Greening Harlem

A Report of the CitiesAlive 2015 Harlem Legacy Project

By Crauderueff & Associates and
The Green Infrastructure Foundation for
The Canaan Baptist Church

About

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Crauderueff & Associates is a New York-based firm that develops green systems for multifamily housing and communities. They design, finance, build, and maintain green systems, saving time and money through green technology improvements for existing building portfolios. They also develop blue-green infrastructure systems, such as green roofs, urban farming and rainwater harvesting for new projects.

The **Green Infrastructure Foundation (GIF)** is a charitable 501(c)(3) organization, affiliated with Green Roofs for Healthy Cities. GIF is dedicated to providing resources to promote the design, installation, and maintenance of green infrastructure in communities. Through activities like research, training, workshops, and events, GIF aims to promote the positive contributions of green infrastructure, while addressing barriers to its implementation.

The **Canaan Baptist Church** was founded in 1932, and has been a focal point of the Harlem community since. The church has been active in a range of community development efforts, including housing, seniors' services, education, and other community services.

The **CitiesAlive** 2015 Conference was the 13th Annual CitiesAlive Green Roof and Wall Conference and Trade Show, organized by Green Roofs for Healthy Cities, and was held in New York City from October 5-8, 2015.

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Executive Summary

Introduction

Harlem, NY is a neighborhood that has many opportunities: it is vibrant, historic, rich in art and culture, and located in the nation's financial and cultural capital. At the same time, poverty, unemployment, displacement, and a lack of green space are all challenges that need to be met.

Greening Harlem, The CitiesAlive Harlem Legacy Project, conducted by Crauderueff & Associates and the Green Infrastructure Foundation for Canaan Baptist Church, seeks to leverage these opportunities in order to improve the quality of life of local residents using green infrastructure and renewable technologies, including green roofs, urban forests, bioswales, solar PV, and urban agriculture. These technologies have many benefits, including improved air and water quality, reduced non-renewable energy use, reduced flooding risk, improved health and well-being, and increased local employment.

The project engaged local community leaders to raise awareness of green infrastructure and renewable technologies and leveraged outside expertise to explore the application of these technologies. This report provided a compelling vision that includes images and financial analysis, working with community leaders and policy makers to move towards implementation, with a focus on generating local employment and improving the quality of life of Harlem residents.

In October 2015, in conjunction with the 13th annual *CitiesAlive* Green Roof & Wall Conference, a design charrette was hosted by the Canaan Baptist Church. After a tour of the neighborhood and an introduction to green infrastructure and renewable technologies, design professionals and community leaders were divided into

three groups to collaborate on and develop neighborhood design improvements. Each group considered the following nineteen types of green infrastructure and renewable technologies to their study areas:

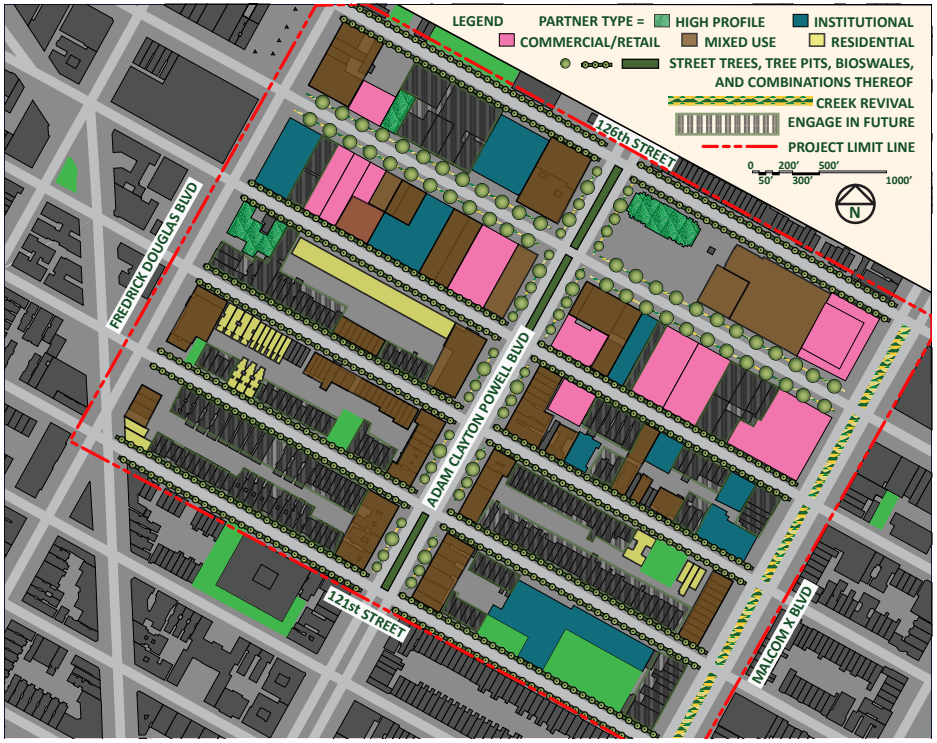
Extensive green roof
Green facade
Living wall - exterior
Bioswale
Street tree - small
Street tree – large
Planting beds
Turf - naturalized
Solar photovoltaic (PV)
Urban farming - green roof
Intensive green roof
Living wall - interior
Rain garden
Porous pavers
Street tree - medium
Wetlands
Turf - active
Solar Thermal
Urban farming - aeroponics

Through the Charrette, each group developed a greening strategy, with goals and design concepts to guide the use of green infrastructure and renewable technologies. Highlights of each study area are presented below:

Charrette Redesign Concepts

Living Surfaces/Thriving Harlem (study area: W 121st St. to W 125th St., between Frederick Douglass Blvd. and Malcolm X Blvd.)

- A framework for achieving a 'social deep green' rooted in community participation and enhancement, cultural celebration, aggressive environmental enhancement, and economic vitality.



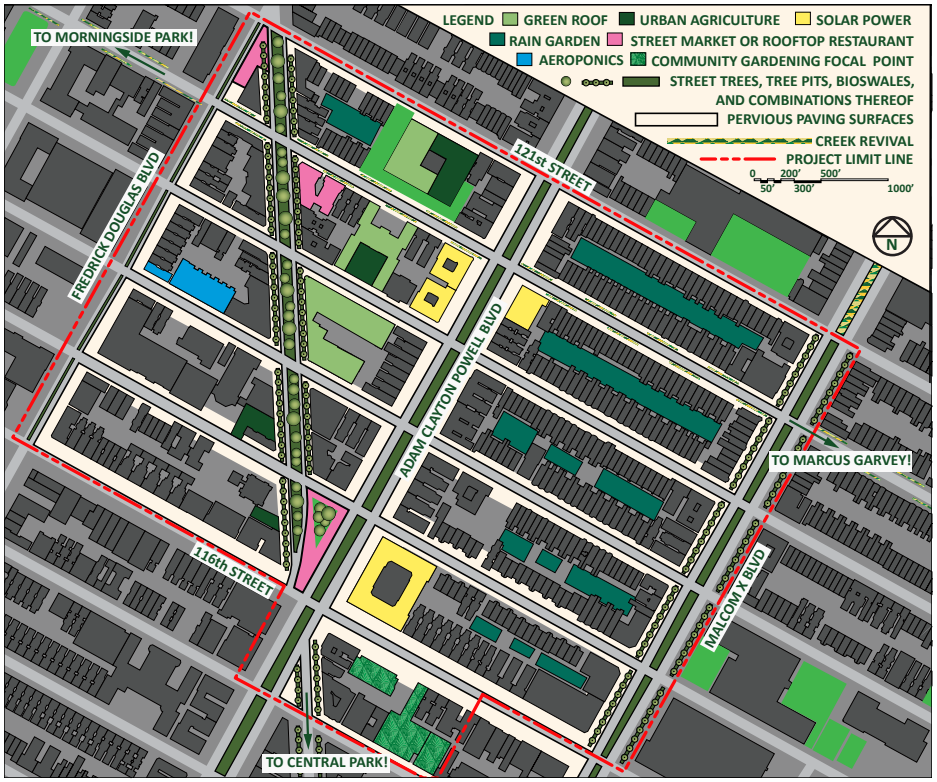
Living Surfaces/Thriving Harlem Redesign Concept

- Performance-based goals in several areas: environmental performance; arts, culture & identity; education & employment; and human & ecosystem health & well-being.
- Design concepts began with a property ownership outreach strategy prioritizing potential early adopters: high profile partners; institutional partners; commercial/retail partners; and mixed-use residential partners.
- While the rooftop spaces are the most prominent of the design prototypes, participants incorporated a greenway / ribbon park, PV sheltered bus stops, and a farm-to-dining outdoor eating experience into the design scheme.

New Harlem Lane 2020 (study area: W 115th St. to 121st St. and Frederick Douglass Blvd. and Malcolm X Blvd.)

- Converting St Nicholas Ave. from W 121st Street to W 116th Street into a parkway only open to pedestrians and bicyclists, along

W 119th St. and St. Nicholas St. (New Harlem Lane Redesign Concept - Before and After)



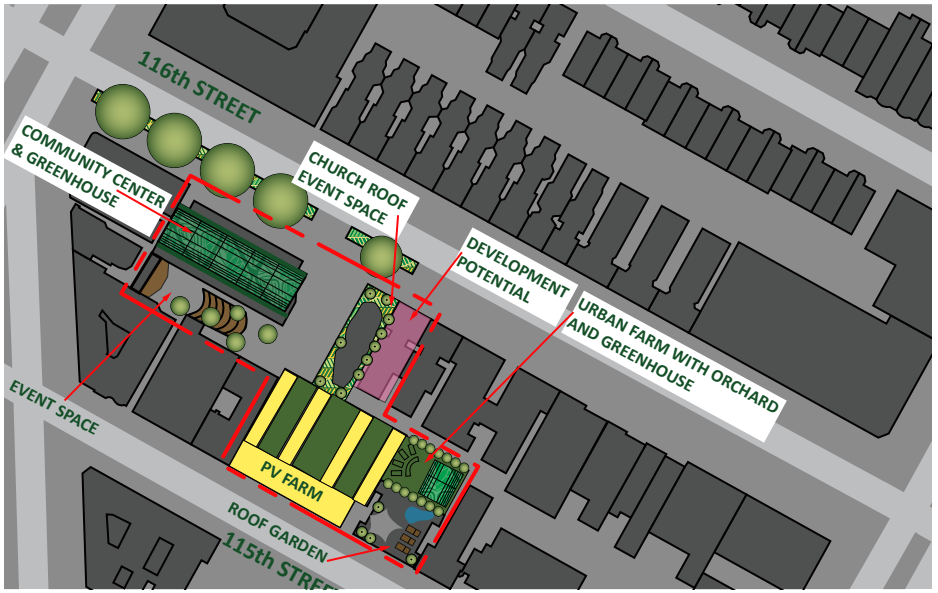
New Harlem Lane Redesign Concept

with broader greening efforts.

- The Canaan Baptist Church properties located at W 116th St. and W 115th St. will serve as a focal point for broader community-wide greening within this study area.
- Utilizing a broad mix of environmental infrastructure throughout the area, including intensive green roofs, bioswales, permeable paving and a mix of small and large trees.

The Greening of Canaan (Five properties along W 115th St. and W 116th St. between Adam Clayton Powell & Malcolm X Blvds.)

- A master plan for five contiguous Canaan properties. Participants sought to develop an inter-generational initiative that would provide opportunities for activities and socializing among churchgoers, youth from the charter school, and seniors from the housing complex. Proposed designs are typologies that could be adapted to community roofs citywide and beyond. Highlights of the plan include:
  - Canaan Beacon: An iconic glass house crowning the senior center at 160 W 116th Street is the top layer of a compelling architecture to draw together the neighborhood around Canaan Baptist Church of Christ. The glass house is lined on two sides with 16ft high towers of aeroponic plantings, a forest of greens and herbs that hold an elevated event space with a grid and glass floor. Beneath the grid flooring is an extensive green roof of income-producing food crops.
  - Church Event Space: An intensive green roof and amenity garden surrounds an open floor, porcelain-paved event space for weddings, celebrations.
  - Charter School Roof: An outdoor classroom, urban farm and performance space includes raised bed food plantings that



Canaan Properties Redesign Concept

face a 40ft x 20ft glass house classroom. Citrus trees in boxes are rolled into the house in winter; on the south side of the roof, a cantilevered umbrella shades a second seating area. This will serve as a room for intergenerational mentoring and interpretive education.

Cost-Benefit Analysis

After the Charrette was completed, an aggregate cost-benefit analysis of the green infrastructure elements employed was conducted using the Green Infrastructure Cost-Benefit Matrix. The values ($/ft^2) used in the cost-benefit analysis were customized to reflect the uniqueness of New York City where possible. In all three cases it is estimated that the green infrastructure investments will pay for themselves in terms of public benefits within twenty-five years or less.

Living Surfaces/Thriving Harlem
4.1 million ft^2 of green infrastructure, would cost an estimated $57.7 million for construction and $1.3 million annually for maintenance. This would lead to a one-time capital benefit of $37.5 million (mostly property value increases realized in 5-10 years upon green infrastructure maturity), as well as an annual benefit of $3.68 million, in areas like stormwater management, reduced energy use, improved air quality, and more. The plan would also create an estimated 980 one-time FTE construction positions, as well as 42 annual maintenance FTE positions.

New Harlem Lane
1.64 million ft^2 of green infrastructure, with an estimated $10.1 million in construction costs and $335,000 in annual maintenance costs. This would lead to a one-time capital benefit of $14.1 million, as well as $1.2 million in annual benefits. This plan would also create 171 one-time FTE construction positions, as well as 7 FTE positions in annual maintenance.

The Greening of Canaan
131,000 ft^2 of green infrastructure, with a construction cost of $991,000, and an annual maintenance cost of $33,500, in addition to $788,000 for 1500 aeroponic tower gardens. $60,000 in annual benefits, in addition to $316,000 in revenue from aeroponic urban farming. This would create 17 one time FTE positions, as well as 0.57 annual maintenance positions, with the potential for several more in urban agriculture.

It is important to note these savings do not include avoided infrastructure costs (i.e. deep tunnels or other forms of grey stormwater infrastructure) that may accrue through widespread implementation of green infrastructure, benefits which can result in major cost savings. Also note that this analysis does not include solar PV or thermal technologies, both of which can be expected to generate revenue.

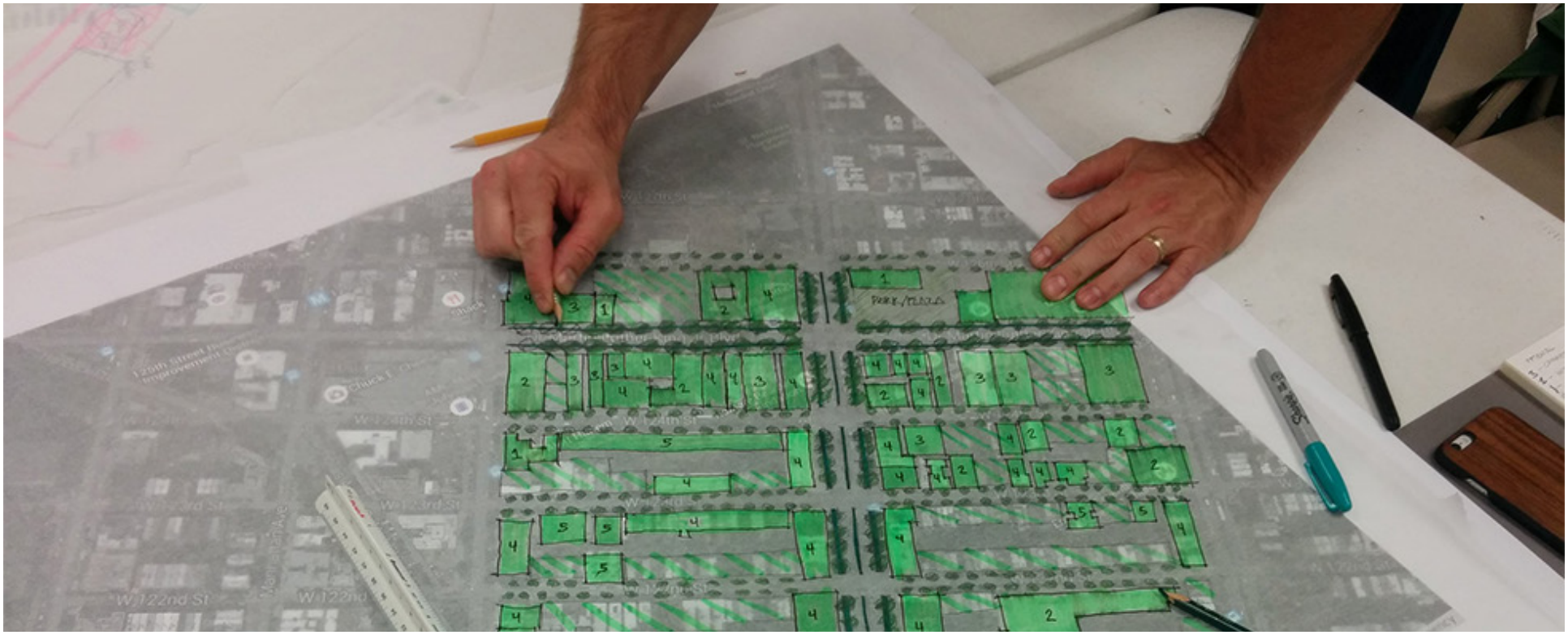
Additional Analysis

Crauderueff & Associates' analysis of Canaan's building portfolio concluded that two sites and three roofs are presently green roof-ready. Additionally, one site is also solar PV or thermal-ready. While the Canaan Baptist Church may wish to pursue the broader vision laid out by the project team, these sites are the most shovel-ready.

Conclusion and Next Steps

To implement the findings of this report, it is recommended that the Canaan Baptist Church use the following two-tiered strategy:

1. Lead by example
Canaan has the opportunity to green numerous contiguous properties. A full range of environmental infrastructure can be implemented.



- Short-term goal: advance three green roof projects at 132 116th St. (two roofs) and create an outdoor classroom at the Sisulu-Walker Charter School of Harlem (1 roof).
- Mid-term goal: advance one urban farming pilot project at 160 116th St, which houses seniors.

2. Advance a Harlem Legacy Project Collaborative

Canaan is well situated to lead like-minded groups in an effort to build community and green Harlem. In the short-run, a meeting should be hosted amongst like-minded organizations to determine priorities and shared short- and long-term goals amongst participants. The ideas and concepts in this project need to be vetted and prioritized by a larger group of local stakeholders. Some of these organizations are suggested in Chapter 2.

- Short-term goal: Host a meeting of potential partners to determine shared goals and interests.
- Mid-term goal: Advance one lower-hanging initiative, such as seeking funding to build an urban farm or a green infrastructure and renewable technologies business center.
- Long-term goal: Advance one ambitious initiative, such as the closing of St. Nicholas Ave.

Greening Harlem aims to build momentum towards a new development and redevelopment path: one that recognizes the contributions that green infrastructure and renewable technologies can make in making communities healthier, more sustainable, and more resilient in the face of climate change.

Chapter 1: Introduction

Context and Goals

Every year, large sums of tax money spent on grey infrastructure to manage rainwater, like sewers, treatment plants, and drains. Some of these investments are unquestionably necessary. However, what if some of this money was spent on green infrastructure instead? Green infrastructure, like green roofs, urban forests, bioswales, and green facades, can manage rainwater while providing myriad other benefits, including improved air quality, reduced energy use, improved health and well-being, carbon sequestration, and a reduced urban heat island. Additionally renewable technologies like green roofs, solar photovoltaic (PV) panels, and solar thermal reduce the operating expenses of buildings, preserving affordable housing. The construction and maintenance of these technologies create jobs and help revitalize neighborhoods. Better public spaces build stronger communities, encourage trust amongst neighbors and reduce crime. Green infrastructure, combined with renewable technologies like solar PV and thermal, have significant potential to improve the quality of life of Harlem residents.

The main goals of this project are as follows:

1. Engage local community leaders to raise awareness of green infrastructure and renewable technology potential

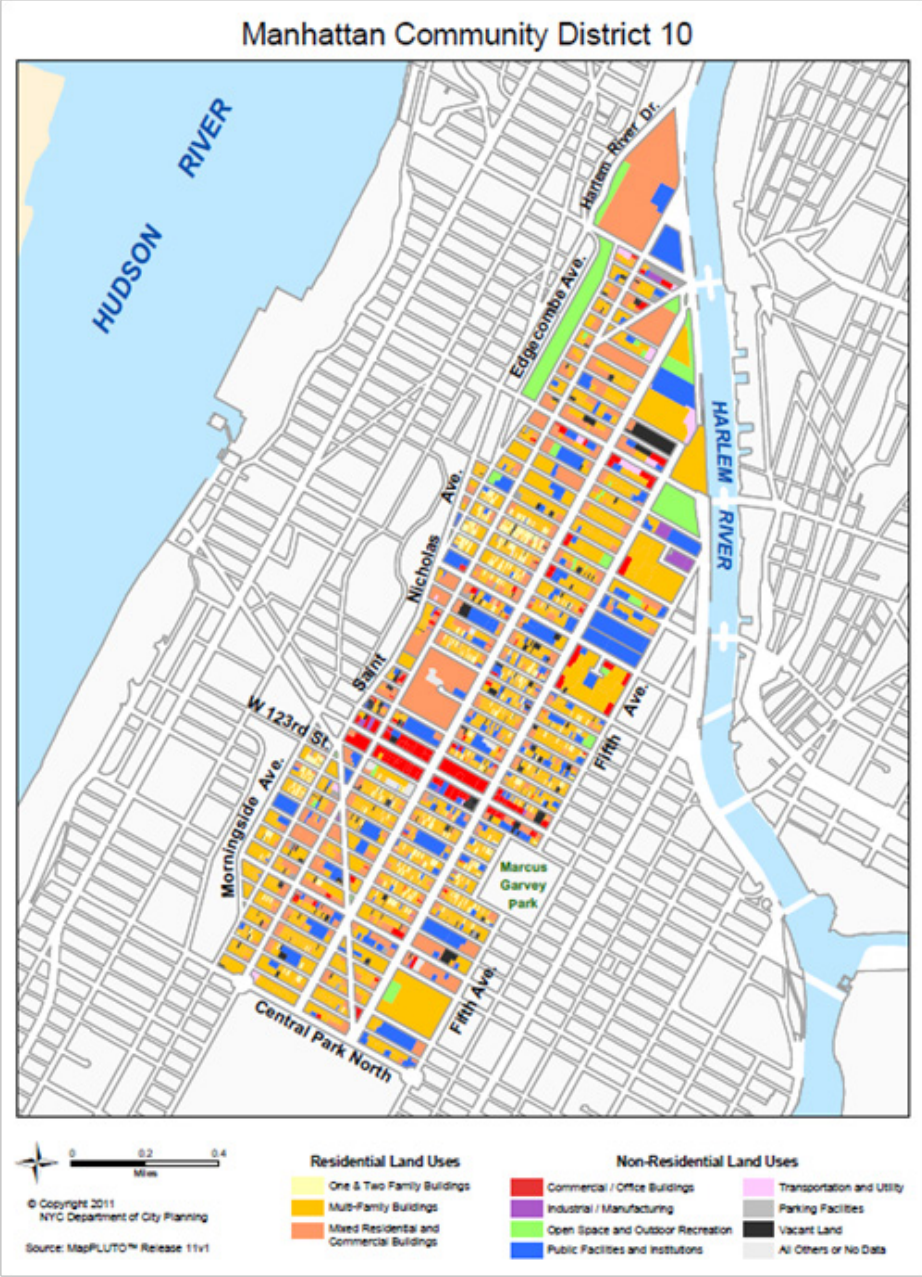
2. Engage local design professionals and policy makers in an integrative design process to explore how green infrastructure and renewable technologies could be applied at different scales

3. Provide a vision and images of what might be possible, given the strengths and weaknesses of the study areas

4. Conduct a financial analysis of the costs and benefits associated with implementation of the vision, customized to reflect local values

5. Provide a platform for further action, with a focus on generating employment opportunities in the local community and improvements in quality of life

Opportunities abound in Harlem to achieve these goals, but there are also many challenges. The neighborhood is vibrant, historic, and rich in culture and identity. At the same time, poverty, unemployment, displacement, and a lack of green space inhibit quality of life.
For decades community members in Harlem have advanced environmental infrastructure through the construction and maintenance of community gardens; the creation of parks; green roof pilot projects; and the construction of green affordable housing. *Greening Harlem*, created as a collaboration between the Canaan



Land-use map of Harlem. Source: NYC Department of City Planning

Baptist Church, the Green Infrastructure Foundation, and Crauderueff & Associates, seeks to improve the quality of life in Harlem by leveraging the community's social and real estate assets. Integrated into the 2015 *CitiesAlive* Green Roof and Wall Conference, run by Green Roofs for Healthy Cities, this Charrette provides a unique and replicable model of industry-community collaboration.

Scaling environmental infrastructure improvements in Harlem, a highly urbanized, mixed-use community, will require the participation of community stakeholders and the construction of many small and mid-sized projects. The vast majority of properties in Central Harlem are a mix of one and two family buildings, multi-family buildings, and mixed residential and commercial buildings (see map). 125th Street, a central commercial thoroughfare with historic buildings and newer developments, is the central business district of the area and represents still another opportunity for greening. The study area is circumscribed north-south by 125th St. and 116th St., and east-west from Malcolm X Blvd to Frederick Douglass Blvd.

The City of New York has taken important first steps to implement

green infrastructure and renewable technologies at a large scale. For example, the NYC Department of Environmental Protection is installing bioswales in Harlem and administers a grant program for green infrastructure on private property. *Greening Harlem* seeks to go a step further through the development of area-wide greening strategies, rooted in community development, within a twenty block area of Harlem. The application of green infrastructure and renewable technologies at the neighborhood scale will yield the greatest societal benefits. This report aims to advance a set of forward-thinking planning and design concepts, as well as economic analyses, that can spur the future development of concentrated green infrastructure and renewable technologies across Harlem.

Methodology

The Green Infrastructure Design Charrette was developed by the

charitable Green Infrastructure Foundation to help community leaders examine how living green infrastructure investment might work on the streets, roofs and walls of their own communities. Living green infrastructure is often not factored in to the development and redevelopment of communities – the Green Infrastructure Design Charrette aims to change that by combining compelling visuals with an aggregate cost-benefit analysis to articulate a broader vision for green infrastructure investment. This was combined with the Green Excellence Matrix, developed by Crauderueff & Associates, which analyzes building portfolios for opportunities to implement solar energy, green infrastructure, and urban farming opportunities.

This project consisted of the following elements:

- Outreach and partnership building with community organizations such as the West Harlem Group, the Harlem Congregation for Community Improvement. The project team reached out and

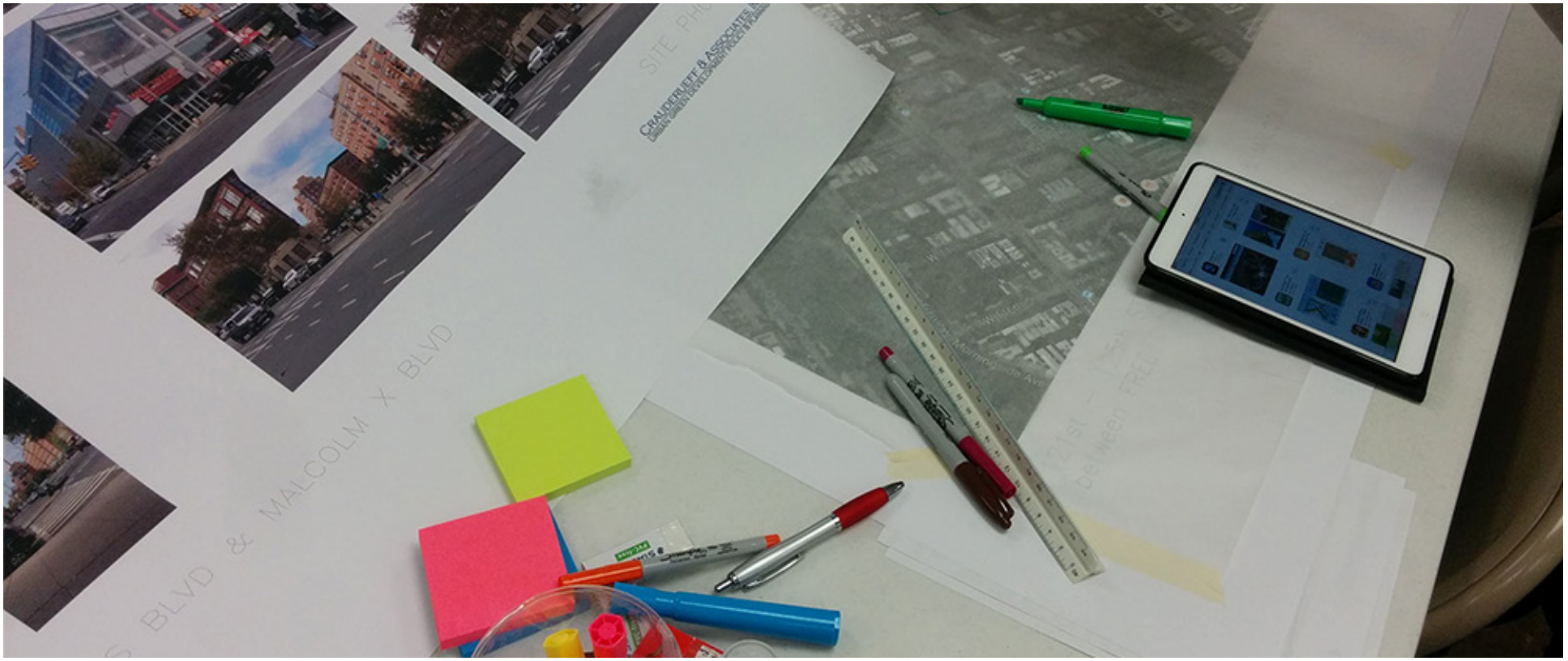
strengthened relationships with city agencies, private sector and non-profit organizations who attended the Charrette, such as the NYC Department of Environmental Protection; the NYC Department of Parks of Recreation; and GrowNYC.

- A two-hour tour of the neighborhood and an introduction to the Canaan Baptist Church, conducted by Harlem resident and Canaan Baptist Church member Dakota Pippins, CEO of Pippins Strategies and Adjunct Associate Professor at New York University. The New York City Department of Environmental Protection also presented on its green infrastructure initiatives in Harlem.

- On the day following the tour, a one-day Green Infrastructure Design Charrette was conducted, where multi-disciplinary teams of volunteers were asked to redesign designated study areas. The teams the following green infrastructure and renewable technologies as their primary tools:

Extensive green roof	Intensive green roof
Green facade	Living wall - interior
Living wall - exterior	Rain garden
Bioswale	Porous pavers
Street tree - small	Street tree - medium
Street tree – large	Wetlands
Planting beds	Turf - active
Turf - naturalized	Solar Thermal
Solar photovoltaic (PV)	Urban farming - aeroponics
Urban farming - green roof	

- Development and customization of a Cost-Benefit Matrix to generate aggregate-level financial analysis of the proposed designs emerging from the Charrette process. The values used in the Cost-Benefit Matrix were customized, to the greatest extent possible, based on research on green infrastructure in



New York City. This customization adds to the robustness of the financial results presented in this report. The Cost-Benefit Matrix includes capital and maintenance costs per square foot for 15 types of green infrastructure, the dollar per square foot values for eleven types of benefits, as well as job creation impacts (see appendix for details).

- Analysis of specific technology opportunities on the Canaan Baptist Church's building portfolio.

- Follow up and the facilitation of like-minded organizations in Harlem that can help move towards implementation of elements of this project.

This report contains a description of the three green infrastructure neighborhood and site redesigns for the ten-block study area, as well as Canaan's building portfolio. Charrette participants were split into three groups: two tasked with developing a strategy to green adjacent ten-block areas and one to green five contiguous buildings owned by Canaan. The nature of the work is inherently visionary, bold, and idealistic; thus, participants were encouraged to not let political or economic barriers inhibit redesigns. On the other hand, the designs developed are backed by economic analysis and are pragmatic enough to be taken to the next planning stage, including implementation. The following three chapters provide summaries of each study area, followed by a conclusion recommending next steps.

Charrette Participants

Charrette Leaders	
Robert Crauderueff	Crauderueff & Associates
Steven Peck	Green Roofs for Healthy Cities
Dakota Pippins	Pippins Strategies Group & Canaan Baptist Church
Team 1: Site-Specific Design	
Mark Morrison (Facilitator)	Mark K Morrison Landscape Architecture
Alan Burchell	Urban Strong
Kate Turney	twelve gardens ltd.
C. Kelly Wright	Pippins Strategies Group
Evan Lai	Evan C Lai Landscape Design
Team 2: W 121st St. to W 126th St. Green Redesign	
David Yocca (Facilitator)	Conservation Design Forum
Elizabeth Calabrese	Calabrese Architects
Gabriel Farrell	Evan C Lai Landscape Design
Rohan Lilauwala	Green Roofs for Healthy Cities
Anasa Scott	West Harlem Group / City College of New York
Gavin Gratson	City College of New York
Gaelle Wormus	Vegetal ID

Team 3: W116th to W 121st Green Redesign	
Jim Davidge (Facilitator)	Davidge Design Studio
Eleanor McKinney	McKinney Landscape Architect, Inc.
Cecil Howell	Future Green Studio
Jordan Clough	Town & Gardens
Blaine Stand	Green Roofs for Healthy Cities
Expert Resources	
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Jeff Keiter	New York City Department of Parks & Recreation
Lenny Librizzi	GrowNYC
Jan Aptaker	Tower Garden
Hamilton Brower	Tower Garden
Raj Parikh	Metropolitan Building Company
Hitesh Parikh	Metropolitan Building Company
Observers	
Marion Yuen	The MYA Group
Jeremy Stand	Stand Consulting

Chapter 2: Living Surfaces/ Thriving Harlem

Introduction and Strategy

The Living Surfaces/Thriving Harlem plan aims to revitalize the community for the benefit of both its residents and the environment. The participants sought to take advantage of the broad range of land uses types, building characteristics, and local institutions within the study area. By incorporating a wide range of green technologies, implemented through local partnerships, Living Surfaces/Thriving Harlem would bring a wide range of environmental, social, and economic benefits to Harlem. A major goal is to optimize the performance of every surface in the district through an elegant, locally authentic integration of high-performance green infrastructure strategies that will improve the public realm and private properties. The group sought to achieve a 'social deep green' rooted in community participation and enhancement, cultural celebration, aggressive environmental enhancement, and economic vitality.

The study area is bounded by W 121st St., W 125th St, Frederick Douglass Blvd. and Malcolm X Blvd. The study area contains a variety of uses, including residential, institutional, and commercial. W 125th St. (Also known as Martin Luther King, Jr. Blvd) is the main street and cultural heart of Harlem.

The site offers many opportunities for greening, including the Adam Clayton Powell Jr. State Office Building (above left)

The public and private realms were divided into three categories each:

Public Realm

- The Boulevard (Adam Clayton Powell Jr. Boulevard): Serves as a primary community gateway. Potential for water art, and can be reconfigured to optimize pedestrian space.
- Main Streets (Martin Luther King, Jr. Blvd., Lenox Ave, Frederick Douglas Blvd.): These streets are active mixed-use streets
- Residential Streets: A number of residential streets line the study area.

Private Realm

- Large-scale uses: These sites present opportunities for larger recreational spaces and commercial organic food production.
- Smaller buildings: These buildings may be ideal for larger gardens.
- Individual residences: These sites may be preferable for smaller gardens.

Goals

Goals were then paired with planning methods in the categories of environmental performance, arts, culture & identity, education & employment, and human & ecosystem health & well-being. Goals were developed in tandem with an analysis of buildings that hold particular cultural, social, and economic importance to the area. A mix of data was used, including maps from Google Maps and information provided by local experts during the Charrette to inform

redesign efforts. The following goals were developed:

Environmental Performance

Goals – Retain the first 1" of rainfall across the entire study area; simulate natural hydrology; eliminate combined sewer overflow events; and minimize the use of potable water for irrigation
Methods – Use 'green streets' with bioswales, downspout gardens, enhanced tree planting areas, permeable pavement; use green roofs (with the long term target of covering 100% of roofs); use grey water, AC condensate, harvested rainwater, and other non-potable sources for irrigation

Goals - Reduce the use of non-renewable energy, generate sustainable revenue streams
Methods – Integrate rooftop solar PV (long term target of 50% of available surfaces) with green roofs; optimize building envelopes to reduce heating and cooling loads, and develop district-scale geothermal energy system to provide renewable-sourced heating and cooling

Arts, Culture & Identity

Goals – Leverage and promote Harlem's unique and rich culture, history, and identity
Methods – Integrate public art into high-visibility spaces throughout the public realm green interventions; use 'showcase green projects' in high-visibility locations such as the Adam Clayton Powell Building and the Apollo Theatre; differentiate unique characteristics of each block within the district

Education & Employment

Goals – Use green infrastructure to expand environmental education; generate local employment
Methods – Establish food production in the neighborhood (e.g. rooftop gardens/greenhouses on P.S. 114 building); partner with institutions to create programs with educational and employment dimensions; create and support groups of property owners within each block to share in decision-making around common resources such as roofscapes, management, assets/community spaces, etc.; amplify distinct characteristics and assets within each block

Human & Ecosystem Health & Well-Being

Goals – provide visual and physical access to nature and authentic natural landscapes; support ecological functions; support healthy trees and vegetation
Methods – create accessible roof gardens; create areas of greenery where biodiversity and native plants are used; support pollinators; provide access to community urban agriculture; improve tree pits and increase root zone volume to support healthy trees.

Design Concept

Redesign concepts begin at the community scale. Five typologies of private property owners were developed; these should be targeted as partners moving toward implementation:

- High profile partners
- Institutional partners
- Commercial/retail partners
- Mixed-use residential partners
- Residential partners

A map was developed, illustrating specific stakeholders and building types Canaan can use as a guide during outreach following the Charrette.

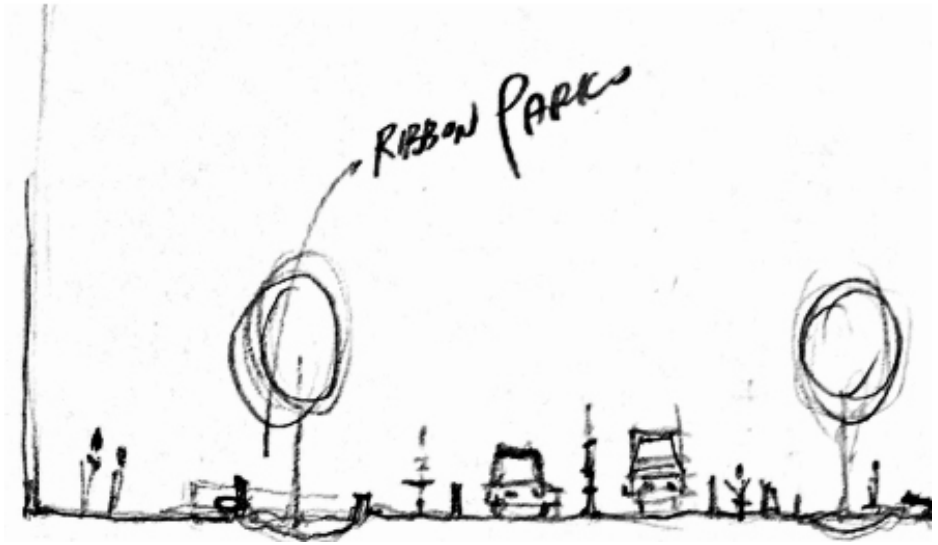
The Harlem Legacy Project should identify projects with the

Map illustrating typology of property owners that could become partners in green infrastructure implementation

potential for short-term implementation. This includes identifying "early stakeholders" among community based, institutional or large commercial partners (Canaan, WHGA, HCCI, P.S. 114, Touro College, Aloft Hotel, State Government); large flat roofs. Showcase, clustered interventions at the street level may be created with a large density of green infrastructure.

During the following phases, the Legacy Project may extend

Concept sketches of enlivened and redesigned streets: a solar PV-integrated bus shelter (above left); cafe chairs and tables spilling onto a greened streetscape (above right); and a redesigned street using bioswales and street trees to form a 'ribbon park' in the public right of way (below)

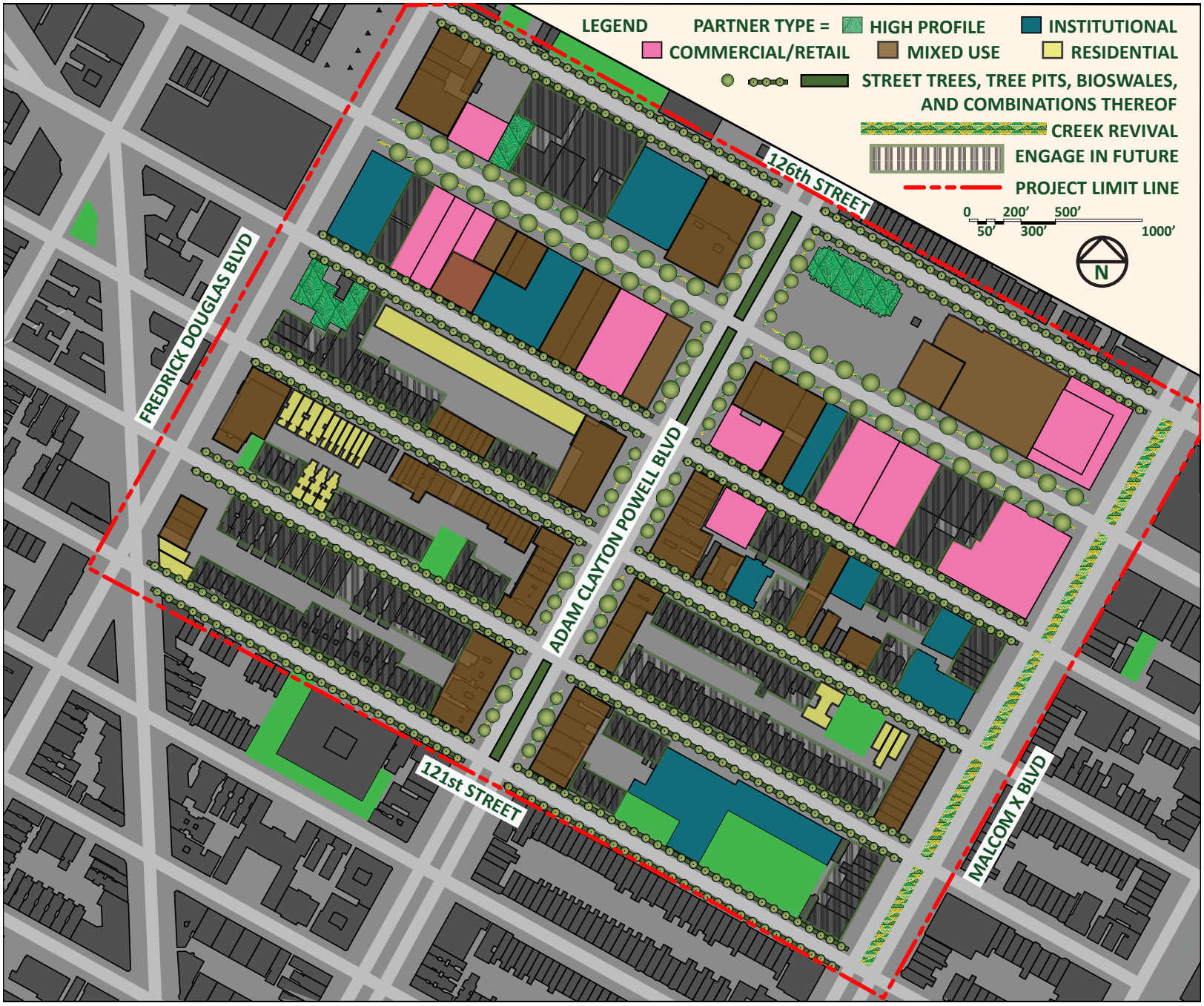


implementation of green roofs and PV panels to all feasible sites and improve the public right-of-way through greening interventions such as green streets with bioswales and enhanced tree pits – particularly when streets are replaced or rebuilt.

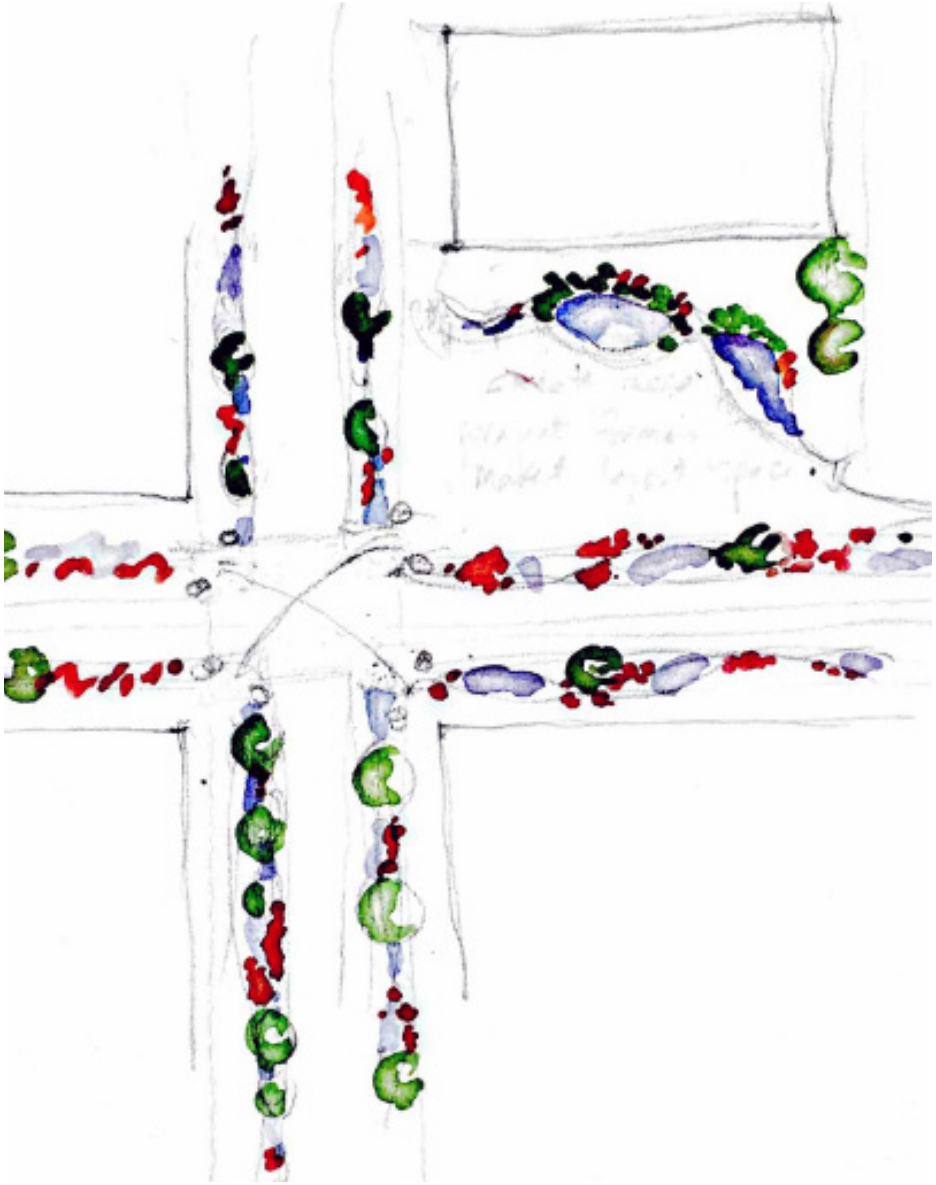
In addition to private spaces, design concepts were developed for the public right-of-way. Bioswales and rain gardens capture rainwater while allowing people to pause, explore and experience their surroundings. Rooftop solar PV and PV over bus shelters and parking lots can be used as protection and shelter. Water should be celebrated – including the sounds of water – by allowing the flows of stormwater runoff to be seen and heard.

These spaces are planned to be active, integrating farm-to-table outdoor dining, spaces to rest, and places to relax and play.

A farm-to-table cafe (left) could serve food sourced from rooftop farms (right).



Refined concept plan for Living Surfaces/Thriving Harlem



A concept rendering by Charrette participants for the intersection of Adam Clayton Powell Jr. Blvd. and W 125th St. (Martin Luther King, Jr. Blvd.). The plaza outside the Adam Clayton Powell Jr. State Office Building forms a ideal location for a high profile green infrastructure and public art installation.

Cost-Benefit Analysis

Following the creation of their concept redesigns, Charrette participants were asked to measure the area of each type of proposed green infrastructure. These numbers were used to conduct an aggregate cost-benefit analysis, based on customized values for costs and benefits in New York City. Some of the highlights of this cost-benefit analysis for Living Surfaces/Thriving Harlem are:

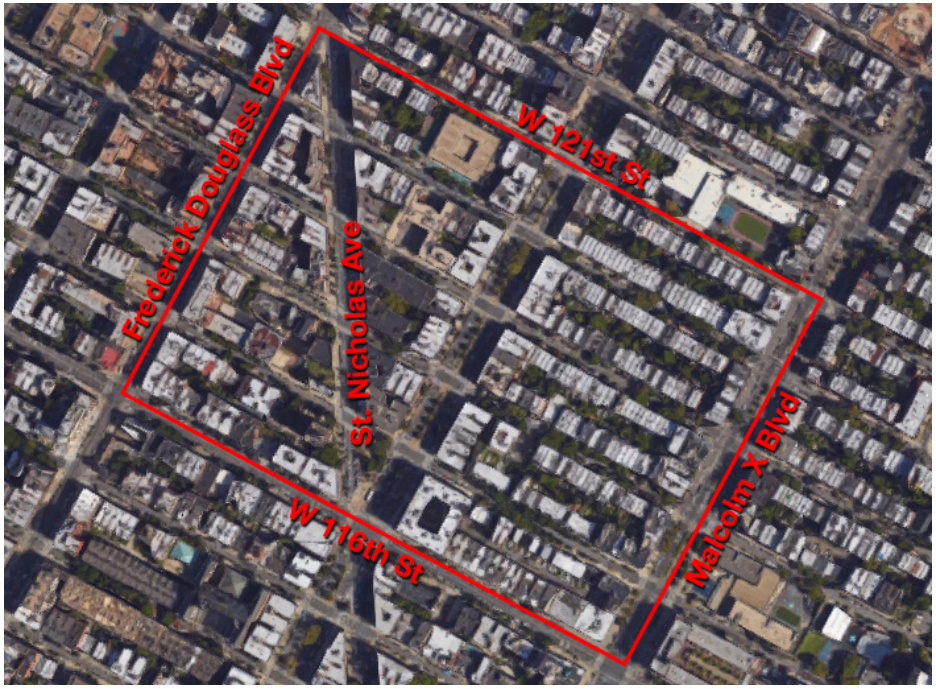
- 4.1 million ft^2 of green infrastructure. This includes 1.2 million ft^2 of extensive green roofs, 300,000 ft^2 of intensive green roofs, 100,000 ft^2 of green facades, 50,000 ft^2 of rain gardens, 45,000 ft^2 of bioswales, 150,000 ft^2 of permeable pavement, and 950 new trees.
- Estimated construction costs are $57.7 million and annual maintenance costs are $1.3 million.
- The proposed vision would create an estimated capital benefit of $37.5 million. While much of these benefits would not be realized until trees mature in 5-10 years, projections include $8.25 million in property value increases that could occur in the near-term once intensive green roofs are installed on properties in the study area.
- The estimated annual benefit associated with this plan is $3.68 million, including $325,000 in increased tax revenue once the trees reach maturity.
- While the public return on investment at the start is -$26.9 million, it improves to -$23.2 million after 5 years, $16.2 million after 25 years, and $69.6 million after 50 years.
- Implementation of the vision would create 980 one-time full-time equivalent (FTE) construction positions, as well as 42 annual maintenance and urban agriculture FTE positions.

See the appendices for detailed results.

Chapter 3: New Harlem Lane

Context and Study area

This team proposed a bold new vision for Harlem - turning St. Nicholas Ave into a vibrant pedestrian and cycling oriented greenway, one where community interaction and green pocket park spaces are paramount and vehicular space is limited or potentially even eliminated. The project team developed a three-tier greening strategy that focuses on People, Places and Communities:



The study area is bounded by W 116th St., W 121st St, Frederick Douglass Blvd. and Malcolm X Blvd. The study area contains a variety of uses, including residential, institutional, and commercial. The Canaan Baptist Church, located within this study area, provides a home base to host and advance the ideas developed in this section. The area is surrounded by parks in three directions: Morningside Park to the west, Marcus Garvey Park to the east, and Central Park to the south.

People: Anthro Green
The 'anthro green' improvements are based on the direct impact on individuals and neighbors. Three design concepts comprise the anthro green approach: 'shallow green' to advance traffic calming, for example, through bioswales that link the three major parks; 'public green' such as raised medians with street trees; and 'private green' that is low impact and has a high economic return, such as solar PV.

Places: Deep Green
New Harlem Lane seeks to advance a 'deep green' use of public spaces, including converting St Nicholas Ave. from 121st Street to 116th Street to a greenway closed to traffic. Eventually, St. Nicholas may be closed all the way from 124th Street south to Central Park at 110th Street. Markets and cultural spaces will be created within the greenway in the process.

Communities: Omni Green
The 'Omni Green' approach recommends using the Canaan Baptist Church properties located at W 116th St. and W 115th St. as a focal points for broader community-wide greening. Green infrastructure pilots and event spaces can be developed at these sites for use by local schools, community centers, and job skills training organizations.

This project approach utilizes green infrastructure to establish clear connections between the iconic neighborhood and its public spaces, while involving the community in the redevelopment and its maintenance.

Design Concepts

The balance of this chapter focuses on greening at two scales: the neighborhood and the street. A third, complementary scale of the study area – as represented by the Church-owned properties at W 116th St. – is critical as well; specific ideas for greening Canaan's properties are laid out in the following chapter.

Neighborhood-Based Greening
New Harlem Lane proposes a broad mix of environmental infrastructure throughout the area, including intensive green roofs, bioswales, permeable paving and a mix of small and large trees. Traffic calming bioswales around schools and community areas provide safe residential and community spaces. New Harlem Lane uses green infrastructure to connect established green spaces and neighborhoods while stimulating economic growth.

Concepts for redesigned streetscapes, with more space allocated for pedestrians, bicycles, and green infrastructure (right).

A rendering of St. Nicholas Ave. - New Harlem Lane - after a green makeover.

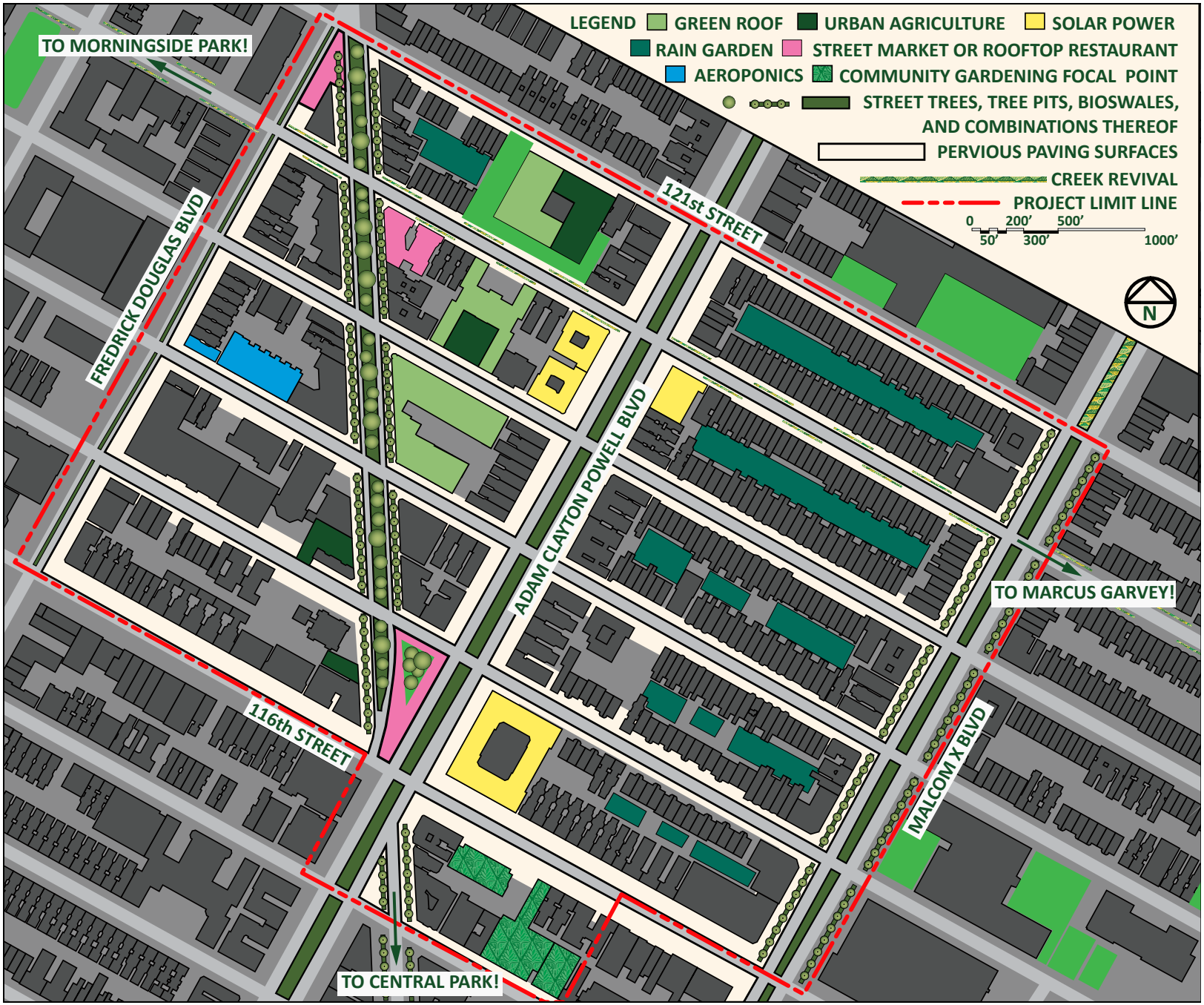
Greening St. Nicholas Ave.

New Harlem Lane proposes transforming St. Nicholas Avenue into a parkway only open to pedestrians and bicyclists. St. Nicholas becomes less active south of W 125st St and the avenue changes from north-south to cutting diagonally at W 124th Street. Two nearby parks can be connected through a network of green spaces and provide a natural connection between Central Park and northern Manhattan communities. Bioswales and street trees along W 120th St. connect St. Nicholas Ave to Morningside Park in the West, as well as Marcus Garvey Park in the East.

Economic Development

The projects will also serve as a catalyst for job creation, business growth and entrepreneurship. Two potential rooftop restaurants have been identified that can be covered by a combination of green roofs and solar technologies, allowing for business expansion. Two open market spaces for stalls have been incorporated into the greenway re-design of St. Nicholas Ave and allowed for vendor space at raised tree beds along Malcolm X Boulevard and Adam Clayton Powell Jr. Boulevard. A green jobs training and business incubation center has been incorporated to train Harlem residents and prepare them for the 'green economy'.

Looking South on St. Nicholas St. from W 119th St. Before and after: New Harlem Lane Redesign Concept



Refined concept plan for New Harlem Lane

Cost-Benefit Analysis

Following the creation of their concept redesign, Charrette participants were asked to measure the area of each type of proposed green infrastructure. These numbers were used to conduct an aggregate cost-benefit analysis, based on customized values for costs and benefits in New York City. Highlights of this cost-benefit analysis for New Harlem Lane are:

- 1.64 million ft^2 of green infrastructure proposed, including 130,000 ft^2 of intensive green roofs, 23,000 ft^2 of bioswales, 46,500 ft^2 of permeable paving, and 496 trees.
- Total construction cost of $10.1 million; maintenance cost of $335,000 a year.
- $14.1 million in capital benefits in the form of property value increases and increased biodiversity, most of which will occur once the planned trees have matured (5-10 years).
- $1.2 million in annual benefits, including $158,000 in increased property taxes once trees are matured.
- The public return on investment is -$7.94 million at construction, but steadily improves to -$6.59 million at 5 years, $10.19 million at 25 years, and $34.36 million at 50 years.
- The vision would create 171 one-time FTE construction positions, as well as 7 FTE positions annually in maintenance, including 1.27 FTE in urban agriculture.

See the appendices for detailed results.

Chapter 4: The Greening of Canaan

Context and Site

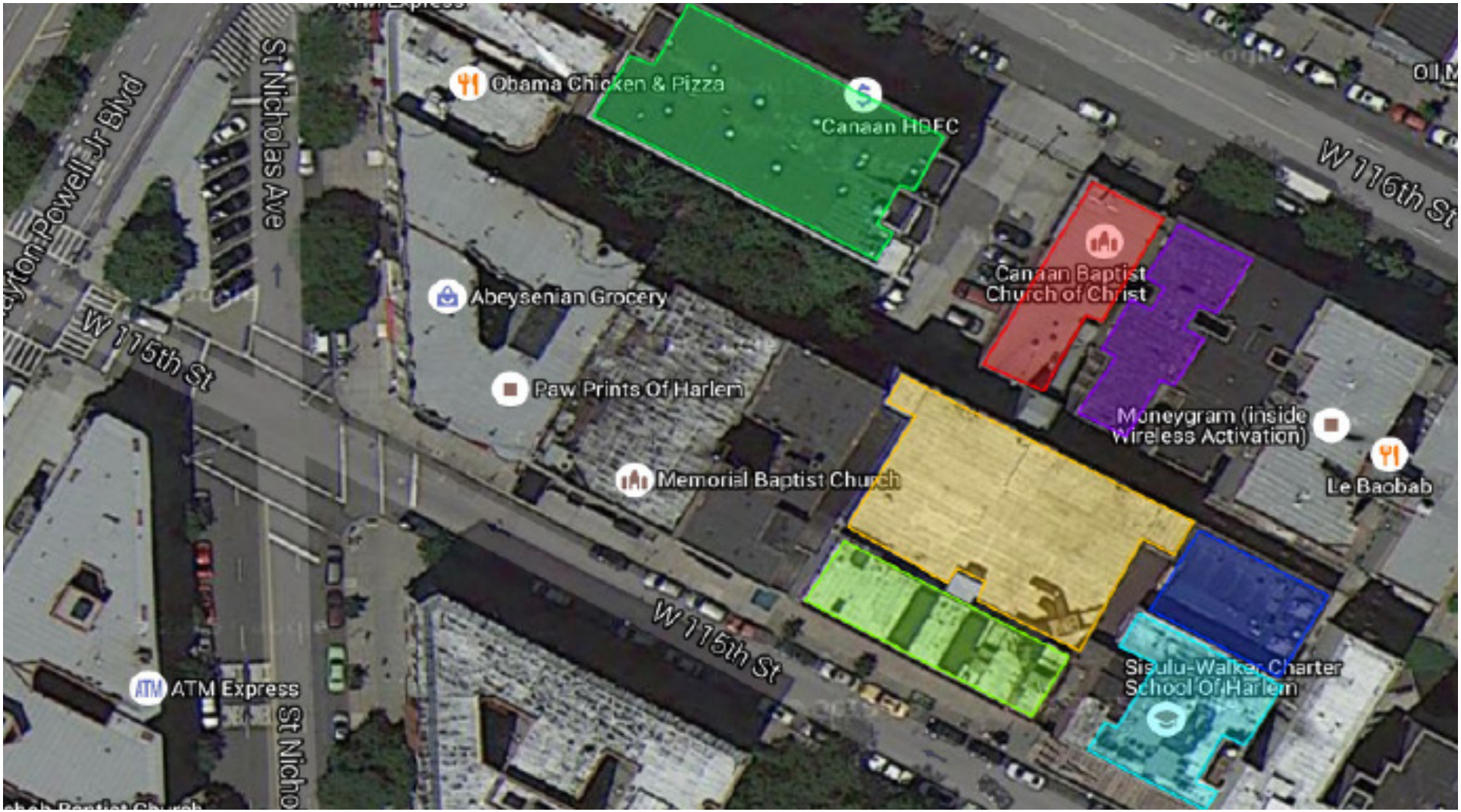
The Canaan Baptist Church seeks to improve the environmental, economic and social well-being of Harlem through green infrastructure and renewable technologies. Founded in 1932, the Canaan Baptist Church ministries have been active in a range of community development efforts. Presently, Canaan and its subsidiaries own eighteen properties, including the buildings that house the church services and administration; multifamily senior and affordable housing; and the Sisulu-Walker Charter School of Harlem – the first

The Canaan Baptist Church (left) and its properties (above)

Charter School in New York State. Located on W 116th Street in central Harlem, the Church is ideally located to hold a leadership position in the greening of community facilities in Harlem.

Five buildings stand out within the Canaan portfolio, because they are larger sites, have a mix of uses, have roofs in good condition, and are contiguous to each other. The buildings are:

- The Canaan Baptist Church entrance (red)
- The Canaan Baptist Church – roofs above services (yellow, light green)
- Canaan Senior Housing (green)
- The Sisulu-Walker Charter School of Harlem – south (light blue) and north (dark blue)
- An abandoned building (purple) (see below for all)



The roofs of some Canaan properties are ideal for technologies like solar PV, solar thermal, green roofs, and urban agriculture.

The Charrette team drafted a master plan for these Canaan properties. They sought to develop an inter-generational initiative that provides opportunities for activities among churchgoers, youth from the charter school, and seniors from the housing complex. Their designs are typologies that can be adapted to a series of community roofs citywide and beyond.

In addition to the Charrette, Crauderueff & Associates analyzed all 18 properties owned by Canaan for greening potential across solar PV, solar thermal, green roof, and urban farming technologies.

Design Concepts

(See map on following page - each design concept corresponds to a letter on the map)

A Canaan Beacon: An iconic glass house crowning the senior center at 160 W. 116th Street is the top layer of a compelling architecture to draw the neighborhood together around Canaan Baptist Church of Christ. Twenty-five feet tall, 60 feet wide by 120 feet long, the glass house is lined on two sides with 16ft high towers of aeroponic plantings, a forest of greens and herbs that hold an elevated event space with a grid and glass floor. Beneath the grid flooring is an extensive green roof of income-producing food crops. The glass house doubles as an event space for church events and for income-producing location rental (weddings, photos shoots, film location, etc). PV will be located on east-facing walls.

B Church Event Space: An intensive green roof and amenity garden will surround an open floor, porcelain-paved event space for weddings, celebrations.

C New condominiums: Development of new condos for income production to offset the costs of green infrastructure retrofits of Canaan properties. The new development will have an intensive green roof.

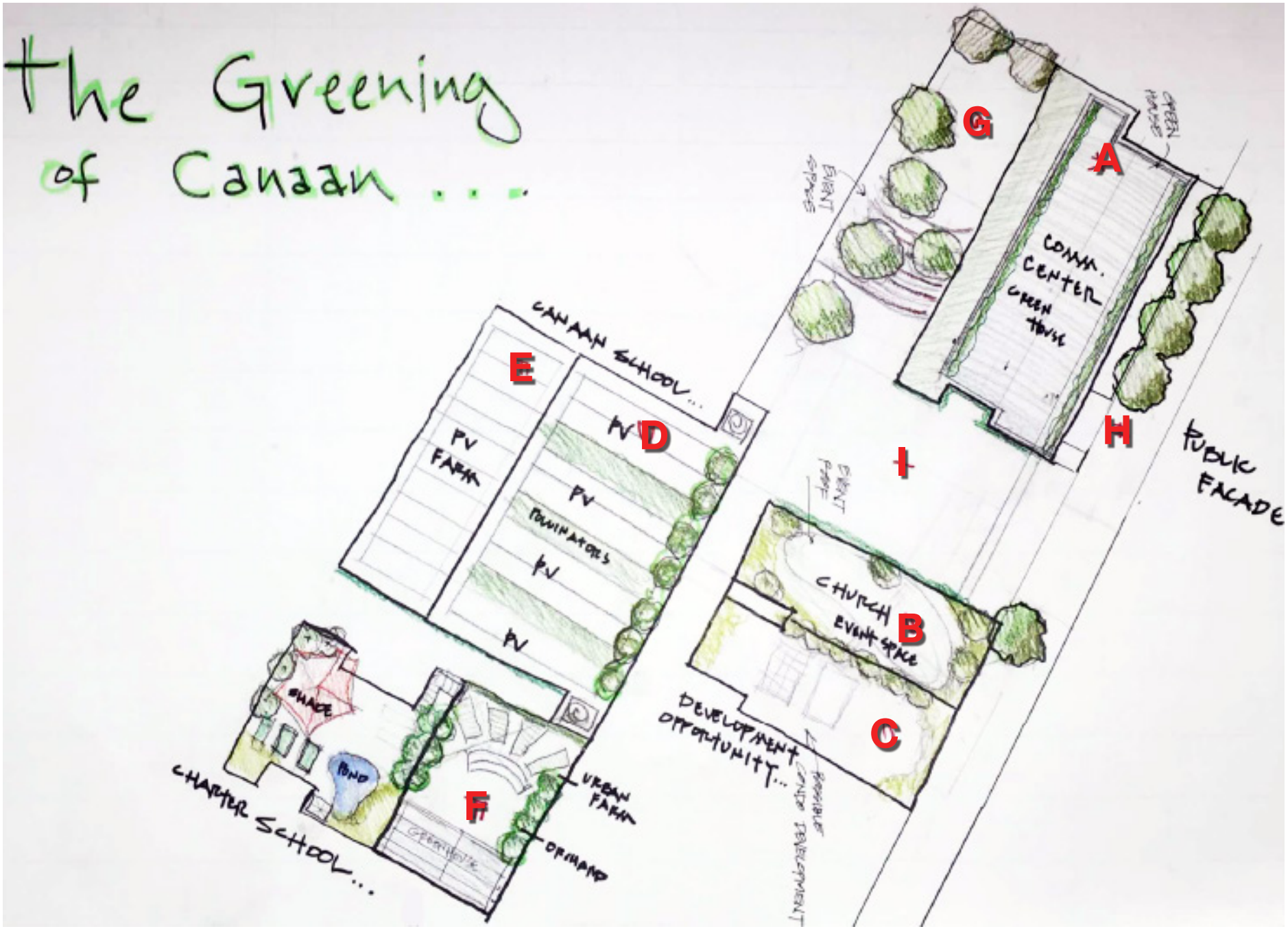
D, E Canaan Elementary School: A green roof will be integrated with solar PV and a pollinator plant selection. Visually prominent to surrounding buildings, this layer of the Greening of Canaan project combines solar PV with a north-side tree grove and areas of intensive green roof for visual impact. Wind turbines on either end of the roof power a windmill that aerates a pond on the Charter school roof.

F Charter School Roof: An outdoor classroom, urban farm and performance space includes a turbine-powered windmill that aerates a pond. Raised bed food plantings face a 40ft x 20ft glass house classroom. Citrus trees in boxes are rolled into the house in winter; on the south side of the roof, a cantilevered umbrella shades a second seating area. This will serve as a room for intergenerational mentoring and interpretive education.

G Backyard Senior Center: A community room back wall opens up to garden that becomes an open seating area. Tiered seating transforms the hill into an amphitheater and the lower level garden into a stage. The upper level is an outdoor dining and grill area that segues to a parking lot, doubling as a movie screening space.

H Street-Side Rain Garden: The Canaan “campus” is delineated by a two-lane sidewalk with a planting bed and rain garden 10ft from 116th Street, and five feet from the senior center. This feature invites the community to area seating and replicates the function of the Harlem “stoop” in the area. It extends visually into a parking lot that also serves as a market, senior seating, parking and movie screening space.

I Parking Lot: With much of th e space still allocated to parking, this area is transformed into an event space, secondary farmers market and movie screening space connecting the back garden to the street. PV will be installed along walls, as well as green screens for vertical surfaces. The front area of the parking lot is redefined with perennial plantings and incorporates a space for chairs and people-watching, as this is an important use of the space currently for the senior center’s residents.


the Greening
of Canaan . . .
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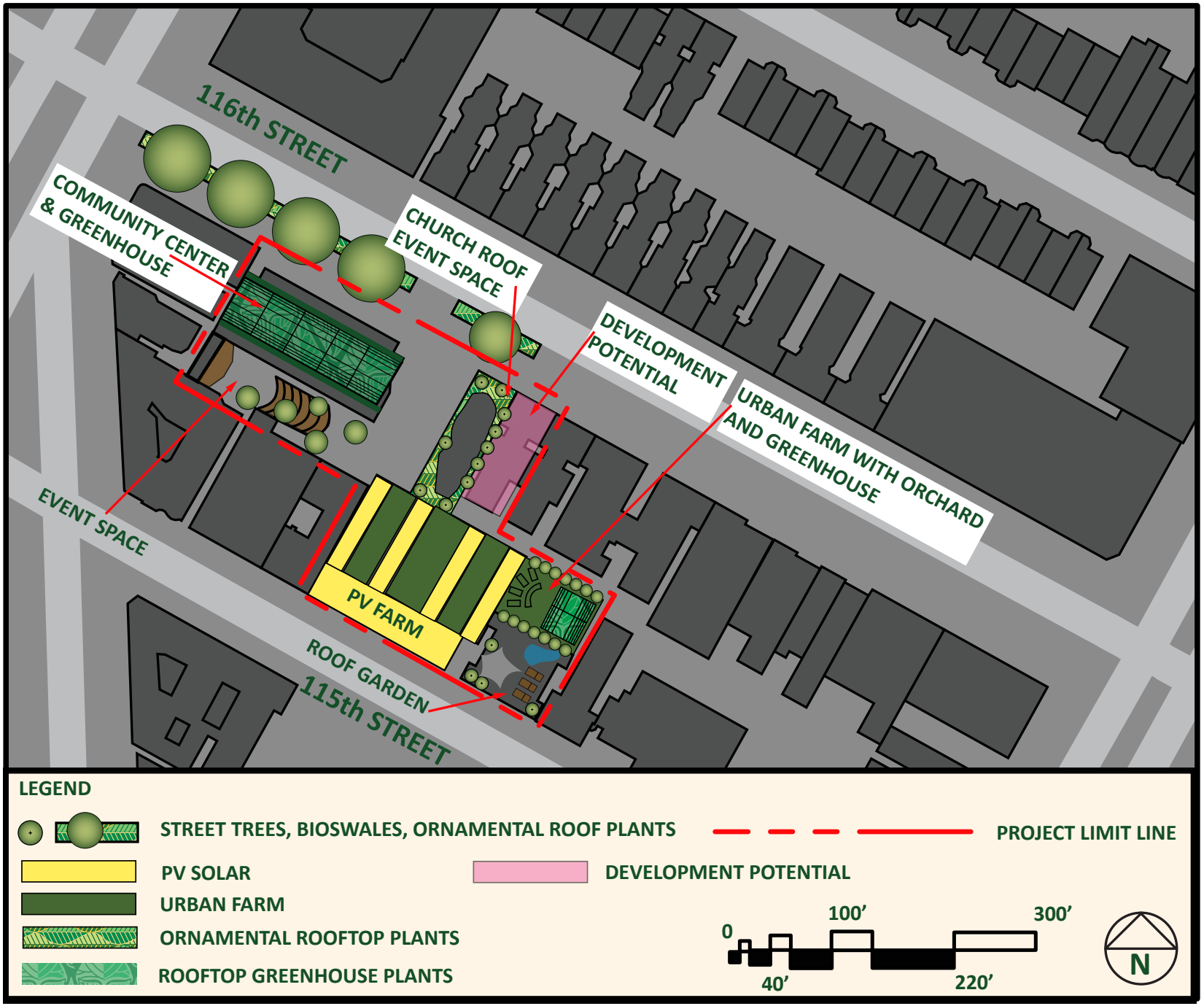


The Greening of Canaan Concept Plan

Cost-Benefit Analysis

Following the creation of their concept redesign, Charrette participants were asked to measure the area of each type of proposed green infrastructure. These numbers were used to conduct an aggregate cost-benefit analysis, based on customized values for costs and benefits in New York City. Highlights of this cost-benefit analysis for The Greening of Canaan are:

- 131,000 ft^2 of green infrastructure proposed, including 14,300 ft^2 of extensive green roofs, 48 trees in total, and 5,000 ft^2 of green facade.
- Total estimated construction cost of green infrastructure is $991,000; total estimated maintenance cost is $33,500.
- The plan also includes 1,500 tower gardens for growing food, at a capital cost of $788,000. Annual costs are difficult to determine, as further analyses will need to consider nutrient and labor costs. The tower gardens may produce $316,000 of food annually, if high-value crops are selected.
- Total capital benefits of green infrastructure are $51,500. Much of this benefit occurs after 5-10 years, when trees reach maturity.
- Total estimated annual benefits are $60,000.
- The public return on investment is -$460,000 at construction, -$403,000 after 5 years, $348,000 at 25 years, and $1.47 million at 50 years.
- The vision would create 16.9 one-time FTE construction positions, as well as 0.57 annual FTE maintenance positions.
- The urban agriculture component of the project (tower gardens) would support 1.67 annual FTE food production positions.

The project team proposed 1500 tower garden vertical aeroponic planters for the property at 160 W 116th St. Image courtesy of Tower Garden.

See Appendices for full results.

Greening Potential Across Building Portfolio

Crauderueff & Associates' analysis of Canaan's building portfolio concluded that two sites and three roofs are presently green roof-ready. While Canaan may wish to pursue the broader vision laid out by the project team, these sites are the most shovel-ready from a roof condition and cost-benefit perspective. The roofs at 132 W 116th St. – the home of the church – are in excellent condition. The roof directly above the church is an excellent candidate both for solar and a green roof; a combined system can be pursued. Further analysis of utility bills and consideration of various economic arrangements (e.g. lease vs. own) will help determine potential savings. Several additional properties (160 W 116th St. and 2117 Frederick Douglas) are good candidates for green roofs but will require roof replacements first. Additionally, the 160 W 116th site, senior housing, could be used for additional uses (e.g. solar PV, urban farming, event space) depending on ownership priorities. The Green Excellence Matrix (GEM) analysis of all buildings in the portfolio may be seen in the appendix.

Canaan Baptist Church Properties Green Excellence Matrix (GEM) – Best Properties

Key

Y= Yes

N= No

M=Maybe

L = Yes, at a later point in time

Address	Bldg area (ft^2)	Green roof	Solar PV	Urban Farming	
132 W 116th St.	15,372	Y	Y	N	Two potential green roofs -- roof above church great candidate, also for PV; lower roof for green roof only
2034 Adam Clayton Powell Jr. Blvd.	8,146	L	N	N	Need to verify next time roof will be replaced
160 W 116th St.	7,563	L	L	L	Upon roof replacement
2177 Frederick Douglas Blvd.	7,353	L	N	N	Upon roof replacement
127 W 115th St.	6,370	Y	N	Y	Lower roof only – upper roof has leaking issues
71 W 118th St.	1,926	N	M	N	Small site; decent layout for PV; small size

Chapter 5: Conclusion and Next Steps

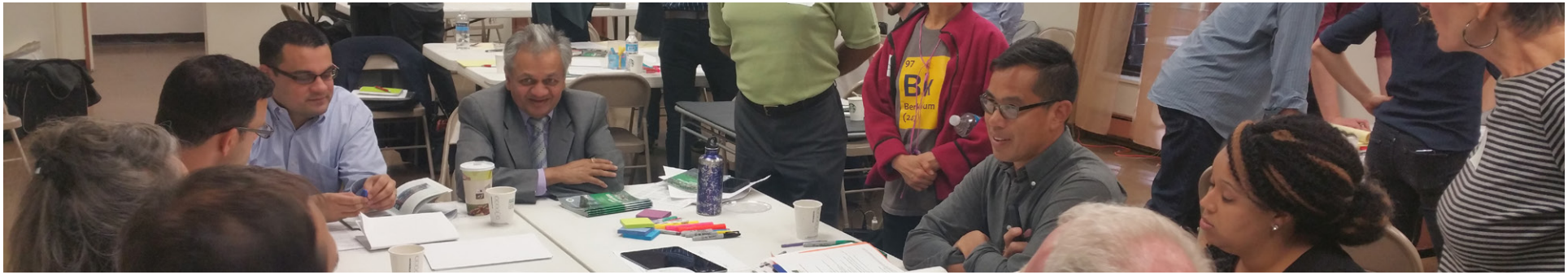
Greening Harlem involved analyzing and developing strategies for improving the quality of life through green infrastructure and renewable technologies at three scales: the neighborhood, the street, and a few buildings. The benefits of green infrastructure and other green technologies extend well beyond the environmental. Their implementation would connect parks, communities and generations; create new jobs and markets; and serve the public good. The 'Social Deep Green' concept developed by the Living Surfaces/Thriving Harlem team seems to best express the planning goals pursued.

To implement the findings of this report, it is recommended that the Canaan Baptist Church use the following strategy:

1. **Lead by example**
   - Canaan has the opportunity to green numerous contiguous properties with a full range of environmental infrastructure.
   - Short-term goal: advance three green roof projects at 132 W 116th St. (two roofs) and create an outdoor classroom at the Sisulu-Walker Charter School of Harlem (1 roof).
   - Mid-term goal: advance one urban farming pilot project at 160 W 116th St. for senior housing.

2. **Advance a Harlem Legacy Project Collaborative**
   - Canaan is well situated to lead an effort to green Harlem. In the short-run, a meeting amongst like-minded organizations should be hosted to determine priorities and identify shared short- and long-term goals amongst participants. Some of these organizations are suggested in Chapter 2.
   - Short-term goal: Host a meeting of potential partners to determine shared goals and interests.
   - Mid-term goal: Advance one low-hanging initiative, such as seeking funding to build an urban farm or a green infrastructure and renewable technologies business center.
   - Long-term goal: Advance one ambitious initiative, such as the closing of St. Nicholas Ave.

Current policy, planning, finance, and development practices undervalue the contribution that green infrastructure and renewable technologies make in communities. This results in suboptimal infrastructure investment, unnecessary expenditures on grey infrastructure, and communities that are far less healthy and sustainable than they could be. *Greening Harlem* aims to build momentum towards a different path: one that recognizes the contributions that green infrastructure and renewable technologies can make in making communities healthier, more sustainable, and more resilient in the face of climate change.



Appendices

Green Infrastructure Cost-Benefit Matrix (Background)

One of the challenges facing the greater utilization of green infrastructure is that society does not properly value the many benefits they provide. Green infrastructure is not even considered a capital asset when financial analyses of local government assets are conducted. Senior levels of government do not typically invest in green infrastructure as a component of infrastructure spending programs.

The Green Infrastructure Cost-Benefit Matrix (Matrix) was developed to help policy makers and community leaders better understand the many costs and benefits associated with various levels of green infrastructure investment in their communities, at an aggregate scale. It also provides a financial context and approximate values for the design work that emerged from the Charrette.

The values that the Matrix uses are averages, reflecting large-scale implementation, rather than project-specific values one may be accustomed to. Hence, the goal of the cost-benefit analysis for the site redesigns is not so much about hitting the bull's eye but rather about starting a conversation about the tangible benefits that green infrastructure can offer each community. The cost-benefit analysis aims to help spur and facilitate engagement with political leaders, community leaders and civil servants in communities focused on the valuation of green infrastructure investments and future policy directions.

One of the reasons the benefits of green infrastructure in communities are not valued properly has to do with complexity. This complexity takes many forms.

The Matrix is a unique and valuable tool that can help promote better infrastructure planning and investment. Monetizing the multi-dimensional benefits of green infrastructure is complex and challenging. These challenges can be addressed by conducting cost-benefit analyses at an aggregate level and focusing on dollars/square foot valuations. The Matrix provides users with an opportunity to customize values, and provides high, medium and low reference values. It also provides a simple payback analysis at one, five, twenty-five and fifty-year intervals for each cost and benefit.

The Matrix assesses whether the costs and benefits are community based, private, or shared. In some cases, opportunities for subsidies in the form of incentives or grants may be considered, splitting the initial cost burden. However, the Matrix does not distinguish between public entities or departments within a local government. These aspects of the analysis are community specific. The Matrix's focus is largely on the public realm. Cost savings on stormwater infrastructure capital and maintenance is a direct form of public benefit, whereas job creation is an indirect public benefit.

If anything, the financial analysis of benefits provided in this report understates the full impact of green infrastructure investments relative to their costs. This is due to the following:

- Not all of the benefits are included, or monetized.
- All of the costs are included.
- The fact that green infrastructure performance often improves over time is not factored into performance assessments.

Cost-Benefit Valuation Methods

The benefits provided by green infrastructure, such as improved public health or aesthetic improvements, are often difficult to monetize or

have been valued using different techniques such as increased quality of life or the happiness index. Green infrastructure can also generate additional employment by providing new opportunities for local food resources, biomass for energy production, and recreational activities. Hence, green infrastructure can facilitate additional economic activity within communities. For the most part, these types of benefits lie outside the scope of the Matrix, but they may be important to your community and deserve to be noted.

Green infrastructure also contributes to economic well-being by extending the life expectancy of paving systems through shading or waterproofing systems through protection from solar radiation and thermal shocks; and by reducing and/or delaying operational and capital cost expenditures associated with conventional energy and water utility practice.

Our systematic failure to recognize and integrate these values often results in policies and investment practices that deliver suboptimal social, economic and environmental outcomes for communities. One of the goals of this project is to begin to address these limitations in decision-making and evaluation processes.

The generic types of green infrastructure included in the Matrix are as follows:

- Green Roofs (Extensive and Intensive)
- Green Facades (Climbing vines)
- Living Walls (Interior and Exterior)
- Rain Garden
- Bioswale
- Permeable/Porous Paver
- Small, Medium and Large Trees
- Wetlands
- Planting Beds
- Turf (Active and Naturalized)

The Green Infrastructure Cost-Benefit Matrix encapsulates a wide range of economic and biophysical research data tied to fifteen generic types of green infrastructure. The Matrix comprises the following components:

- Fifteen generic living green infrastructure types
- Two cost values per square foot derived from literature and peer reviews for capital and maintenance
- Eleven benefit values for each type of generic green infrastructure that are evaluated as either public or privately realized benefits
- Values for most costs and benefits are expressed in dollars per square foot of implemented green infrastructure
- Values for job creation are expressed in person years of employment based on the investment made
- Values are often provided in high, medium, and low ranges to facilitate customization. Custom values based on local numbers are also possible, and increase the accuracy of the matrix
- Values may be expressed as one time capital cost or benefit or an annual cost or benefit
- Property values require additional calculations based on city-specific land value and property tax

The Matrix expresses most costs and benefits in dollars per square foot. This facilitates the ability to quickly provide aggregate estimates of significant green infrastructure deployment at various scales. Expressing monetary values in terms of area also provides the basis for calculating the cost and benefits of study area redesigns from the Charrette. For example, Charrette design teams may call for 1,000 square feet of extensive green roof to be developed. The area (1,000 square feet) provides the basis for estimating the resulting costs and benefits from the values ($/ft^2) in the Matrix.

For purposes of the Charrette, a cost-benefit analysis is provided that is on a first cost basis, at five years, at twenty-five years, and at fifty years. Some green infrastructure investments, particularly trees, provide greater benefits as they mature. The stormwater retention

benefits of trees are minimal in the first few years but increase as trees reach maturity in 5-10 years. The five, twenty-five and fifty year calculation of benefits takes this into account. Given the high degree of importance associated with maintaining the performance of green infrastructure, annual maintenance costs are provided.

The Matrix does not incorporate inflation rates, rising utility costs or discount rates on capital. Monetary values presented in the literature have not been adjusted for currency differences or the impact of inflation except where it has been deemed that the gap in time has become too significant.

When it comes to green infrastructure benefits at an aggregate scale precision is costly to attempt, impossible to achieve, and ultimately, unnecessary to the task at hand. Many important benefits cannot be expressed in monetary terms. For example, the Matrix does not include the human health benefits that will result from widespread green infrastructure development, such as reduced rates of asthma in children or decreased levels of stress, because such benefits are difficult to quantify. Similarly, extending the serviceable life expectancy of roads due to shading, or pipes due to reduced water flows is not incorporated in the Matrix.

As stated above, the Matrix is not designed to provide estimates of specific projects, but rather is a tool for aggregate analysis of significant levels of investment. As such, it is the result of a number of stages of data aggregation and simplification, which are described as follows.

The first stage of aggregation involves the identification of commonly accepted generic green infrastructure types drawn from the literature. Each type is simplified. For example, vegetated buffer strips were added into the typology of 'Turf' based on their similar properties. While there are hundreds of species of trees with different properties, the categories small, medium and large are used – the area of the canopy at maturity is used in value calculations. There are several categories of wetland in the literature but only one is used.

This is justified because the Charrette is not focused on one project, such as a building or a proposed park, but on a much larger area. Furthermore, in order to be able to administer the Charrette in one day, and to derive average values, the types of green infrastructure had to be simplified. Site-specific design and cost-benefit evaluation would require a level of design detail and performance research more appropriate to a later stage.

The second stage of aggregation concerns a comprehensive identification of benefits associated with green infrastructure that are quantifiable and non-quantifiable as seen in the literature. The values included in the Matrix cover a very wide variety of public and private costs and benefits. Some benefits are common to all green infrastructure types while others are only applicable to certain types. For example, active recreational turf will not provide habitat value.

A comprehensive listing of public and private benefits resulting from green infrastructure is as follows:

- Waste diversion
- Aesthetic improvement
- New amenity spaces
- Increased property value
- Increased rental income
- Increased retail sales
- Horticultural therapy
- Increased productivity
- Increased recreational activity
- Reduction of the urban heat island
- Energy efficiency
- Carbon sequestration
- Blockage of electromagnetic radiation

- Improved air quality (particulates and chemicals)
- Shading
- Stormwater management: quality and quantity benefits
- Noise/ sound reduction
- Improved soundscape
- Increased biodiversity (flora and fauna)
- Integrated water management
- Improved marketability of development
- Educational opportunities
- Increased membrane durability
- Increased pavement durability
- Reduced grey infrastructure capital costs
- Improved human health and well-being, (physical and mental)
- Fire retardation
- Local and regional job creation
- Enhanced photovoltaic panel performance
- Food production
- Biomass for energy production

Each of these benefits was evaluated according to its ability to be monetized. Only benefits that could be quantified and monetized were chosen for inclusion in the Matrix. It is however, a goal of the project to create a framework within which new benefits can be added as more research is published on quantitative data. Although all costs for green infrastructure can be quantified, not all benefits can be. The following costs and benefits are included in the Matrix at this stage in its development:

- Cost: Total Capital Investment
- Cost: Annual Maintenance
- Benefit: Annual - Stormwater Management
- Benefit: Capital - Biodiversity and Creation of Habitat
- Benefit: Annual - Increase in Air Quality
- Benefit: Annual - Green House Gas Sequestration
- Benefit: Annual - Reduction in Urban Heat Island
- Benefit: Annual - Reduction in Building Energy Use
- Benefit: Capital - Job Creation (Total Capital Investment)
- Benefit: Annual - Job Creation (Maintenance)
- Benefit: Annual - Property Value/ Tax Revenue
- Benefit: Annual - Urban Food Production
- Benefit: Annual – Increase in Roof Lifespan

The third stage of aggregation involves applying monetary values to performance. Average ecosystem, (biophysical) service values (such as gallons of stormwater retained) are monetized. The literature referenced utilizes a variety of market and non-market valuation techniques to accomplish this. These values vary considerably from community to community, particularly given the different regulatory and economic approaches to financing and operating grey infrastructure such as stormwater management and electricity production.

The fourth stage of aggregation involves estimates of performance. Generic performance values were derived from the literature about green infrastructure ecosystem services performance. The exact performance of green infrastructure technology may vary, because it is a function of its design characteristics as well as its location. For example, a tree on the north side of a building will provide less energy savings than one located on the south side. A green roof can eliminate anywhere from 40 to 90% of the total stormwater runoff, depending on its design and the duration and frequency of the rainfall events in the region. Hence, further simplification is necessary in order to arrive at average cost and benefit values used in the Matrix.

The fifth stage involves a combining of both the third and the fourth stages. Performance values (gallons of stormwater) are combined with monetary values ($/gallon retained) for the benefit in question. When combined, a final valuation for each benefit specific to each form of green infrastructure's performance is obtained. These values are presented in a range of high, medium, and low values due to

ranges in performance as well as ranges in benefit valuation.

During the Charrette process participants were asked to redesign neighborhoods using the fifteen generic types of green infrastructure used in the Matrix. This process involved exact scaled measurements to properly allow for cost-benefit analyses following the Charrette.

Customized Values for Harlem/New York City

Unless specified below, all cost and benefit values selected are the medium value determined using the methods described in the previous section. When possible, locally appropriate numbers were used to customize the Matrix used in the Charrette. The following values were customized based on available data drawn from the New York City Department of Environmental Protection's (NYC DEP) Green Infrastructure Co-Benefits Calculator (the Co-Benefits Calculator) (www.nycgicobenefits.net).

Green Infrastructure Capital and Maintenance Costs
Cost values from the Co-Benefits Calculator were used when available. Green roofs, bioswales, rain gardens, porous pavement and constructed wetland construction and maintenance costs were incorporated into the Matrix.

There are important differences between the value found in previous research and those found in the Co-Benefits Calculator. Many capital and maintenance costs for New York were significantly higher than previous research suggests. For example, the Co-Benefits Calculator provides a capital cost of $250/ft^2 for a bioswale, and $120/ft^2 for a rain garden (referred to by the NYC DEP as large bioretention), while previous research provides values of $15/ft^2 for a bioswale, and $10-17/ft^2 for rain gardens. This could be because of higher labor and material costs in New York City, the presence of trees in these projects (our methodology costs trees separately), or because the NYC DEP conducts a geotechnical survey for every installation, which drives up costs. For example, this requirement means that the design and survey costs alone for the average 20'x5' bioswale are $7,700 – a figure that is likely significantly higher than the examples found in the literature.

The Co-Benefits Calculator does not differentiate between extensive and intensive green roofs, providing one construction and maintenance cost value for both. The same value for both extensive and intensive green roofs has been used: $21/ft^2 for construction, and $1/ft^2 for maintenance. Because there is only one cost here, the costs of extensive green roofs ($14-$23/ft^2 for construction, and $0.19-$0.47/ft^2 for maintenance in previous research) are likely overestimated, and the costs of intensive green roofs ($28-$43/ ft^2 for construction, and $0.90-$4.65/ft^2 for maintenance) are likely underestimated. New York City's Green Roof Tax Abatement of $5.23/ ft^2 is also included in the matrix – that incentive is factored into public costs, while the remaining installation and maintenance costs are borne by the private sector.

Stormwater Management
The NYC DEP's Green Infrastructure Co-Benefits Calculator uses a stormwater treatment savings value of $0.0003/gallon. This likely represents the additional operating costs of treating a gallon of stormwater through an existing water treatment facility, and likely does not include capital costs. Previous research values stormwater management at $0.006/gallon (low), $0.011/gallon (medium), or $0.014/gallon (high). The values used in New York are likely to be very low because they do not reflect avoiding many of the costs associated with conventional stormwater management, including pollutant control, erosion control, beach closures, and stormwater storage. Values per square foot have been adjusted to reflect the values used in New York and have not included the additional avoided costs mentioned here.

Urban Heat Island Reduction
The values used were determined by a study conducted by Arup on behalf of the US General Services Administration that looked at the nationwide costs and benefits of reducing the urban heat island. Because the study area is located in the heart of the largest and densest metropolitan area in the US, and is particularly prone to Urban Heat Island effects, the high value was selected when measuring benefits in this category.

Building Energy Reduction
The values per square foot established here are based on reductions in energy costs associated with green infrastructure established on a nationwide basis by the US General Services Administration. According to the US Energy Information Administration, New York State energy prices are 54.77% higher than the national average. The customized value reflects energy prices in New York State.

Trees
Our literature review suggests that as trees mature, the benefits they provide increase. The benefits of trees are, therefore, not fully attributed at planting. Beginning at the 5th year, all benefits of trees are attributed at a 50% value. From the 10th year on, all benefits are fully attributed.

Job Creation
Job creation numbers reflect the values used in NYC DEP's Green Infrastructure Co-Benefits Calculator. Based on job creation software IMPLAN, NYC DEP estimates that one FTE position is created for every investment of $58,824. This falls within the existing range of values, which is one FTE position created for every investment between $45,455 and $66,667.

Additionally, job creation potential of commercial urban agriculture was valued based on interviews with Ben Flanner, Head Farmer at Brooklyn Grange, a rooftop farming operation that has two locations in Brooklyn and Queens (with 80,000 ft^2 of tillage). Brooklyn Grange employs 4-5 full-time employees, as well as 3,000-4,000 hours of part-time, seasonal labor. Based on an FTE position of 1960 hours, it was determined that 1 ft^2 of urban agriculture can support 0.000079 FTE positions (1 FTE position for every 12,658 ft2 of urban agriculture).

Property Value Increase
A wide body of research suggests that intensive green infrastructure use improves the property values of the buildings that support or surround it. Property value increases for green roofs are based on previous research (7.06% for extensive green roofs, 11% for intensive green roofs). Property value increases for other types of infrastructure reflect the value used in NYC DEP's Green Infrastructure Co-Benefits Calculator (9%). Because green infrastructure (especially trees) does not increase property values until it reaches greater levels of maturity, the property value increases have been phased in at the 5 and 10-year marks (50% of the effect at the 5th year, and the full effect at the 10th year).

Mean property values (prior to neighborhood greening) for Class 1 (1-3 family dwellings) properties was determined using the NYC Department of Finance's NYC Tax Class 1 Property Tax Map. Any green infrastructure within 100 feet of a Class 1 property was assumed to increase property values by 9%.

Class 2 (multi-family dwellings) property value increases are not accounted in the Matrix for due to limitations in data. Property value increases for this class of property are likely to be several orders of magnitude larger that of Class 1 properties because of their larger size and higher value. Additionally, most of the buildings in the study area for the Charrette fall into this category. Property value increases are a substantial economic benefit over the long term, but data limitations mean that this impact is likely significantly underestimated.

Property Tax Increase
Increased property values over time will provide local governments with additional tax revenue. Property tax increases resulting from proposed green infrastructure investment were determined based on rates levied and values assessed by the NYC Department of Finance. The effective tax rate on Class 1 properties is 1.17324%*. The formula used to determine increased property tax revenue from green infrastructure investment is:

(Assessed value before green infrastructure) x (Green Infrastructure Effect) = (Increase in assessed value due to green infrastructure investment)

(Increase in assessed value due to green infrastructure investment) x (Tax rate) = (Increased tax revenue)

For example, if the assessed value of a property is $1,500,000, the tax rate is 1.17324%, and an intensive green roof is installed on the property:

(Assessed value before green infrastructure) x (Green Infrastructure Effect) = (Increase in assessed value due to green infrastructure investment)
($1,500,000) x (0.11) = ($165,000)
(Increase in assessed value due to green infrastructure investment) x (Tax rate) = (Increased tax revenue)
($165,000) x (0.017324) = ($2858)

With green roofs, this benefit is calculated in the first year after installation. With other forms of green infrastructure it is calculated in years 5 and 10, as previously described. The total property tax increase resulting from the propose green infrastructure investment is greatly understated due to the lack of Class 2 property data.

* *This is based on a tax rate of 19.554% multiplied by the level of assessment (6%) = 1.17324% (Source: New York City Department of Finance)*

Tower Gardens
Tower gardens, a form of aeroponic urban agriculture was incorporated into site designs by one of the design Charrette groups. Information about specifications and yield for tower gardens is limited, so a number of assumptions have been made about their value. Based on a base width of 2.5', it is assumed the width of the growing portion is 1'. Based on a total height of 5.5', it is assumed the height of the growing portion is 4.5'. Based on these assumptions, the surface area of the growing portion of each tower garden is 14.13 ft^2. This surface area calculation was used to determine yields and jobs created. Because aeroponic farming is more efficient than soil-based farming, the high value for food production has been selected: $14.91/$ft^2$. Data is limited on the cost of nutrients and the frequency of their application, as well as the labor involved in setting up tower gardens, and the cost of urban agriculture labor. Therefore, these numbers have not been included in the Matrix and their omission is noted wherever relevant.

Cost-Benefit Analysis Results

The results of the green infrastructure cost-benefit matrix analysis follow.

Legend	
	Public Costs/Benefits
	Private Costs/Benefits
	Shared Costs/Benefits

Living Surfaces/Thriving Harlem - Costs and Benefits of Planned Green Infrastructure by Green Infrastructure Type

Generic Green Infrastructure Type	Area (ft^2)	COSTS (Public and Private)		BENEFITS (Public and Private)	
		Construction (Capital)	Maintenance (Annual)	One-Time[1]	Annual[2]
Extensive Green Roof	1,208,000	$25,462,290	$395,500	$487,030	$598,547
Intensive Green Roof[3]	300,000	$6,309,240	$300,440	$8,370,680	$1,507,699
Green Facade	100,000	$4,650,000	$93,000	$40,083	$16,366
Rain Garden	50,000	$6,053,600	$73,649	$20,257	$14,298
Bioswale	45,000	$11,268,600	$282,534	$18,102	$15,625
Permeable Pavement	150,000	$3,010,000	$145,740	$0	$454
Tree - Small	277,000 (250 trees)	$250,002	$7,482	$111,198	$111,820
Tree - Medium	601,000 (250 trees)	$250,172	$7,358	$243,946	$293,084
Tree - Large	1,371,000 (450 trees)	$449,856	$14,058	$550,818	$794,411
Neighborhood Green Infrastructure: Property Value Increases[4]	N/A	N/A	N/A	$27,675,000	N/A
Neighborhood Green Infrastructure: Property Tax Increases[5]	N/A	N/A	N/A	N/A	$324,694
TOTAL	**4,102,000**	**$57,703,760**	**$1,319,761**	**$37,517,114**	**$3,676,998**
	ft^2 of Green Infrastructure	Capital ($)	Annual ($)	One-time ($)	Annual ($)

1 Capital Benefits include biodiversity (public benefit), and increased property value (private benefit). Biodiversity benefits and property value increases associated with trees and neighborhood green infrastructure as a whole are only a factor at maturity, 5-10 years after planting. Property value increases associated with green roofs occur on installation ***2*** Annual benefits include stormwater management, reduction in urban heat island, greenhouse gas sequestration, air quality improvements, and increased property tax (all public benefits), as well as reduction in building energy use, increased roof membrane lifespan, and yield from urban agriculture (all private benefits). No benefits associated with trees occur until maturity. The return on investment factors half the benefits occurring beginning in the 5th year after planting, and the full benefit occurring beginning in the 10th year after planting. ***3*** Includes 75,000 ft2 of area designated for urban agriculture. ***4*** The NYC DEP's Green Infrastructure Co-Benefits Calculator suggests that green infrastructure in the area boosts property values by 9%. This is based on an estimate of the number of Class 1 properties within 100 feet of planned green infrastructure. See section on Customized Values for New York City/Harlem for further information. Property value increases do not occur until trees reach maturity. The return on investment factors half the benefits occurring beginning in the 5th year after planting, and the full benefit occurring beginning in the 10th year after planting. ***5*** Property tax increases do not occur until property values increase; see above.

Living Surfaces/Thriving Harlem - Public Return and Job Creation by Green Infrastructure Type

Generic Green Infrastructure Type	PUBLIC RETURN ON INVESTMENT (ROI) AND/OR LATENT RETURN[1]				JOB CREATION (person years of employment [direct, indirect and induced])	
	YEAR 1 (capital)	YEAR 5 (capital + annual)	YEAR 25 (capital + annual)	YEAR 50 (capital + annual)	CAPITAL (Construction)	ANNUAL (Maintenance)
Extensive Green Roof	-5,854,293	-4,108,511	2,874,618	11,603,529	432.855	20.612
Intensive Green Roof	95,427	2,637,153	18,988,252	39,427,124	107.256	10.987[2]
Green Facade	40,083	121,354	446,440	852,797	79.049	1.581
Rain Garden	-6,033,343	-6,330,100	-7,517,128	-9,000,912	102.910	1.252
Bioswale	-11,250,498	-12,585,043	-17,923,222	-24,595,946	191.565	4.803
Permeable Pavement	-3,010,000	-3,736,428	-6,642,141	-10,274,282	51.170	2.478
Tree – Small	-250,002	-120,276	1,626,038	4,227,405	4.250	0.127
Tree – Medium	-149,990	227,484	5,025,101	12,148,430	2.550	0.125
Tree – Large	-449,856	546,862	13,602,495	33,041,020	7.647	0.239
Neighborhood Green Infrastructure: Property Tax Increases[3]	0	162,347	5,682,148	12,176,031	N/A	N/A
TOTAL ROI FOR STUDY AREA REDESIGN	**$-26,862,472**	**$-23,185,157**	**$16,162,601**	**$69,605,197**	**979.25 FTE**	**42.22 FTE**

1 Public return on investment includes the following benefits: stormwater management, reduction in urban heat island, greenhouse gas sequestration, air quality improvements, and increased property tax. All benefits associated with trees are accounted for at 50% value from year 5, and full value at year 10, as benefits are limited until trees are mature. Property tax increases associated with trees and neighborhood green infrastructure are also accounted for at 50% value from year 5, and full value at year 10. ***2*** Includes 5.88 FTE jobs supported by urban agriculture***. 3*** The NYC DEP's Green Infrastructure Co-Benefits Calculator suggests that green infrastructure in the area boosts property values by 9%. This is based on an estimate of the number of Class 1 properties within 100 feet of planned green infrastructure. See section on Customized Values for New York City/Harlem for further information.

New Harlem Lane - Costs and Benefits of Planned Green Infrastructure by Green Infrastructure Type

Generic Green Infrastructure Type	Area (ft^2)	COSTS (Public and Private)		BENEFITS (Public and Private)	
		Construction (Capital)	Maintenance (Annual)	One-Time[1]	Annual[2]
Intensive Green Roof	130,000[3]	$2,726,493	$129,833	$52,151	$339,660
Rain Garden	2,250	$270,480	$3,291	$905	$713
Bioswale	23,000	$5,634,300	$141,267	$9,051	$12,594
Permeable Pavement	46,500	$924,500	$44,763	$0	$8,643
Tree – Small	39,700 (36 trees)	$35,853	$1,073	$15,947	$16,236
Tree – Large	1,401,000 (460 trees)	$459,712	$14,366	$562,886	$817,349
Neighborhood Green Infrastructure: Property Value Increases[4]	N/A	N/A	N/A	13,500,000	N/A
Neighborhood Green Infrastructure: Property Tax Increases[5]	N/A	N/A	N/A	N/A	158,387
TOTAL	**1,642,450**	**$10,051,338**	**$334,593**	**$14,140,940**	**$1,195,195**
	ft^2 of Green Infrastructure	Capital ($)	Annual ($)	One-time ($)	Annual ($)

1 Capital Benefits include biodiversity (public benefit), and increased property value (private benefit). Biodiversity benefits and property value increases associated with trees and neighborhood green infrastructure as a whole are only a factor at maturity, 5-10 years after planting. Property value increases associated with green roofs occur on installation. ***2*** Annual benefits include stormwater management, reduction in urban heat island, greenhouse gas sequestration, air quality improvements, and increased property tax (all public benefits), as well as reduction in building energy use, increased roof membrane lifespan, and yield from urban agriculture (all private benefits). No benefits associated with trees occur until maturity. The return on investment factors half the benefits occurring beginning in the 5th year after planting, and the full benefit occurring beginning in the 10th year after planting. ***3*** Includes 17,000 ft2 of area designated for Urban Agriculture Uses. ***4*** The NYC DEP's Green Infrastructure Co-Benefits Calculator suggests that green infrastructure in the area boosts property values by 9%. This is based on an estimate of the number of Class 1 properties within 100 feet of planned green infrastructure. See Section on Customized Values for New York City/Harlem for further information. Property value increases do not occur until trees reach maturity. The return on investment factors half the benefits occurring beginning in the 5th year after planting, and the full benefit occurring beginning in the 10th year after planting. These estimates are likely extremely low due to the lack of data available on Class 2 properties, which make up a majority of properties in the study area. ***5*** Property tax increases do not occur until property values increase; see above.

New Harlem Lane - Public Return and Job Creation by Green Infrastructure Type

Generic Green Infrastructure Type	PUBLIC RETURN ON INVESTMENT (ROI) AND/OR LATENT RETURN[1]				JOB CREATION (person years of employment [direct, indirect and induced])	
	YEAR 1 (capital)	YEAR 5 (capital + annual)	YEAR 25 (capital + annual)	YEAR 50 (capital + annual)	CONSTRUCTION (One-time)	MAINTENANCE (Annual)
Intensive Green Roof	-626,876	337,168	4,193,345	9,013,565	46.350	3.477[2]
Rain Garden	-269,575	-148,151	-334,016	-398,457	4.598	0.022
Bioswale	-5,625,249	-6,268,612	-8,842,064	-12,058,878	95.782	2.402
Permeable Pavement	-924,500	-1,105,100	-1,827,500	-2,730,500	15.716	0.761
Tree - Small	-35,853	-17,054	236,596	614,523	0.609	0.018
Tree - Large	-459,712	564,022	13,991,145	33,985,026	7.815	0.244
Neighborhood Green Infrastructure – Property Tax Increases[3]	0	79,194	2,771,780	5,939,528	N/A	N/A
TOTAL ROI FOR STUDY AREA REDESIGN	**$-7,941,764**	**$-6,558,533**	**$10,189,286**	**$34,364,806**	**170.87 FTE**	**6.96 FTE**

1 Public return on investment includes the following benefits: stormwater management, reduction in urban heat island, greenhouse gas sequestration, air quality improvements, and increased property tax. All benefits associated with trees are accounted for at 50% value from year 5, and full value at year 10, as benefits are limited until trees are mature. Property tax increases associated with trees and neighborhood green infrastructure are also accounted for at 50% value from year 5, and full value at year 10. ***2*** Includes 1.27 FTE jobs supported by urban agriculture***. 3*** The NYC DEP's Green Infrastructure Co-Benefits Calculator suggests that green infrastructure in the area boosts property values by 9%. This is based on an estimate of the number of Class 1 properties within 100 feet of planned green infrastructure. See section on Customized Values for New York City/Harlem for further information.

The Greening of Canaan - Costs and Benefits of Planned Green Infrastructure by Green Infrastructure Type

Generic Green Infrastructure Type	Area (ft^2)	COSTS (Public and Private)		BENEFITS (Public and Private)	
		Construction (Capital)	Maintenance (Annual)	One-Time	Annual[1]
Extensive Green Roof	14,300	$292,929	$4,550	$5,603	$7,692
Intensive Green Roof	4,800	$101,399	$4,829	$1,940	$4,978
Green Facade	5,000	$225,000	$4,500	$1,940	$793
Rain Garden	1,200	$141,680	$1,724	$474	$335
Permeable Pavement	5,500	$107,500	$5,205	$15,947	$16
Tree – Small	13,000 (12 trees)	$11,628	$348	$5,172	$5,203
Tree – Medium	87,000 (36 trees)	$35,802	$1,053	$34,911	$41,955
Wetland	200	$17,160	$320	$86	$77
Planting Bed	3,500	$58,557	$1,654	$1,379	$1,174
Tower Garden	21,195	$787,500	N.D.	N/A	$316,000
TOTAL	**131,000**	**$1,779,154**	**$24,183[2]**	**$51,505**	**$378,222**
	ft^2 of Green Infrastructure	Capital ($)	Annual ($)	One-Time ($)	Annual ($)

1 Annual benefits include stormwater management, reduction in urban heat island, greenhouse gas sequestration, air quality improvements, and increased property tax (all public benefits), as well as reduction in building energy use, increased roof membrane lifespan, and yield from urban agriculture (all private benefits). No benefits associated with trees occur until maturity. ***2*** This number does not include labor or nutrient costs for the tower garden array, and is likely to be higher as a result.

The Greening of Canaan - Public Return and Job Creation by Green Infrastructure Type

Generic Green Infrastructure Type	PUBLIC RETURN ON INVESTMENT (ROI) AND/OR LATENT RETURN[1]				JOB CREATION (person years of employment [direct, indirect and induced])	
	YEAR 1 (capital)	YEAR 5 (capital + annual)	YEAR 25 (capital + annual)	YEAR 50 (capital + annual)	CONSTRUCTION (One-time)	MAINTENANCE (Annual)
Extensive Green Roof	-67,350	-47,266	33,071	133,492	4.980	0.237
Intensive Green Roof	-23,314	-10,495	40,779	104,871	1.724	0.082
Green Facade	1,940	5,872	21,602	41,264	3.825	0.076
Rain Garden	-141,206	-148,151	-175,933	-210,660	2.409	0.029
Permeable Pavement	-107,500	-133,444	-237,219	-366,939	1.827	0.088
Tree - Small	-11,628	-5,594	75,630	196,623	0.198	0.006
Tree - Medium	-35,802	18,218	704,803	1,724,219	0.609	0.018
Wetland	-17,074	-18,291	-23,158	-29,242	0.292	0.005
Planting Bed	-57,178	-59,577	-69,176	-81,174	0.995	0.028
Tower Garden	N/A	N/A	N/A	N/A	N.D.	1.67
TOTAL ROI FOR SITE REDESIGN	**$-459,112**	**$-398,728**	**$370,398**	**$1,512,456**	**16.86 FTE**	**2.24 FTE**

1 Public return on investment includes the following benefits: stormwater management, reduction in urban heat island, greenhouse gas sequestration, air quality improvements, and increased property tax. All benefits associated with trees are accounted for at 50% value from year 5, and full value at year 10, as benefits are limited until trees are mature.

Canaan Baptist Church Properties Green Excellence Matrix

Key
Y= Yes **N**= No **M**=Maybe **L** = Yes, at a later point in time

Address	Building area (sf)	Green roof	Solar PV	Urban Farming	Comments
132 W 116th St.	15,372	Y	Y	N	Two potential green roofs -- higher upper roof great candidate, also for PV; lower roof for green roof only; could be used as event space
2034 Adam Clayton Powell Jr. Blvd.	8,146	M	M	N	Need to verify next time roof will be replaced
160 W 116th St.	7,563	L	L	L	Upon roof replacement
2177 Frederick Douglas Blvd.	7,353	L	L	N	Upon roof replacement
127 W 115th St.	6,370	Y	N	Y	Lower roof only -- upper roof has leaking issues
130 W 116th St.	2,364	N	N	N	Abandoned
71 W 118th St.	1,926	N	M	N	Small site; decent layout for PV; small size
146 W 124th St.	1,888	N	N	N	Small site; not cost-effective for green roof
144 W 124th St.	1,865	N	N	N	Small site; not cost-effective for green roof
283 W 118th St.	1,839	N	N	N	Small site; not cost-effective for green roof; small for solar & shaded
273 W 118th St.	1,745	N	N	N	Small site; not cost-effective for green roof; small for solar
277 W 118th St.	1,739	N	N	N	Small site; not cost-effective for green roof; small for solar
275 W 118th St.	1,737	N	N	N	Small site; not cost-effective for green roof; small for solar
279 W 118th St.	1,732	N	N	N	Small site; not cost-effective for green roof; small for solar
73 W 118th St.	1,506	N	N	N	Small site; not cost-effective for green roof; small for solar
126 W 124th St.	1,235	N	N	N	Small site; not cost-effective for green roof; small for solar
128 W 124th St.	1,202	N	N	N	Small site; not cost-effective for green roof; small for solar
77 W 118th St.	1,177	N	N	N	Small site; not cost-effective for green roof; small for solar
83 W 118th St.	1,165	N	N	N	Small site; not cost-effective for green roof; small for solar
2173 Frederick Douglas Blvd.		-	-	-	No building

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