Onondaga Creek Water Quality: A Green Infrastructure Approach

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Executive Summary

Syracuse, along with many other cities in the United States, centralized their sewage systems by building combined sewer systems during the late 19th and early 20th centuries. Mixed wastewater and surface run-off carrying urban pollutants is conveyed through the city's combined sewer system to Onondaga County's "METROpolitan" wastewater treatment plant. During a rain event, the combined sewer system is inundated with run-off and cannot accommodate both wastewater and surface run-off, causing an overflow into open waterways. In order to improve water quality in Onondaga creek, overflow events must be mitigated. Storm water volume calculations, green infrastructure and its cost of implementation were investigated and simulated to recommend the best site specific options for improving water quality in Onondaga Creek.

The site selected is within 060 and 077 sewer shed, a high volume overflow area, and a representative part of the urban landscape. The site was also selected to contain a mixture of land uses and include both pervious and impervious surfaces. Techniques illustrated for this site are meant to serve as a model for many similar urban sites within the creek watershed. Furthermore, this site was chosen to depict an alternative to the proposed Midland Phase III pipeline which would convey upstream CSOs to the Midland RTF for chlorinated treatment or storage (1). The construction of the Phase III pipeline would increase the cost of the Midland RTF project to $150 M – more than doubling the original estimate made in 1999 (4). The proposed methods are more sustainable, less costly alternatives to the pipeline.

A combination of water volume calculations, cost, and green infrastructure simulations were conducted. Recommended methods include curb-cuts and bump outs to allow road runoff to be mitigated, bio-swales to channel water into green areas, and rain gardens to absorb excess water. Above ground methods include blue roofs to trap rain water for later drainage into rain barrels and cisterns, and permeable pavement to promote infiltration of runoff. Cost effectiveness, as estimated in a cost analysis, was taken into consideration when choosing these infrastructures, and explains why otherwise effective means were excluded. Photo simulations were constructed to depict the visual, spatial, and logistic impacts of implementing green technologies, and as a means for community members to understand how these changes would impact the community.

This model, based on community desires laid out in the Onondaga Environmental Institute Onondaga Creek report, and other community groups, will be a potential means toward reaching the goal of implementing cost effective, sustainable green infrastructure as a means of improving water quality in Onondaga Creek.

Introduction

The city of Syracuse, like many historically industrial cities in the Northeast, holds within its city limits sites of environmental negligence and degradation. These sites hold the greatest potential for change and future improvement. Many industrial initiatives located within Syracuse have exploited raw mineral resources including salts from the Tully area and Calcium from limestone bedrock. In its recent history, Syracuse was a premier location along Onondaga Lake and the Erie Canal from which it exported its exploited resources throughout the Northeast Region. Profits, growth and prosperity were generated for the city's people to the extent of which we are just beginning to understand. The degraded sites created out of both ignorance and negligence now requires environmental remediation and restoration.

A central and integral part of the ecosystem of the Northeast region is water. Abundant precipitation in the region promotes the formation of large aquifers and freshwater bodies. A high diversity of amphibians, fresh water fish, and aquatic birds are supported by this resource. As residents of Syracuse it is our duty to support the health of these water bodies not only for ourselves, but for wildlife, and future generations. Since the industrial revolution, negligence, ignorance and indifference have been the driving forces for change – until now. In the Syracuse area, as well as the Great Lakes region, increased understanding of the extent of aquatic ecosystem degradation has led to a movement for water quality improvement. This progression is just as important today as it was when it began with the Clean Water Act of 1972. Our goal is to continue the important work executed by local Syracuse resident groups, university professors, local NGO's, and more specifically, the Onondaga Environmental Institute (OEI).

Onondaga Lake and its main tributary, Onondaga Creek, have and continue to be a source of great potential for water quality improvement. Now greatly polluted from industrial by-products, Onondaga Lake faces additional environmental contamination from heavy metals (mainly mercury) and eutrophication from influxes of phosphorous and nitrogen generated from an inadequate city sewer system. While improvements have been made in sewer treatment for this purpose, a combined sewer and rain water drainage system is still polluting Onondaga Creek and subsequently the lake which is undergoing major remediation for other contaminates. Due to the large volume of precipitation received in this region, frequent occurrences of storm events lead to regular overflow of untreated human waste into Onondaga Creek. County officials, waste water treatment facilities, and residents realize the need for change within this system. Discussions have been ongoing regarding the best approach. Measures involving a sewer separation pipeline, as well as a secondary waste water treatment facility have been implemented. A further measure agreed upon by the county and other interest groups, but not yet acted upon, has been the implementation of green infrastructure and technologies in residential and business areas designed to reduce the amount of storm water runoff into the system to prevent overflow. Many ideas by the OEI and community interest groups have been put forth, and the large majority of residents are interested in these ideas. Now, a realistic design and demonstration model is needed for these ideas to be realized.

Our aim is to contribute a design template based on the recommendations for improved water quality laid out by the OEI. The site chosen is located in an environmentally degraded area that is representative of many neighborhoods along the creek. The OEI has already done the important work of collaborating with residents and other stakeholders to come to an agreement of goals, acceptable technologies and problematic areas in need of additional attention.

Our design process will take these important objectives one step further. The purpose of this design is to demonstrate specific infrastructure and technologies designed to decrease storm water runoff and pollution into the creek. The designs are customized to individual locations including residential, commercial, and recreational areas along the creek. The resulting product is a template of these techniques that will be applicable to urbanized areas along the creek involving minor adjustment to site.

The issue at hand is to address water quality from the input source, storm water, which carries any pollutant within the flow path to the final destination, the creek. Controlling runoff into the drains of the sewer sheds will also decrease the amount of water in the system and eventually, reduced or eliminated mixed sewage/ water overflow. Measures to mitigate storm water runoff from impervious areas, residential and business roofs, and parks will be demonstrated in a designed and detailed description for a representative block of sewer shed 077 and 060 areas identified as problematic by the OIE. Residential, commercial, and recreational areas adjacent to the creek are the subject of the design report, which are representative of a range of prominent land uses near the creek. Each section within our design area will be designed to reduce runoff in the most practical and efficient manner, as a compliment to the OEI plan. It is our hope that this design will aid in the implementation of green infrastructure in sewer sheds 077 and 060 highlight these technologies, prove their effectiveness and act as a model for other sections of the creek sewer shed.

Site Selection

CSO Background and Recent History

Syracuse, along with many other cities in the United States, centralized their sewage systems by building combined sewer systems during the late 19th and early 20th centuries. These combined sewer systems carry wastewater (domestic sewage, wastewater from commercial and industrial establishments and groundwater infiltration) in addition to surface run-off from rain and snow events. Mixed wastewater and surface run-off flow is conveyed through the city's combined sewer system to Onondaga County's "METROpolitan" wastewater treatment plant. During a wet weather event, the combined sewer system is inundated with surface run-off and does not have the conveyance, volumetric, or structural capacity to accommodate both wastewater and surface run-off. As a strategic measure to mitigate sewage backups in basements and the streets, the City of Syracuse developed relief structures called combined sewer overflows (CSOs) that discharge sewer lines into nearby creeks. The development of CSOs were depicted and understood to be legal and necessary until the development of the Clean Water Act, which decreed further development of CSOs as illegal (Baptiste and Lane 2008).

The Atlantic States Legal Foundation (ASLF) and the New York State Department of Environmental Conservation (NYSDEC) sued Onondaga County for discharges from METRO and 63 active CSOs that were polluting Onondaga Lake and contributing tributaries (Baptiste and Lane 2008). The product of this litigation was the 1998 federal Amended Consent Judgment that called for the construction of five regional treatment facilities (RTFs) that were to be built in neighborhoods along Syracuse creeks (Baptiste and Lane 2008).

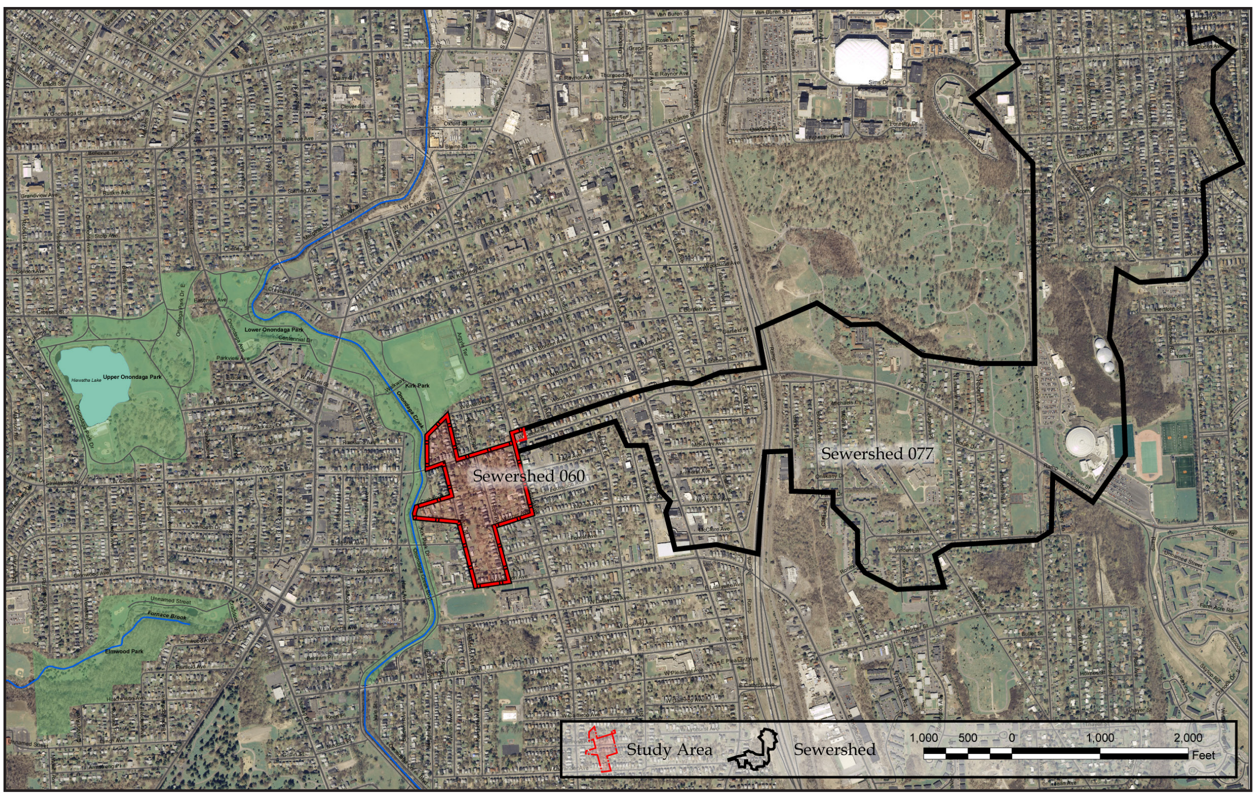
One of the largest RTFs, the Midland Avenue RTF, was to be completed as a three-phase complex, including a mile-long CSO conveyance in Phase III. Phase I included the construction of approximately 900 linear feet (lf) of 54-inch and 84-inch conveyance pipeline (Midland Avenue Regional Treatment Facility and Conveyances…[updated 2007]). Phase II included the construction of a 213 million gallon per day (mgd) USEPA swirl concentrator at Midland Ave RTF, in addition to 1,200 lf of 144-inch conveyance pipeline. The Midland Avenue RTF included: upstream 2.5 million gallon (MG) underground storage tank with automated flushing gates; influent coarse screening and grit removal facilities; three 110 mgd mixed flow influent pumps; two 42-foot-diameter vortex solids separators (USEPA swirl concentrators); two 3,700 gallon per minute (gpm) underflow control/de-watering pumps; liquid sodium hypochlorite/ sodium meta bisulfite storage and feed facilities; a 1.0 MG underground high-rate disinfection tank and; a 116,000 cubic feet per minute (cfm) activated-carbon odor control system (Midland Avenue Regional Treatment Facility and Conveyances…[updated 2007]). To date, Phase I and II have been completed (Midland Overflow Abatement Project…[updated 2009]). Phase III is partially completed and currently presents an opportunity for a mixture of green and gray (old methods of CSO abatement) technologies.

The proposed Midland Phase III pipeline conveys upstream CSOs to the Midland RTF for chlorinated treatment or storage (Baptiste and Lane 2008). The construction of the Phase III pipeline would increase the cost of the Midland RTF project to $150 M – more than doubling the original estimate made in 1999 (Monthly Report…[updated 2008]). The proposed methods are cheaper and greener alternatives to the costly pipeline.

Site Specificity

Although Onondaga Creek would benefit greatly from de-channelization and other large-scale restoration efforts, the green infrastructure methods are prescribed preliminary steps that can be implemented to decrease the water load that currently inundates the creek and its contributing combined sewer systems.

Proposed green infrastructure in this report was targeted to mitigate areas whose storm water would be captured by the Phase III pipeline. The area is a contributing sewer drainage area linked to CSOs 077, 060 and 052. A mixture of pervious and impervious surfaces are represented in the site selected. The area of study is exemplary of many neighborhoods that share the commonality of Onondaga Creek and the necessity for green infrastructure and environmental justice.



Context Map

Planning for Green Infrastructure

A five step process for stormwater site planning and practice selection has been developed by the DEC in order to establish an effective means by which stormwater management and green infrastructure practices can be implemented. This process is detailed in chapter 3 of the New York State Stormwater Management Design Manual which is commonly referred to as the “White Book”. Currently the white book is undergoing draft revisions and a public review process which will be complete in April 2010. The amendments to the book will add sections specifically pertaining to green infrastructure and runoff reduction volumes.

The process described in the white book contains specific procedures for planning and selecting practices not only for general stormwater management but specifically for green infrastructure. It is recommended that any project attempting to integrate green infrastructure into an existing site or community incorporates the planning process prepared in the white book. This process is required for all development and redevelopment projects, it is however not limited to these types of projects. Although retrofit applications are not considered in the white book, the same process could be applied to an existing community which has never had the benefit of proper storm water management planning.

For the purposes of this report an abridged version of this process has been applied to our chosen site. Due to constraints of time and ability this report provides a preliminary investigation into the use of the planning process, covering most of the five steps but not in the detail and depth required for implementation.

Site Profile

Unlike the regulation of stormwater for new development, existing urban environments have little incentive and support for developing plans and practices which would reduce the amount of stormwater runoff. Planning Green Infrastructure for existing situations requires a retrofit solution into situations less than optimal for implementation. During the planning of new development the integration of stormwater management practices and green infrastructure can be designed to fit within and act harmoniously with architectural and landscape designs. Where as retrofitting infrastructure requires a great deal of adaptation, compromise, and the possibility of a less integrated more costly approach to implementing green infrastructure practices.

To the greatest extent possible the existing pervious areas and natural features should be utilized in order to promote infiltration and reduce runoff. The water draining off of impervious areas into large enough pervious areas will never reach sewer drains thereby disconnecting the impervious areas from the sewer system. These pervious areas should be protected and utilized as part of a green infrastructure plan.

Features of particular importance in the site are the large areas of lawn, brush, and garden located on the interior of each block. These areas serve to disconnect rooftops and other impervious surfaces which drain into them. Other large amounts of pervious surface can be found on the great number of vacant lots located within the site. These areas also help to disconnect rooftops and can serve as sits for implementing green infrastructure practices.

Water Quality Volume

In order to determine the volume of water which must be detained on site the “simple method”, or water quality volume (WQv) equation was used. The result of this equation is a volume in acre-feet which will inform the sizing of green infrastructure practices. The volume required has a direct relation to the amount of impervious area on the site. Because our site lies within the impacted watershed of Onondaga Lake, the a slightly revised version of the simple method must be used to account for impacted watershed conditions. This revised version of the equation is referred to as Enhanced Phosphorus Removal. The use of this revised method results in a much larger WQv requirement. The information required as inputs for this equation are; site area, off-site drainage area, total drainage area, impervious area, soil types, land use, and runoff depth from a 1-year 24-hour storm.

Site area in acres was determined by areal photo. Approximate calculations of impervious area were performed by measuring areas of individual parking lots and adjacent rooftops, where not disconnected from other impervious area. For the purpose of this specific site scale it was assumed that any off-site runoff is diverted, allowing the use of only the area within the sites boundaries in the WQv equation.

Soil types were gathered from the NRCS Web Soil Survey on the NRCS website. Soil composition of the site is primarily Palmyra at 78% and Hamlin at 21%, both of which fall into the hydrologic soil group B. Due to the urban nature of the site soil group classifications may be incorrect and can only be correctly determined by on-site analysis.

Runoff depth was calculated using the TR-55 runoff equation which can also be found as

Site Map

part of the white book.

Enhanced Phosphorus WQv Equation: WQv=(site area in ac)(runoff from 1yr 24h storm)

Weighted Curve Number: 91 (Corresponds to the percent impervious area)

1-year 24-hour rainfall: 2.2"

Runoff (Q): 1.3" (Calculated from curve number and rainfall)

Area: 29.34 acres

WQv= (29.34)(1.3")/12 =3.18 acre-feet x 43,560ft^3 in one acre-foot

In order to satisfy the water quality volume standards 138,521 ft^3 of green infrastructure volume is required. This can either be handled in a consolidated pipe-end solution such as a detention pond or wetland, or runoff reduction volume techniques can be applied throughout the site. The use of these techniques which is detailed below distributes the volume in a widespread system of green infrastructure effectively reducing runoff ideally to a point where it has accounted for the entire WQv.

Limitations to this method can be attributed to a 25% margin of error with TR-55. Using this method on a large area may be time intensive requiring an estimation of impervious area leading to an even greater margin of error.

Runoff Reduction Volume

The runoff reduction volume is defined as: Runoff reduction of the total WQv by application of green infrastructure techniques that reduce contributing area or runoff volume to the maximum extent practicable. The minimum required runoff reduction is based on the Hydrologic Soil Group (HSG) of the site and defined as the Specified Reduction Factor (S).Our site which is primarily of the HSG-B category would have a runoff reduction volume S factor of .4 acre-feet. This means that 55,408ft^3 of runoff reduction techniques must be employed on the site if the runoff reduction volume standards are to be met. The remaining 83,113ft^3 of volume can be satisfied with larger scale, more conventional end pipe solutions.

Specific designs and calculations of green infrastructure practices would allow the runoff reduction volume to be determined. These designs need to be based on the pervious area available on site for their implementation. Once these techniques are applied and if they fulfill the WQv requirement there is no need for further implementation of standard storm water management practices.

Neighborhood Integration Simulations

In order to assess and relate the visual impact green infrastructure practices (GIP) will have on a neighborhood we are able to use site photos and computer software to develop photo simulations of the proposed GIPs. This is done to help the community and other stakeholders understand the visual, spatial, and logistic impacts of implementing GIPs. These simulations are not meant as concrete examples of how and these practices will be implemented but rather a tool to promote understanding of the general idea.

A wide variety of site photos were taken over two days in November 2009. From the photos taken several were selected based on their quality, area framed, and potential for implementing GIPs in that location. Images were then manipulated in Google Sketchup 7 and Photoshop CS4 to illustrate appropriate GIPs layered over the existing photograph.

Green Infrastructure

Green infrastructure for water quality improvement refers to non-centralized means of using ecological processes to channel and purify waste water as an additional process to conventional waste water treatment plant methods. These technologies have been shown to be effective in reducing CSO events and improving water quality by reducing runoff volume, peak flow rates, and duration by promoting infiltration and evapotranspiration (Coffman 2002, USEPA 2007). Other benefits include aquifer recharges, protection of downstream water quality, reduced flooding, reduced water treatment costs, and improved wildlife habitat (Coffman 2002, USEPA 2007).

In addition to reducing CSO events, water quality is improved through green technologies by reducing common urban pollutants including organic and inorganic compounds, silt, and pathogens. An excess of silt can increase turbidity in creek waters and inhibit site sensitive aquatic organisms. Inorganic compounds such as lead, chromium, cadmium and other heavy metals are also commonly found in urban storm water runoff. Lead is commonly found in urban environments stemming from roadways, parking lots and gasoline stations, and has contaminated many of the areas surrounding Onondaga creek. Pollutants from organic chemicals result from overuse of fertilizers and pesticides in urban landscaping and can lead to a variety of aquatic ecosystem disturbance including eutrophication. In addition, pathogenic pollutants can enter the water way from a combined overflow event, or from surface runoff containing animal wastes, causing a variety of diseases in humans and aquatic organisms. Urban environments, especially Syracuse warrant the widespread use of technologies that will limit the flow of water pollutants into open waterways.

In an effort to improve water quality through urban pollution removal and elimination of CSO events, a diversity of green infrastructure techniques are recommended for the Onondaga Creek sewer shed. Recommended approaches including bio-swales, curb-bump-outs, rain gardens, blue roofs, and cisterns, are outlined and diagramed according to the specific site conditions in which they are best utilized.

Bio-swales

A bio-swale is a method of landscaping used to control water runoff as an alternative to using culverts or pipes. They are defined as an open drainage channel or depression explicitly designed to detain and promote the infiltration of storm water runoff into the soil (NYS DEC 2009). Bio-swales can also be designed to channel storm water runoff from impermeable surfaces into an area where infiltration occurs. By allowing storm water to percolate back into an underground aquifer, natural water purification processes remove pollutants and the volume of water entering the CSO.

Bio-swale designs typically consist of a drainage course with sides sloped at a six percent grade or less (NYS DEC 2009). Ground structure, soil, and bacteria act on pollutants to purify water. By planting the area with vegetation, more water will be captured in the transpiration of vegetation, and erosion of the slopes prevented. The water's flow path, along with the shallow design of the depressed swell, is designed to maximize the time water spends in the catchment area, maximizing the trapping of pollutants and silt. Curb adjustments to channel water in conjunction with a bio-swale have been demonstrated to be a successful means of trapping storm water runoff and reducing pollutant influxes into open water (France 2002).

Roadways and parking lots represent a large area of impermeable surfaces in surrounding Onondaga creek, where bio-swales could be utilized to channel and mitigate storm water runoff. It is recommended in urban areas within the creek watershed that parking lots draining into the combined sewer as well as roadways with a negative slope, be altered with bio-swales.

Curb Cuts and Bump Outs

Roads are an impermeable surface that greatly contributes to runoff. In addition to planting street trees and grassy borders, directing the water through curb designs can help with significant pollution reduction (France 2002). A curb line of the street can be cut and bumped out into the existing parking lane, median, or border of the street and direct water into a swale or rain garden which provides infiltration and retention. The curb cut should be designed in a way that bypasses gutters and directs the flow line of the water. The bump out area will be designed to capture the flow of water before it overflows into the bio-swale, rain-garden, or infiltration basin. We recommend the use of curb cuts and bump outs on all existing roadways on a negative slope, draining directly into a sewer inlet in conjunction with a bio-swale and rain garden, where appropriate.

Rain Gardens and Infiltration Basins

Rain gardens are designed to capture rain runoff from a residential or business roof, parking lot, or other impermeable surface, and allow it's volume to be taken up by numerous plant species as well as infiltrating into the ground. The size of the garden is a function of volume of runoff to be treated and recharged as well as the soil texture. Garden areas are typically 100–300 sq. ft. and are built to treat all the runoff from a 1.25 inch rainfall event. The average storm average over two hours is 1.25 inches (NJAES 2006). If treating 1,000 sq. ft. of roof runoff for the 1.25 inch rainfall event, a garden should be designed that can hold 100 cu ft. of water, which is approximately 10 ft x 10 ft x 1 ft deep. A garden of this size will treat approximately 90% of the yearly rainfall (NJAES 2006). For plantings, native hardy species with deep root systems that survive in both dry and wet conditions should be planted in the slightly

Table 1 -Northeast/Mid Atlantic Native Plant Suggestions for Wet Sites
(NJAES 2006)

	Common Name	Mature size	Bloom Time	Exposure
Perennials				
Asclepias incarnata	Swamp Milkweed - pink	5 ft.	May/June	Sun-partial shade
Chelone glabra	White Turtlehead	2-3 ft.	Aug./Oct.	Sun-partial shade
Eupatorium maculatum	Joe-Pye Weed - pink	2-7 ft.	July/Sept.	Sun
Helenium autumnale	Sneezweed - gold to red	2.5-3 ft.	Aug./Sept.	Sun
Lobelia cardinalis	Cardinal flower - red	1-5 ft.	July/Sept.	Sun-partial shade
Lobelia siphilitica	Great Blue Lobelia - blue	1-3 ft.	Aug./Oct.	Sun to shade
Ferns & Sedges				
Athyrium filix-femina	Lady Fern	2-3 ft.	N/A	part sun to shade
Osmunda regalis	Royal Fern	2-5 ft.	N/A	part sun to shade
Osmunda cinnamomea	Cinnamon Fern	4 ft.	N/A	part sun to shade
Carex pendula	Drooping Sedge	2-3 ft.	May/June	part shade
Carex stipata	Tussock Sedge	1-3 ft.	July/Aug.	Sun to part shade
Shrubs				
Fothergilla gardenii	Dwarf Fothergilla - white	1.5-3 ft.	April/May	Sun to part shade
Cephalanthus occidentalis	Buttonbush - white	3-10 ft.	Jul./Aug	Sun
Viburnum dentatum	Arrowwood - white	8-10 ft.	May/June	Sun to part shade
Lindera benzoin	Spicebush - chartreuse	6-12 ft.	March/May	Sun to shade

depressed area (Table 1). As water flows along the down slope, it will be captured and used by the garden plants rather than contributing to runoff. Rain gardens used on properties not having a complete gutter system can be an effective and low-cost means of mitigating residential storm water runoff. Numerous gardens in the city will not only improve water quality, but show citizens a practical and aesthetic way to help improve the health of the creek from their backyards.

Infiltration basins, or dry wells, are shallow depressions designed to store storm water volumes before it is infiltrated back into the ground (NYS DEC 2009). These designs are best used in runoff areas, such as in the treatment of concentrated rooftop runoff.

Existing conditions, Crehange St. looking west towards creek.

Photosimulation, Crehange St. showing vegetated swale, curb extensions, and parking with pervious surface.

Infiltration trenches, gravel lined open ditches, can guide water into a basin and allow some infiltration to occur along the path. It is important to note that infiltration designs work best on hydroscopic soils, which are found in the area surrounding Onondaga creek. While rain gardens and infiltration basins are in use sporadically, we recommend employing these measures at all willing residences and small businesses. Rain gardens should also be utilized by the city on a larger scale in conjunction with the above mentioned curb bump-outs and as an end point for water flows redirected by bio-swales.

Above Ground Systems: Blue roofs and Cisterns

In addition to rain gardens, residences and businesses with a gutter system can use rain barrels or cisterns, a cost effective and simple method of capturing water for reuse. Storm water runoff and rain water can be captured by placing large rain barrels at the outpouring of the gutter system, rather than allowing the water to flow freely. Cisterns provide a larger containment area and can be placed on the roof or alongside the house for the same purpose. Water captured is generally suitable for any grey water purpose (NYS DEC 2009).

Blue roofs refer to rooftop detention systems that are constructed by installing slotted flow restriction devices, known as collars, around the roof drains of flat, structurally sound, waterproof roofs. In these systems, storm water is detained on the roof and then channeled to drain off into containment, reducing the rate of storm water discharge (NYS DEC 2009). The use of blue roofs will be limited by structural soundness in some residences, but is more economically feasible and places less demand on the structure than green roofs (planting green space on a roof). We recommend the use of rain barrels or cisterns for all willing residents and businesses, and a blue roof where structural soundness permits.

Permeable Surfaces

Permeable surfaces include any ground type that water can move through to reach underground aquifers. Ways of increasing permeable surface in an urban area include development of green spaces such as parks, vegetated road medians, and gardens. Other options include permeable pavement, a porous material used in place of asphalt which can be utilized for driveways and other normally impervious pavement. Gravel or sand surfaces can also be utilized for driveways and in place of asphalt and cement groundcovers.

While possibly effective for businesses, permeable pavement options can be prohibitively expensive for homeowners, and a gravel driveway may be a better option (Lumina Technologies 1998). Our recommendations for the watershed around Onondaga creek are to encourage businesses to use permeable pavement where a paved surface can be avoided, and to encourage homeowners to utilize crushed gravel or permeable pavement in place of a traditional impervious driveway. On a larger scale, we encourage the city to incorporate more green spaces surrounding roadways, reduce unnecessary pavement, and to create more parks. The creation of green space not only aids in water quality, but adds a positive environment for city residents.

Existing conditions, corner of Midland Ave. and Colvin St. looking east.

Photosimulation, showing pervious parking area, rain barrels, and tree plantings.

Cost Estimation

Traditional approaches to storm water management in urban areas have a number of problems including flooding, stream water erosion, the degradation of water quality, and reduced groundwater levels and stream base flows. Managing runoff from urban areas, which largely comes from impervious surfaces, can be prevented by the implementation of green infrastructure, which has proven to be more economical than traditional approaches.
In order to assess the feasibility of these types of infrastructure, it is necessary to put them into context. Each of the proposed technologies has been implemented in other areas, and each has proven effective in serving their purpose. There is, however, a wide range in terms of equipment and cost, associated with each of the techniques. Some techniques are simple and can be done without professional help, and others are not, requiring planning and construction. These differences show that the costs of implementation may vary widely.

A rain garden can be a very simple and inexpensive addition to the landscape. The costs associated with its implementation are dependent upon the soil type, the size of the roof, patio, or area to be drained into the rain garden, the types of plants desired, as well as the site conditions. Native plants are less expensive and better for the local environment than ornamentals. We used the average cost provided by four different companies (Applied Ecological Services, Low Impact Development, The Groundwater Foundation, and the Rain Garden Alliance) to arrive at a representative cost for the installation of a rain garden. According to our references, the average cost for a residential rain garden is $5-$9 per sq. ft., and the cost of a commercial rain garden is $10-$25 per sq. ft.

Bioswales are also a relatively inexpensive infrastructure to implement relative to curb and gutter treatment or underground storm water treatments. Maintenance is required more frequently but is less expensive than maintenance for curb or gutter systems. Cost estimations were difficult to make due to the variance in terms of area and vegetation type. Their recent emergence as a feasible green infrastructure places a limit on the frequency of their use. They do, however, present cost reductions for areas where traditional curb and gutter systems are used, as maintenance is minimal and less costly. According to Florida's Field Guide to Low Impact Development, the approximate cost of bioswales is $0.50 per sq. ft.

Curb bump outs are more difficult to implement in terms of cost. To bump out a curb costs twice as much as conventional curbing because it requires modifications to the drainage and catch basin system. These systems must be constructed by the city, and require invasive and extensive construction. Costs would be less expensive than traditional practices because pervious materials would be used instead of asphalt. Information for costs associated with bumping out a curb is limited as this is not a simple single construction. Most cities are doing this in conjunction with other green infrastructures, such as curb cuts and vegetated swales. In cities where this type of infrastructure was implemented, the costs ran on average $20,000 for areas of around 9,500 sq. ft. (Wise 2008).

Pervious surfaces range in terms of the types of materials and the costs associated with each. These materials also depend on the size and type of material just as the above green infrastructures. According to four leading green infrastructure sources, Urban Design Tools Low Impact Development, Concrete Network, PaverSearch, and Terra Firm Industries, grass pavers are an easy method to implement, running on average $1.50-$5.75 per sq. ft. without the cost of maintenence. Porous concrete or pervious pavement materials range from $2.00-$9.00 per sq.

ft., compared to asphalt, which cost $0.50-$1.00. These materials require maintenance, however, the reason why this method is not as popular and has a smaller success rate. These materials are commonly used in parking lots, sidewalks, and are beginning to be used in residential areas. Pervious pavers are most commonly used for walkways, open areas, and serve a number of residential uses as well. Unlike the aforementioned pervious materials, the pervious pavers require one layer of fine gravel or sand, which allows for increased storm water infiltration. However, these are most effectively used in shaded and wet areas. According to the four green infrastructure sources, pervious pavers cost approximately the same amount as grass pavers, running on average $5 per sq. ft.

Implementation

Sustainable infrastructure has been implemented in a number of areas worldwide, many of which have been very successful in improving water quality. These successes can be used as a template for Onondaga County, as they can help to put these green infrastructures into context. In Illinois, 60 grants were issued by the government as well as the United States Fish and Wildlife Service in 2005 in an effort to integrate rain gardens into the community as a means to improve water quality. Not only have the rain gardens solved water quality issues, but they have also solved problems associated with increased runoff from impervious surfaces, such as erosion, habitat restoration, and drainage (Office of Governor, Pat Quinn). The city of Salem, Oregon created a bioswale project in 2002 in Kroger Park to treat storm water before it entered the nearby creek. Pringle Creek has seen an improvement in water quality since the bioswale implementation (City of Salem). In Portland, Oregon, a "Green Street" project has been put in place, where curb bump-outs were utilized. Here 590 sq. ft. of street pavement was converted into landscape. Native vegetation was placed alongside the curb that drained a 9,300 sq. ft. area (Wise 2008). In places like Newton, Massachusetts, curb bump-outs are being used as a means to slow traffic, giving this infrastructure a dual purpose (Newton 'bump-outs'…[updated 2009]). The city of Savannah, Georgia has been using pervious pavement to protect trees that are hundreds of years old. The materials enable the transfer of air and water to tree roots. Developers in the area have also been using pervious concrete. A Wal-Mart Superstore was allowed to build next to protected wetlands as the pervious concrete enabled them to stay within the city's storm water regulations (Georgia Implementation Examples…[updated 2009]).

Conclusion and Future Recommendations

The use of CSOs presents a large and costly problem for the city of Syracuse. Not only are they an outdated technology, but they are costly to maintain and have severe consequences for the water quality of the surrounding area. This impact is not limited to water quality, but also has impacts on a historical, community, and recreational level. A proposed alternative to the construction of an additional pipeline is to implement green infrastructures that can target the primary problem, runoff from impervious surfaces. Green infrastructure is more economical to implement, in terms of cost, and is also aesthetically pleasing, minimizing the persistent presence of concrete structures.

If the city is able to retrofit the suggested green infrastructure technology as an alternative to the proposed Midland Phase (III), the impact of the various sewersheds will be minimized by the decreased total amount of runoff. In order to be effective in these strategies, one must follow the planning steps of the New York State storm water design manual to perform water quality calculations for the entire Onondaga Creek sewershed. These calculations will help to determine the extent of green infrastructure that will need to be implemented to alleviate water quality issues in the area.

Specific site and practice designs are also a major component of green infrastructure planning and implementation. A detailed design must be established for every green infrastructure practice planned, which in sewer shed the size 077, represents a large amount of work.

Flood protection measures must also be implemented where necessary. This requires a different set of calculations from the WQv and is an important part of the green infrastructure planning process to ensure surrounding public and private property is not impacted by severe storm events.

In order for a project which retro-fits green infrastructure into an existing neighborhood a great deal of community support and public process should be utilized. Community involvement needs to be integrated throughout the entire planning process to ensure the immediate and long term success of any project.

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