site specific recreational usage data. It should be noted that only GI that increases recreational usage should be quantified. For example, bioretention in a parking lot island does not increase recreational space.

8.5.4 Property Value Uplift

Managing runoff from impervious surfaces and improving aesthetics can provide an increase in property value; an economic benefit to the community. To assess property value increase, the following information needs to be obtained:

- City population
- Average persons per household
- Average property value
- Total acres of GI
- Total acres of city area

This information can be used to determine a scaling factor represented as a ratio of GI practice footprint to city area. Double counting of value uplift can occur when accounting for other TBL benefits, so accounting for this appears to be standard procedure when performing this calculation. Others have assumed a 50% discount rate in the property value uplift calculation to avoid double counting.

Summary of Impacts on Property Prices from LID (GI) Projects

Reference	Uplift Value from 100% Low Impact (GI Design		
	Low	Expected	High
Ward et. al. (2008)	3.5%	4.3%	5.0%
Shultz and Schmitz (2008)	0.7%	1.1%	2.7%
Wachter and Wong (2006)	-	2.0%	-
Anderson and Cordell (1988)	3.5%	4.0%	4.5%
Braden and Johnston (2003)	0.0%	2.5%	5.0%

Source: <Insert Notes or Source>

As an example: A City of 100,000 people and 2.6 person per household = 40,000 households. Let's assume an average property value of $100,000. If there is 10 acres of GI in the 100-acre city area this would give a scaling factor of 10%. For a property uplift factor of 2.5% and a 50% possible double counting the uplift is 1.25%. The calculation would be:

$$40{,}000 * \$100{,}000 * 10\% * (2.5\% * 50\%) = \$5{,}000{,}000$$

8.5.5 Water Quality Treatment

As stormwater runs over different surfaces (fertilized lawns, roadways, parking lots, etc.) it gathers anthropogenic pollutants (e.g. phosphorus from fertilizer application, oils, greases, metals, etc.) along with naturally occurring pollutants (e.g. soil or total suspended solids). Properly designed GI mimics natural hydrologic processes that can reduce some of these pollutants. The removal potential for each pollutant will vary for different kinds of GI practices. Further, pollutant removal potential can also vary based on site-specific conditions such as rainfall patterns, local soil conditions, and design components.

GI practices provide multiple mechanisms to remove pollutants including, but not limited to: sedimentation and filtration, sorption and precipitation, biological degradation, and vegetative uptake.

Sedimentation and Filtration

Sedimentation is a process driven by gravity that settles suspended particles out of the water. Filtration removes particles through a physical process that only allows the passage of water and certain sized particles. Several parameters such as particle size, detention time, and filter material (e.g. bioretention media, stone, soil) have effects on removal potential. The pollutants targeted are:

- Total Suspended Solids (TSS)
- Metals, organics, and pathogens absorbed to soil particles (e.g. polychlorinated biphenyls (PCBs))
- Suspended phosphorus

Sorption and Precipitation

Sorption encompasses adsorption (physical process of molecules adhering together) and absorption (process of molecules entering another substance). Whereas precipitation is a chemical process where a solid emerges from water. Factors within the GI practice such as pH, chemical and organic content, and available treatment surface areas can have effects on removal potential. The pollutants targeted are:

- Dissolved metals and organics
- Orthophosphate
- Ammonia
- Pathogens

Biological Degradation

Biological degradation involves any microbial process that breaks down organic and inorganic compounds found in stormwater runoff. Examples include nitrification and denitrification processes within the GI practice soil profile. Factors that influence the removal capabilities of microbial communities are oxygen concentrations, available nutrients and organic material, temperature, and salinity (e.g. influenced by road salting or in tidal areas). The pollutants targeted are:

- Organic and inorganic compounds
- Nitrogen compounds
- Pathogens and bacteria
- Hydrocarbons (e.g. car grease and oil)

Vegetative Uptake

GI practices that contain vegetation will benefit from this mechanism. Plant roots soak up pollutant-laden stormwater, removing the pollutants from the water. The types of vegetation used will cause some variation in removal potential. The pollutants targeted are:

- Excess nutrients (e.g. fertilizers)
- Heavy metals
- Hydrocarbons

Quantifying Water Quality Improvement with GI

Reducing the amount of stormwater that reaches the storm sewer system is a major benefit to water quality; as this will ultimately reduce discharge volumes to nearby waterbodies, such as the Long Island Sound. The pollutant removal capabilities of GI can also provide additional enhancement to water quality by helping to treat the stormwater before it is infiltrated or before it re-enters the storm sewer system, thereby reducing the pollutant loading to the treatment plant. Generally, the pollutants of focus associated with stormwater runoff are total suspended solids, total phosphorous, total nitrogen, and heavy metals. Removing these pollutants from stormwater discharges to nearby waterbodies can also improve wildlife habitat, prevent eutrophication, and improve the quality of aquatic ecosystems. Quantifying the pounds of each pollutant potentially removed annually should follow this general approach:

1. Determine Annual Pollutant Loadings
2. Determine Pollutant Removal Potentials
3. Determine Annual Pollutant Removals

Step 1: Determine Annual Pollutant Loadings

Utilize a computer-based model to delineate the different land covers in the storm sewer system. Determine an annual loading rate for each type of land cover and calculate an annual loading mass in pounds per year tributary to the storm sewer system. See Table 6-9 for pollutants loadings for total phosphorus, total nitrogen, and TSS.

Pollutant Loadings by Land Use Category

Land Cover	Total Phosphorus (lbs./acre/yr.)	Total Nitrogen (lbs./acre/yr.)	Total Suspended Solids (lbs./acre/yr.)
High, Medium Density Residential	1.4	15	140
Low Density, Rural Residential	0.6	5	100
Commercial	2.1	22	200
Industrial	1.5	16	200
Urban, Mixed Urban, Other Urban	1.0	10	120

Land Cover	Total Phosphorus (lbs./acre/yr.)	Total Nitrogen (lbs./acre/yr.)	Total Suspended Solids (lbs./acre/yr.)
Agriculture	1.3	10	300
Forest, Water, Wetlands	0.1	3	40

Source: NJDEP Stormwater Best Management Practices Manual (2004)

Step 2: Determine Pollutant Removal Potentials

Unlike in a wastewater treatment facility where the environment is controlled, environmental conditions are constantly changing (temperature, moisture, etc.) making pollutant removal capabilities difficult to predict. It is important to determine a reasonable removal potential for GI practices.

Step 3: Determine Annual Pollutant Removals

With the annual loadings of total suspended solids, nitrogen, and phosphorous and their respective pollutant removal potentials determined, the final step will be to determine how much of each pollutant will be removed annually.

Utilize the following equation to determine the annual pollutant loadings that will be treated by GI:

$$Annual\ Loading\ Rate\ of\ Pollutant\ \left(\frac{lb}{acre}\right) * Drainage\ Area\ Captured\ by\ GI\ (acre) = Annual\ Loading\ of\ Pollutant\ \left(\frac{lb}{year}\right)$$

The amount of pollutant removed annually (lb./year) can be determined by taking the annual loading calculated above for each pollutant and multiplying against the relevant pollutant removal potentials for the GI practice being employed.

For example, consider an infiltration basin with a TSS removal efficiency of 80% that captures 0.5 acres of commercial land use cover. The amount of TSS removed will be calculated as follows:

$$\left(200\ lb \frac{TSS}{Year * Acres} * 0.5\ acres\right) * 80\% = 80\ lbs\ TSS\ removed\ annually$$

Once the pollutant loads removed annually are calculated, a percent reduction of annual pollutant loading for the watershed can be determined for each pollutant. There are additional benefits associated with avoided wastewater treatment costs was discussed on a volume basis. These avoided costs can be taken a step further by considering the avoided costs to treat the pollutant loads specifically ($/lb. Pollutant Treated).

8.5.6 Benefit Calculation

The Center for Neighborhood Technology's the Value of GI – A Guide to Recognizing Its Economic, Environmental, and Social Benefits provides detailed calculation approaches for the following benefits:

- Reduced Stormwater Runoff
  - Total runoff reduction (gal) = [annual precipitation (inches) * GI area (SF) * % retained] * 144 sq. inches/SF * 0.00433 gal/cubic inch
- Reduced Energy Usage

  - Annual cooling savings (Btu/SF) = annual number of cooling degree days (°F days) * 24 hrs./day * ΔU
  - Annual heating savings (Btu/SF) = annual number of heating degree days (°F days) * 24 hrs./day * ΔU
    - U = heat transfer coefficient, or 1/R
    - R = a measure of thermal resistance
- Reduced Air Quality Criteria Pollutants
  - Total annual air pollutant uptake/deposition (lbs.) = area of practice (SF) * average annual pollutant uptake/deposition (lbs./SF)
  - Total annual air pollutant reduction (lbs.) = no. of trees * average annual uptake and avoided pollutant emissions (lbs./tree)
  - Total value of pollutant reduction ($) = Total annual criteria pollutant reduction benefit (lbs.) * price of criteria pollutant ($/lb.)
- Reduced Atmospheric CO_2
  - Annual amount of carbon sequestered (lbs. C) = Total area of practice (SF) * average annual amount of carbon sequestered (lbs. C / SF)

http://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf

The Natural Resources Defense Council (NRDC) released The Green Edge: How Commercial Property Investment in GI Creates Value in December 2013. This report outlines the potential benefits (quantifiable and non-quantifiable) to property owners that implement GI. The report provides examples of methods to determine quantified benefits such as energy savings, avoided conventional/replacement costs, and increased rental income.

https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf

8.6 Recommendations

The following recommendations related to cost-benefit analysis should be considered:

- Conduct a benefit analysis as described in this report to verify both the tangible and intangible project benefits. This should be incorporated into the decision-making process for whether or not to proceed with the incorporation of GI practices into a specific project. Other decision factors include:
  - Detrimental environmental and social impacts that outweigh the need for the GI improvements.
  - Cost of accommodations is accessibly disproportionate to the cost of the overall project.
  - The safety or timing of the project is compromised by the inclusion of GI infrastructure.
- Promote GI infrastructure on existing City properties, examples include:
  - A program to include new tree plantings on municipal properties following GI practices.
  - A native planting program to promote the installation of native plants and trees in place of turf grass for open space areas not used for specific recreational purposes.
  - Incorporating GI designs when stormwater mitigation is required.

9 Financing Green Infrastructure

Overview

GI projects and programs can be funded by a wide-range of financing strategies due in part to the many sources of funding that the benefits of GI attract. Traditional financing methods such as loans and bonds may be utilized, as well as GI standards for development or redevelopment projects or rebates and incentives for residential and commercial property owners that install GI directly. This chapter provides a summary of potential financing methods, as well as website references and case studies of possible funding strategies and resources. The figure below illustrates the different financing methods:

Developer Standards and/or Ordinances

- Developer Standards
- Ordinances

Public Funding Programs

- Public-Private Collaboration Ordinances
- Incentives
- Rebates
- General Fund
- Bonds

State/Federal Funding Programs

- State Revolving Fund Program Loans
- Grants Program & Funding Opportunities for the Hudson River Estuary
- Water Quality Improvement Project Program
- Green Innovation Grant Program
- Environmental Protection Fund: Local Waterfront Revitalization Program Grants
- Long Island Sound Future Fund 2018
- Environmental Justice Grants Program
- Urban & Community Forestry Grants
- Environmental Protection Agency Funding Programs
- EPA Urban Waters Small Grants
- Clean Water Act, Section 319(h) Grants
- HUD Community Development Block Grant Program

Other Funding Sources

- Private Grant Funding
  - Green Infrastructure Grant Program (GIGP)
  - SURDNA Foundation Grants

9.1 Development Standards and/or Ordinances

Development Standards

Development standards imposed by the municipality can help achieve desired goals. The advantage to imposed development standards is that it requires the owner to pay the capital cost for GI rather than the municipality to treat the stormwater that originates from their site. The municipality should review their existing stormwater regulations and identify opportunities to modify the existing storm sewer connection requirements and the stormwater management design criteria so to target reducing stormwater volumes. This may entail different requirements for new development and redevelopment projects. For redevelopment projects that have challenges managing stormwater on site, the municipality should consider offering stormwater credits or a Fee in Lieu so that equivalent or greater stormwater management can be achieved offsite.

Large-scale redevelopment can provide a unique opportunity for sharing the cost of GI between a private entity and a municipality.

9.2 Public Funding Programs

GI projects can be incorporated into other development or infrastructure projects to manage stormwater. By bundling GI into other projects, multiple funding sources can be leveraged, and total project costs can be reduced through construction efficiencies. For example, small-scale GI practices such as street tree trenches could be incorporated into a street restoration project. Utility replacement projects that involve street or sidewalk restoration may also provide an opportunity to incorporate GI as an amenity to the community. Incorporating natural stormwater features into a street restoration project can also enhance urban corridors.

Public – Private Collaboration

Public-Private collaboration is an important tool to leverage funding and resources for the development and implementation of GI projects. Public agencies may be interested in collaborating on GI projects that involve parks, schools, recreation activities, or other public sites. Opportunities to collaborate with private institutions such as businesses or other private property owners may allow for the private sector involvement in capital financing, planning, and maintenance of GI features. These programs typically require a contractual agreement that addresses each party's involvement and responsibilities.

Case Study: A community based private-public partnership was developed in Prince George's County, MD. The County entered into a 30-year agreement with Corvias Solutions and formed the Clean Water Partnership to meet the requirements of the Chesapeake Bay TMDL and the County's MS4 permit. Through this partnership, Corvias is responsible for the design, construction, and maintenance of the stormwater assets. The County will be retrofitting approximately 15,000 acres of impervious surfaces at a cost of $1.2 Billion. More information can be found at the links below: https://www.epa.gov/G3/prince-georges-county-maryland-clean-water-partnership and https://thecleanwaterpartnership.com/.

Incentives

Local government incentives, such as grants or loans, may encourage property owners to install GI on privately owned property. These incentives may be one of the best approaches to spur the installation of GI in highly developed areas that are not likely to experience redevelopment projects. In Lexington Kentucky, the city offers grants for infrastructure that improves stormwater quality, reduces runoff or educates the public on the importance of treating stormwater. More information can be found at this link: https://www.lexingtonky.gov/incentive-grant-program.

Case Study: In Washington DC, the Riversmart Program encourages homeowners to reduce stormwater runoff. The program requires the homeowner to meet with the city inspector to discuss ways to improve stormwater management on their property. Homeowners provide a co-payment directly to a certified contractor for the installation of one or more approved stormwater features, including use of rain gardens, pervious paving systems, bayscaping, and shade tree planting. The contractor is paid by the program for the remainder of the service cost. https://doee.dc.gov/service/riversmart-homes-overview

Rebates

Since most of the properties in municipalities is privately owned, GI installation on private property can be critical in helping to meet GI goals. One way to encourage this is to offer rebates to homeowners to offset a portion of the cost of GI installation.

Montgomery County Maryland has a Rainscape Rebate Program which is funded by the County and issues rebates up to $2,500 for residential projects and $10,000 for commercial projects that meet the Program design criteria. Funded features have included water harvesting projects, pervious paving systems, pavement removal, and conservation landscaping. https://www.montgomerycountymd.gov/water/rainscapes/index.html

Case Study: The Rutgers Cooperative Extension (RCE) Water Resources Program partnered with the New Jersey Water Supply Authority (NJWSA) to implement a rain garden rebate program piloted in Somerville, Bridgewater, Raritan, and Hillsborough in NJ. Provided that homeowners attend a community workshop, a technical workshop for rain garden design assistance, and install the rain garden, they are then qualified to apply for a rebate of $3 per square foot of garden up to $450. Homeowners also have the option to design their own garden and have it approved by the RCE Water Resources Program. Twenty-nine rain gardens have been installed on homeowners' properties since the start of the program. For more information, visit: http://water.rutgers.edu/Projects/RGRebate/RGRebate.html

General Funds

Nationally, most municipal stormwater and GI programs are funded by general revenues which come from the local real estate or property taxes that are collected based on property value. Reserving these funds for GI will greatly depend on local needs. The funding allocation will typically change annually which makes it difficult to ensure the continuity of a GI program.

Bonds

Selling bonds is a traditional approach for funding infrastructure projects. Green Bonds are like traditional bonds; however, all investments are specifically for environmentally sustainable programs. Green bonds are also backed by credit ratings through Moody's Investors Service, Standard & Poor's and Fitch Ratings. The stipulations for funding and credit rating of each program varies.

The World Bank green bond is geared to support environmental projects. As of November 2016, the World Bank has raised over 500 million dollars to finance environmental projects including watershed management and infrastructure to prevent flood damage. Information can be found at this link: http://treasury.worldbank.org/cmd/htm/World-Bank-USD-500-Million-Green-Bonds-Support-Global-Climate-Action.html

9.3 Federal & State Funding Sources

Federal and State funding supports numerous programs and agencies, subject to annual budgeting allocations. A listing of relevant federal and state funded programs is included below.

State Revolving Fund Program Loans

The Clean Water State Revolving Fund (CWSRF) is a well-known federal-state partnership that provides communities a long-term source of low-interest financing for a wide range of water quality infrastructure projects.

There are several ways that GI can be incorporated into a project. It can be:

- a centralized GI project, such as a resiliency park or green street project;
- a group of practices distributed throughout an area, such as rain gardens and street trees;
- a stand-alone project, such as replacement of impervious pavement with pervious paving systems;
- included as part of a green/grey project with other necessary infrastructure upgrades. For example, stormwater pipe replacement, removal of buried utilities, and construction of street tree planters and pervious concrete sidewalk;
- included as part of a private development project, through a municipality or utility authority as a conduit via a public/private partnership.

The funding of these projects has historically been selected on a priority ranking basis. The funding available for these projects is approved each year by the NYS Department of Environmental Conservation

Additional information about the program and application process can be found on their website at https://www.efc.ny.gov/CWSRF.

Grants Program and Funding Opportunities for the Hudson River Estuary

Funded by the New York State Department of Environmental Conservation, these grants advance five categories of projects and programs through planning, feasibility studies, and/or design, including Watershed and source water management planning. Grant awards range from $10,500 to $50,000

Water Quality Improvement Project Program

Funded by the New York State Department of Environmental Conservation, these grants fund projects that directly address documented water quality impairments. There is $79 million in total funding available. GI can be utilized for nonagricultural nonpoint source abatement and control, which is an eligible project type.

Green Innovation Grant Program

Funded by New York State Governor's Consolidated Funding Application (CFA), this grant opportunity supports projects across New York State that utilize unique stormwater infrastructure design and create cutting-edge green technologies. The grant provides funding of a minimum of 40% up to a maximum of 90% of the total eligible project costs as provided in the application. A minimum of 10% up to 60% match from state or local sources is required. Municipalities are eligible Applicants.

Environmental Protection Fund: Local Waterfront Revitalization Program Grants

Funded by New York State Governor's Consolidated Funding Application (CFA), this grant opportunity funds eligible villages, towns, cities, and counties located along New York's coasts or designated inland waterways to advance the preparation or implementation of strategies for community and waterfront revitalization. All awards made through this grant must be consistent with the State's Smart Growth Public Infrastructure Policy Act. The program will make up to $15 million available to fund applications.

Long Island Sound Futures Fund 2018 (Other)

National Fish and Wildlife Foundation's Long Island Sound Futures Fund supports projects in local communities that aim to protect and restore the Long Island Sound. Since 2005, the Sound Futures Fund has invested $17 million in 380 projects. With grantee match of $33 million, the program has generated $50 million for locally based conservation.

Environmental Justice Grant Programs

New York State's Department of Environmental Conservation, Office of Environmental Justice offers Community Impact Grants to provide community-based organizations with funding for projects that address various environmental and public health concerns. The program has a focus on low-income and minority communities that have historically been burdened by environmental problems. Projects that have been funded include: research, community gardens, tree plantings, education and curriculum development, urban farming training, habitat restoration, water quality monitoring, air quality monitoring and more.

Urban and Community Forestry Grants

New York State's Department of Environmental Conservation, provides support and assistance to communities in comprehensive planning, management, and education to create healthy urban and community forests, and enhance the quality of life for urban residents through its Cost Share Grant program. Eligible project categories include tree planting, which can be implemented via GI.

Environmental Protection Agency Funding Programs

General EPA funding programs cover a large range of environmental initiatives. The EPA maintains a website which summarizes financial tools available to communities for funding water infrastructure programs and projects: https://www.epa.gov/waterfinancecenter/water-finance-clearinghouse. A useful reference for EPA related grants is on their website: https://www.epa.gov/grants. The EPA also maintains an additional website that provides additional information on GI funding. https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities

Funding for GI projects through EPA specific programs is case specific and can include additional program requirements, as described in a few EPA programs below.

EPA Urban Waters Small Grants

Since its inception in 2012, this program has awarded over 100 communities small grants up to $60,000 to support community urban water quality in underserved communities, including GI programs. New York specific awards have been granted to the Sarah Lawrence College (Rockland and Westchester Counties, and the Bronx), New York City Department of Parks and Recreation (Bronx) and the Hudson River Sloop Clearwater, Inc. (Dutchess County). https://www.epa.gov/urbanwaters/urban-waters-small-grants

Clean Water Act, Section 319(h) Grants

This program is supported through the Clean Water Act, which allocates funding to each state to reduce water quality impairment through non-point source pollution control. The New York State's Department of Environmental Conservation manages the monetary disbursement. As mandated by the federal rule, the state is required to distribute at least one-half of the funding received to projects with approved watershed plans, including the Atlantic Ocean/Long Island Sound Watershed.

HUD Community Development Block Grant Program

The U.S. Department of Housing and Urban Development (HUD) Community Development Block Grant (CDBG) program allocates grants for entitlement communities. These entitlement grants are approved for communities which meet criteria for low- and moderate-income persons.

The CDBG grant program includes funding for infrastructure and public improvements in addition to expansion of economic opportunities. CDBG-financed projects can incorporate components of GI. For example, The City of Chicago used CDBG funding to put a new green roof on its historic Cultural Center.

9.4 Municipal Maintenance Funding

As discussed, the City of New Rochelle must be able to maintain those GI improvements. However, maintenance requires resources – equipment, personal – and funding. A dedicated, stable and adequate source of funding to pay for GI maintenance is essential. Although there are numerous grant and loan funding sources for the design and implementation of GI improvements, most of these sources do not pay for the maintenance of GI post construction. As such, additional funding sources for the maintenance of GI improvements are discussed below.

9.4.1 Private GI Improvements

The maintenance of all privately-owned GI improvements should be the sole responsibility of the private entity. No municipal funding is to be allocated for privately-owned GI improvements. The municipality's sole responsibility for privately owned GI is to enforce their maintenance agreements. If the owner does not fulfill the duties of its maintenance agreement, measures should be taken by the Municipality to enforce the agreement by issuing a zoning enforcement notification. It is the GI owner's responsibility to be educated in the maintenance requirements of their GI infrastructure.

9.4.2 Taxes and General Funds

Tax revenue is the most basic and simplistic way to fund the maintenance of GI improvements. Allocations would need to be appropriated from the City's operating budget for GI. GI maintenance funding would have to compete with all the other areas of general fund revenue such as recreational, police, fire, and road maintenance, which is often difficult. Reserving these funds for GI will greatly depend on the local needs of New Rochelle. The funding allocation will typically change annually which makes it difficult to ensure the continuity of a GI maintenance program.

9.4.3 Capital Improvement Funds

Capital improvements funds are a specific type of tax and general funding that can be used to fund the initial building (design and construction) of a GI project, but not the maintenance of a project. The capital improvement fund involves long-term planning and would require several years of planning and forecasting to appropriate the necessary funds for the design and construction of GI projects.

9.4.4 Stormwater Tax

As described above, funding GI maintenance and stormwater related improvements in general is difficult as it does not have the same appeal as budget lines such as “safety” and “recreation”. As such, a direct stormwater tax can be imposed on residents of the City is several ways. This tax would only be appropriated for GI maintenance and stormwater related improvements. The most popular method for imposing a stormwater tax is that a stormwater utility fee is charged to every property owner to convey stormwater from their property to the municipal system. The fee can be set by ordinance. It can be a set fee for each property or based on a parameter such as the amount of impervious coverage on the subject property. The fee can be monthly, yearly, or quarterly depending on the City’s preference. The budget, expenditures, and revenues for the stormwater utility fund can be examined on an annual basis in accordance with established budgetary processes in the City. The fee is often added onto an existing utility bill, such as sewer or water bills. This streamlines the process. Incentives can be built into the framework of the stormwater tax to allow for discounts to the stormwater fee for property owners who implement and maintain GI. For example, a residential homeowner who installs rain barrels can be eligible for a discounted fee. This is an effective means of creating an incentive to implement GI and have property owners take a role in managing their own stormwater.

9.4.5 Fees

Municipalities can fund the maintenance of GI improvements through fees. Fees may be obtained from permit review, plan reviews, special user fees, etc. These fees can be applied for the specific purpose of maintaining GI infrastructure. Permit fees associated directly with stormwater management or drainage systems show a clear connection between the fess being collected and the maintenance being financed by those fees. Permit fees however cannot be guaranteed from year to year. Furthermore, fees tend to be moderate and therefore may be a supplement to another funding source for GI maintenance rather than the sole funding source.

9.4.6 Regional

This would require multiple municipalities to come together, and/or the county to form, a regional GI/stormwater maintenance group. They would be responsible for conducting and coordinating maintenance related activities for GI improvements. This is a good practice for GI improvements that require specialized training or specialized equipment. A regional coalition can aid and split the cost burden among several entities.

9.5 Other Potential Grant Funding

Private grant funding may also be available for GI projects. One example of a private grant opportunity is through the SURDNA Foundation. This funding program specifically targets urban water management and pilot projects that demonstrate innovative stormwater practices. See more information at the link below:

http://www.surdna.org/what-we-fund/sustainable-environments/urban-water-management.html.

Another example is the Green Infrastructure Grant Program (GIGP) which offers grants to private property owners in New York City. Funds are provided for the design and construction of the GI system. Eligible projects include green roofs and infiltration projects such as: rain gardens and porous pavement.

9.6 Recommendations

The following recommendations related to funding should be considered:

- Continue to pursue local, state, and federal grant opportunities for GI implementation, studying, and planning.
- Although less desirable, the Stormwater Tax option is comprehensive, dedicated, steady, and reliable. The amount of the “tax” can be raised or lowered depending on the municipalities needs for funding as the program grows and expands. To incentivize privately owned GI infrastructure, consideration should be given to providing a discounted “tax” rate if a property owner installed rain barrels, rain gardens, or other methods of GI and fulfills the requirements of their maintenance agreement.
- Incorporate GI into local budget and capital bonding where appropriate and feasible.

10 Local Employment Opportunities

GI implementation can both directly and indirectly create local employment opportunities. GI implementation has three general phases which include the design phase, the construction phase, and the maintenance phase. The design phase generally involves the work of professionals – professional engineers, professional planners, and often, licensed landscape architects. The construction phase generally involves the work of contractors – foremen, operators, laborers, landscapers, and office administrators. The maintenance phase is similar to the construction phase, however is generally more limited to laborers and landscapers. To successfully implement GI, skilled workers are required for each of the three phases and directly result in a demand increase in the workforce.

GI implementation will also drive investment in the new infrastructure. There are many funding sources that are unique to only GI projects. These new investments are critical as they create new job opportunities, instead of simply re-allocating employment opportunities from related job sectors.

As GI is a relatively new endeavor and may be unfamiliar to contractors, training of the workforce is necessary. Training will increase implementation of GI and provide a new, and marketable, skillset to workers. As previously noted, as familiarity with GI rises amongst contractors, construction costs of GI may potentially decline.

GI implementation can indirectly create local employment opportunities but increasing the demand for certain products and manufactured devices. These enterprises will see increased demand due to their use in GI projects, on both small and large-scale projects.

As GI grows as a stormwater management technique, the workforce will in turn learn through training and experience the skills necessary to provide design, construction, and maintenance of GI infrastructure. The workforce will benefit by learning skills that are valuable within New Rochelle, the State of New York, and beyond.

While putting an exact number on local employment opportunities may be difficult, it is reasonable to assume that GI projects, on both small and large-scales, will create local employment opportunities.

Appendices

A. Natural Resources Conservation Service (NRCS) Soils

B. National Flood Insurance Program (NFIP), Flood Insurance Rate Maps (FIRM)

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