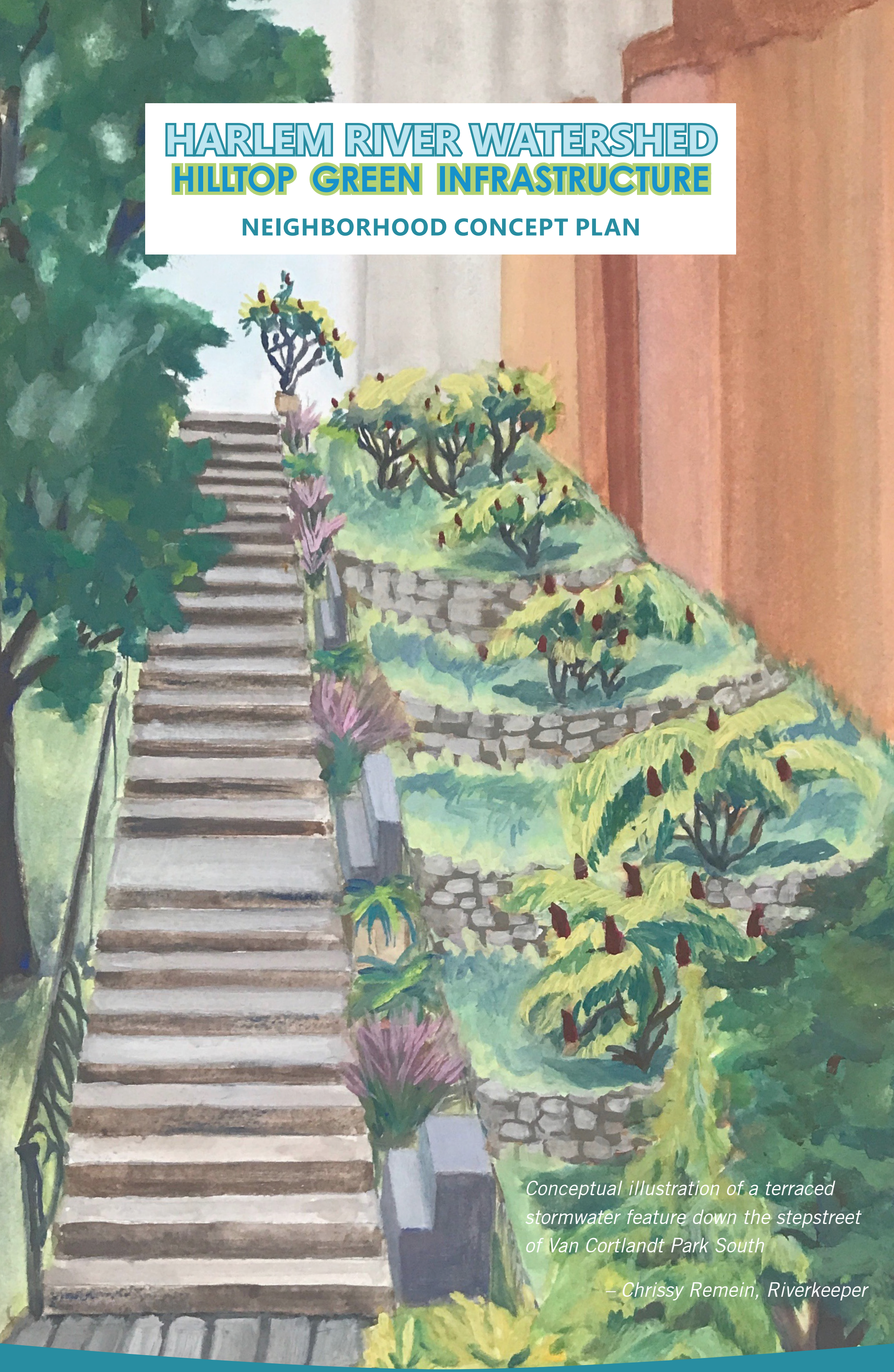
HARLEM RIVER WATERSHED
HILLTOP GREEN INFRASTRUCTURE

NEIGHBORHOOD CONCEPT PLAN



Conceptual illustration of a terraced stormwater feature down the stepstreet of Van Cortlandt Park South

– Chrissy Remein, Riverkeeper

JUNE 2018

RIVERKEEPER
NY's clean water advocate

BRONX COUNCIL FOR ENVIRONMENTAL QUALITY

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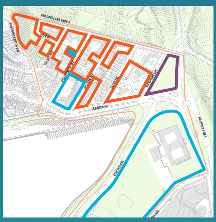
WHY HARLEM RIVER HILLTOP?

The project area for this green infrastructure plan is at the top of the Harlem River watershed. Saddled between Van Cortlandt Park, Jerome Park Reservoir, and several schools, this area contributes to two major Combined Sewer Overflows (WI-056 and WI-068) that discharge raw sewage and polluted stormwater into the Harlem River nearly every time it rains. This area borders Van Cortlandt Park and has corridors of mature trees along Mosholu Parkway, but there are also many impervious surfaces and compacted soils that channel stormwater to the street during heavy rainfall and cause flooding throughout the neighborhood. A comprehensive green infrastructure plan for this area will help mitigate CSO pollution in the Harlem River and local flooding, as well as provide many environmental benefits to the neighborhood.



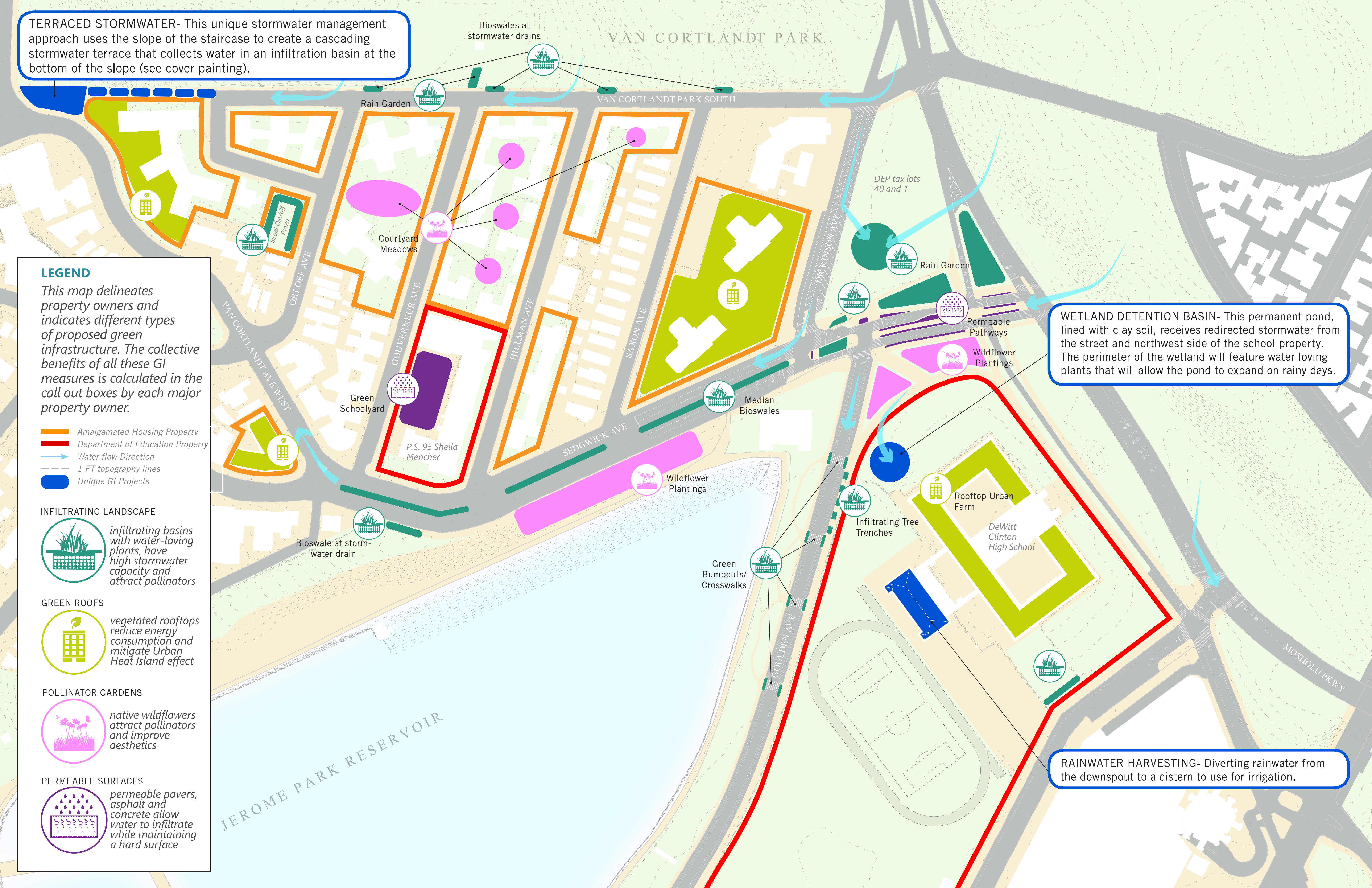
FEW LAND OWNERS :
Much of the land is owned by Amalgamated Housing Co-op, the Parks Department (NYC Parks), Department of Environmental Protection (DEP), Department of Education (DOE), and the Department of Transportation (DOT). This simplifies getting buy-in from multiple property owners.

COMMUNITY BENEFITS:
Green infrastructure has many extra benefits beyond stormwater management. Improving air quality and aesthetics, increasing recreational and educational opportunity, and providing space for potential urban agriculture are just some of the community benefits that can be gained through green infrastructure.

MAGNITUDE:
Green infrastructure benefits are maximized when they are part of an interconnected system. This hilltop plan at the top of the watershed is a template that can be replicated throughout the watershed, magnifying the water quality impact and distribution of benefits.

WHY GREEN INFRASTRUCTURE?

Green infrastructure (GI) is a cost-effective way to manage stormwater runoff to reduce combined sewer overflow into the Harlem River, when compared to traditional systems of grey infrastructure that capture and convey stormwater to a wastewater treatment plant. GI manages stormwater on site by infiltrating it into the ground. GI also provides many benefits that traditional grey infrastructure does not; GI can have positive impacts on energy consumption, air quality, atmospheric carbon reduction and sequestration (capturing carbon), urban heat island effect, education, habitat, and other elements of community and environmental health. Some of those benefits are quantified in this brochure.



TERRACED STORMWATER- This unique stormwater management approach uses the slope of the staircase to create a cascading stormwater terrace that collects water in an infiltration basin at the bottom of the slope (see cover painting).
Bioswales at stormwater drains
VAN CORTLANDT PARK
VAN CORTLANDT PARK SOUTH
Rain Garden
Israel Ostroff Plaza
Courtyard Meadows
ORLOFF AVE
VAN CORTLANDT AVE WEST
GOUVERNEUR AVE
HILLMAN AVE
SAXON AVE
DICKINSON AVE
SEDGWICK AVE
Green Schoolyard
P.S. 95 Sheila Mencher
Median Bioswales
Wildflower Plantings
Bioswale at storm-water drain
DEP tax lots 40 and 1
Rain Garden
Permeable Pathways
Wildflower Plantings
WETLAND DETENTION BASIN- This permanent pond, lined with clay soil, receives redirected stormwater from the street and northwest side of the school property. The perimeter of the wetland will feature water loving plants that will allow the pond to expand on rainy days.
Rooftop Urban Farm
DeWitt Clinton High School
Infiltrating Tree Trenches
Green Bumpouts/ Crosswalks
GOULDEN AVE
MOSHOLU PKWY
RAINWATER HARVESTING- Diverting rainwater from the downspout to a cistern to use for irrigation.
JEROME PARK RESERVOIR
LEGEND
This map delineates property owners and indicates different types of proposed green infrastructure. The collective benefits of all these GI measures is calculated in the call out boxes by each major property owner.
Amalgamated Housing Property
Department of Education Property
Water flow Direction
1 FT topography lines
Unique GI Projects
INFILTRATING LANDSCAPE
infiltrating basins with water-loving plants, have high stormwater capacity and attract pollinators
GREEN ROOFS
vegetated rooftops reduce energy consumption and mitigate Urban Heat Island effect
POLLINATOR GARDENS
native wildflowers attract pollinators and improve aesthetics
PERMEABLE SURFACES
permeable pavers, asphalt and concrete allow water to infiltrate while maintaining a hard surface

AMALGAMATED HOUSING

The housing co-op owns much of the land between Jerome Park Reservoir and Van Cortlandt Park, including several towers, grassy courtyards, a shopping center and pocket park. There are opportunities on the property for several green roofs and conversion of grassy lawns to wildflower meadows, among other projects.

3.4 Mgal
Annual stormwater capture in millions of gallons

4,000 kwH
Annual cooling savings

5,000 lbs/yr
Annual carbon sequestered

DEPARTMENT OF EDUCATION

There are two public schools within the study area - P.S. 95 and DeWitt Clinton High School. A green schoolyard would fit well in P.S. 95, and a wetland detention pond and additional bioswale complement ongoing sustainability initiatives already underway at DeWitt Clinton school. Rooftops offer opportunity for an urban farm and rainwater harvesting for their existing garden.

4.9 Mgal
Annual stormwater capture in millions of gallons

24,000 kwH
Annual cooling savings

4,500 lbs/yr
Annual carbon sequestered

PUBLIC LAND

A large swath of underutilized land separates DeWitt Clinton High School from Van Cortlandt Park, and provides ample potential for green infrastructure. This area includes traffic triangles in DOT's jurisdiction, a DEP-owned park, and boundaries of parkland. GI proposals include many infiltrating landscapes and some wildflower plantings.

10.5 Mgal
Annual stormwater capture in millions of gallons

550 kwH
Annual cooling Saving

4,000 lbs/yr
Annual carbon sequestered

CONSIDERATIONS AND NEXT STEPS FOR THE HARLEM RIVER HILLTOP GREEN INFRASTRUCTURE PLAN

Some of the recommended projects in this plan can be implemented easily and immediately, some will require significant funding and design, and there are many in between. Overall, future implementation of this plan relies on coordination between the city agencies involved and securing funding from multiple sources, including DEP.

For more information on all the proposed projects & their benefits, please visit: www.riverkeeper.org/harlemriverhilltop. Below is a brief synopsis of the recommended projects for each of the major land owners in the study area:

Amalgamated Houses: Courtyard meadows and rain gardens can be planted in existing open spaces immediately, but Amalgamated Housing's gardening staff will have to be trained on new management techniques. To initiate more technical projects, like a terraced stormwater feature along Van Cortlandt Park South or a green roof, Amalgamated should work with a landscape architecture firm to develop conceptual plans. These projects would be eligible for funding under DEP's Green Infrastructure Grant Program.

Department of Education: P.S. 95 has a small yard that could be turned into a green schoolyard immediately. There are several examples of green schoolyards throughout NYC, overseen by the Trust for Public Land and funded by DEP. The proposed wetland detention basin on DeWitt Clinton High School's campus could be implemented alongside the school's ongoing sustainability initiatives.

Public Land: There is ample space here for DEP, DOT, & Parks to collaborate and implement innovative green infrastructure designs. For example:

- DOT is currently assessing Mosholu Parkway and Sedgwick Avenue for traffic calming under the City's Vision Zero plan. Traffic calming features should incorporate green infrastructure to maximize public benefits.

- The Parks Department is currently developing a Harlem River Watershed & Natural Resources Management Plan, which will include recommendations for new green infrastructure features in Van Cortlandt Park.

- DEP owns underutilized land adjacent to DOT land that could be improved to maximize stormwater capture as well as public use of the space.

- Across all public lands, grassy lawns that cannot be converted to infiltrating green infrastructure due to underground utilities could be transformed into aesthetically-pleasing productive pollinator spaces by planting native wildflowers and meadow vegetation.

THANK YOUS

This area was selected through input from the Bronx Council for Environmental Quality and the Bronx Community Board 8 Environment & Sanitation Committee. Challenges and opportunities were identified collaboratively with the Bronx Council for Environmental Quality, Amalgamated Housing Board of Directors, the DeWitt Clinton High School sustainability coordinator, and representatives from DEP, Parks, and DOT. Ideas were collected and evaluated by New York City Soil & Water Conservation District and Riverkeeper and this brochure was designed by Perkins + Will.

This Project has been funded in part by a grant from the New York State Environmental Protection Fund through the Hudson River Estuary Program of the New York State Department of Environmental Conservation.

NEW YORK STATE OF OPPORTUNITY | Hudson River Estuary Program

A Program of the New York State Department of Environmental Conservation

TO LEARN MORE

Visit our website www.riverkeeper.org/harlemriverhilltop

Email korin@nycswcd.net

Harlem River Watershed
Hilltop Green Infrastructure

Neighborhood Concept Plan – Background & Methodology

Introduction

The Harlem River Watershed Hilltop Green Infrastructure Conceptual Neighborhood Plan is a proposal to implement a comprehensive green infrastructure plan to reduce combined sewer overflow (CSO) into the Harlem River. The study area is about 75 acres and contributes to two major CSO outfalls that discharge into the Harlem River: WI-056 discharges 735 million gallons a year into the Harlem River at Kingsbridge Heights, and WI-068 discharges 227 million gallons a year into Bronx Kills[1]. Green infrastructure (GI) manages stormwater on site by infiltrating stormwater into the ground or detaining stormwater during peak flow to later be released back to the combined sewer and stormwater system. GI in these two CSO drainage areas will help reduce stormwater contributions to CSOs, as well as provide many additional benefits, or co-benefits.

Complementary Planning Initiatives

This neighborhood Green Infrastructure Plan brings together various complementary planning processes occurring throughout the study area. The NYC Department of Environmental Protection (DEP) is developing a CSO Long Term Control Plan to address water quality in the Harlem River.[2] DEP is currently analyzing the waterbody and watershed, and evaluating alternatives to reduce CSO. Green infrastructure could be a major component of that plan, and this plan provides an initial template to investigate other areas of the watershed for green infrastructure potential.

NYC Department of Transportation (DOT) has been studying Mosholu Parkway for pedestrian and bike improvements under their Vision Zero plan, with a mission to end traffic injuries and fatalities[3]. There is currently underutilized space where Sedgwick and Goulden Avenues meet Mosholu Parkway. DOT has developed a draft conceptual plan to create safer pedestrian crossings and bike connections through those intersections. Rededicating space to pedestrians allows opportunity to fill in some of those interstitial (in between) spaces with green infrastructure.

NYC Department of Parks and Recreation (NYC Parks) is developing a Watershed and Natural Resources Management Plan for the Harlem River Watershed in the Bronx. One of the goals of the plan is to identify opportunities for stormwater management, including expansion of green infrastructure on NYC Parks properties.[4] Van Cortlandt Park lies within our study area, and NYC

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[1] According to DEP's 2016 model year: http://www.nyc.gov/html/dep/pdf/harbor/spdes_bmp_report_2016.pdf

[2] This is part of the Citywide East River/Open Waters Long Term Control Plan: http://www.nyc.gov/html/dep/html/cso_long_term_control_plan/citywide-ltcp.shtml

[3] http://www1.nyc.gov/site/visionzero/index.page

[4] https://www.nycgovparks.org/planning-and-building/planning/conceptual-plans/harlem-river-watershed

Parks actively manages this park to protect and restore natural resources along with providing recreational opportunities. A major long term project in Van Cortlandt Park is the daylighting[5] of a freshwater stream that currently enters the sewer system after flowing through Van Cortlandt Lake. On dry days, it is then piped to the Wards Island Treatment Plant for treatment. On wet days, it contributes to CSO. Daylighting the stream and separating it from the sewer system would reduce the unnecessary flow treated at the treatment plant and reduce CSO. During the planning process, NYC Parks has identified several opportunities for GI within and adjacent to Van Cortlandt Park, some of which are along the southern perimeter of the park.

The neighboring high school, DeWitt Clinton High School, has several ongoing sustainability initiatives. It currently has a community garden and hydroponic farm, and is planning the James Baldwin Outdoor Learning Center[6] and Trail. Stormwater management projects in coordination with its sustainability initiatives provide an opportunity to teach students about green infrastructure and combined sewer overflow, as well as job training in maintenance of the green infrastructure on campus.

Amalgamated Houses is a housing cooperative with a twelve-member Board of Directors. The Board oversees contracts, budgets and maintenance of projects in the co-op.[7] Amalgamated Houses is currently working on façade improvements and a boiler replacement. While there are no immediate projects that could incorporate green infrastructure, there is interest in future projects to help relieve nuisance flooding residents experience during heavy rainstorms.

Benefits of Green Infrastructure

GI increases the amount of vegetation on previously impervious surfaces, usually using native species, and has many environmental benefits. In addition to managing stormwater runoff and improving water quality, higher density of vegetation could lead to less air pollution, which means lower instances of asthma and respiratory-related illnesses. Vegetation takes in carbon dioxide, removing the greenhouse gas from the environment and curbing Climate Change, as well as increasing shade and mitigating Urban Heat Island effect. While there may not be clear, immediate financial benefit, there is certainly environmental health benefits to be gained, which will overall improve the health of the community. Green roofs do have direct financial benefit to the property owner, as vegetation on the rooftop creates a layer of insulation that will help reduce heating and cooling costs throughout the year. GI can also provide opportunities for education and recreation, for example a farm on a school rooftop, or studying a nearby green infrastructure installation's performance. By using native plants that attract pollinators like bees and butterflies, GI can provide habitat and help those species thrive. Replacing grassy lawns with wildflowers and pollinator plants can help make these spaces more environmentally productive. Wildflowers have deeper roots than grasses, which can penetrate further into the ground and better absorb stormwater.

[5] Daylighting a stream means bringing a stream that has been buried back to the surface, and restoring it to its natural state.

[6] The Baldwin Outdoor Learning Center is a project envisioned by the Dewitt Clinton High School community and partners to create a nature-based educational and social space on the high school campus.

[7] https://www.amalgamated-bronx.coop/board-management/

GI typologies

Infiltrating Landscapes

There are many types of green infrastructure practices that infiltrate into the ground, which we are calling collectively in this proposal "infiltrating landscapes". This includes rain gardens, infiltrating tree trenches, and stormwater bumpouts, all described below.

Rain gardens are depressed (as in low points, topographically) areas with plantings especially effective at evapotranspiration. They typically are designed to take on stormwater runoff from nearby paved surfaces, and have a very high stormwater capture capacity as long as the soils below can receive water[8]. Deep-rooted native grasses have high stormwater capture capacity and are common in rain gardens. The deep roots help keep the soils below porous, and native grasses are able to soak up and evapotranspire more water than other plant types. However, grasses may look unwieldy and unkempt, so some education is necessary to ensure that rain gardens don't appear to be eye-sores to the community. If the soil below is not ideal for infiltration (for example, clay soils, high bedrock, high ground water table, or contaminated soils), a non-infiltrating rain garden is an emerging practice in NYC and an option in these scenarios. These systems would be designed to hold water during the peak flow of the storm (when the flow of stormwater runoff is the highest). Non-infiltrating rain gardens would have a soil and gravel layer below the vegetation (much like an infiltrating rain garden), but instead of allowing water to soak into the ground, the bottom of the water storage layer would be lined, and an underdrain would connect to the sewer system and allow stored stormwater to slowly discharge to the sewer system.

DEP Standard Right-of-Way Rain Garden. Source: NYC DEP.

Rain gardens, in addition to having immense stormwater capture capacity, provide many ancillary benefits. Rain gardens often feature native plantings that support pollinators such as bees and butterflies. Rain gardens that replace areas that are paved or grassy lawns will mean more productive plant species that are more effective at filtering the air, sequestering atmospheric CO_2 and mitigating urban heat island effect. Rain gardens provide an educational opportunity for students to learn about stormwater management and pollinator habitat creation.

NYC DEP has installed thousands of rain gardens in the right-of-way (also called ROW bioswales) throughout the city. These rain gardens have curb cuts to capture stormwater from the street and gravel basins underneath to store large volumes of stormwater and allow it to slowly discharge into the ground. They are designed to manage an inch of rainfall (which can accumulate to up to thousands of gallons of stormwater per rainstorm) and often manage more. We propose some

[8] More porous soils, like sandy soils, are able to receive water better than fine soils, like clay.

standard ROW bioswales slightly uphill from storm drains where there is sidewalk space and no existing trees. We also propose rain gardens where there are unutilized spaces other than the right-of-way. These would be specifically designed to fit the space, and are described in the Recommendations section.

An infiltrating tree trench, or stormwater tree trench, on the surface doesn't look much different than a regular street tree. Underground, a system of gravel and distribution pipes allows for high volumes of stormwater to enter the trench, water the trees, and infiltrate into the ground. Infiltrating tree trenches have high stormwater management capacity. Adding street trees will create shade to help cool in the summer, and intercept winds to keep warm in the winter. Trees absorb many air pollutants and intercept particulate matter, as well as sequester atmospheric carbon dioxide and mitigate Urban Heat Island Effect. A system of infiltrating tree trenches was recommended along a barren portion of sidewalk along Goulden Avenue where there were no existing street trees.

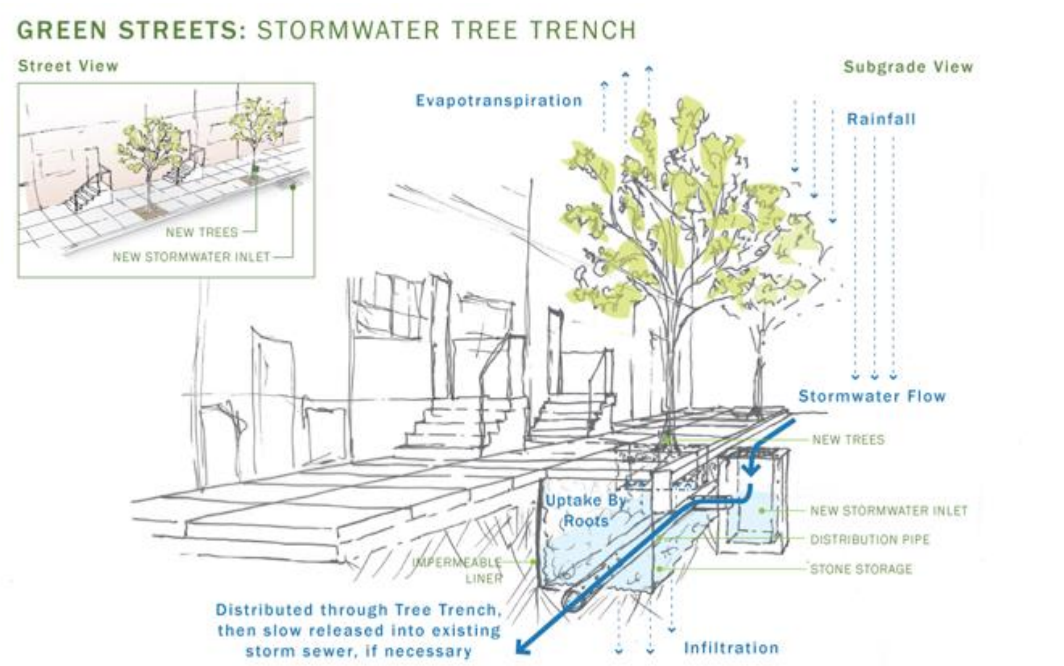


Diagram of a stormwater tree trench from the Philadelphia Water Department.

Stormwater bumpouts are similar to ROW bioswales, but bulb out from the sidewalk to dually act as a stormwater management and traffic calming mechanism. They may replace a parking spot or bulb out from the corner, leaving a pathway for a pedestrian crossing. Shorter plantings are usually selected to maintain good traffic visibility. These are proposed along a road where there are few pedestrian crossings and low demand for parking.

Example of a Stormwater Bumpout. Photo from Kentucky Waterways. Alliance.

All vegetated infiltration projects will require maintenance that will differ from standard street tree and right-of-way plantings. Stormwater inlets may carry litter into the swale or planting, where it may collect and be an eye sore. Checking on the sites regularly and removing litter, especially after a rain event, is helpful for community acceptance. During the first year or more, plantings will need to be weeded and watered to make sure they become well established, though selecting native plant species will minimize irrigation needs and improve the plants' chances of outcompeting weeds. The more established the plants become, the easier maintenance will be in the future, so regular maintenance in the first few years is crucial to its success. Sites that are well maintained are more likely to have higher stormwater capacity than sites that are clogged with litter and overgrown with plants that don't have high water uptake.

Green Roofs

Green roofs are vegetated areas on top of a roof. Green roofs utilize lightweight soils, drainage and water storage layers, and a root barrier. There are generally two types of green roof. An extensive green roof is lighter weight and has a soil depth of two to six inches. This is better for roofs with a lighter structural load capacity, but also limits stormwater capture capacity and insulation benefits. Extensive green roofs have shorter plants and require less maintenance. An intensive green roof has soil depths greater than six inches. In general, the deeper the growing medium (soil depth), the greater the environmental benefit. This comes with greater cost and maintenance requirements.

Green roofs provide ancillary benefit to the building, the surrounding community, and the environment. Vegetation on the roof helps filter the air and remove harmful air pollutants, while sequestering (capturing) carbon and reducing atmospheric CO_2, a greenhouse gas that contributes to climate change. Growing media on the roof helps insulate the building, which can reduce a building's energy consumption in both winter and summer months. Green roofs can provide recreational space for the community or building residents, and in structurally sound buildings can be used for a rooftop garden, promoting food access and potential income and educational opportunities. Vegetated rooftops also provide habitat for birds, bees, butterflies and other pollinators, especially when utilizing native plant species.

Maintenance of a green roof depends on the type of green roof. Extensive green roofs are easier to maintain, but either type needs regular watering and weeding (weekly or biweekly) until the plants are established.

Green roofs were considered for each rooftop in the study area. Many rooftops in the Amalgamated Housing Co-op were identified by the Board as unable to support a green roof, but the parking garages provided some opportunity to increase vegetation, even if would have no direct benefits to the building.

Bronx County Courthouse Green Roof. Photo from Bronx Council for Environmental Quality.

Pollinator Gardens

Where there may not be capacity for infiltration, or there is room for minimal improvement, a pollinator garden is a quick, easy strategy to improve stormwater retention and provide wildlife habitat. A pollinator garden, also called a wildflower meadow, is simply a mix of native plants that provide habitat for birds and pollinators. There are several grassy lawns throughout the study area: along the Jerome Park Reservoir and on top of the aqueduct to the reservoir, as well as within the courtyards of some of the Amalgamated Housing buildings. Grassy lawns are only slightly better than concrete at managing stormwater; short grasses do not have much stormwater capture capacity as the roots are short and soils become easily compacted. Converting these lawns into pollinator gardens makes for a more productive and aesthetically pleasing landscape. Wildflower meadows are also suitable for steep slopes, as they prevent erosion and reduce the need for mowing. While in the long term, a good wildflower meadow will require less maintenance than a grassy lawn, it is important for maintenance crews to understand the requirements in establishing a wildflower meadow. The first few years of a pollinator garden will require intensive weed control. Once the wildflowers establish a natural advantage over the weeds, it will require minimal maintenance and will only need to be mowed once a year. Central Park in Manhattan is establishing a wildflower meadow, and may be a useful resource for wildflower meadows in NYC.[9] The Greenbelt Native Plant Center on Staten Island also has many resources and a nursery.[10]

Pollinator gardens are recommended in areas where infiltration is unlikely, such as over important water infrastructure for the viaduct to the Jerome Park Reservoir, or as a quick and easy approach for a productive landscape with some stormwater management benefit, such as on underutilized grassy lawns.

Before & After of Cook Wissahickon School in Philadelphia. Photo from Community Design Collaborative.

[9] http://www.centralparknyc.org/about/blog/establishing-wildflower-meadow.html
[10] https://www.nycgovparks.org/greening/greenbelt-native-plant-center

Permeable Surfaces

Permeable surfaces include permeable pavers, porous concrete, porous paving, or other pervious surfaces. These types of surfaces have porous features that allow water to pass through and infiltrate into the ground while maintaining a hard surface. Porous surfaces are usually suited for light weight activities, such as sidewalks, bike paths and parking spots, and not for heavy traffic.

Grass pavers, permeable pavers and porous asphalt. Photos from Rutgers University.

Permeable surfaces have porous spaces that can clog easily and must be maintained to be effective. Typically permeable surfaces must be vacuumed several times a year.

Permeable surfaces are recommended where there is a need for a hard surface like a path or a playground.

Co-Benefits Matrix

Below are the co-benefits associated with each green infrastructure type, adapted from the benefits matrix developed by the Center for Neighborhood Technology's "The Value of Green Infrastructure; A Guide to Recognizing Its Economic, Environmental and Social Benefits"[11].

Benefits of GI type	Infiltrating Landscapes	Green Roof	Pollinator Garden	Permeable Surfaces
Manages Stormwater	●●●	●●	●	●●
Reduces Energy Use	●●	●●●	●	-
Improves Air Quality	●●	●●	●●	-
Reduces Atmospheric CO2	●●	●●	●●	-
Reduces Urban Heat Island Impact	●●	●●	●●	-
Creates Habitat for Pollinators	●●	●●	●●●	-
Increases Educational Opportunity	●●	●●	●●	●
Enhances Recreation Opportunity	-	●	●	●●●

● Maybe

●● Yes

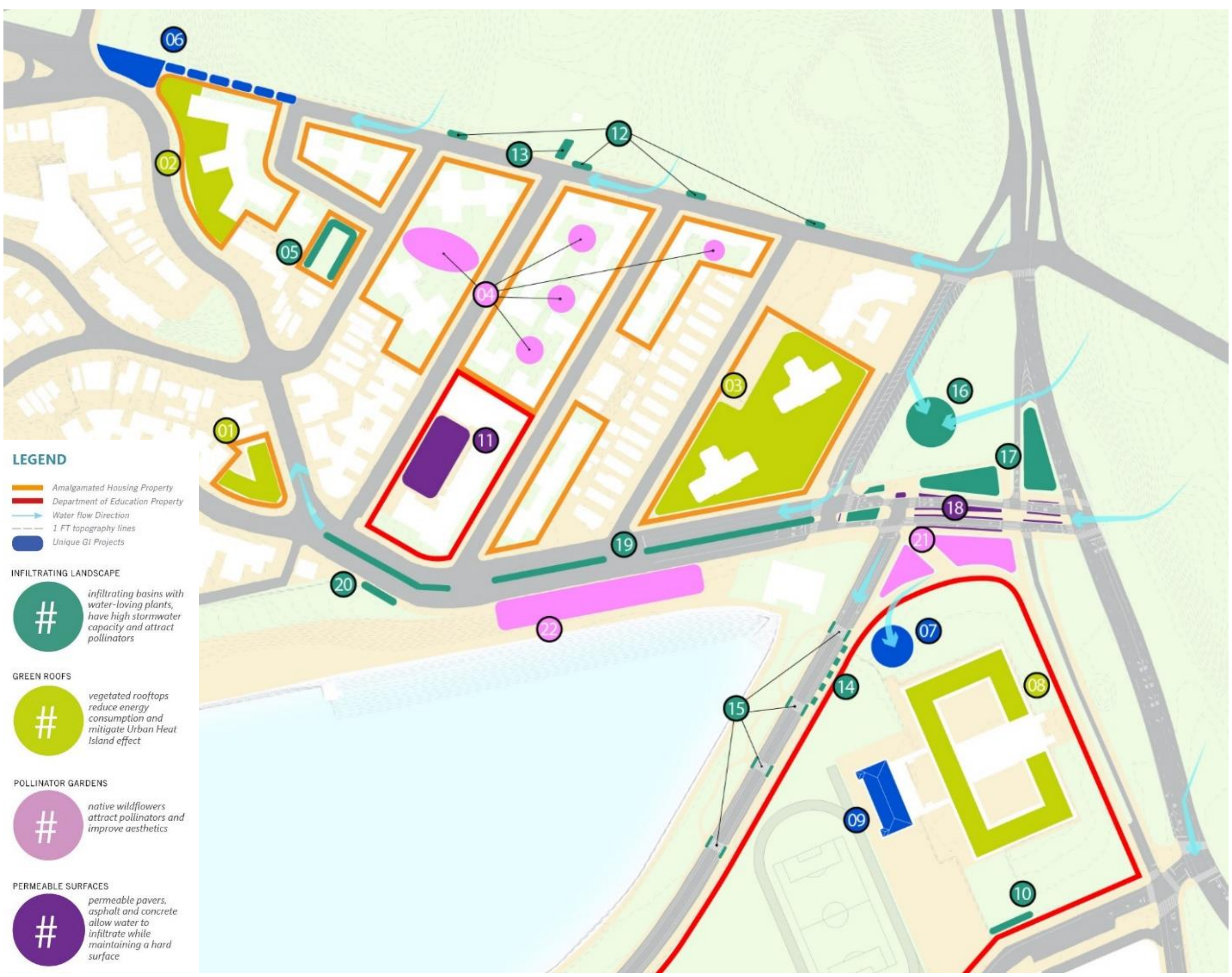
●●● Major Benefit

[11] https://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf

Recommendations per Property Owner

There are two major property owners in the study area: Amalgamated Houses, and the City of New York with jurisdiction by multiple agencies. We excluded other private property owners from the recommendations, as they make up a small portion of the study area and we do not have an existing relationship with those owners. To understand site conditions and develop recommendations, we met with stakeholders from city agencies, the housing co-op and from the community. We met with DEP and DOT in their respective offices to better understand constraints and current planning efforts for the study area. We also conducted a site visit and were joined by the sustainability coordinator for DeWitt Clinton High School, NYC Parks, Board members of Amalgamated Houses and Bronx Council for Environmental Quality.

We developed recommendations during the site visit and through follow up conversations. We considered how the site was currently being used, where and how much stormwater was flowing through the site, and preferences and capacity of the property owners. We simplified our green infrastructure recommendations into the four typologies (described above): infiltrating landscapes (includes tree trenches, rain gardens and bumpouts), green roofs, pollinator gardens and permeable surfaces. There were several locations where stakeholders had suggestions or requests to look at areas that were unique and do not fit into the categories above. This includes a terraced green infrastructure feature located along the stepstreet of Van Cortlandt Park South, and wetland detention basin and rainwater harvesting at DeWitt Clinton High School.



In the map above, Amalgamated Houses property is outlined in orange, public schools in red. The right-of-way, parkland and reservoir are owned by three public agencies: Department of Transportation, Department of Environmental Protection, and the Parks Department. The green infrastructure recommendations are described below, grouped by Amalgamated Houses, Public Schools, and Other City Owned Land.

Amalgamated Houses

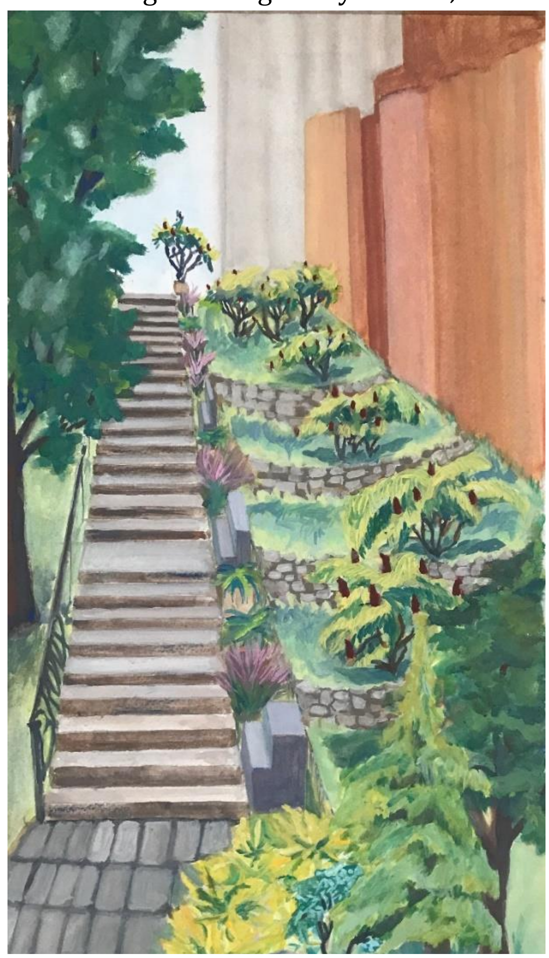
Amalgamated Houses experiences issues with street flooding during major rain storms. Even though Van Cortlandt Park makes up the northern border of the property, runoff from the park streams down Van Cortlandt Park South. The cooperative had installed permeable pavers between the street trees along the sidewalk, but have not noticed much impact on reducing stormwater runoff. Stormwater improvements surrounding Amalgamated (to the North and East of the property) will help, and there are some opportunities for improvements within Amalgamated Houses.

Green roofs will not make an impact on street flooding, but will reduce overall stormwater entering the sewer system. The green roofs proposed here will be provide energy saving benefits and recreational opportunities for the residents. The shopping center at Sedgwick Avenue and Van Cortlandt Avenue West (1) has a flat rooftop that could likely support a green roof. The businesses inside the shopping center would benefit from reducing heating and cooling needs from the extra insulation from a layer of vegetation. The Gale Place Garage rooftop (2) is another ideal location for a green roof as it is easily accessible to the residents of Amalgamated Houses. There would not be energy saving benefits to this green roof, as the garage does not have heating or cooling. However this green roof would provide a new open space for residents to enjoy.

The impervious courtyard that covers the Towers' underground parking garage (3) currently pools water due to poor drainage. This courtyard is the roof of the parking garage and is at-grade. There is also a portion that is built up to a plateau with trees and grass. The function of this site is unclear and it is currently not utilized. We recommend redoing this space as a green roof-style courtyard. Like a green roof, there would be a drainage layer on the bottom to direct excess water to a drainage system, and soil and vegetation to store and take up stormwater. If desired, there could be paths and seating areas throughout the courtyard to make it more of a community amenity. Since this is not a traditional green roof, there may be more complications in the feasibility study and design process, but the potential constraints should not be prohibitive.

Amalgamated Houses has many grassy courtyards (4) that are maintained by the staff gardener. The courtyards are not accessible for residents to use or walk through. During heavy rainfall, the grasses cannot absorb all the rain, and stormwater runoff flows into the streets. We propose converting these courtyards into pollinator gardens or wildflower meadows. This space would be more ecologically productive, easy to maintain in the long term, and the deeper roots of these plants would help retain more stormwater. This is an easy to implement and cost-effective strategy. However, the gardening crew would need to undergo training to identify native flowers and understand the maintenance needs of wildflower plantings, as careful maintenance during the first few years is crucial to establishing advantage over weeds. Another alternative to this area is to build rain gardens to replace the hedges along the perimeter of the courtyards with water-loving shrubs. This would help take on the excess stormwater that is running past the hedges into the street. Amalgamated would have to perform an infiltration test[12] to ensure that large amounts of stormwater can soak into the ground before pursuing rain gardens in these areas.

Israel Ostroff Plaza Choochoo Train Park (5) is a small pocket park that is mostly asphalt with a perimeter of exposed soil and some mature trees. Amalgamated could improve the stormwater performance of this park by filling in the exposed soil between the trees with rain garden plantings.



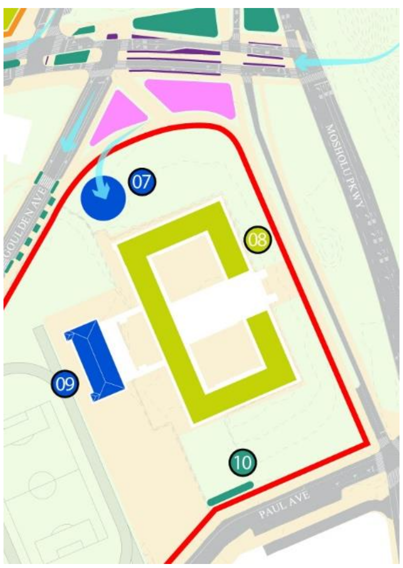
Terraced GI down the stepstreet of Van Cortlandt Park South. Painting by Chrissy Remein.

[12] A soil test to see how well water drains through soil. For large projects, this will require an engineer, geologist or soils scientist. There are DIY guides for infiltration tests that involve digging a hole and timing how long it takes for water to drain. DIY tests are only suitable for small projects.

Lastly on Amalgamated Houses property is a stepstreet from Van Cortlandt Park South down the side of the Westernmost Amalgamated Housing tower to Van Cortlandt Avenue West (6). Along the stepstreet is a mostly barren slope. This slope can be transformed into a terraced stormwater feature, taking in stormwater from Van Cortlandt Park South, running through stormwater plantings along the slope, and landing in a rain garden at the bottom of the slope at Van Cortlandt Avenue West (see painting). This is a very unique and site-specific project that would require an engineer and designer to assess the feasibility. It is unclear whether this strip of land is owned by Amalgamated or the City. This would need to be resolved through a request to Bronx Borough Hall to figure out how to fund the project.

The major projects on Amalgamated Houses' property are eligible for a DEP Green Infrastructure Grant, and could be applied for together because they are all owned by Amalgamated Houses. The smaller projects like the pollinator gardens could be implemented without waiting for a DEP grant.

Public Schools



DeWitt Clinton High School has robust sustainability initiatives which has brought a hydroponic farm, community garden, an orchard and a bioswale to the school already. The sustainability coordinator has been leading an effort to develop a plan for the James Baldwin Outdoor Learning Center and Trail that will promote healthy eating, accessibility to nearby trails, and environmental sustainability. The community garden and orchard make up parts of the trail, and Marpillero Pollak Architects has been drafting designs with the planning team for the Learning Center. Included in this plan is a proposal for a wetland retention basin next to the community garden (7). This unique green infrastructure project would direct drainage from the nearby street and grassy lot to a permanent pond, lined with clay soil and will take on excess water on rainy days. This would require some design and engineering, but is feasible for this space.

In the long term, DeWitt Clinton High School is interested in converting the roof top of the main building into a green roof that can be used as an urban farm. In the short term, the small roof of the small building (9) can be investigated for rainwater harvesting to use for irrigating the community garden and orchard. Finally, the parking lot would benefit from an additional bioswale along the perimeter (10). The school is currently undergoing renovations, including retrofitting the rooftop and resurfacing the parking lot, so the rooftop farm and parking lot bioswale will likely have to wait until the roof and parking lot need to be replaced again.

There is another public school in the study area: P.S. 95 Sheila Mencher is a public school near Amalgamated Houses (11 - see map on page 8 for reference). The school has a blacktop playground and flat rooftop. P.S. 95 could benefit from developing a "green schoolyard" through the Trust for Public Lands Playgrounds Program. Through this program, students help design an environmentally friendly playground. IS 250 in Flushing, Queens, recently went through the program, and designed a playground that will manage 1.2 million gallons of stormwater a year.

Funding for the playground came from the Queens Borough President, DEP, the Council Member Rory Lancman, and Supporters of the Trust for Public Land.[13]

Other City Owned Land

Much of the rest of the land in the study area surrounding and in between Amalgamated Houses and the schools is under the jurisdiction of several city agencies: NYC Parks, DEP or DOT. These city agencies all have staff working on green infrastructure initiatives and could come together to share resources on this comprehensive green infrastructure plan.

13 http://qns.com/story/2018/04/18/ground-breaks-new-student-designed-playground-flushing/

Along Van Cortlandt Park South are opportunities to implement DEP's standard right-of-way (ROW) bioswales (12). This segment of Van Cortlandt Park South currently has some street trees and has a buffer between the sidewalk and street where ROW rain gardens could go. This part of the ROW has been detrimentally eroded from stormwater running down the street, demonstrating the need for better stormwater management on this block. The four ROW rain gardens proposed here are right before each catch basin on north side of the street. A standard ROW bioswale on the sidewalk falls under DEP's jurisdiction, but could be recommended through NYC Parks' Harlem River Watershed Plan.

DEP's standard ROW bioswale, and photo of existing conditions along Van Cortlandt Park South.

Also in this area at the park entrance at Gouverneur Avenue (13), a rain garden would help capture stormwater accumulating and running off along the paths near the entrance. On a rainy day, this flow continues to the street and into the sewer system.

Along Goulden Avenue, there are opportunities for two types of infiltrating landscapes. On the Eastern side of the road closest to the school, there are no trees (14). On a hot, sunny day, this area feels very barren, and on a rainy day, stormwater runs along this street past the school to the nearest catch basin. This area is ideal for infiltrating tree trenches, as there is no existing tree canopy. Further along Goulden Avenue (15), we recommend eight stormwater bumpouts, four on each side of the street. These are proposed where we suggest pedestrian crossings at the entrances of the linear park next to the Jerome Park Reservoir. There are currently no formal pedestrian crossings that would connect the high school to the park.

Example of a stormwater bumpout from the Philadelphia Water Department, and existing conditions along Goulden Avenue.

Where Mosholu Parkway, Sedgwick Avenue, and Dickinson Avenue converge is a park owned by DEP (16). Stormwater currently runs along the sides of the parks into catch basins along Sedgwick Avenue. The park itself has a perimeter of mature trees, but has a large grassy patch in the middle that is only used as a shortcut to walk through. There is ample space in the middle to build a rain garden and channel stormwater between the trees from each of the neighboring streets. This could be coupled with some amenities such as benches to become a more utilized space by the community. To maximize stormwater input, Dickinson Avenue could be regraded to slope towards the rain garden inlet.

Left: runoff pooling on edge of Dickinson Avenue. Right: street runoff channeled to rain garden in Philadelphia. Photos by Korin Tangtrakul.

Just along the Southern boundary of the park is where Sedgwick Avenue meets Mosholu Parkway. This area is currently being considered by DOT for traffic calming improvements. This entails taking away part of the roadway and allowing more space for pedestrians and cyclists. Opening up this space for non-vehicular use also opens up room for some infiltrating landscapes. The larger triangles and odd spaces can be used for attractive rain garden (17) and the linear spaces for pathways using permeable surfaces (18).

Further down Sedgwick Avenue is a typical vegetated median that is slightly elevated so that it does not take in stormwater from the street (19). We recommend converting the median to rain gardens and regrading Sedgwick Avenue to drain to these gardens. As with all rain gardens, an overflow allows excess water to drain into the combined sewer system so the street will not get flooded. At the bottom of hill before Stevenson Place (20), there is an opportunity for a standard DEP ROW bioswale that could manage runoff from the sidewalk along the side of Jerome Park Reservoir.

There are two grassy areas that house important accessways for DEP infrastructure: the land between Sedgwick Avenue and the DeWitt Clinton High School (21), and along the Northwest slope of Jerome Park Reservoir (22). Since these areas are near or over important infrastructure, infiltration projects were not recommended here; rather these areas would benefit from light improvements such as pollinator gardens that create ecologically productive spaces while maintaining infrastructure accessways.

Rendering of median rain gardens in NYC. Image from Biohabitats.

Below is a summary of all of the projects discussed for each property types, and the feasibility to implement. This is based on precedence for similar projects in NYC and other cities, and the need for technical assessments.

	Project	Immediately Implementable	Precedence, Feasible	Needs Feasibility Analysis	Distant Future
AMALGAMATED	1) Green Roof on Shopping Center		●		
	2) Green Roof on Gale Place Garage		●		
	3) Green Roof-style Courtyard on Amalgamated Towers Parking Garage			●	
	4) Transform Grassy Lawn into Courtyard Meadows	●			
	5) Rain Garden Plantings at ChooChoo Train Park	●			
	6) Terrace Stormwater Feature along Van Cortlandt Park South Stepstreet			●	
SCHOOLS	7) DeWitt Clinton Wetland Retention Basin		●		
	8) DeWitt Clinton Green Roof & Farm				●
	9) DeWitt Clinton Rainwater Harvesting	●			
	10) DeWitt Clinton Parking Lot Regrade and Rain Gardens				●
	11) P.S. 95 Green Schoolyard		●		
PUBLIC LAND	12) Van Cortlandt Park South ROW Bioswales		●		
	13) Van Cortlandt Park Entrance Rain Garden		●		
	14) Goulden Avenue Infiltrating Tree Trenches		●		
	15) Goulden Avenue Stormwater Bumpouts		●		
	16) Dickinson Avenue Park Rain Garden		●		
	17) Sedgwick Avenue / Mosholu Parkway Rain Gardens		●		
	18) Sedgwick Avenue / Mosholu Parkway Permeable Surfaces		●		
	19) Sedgwick Avenue Median Rain Gardens			●	
	20) Sedgwick Avenue ROW Bioswale		●		
	21) Sedgwick Avenue Triangle Pollinator Planting	●			
	22) Jerome Park Reservoir Northwest Berm Pollinator Planting	●			

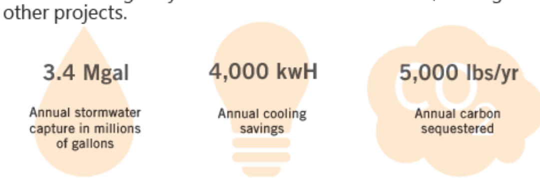
Quantification of GI benefits

Quantifying benefits of green infrastructure is an emerging research topic with a variety of methodologies and variables. Some benefits are quantified here using a methodology developed by the Center for Neighborhood Technology (CNT) in its published guide: "The Value of Green Infrastructure; A Guide to Recognizing Its Economic, Environmental and Social Benefits"[14]. The guide provides formulas for green roofs and tree plantings. The calculations using the formulas were used in this study area to quantify stormwater volume managed, energy demand reduction, air quality improvement, and carbon dioxide sequestration for green roofs and street trees. The guide does not yet identify formulas for these benefits for rain garden plantings. Thus the calculations for rain gardens in this study area assumed one new tree, and uses the same calculation of benefits for one new tree. This is likely an underestimation, as rain gardens have other plantings such as grasses and shrubs, which would add to the benefits.

If fully implemented, this combination of projects would result in significant environmental benefit for the community. There would be nearly a 20 million gallon reduction in stormwater sent to the sewer, 30 thousand kwH of electricity saved and 15 thousand pounds of carbon captured. The full scope of potential cumulative benefits is summarized in a table later in this section.

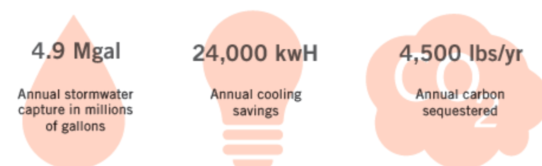
AMALGAMATED HOUSING

The housing co-op owns much of the land between Jerome Park Reservoir and Van Cortlandt Park, including several towers, grassy courtyards, a shopping center and pocket park. There are opportunities on the property for several green roofs and conversion of grassy lawns to wildflower meadows, among other projects.



DEPARTMENT OF EDUCATION

There are two public schools within the study area - P.S. 95 and DeWitt Clinton High School. A green schoolyard would fit well in P.S. 95, and a wetland detention pond and additional bioswale complement ongoing sustainability initiatives already underway at DeWitt Clinton school. Rooftops offer opportunity for an urban farm and rainwater harvesting for their existing garden.



PUBLIC LAND

A large swath of underutilized land separates DeWitt Clinton High School from Van Cortlandt Park, and provides ample potential for green infrastructure. This area includes traffic triangles in DOT's jurisdiction, a DEP-owned park, and boundaries of parkland. GI proposals include many infiltrating landscapes and some wildflower plantings.

Stormwater Managed

To calculate the volume of annual stormwater managed, we first measure the tributary area for each green infrastructure project. For green roofs or green roof-like structures and permeable surfaces, the area managed is the same area of the green infrastructure project. For infiltrating landscapes, we used topography to estimate the area that would contribute to each GI installation. We did not include area managed for pollinator plantings, as we cannot at this time estimate how much stormwater runoff they can manage.

The following formula from the CNT was used to calculate annual runoff reduction in gallons:

*[Annual precipitation (inches) * GI area (SF) * % retained] * 144 sq inches/SF * 0.00433 gal/cubic inch*

[14] https://www.cnt.org/sites/default/files/publications/CNT_Value-of-Green-Infrastructure.pdf

We estimated annual rainfall to be 49 inches, according to NOAA's "Normals" from 1981 to 2010 for average rainfall for the Bronx. We estimated a 60% retention rate, a conservative estimate for how much stormwater a green infrastructure practice will retain over the year.

Reducing Energy Demand

Adding vegetation to a rooftop provides a layer of insulation which helps reduce cooling needs in the summer and heating needs in the winter. The CNT provides the following formula for determining cooling and heating savings from a green roof:

*Annual number of cooling degree days (°F) * 24 hrs/day * ΔU = annual cooling savings (kWh/SF)*

*Annual number of heating degree days (°F) * 24 hrs/day * ΔU = annual heating savings (Btu/SF)*

Where: U = heat transfer coefficient, or 1/R; and

R = a measure of thermal resistance.

For the green roofs in this study area, we assumed the buildings are heated or cooled to 68° year round. We calculated the number of "cooling days" and "heating days" per the CNT guidelines, using NOAA's "Normals" from 1981 to 2010 for average temperatures for the Bronx. Cooling degree days were determined by subtracting a balance temperature (68°) from the mean daily temperature in the Bronx, and summing only positive values. This gave us the value of 718.4. Similarly for heating days, we subtracted the mean daily temperature for the Bronx from the balance temperature (68°), and summed the positive values. This gave us a value of 5,286.9.

The guide provides default R values for conventional and green roofs, which were assumed on these buildings because we did not have the means to measure the R value of existing buildings, nor know what kind of green roof would be used on these buildings. The guide suggests:

For conventional roofs: R = 11.34 SF * °F * hrs/Btu

For green roofs: R = 23.4 SF * °F * hrs/Btu

ΔU, or the change in the overall heat transfer, is the inverse of R, the thermal resistance value. Using the suggested R values above, CNT suggests the following formula:

$\Delta U = (1/R_{conventional\ roof}) - (1/R_{green\ roof})$ *or* $\Delta U = (Btu/11.34\ SF * °F * hrs) - (Btu/23.4\ SF * °F * hrs/)$

To find cooling savings in electricity, convert Btu to kWh using the following formula:

Btu / SF x 1 kWh / 3,412 Btu = annual cooling savings

This combination of formulas was used to approximate the heating and cooling reductions on the green roofs proposed for the shopping center green roof (Amalgamated) and the large roof of the DeWitt Clinton High School.

Energy saved has a direct benefit for the property owner as it will reduce heating and cooling costs. Simply multiple the kWh and Btu saved by the current cost of electric and oil or gas to determine you annual savings.

To calculate the energy demand reduction from street trees, CNT refers to the "Northeast Community Tree Guide; Benefits, Costs, and Strategic Planting"[15] to find calculations for trees in the Northeastern United States. We assumed a Red Maple (*Acer rubrum)*, classified as a medium tree, would be planted in the tree trenches and rain gardens. A medium mature street tree (20-years old) is calculated in this guide to provide electricity savings of 33 kWh/year.

Air Quality Improved and Carbon Sequestered

The CNT guide and Northeast Community Tree Guide provide the following quantification of air pollution emissions avoided from installing a green roof or street tree.

	Green roof: low estimate (lbs/SqFt)	Green roof: high estimate (lbs/SqFt)	Medium mature tree Red Maple (lbs/tree)
Nitrogen dioxide (NO_2)	3.00×10^{-4}	4.77×10^{-4}	0.33
Ozone (O_3)	5.88×10^{-4}	9.20×10^{-4}	0.24
Sulfur dioxide (SO_2)	2.29×10^{-4}	4.06×10^{-4}	0.35
Particulate matter with diameter of ten micrometers or fewer (PM-10)	1.14×10^{-4}	1.33×10^{-4}	0.26
Carbon dioxide (CO_2)	3.32×10^{-2}	3.44×10^{-2}	241.93

The following page shows the benefits calculated for all of the proposed projects.

[15] https://www.fs.fed.us/psw/topics/urban_forestry/products/2/psw_cufr712_NortheastTG.pdf

Owner	Project	Area (s.f.)		Benefits (annually)							
		GI Area	Area Managed	SW capture in gallons*	Cooling Savings (kwH)	Heating Savings (Btu)	NO_2 (lbs)	O_3 (lbs)	SO_2 (lbs)	PM_{10} (lbs)	Carbon (lbs)
Amalgamated Houses	Green Roof on Shopping Center	17,890	17,890	327,950	4,109	104,427,508	8.53	16.46	7.26	2.38	615.42
	Green Roof on Gale Place Garage	28,565	28,565	523,639	-	-	13.63	26.28	11.60	3.80	982.64
	Green Roof-style Courtyard on Amalgamated Towers Parking Garage	139,120	139,120	2,550,277	-	-	66.36	127.99	56.48	18.50	4,785.73
	Transform Grassy Lawn into Courtyard Meadows	145,731	-	-	-	-	-	-	-	-	-
	Rain Garden Plantings at ChooChoo Train Park	*not calculated*									
	Terrace Stormwater Feature along Van Cortlandt Park South Stepstreet	7,856	32,521	596,158	-	-	-	-	-	-	-
Schools	DeWitt Clinton Wetland Retention Basin	1,535	59,215	1,085,499	-	-	-	-	-	-	-
	DeWitt Clinton Green Roof & Farm	103,269	103,269	1,893,074	23,717	602,801,807	49.26	95.01	41.93	13.73	3,552.45
	DeWitt Clinton Rainwater Harvesting	15,083	15,083	273,494	-	-	-	-	-	-	-
	DeWitt Clinton Parking Lot Regrade and Rain Gardens	5,240	60,712	1,112,941	132	-	1.32	0.96	1.40	1.04	967.72
	P.S. 95 Green Schoolyard	29,858	29,858	547,342	-	-	-	-	-	-	-
Public Land	Van Cortlandt Park South ROW Bioswales	400	50,000	916,574	132	-	1.32	0.96	1.40	1.04	967.72
	Van Cortlandt Park Entrance Rain Gardens	*not calculated*									
	Goulden Avenue Infiltrating Tree Trenches	1,183	7,295	133,728	165	-	1.65	1.20	1.75	1.30	1,209.65
	Goulden Avenue Stormwater Bumpouts	1,200	37,197	681,876	264	-	2.64	1.92	2.80	2.08	1,935.44
	Dickinson Avenue Park Rain Garden	11,012	213,763	3,918,594	-	-	-	-	-	-	-
	Sedgwick Ave/Mosholu Pkwy Rain Gardens & Permeable Surfaces	32,228	105,247	1,929,334	-	-	-	-	-	-	-
	Sedgwick Avenue Median Rain Gardens	14,133	113,375	2,078,332	-	-	-	-	-	-	-
	Sedgwick Ave ROW Bioswale	100	12,500	229,144	33	-	0.33	0.24	0.35	0.26	241.93
	Sedgwick Avenue Triangle Pollinator Planting	21,279	-	-	-	-	-	-	-	-	-
	Jerome Park Reservoir Northwest Berm Pollinator Planting	28,469	-	-	-	-	-	-	-	-	-
Total Public		117,760	571,898	10,483,741	594	-	6	4	6	5	4,355
Total Schools		154,985	268,137	4,915,350	23,849	602,801,807	51	96	43	15	4,520
Total Amalgamated		331,306	185,575	3,401,866	4,109	104,427,508	89	171	75	25	6,384
TOTAL		604,151	1,025,610	18,800,957	28,551	707,229,315	145	271	125	44	15,259

*assumes 60% retention rate

Unquantified Benefits

While there is currently a lack of research to quantify benefits that individual GI installations have for Urban Heat Island Effect, habitat creation, and recreational/educational opportunity, there are broader studies to support these theories. The Center for Neighborhood Technology found that "vegetation within building sites reduce temperatures by about 5°F when compared to outside non-green space. At larger scales, variation between non-green city centers and vegetated areas has been shown to be as high as 9°F."

The CNT guide describes that native vegetation helps support native species and creates habitat for resident and migratory species. Bees, butterflies, hummingbirds and bats provide important environmental services of pollinating plants, and are challenged by lack of vegetation and invasive plants that do not provide habitat for them. In the United States, insect pollinators produce about $20 billion worth of food, fibers, medicines, fats, and oils annually[16]. While their regional and global impacts are well documented and researched, there are currently no studies measuring their impact at the neighborhood scale.

Considering the proximity of these projects to several schools, there is ample opportunity to utilize the green infrastructure proposed for educational purposes. Students could learn how to maintain the GI, and bring lessons back to the classroom on stormwater management, water pollution, combined sewer overflow, natives planting and habitat, Urban Heat Island Effect and climate change. The benefits of educating future generations on these topics is invaluable.

Conclusion and Next Steps

There are a variety of projects proposed in this Hilltop Green Infrastructure Plan, some that can be implemented very quickly and easily, and some that will require significant study, funding, and agency coordination. Implementation of all of the recommendations will require pressure by local stakeholders such as Bronx Council for Environmental Quality and Community Board 8 on city agencies to coordinate and implement large scale green infrastructure projects here. In the meantime, Amalgamated Houses can look into NYC DEP's green infrastructure grant and other funding sources such as the NYS Green Innovation Grant Program to implement some of the green roof proposals. Amalgamated Houses could engage with the gardening staff to explore opportunities to transform the courtyard spaces into native wildflower meadows, or replace shrubs with rain garden plantings. DeWitt Clinton School is actively working on designs, grants and funding opportunities for many of their sustainability projects; stormwater management in these plans may help secure further funding, from city, state or private grants. Students at DeWitt Clinton School could look for opportunities receive green infrastructure maintenance training to help maintain future projects at the school and in the surrounding areas.

NYS Soil & Water Conservation District and Riverkeeper will continue to provide technical assistance and guidance for local stakeholders. Implementation of this Hilltop Green Infrastructure Plan is important precedence for watershed planning to improve water quality in a polluted waterway while bringing environmental and social amenities to the community. We hope this plan catalyzes future planning initiatives at the top of the watershed.

[16] https://www.nycgovparks.org/greening/greenbelt-native-plant-center/bee-watchers